Deathways and Lifeways in the American Southwest

Tucson's Historic Alameda-Stone Cemetery and The Transformation of a Remote Outpost into an Urban City

Edited by
Michael Heilen,
Joseph T. Hefner,
and Mitchell A. Keur

Volume 2
The History, Archaeology, and Skeletal Biology of the Alameda-Stone Cemetery

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Michael Heilen and
Marlesa A. Gray,
series editors

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CHAPTER 1

Bioarchaeology of the Alameda-Stone Cemetery

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Bioarchaeological investigations of historical-period cemeteries offer a rare opportunity to study the human past through the examination of a combination of historical, contextual, and osteological evidence. In North America, bioarchaeology refers to the study of physical human remains and the archaeological contexts in which they are found. Bioarchaeology therefore includes the study of both skeletal biology and mortuary contexts, as well as benefits from other sources of information, such as ethnographic and historical studies, that add to these investigations. The exploration and integration of these multiple lines of evidence can be powerful means of documenting and interpreting the human experience in ways that are inaccessible to other forms of archaeological investigation. A tremendous amount can be learned by combining these interrelated lines of evidence to understand how a cemetery was used and the lives and deaths of the population that used it.

More than 3 decades ago, Buikstra (1977) argued that bioarchaeological investigations should include the study of "(1) burial programs and social organization; (2) daily activities and the division of labor; (3) paleodemography, including estimates of population size and density; (4) population movement and genetic relationships; [and] (5) diet and disease" (summarized in Buikstra 2006:xviii). Much bioarchaeological research in the Americas follows the foci outlined by Buikstra, but despite the integrated focus of bioarchaeological studies, it is not always the case that mortuary contexts are fully considered along with osteological evidence in drawing conclusions. Many bioarchaeological investigations are limited in the kinds of conclusions that can be drawn by low sample sizes, time and budgetary constraints, or limited integration of multiple lines of evidence (Goldstein 2006). Although time and budgetary constraints will always have an impact on what can be learned from cemetery excavations, and this project is no exception, studies of the Alameda-Stone cemetery have benefited from a comparatively large sample size and have endeavored to fully integrate biological and contextual information, to gain a more complete understanding of the Alameda-Stone cemetery and the people who used it. At the same time, distinct analyses of artifact and feature types, historical demography and paleodemography, pathology, trauma, and morphology are necessary to develop the evidence to be integrated. This volume presents these analyses, which are further integrated in Volume 1 of this series.

This volume represents the culmination of research conducted by mortuary analysts and osteologists for the Joint Courts Complex Archaeological Project in Tucson, Pima County, Arizona; this chapter provides an introduction to the analysis of the Alameda-Stone cemetery. We begin with a brief description of the project's history—how it came about, how it was funded and organized, and how archival data, mortuary-context data, and skeletal-biological data fit into the overall project. (A more complete discussion of project history is provided in Chapter 2, Volume 1 of this series.) Following is a brief outline of the research perspectives that guided the mortuary analysis and skeletal-biological research, along with explanations of how these perspectives contributed to the design and implementation of analyses presented in this volume. Bioarchaeological investigations are, ultimately, most meaningful when placed in a larger, comparative context. We therefore present background information on several of the key bioarchaeological projects and cemetery contexts that we used in comparison with our findings for the project. Finally, we explain the organization of the volume, outlining the purpose and content of each chapter and its contribution to our research goals.

Project History, Archaeological Excavations, and Bioarchaeological Research Questions

In 2005, in preparation for the construction of a planned multistory city/county courts facility on a 4.33-acre parcel in downtown Tucson, Arizona, called the Joint Courts Complex (Figure 1), Pima County issued a contract to Statistical Research, Inc., to prepare an initial cultural resource overview of the project area. The purpose of the work was to determine the potential impact of construction on cultural resources in the project area. The resulting overview (O'Mack 2005; see Appendix A) confirmed that the project would directly impact an abandoned nineteenth-century cemetery informally known as the "national cemetery" and subsequently designated archaeological site AZ BB:13:682 (ASM). Subsequent research showed that the cemetery, most of which was public rather than military, was never officially designated a national cemetery, and that term is not used in this report, except in direct quotes. In the absence of a formal name that encompasses the area under discussion, we have chosen to use the informal designation "Alameda-Stone cemetery," in reference to two current major cross streets adjacent to the project area that also existed during its period of use as a place of burial. The project also had the potential for impacting unidentified prehistoric period resources and known historical-period features relating to postcemetery residential and commercial use of the project area (see Volumes 1 and 3 of this series).

A subsequent, in-depth, archival study of the cemetery by Statistical Research, Inc. (O'Mack 2006; see Appendix B), established two discrete areas: a small, adobe-walled military cemetery used by the U.S. Army from 1862 until 1881 and a larger, civilian cemetery, adjacent to the military cemetery, that was used by the general population of Tucson from the early 1860s until 1875 (see Figure 1). The archival research suggested that some portion of the burials in the military cemetery were removed by the U.S. Army in 1884, but there was no evidence for the systematic removal of burials from the civilian cemetery. Unfortunately, no full record exists of the number of burials in the civilian portion of the cemetery, but an examination of early Tucson burial records and federal-census data suggests that the total number of deaths in Tucson during the period the cemetery was in use ranged from approximately 1,800 to more than 2,100 (see Chapter 4).

To mitigate the impact of the Joint Courts Complex construction project on the cemetery and other archaeological resources in the project area, Pima County contracted with Statistical Research, Inc., to carry out archaeological data recovery of the entire 4.33-acre parcel. Modern archaeological fieldwork in the project area had been restricted to a monitoring project in November 2001 for a fiber-optic-line installation (Zaglauer and Doak 2003). During monitoring, one historical-period burial was encountered (our Grave Pit 28339), consisting of an adult skeleton and the remnants of a coffin. The archaeologists concluded that the discovery was associated with the Alameda-Stone cemetery. This discovery was the first burial to be documented in situ in the Joint Courts Complex project area by a professional archaeologist, but earlier, accidental discoveries of burials originally placed in the cemetery had also occurred, including a 1953 salvage recovery of the remains of 80–120 individuals during excavation for the basement of the Tucson Newspapers building (O'Mack 2005, 2006). The remains of 48 individuals recovered during the 1953 excavation were curated at the Arizona State Museum and were analyzed and repatriated as part of the current project (our Burial Feature 10235, Individuals 1–48).

Excavations conducted by Statistical Research, Inc., in the project area began in November 2006 and were structured according to a treatment plan (Beck et al. 2006; see Appendix C) prepared prior to fieldwork. During the next year and a half (full time through March 2008, with final excavations occurring in August 2008), Statistical Research, Inc., excavated the remains of more than 1,300 individuals from 1,083 grave pits and disturbed or secondary contexts (Figure 2). Additionally, the project featured a small but significant prehistoric period component (see Chapter 3, Volume 1 of this series) and a sizable postcemetery component (see Volume 3), both of which were excavated and analyzed concurrently with the cemetery component. This volume reports the conclusions drawn from in-field and laboratory analyses of grave pits, burial features, and the human-skeletal remains found in the project area. Volume 1 of this series introduces the project, provides historic contexts for interpreting the prehistoric period and historical-period archaeology of the project area, and synthesizes the historical, archaeological, contextual, and human-osteological data, in order to address the major

research questions for the project. Burial descriptions and maps of individual burials are provided in Volume 4. Descriptive information on archaeological finds postdating the cemetery is presented in Volume 3.

Several aspects of life and death in nineteenth-century Tucson were considered during analysis and interpretation of the Alameda-Stone cemetery. Because the Alameda-Stone cemetery was the only cemetery in Tucson during most of its period of use, the human remains and graves excavated there potentially represent a biological and cultural cross section of the entire community. To make the most of their historical value, the interments were studied using the methods and models of two subdisciplines of bioarchaeology: skeletal biology and mortuary analysis. Skeletal biology is the study of the biological history of individuals and populations as preserved in their physical remains; mortuary analysis is the study of social, ideological, and cultural identity as revealed in the treatment of the dead.

The analysis of mortuary contexts from the Alameda-Stone cemetery involved the investigation of archival and archaeological information about variation in mortuary practices within the project area, including the evaluation of cemetery formation, use, and abandonment and variation in mortuary practices in different areas of the cemetery and among different segments of the burial population. The osteological analysis of human remains from the Alameda-Stone cemetery involved investigations of paleodemography, pathology, dental anthropology, epigenetic-trait analysis, paleonutrition, and behavioral analysis. In the treatment plan (Beck et al. 2006) prepared prior to fieldwork, we proposed some specific research questions along each of these lines of inquiry that could be addressed by the Joint Courts Complex project bioarchaeological data. Foremost was understanding who was buried within the cemetery. Mortuary analysis was geared toward exploring the ways in which differential treatment of the dead could help in defining group affiliation and cultural identity and how variations in these could inform on the internal organization of the cemetery, potential changes through time, and religious, social, and economic distinctions within the community of Tucson during the 1860s and 1870s. The primary goal of our osteological analysis was to reconstruct the composition of the cemetery sample: the age, sex, and group affinity (biological, cultural, or both) of each recovered individual. Documentary sources suggested that people buried in the Alameda-Stone cemetery were probably Hispanic or Euroamerican, but a significant number of Native American (including Tohono O'odham, Apache, and Yaqui) individuals were also expected. So, maximizing the possibility of establishing group affinity was of the utmost importance from the beginning (Beck et al. 2006).

The investigation of mortuary practices is an important avenue to documenting and interpreting differences in cultural affinity and their relationship to the organization of the cemetery. The characteristics of grave-pit and burial features—including information on grave-pit size and shape, burial containers, how individuals were placed in the graves, body preparations, and accompanying goods—provide a wealth of information on burial treatment. Analysis of mortuary practice allows us to understand how burials were carried out in the multiethnic, frontier community of Tucson at a time when burial practices were changing in both the United States and Mexico and when the community itself was undergoing dramatic political, social, and economic change. Likewise, the information osteological data yields (e.g., on general health, interpersonal violence, and cultural practices) was also an important consideration that served to inform on variations in cultural affinity, as well as similarities and differences among the burial population in health and life experience.

The thorough examination, diagnosis, and interpretation of pathological conditions can serve to confirm, refute, or revise previous assumptions about death and dying in Tucson during the nineteenth century. Data derived from dentition can provide a vast amount of information about a given population, including qualitative measures of nutrition, idiosyncratic behaviors, and cultural practices. Furthermore, dental data can provide clues to population dynamics, such as familial relationships, without the destructive methods associated with genetic tests (e.g., DNA or mtDNA). The collection of epigenetic-trait data for establishing meaningful patterns throughout the cemetery was considered from the outset, although neither the nature of epigenetic traits nor the heritability of each is fully understood. Finally, skeletal indicators of behavior—including specific pathological conditions, as well as bone geometry, nonpathological bony responses to physical activity, and attrition—can provide information about individuals, as well as the population as a whole. We hoped to determine, for example, differences in activity patterns between Euroamerican and Hispanic samples. As the project progressed, we discovered, in nearly all cases, that our initial research questions could be strengthened, or in

some cases discarded, in favor of more-pertinent questions. Below, we discuss the general research issues for bioarchaeology that structured the analysis and interpretation of data that are the focus of this volume.

The specific techniques used were dictated by the burial agreements developed for the project by Pima County and the Arizona State Museum in consultation with the Catholic Diocese of Tucson and representatives of the principal descendant groups, including Los Descendientes del Presidio de Tucson, the Tohono O'odham Nation, the Pascua Yaqui Tribe, and the San Carlos Apache Tribe (see Chapter 2, Volume 1 of this series). One burial agreement covers human remains predating the establishment of the Tucson Presidio in 1775; the second covers all human remains from 1775 and later. These burial agreements constitute Appendix 2.A.1, Volume 1 of this series.

Bioarchaeological Research Perspectives

Bioarchaeological investigations of the Joint Courts Complex project area were not necessarily undertaken from the perspective of a descriptive series of individual assessments or case studies. However, basic contextual information about each grave-pit and burial feature and biological information about each individual—including assessments of age, sex, and ancestry—provide the framework for understanding the population as a whole and the history shared by that population. As in other bioarchaeological studies, the Alameda-Stone cemetery sample can be understood through analyses of the demographic composition of the cemetery, variation in mortuary treatment, the pathological conditions affecting individuals, the injuries they suffered, their relationships to one another and to distant populations, and their daily activities and how those affected their skeletons.

Building from these fundamental data sets, we can develop an understanding of Tucson's inhabitants during the nineteenth century at various scales—from individual attributes to demographic dynamics, from patterning in the artifacts and feature attributes in a single grave pit to mortuary programs, and from unique skeletal lesions to disease patterns across groups. On one level, we can develop a well-rounded picture of the individual, and on another level, the size of the Joint Courts Complex sample also permits us to draw inferences about the larger population of mid-nineteenth-century Tucson. Therefore, many of the analyses that follow are structured in ways that maximize comparisons of, and enable distinctions to be made between, various aspects of the individuals, from age, sex, ancestry, and burial treatment to the arrangement of individuals within the cemetery. In that way, any correlation between an individual's biology (e.g., sex) and their burial context within the cemetery is established, and any extrinsic factors affecting the skeleton (e.g., pathologies) are also considered. Identifying a structured spatial distribution of the individuals associated with a particular burial treatment or a particular disease process, for instance, may reveal patterns of social organization and differential treatment that would be unrecognizable from artifacts or historical records alone. Because the living population and the skeletal assemblage existed on a continuous spectrum of health and disease, discussing the mortality and morbidity of the burial sample reveals the conditions under which the living population survived. Additionally, identifying and scrutinizing the disparate impacts of disease and pathology among groups differing in age, sex, or biological affinity offer a perspective—both epidemiological and sociocultural—of life in nineteenth-century Tucson.

Very few skeletal studies have focused primarily on individuals identified as Hispanic, particularly using a sample as large and as well preserved as the Alameda-Stone cemetery sample. The analysis and interpretation of this data set have presented a unique opportunity to develop a better understanding of Hispanic individuals in the greater Southwest region. Perhaps more importantly, the Alameda-Stone cemetery sample will undoubtedly serve as reference material for other sites with Hispanic components as they are identified.

Comparative Samples

A broad range of samples are used in this volume for comparisons with the Alameda-Stone cemetery. For the mortuary analyses described in Chapters 5 and 6, reports from over 130 investigations were consulted, in order to compare project results with those of other investigations (see Chapter 5, Table 43). The vast majority of projects consulted pertain to cemeteries in North America dating to the nineteenth century, although several compared projects investigated burial contexts from the seventeenth, eighteenth, or twentieth centuries. Similarly, a wide range of projects were consulted for the osteological analysis.

Although many samples were available for use, researchers chose to focus many comparisons on a selection of the better-documented and more-pertinent samples. This section details the major comparative samples employed by researchers in subsequent chapters of this volume. Even though these samples were scattered across the United States and Canada, they are similar to the Alameda-Stone cemetery sample in various parameters, such as size, temporal or geographic placement, breadth of data set, or demographic composition. No sample was identical to the Alameda-Stone cemetery in all of these characteristics (see Chapters 1 and 10, Volume 1 of this series). Nevertheless, the similarities and dissimilarities among the data from these samples permitted directed comparisons along specific lines of inquiry, allowing exploration of the various reasons for consistency and inconsistency in predictions and observations. The samples used for comparison, along with their geographic locations, temporal placement, approximate sample sizes, and general ethnic compositions, appear in Table 1.

Arikara, Mobridge Site (39WW1)

Located on the north bank of the Missouri River, the Mobridge Site in South Dakota represented the occupation of Protohistoric period agricultural Arikara, dating to the early half of the eighteenth century. Two excavations, conducted by William Bass (1968–1970) and Douglas Ubelaker (1971), unearthed a total of 654 skeletons. Only 193 were complete enough for full analyses by Merchant and Ubelaker (1977). The information presented by Merchant and Ubelaker, particularly in the use of juvenile long-bone lengths to predict age at death, has been used by many investigators and is included in comparative examinations in Chapter 9.

Dove Cemetery (CA-SLO-1892/H)

Located on a hillock overlooking El Camino Real in the southern portion of Atascadero, California, and originally associated with small, nearby, rural communities, such as Dove (Paloma) and Santa Margarita, Dove Cemetery (CA-SLO-1892/H) was a small, Victorian-era cemetery evaluated and moved by Statistical Research, Inc., personnel in the spring of 2004 (Sewell and Stanton 2008). During the course of the excavation, 17 burials were recovered, 16 of which were clustered in a 15-by-10-m area. The final individual was located approximately 7 m north of this concentration.

The skeletal sample at Dove Cemetery was largely adult male, with only three adult females and four juvenile individuals of indeterminate sex represented. Many of the individuals were identified as either Hispanic or European.

Although much smaller than many of the comparative samples used for this study, the information gathered from Dove Cemetery is important because it not only represents a sample both temporally and ethnically similar to the Alameda-Stone cemetery sample but also provides a foil by which analysts might compare urban versus rural patterns of mortuary behavior.

Freedman's Cemetery (41DL316)

Between 1990 and 1994, a 0.95-acre area of Freedman's Cemetery, a historical-period (circa 1869–1907) African American cemetery located immediately north of downtown Dallas, Texas, was excavated for planned highway expansion (Condon et al. 1998:vii, 1). Although less than a quarter of the total cemetery was excavated, 1,157 individuals (278 adult females, 288 adult males, 87 indeterminate-sex adults, 487 juveniles, and 17 empty coffins) were recovered and analyzed (Condon et al. 1998:v).

The burial sample associated with Freedman's Cemetery was compared to several other relatively contemporary burial samples of Euroamerican, Chinese, and free and enslaved African American individuals. Researchers examined mortuary treatment, infectious illnesses, biomechanical and nutritional stress indicators, trauma, and dental health. As can be expected, when the Freedman's Cemetery sample was compared to the samples of enslaved African American individuals, the samples of the enslaved individuals were found to exhibit greater frequencies of nutritional and biomechanical stress, as well as lower life expectancy (Tiné 2000:519–520).

Freedman's Cemetery was different from the Alameda-Stone cemetery in a number of significant ways, including relatively singular ethnic composition and later temporal placement for the majority of burials. These differences from the Alameda-Stone cemetery are muted, however, by two important attributes shared by both: burial-sample size and proximity to an urban center. Comparisons for bioarchaeological investigations are not necessarily limited to strictly biological characteristics, and the attributes of the site itself—and not just the individuals interred within it—are important to consider.

Mission Nuestra Señora del Refugio (41RF1)

To prepare for proposed highway improvements, the Catholic cemetery associated with the Mission Nuestra Señora del Refugio was excavated in 1999 by the Texas Department of Transportation in conjunction with the Center for Archaeological Research, University of Texas, San Antonio (Meadows-Jantz et al. 2001).

A minimum of 177 individuals, primarily of Native American or Hispanic descent, were identified in this skeletal sample. Although 165 of these individuals were identified as burials, most of the remains associated with these individuals were fragmentary and found in a commingled state. Approximately one-third of the individuals were identified as juveniles, and the adult sex ratio was 1.6 (male to female). As is the case with many historical-period cemeteries, historical documentation—specifically Mission documents and 1810 census records—was available to the researchers for comparison to the skeletal series, and it allowed researchers to compare the physical evidence recovered from the cemetery to what was reported at the time.

Skeletal observations reported by investigators included demographic analyses, dental health and pathology, cranial and postcranial pathological conditions, and evidence of antemortem and perimortem trauma. These observations permitted both broad and focused comparisons to the Alameda-Stone cemetery skeletal data set.

New York African Burial Ground

The African Burial Ground project began in 1991, when construction workers accidentally uncovered human-skeletal remains. The remains of over 400 men, women, and children were removed. Archival research revealed that thousands of African and African American individuals, many of them enslaved, were buried during the seventeenth and eighteenth centuries in a burial ground in lower Manhattan, outside the boundaries of the settlement of New Amsterdam, which would become New York. After the burial ground was closed to further burial in the late-eighteenth century, the burial ground was covered with as much as 25 feet of fill dirt and developed for other uses (Blakey and Rankin-Hill 2009; Medford and Brown 2009; Perry and Howson 2009).

The burial sample was composed primarily of enslaved African individuals. Investigators reported a variety of mortuary and skeletal analyses, including evidence of African ancestry and African-derived mortuary

behaviors. Analyses revealed nutritional deficiencies, biomechanical stressors, relatively high rates of trauma, and high mortality rates. Although the time period and general composition of the African Burial Ground are inconsistent with those of the Alameda-Stone cemetery, several characteristics in common provided for useful comparison. Chief among these characteristics were sizable skeletal samples and the impact of postcemetery development as land use changed over the decades. Conversely, this site formed a frame of reference for a highly stressed, enslaved, immigrant population with which the presumably less-stressed, free, frontier population represented in the Alameda-Stone cemetery sample could be compared.

San Agustín Mission

Constructed in the later-seventeenth century, the San Agustín Mission was located on the west bank of the Santa Cruz River, near present-day Tucson, Arizona. An O'odham village was associated with this mission, and the population connected to the mission was primarily Native American, with a small number of individuals of Hispanic descent (Dayhuff 2002:17–18; Hard and Doelle 1978). Despite a principally native composition, Christian burial practices were performed. In 1949, an expansion of the Tucson Pressed Brick Company threatened the mission, and investigators from the University of Arizona recovered approximately 50 burials (Dayhuff 2002:21); 33 additional burials were recovered by University of Arizona staff the following year.

Two studies of the San Agustín Mission remains investigated the extent and success of adaptation by both native populations and European immigrants (Dayhuff 2002). These lines of inquiry provided an invaluable basis for comparison to the Alameda-Stone cemetery sample. In addition to the similar geographic location in Tucson, both the San Agustín Mission and the Alameda-Stone cemetery featured the dynamic element of established native populations interacting with arriving individuals of differing biological and cultural backgrounds.

Tucson Presidio

Constructed in 1776 across the river from the San Agustín Mission and only a few hundred yards west of the land that came to contain the Alameda-Stone cemetery, the Tucson Presidio was home to Hispanic soldiers, their families, and numerous immigrants of various ancestries. Since 1966, the Arizona State Museum has recovered numerous individuals from the Tucson Presidio that were encountered during construction projects in downtown Tucson. Following examination, many individuals were repatriated to the Tohono O'odham Nation and to Los Descendientes del Presidio de Tucson, a local organization representing the descendants of the early Hispanic inhabitants of colonial Tucson (Dayhuff 2002:15, 26; Thiel et al. 1995). As of 2002, 104 burials recovered from the Tucson Presidio were curated at the Arizona State Museum.

Like the individuals from the San Agustín Mission, these individuals represent remains from the same geographic context as that of the Alameda-Stone cemetery sample, as well as remains from a population ancestral to many of the individuals interred in the Alameda-Stone cemetery. Additionally, like the San Agustín Mission, the Tucson Presidio provides a sample of individuals experiencing the rapidly evolving dynamics of interactions between local and immigrating populations.

St. Thomas' Anglican Church Cemetery Project

Constructed in 1819, St. Thomas' Anglican Church is one of the oldest churches in the community of Belleville, Ontario, and its cemetery represents the first public burial ground established in the town (Saunders et al. 2002:131–132, 137–138). Parish records indicated that nearly 1,500 individuals were interred in the cemetery. In 1989, in response to a proposed expansion project, a portion of the cemetery associated with the church was excavated. Nearly 600 burials were recovered during these investigations and subsequently analyzed.

The period of use for the St. Thomas' Anglican Church cemetery was similar to that of the Alameda-Stone cemetery. The geographic distance between the two cemeteries (Ontario to Tucson) provided an important control for comparisons between the two, both directly environmental and indirectly demographic. In other words, meaningful comparisons could be drawn between two different groups of people in two different places who shared a common span of time. The differences and similarities were utilized extensively in Chapter 9.

Elmbank Cemetery

Established in the churchyard of the original Elmbank mission, Elmbank Cemetery was the burial ground for many of northwest Toronto's early Roman Catholic settlers from 1832 until around 1933. The majority of individuals interred at Elmbank were of Irish descent (although other descendant groups were identified, including Anglo-Irish, German, and Austrian).

Excavations in the fall of 2000 led to the exhumation of 622 individuals. Nearly two-thirds of the individuals were adults, with males slightly outnumbering females. Fetal and neonatal remains were recovered in small numbers. A relatively large number of elderly individuals were also recovered, suggesting low mortality and high survivorship, along with low infant mortality. Over half the sample presented evidence of pathology (Williamson 2003:31). Additionally, investigators reported the incidence of trauma among individuals from Elmbank Cemetery in a fashion that made it easily comparable to other sites, including the Alameda-Stone cemetery.

Voegtly Cemetery

The Voegtly Cemetery was in use from 1833 to 1861 and was associated with the Voegtly Evangelical Lutheran Church in Pittsburgh, Pennsylvania. An extensive survey and excavation was performed in 1987, in preparation for a proposed highway expansion (Ubelaker and Landers 2003:1). The excavation led to the exhumation and analysis of 724 human-burial features by Douglas Ubelaker and his colleagues at the Smithsonian Institution.

Using death records from the German Evangelical United Church, a demographic analysis was conducted, including burial-sample profiles, causes of death, childhood mortality, intervals between death and burial, marriage patterns, professions, and patterns of immigration (Ubelaker and Jones 2003:20–24). The skeletal data generally compared favorably with those of the death records (Ubelaker and Jones 2003:25).

Extensive analyses of dental and skeletal pathology were also performed on the sample from Voegtly Cemetery (Ubelaker and Jones 2003:41–43). These analyses were helpful in comparing skeletal and dental pathology in the Alameda-Stone cemetery sample by examining frequency and distribution of illness and disease, as well as in attempts to identify patterns of similarity or difference in the presentation and pervasiveness of pathological conditions.

Volume Organization

This volume consists of 15 chapters, beginning with chapters on project methods, the project area environment, and an overview of the history and archaeology of the cemetery. These are followed by 2 chapters detailing the mortuary analysis; 7 chapters detailing the osteological analysis; a chapter detailing case studies from the cemetery, using a combination of contextual and osteological evidence; and conclusions.

Chapter 2, by Hall et al., provides the reader with a detailed description of the archaeological and osteological methods that were used in the field and laboratory to collect data; process artifacts, human remains, and samples; and conduct the necessary analyses. A thorough description of the environmental setting of the project area is provided by Windingstad and Hall in Chapter 3. Of particular interest is the discussion of the

environmental factors that affected the level of bone and other organic-matter preservation in the project area. In Chapter 4, Heilen and Hall discuss the organization of the cemetery, incorporating both historical and archaeological information to address questions concerning demography, cemetery organization, cemetery size, internal subdivisions, exhumations, and disturbance. Chapters 5 and 6, by Sewell et al., provide the results of the mortuary analysis and document variation in artifact types and feature attributes according to burial location and demography. Chapter 5 is concerned with the physical manifestations of the grave pits and burial features and their elucidation of nineteenth-century mortuary practices in Tucson. A description of the personal artifacts that were interred with the individuals buried in the cemetery is the focus of Chapter 6, with a focus placed on how personal artifacts inform on identity and burial practices.

The burial-sample demographic structure of the Alameda-Stone cemetery is described in Chapter 7. Relying on various hazard models, Trask explores the mortality and survivorship of the overall sample but also further divides the sample into a series of smaller subsets, to document differences in mortality as they relate to age, sex, and biological affinity. In Chapter 8, Hefner addresses, from a biological standpoint, the question, Who is represented in this burial sample? Differences in the biological makeup of cemetery samples are investigated using dental, craniometric, nonmetric, and spatial data. In Chapters 9 and 10, Keur and Harrison, respectively, describe the juvenile and adult skeletal morphology of the cemetery sample as it relates to ancestry, stature, sexual dimorphism, and functional morphology.

Leher, Black, and Stanton extensively explore the frequencies of pathological conditions observed in the Alameda-Stone cemetery sample in Chapter 11. Included in this chapter is a discussion of joint disease, infectious conditions, metabolic disturbances, and bony masses, as well as a discussion of how the frequencies of these conditions in the Alameda-Stone cemetery sample compare to other contemporary samples. In Chapter 12, Keur, Stanton, and Dayhuff explore the distribution of evidence for trauma across the site, comparing frequencies of injury according to age at death, sex, biological affinity, and location in the cemetery. Specific types of trauma, such as those from weapons and injuries to the spine, are addressed separately. In Chapter 13, Lincoln-Babb and McClelland explore dental health in the Alameda-Stone burial sample and discuss general dental pathological conditions. Dental restorations and dental devices observed in the sample are also discussed in this chapter.

Individual case studies are described in Chapter 14, in which Keur, McClelland, and Stanton use a combination of contextual and osteological evidence to explore the concept of the individual in a burial sample and how data from individuals cases shed light on the sample as a whole.

The final chapter, Chapter 15, summarizes the data presented in this volume and shows how bioarchaeological data contribute to answering the major research questions for the project, including those of identity, spatial distribution and cemetery organization, and the distributions of skeletal and dental pathological conditions.

Final Thoughts

The analyses and conclusions in the following chapters comprise a suite of investigations designed to better understand the population in and around Tucson in the middle to late nineteenth century. In comparison to other cemeteries investigated bioarchaeologically, the Alameda-Stone cemetery is unique in its size, location, and composition. The investigations in this volume are a fraction of those warranting consideration and examination. Every reasonable effort was made to address the bioarchaeological questions demanded by responsible science and those questions unique to this site. Because not every line of inquiry or perspective of research could be explored, the reader is encouraged to develop from and add to the research in the following chapters.

Additionally, bioarchaeological investigations are just one element of a reasoned attempt to understand a population. The history of the Joint Courts Complex project area—from its earliest evidenced human use to the excavations described in this report—is composed of a sequence of events, and each event is critical in its need for analysis. The material culture both associated with and incidental to the interred individuals helps to

develop the picture of this area as an intentional cemetery, used in various ways, for a particular purpose. This volume describes the bioarchaeological findings, and Volume 1 draws from and synthesizes every analytical effort to create the most complete and inclusive discussion of the Joint Courts Complex project area. The following chapters detail the mortuary context and biology of the individuals and groups of individuals interred in the cemetery component, and the reader is urged to incorporate information from the other volumes into information from this volume, in order to gain the most complete understanding of this unique data set.

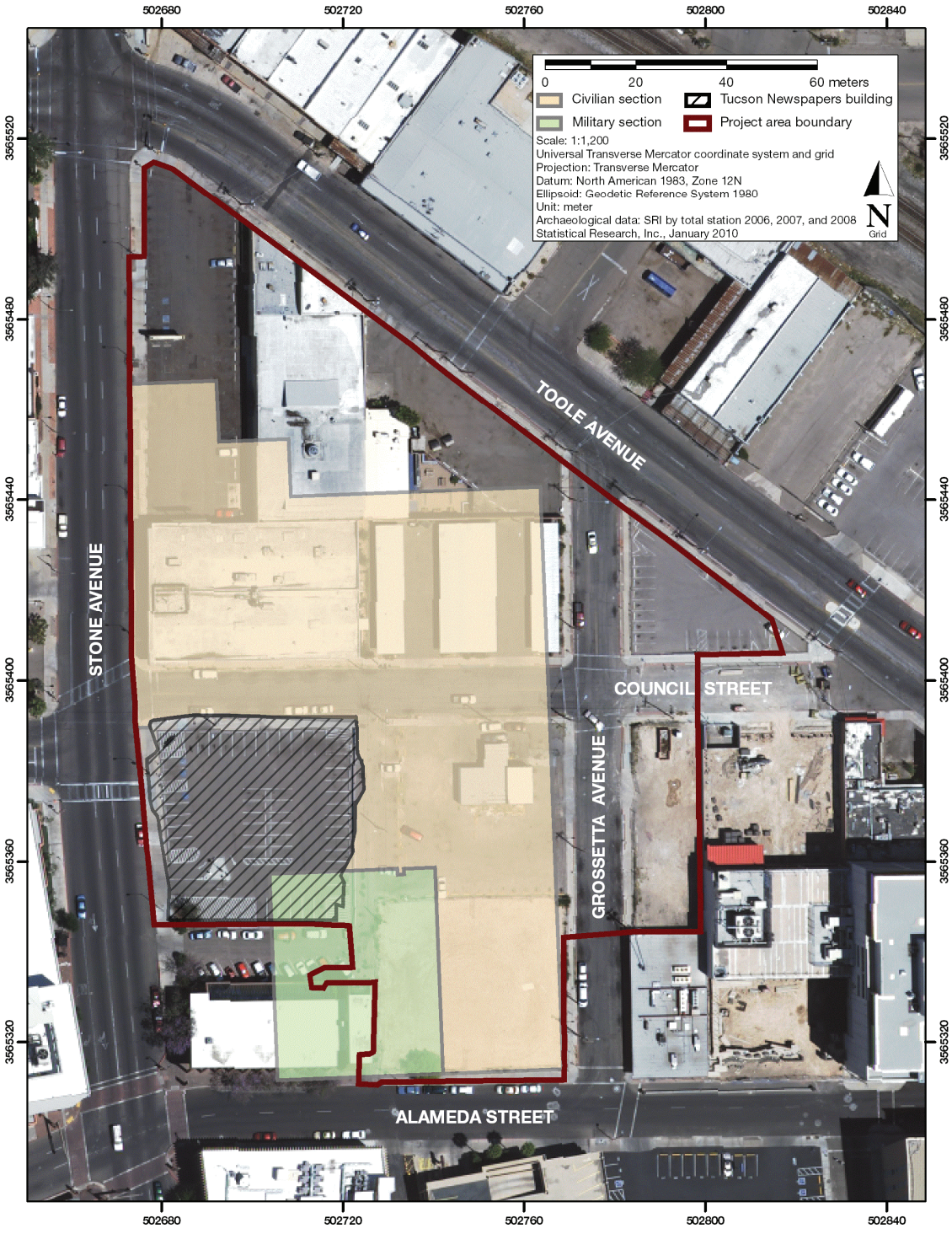

Figure 1. Map of the Joint Courts Complex project area, showing military and civilian sections of the Alameda-Stone cemetery.

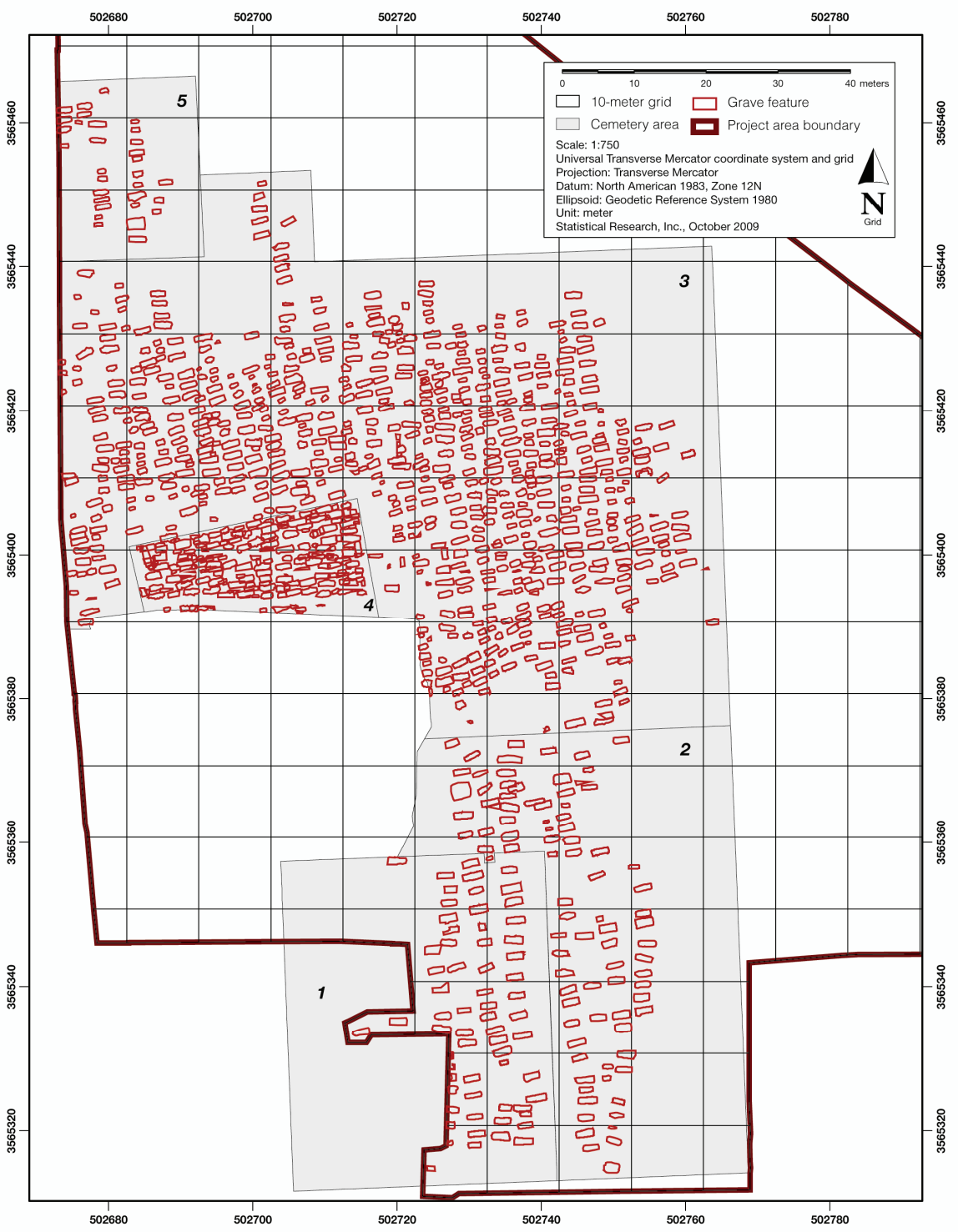

Figure 2. Map of the Joint Courts Complex project area, showing grave features.

Table 1. Skeletal Series Used for Comparison

Population/Site Name	Site Designation	Geographic Location	Time Period	Approximate Sample Size	Ethnic Composition
Mobridge	39WW1	Mobridge, South Dakota	Protohistoric	193	Arikara/ Native American
Dove Cemetery	CA-SLO-1892/H	Atascadero, California	Victorian era	17	Hispanic and Euroamerican
Freedman's Cemetery	41DL316	Dallas,Texas	1869–1907	1,157	African American
Mission Nuestra Señora del Refugio	41RF1	San Antonio, Texas	ca. 1810	165	Native American and Hispanic
African Burial Ground		Manhattan, New York	sixteenth–seventeenth century	400+	African
San Agustín Mission		Tucson, Arizona	seventeenth century	83	Native American
Tucson Presidio		Tucson, Arizona	1776	104	Spanish and Native American
St. Thomas' Anglican Church Cemetery Project		Belleville, Ontario, Canada	nineteenth century	~600	Euroamerican
Elmbank Cemetery		Mississauga, Ontario, Canada	1832–1933	622	Euroamerican
Voegtly Cemetery		Pittsburgh, Pennsylvania	1833–1861	724	Euroamerican

CHAPTER 2

Archaeological Field, Laboratory, and Analytical Methods Used on the Joint Courts Complex Project

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One of the hallmarks of the Joint Courts Complex project was the use of rigorous and innovative field, laboratory, and analytical methods for a data recovery. A strict provenience and database system, on-site inventory and analysis, and exacting cartographic control both increased productivity and heightened our ability to collect the most accurate information possible. As the primary focus of this project was the Alameda-Stone cemetery, we endeavored to structure our excavations to account for the complexities of the features as well as the most favorable way to maintain contextual control while ensuring integrity of features and protection of human remains. However, the presence of both a prehistoric component (see Volume 1 of this series) and a postcemetery residential and commercial component (see Volume 3 of this series), in addition to the cemetery, demanded that our procedures be both broad in scope and flexible in response to the intricacies of the cultural deposits.

General Field and Documentation Methods

Fieldwork is the most important part of any archaeological project. The recovery of accurate and comparable data, as well as the quality of the observations, paves the way for subsequent stages of analysis and writing. The following is a discussion of the field procedures used during the Joint Courts Complex data recovery project.

Demolition of Extant Buildings

Statistical Research and Pima County contracted Barnett & Shore Contractors LLC, Tucson, Arizona, to demolish buildings and remove concrete and asphalt from the project area. Demolition included removal of three buildings: 296 N. Stone Avenue (most recently used as Coconut's Nightclub), a former gas station building (55 E. Council Street), and a building at 240 N. Stone, previously used as a bank and most recently as a social service agency. Statistical Research initially used the 240 N. Stone building as an on-site laboratory. By the end of April 2007, however, the project lab had moved out of the building into on-site modular trailers, and Barnett & Shore began demolition of the building.

To minimize impacts of demolition to cemetery features that existed below, large slabs of concrete were saw-cut prior to removal. A concrete bank vault within the 240 N. Stone building created a logistical concern for demolition. A specialized pivoting grappler was attached to a track hoe to demolish the walls of the bank vault. The thick concrete floor of the vault proved too massive to cut with conventional concrete saws; therefore, a specialized 20-inch concrete saw was used to section pieces of the vault floor. Demolition of the buildings and slabs was justified by the exposure of numerous cemetery and noncemetery features below the concrete. Removal of concrete debris from the area became a daunting task during the project, with the tremendous amount

of intact concrete foundations, slabs, and walls. Asphalt from Council Street, Grossetta Avenue, and various other parking lots also accumulated to vast amounts of debris. Pima County arranged for regular removal of debris, as well as screened backdirt, from the project area.

Measurements

All measurements taken during excavations of the Joint Courts Complex project area were in metric units. The metric system is the universal standard scientific system of measurement, which is predicated on a decimalized number base. Prior to fieldwork, our cartography department established a project area grid using Universal Transverse Mercator coordinates, which are based on the metric system. The metric system was also applied to all analytical departments, with the exception of the historical-period artifact analysis, for which English (inches) was used as the default measurement. Once fieldwork was complete, all metric measurements of post-cemetery features were automatically converted to English measurements to accurately reflect the original measurements used in the construction of historical-period features.

General Hand-Excavation Strategy and Methods

Apart from the mechanical excavations used on this project to remove overburden and uncover features, and with the exception of the controlled mechanical excavation of deep features because of safety considerations, the majority of excavations were by hand, focused on meaningful feature contexts. Hand-excavation procedures were structured to create a high level of consistency for the project. Depending on the type of feature or the circumstances surrounding the discovery of the feature, certain standardized excavation methods applied. In general, excavation of non-grave-pit features occurred in two phases. The first phase consisted of a controlled section or sections, usually representing half of a given feature. The controlled section was excavated by hand in arbitrarily defined levels, at 10–20-cm intervals. The removed fill was always screened and appropriate samples were collected. The second half of a feature was then evaluated for internal stratigraphy and excavated in culturally or naturally defined levels, depending on the predetermined level of effort for that particular feature type. Test units were also utilized during this project. Test units served a similar function as the controlled sections, in that they were excavated in arbitrary levels to determine the internal stratigraphy of a feature. Excavation of grave pit and burial features required a diversion from the normal excavating techniques, and this strategy is discussed later in this chapter.

Mechanical Stripping

The procedures for mechanically excavating the site were complex and dynamic. As stated in the treatment plan (Beck et al. 2006), both Pima County and Statistical Research emphasized the importance of recovering all human remains from the project area, not only from pristine contexts but from disturbed overburden or redeposited sediments as well. The possibility of encountering human bone anywhere in the project area led to the development of a strict methodology for mechanical excavation, including the mechanical screening of all excavated sediments (discussed below). Statistical Research contracted Innovative Excavating, Tucson, Arizona, to mechanically excavate the project area using a specially designed backhoe blade for precision excavating and the maximization of feature identification (Figure 3).

To recover all displaced human remains in accordance with the treatment plan (Beck et al. 2006), Statistical Research created an initial exploratory mechanical excavation strategy. We began with several mechanical stripping units excavated in 5-m-wide swaths, ranging from 15 to 75 m in length. Separate 5-by-5-m units within each swath were given unique proveniences, and each was excavated in 10-cm levels. Once cultural features were identified in each 5-by-5-m unit, mechanical excavations were halted and hand excavation commenced. This procedure was continued until culturally sterile sediments were encountered (for a discussion

of culturally sterile sediments, please see Chapter 3). The mechanical stripping units were strategically placed throughout the project area in an attempt to estimate the density of grave pits and to determine the limits of the cemetery.

This mechanical excavation procedure was initiated at the outset of the project, but was soon realized to be cumbersome in terms of backdirt management and access to unexcavated portions of the project area, as well as the project's rigorous schedule. Over time, the mechanical stripping methodology was revised to be more efficient and to uncover features more rapidly for hand excavation. The use of 5-by-5-m sections within the mechanical stripping units was reevaluated, and further stripping units were altered to conform to different areas of the project area as well as scheduling goals. Larger and irregularly shaped units became the norm, as it became evident that the overburden was already so disturbed that gross provenience units would be sufficient to capture general locational data for the materials recovered.

By June 2007, Pima County required a generally accurate count of cemetery features within the entire project area for project planning purposes. At that point, the goal of the mechanical excavations changed from exploration to the complete exposure of all the area within the limits of the cemetery. To accomplish this goal, large stripping units were excavated, features were identified and mapped with the total station, and the stripping units were then covered with plastic and backfilled. This allowed Statistical Research to document the total number of grave pits in the project area while the backfilling of the units protected the features from exposure to the elements. These areas were later reexposed and excavated according to a systematic plan that minimized disturbance to as-yet unexcavated areas of the site.

Once a mechanical stripping unit was initiated, its boundaries were mapped using the total station, and mechanical excavations commenced. All mechanical excavations were monitored and directed by a crew chief or field director to ensure the accurate identification of features as soon as they appeared. All identified features were marked with spray paint to ensure later visibility, assigned a unique feature number, and their shape was recorded with the total station. Sediments removed during excavation of mechanical stripping units were segregated and tagged with the appropriate provenience. Each pile of dirt was then processed through a mechanical screening machine. Once a mechanical stripping unit was completely excavated, the bottom elevation of the stripped area was recorded with the total station to provide the volume of sediment removed from each stripping unit. In all, a total of 4.33 acres (17,522 m^2) was mechanically excavated within the project area, which included 45 mechanical stripping units.

Mechanical Screening

One of the innovative procedures implemented during this project was the use of a mechanical screening machine, or power screen. All overlying sediments (overburden) removed during mechanical excavations of the cemetery and its immediate surroundings were placed through the power screen. The overburden consisted of disturbed sediments usually containing historic or modern debris. In most urban archaeological settings, the overburden would be of little or no analytical value and would simply be removed and discarded during excavations. However, the presence of the former cemetery along with the amount of subsequent historical-period and modern disturbance meant that the presence of displaced human bone was likely to be encountered. The most efficient way of completing the recovery of displaced human bone was to mechanically screen the overburden. Indeed, once excavations began, displaced human bone was occasionally recovered from sediments removed from mechanically stripped units. The amount of human bone recovered from mechanical stripping units varied across the site. Some mechanical stripping units produced very little, if any, displaced human remains, whereas other units had significant disturbances that yielded large numbers of human bone. In particular, the dense area of Council Street (Cemetery Area 4) had numerous overlapping grave pits during the use of the cemetery, which displaced many skeletal elements. The subsequent excavation of utility trenches through Council Street also severely disturbed burials and further dislodged remains from their primary grave pit context. Finally, areas that had been graded historically resulted in the presence of shallow grave features that were more prone to later disturbance. By screening the disturbed overburden we were able to recover all displaced skeletal elements, thereby ensuring our best effort to collect all human remains from the project area.

The power screen used on this project was a Powerscreen Mark II manufactured by TEREX (Figure 3). The screen size was adjustable, and we utilized both a 1/2-inch and 1/4-inch mesh during this project. We used a dry-screening process but added a sprayer to reduce dust. Once the power screen had processed mechanically excavated sediments, the waste material was either removed from the project area or was used to backfill other portions of the site. A skip loader then carefully spread out the screened material onto an area of pavement. Once on the pavement, archaeologists could sort through the material using shovels and rakes to collect artifacts and bone. Strict contextual control was maintained during this process, and sediments removed from a particular mechanical stripping unit were kept separate from sediments removed from other areas. The artifacts and bone collected during the sorting process were bagged with a unique provenience number assigned to the stripping unit. All bone was recovered for a determination of whether it was human or faunal. The human bone was further analyzed; the faunal bone from the disturbed contexts was not. Artifacts were collected and analyzed if they were determined to be from mortuary contexts or if they represented unique artifacts from non-mortuary contexts.

Sample Collection

Procedures for collecting samples from meaningful contexts were set up prior to fieldwork. In situations where preserved wood or charcoal was encountered, macrobotanical samples were collected. Wood was observed and collected on this project mainly from well-preserved coffins, as well as a variety of specimens from privy pits. Charcoal was also collected as macrobotanical samples, including burned plant remains from prehistoric features. In general, pollen and flotation samples were collected from each arbitrary level or each culturally or stratigraphically defined layer within a feature. In addition, parasite samples were collected from certain contexts, such as from burials or historical-period privy pits. Although many samples were recovered during the fieldwork, decisions about which samples to analyze were not made until after fieldwork was completed. This allowed the analysts to select representative samples from each project context, thus minimizing analytical gaps.

Site Mapping and Photography

Statistical Research's Department of Cartography and Geospatial Technologies was responsible for maintaining control and documentation of spatial information for all archaeological fieldwork activities. This included establishment of site datums, managing spatial data, digitizing and rectifying field maps; conducting close-range photogrammetry, three-dimensional laser scanning, and balloon aerial photography; producing topographic contours and elevation levels; and creating all field and report maps.

Site Mapping

Darling Environmental and Surveying, Ltd, Tucson, Arizona, was contracted to establish a series of permanent control points in the area immediately surrounding the project area. In October 2006, five control points were placed around the perimeter of the project boundary along Stone Avenue, Toole Avenue, and Alameda Street. Throughout the project, these five control points were used to establish additional datums within the project boundary. Once control was established, all spatial and elevation data was acquired with a Sokkia Set 6 total station using a Panasonic Toughbook laptop computer and PenMap software. All total station point data was collected to within subcentimeter horizontal and vertical accuracy.

Mapping staff collected total station data with the assistance of an archaeological crew member. Every total station point received the provenience number associated with the unit, artifact, feature, or map nail being mapped. All modern features also received provenience numbers. If multiple shots were needed for a single unit or feature, multiple shots received the same provenience number. The total station data was exported from Penmap as a .dat file and placed in the Joint Courts Complex project folder.

Donoghue and Associates, Tucson, Arizona, was contracted to create an ArcSDE feature class data structure and to build a customized GIS data entry scheme to convert total station point data to polygons and link them to descriptive database attributes. The Statistical Research Database (SRID) GIS Data Editor was developed to facilitate semiautomated polygon creation and entry of GIS data in ArcSDE in a manner that ensured compatibility and easy integration with aspatial data stored in the database. The data editor used the project name, site name, and provenience number to look up the provenience and project site hex codes for each GIS feature's corresponding provenience. It then populated the GIS feature's attribute table with the relevant SRID hex codes to establish a one-to-one relationship.

Additional spatial data were obtained by rectifying and digitizing features from close-range photogrammetry data and hand-drawn plan maps. In coordination with the authors, cartographic staff produced all site maps used in this report with ESRI ArcGIS software.

High-Resolution Aerial Photography

Prior to the beginning of fieldwork, digital orthophotography of the project area was obtained from the Pima Association of Governments. This May 2005, 1-foot orthorectified, imagery was used as the background for daily field maps. Daily field maps were produced to present a visual progress of the spatial data collected during the project, as well as the extent of excavations. These maps became a vital visual tool for Statistical Research's archaeological staff to track the spatial extent of excavations and feature discoveries, as well as an updated visual presentation for Pima County during weekly progress meetings.

Balloon Aerial Photography

To obtain low-level aerial photographs of the site, Statistical Research's cartographic staff operated a remote-controlled digital camera mounted to a tethered, 6-foot-diameter helium balloon. Spatial control was achieved by setting targets that were visible from the air and then recording those points with a total station. The resulting digital data was processed and corrected to remove distortion, and then multiple images were stitched together into a single mosaic for the site. These photographs were used as the background imagery for several presentations.

Oblique Photography and Computer Animations

To obtain low-angle oblique photographs of the site over the course of the 17-month fieldwork period, project staff took oblique photographs from nearby building rooftops. The Tucson City Courts building is located to the immediate east side of the project area, and the Pima County Public Works building is located to the immediate west side of the project area. Although initially taken as part of the project documentation, these weekly series of photographs provided the source data for creating custom time-series panoramas and animations of the project site.

Although there were some inconsistencies in the time period between sets of photos that ranged between 3 and 17 days, the typical interval was 7 days. The time of day also varied from early morning to late afternoon. Because a tripod and precise pivot point was not established and used consistently, the number of photographs needed to show the site was irregular and ranged from three to seven viewpoints depending on the amount of overlap. During the final 8 months of the project, four viewpoints were used consistently to capture the extent of the site.

Geospatial staff organized the time-series photographs and created a variety of panoramas from both the east- and west-side points of view. In addition, these panoramas were assembled into a series of brief computer animations using PtGui Pro software. Adobe Photoshop CS2 software was employed for cropping the panoramas and adding a background mask layer. Finally, the panoramas were assembled into a movie animation using Morpheus Photo Animation Suite.

Establishing Surface Elevation for the Joint Courts Complex Project

Because of significant alteration to the project area during the postcemetery period, attempts to establish original surface elevations were fraught with difficulty. What resulted from this analysis was our best determination of the surface topography during the time the cemetery was in use. A total of 104 points were placed into a separate shapefile, including 20-by-20-m grid points, total station datums, site boundary points, water-flow points, and a southeast corner point for Mechanical Stripping Unit 26787. Originally, 20-by-20-m grid points and water-flow points were selected for this layer, but after running a series of interpolations it was determined that more points were needed at the northern, eastern, southern, and western boundaries for the interpolated surface to cover the extent of the site boundary. Most of these selected surface points were collected by total station in November 2006. From this data, a 50-cm contour line shapefile was generated using 3D Analyst. Three different interpolation methods (Spline, Inverse Distance Weighted, and Kriging) were used to interpolate a raster layer from the new shapefile, and a spreadsheet was created to keep record of variable input settings for each interpolation. In sum, we ran a total of 19 test Inverse Distance Weighted interpolations, 5 test Spline interpolations, and 6 test Kriging interpolations. These test-runs further examined how the outcomes of different settings for each interpolation method would affect the data. In general, excepting the defaults for each interpolation type produced the best respective results for each method. All interpolated layers were reclassified as Defined Interval with a 0.5 Interval Size for comparison to the 50-cm contour lines.

After examining interpolation layers created from Spline, Inverse Distance Weighted, and Kriging interpolation methods, it was determined that an interpolated surface from the Kriging method was best suited for the Joint Courts Complex surface data. Kriging interpolation results generally complemented contour line curvature and direction. Spline interpolation created a very smooth surface raster in concordance with expectations but did not match up well to observed contour patterns. Inverse Distance Weighted interpolation generally did not provide a smooth surface raster. Additionally, it was noted that the latter interpolation would not be an advisable method for purposes associated with deriving surface elevation coverage for the project area. After selecting the Kriging interpolation method, 3D Analyst defaults for this method were excepted. Finally, the interpolated surface raster layer was converted into a point shapefile and was spatially joined to all total station points. A query for mapping nails was written to allow the calculation of grave depths.

The Provenience Designation System

Over time and through many successful archaeological field projects, Statistical Research has perfected a provenience designation system for the capture and organization of all spatial and aspatial data from a project. Provenience numbers, referred to as PD numbers, are assigned to any arbitrary or culturally meaningful space, whether a single mapping nail or an entire site boundary. Provenience numbers for the Joint Courts Complex project were maintained through a provenience log, and each number was assigned consecutively. The provenience log has basic information for each number assigned, including information regarding the nature of the space being defined. Every feature, excavation unit, point-located artifact or sample, etc., has a unique provenience number, and this number was assigned as soon as the recovery space was defined by the archaeologist. Once assigned, a provenience number was never reassigned during the course of the project.

Over the course of 17 months of fieldwork, more than 30,000 provenience numbers were assigned for the Joint Courts Complex project, including more than 2,800 cultural features, 9,900 mapping nails, and 12,100 point-located artifacts or samples. On average, there were approximately 90 provenience numbers assigned per working day, a staggering amount of information! As one can see, the control of data was an essential component to this project.

Database Development

The Statistical Research Database (SRID) provided data-driven project management, facilitated descriptive goals, and enhanced analyses and research. The Joint Courts Complex project data sets were large, so integration of the data was crucial for meeting the project's goals. A variety of tools were used to support SRID. The backbone of the system was a dedicated MySQL database server with an Access 97 user interface. Some aspects of Access 97 are outdated, so when more-recently developed techniques were necessary (e.g., media or advanced reports), VB.Net was used. Other less utilized technologies included Excel, Python Web applications, and Graphviz.

Database and Project Management

Reporting accurate and timely information was an important requirement of SRID for the Joint Courts Complex project. Before producing a SRID report, the database team had to ensure that each report question had adequate data in support of the answer. An example was the daily burial discovery report (or daily report). This daily report was part of the contractual agreement between Statistical Research, Pima County, and the descendant groups to ensure that an accurate and updated list of grave pit and burial features was provided to all stakeholders every day during the course of the fieldwork. When a grave pit was discovered, the feature was attributed as a "possible grave pit" for that day. It remained as such until either: (1) a value was set for the Final Interpretation field, or (2) a feature-to-feature relationship of "holds" was created to signify a burial feature was present within the grave pit (see Feature-to-Feature Relationships section, below). The final interpretation field was used to reattribute a possible grave pit when it was definitively established that it was not a grave pit, and this determination was made through excavation. When the final interpretation field was used, the "possible grave pit" on the daily report was changed to a "nongrave pit feature." Once a feature relationship of "holds" was created for a burial feature, the word "possible" was removed from the corresponding grave pit, and the grave pit was displayed alongside the burial feature number on the report. The daily report also integrated with the cartographic data to indicate if the grave pit fell within the boundary of the military cemetery. This and other reports were crucial to the management of the project because of the large number of features.

Progress summaries were also tracked by SRID. In addition to the data necessary for the daily report, field forms were data entered to indicate the completion of a feature excavation. The creation of an osteology inventory (i.e., human bone) indicated that the burial removal had begun. These details were crucial for managing the project. Another way to track progress was through the generation of maps. The cartography department had access to SRID, and any data could be made available as a view on our database server. For example, the same data that provided the excavation complete status for a feature could be used to generate a map of those features that had been discovered but not yet excavated.

Another example of SRID reporting was the feature write-up report. Because of the tremendous number of grave pit and burial features in the project area, we needed an efficient and accurate way to produce cemetery feature descriptions for the project report (see Volume 4). This process began with entering written descriptions of each grave pit and burial feature into summary fields within the database. After these summary fields had been written, a formatted report displayed them along with selected values from other fields. Each field was formatted into standardized headings which displayed pertinent information about the grave pit, burial feature (human remains), and mortuary artifacts. The data for these headings was compiled from all areas of the database, including data from fieldwork, analysis, and cartography. This standard layout provided a consistent presentation for the editors and for the readers. The investment in planning and designing this feature description report saved hundreds of person-hours throughout the process and can ideally be used for future projects.

The burial agreements between Statistical Research and Arizona State Museum required specific procedures for the storage and handling of human remains and mortuary items. Keeping human remains and mortuary materials together was part of this contractual requirement. SRID was well equipped for the management of the Joint Courts Complex collection, which included bar codes for inventories, containers, and location information. The integration of the data also allowed excavation and analytical information to be considered

together with inventory location information. So in this case, it was natural to require inventories to be kept together if they were from the same excavation context or concluded to be related through analysis.

Descriptive Goals

An important reason to collect data is simply to be able to describe what is being discovered. Accurate and replicable counts of features and artifacts are a natural product of data entry. Early exploratory data analysis helped to establish relationships between independent variables (e.g., initial demographic information and spatial patterning of grave pits). SRID provided one source for these answers. Data output was primarily accomplished with queries, mapping, and SRID reports. The queries interface in MS Access became quite complex with the dependence of multiple queries upon each other. These same data were also available to others involved in the project, such as the cartography department for labeling and filtering maps. All data for the project were kept on one database server, as opposed to multiple spreadsheets or database files, and therefore all queries were pulled from the same set of tables. This also allowed the content of the queries to change dynamically and consistently. Because SRID is similar across projects, many tools from other projects could be used. This saved both programmer development and user training time.

Analysis and Research

The analysis of artifacts was facilitated by environments particular to historical-period artifacts, lithics, prehistoric/Native American ceramics, fauna, and human osteology. These data were linked to the unique identifier for the inventory. For this project, a unique hexadecimal code was created for each inventory number that was assigned. This inventory code was printed as a bar-code label so that our laboratory and analysis staff could utilize a laser bar-code scanner to instantly upload inventory information when used in the appropriate field of the database. This inventory code was dynamically linked in the database to all provenience information and subsequent analytical data, thereby allowing easy viewing of data that was instantly updated. Each analytical environment was rich with available attributes determined by the respective department heads, and could facilitate specific project goals. Efforts were also made to increase the efficiency of workflow and data entry.

Various digital media that were useful for analysis and research included digital scans of hand-drawn field maps, digital photographs, photogrammetric images, and three-dimensional laser scans. The database stored a network path for each digital image with about 46,500 files total. The database also stored a unique identifier for a particular provenience or inventory (point-located artifact, feature, excavation unit, etc.) for each media. The most crucial application among all the tools developed for our media was a Web viewer. This allowed server side compression of high-resolution images, which made browsing and uploading images much more efficient.

Database Summary

Multidisciplinary planning for data collection, organization, storage, and application was the key to success for the Joint Courts Complex project. The crucial groups included archaeologists and their experts, geospatial analysts, and database professionals. The resulting benefits greatly increased the success of the project. Efficiency and accuracy made possible the processing of numerous features, proveniences, artifact inventories, and osteological elements. In addition, because SRID is custom in-house software, there were continual enhancements of capabilities throughout the project.

Archaeological Field Methods for the Cemetery

The following is a summary of the specific field methods that were developed for the excavation of the cemetery. The nature of the cemetery features, such as their depth and the sensitive remains contained within, required us to implement certain methods and procedures to better account for the complexities of excavating this historical-period cemetery.

Searching for the Cemetery Wall

Our background research (O'Mack 2005, 2006) indicated that the cemetery had several surface features during its period of use, including an adobe wall enclosing the small military cemetery and another adobe wall bounding a portion of the much larger civilian cemetery. A variety of grave markers, including headstones, headboards, and at least a few aboveground brick-and-mortar burial vaults were also present while the cemetery was in use. Our excavations of the project area uncovered virtually no hard evidence of any of these features. At some point after the civilian cemetery was closed in 1875 and the military cemetery was closed in 1881, the surface of the site was apparently graded in anticipation of selling off plots for residential development. Beginning in about 1890, the surface of the former cemetery was drastically altered by postcemetery residential and commercial development (see Volume 3 of this series). During our mechanical excavations of the cemetery, we endeavored to locate any traces of the former civilian cemetery walls, such as adobe or stone foundations, though ultimately this was unsuccessful.

The military cemetery wall also proved difficult to locate. A conspicuous space existed between grave pits in the military cemetery (Cemetery Area 1) and grave pits in the southernmost civilian portion of the cemetery (Cemetery Area 2). This space was interpreted as where the military wall once stood, or perhaps as a road or path within the cemetery itself. We focused our efforts on this area by carefully monitoring the mechanical excavations in an attempt to locate any adobe or other traces of the former military cemetery wall. We did find one short alignment of badly deteriorated remnant adobe in the southernmost portion of the project area, in almost exactly the place where we suspected the south wall of the military cemetery once stood. The adobe consisted of a thin, irregular layer of distinctively colored dried mud, apparently laid directly on the unmodified ground surface, probably as preparation for the first course of adobe blocks. This feature was so faint that it was hard to be certain it was a part of the former military cemetery's wall, but it was the only possible surviving remnant of the former cemetery surface. Upon further research into the military section of the cemetery, a historical map was uncovered that shows the positions of the military graves, as well as the location of the military cemetery wall. When we aligned and rescaled the historical map to fit our current excavation map of the military cemetery, this remnant adobe foundation did not align with the location of the wall on the historical map. Ultimately, we concluded that the cemetery walls must have been either completely destroyed or scavenged once the cemetery was officially closed in 1881.

Grave Pit and Burial Discovery

Our first characterization for the cemetery features was to differentiate *grave pits* and *burials* as distinct feature types. The actual pit excavated into the ground defined a grave pit. Upon identifying human remains within a grave pit, a determination was made based on the overall context and articulatory integrity of the human remains whether or not a *burial event* could be established. The burial event (also known as a burial feature) was defined by the purposeful placement of an individual(s) in the grave pit, including all funerary objects and associated container. As many postcemetery disturbances removed skeletal remains from their primary (grave pit) context, the presence of human bone in a grave pit did not automatically predetermine a burial event. Burial features were further characterized as either articulated or disarticulated, depending on the articulatory integrity of the skeletal elements within the grave pit. A grave pit and burial were originally seen as generally

contemporaneous; however, it came to light that many grave pits were reused through the course of the cemetery use life.

During the process of mechanically excavating the project area, an enormous number of features were identified, including 1,083 grave pits. The procedures for discovering and attributing grave pits were predicated on collecting the most accurate depiction of the grave pit in our database system. As soon as a possible grave pit was identified in a mechanical stripping unit, the outline, or polygon, was mapped with a total station. This initial outline was considered the discovery polygon, corresponding to the highest point of the grave pit that was visible to the archaeologist. Oftentimes this discovery polygon was incomplete, being obscured by postcemetery disturbances such as sewer trenches or building foundations. Further mechanical excavations of the grave pit frequently occurred, and a more defined outline was uncovered. Once a grave pit outline was completely defined by the archaeologist, usually postexcavation, the polygon was re-mapped with the total station as a final polygon. This final polygon was considered the most accurate shape of the grave pit, whereas the discovery polygon was considered to be on the plane where the grave pit originated on or near the modern surface of the site.

Feature-to-Feature Relationships

One of the more interesting characteristics of the Joint Courts Complex project was the elaborate feature-to-feature relationships that were developed over the course of the project. The relationship referred to the spatial and chronological associations of cultural features. Overlapping features necessarily had a relationship on the basis that they were connected spatially, and investigation of these features, usually through excavation, determined the chronological relationship. A relationship of *earlier than* was created for two features where a determination was made that one feature was intruded upon by the other, thus having come into existence earlier. The logical characterization of this feature-to-feature relationship would read: Feature *y* was intrusive to, or overlapping Feature *x*; therefore, Feature *x* was earlier than Feature *y*. Similarly, contemporaneous features were characterized as having an *equal to* relationship. A unique relationship of *holds* was developed for the cemetery portion of this project, referring to the grave pit and burial relationship. With this logic, a grave pit would "hold" a burial, meaning that the burial was contained entirely within the boundary of the grave pit. The "holds" relationship also assumed that there was an observable burial event.

The feature-to-feature relationships were based on the Harris Matrix, a graphic and interpretative tool used to depict temporal stratigraphic relationships (Harris 1989). The Harris Matrix is based on the Law of Superposition, which states that layers accumulate vertically over time. This means that layers in a stratigraphic profile are sequential, with the upper layers being younger than the layers below. Difficulty can arise when using the Harris Matrix with cultural features. The vertical position alone of features may not infer ordering, as features can be excavated at different depths. A feature may be erroneously interpreted as older because it is deeper than others. It became the challenge for the archaeologists to decipher the temporal order of features in the field and comment on this order so that the feature-to-feature relationships could accurately be constructed.

The overall goal of the feature-to-feature relationships was to develop a simple, database-driven mechanism to interpret the ordering of features. Even though this site did not contain complicated stratigraphy, there existed complex overlying cultural components such as the prehistoric, cemetery period, and postcemetery period. Within these components, especially within the cemetery period, there were areas of multiple overlapping features containing valuable information concerning the history of use for the cemetery (see Cemetery Area 4 discussion).

Mechanical Assistance in Grave-Pit Excavation

One of the initial hardships encountered during the excavation of grave pits was the overall depth of the features. It quickly became apparent that this project would not meet its scheduling goals without some means of expediting the grave pit excavations. Removal of burials also proved difficult from such deep and narrow

grave pits, with an added challenge of excavating the fragile in situ human remains. During the course of the grave pit excavations it was observed that the upper portion of the grave pits were generally devoid of cultural material. Incidental or intrusive artifacts and features were the exception, such as prehistoric artifacts that were present prior to the excavation of the grave pit, or clay sewer pipes, bricks, concrete, and other material from postcemetery features. With the need to increase our rate of excavation and the lack of significant amounts of cultural remains in the upper fill of the grave pits, a decision was made in consultation with Pima County to excavate the upper fill of the grave pits mechanically. Our approach was cautious, and we developed several techniques to ensure protection of the human remains. Ultimately, the archaeological monitor used a slender 1-m metal probe to test the depth of grave pits, taking great care to only use the probe along the outer margins of the grave pit so as not to disturb the buried remains. Also, the top of the coffin was generally located 10–40 cm above the human remains, and occasionally the identification of coffin wood was used to gauge an appropriate point to halt mechanical excavation. Through the course of the project, only 1 percent of the burial features (n = 15) were at all disturbed by mechanical excavation, and the majority of these cases were the result of uncharacteristically shallow grave pits. Our methods were tested and proven effective, allowing the archaeologists and osteologists easier access to the burials for removal, as well as permitting greater accuracy for the photogrammetric images and three-dimensional scanning of the remains.

In the unique area of Council Street (Cemetery Area 4), nearly all grave pits were overlapping or reused, creating significant amounts of displaced human bone. This scenario prevented our use of machinery in excavating the upper fill of a grave pit. Once the asphalt was removed from Council Street, the mechanical excavations were carried out until the outlines of features were first observed. The excavations in Cemetery Area 4 were hence limited to hand excavations in the interest of preserving the displaced remains and maintaining contextual control.

Another innovative approach to grave pit excavation was the "stepping back" of grave pits. Occasionally, grave pits were too deep and narrow for the removal team (an archaeologist and an osteologist) to excavate the human remains. If conditions were favorable, the backhoe was used to excavate the sterile sediment away from one side, usually the long axis of the grave pit. The wall of a grave pit could only be removed once adjacent grave pits were completely excavated and recorded to prevent loss of any contextual information. This technique allowed access to the burial feature without disrupting the integrity of the grave pit or human remains. Great care was taken not to disturb the intact burials during this process, and wooden boards were used to shield the coffin or human remains from collapsing sediment.

Grave-Pit and Burial Excavation

Once a grave pit was discovered, it was excavated in its entirety, including all burials and unassociated materials within the grave pit. The excavation of grave pits and burials had three main stages: (1) grave-pit excavation, (2) coffin and burial definition, and (3) burial removal. Stage 1 began once a possible grave pit had been identified through mechanical stripping, a feature number was assigned, and the grave pit outline was indicated with spray paint. At least four mapping nails were placed beyond the corners of the grave pit, with one nail selected as the elevation, or vertical nail. The fill of a grave pit was generally excavated in its entirety as Level 1, and the contents were placed through ¼-inch hardware mesh. If human bone was encountered in the Level 1 grave pit fill, than the screening mode was switched to $^{1}/_{8}$-inch hardware mesh for greater potential recovery of small or fragmentary bone.

Stage 1 ended and Stage 2 began once a reasonable outline of a coffin was discovered. A coffin unit was initiated to represent the volume of fill held by the coffin, and the coffin wood and nails were collected under a unique point-provenience number. Level 2 designations were given to both the coffin fill and the surrounding grave pit fill. This differentiation of coffin and grave pit fill was intended to maintain contextual control for any artifacts present in the grave pit versus anything placed within the coffin and associated with the burial. All Level 2 grave pit and coffin fill was separately placed through $^{1}/_{8}$-inch screen for adults and $^{1}/_{16}$-inch screen for subadults. Standard procedure was to excavate the Level 2 grave pit fill first and pedestal the coffin, if possible. Pedestaling the coffin allowed archaeologists a greater opportunity to observe any intact coffin structure,

such as sideboards or coffin hardware. Once the coffin was recorded, an exploratory window was excavated into the coffin fill to determine whether or not human remains were present and if the remains were articulated. The presence and condition of human remains dictated whether or not a burial feature number was assigned. The coffin and its fill were then removed, taking care to leave the human remains as unexposed as possible. Ideally, this stage ended with the grave pit cleared to the bottom, the coffin removed to its floor, and the human remains left intact with a layer of soil to protect them. This procedure was referred to as pre-exposing the burial. In some instances, a coffin was not present within a grave pit; therefore, no Level 2 excavation proveniences were assigned. In these cases, the Level 1 excavation was maintained to the base of the grave pit, as well as accounting for any fill surrounding the human remains. As mentioned earlier, encountering human bone in the grave pit necessitated the shift in recovery mode from $^{1}/_{4}$-inch screen to $^{1}/_{8}$- or $^{1}/_{16}$-inch screen size.

Stage 3 consisted of the removal of the individual or burial feature. Bone deteriorates rapidly after exposure, so this stage was not started unless it was feasible to complete the removal by the end of the workday. An osteologist, assisted by an archaeologist, began by clearing all remaining dirt from the feature to fully expose the remains. All burial-related (mortuary) artifacts encountered during exposure of the remains were point-provenienced and collected separately. Once the remains were exposed, four additional map nails were placed at the level of the remains for use by the three-dimensional scanning and photogrammetry team. Once the three-dimensional scanning and photogrammetry imaging was completed, the remains were collected. If preservation was poor, in-field observations were performed on the vulnerable elements that provide the most demographic information (e.g., femoral head diameter, facial cranial measurements, etc.). After all the remains were removed from the grave pit, the archaeologist finalized the hand-drawn map including cross-sectional drawings of the grave pit. A more detailed discussion of the procedures used to remove an articulated burial is presented below.

Articulated Burial Removals

Careful recording of the in situ context and condition of skeletal remains was among the highest priorities on the Joint Courts Complex project. Only after a set of remains had been documented with field notes, photographs, close-range photogrammetry, and three-dimensional laser scanning were the remains moved from their discovery position and location. This ensured a seamless transition from context-based information recovery to biology-based information recovery. Owing to the luxury of access to on-site laboratory facilities, osteological data collected in the field were typically limited to contextual attributes. Although there is certainly overlap between contextual and biological data, the goal of in-field data collection was to gather information that could not be reconstructed or recreated in the laboratory. Broadly, these attributes included those that became unobservable once skeletal elements had been moved from their in situ position, such as the cardinal direction of the remains (i.e. burial orientation), the relative positions of the head and arms, depth and elevation information, and the presence and distribution of mortuary artifacts.

Although bone preservation was generally good across the site, some sets of remains were particularly fragile and friable. If the field personnel were unsure if certain osteological characteristics would remain observable after exhumation and transport to the laboratory, these data were recorded in situ. Nevertheless, certain biological attributes were recorded in the field as a matter of protocol. These included basic age, sex, and biological affinity assessments, as well as instances of trauma and evidence of notable taphonomy. These data were recorded largely for administrative and workflow monitoring purposes; each of these attributes was ultimately available for revision following closer scrutiny in the laboratory.

Once in situ attributes were fully documented, preparations began to recover the skeletal remains. By virtue of skeletal articulation, one provenience designation number was assigned for the skeleton in its entirety. In addition to dramatically reducing the overhead of information collected, a single provenience number for the remains proved a sensible approach to the spatial reality of the remains. In other words, an articulated skeleton represented one congruous set of remains (i.e., the decedent) that was buried. At the time of interment, the individual was a single body, not a collection of unique bones. Regarding the skeleton as a unit was deemed to comport with the mortuary behavior of interring an individual.

The recovery effort was aided and directed by the in situ documentation, as well as subsequent laboratory analyses. Skeletal elements were removed and packaged in tissue paper or paper bags according to reasonable sets of functional groups of bones. For example, cervical vertebrae were packaged collectively, in order, separate from thoracic and lumbar vertebrae. Elements of each hand and foot were packaged accordingly, with internal separations by digit. As noted below, osteological analyses and documentation allowed for unique identification of each skeletal element. In situ articulation permitted the osteologist in the field to quickly and accurately distinguish among similar elements, such as phalanges from different digits of the same hand. Internal division of, for instance, the left hand package and the right hand package transmitted that knowledge to the laboratory, where separating like elements is often impossible.

Skeletal elements recovered from screened matrix were assigned to the provenience number of the screened material (e.g., coffin fill), and not simply returned to their anatomical positions. The reasons for maintaining this separation were twofold. First, data integrity was ensured by faithfully documenting the provenience from which items were recovered, not the provenience from which they were presumed to have originated. Second, an appropriate understanding of osteology and skeletal articulation led the field osteologist to reasonably presuppose the relative locations of skeletal elements. Simply put, elements appearing in the screen were recovered from a context inconsistent with their expected anatomical location. This inconsistency, and its taphonomic foundations, was an important consideration when reconstructing the burial event. These elements were reunited with their skeletal elements during laboratory examination for strictly biological assessments, but their contextual provenience was maintained throughout.

Excavation of Previously Exhumed and Disturbed Burials

As noted above, burial features were identified as either articulated or disarticulated. Disarticulated burial features required different excavation procedures than those used for articulated burials. The most notable difference was the documentation and preservation of provenience when postdepositional events led to displaced or absent skeletal elements. As such, the single provenience designation used for an intact, anatomically congruous set of human remains was unavailable. The degree and extent of disturbance to the remains varied widely, so a flexible method for recovering provenience information was necessary.

Disarticulated burials were removed according to a system of sectors imprinted on the coffin or, in the absence of a coffin, the grave pit itself. These sectors segmented the coffin unit or grave pit into five divisions of approximately equal area. The sectors were given a point-provenience designation, composed of all human remains and artifacts within each sector. Because each sector was a point-provenience, they were treated differently than typical excavation units. First, a sector provenience was not assigned until remains or artifacts were discovered within it. Second, the matrix in each sector was screened separately from that of any other sector. Each sector was accurately reflected on the hand-drawn map.

Once a sector was initiated by the presence of remains or artifacts, the elevation of the topmost item was recorded by tape from the vertical nail. This elevation served as the top elevation of the sector. The bottom elevation was recorded from the lowest element or artifact. In some cases, this bottom elevation was the floor of the coffin or grave pit. Thus, the three-dimensional spatial information comprised the area of the sector, and the vertical measures of the top and bottom items within the sector. This volume allowed us to standardize each sector, and compare sectors within and among features.

Comparing different sectors within each feature and among different features was an integral step in drawing inferences related to the nature, cause and intent of disturbance to the burials. This was of particular importance for burials that were disinterred prior to the current excavation effort, known as previously exhumed burials. These were most commonly associated with the military cemetery (Cemetery Area 1), but some examples existed throughout the civilian cemetery. Previously exhumed burials were characterized by human remains of significantly reduced completeness within the feature and absent any clear intrusion by other features, utility trenches or other disturbances.

Although the mortuary behavior related to the inhumation was necessarily compromised by the previous removal, what persisted in the feature gave us insight related to this intentional removal of a burial. For example,

the number of recovered skeletal elements and artifacts and their position in the feature (as reflected by their sector) might have indicated a method employed during this previous removal. The number, distribution, and ratio of skeletal elements to artifacts may also have suggested a preference of one over the other during previous removal. A level of effort for the previous removal could have been inferred from what appeared to be specific targeting of elements such as the cranium and long bones and a general avoidance of smaller or numerous elements such as those of the hands, feet and ribcage.

In addition to the burial integrity and articulatory integrity recorded for all burials, an additional attribute was recorded for previously removed burials: anatomical integrity. Whereas burial integrity relates to the completeness of the set of remains and articulatory integrity describes the articulation of the remains, anatomical integrity provides for the presumed placement of remains within the feature. Depending on the stage of decomposition when the previous removal occurred, functional collectives of remains (e.g., hand, foot, and sections of spine) may have become separated from the rest of the individual, yet retained enough soft tissue to maintain articulation among their contributory elements. Anatomical integrity reflects movement of elements within the coffin or grave pit irrespective of articulation. Like burial integrity and articulatory integrity, anatomical integrity was scored as high, medium, or low.

Samples

Initially, for grave pits and burial features, flotation samples were collected from the Level 1 grave-pit fill as well as the Level 2 coffin fill. Over the course of the project, the sheer number of flotation samples became onerous from the perspective of processing, as well as the overall project sampling strategy. Therefore, the flotation sampling strategy was reevaluated to reflect only a sample of grave-pit contexts. The revised flotation sampling strategy outlined the collection of flotation samples from the Level 2 coffin fill of grave pits selected based on their location within the cemetery and overall preservation. For other, non-grave-pit contexts, flotation samples were collected in accordance to the general excavation methods.

A series of three pollen samples were collected from grave pits, generally corresponding to the position of the coffin. The first pollen sample was collected from above the coffin (i.e., above-coffin pollen sample), the second pollen sample was collected from the fill surrounding the human remains (i.e., within-coffin pollen sample), and the third pollen sample was collected from beneath the coffin (i.e., below-coffin pollen sample). In instances where a coffin was absent, pollen samples were collected using a similar strategy but using different terminology (i.e., above-remains, within-remains, and below-remains). These pollen samples were collected to test for seasonality as well as the presence of flower pollen that may have preserved from the interment of the individual.

Parasite samples were also routinely collected from burial contexts to test for the presence of parasitism in the burial population. Parasite samples were collected from the lower torso area of the remains, and a corresponding parasite control sample was taken from either the head or foot area.

Hand Mapping

All grave pits were recorded using a 1:5- or 1:10-scale hand-drawn feature map. Each feature map depicted the grave pit in plan view and cross-section, as well as any spatially related features or disturbances. The outline of the coffin (if applicable) was recorded on the hand-drawn map, which also corresponded to the coffin unit. The locations of all pollen samples were also depicted on the hand-drawn map. The human remains were not drawn on the feature map, however, and the recording of the in situ skeleton was accomplished by the use of digital close-range photogrammetric images and three-dimensional laser scanning, discussed below.

Close-Range Photogrammetry

All articulated burial features were recorded using photogrammetric imaging. Photogrammetry is a remote sensing technology in which the geometric properties of objects are determined from photographic images. Preliminary field-testing indicated that the application of close-range photogrammetry and digitization would be a viable and time-saving technique to replace hand-drawn in situ plan view maps of human remains. By georeferencing and rectifying digital photographs taken from a height of less than 1 m, we were able to obtain high-quality imagery for more than 1,000 burial features. Not only did the resulting close-range photogrammetry prove to be more accurate than traditional methods, it was very efficient and contributed to a 75 percent reduction in field time per burial. The following paragraphs describe the specific field procedures that were undertaken.

The photography equipment consisted of five pieces: a digital camera, a remote control for the camera, a 5-inch display monitor, a tripod, and a macro arm extension for the tripod. A 7.2-megapixel Sony dsc-V3 digital camera set to automatic shot with no zoom or flash was used to take the photos in JPEG format. The use of a remote control and display monitor was essential in situations in which the camera was in precarious, elevated positions above the grave pit. These pieces of equipment allowed the photographs to be taken from a safe location on the ground. In addition, a heavy-duty Manfrotto 3258 tripod extendible to 2.67 m was used. The tripod, paired with a 34-cm macro arm, allowed sufficient maneuverability up/down and forward/backward to take most photos at a nadir position (downward facing view) above each grave pit. On occasion, it was not possible to center the camera over the human remains using the tripod and macro arm setup. This was due to limited nearby surface area from the high density of open grave pits and the presence of shade tents that shielded zones of active excavation. In these circumstances, the only way in which to capture the image was to use a slanted, non-nadir camera angle that resulted in a slight, but inconsequential increase in root mean squared error (standard error). In a few cases, additional height was required to capture a larger ground footprint, so the tripod was placed on a 1-m-high table.

In the field, digital photography was undertaken immediately prior to the removal of a set of human remains after their full exposure. For each set of human remains that was photographed, four to six nails were placed around the perimeter of the individual and served as control points. The precise location of each nail was recorded with a Sokkia total station. The tops of the nails were painted bright red so that they would be visible in the image and identified easily during the georeferencing process. For fetus and infant burial features, four nails were typically used, and for adult burial features, six nails were typically used (Figure 5). Not only did the use of six nails result in lower standard error, it also served as a precaution against losing any of the nails before they could be recorded with the total station.

Numerous in situ cases, such as multiple horizontally and/or vertically situated burial features, required unique photogrammetry solutions. For example, individuals lying side by side shared the three nails on their long axis (Figure 6), whereas stacked individuals at different vertical levels that were visible simultaneously shared the same set of nails (Figure 7). In other cases, the spatial position of the individuals required unique combinations of nail placements. For all multiple burial scenarios, a composite overview reference photo was taken prior to photographing each of the individuals separately.

Immediately after taking approximately 8–10 photographs per set of human remains, the images were downloaded, and the best examples were printed on 11-by-17-inch paper, including its four-digit reference photo number. While excavating the human remains, the osteologist annotated the photo to record specific information such as overlapping human remains, artifacts obscured by human remains, and relative locations of pollen and parasite samples, as well as the coffin outline, if applicable.

In addition to the standard paper photographic log and subsequent data entry of that information in SRID, the cartographic department designed a more comprehensive photogrammetry database to track specific details for each image. Each photo was assigned and associated with three provenience numbers: feature proveniences (both grave and burial number), mapping nail proveniences (photogrammetry nail number), and point-provenience numbers (human remains recovery number). For each set of human remains, primary and secondary photos were designated based on the clarity of the human remains and the visibility of the photogrammetry nails. The primary image was selected to be used for rectification and digitization and the secondary one served as a backup.

When each of the photos was georeferenced and rectified, the root mean squared error was typically less than 1 cm. As a result, the digitization of human remains from the rectified photographs was extremely accurate in real-world spatial coordinates. During the heads-up digitizing of human remains in ArcGIS, the use of the annotated photographs from the osteologists served as an invaluable guide that enhanced the accuracy of shape, position, and material interpretation.

Three-Dimensional Field Scanning

Articulated burials were scanned in the field using laser line scanning technology prior to the burial's removal. The three-dimensional scanning of burial features was utilized with the intention of cataloging a spatially accurate representation of the burial feature (Figure 8). The process, from field data acquisition to a fully processed three-dimensional mesh, took anywhere from 2 to 5 hours to complete, depending on the number of scans. Laser line scanning uses a method of triangulation to extrapolate three-dimensional coordinates of the desired object with a capture rate of 307,000 points per acquisition, a point-placement accuracy of around 0.005 mm, and point spacing within a millimeter. A complete mesh, usually composed of 10–20 individual scans, averages a point count around 1.5 million, creating a usable mesh with a poly-vertex count around 3 million faces.

The scanner used for this project was the Konica Minolta Vivid 910. This scanner, as with most short-range scanning devices, was developed primarily for use within a laboratory setting. To outfit the scanner for use in the field, a few problems first needed to be addressed. The primary issue in dealing with laser line scanning is that it uses a near infrared laser to capture the XYZ spatial information. Natural light tends to overpower the laser light, creating the need for a more powerful laser beam. A more powerful beam creates a thicker laser line, leading to a decrease in overall accuracy. To circumvent this problem, a combination of neutral density filters, as well as shade tents, were used to lessen the intensity of daylight. These filters limited the amount of light allowed through the capture device, which increased the detail and accuracy of the scan. The charged-coupled device within the scanner, as with most hi-resolution three-dimensional imaging devices, was developed to be most accurate under indoor conditions. It is possible to calibrate the scanner for lab-specific lighting conditions, but natural daylight far exceeds the gamut for which the device was designed. Even after being filtered with the neutral density filters, the images appeared reddish in color. This problem was addressed by using the processing software's color module, which allowed us to alter the color metric data back to its original values. The next set of problems that needed to be overcome was making the device mobile enough to use within the entirety of the 4-acre project boundary. At the outset of the project, a battery-based power supply was used to power the scanner. Over the course of the project, it was decided that a gas generator producing a true sine wave a/c output would preserve the electronics within the scanner better over the long term. The generator, accompanied by a heavy-duty Manfrotto tripod, extendable to a length of nearly 3 m, proved very useful in allowing the scanning team to set up in a variety of locations that would otherwise have been inaccessible. As the working project area increased, carrying more than 150 pounds of equipment became quite a daunting task that was alleviated by the use of wagons and carts.

A few other limiting factors should be acknowledged, the first being that the burials resided in deep grave pits. This limited the amount of information that could be collected, as the scanner only has the capacity to scan from above the feature and not from within the feature. The narrower and deeper the grave pit, the smaller the viewing window available for the resultant three-dimensional mesh, and therefore the fewer the overall data could be captured. Nevertheless, the overall impact on the data did not create issues with usability, as it was still possible to retrieve measurements from the most important elements within a given feature. To capture the entirety of the feature, it would take a combination of different scanners to provide the ideal solution to this problem. Other limiting factors included time lines for removal of the features, as each burial feature had to be exposed, documented, and removed in a single day. This provided a short window of time for the scanning to be completed.

One exciting outcome from the use of three-dimensional scanning on this project was the ability to capture information that photogrammetry was unable to capture. In the case of the head niches that were found throughout the cemetery (see Chapter 5), photogrammetry was unable to georeference the areas within the

head niches. The three-dimensional scan data proved useful, as the data was already ortho-rectified in three-dimensional space, and all that needed to be done was to overlay the two image sets and create a composite, giving the osteologist a more complete image for annotation, as well as for the digitization of the remains. One other exciting outcome of the field scanning came in combination with the lab scans. Many of the bones that came out of the field were in a delicate state. There were instances where an element that was complete in the field fractured upon removal, leaving the osteologist in a situation in which he or she was unable to complete the necessary analysis. By using the field data as a template, the scanning team was able to reconstruct elements to allow the appropriate analysis to be completed.

The original scope of the project had the laser scanning strictly playing the role of documentation of the in-field remains. Throughout the course of the project, as more people became aware of the potential implications of working with the virtual models, the scanner took on a different role within the project. The Joint Courts Complex project has just begun to tap the potential of three-dimensional scanning technologies as applied to archaeological cemetery excavations. We saw new and exciting possibilities arise out of problems that were encountered on this project, providing inventive solutions to problems that otherwise could have gone unresolved. It would have been interesting to see this technology applied more liberally throughout the project, although this was not a possibility as there was access to only a single scanner, which was in service throughout the workday for burial removals. The implications of recording features in three dimensions are far reaching, as it will allow exploration of the feature in a far different way than ever before. Mainly, it is now possible to record three-dimensional spatial relationships and preserve them as a digital record that can be revisited and reanalyzed. This changes the way an analyst interacts with the collected data, especially in the long term, or how someone who did not participate in the fieldwork can interact with data. One aspect that has yet to be explored is the potential of layering relevant data sets over the collected three-dimensional data set, providing the analyst with a comprehensive view of the feature. In this way, the three-dimensional data becomes a template that all other collected visual information can be placed inside (e.g., photogrammetry, hand maps, digitization, field annotations, lab scans). Eventually, all feature photographs taken in the field can be wrapped onto the three-dimensional feature image, further increasing the level of detail and documentation of individual features and the site overall. Three-dimensional data becomes most useful in its ability to provide more-accurate data and fill in gaps resulting from more traditional methods of documentation, while also providing the ability to go back into the data to reanalyze existing information.

Laboratory Analysis Methods

During the course of Joint Courts Complex project fieldwork, Statistical Research maintained an on-site laboratory and analysis facility. Initially, the project staff—including the field laboratory personnel, osteologists, and mortuary analysts—was housed in an unused building in the project area (240 N. Stone Avenue). As stated previously, by the end of April 2007, the project staff had moved out of this building and into modular trailers so that the building could be demolished and excavations undertaken within its footprint (see Chapter 2, Volume 1 of this series). The modular trailers served as the field laboratory and analysis facilities for the remainder of the fieldwork portion of the project. While excavations were underway, all paperwork, artifacts, samples, and human remains were stored, processed, and cataloged immediately at our on-site facility. Mortuary and osteological analysis began while fieldwork was underway and continued once the fieldwork was complete. This was carried out to facilitate the rigorous project schedule to complete analysis of the cemetery no later than 6 months after the end of fieldwork. In compliance with the burial agreements, no human remains or associated mortuary artifacts left the project area until removal to Holy Hope Cemetery for storage prior to reburial or repatriation. Prehistoric and historical-period artifacts and samples not associated with the cemetery were allowed to be transported from the project area, and the analysis of artifacts from noncemetery contexts was carried out at our main laboratory after fieldwork had ended. The following is a discussion of the laboratory and analysis methods used in our laboratories, both on-site and at our main office.

Field and Nonfield Laboratory Methods

In accordance with the treatment plan (Beck et al. 2006), all human remains and mortuary artifacts came into the field lab with corresponding provenience numbers. Once in the laboratory, each bag was assigned an inventory number, and an inventory label was created that contained this inventory information as a bar code. All the human remains and artifacts were placed in plain cardboard boxes by feature, and each box was assigned a container number; also displayed with the bar code label. Each numbered box was then assigned to a specific storage location, corresponding to its physical location in the storage units, as well as in the inventory tracking system in the database. The human remains and mortuary artifacts were placed in Arizona State Museum-approved boxes and secured in storage containers, which were alarmed and guarded during nonworking hours. Materials to be repatriated and reburied were cared for with great respect and in accordance with the burial agreements. The detailed laboratory and analysis procedures for the recovered human remains are detailed in Volume 2 of this report, and will not be reported on here.

Nonmortuary artifacts and samples came into the field laboratory with their corresponding provenience numbers. Each bag was assigned an inventory number in the field laboratory and packed in cardboard boxes. Each box was assigned a container number, and each numbered box was then assigned to a specific storage location. Initially stored on-site, the nonmortuary collection was moved to a storage trailer at the Statistical Research main laboratory in August of 2007. Nonmortuary collections generated after that date were transported to the main laboratory as the demand for space increased on-site.

Statistical Research's field laboratory manager oversaw the cleaning of artifacts, and the inventorying and procurement of botanical materials from flotation samples. These responsibilities were undertaken by the Statistical Research laboratory director at our main laboratory. Sample and artifact processing followed guidelines established by Statistical Research on previous projects, which meet the Arizona State Museum repository standards (Griset et al. 2004). The laboratory maintained computerized database inventories of the provenience log and artifacts. No materials destined for repatriation were taken off-site until their removal to Holy Hope Cemetery.

Artifact and Sample Inventorying

All mortuary artifacts were processed in the field laboratory prior to analysis and all mortuary artifacts were analyzed. For the noncemetery artifacts, processing and analysis priorities were established based on context and overall project sampling design. For instance, postcemetery artifacts found in disturbed contexts were not subject to further processing and analysis, except in unusual circumstances.

Items selected for cleaning followed the approved instructions listed below. Specific processing instructions noted on the field bags were given precedence over standard instructions, and no artifact was cleaned if the cleaning process would damage the item. After cleaning, all artifacts were bagged in 4-milliliter plastic, white-front, zip-lock bags. The white front section of each bag was labeled in black permanent marker with the project name, project number, site number, and provenience number, and the adhesive inventory label was clipped or stapled to the bag. The front of the paper field bag was then cut out and saved in a box in the laboratory for later curation. Pollen samples were kept in their tape-sealed paper field bags. Each pollen sample was placed in its own 4-milliliter zip-lock bag, which was left open and upright in the box to ensure samples would continue to dry if necessary. The plastic bags were labeled as described above. The materials were then placed back into boxes and shelved to await analysis.

Artifact Cleaning

All Native American ceramics were washed in plain water. Ceramic sherds were soaked in a dishpan of clean water to loosen soil deposits and scrubbed with a soft toothbrush. Care was taken not to scrub off soluble pigments. The sherds were then rinsed in a second dishpan of clean water and then placed on drying racks with fan-blown, circulating air for 48 hours. Dry ceramics were rebagged and reboxed.

Flaked stone and ground stone artifacts were soaked in a dishpan of plain water to loosen soil and caliche deposits. They were then scrubbed with a soft toothbrush and placed in a second dishpan to rinse. They were placed on drying racks overnight. Dry lithics were rebagged and reboxed.

Faunal bone and shell were not washed. Instead, after being allowed to dry thoroughly, they were carefully brushed with a soft toothbrush. Cleaned faunal bone and shell was rebagged and reboxed. Wood items were allowed to dry thoroughly before attempting any cleaning. Wood was brushed lightly with a soft toothbrush or cloth to remove excess dirt.

Glass with paper labels or mirror treatment were dry-brushed, avoiding the labels and mirroring. Many of the labeled bottles had been cleaned and photographed in the field and needed no further handling. All other glass was washed in plain water, scrubbed with a soft toothbrush, and rinsed in fresh, clean water. Glass was dried thoroughly on the drying racks. After drying, glass was bagged by color with all bags clipped or stapled together. If residues were observed in bottles, the bottles were cleaned without disturbing the residues. However, if the residues were not immediately observed, the bottles were washed as described above.

Historical-period ceramics were washed in plain water and cleaned with a soft toothbrush. They were then rinsed in fresh, clean water and dried thoroughly on the drying racks. Items with over-glaze treatments were handled with caution.

Metal items were allowed to dry thoroughly before attempting any cleaning. They were brushed lightly with a soft toothbrush or cloth to remove excess dirt. After cleaning, metal was bagged in more specific categories, such as can, nail, aluminum and general categories. All bags were clipped together.

Leather items were allowed to dry thoroughly before attempting any cleaning. Leather was brushed lightly with a soft toothbrush or cloth to remove excess dirt. Fabric and basketry was allowed to dry thoroughly before attempting any cleaning. It was then brushed lightly with a soft toothbrush or cloth to remove excess dirt. Paper items were cleaned and photographed at the field laboratory to preserve information prior to decomposition. The project budget did not allow for their conservation.

If powdery, crumbly, or delicate in any way, minerals were not cleaned. Stable, solid minerals were brushed lightly with a soft toothbrush or cloth to remove excess dirt. Other materials followed similar guidelines depending on their stability in water.

Flotation Procedures

Flotation samples were inventoried and stored in their paper field bags to allow for thorough drying. Samples selected for flotation were measured into clean dishpans. The number of liters was recorded on the field bag, which was cut and saved. Samples were floated using the Flote-Tech Model, manufactured by Dausman Technical Services. Heavy and light fractions were recovered and allowed to dry on racks with fan-blown, circulating air for 48 hours. The light fraction residue was inventoried, bagged, and boxed. The heavy fraction residue was sorted into two categories according to screen size. The heavy fraction was processed as follows, then bagged and boxed:

Size 1: >1/4-inch residue was sorted for artifacts. The artifacts were inventoried in the database by artifact type. The noncultural gravels were then discarded.

Size 2: <1/4-inch residue was sorted for artifacts. The artifacts were inventoried in the database by artifact type. The noncultural materials were then discarded.

Samples not selected for flotation were dry-screened through 1/4-inch mesh. Recovered artifacts were inventoried in the database by artifact type, then bagged and boxed.

Osteological Data Collection Approaches

Many bioarchaeological investigations follow the same general procedures and protocols, outlined in *Standards for Data Collection from Human Skeletal Remains* (Buikstra and Ubelaker 1994). A critical examination of these standards, however, revealed that the methods recommended by Buikstra and Ubelaker (1994) in some cases had to be expanded to accommodate data collection requirements and research goals for the Joint Courts Complex project. Therefore, Buikstra and Ubelaker's (1994) book served as its authors recommended: as a set of minimum guidelines, to which additional procedures and tools could be added.

Below is a discussion of the various procedural and theoretical concerns in collecting biological data from the skeletal remains from the Joint Courts Complex project. This discussion follows five general topics. First, two important data collection approaches unique to Statistical Research, Inc., are explained. These include (1) the manner and structure of recording skeletal-element inventory and (2) the methods used to designate a set of skeletal remains as an "individual." Second appears a brief description of the laboratory facilities and equipment used during examination, including specialized technologies. Third, a detailed chronology of the data collection protocols is presented, with additional information relating to alterations or expansions of techniques described by Buikstra and Ubelaker (1994). Fourth is a discussion of how synthesized conclusions about the skeletal individual, such as age at death, sex, stature, and biological ancestry, were developed. Last appears a description of salient particulars of the osteological database used on the Joint Courts Complex project, and its interaction and integration with other data management systems used on the project.

Discrete Elements and Composite Elements

Upon receipt of remains in the laboratory, the analyst began by inventorying the skeletal elements present. This step is among the first in all osteological examinations by nearly all practitioners (Buikstra and Ubelaker 1994:5). On the Joint Courts Complex project, however, the inventory process differed from that of many recognized sources, expanding the specificity and level of detail for osteological analysis. In addition to capturing more data, this expanded approach corresponded to the data collection system at Statistical Research, Inc. (see Osteological Database below).

The first departure from more-standard skeletal-inventory methods was the establishment of two categories of elements, Discrete Elements and Composite Elements. Discrete Elements are defined as the smallest functional unit of osteological observation, in its adult form. This approach allows for meaningful data to be collected on each named skeletal element and provides a recognizable basis for relative statements regarding the degree of presence, or completeness, of each element. Discrete Elements include such elements as frontal, parietal, occipital, and ethmoid. "Skull" and "cranium," however, are not Discrete Elements. Each of these terms refers to a group of elements, such as frontal, parietal, and occipital. By maintaining a strict and finite list of Discrete Elements, the analyst avoids the pitfalls of recording a skeletal inventory using increasingly vague and ill-defined terms. "Cranium" is a fairly well-understood term among osteologists, referring to the elements composing the casing for the brain, and the elements of the face, excluding the mandible. To refer to a "partial cranium," however, invites confusion about which elements are present. Conversely, an inventory that indicates the degree of completeness for, e.g., the frontal, the parietals, or the occipital allows for a more meaningful and substantive reconstruction of the individual from recorded data.

The system for recording Discrete Elements uses a nested architecture of specificity. Thus, every adult element can be recorded individually, including, among others, each of the 24 ribs, all 28 carpal phalanges, and all 28 tarsal phalanges. The analyst is not, however, limited to each unique element. Often, taphonomic processes make identifying each particular element difficult, at best. Under those circumstances, the analyst may be limited to counts of elements within a particular category, such as middle carpal phalanges. This approach is more consistent with standard recording practices, such as those described by Buikstra and Ubelaker (1994:7). The difference, however, is that the analyst is not limited to a categorical census of like elements when the context during excavation allows for unique identification of specific elements. In other words, during recovery, an individual's right hand may be complete and undisturbed, lying supine, with each of the 14 carpal

phalanges clearly identifiable from its position. The Discrete Element approach allows for directly recording the presence of each element, whereas more-classical approaches would require the analyst to disregard field data in favor of a simple count of the elements. The difference between the two methods becomes even more meaningful when specific elements are missing, clearly identifiable from their position in situ. The Discrete Element approach could, for example, indicate that the distal phalanx of the third digit of the right hand is missing. Under standard recording procedures, the analyst could note only that 13 right carpal phalanges are present, despite knowing precisely which phalanx is missing. Nevertheless, nonspecific categories of elements may be recorded if necessary. These include cervical, thoracic, and lumbar vertebrae; ribs; metacarpals; carpal phalanges; metatarsals; and tarsal phalanges.

On the other hand, Composite Elements reflect functional or analytical complexes of the aforementioned Discrete Elements requiring a synthetic unit of observation. Composite Elements do not "exist" as tangible items. Rather, each Composite Element comprises its constituent elements in the form of inventoried Discrete Elements. For example, cranium is a Composite Element, its constituent elements including the Discrete Elements frontal, parietals, occipital, and so on. The need for Composite Elements becomes clear when osteological analyses move beyond a simple inventory of the elements present. A good illustration of this would be craniometric data collection. Maximum cranial length, for example, uses landmarks on both the frontal and occipital but is a measure of the cranium in its totality. All adult craniometrics were recorded for the Composite Element cranium, despite several measures, such as minimum frontal breadth and mastoid length, existing on a single Discrete Element. This convention was developed to avoid confusion about which element to link to a particular observation. Composite Elements and their constituents appear in Table 2.

Osteological Individual Assessment

The determination of distinct osteological individuals was of paramount concern on the Joint Courts Complex project, for both documentary and analytical purposes. Following the relationship of graves to burials discussed earlier in this chapter, it was critical to define discrete osteological individuals to establish the connections among spatial, aspatial, mortuary, and biological information. Strict conventions were developed and maintained to ensure consistency in all phases of excavation, documentation, data entry, analysis, and synthesis.

The first convention is a matter of protocol in all osteological analyses: determining the number of discrete individuals in a given context. Because of taphonomic forces or disturbances, skeletal elements from more than one individual occasionally occupied the same or a closely associated in situ context. Recovery efforts in the field often led to commingling of these single-context remains, but with the understanding that the laboratory was the appropriate environment in which to separate individuals. For example, grave-pit fill from above the coffin was considered an individual provenience, and all skeletal elements encountered in that context were collected under that provenience. The controlled setting of the osteology laboratory would allow analysts to differentiate individuals if elements from more than one individual were recovered from that provenience. Separating individuals was accomplished primarily by the inventory of skeletal remains recovered from that context, with considerations for basic biological and demographic characteristics. Remains were separated in the laboratory according to biological attributes, most commonly the age at death. This strategy proves efficient when the ages of multiple individuals are widely disparate. If the ages were too similar to separate individuals through cursory examination, then the presence of multiple unique elements was used to determine the minimum number of individuals for the given context.

The second convention relates to establishing the analytical nomenclature for each individual according to the context from which it was recovered. These Individual Names reflected both the recovery context and a natural language identifier. In other words, the Individual Name comprised the feature number from which the individual was recovered, and a letter or number suffix. The alphanumeric suffix served to separate multiple individuals recovered from a single feature, as well as to indicate what type of feature it was. Individuals recovered from a burial feature were considered Primary. The Primary designation indicated that the skeletal remains represented the biological component of the burial event and were presumed to be the individual for whom the burial event occurred. The natural language identifier for all Primary Individuals was in the form of

the burial feature number, followed by a capital P. In the case of multiple individuals interred under a single presumed burial event, each individual received a numerical modifier to the P designation. For example, if two Primary Individuals were part of the same burial event, they were named P1 and P2. These numerical modifiers were assigned consecutively, starting with P1, with no inherent assumption in the order. The purpose of the numerical modifiers was to establish a unique reference name for each Primary Individual, and not to imply any temporal or otherwise meaningful hierarchy. The highest number of Primary Individuals encountered in a single burial in the cemetery was five, named P1 through P5 (Burial Feature 21548; see Volume 4 of this series for details of these five individuals).

Remains were also recovered from features other than burials. The most common nonburial features to yield human remains were grave pits. As noted earlier in the chapter, grave pits and burials are two distinct feature types with differing criteria and assumptions. Although grave features and burial features are closely related to each other, the two represent different contexts for the recovery of remains and artifacts. Items recovered from the burial feature were those that were clearly associated with the burial event. Items in the grave pit *not* clearly associated with the burial event were attributed to the grave pit, the hole dug in the ground. Remains and artifacts recovered from the grave pit were provisionally treated as attributes of that hole in the ground, and subsequent analyses had the potential to lead to their reassociation to a burial feature.

Human remains recovered from nonburial contexts, including grave pits, followed a naming convention similar in structure to that for Primary Individuals: the name of the feature from which the elements were recovered, followed by a natural language identifier. By definition, only Primary Individuals, having necessarily come from burial features, can receive a P designation. Unique individuals with remains in any feature type other than burial (e.g., grave pit, trench, building foundation) were termed Enumerated Individuals and were given only a number designation, starting with 1. No inferences relating to mortuary behavior were made of Enumerated Individuals, having been recovered from nonburial contexts. Enumerated Individuals were defined within features, on the basis of the minimum number of individuals represented by a collection of elements not associated with a Primary Individual, and any osteological information that could be used to distinguish among Enumerated Individuals within a specific feature context. For example, skeletal elements in a grave pit that could not have come from any Primary Individual associated with that grave were recognized as a separate and unique individual. Enumerated Individuals represented provisional individuals based on their own recovery context. They could, however, become associated with Primary Individuals in adjacent features. A basic assumption employed during excavations for the Joint Courts Complex project was that all human remains came originally from burial features, and that skeletal elements not initially associated with burial features could eventually become reassociated through spatial and osteological analyses. Thus, Enumerated Individuals were established with the understanding that the elements composing them eventually might be reassociated with different Primary Individuals. If all elements representing an Enumerated Individual became reassociated with other named individuals, the Enumerated Individual distinction was discarded.

Remains recovered from the grave pit, but not the burial, were first compared to the remains from the burial to determine if they belonged to the Primary Individual. If the analyst was able to reasonably conclude that the element from the grave pit belonged to the Primary Individual, then he or she attributed the element to the Primary Individual while maintaining the provenience information describing where the element was recovered. This reassociation of elements to individuals followed a two-step process to describe (1) the evidence supporting the association and (2) the analyst's level of confidence in the association. The Individual Determination Method and the Individual Determination Quality were protocols established at Statistical Research, Inc., primarily to reconstruct commingled remains from an ossuary context (Playa Vista Archaeological and Historical Project; Stanton 2009). The need for such reconstruction was significantly lessened on the Joint Courts Complex project; most remains were recovered from distinct burial features in discrete grave pits. Nevertheless, the information describing the nature of, and confidence in, element associations is potentially critical when anomalies and outliers are examined.

The Individual Determination Method is an attribute that indicates why the analyst concluded that separated elements belonged to the same individual. A finite list of values for the Individual Determination Method attribute is available in the Statistical Research, Inc., database; these describe the reasons for the reassociation. The available values appropriate for the Joint Courts Complex project were Articulation, Proximity, Container,

and Age. Articulation required direct or nearly direct contact between congruous elements, during either excavation or laboratory reconstruction. Articulation is the strongest method for reassociation. Proximity refers to a limited physical distance between recovery contexts of the element and the individual, typically within a single feature boundary. Proximity was most commonly used as the method to reassociate elements recovered from the grave pit with the Primary Individual. The two shared a relatively small common space, and taphonomic forces often moved the element away from its individual. Conversely, if an element and an individual were to be reassociated across a great distance over the site, Proximity would not be employed as the method. The use of the Proximity method was based on a logical conclusion that the separated element was more likely from the nearby Primary Individual than from a different individual farther away. Container was a method of reassociation applied to elements in the same coffin as the Primary Individual, particularly if there was no reason to believe that the remains of more than one individual were discovered within the same container. Strictly, Container is a specialized subset of the Proximity method. Whereas the Proximity method is usually applied within a feature boundary, the Container method involves a smaller defined space within a feature boundary, such as a coffin or an urn. The reliability of the reassociation is greater for the Container method than for the Proximity method, because of the reasonable assumption that skeletal elements from a different individual are less likely to find their way into a burial container than into a larger area, such as a feature boundary. Finally, the Age method was employed when a grave pit or the burial or burials it held contained the remains of more than one individual of widely disparate ages. As noted above, age at death is often an efficient way to establish individuality for a set of remains. For example, if a burial contained two Primary Individuals, named P1 and P2, one of which was an adult and the other an infant, commingled remains from that particular context could be reassociated using Age as the method.

The Individual Determination Quality provided the opportunity to describe the confidence in and reliability of the element to individual association. In SRID, Statistical Research, Inc.'s relational database, three responses were available: Definite, Inferred, and Indeterminate. The Individual Determination Quality was dictated by the Individual Determination Method employed. Only the Articulation and Container methods allowed for associations with Definite quality. The inherent assumption was that only direct articulation or shared presence in a coffin was sufficient to conclude that the elements all belonged to the same individual, to the exclusion of all others. The Proximity and Age methods, consequently, received a quality of Inferred. These methods could not rise to the level of certainty required for a quality of Definite, largely because the connection between the elements and the individual was not unique to that individual. The age of the element may be consistent with that of a number of individuals. Likewise, the distance of the element from its presumed individual may not be remarkably less than its distance from other individuals. In other words, the element may be consistent with a number of individuals. The Inferred association simply represents the most reasonable of those possibilities. If no association to an individual could be made, both Individual Determination Method and Individual Determination Quality were recorded as Indeterminate.

Laboratory Facilities and Equipment Used in Osteological Analysis

The Joint Courts Complex project enjoyed the luxury of on-site facilities to perform complete osteological analyses of remains soon after their removal. Typically, remains were stored in a climate-controlled environment for at least 1 day following removal, to allow gradual and uniform evaporation of latent moisture. The arid conditions in Tucson had the potential to cause too-rapid moisture loss, leading to structural damage of the bone. Degradation of skeletal material after excavation was limited by controlling potential environmental sources during the transition from removal to examination.

The recovery context in the field was the first consideration in osteological examination. Under most circumstances, a reasonable assumption was that each grave-pit feature held one burial, and that one burial consisted of one individual. Artifacts and skeletal remains for each grave pit were generally separated into one or more cardboard boxes arriving in the laboratory. The remains and artifacts from one grave occasionally required more than one box, but commingling was avoided by ensuring that no more than one grave pit was housed in a single box.

Remains and artifacts reached analysis after a detailed laboratory check-in process. This process established the connection between spatial and provenience information, and the tracking of inventoried items. Care was taken to maintain separation of recovery proveniences before laboratory examination to preserve spatial information. Often, elements from a single individual were recovered from multiple contexts, and it was important to manage provenience designations when elements were reincorporated. These distinctions were critical for data entry of osteological information, as provenience is the basis for the relational data structure. This relational data structure is further discussed later in this chapter (see Osteological Database below).

Specialized Laboratory Equipment

The on-site laboratory on the Joint Courts Complex project featured standard osteological equipment such as spreading calipers, digital sliding calipers, osteometric boards, mandibulometer, and dental calipers. Two digital photographic stations with adjustable lighting were used for specimen photographs. Photographs were logged according to feature context, element(s), aspect, and subject. Photographic logs were data entered at the end of each work day.

Additionally, two pieces of specialized technology were employed during osteological examination. First, a MicroScribe G2 Desktop Digitizing System was used in concert with 3Skull20.111P (2005, Stephen D. Ousley), a computer program to collect craniometric data from cranial material. The MicroScribe G2 is a contact digitizing tool to collect coordinate data in three dimensions (Figure 9). 3Skull was developed for use with 3-D digitizing equipment to calculate interlandmark distances following Howells (1973). The technique was applied to all intact, nonpathological crania. The MicroScribe G2 was used to collect 3-D coordinate data on 81 cranial landmarks and 5 arcs, resulting in more than 600 unique XYZ points on the cranium. Coordinate data were collected on 119 adult crania. Interlandmark distances, rounded to the nearest millimeter, were also calculated by 3Skull. The MicroScribe G2 and 3Skull were used as frequently as completeness and integrity of the remains allowed.

The second advanced tool used during osteological examinations on the Joint Courts Complex project was 3-D scanning. The Konica Minolta Vivid 910 is a freestanding, noncontact laser line scanner capable of 307,000 points of acquisition per scan (Figure 10). The points are then connected into a 3-D mesh of triangle faces by 3-D modeling software. Rapidform XOR2 (2007, INUS Technology, Seoul, Korea) takes the accumulated point cloud of a specimen scan, often more than 15 million points for a cranium, and refines and processes the textures and contours. The result is a graphical three-dimensional representation of the element or elements, accurate to ± 0.005 mm.

At this time, the primary function of 3-D scanning is documentary. The time and resources required for scanning and processing were finite, and assessments were made to capitalize on the most efficient use of the technology. As a matter of protocol, all intact crania, as well as intact elements of the pelvis, were scanned. Notable and uncommon pathological conditions were evaluated to determine if (1) a 3-D scan would capture characteristics missed by photography, sketches, and descriptions; and (2) the disease or injury was unusual enough in manifestation and presentation to warrant additional scrutiny. Nevertheless, a total of 862 3-D scans of skeletal elements from more than 200 separate individuals were acquired and processed. These included, as noted above, intact crania, intact pelvic elements, and notable pathological conditions. Additionally, 6 fragmentary crania and 21 pelvic elements were scanned as individual fragments and reconstructed in the 3-D graphical environment. This was a rare endeavor because of the time commitment required, as well as the absence of any means to verify the accuracy of the reconstructions.

Beyond novel documentation of burial features and laboratory specimens, the 3-D scans offered a unique opportunity to gather metrics in a fashion not possible with actual physical specimens. Within Rapidform XOR2, set points on the 3-D mesh could be measured with accuracy and precision to within 50 μm. In addition to linear distances between any two points, curve and shape analyses are possible across the entire scanned sample. Although these potentials have not yet been fully developed and realized, the durability of the 3-D data set allows for future analysis (Figure 11).

Chronology of Osteological Data Collection Protocols

Inventory

As noted above, the first step in this osteological analysis was to record a detailed inventory of the remains present. The purpose of the skeletal inventory was to (1) determine the degree of elemental representation for the individual and (2) discover whether additional individuals were present. The skeletal inventory presumed a single individual; additional individuals were given full inventory protocol, while maintaining provenience information. In other words, elements from additional individuals were not treated as isolated, commingled items but were inventoried as unique individuals (see Skeletal Data Collection Approaches: Individual Assessment above).

The inventory process by Discrete Element served to record both the presence and the completeness of each Discrete Element. The osteologist employed a Skeletal Inventory that listed each type of Discrete Element, prompting a side assessment for paired elements. If the side from which a paired element originated could not be determined because of fragmentation or poor preservation, it was flagged by way of an Unsided checkbox. The Unsided flag was available for all paired elements, including some categorical nonspecific elements, such as those for carpal phalanges and tarsal phalanges.

The degree of completeness for a Discrete Element was recorded in the form of a letter designation for Fragmentary (F), Partial (P), or Complete (C). Fragmentary was defined as 1–25 percent of the total element (Buikstra and Ubelaker 1994:7). Partial was defined as 25–75 percent of the total element. Complete was defined as 75–100 percent of the total element. Despite some shortcomings of this approach—such as a Partial designation encompassing a wider range of presence than either Complete or Fragmentary, and the counterintuitive notion of regarding a less-than-whole element as "Complete"—the system worked very well to describe what parts of the skeleton were present, and to what extent each part was represented.

Further information was deemed necessary for the inventory of long bones. Each long bone, in addition to a side determination and a completeness score, featured five segment checkboxes that the analyst could strike to inform the score for completeness. These were identical among all long bones and included (1) proximal epiphysis, (2) proximal diaphysis, (3) mid-diaphysis, (4) distal diaphysis, and (5) distal epiphysis. These segments were not intended to divide the long bone into equal sections, but rather to inform on the underpinnings of the completeness score. For example, a femur absent only its head would be greater than 75 percent present and thus would be given a completeness score of Complete. The checkbox for Proximal Epiphysis, however, would remain blank, and subsequent observations could be interpreted properly. Information specifying the presence of particular long-bone segments was useful for subsequent analyses. For example, joint pathology was appropriately limited to individuals and elements with observable joint surfaces (i.e., presence of proximal and/or distal epiphyses; see Chapter 11).

Taphonomy

Once the skeletal elements were inventoried, taphonomic effects on the bone were surveyed. Taphonomy includes both natural and anthropogenic forces altering the remains (Buikstra and Ubelaker 1994; Haglund and Sorg 1997). The preservation of the remains was described generally, including statements of bone condition and extent of fragmentation. These remarks served to inform element completeness scores recorded during the skeletal inventory by assessing the set of remains as a whole instead of limiting analysis to information for each particular element.

The remains were evaluated for taphonomic conditions such as surface staining from soil, metals, and lime; weathering; friability; and adherent materials. Surface changes due to plant or animal activity were described. Additionally, any thermal alteration to the bone was recorded after Buikstra and Ubelaker (1994). Because of the wide variety of possible taphonomic forces and circumstances, efforts were not made to operationalize the universe of taphonomic data. Instead, analysts discussed taphonomy in a manner that would best describe the nature and extent of postmortem changes for each individual specimen.

Age Assessment

Following the inventory of skeletal remains and description of taphonomic conditions, the next step in osteological laboratory procedure was the collection of age-related data. The methods employed and characteristics observed were divided into Juvenile Age assessment and Adult Age assessment. These observations were not categorically exclusive, as many individuals in late childhood and early adulthood exhibit characteristics falling into both categories. Nevertheless, Juvenile Age assessment and Adult Age assessment are described separately below.

Elements of juvenile individuals were examined for age-related change as evidenced by the formation of primary and secondary centers of ossification, and their degree of fusion (Scheuer and Black 2000). The elements and their corresponding epiphyses are displayed in Figure 12. Epiphyseal fusion was recorded along a three-point scale: 0 = open/no union, 1 = partial union, and 2 = complete union. For paired elements, both left and right sides were recorded. Elements of the extremities were observed collectively by group. The proximal epiphyses for the first metacarpal and first metatarsal were recorded, as well as the distal epiphyses of second through fifth metacarpals and metatarsals. The hands and feet were treated collectively by type of phalanx. The proximal epiphyses of the proximal row carpal and tarsal phalanges were given collective scores. For economy of data collection, only left-side extremities were assessed for epiphyseal union.

The left innominate, if present, was observed for the stage of union among the ilium, ischium, and pubis. Each category of vertebra was evaluated for (1) the degree of union of the neural arches to each other and (2) the union of the neural arches to the centrum. Elements of the skull were examined for developmental indicators. The occipital was recorded for fusion of lateral portions to squamous portions, and basilar portion to lateral portion. The presence and persistence of the metopic suture were scored on the frontal bone, as was the symphysis on the mandible. Finally, the extent of fusion of the spheno-occipital synchondrosis was evaluated.

Each observation for skeletal age of both juveniles and adults was regarded separately according to its element or elements. Because the manifestation of age-related change appears on the skeleton in a regular—yet often unpredictable—pattern, it was important to consider each element as a separate line of evidence leading to a conclusive statement of the age of the individual (White 2000:341). Published age ranges for each separate line of evidence were considered, and a composite age range was created based on the reliability of each method, the range associated with it, and the osteologist's professional opinion and interpretation.

For adult individuals, several cranial and postcranial elements were evaluated for age-related and degenerative change. These observations were modeled after Buikstra and Ubelaker (1994). Attributes of the innominate were considered first, with both left and right elements assessed. Surface characteristics of the pubic symphysis were evaluated according to both the Todd (1921a, 1921b) and the Suchey-Brooks methods (Brooks and Suchey 1990; Suchey and Katz 1986). Diagrammatic exemplars from Buikstra and Ubelaker (1994:22) were used for the Todd pubic-symphysis evaluation method. Male and female pubic-symphysis casts from France Casting were the basis of Suchey-Brooks age assessments. The auricular surfaces of the ilia were also examined for age-related change (Lovejoy et al. 1985; Meindl and Lovejoy 1989; Osborne et al. 2004). Cranial-suture closure was observed next, according to the 17 external vault, palatine, and internal vault locations described by Buikstra and Ubelaker (1994). These were recorded along a four-point scale, wherein 0 = open/no fusion, 1 = minimal fusion, 2 = significant fusion, and 3 = complete fusion/obliteration (Meindl and Lovejoy 1985). The sternal ends of ribs 3, 4, and 5 were scored for age-related change (İşcan et al. 1985, 1984; Loth and İşcan 1989). The left ribs were evaluated by default, substituted by right elements if the left were unobservable. Additionally, Dudar (1993) demonstrated that ribs closely outside the range of 3 through 5 may be examined with similar reliability. If poor preservation or taphonomic conditions prevented identification of a specific rib to its position, the analyst could still record a score, provided that a reasonable estimation placed that rib somewhere between positions 2 and 6. The criteria used in Adult Age assessment appear in Table 3.

Other elements were examined to determine the extent to which the individual had entered adulthood, as evidenced by epiphyseal union. These were scored using the same four-point scale used for cranial-suture closure. The spheno-occipital synchondrosis was observed for the degree of fusion (Scheuer and Black 2000). The medial epiphysis of the clavicle and the iliac crest were surveyed for stage of epiphyseal union, again with preference to the left side, if available (Black and Scheuer 1996; Webb and Suchey 1985). Superior and

inferior vertebral annular epiphyses for each category of vertebra were examined for fusion stage, as was the union of the first and second sacral elements (Scheuer and Black 2000).

Sex Assessment

Following observations of age-related attributes, characteristics of sex were documented. Examinations were necessarily limited to individuals of sufficient age for dimorphic traits to appear reliably. All observations for sex determination were collected from the skull and innominates. These elements have shown remarkable sensitivity to differentiate males and females (Buikstra and Ubelaker 1994). Observations of the innominates were taken from both left and right elements. The characteristics examined are listed in Table 4. Characteristics were assessed along an ordinal scale after Buikstra and Ubelaker (1994:16).

Although sexual dimorphism is manifest in several skeletal elements, assessments of sex were limited to diagnostic attributes of the skull, and especially the innominates. Evaluating general robustness or gracility, though typically not misleading, suffers from individual and group variation that is not yet fully understood (Walker 1995:36). Subjective conclusions were avoided in favor of well-documented sex-determination techniques: for example, evaluation of femur-head diameter (France 1998). The limitations of such techniques across time and populations have not been fully explored, and the effect of their broad application is not completely understood. Nevertheless, information gleaned from these techniques was described in notes but did not appear as primary data.

Dentition

Documentation of dental remains followed a separate path in the osteology laboratory because these observations were recorded exclusively by analysts with specific training in dental anthropology. All trained osteologists can perform basic tooth inventory, but identification and siding of loose or heavily worn teeth can be very challenging. Experience has also shown that documentation of many dental pathological conditions can be subject to considerable interobserver variation. Consistency was greatly improved on the project by reducing the number of analysts involved with dental documentation, and by including a review of all work by one of two senior dental anthropologists.

The first step in dental documentation was the removal of adhering sediment with the use of soft, natural-bristle brushes and water. The initial assessment of tooth presence, as well as the presence or absence of alveolar bone, was recorded on a visual-recording form. The presence of pathological conditions was also initially noted on this same form. Subsequent paper forms were used to code variables for entry into the database. The entire suite of dental documentation included taphonomic conditions, tooth presence, development and eruption status, wear, occlusion pattern, pathology, crown measurements, and morphological variables of the roots and crowns. Tooth identification and assessment of wear and pathology were guided by the work of Hillson (1996) and of Buikstra and Ubelaker (1994).

General notes concerning preservation were recorded on the dental condition form. Observability was often adversely affected by taphonomic factors. A checklist on the visual-recording form was used to indicate whether different classes of dental pathology were observable.

Each tooth location was coded for presence using the system proposed by Buikstra and Ubelaker (1994:49), with the following clarifications. Condition code 1 refers to a partially erupted tooth, not fully in occlusion. Condition code 2 refers to any tooth that had been fully in occlusion at the time of death, regardless of the presence or absence of alveolar bone. Condition code 8 refers to the presence of any unerupted tooth. This includes teeth contained within crypts and partially visible, as well as loose unerupted teeth no longer in situ because of fragmentation of the alveolar bone. Development stages were recorded for all teeth according to a 14-stage system illustrated by Buikstra and Ubelaker (1994:50) and initially proposed by Moorrees et al. (1963a, 1963b).

Tooth wear was recorded individually for each tooth, according to an 8-stage system (Smith 1984) for incisors, canines, and premolars, with the addition of stage 0, referring to a crown not yet in occlusion. Molar tooth wear was recorded with reference to a 10-stage system (Scott 1979), with separate values recorded for each crown quadrant.

Occlusion patterns were noted with reference to the systems described by Hillson (1996:106–110). The presence of tooth crowding or rotation or unusual wear angles was also described in general notes.

The presence or absence of alveolar abscesses, caries, calculus, enamel hypoplasia, and dental restorations was coded individually for each tooth. The codes for caries followed a seven-stage system (Buikstra and Ubelaker 1994:55). In addition, teeth were coded to indicate if the pulp chamber had been exposed by a carious lesion. This observation is required in order to calculate caries rates that correct for the influence of antemortem tooth loss (Lukacs 1995). Abscesses were coded for location on the lingual or buccal surface as recommended by Buikstra and Ubelaker (1994:55). Dental-calculus severity was recorded using a three-stage system following Buikstra and Ubelaker (1994:56).

Enamel hypoplasia and opacities were coded with the use of a seven-stage system (Buikstra and Ubelaker 1994:56). An eighth stage was added to the recording system, referring to localized missing enamel defects. These are shallow depressions in deciduous-tooth enamel, normally having an irregular outline, and sometimes deep enough to expose dentin. Lukacs and Walimbe (1998) and Skinner and Newell (2003) referred to the defect as localized hypoplasia of the primary canine, but this condition has also been observed on deciduous incisors and first deciduous molars.

The location of each instance of enamel hypoplasia was recorded as a linear measurement from the cementoenamel junction to the center of the defect (in the case of a pit or horizontal groove), or to the apical and occlusal boundaries of the defect in the case of other types of defects. Observations of enamel hypoplasia have proven highly susceptible to interobserver error. On this project, hypoplasia presence was recorded with reference to a photographic image of minimum expression. In practice, groove presence was confirmed when an interruption of the crown surface could be palpated.

The presence of dental restorations was coded individually for each tooth as a categorical variable reflecting the type of prosthetic alteration (filling, crown, or bridgework) and the apparent material employed. A subsample of dental restorations was analyzed with X-ray fluorescence spectroscopy in order to determine the alloys that were used. Details of these analyses are described in Appendix D.

Tooth measurements were recorded for a selection of "polar" teeth as recommended by Stojanowski (2005), generally representing the more mesially placed tooth in each class. Both deciduous and permanent teeth were measured. The right side of the dental arcade was recorded, but if the right side was not observable, the left side was substituted. Crown measurements were taken with the use of Hillson-Fitzgerald digital dental calipers and included buccolingual and mesiodistal maximum crown measurements, buccolingual and mesiodistal crown measurements at the cementoenamel junction, and crown height. The cementoenamel measurements have been recommended in order to compensate for the effect of wear. Measurements were recorded to the nearest 0.1 mm and followed measuring protocols suggested by Hillson et al. (2005).

Nonmetric morphological traits of permanent tooth crowns and roots were recorded according to the scoring system developed by Turner et al. (1991), and additional traits as defined by Bailey-Schmidt (1995) and Lincoln-Babb (1998). Deciduous-tooth nonmetric traits were derived from and scored according to the work of Brook and Winter (1970), Butler (1979), Hanihara (1961), Jørgensen (1956), McClelland (2003), and Sciulli (1998). Documentation of morphological variants was facilitated by reference to dental casts obtained from the Department of Anthropology at Arizona State University. Trait presence was recorded for each tooth in the dental arcade.

Craniometrics

Because of the importance of skull measurements in determining ancestry and biological distance, all intact adult skulls were measured according to the 24 standard cranial and 10 standard mandibular measurements described by Moore-Jansen et al. (1994). These measurements and their corresponding landmarks

appear in Table 5. Any appropriate measurement was taken, provided only that taphonomic processes or pathology had not deformed or destroyed the skull. In other words, all available measurements were collected, without respect to the observability of any other measurement. This is important to note, in that the adult craniometric data set is not limited just to individuals for whom all measurements were available. This approach not only preserves important data but also allows for more-robust analyses that are not dependent on the availability of all standard cranial measurements.

Partial and fragmentary skulls were measured after Moore-Jansen et al. (1994). Digital sliding calipers, spreading calipers, and a mandibulometer were used to measure incomplete skulls. All intact adult crania were digitized using the MicroScribe G2 (n = 119). In conjunction with the 3Skull computer program, three-dimensional coordinate data on established landmarks on the skull were recorded. Using these defined landmarks, 3Skull calculated the interlandmark distances with greater accuracy and precision than standard handheld calipers.

Juvenile crania were measured according to Fazekas and Kósa (1978) and Buikstra and Ubelaker (1994). Many of these measurements are taken on bilateral segments of elements unpaired in their adult form. Therefore, each particular measurement was limited to individuals of appropriate age.

Postcranial Metrics

To establish primary data for stature in adult individuals and, in some cases, age in juvenile individuals, postcranial elements were measured in linear, diametric, and circumferential dimensions. Postcranial elements were measured after Moore-Jansen et al. (1994) for adults, and after Fazekas and Kósa (1978) and Buikstra and Ubelaker (1994) for juveniles. Digital sliding calipers, spreading calipers, and osteometric boards were used to collect 43 standard adult and 24 standard juvenile postcranial measurements. With the exception of unilateral measures of the adult sacrum, all metrics for adults and juveniles were collected on both right and left elements when available.

Nonmetric Observations

Nonmetric observations of human remains were performed in a single documentary effort that included both epigenetic and morphoscopic traits (Buikstra and Ubelaker 1994; Hefner 2007). Epigenetic variants were recorded according to the 24 standard nonmetric traits described by Buikstra and Ubelaker (1994). Additionally, one cranial trait was scored according to Hauser and De Stefano (1989). Epigenetic variants recorded on the Joint Courts Complex project appear in Table 6. As noted above, morphoscopic traits were evaluated concurrently with epigenetic traits. Fifteen morphoscopic traits on the skull—13 cranial and 2 mandibular—were observed after Hefner (2007, 2003) and Parr (2005). These traits are listed in Table 7.

Epigenetic and morphoscopic traits were assessed on all adult individuals for all available characteristics. Traits unavailable for examination because of damage or taphonomic effects were recorded as Unobservable, provided that the element was present. In other words, no nonmetric data were recorded for wholly missing elements. If, however, the element was present—in any form or level of preservation—data were recorded, even if limited to the affirmative Unobservable designation. This is an important distinction, allowing the analyst to know with certainty that a given trait *could not be observed*, rather than to know only that a trait was not observed, whether because it was unobservable or because it was not subject to observation. Because of incomplete development, the suite of nonmetric traits was reduced for individuals estimated to be under the age of 2 years. The attributes applicable to individuals less than 2 years old are indicated in Tables 6 and 7.

Cranial Deformation

Crania of sufficient completeness were evaluated for the presence of anthropogenic deformation. Cultural practices in life, such as cradle boarding, may lead to persistent alterations in the shape of the cranium (see Buikstra and Ubelaker 1994 and Chapter 8). These are separate from pathological conditions or developmental defects in that behaviors and practices cause the deformation for a particular aesthetic or other cultural purpose. Cranial deformation was recorded according to Buikstra and Ubelaker (1994) and was considered an important line of evidence in establishing Biological Affinity as described below.

Pathology

The systematic documentation of pathological conditions is a challenging enterprise. On the Joint Courts Complex project, pathological conditions were recorded with an emphasis on symptoms rather than diagnoses. This approach allowed analysts of varying levels of training and experience who were interpreting skeletal pathology to adequately describe conditions without committing to any differential diagnoses.

Pathological conditions were documented in a manner that amalgamated Arizona State Museum recording standards and Statistical Research, Inc., data collection protocols. The skeleton was separated into four regions: cranial, axial, appendicular, and extremities. Each region prompted the analyst to observe general classes of responsive bone, such as periosteal, proliferative, or lytic reactions. Additionally, region-specific conditions such as cribra orbitalia and vertebral ankylosis were evaluated. The analyst responded to each of these prompts by designating a condition Present, Absent, or Unobservable. The distinction between the two types of negative observation was important to later efforts at differential diagnosis.

The symptom-based strategy, organized by skeletal regions, provided for a cursory assessment of pathological conditions for the individual. Once a condition was identified for a region, detailed notes were taken identifying the elements affected and describing the overall expression of the condition. Lesions and defects were measured for their own dimensions, as well as their distance from skeletal landmarks. Visual records were taken in a variety of ways. Pathological elements were photographed in a sufficient number of aspects and ranges to adequately document lesions. If subtleties of the condition were not amenable to photographic documentation, diagrammatic representations of all elements were available for the analyst to sketch and annotate defects. A number of severe or remarkable cases of pathological conditions were documented using noncontact 3-D laser line scanning. Resource limitations prevented scanning all instances of all conditions; therefore, a determination of priorities was made to ensure the most beneficial use of the technology.

Instances of trauma were documented at the same time and in the same fashion as pathological conditions. In both sets of observations, the analyst established whether the defect or lesion was ante- or perimortem. If it was antemortem, statements were made regarding the likely time before death when the injury or disease was manifest, evidenced by the degree of skeletal healing observed. Perimortem lesions and defects were noted as occurring around the time of—possibly contributing to—the death of the individual. Because of the absence of necessary physiological material for observation, however, analysts did not speculate as to the cause of death.

Injuries and diseases were recorded only on Discrete Elements, maintaining the convention that (1) the skeletal element is the unit of osteological observation and (2) defects and lesions may be present only on tangible, identifiable elements. For example, consider surface macroporosity consistent with porotic hyperostosis on the frontal and right parietal. To assert that the condition was on the Composite Element cranium would be overly vague and might misleadingly suggest a more expansive presentation than was observed. The affected Discrete Elements, when regarded in their totality, establish the extent of trauma or pathology just as a suite of observed conditions leads to a differential diagnosis. Notes accompanying all observed conditions afforded the analyst the opportunity to describe the pattern and distribution of defects and lesions in a manner that maintained the integrity of primary, systematic data collection.

Osteophytosis and Degenerative Joint Disease

Spinal osteophytosis and degenerative joint disease were observed after Ubelaker (1999:84–87). Osteophytosis was recorded on cervical, thoracic, and lumbar vertebrae. The superior and inferior aspects of each class of vertebra were surveyed for osteophytic growth along a five-point scale from 0 to 5. The data were collected for each class of vertebra as a single score applicable, overall, to each constituent vertebra. In other words, the superior surfaces of all seven cervical vertebrae were evaluated, and a single determination was made for the most appropriate score for all cervical vertebrae collectively.

Degenerative joint disease was recorded on both completeness and Composite Elements as was necessary, against a framework of multielement joints. Table 8 presents the elements of observation and the joints to which they contribute. Both left and right sides of appendicular and extremity-region elements were assessed for degenerative joint disease. Five scores were available to describe the nature and quality of the joint-surface disease. These scores appear in Table 9. Only a score of "a" was exclusive of all other scores. In other words, a determination of a "normal articular surface" precluded any other assessment. The other scores, however, were available for combination to properly describe the joint-surface disease. Fragmentary elements were flagged with an asterisk to inform the interpretation of degenerative joint disease. This allowed the analyst to indicate when the applied score or scores might not have completely described the articular surface. Observers also had the opportunity to augment scores with written notes to further detail joint-surface evaluations.

The axial skeleton was assessed for degenerative joint disease in two ways. First, vertebral articular facets were recorded after Ubelaker (1999:85). Second, the three Composite Element vertebral classes, as well as the sacrum, were evaluated for collective scores of left and right, and superior and inferior, facets. The scoring scheme presented in Table 9 was employed.

Biological-Profile Synthesis

As noted above, the individual was considered the unit of conclusion in osteological analysis. Observations among several elements contribute to the overall assessment of biological characteristics for the individual. The methods and attributes of those elemental observations are described above. What follows is a discussion of the manner in which those elemental observations were synthesized to form conclusions about the individual. A suite of four general characteristics of the individual are standard for most osteological analyses. This Biological Profile includes the age at death, sex, biological ancestry, and stature. Age at death and sex were recorded for all individuals, Primary and Enumerated. With few exceptions, biological ancestry and stature were established only for Primary Individuals, because of a dearth of diagnostic elements associated with Enumerated Individuals. In other words, the number and completeness of elements required to suggest or calculate biological affinity or stature are greater than the number of elements needed to estimate the age and sex of the individual. Each component of the Biological Profile is described below.

Individual Age

The first component of the Biological Profile applied to all individuals, both Primary and Enumerated, was an assessment of the age at death of the individual. Markers on and measures of the remains were examined on particular elements and synthesized along these multiple lines of evidence to make meaningful statements about the individual from which the elements came. Each available characteristic for determining the age of the individual was considered, with more or less weight placed on each according to its reliability.

An approach to osteological analysis not shared with many other practitioners is the assignment of numerical age ranges to an individual, rather than simply a placement within rigid, exclusive age categories. The benefits of numerical age ranges over age categories are two. First, methods for determining the age at death of an individual, described above, are the product of investigations using known ages in years of sample individuals, and not their place within certain inflexible age categories. Therefore, each method for estimating the

age at death for a set of skeletal remains provides ranges in years based on these observations. For example, a pubic-symphysis score of Phase 7 after Todd (1921a, 1921b) suggests an age range of 35–39 years. A proper application of this technique discourages the investigator from further categorizing these ranges at the primary observation level. In other words, the known ages of individuals used to develop the technique were expressed in years, not categories.

The second advantage to numerical age ranges is the simple attrition of data experienced when moving from interval data to ordinal data. A numerical age range may cross two or more defined age categories, and the analyst is forced to abandon more-precise assessments for categorical designations that may prove misleading. Furthermore, reducing a numerical age range to the age category in which it fits may skew or expand a justifiably more precise age range. Thus, the age-assessment data do not lose resolution when statistical tools are applied during analysis. For example, demographic hazard modeling relies on numerical age ranges to minimize the effects of biases introduced by ordinal age data (see Chapter 7 of this volume).

Following the protocol of numerical age determinations, an Age Minimum and an Age Maximum were recorded for each individual. These values existed as decimals of years. Thus, the theoretical low limit for an Age Minimum was -0.75 years, representing conception. This is derived from the common understanding of a typical 9-month human gestation, divided by a 12-month calendar year. The finer precision afforded by fetal-age-assessment methods often allowed for determinations framed as lunar months or lunar weeks. These ages appeared as decimals of a 52-week year. Because of diminished precision in age estimates as an individual advances in years, age determinations for older individuals increasingly appeared as integer, rather than decimal, Age Minimum and Age Maximum (White 2000:338). To maintain a numerical value for individuals whose Age Maximum could not be determined by available osteological methods, the number 99 was used as the upper bound when the age could not be adequately bracketed. It should be noted the entire range of -0.75–99 years represents a theoretical, and not practical, inclusive range for human age. This attenuates the problem of open-ended age ranges, such as "less than 2 years" or "age 65+" for statistical examinations.

Age categories were not wholly abandoned, however. They appeared in concert with numerical age ranges as a means to generalize demographic characteristics of the site overall. Preference was always given to the numerical age range; age categories served to establish natural language references to the age-at-death assessment but did not supersede the accuracy and precision of a numerical range. Following Arizona State Museum standards, the age categories used on the project were as follows:

Fetus:	-0.75–0 years
Infant:	0–2 years
Child:	2–12 years
Subadult:	12–18 years
Young adult:	18–35 years
Middle adult:	35–50 years
Old adult:	50–99 years

The age at death for each individual was established by culling and synthesizing available elemental data. These data included growth and development observations of juvenile dentition and skeletal elements, and predictable degenerative changes in adult skeletal elements. Again, it should be noted that each characteristic was evaluated independently of all others and contributed to multiple lines of evidence for an overall conclusion.

Additionally, not every age-related change in the human skeleton was considered when estimating age at death. Two frequently noted changes to the adult skeleton are dental wear and the accumulation of degenerative joint disease (see Buikstra and Ubelaker 1994). These observations were not included in the calculation of age for the Joint Courts Complex project. First, unlike attributes such as auricular-surface morphology or pubic-symphysis change over time, dental wear and degenerative joint disease do not yet enjoy methodological standards for accuracy, precision, or reliability. Efforts were made to avoid basing conclusions on observations untested for their applicability. Second, dental wear and degenerative joint disease are necessarily affected by

behavior and do not offer sufficient predictability within a single individual, much less across a sample. Dental wear and degenerative joint disease therefore did not contribute to the synthetic estimation of age when more-reliable methods were available.

Dentition did, however, contribute to the age assessment for juvenile individuals. As has been established by Hillson (1996:146), juvenile dental development and eruption offer a more reliable estimate of age than most juvenile skeletal elements. In cases of conflict between juvenile age ranges determined from skeletal elements and those from dental development, preference was given to the dental information.

Individual Sex

As with the estimation of age for the individual, the determination of sex was accomplished by considering multiple lines of evidence. The skeletal elements examined and the methods by which they were assessed for sex are described above in Chronology of Data Collection Protocols: Sex Assessment above. Absent from the operationalized attributes contributing to sex determination was the general robustness of the remains. Although this characteristic has been used by other investigators to ascertain sex, the method suffers from the perils of individual variation and unclear manifestation within populations, particularly when dealing with a multiethnic burial population whose members had diverse biological ancestries and life histories (Walker 1995:36; White 2000:362–363). Therefore, general robustness could not provide appropriate reliability for determining sex in the presence of more-dimorphic features of the skeleton. Additionally, because of the unreliability and unavailability of adequate techniques to establish sex for immature individuals, sex was recorded only for individuals estimated to be at least 15 years old at the time of death. By that age, a reasonable suite of secondary sexual characteristics have begun to manifest in the postcranial skeleton. Before that age, persistent pedimorphism misleadingly skews sex determination toward female. If the sex of the individual could not be determined because of juvenility or absence of diagnostic elements, sex was recorded as Indeterminate.

Individual Stature

The third component of the Biological Profile defined for individuals was stature. As noted above, stature was calculated only for Primary Individuals. This was a matter of protocol for two reasons. First, Enumerated Individuals almost invariably lacked the breadth and number of skeletal elements required to reliably compute stature. Second, as noted above, the association of skeletal elements to particular Enumerated Individuals was, by design, flexible. In other words, the designation of Enumerated Individuals existed in order to set extra or inconsistent elements apart from the Primary Individual within a single grave pit. As examinations progressed across features, it was possible, if not expected, that elements composing an Enumerated Individual would be reassociated with their Primary Individual. Consequently, any calculation of stature based on Enumerated Individual elements could run the risk of including elements that, though not inconsistent with each other, might have come from different individuals.

The second condition limiting the applicability of stature estimation was the age at death of the individual. Only the adult forms of skeletal elements are appropriate for stature calculation, as stature calculations are necessarily limited to adult individuals. Absent or incompletely fused epiphyses may affect linear regression estimates in ways that are not yet fully understood. To that end, only Primary Individuals whose applicable skeletal elements had reached adult form were evaluated for stature.

Stature was calculated by entering postcranial measurements into FORDISC 3.0 (2005, Richard L. Jantz and Stephen D. Ousley, University of Tennessee, Knoxville). A reference sample of nineteenth-century cadavers, pooled from the Terry Collection at the Smithsonian Institution National Museum of Natural History, and a sample of twentieth-century Hispanics from the Forensic Data Bank (Jantz and Moore-Jansen 1988) are integrated into the program to provide for temporally and culturally consistent regression calculations. Based on least-squares regressions of the integrated data sets, FORDISC 3.0 calculates stature estimation with a selected prediction interval of 90 percent. From the measurable elements available for the individual, as many as

25 different combined element formulae are employed, each providing a calculated stature and appropriate range to include the 90 percent prediction interval. The estimation with the smallest range encompassing the 90 percent prediction interval establishes the most precise stature estimation and was selected as the determined stature for the individual.

Individual Biological Affinity

Efforts were made to establish the ancestry for each Primary Individual on the Joint Courts Complex project. These examinations were based solely on skeletal observations and contributed to assessment of Cultural Affinity (see Appendix E). Evaluation of ethnohistoric and geographic information, and the input from consultants, provided a list of biological groups to which individuals could reasonably belong. These included African American, Native American, Apache, Asian American, Euroamerican, Hispanic, Akimel O'odham, Tohono O'odham, and Yaqui. Additionally, a designation of Indeterminate was available when Biological Affinity was inconclusive.

Osteological reference samples were of limited availability for some of the identified groups. To address this problem, additional comparative data on nineteenth-century Southwest Hispanics were collected from the Smithsonian Institution National Museum of Natural History, as well as data on modern individuals from the Pima County Medical Examiner's Office. Comparative data included digitized craniometrics using the MicroScribe G2 and 3Skull, cranial morphoscopic data, and postcranial metrics. Nevertheless, a level of specificity was often elusive. A Biological Affinity designation of Native American was concluded for individuals when observations were too limited to reliably differentiate among Apache, Akimel O'odham, Tohono O'odham, and Yaqui.

The first characteristic evaluated for ancestry is unique in that it represents the effects of behavior on the skeletal remains. Cranial deformation was regarded as unequivocal proof of a Native American designation. Cranial deformation was rare among the individuals on the Joint Courts Complex project, but its appearance superseded other biological indicators. Other methods for determining Biological Affinity were applied according to a hierarchy of accuracy and reliability, as described below. Each method was performed independently of all others as available skeletal material allowed. Then, conclusions regarding the ancestry were finalized according to the applicable method with the highest reliability.

The first approach was based on craniometric analysis of complete crania. Because of the precision afforded by digitized data, emphasis was placed on craniometrics collected with the Microscribe G2 and 3Skull. These data were considered of the highest quality, followed by craniometrics collected with traditional sliding and spreading calipers. Craniometric data were interpreted using a variety of statistical software packages, including FORDISC 3.0 and SYSTAT 12.0 (2007, Windows standard version, SPSS, Inc., Richmond, California). Canonical variates analyses compared intergroup variation, placing the observed cranium among reference samples of known ancestry. The posterior probability established the ancestry, and the typicality described fitness of the cranium in that group according to within-group variation (see Chapter 8 of this volume). The result of these analyses was a categorical placement of the cranium within a defined Biological Affinity, and a recitation of the posterior probability.

The second method for determining Biological Affinity was nonmetric, morphoscopic evaluation of the cranium. Eleven traits were evaluated after Hefner (2003, 2007). These observations were compared to reference samples from a variety of geographical and temporal contexts, acquired from data collection at the Smithsonian Institution National Museum of Natural History and the Pima County Medical Examiner's Office. The data were analyzed using a variety of statistical methods (see Chapter 8 of this volume). The results of these analyses allowed classification of the remains to a defined ancestry, as well as a statement of statistical confidence.

The third method for assessing Biological Affinity was an examination of morphological characteristics of the dentition. Seventeen maxillary and 13 mandibular morphological traits were assessed for their presence or degree of expression in all Primary Individuals. These traits were then examined using a modified discriminate function analysis (Krzanowski 2000) to classify individuals into the proposed Biological Affinity groups.

The traits under evaluation are described more completely in Chapter 13 of this volume. In addition to cranial deformation, analyzing dental morphology was the only method applicable to juvenile individuals.

The fourth method for determining Biological Affinity was metric analysis of postcranial elements. This approach was similar to the craniometric diagnoses in that canonical variates analyses compared postcranial measurements from observed individuals to those of acquired reference samples. Although the statistical underpinnings of postcranial assessments for ancestry were identical to those for craniometric evaluations, available reference samples are remarkably limited. Indeed, additional data collected from the Smithsonian Institution National Museum of Natural History and the Pima County Medical Examiner's Office were insufficient to adequately raise the level of reliability for this method to that enjoyed by craniometric analysis.

The fifth and final method for establishing Biological Affinity was to appraise nonmetric epigenetic traits. As noted above, data collection on the project expanded the standard suite of 24 epigenetic traits describe by Buikstra and Ubelaker (1994). For the purposes of establishing Biological Affinity, however, several of these novel observations were excluded because of unclear applicability and sensitivity of these traits to assign an individual set of remains to a particular ancestry.

Osteological Database

As noted above, Statistical Research, Inc., maintains specific conventions for the collection and management of osteological data. These protocols ensure integration into a relational data structure linking all field, inventory, and analytical information. The conceptual basis for osteological analysis at Statistical Research, Inc., is a product of this need for relational integrity. Given that the element is regarded as the unit of observation and the individual as the unit of conclusion, the element represents the tangible contribution to osteological analysis. It occupies space, is recovered from a provenience, and exists as an item to be inventoried. The individual, *as an analytical unit*, however, is aspatial and exists as the synthesis of the information ascertained from the skeletal elements. Elements are dynamically linked to the individual, allowing for revision of element associations to individuals without loss of information about that particular element. Element-data autonomy is most important in commingled contexts when individual association of particular elements is not immediately clear. The attributes of those elements are linked to those elements—not to an individual—and will follow that element as the context is deciphered and individuals defined. For example, the measured maximum length of a femur is a data attribute of that femur, not of the individual from whom it came. Indeed, several elements were analytically reassociated with their proper individuals as a product of data-driven analysis described in Chapter 7.

The osteological data management system consists principally of skeletal elements, which serve as the basis for a wide array of observational data, including metric and nonmetric observations, and assessments of trauma and disease. Each skeletal element exists as its own data node, capable of supporting all osteological observations for that particular element. These nodes may then be linked together to create a larger observational unit in the form of the individual.

Information unique and specific to an element, be it a Discrete or a Composite Element, links directly to that element. The individual, on the other hand, is the foundation for several synthetic conclusions based on the elements, as well as the proper basis of discussion for characteristics spanning many elements. Several Individual Attributes were assessed, and these data were recorded as attributes of the individual, regardless of the elements contributing to these assessments. For example, the age of the individual is expressed as a numerical range, discovered by multiple lines of element-based evidence. The age for the individual does not, however, become an attribute of the element. This is of critical importance when dealing with atypical expressions of specific elements. In other words, conclusions drawn from one element do not alter data drawn from another element. The characteristics recorded as Individual Attributes appear in Table 10.

Nonosteological Analytical Methods

Analysis was conducted on mortuary artifacts, prehistoric artifacts, postcemetery historical-period artifacts, vertebrate and invertebrate faunal remains, macrobotanical remains, and both parasitological and pollen samples. Analysis of artifacts and other samples from mortuary contexts was conducted entirely on-site, with the exception of specialized analyses such as those from flotation and pollen samples, for which we received permission to send the samples to experts for analysis. Analysis of nonmortuary artifacts and faunal remains were conducted at Statistical Research laboratories. Other specialized nonmortuary samples were sent out for analysis.

Prehistoric and Native American Artifact Analytical Methods

Prehistoric and Native American artifacts were analyzed from two main feature contexts: prehistoric features and cemetery features (see Chapter 8). Prehistoric features encountered in the Joint Courts Complex project area included two pit structures and a roasting pit, and all artifacts from these contexts were analyzed. All prehistoric artifacts recovered from cemetery contexts (grave pits and burial features) were also analyzed. Prehistoric artifacts from cemetery contexts were analyzed as a priority to facilitate the reburial effort and to ensure that all artifacts with potential mortuary associations would be examined. In general, prehistoric artifacts from grave pits consisted of lithics and ceramics; therefore, they were analyzed on-site as a part of the general mortuary collections. Once the prehistoric artifacts from cemetery contexts were analyzed, they were reboxed with the rest of the human remains and mortuary items for reburial. Prehistoric artifacts from prehistoric contexts were analyzed according to current standards for artifact analysis, as discussed below. For the most part, as discussed in Chapter 8, prehistoric artifacts from postcemetery contexts were not analyzed because of their loss of primary contextual data. However, historical-period Native American artifacts, mainly ceramics, were analyzed from postcemetery contexts.

Stone Artifacts

In this analysis, stone artifacts were divided into three categories: flaked stone (e.g., debitage and tools), ground stone (e.g. manos and metates), and unmodified stone (e.g. manuports). A morphological classification developed by Andrefsky (1998:74) was used to sort the flaked stone collection from the Joint Courts Complex project area. Flaked stone artifacts were initially divided into the two categories of debitage and tools. These two categories were further broken down based on established morphological attributes. Following J. Adams (2002), ground stone was initially classified into general morphological categories (mano, metate, etc.), which were then divided into subtypes (slab metate, trough metate, etc.). Only the basic attributes were studied for manuports (material type and size), with the majority represented by imported raw materials for unspecified uses.

Flaked stone tools were divided into two categories: bifaces and nonbifaces. All bifaces have two sides that meet to form a single edge, and each side has at least 50 percent of the face covered in flake scars (Andrefsky 1998). Bifacial tools were then divided between hafted and unhafted bifaces. Hafted bifaces include projectile points, drills, and knives. Projectile points were further subdivided into a specific cultural affiliation based on previously identified projectile point typologies (Justice 2002; Sliva 1997). Unhafted bifacial tools were further subdivided into five stages, depending on their level of manufacturing effort. Nonbifacial tools were divided into two groups: flake tools and core tools. Flake tools are defined as artifacts that have been retouched or have use wear present but do not have multiple striking platforms. Examples of flaked stone tools include scrapers and unimarginally or bimarginally retouched lithics (e.g. edge-modified pieces or edge-modified flakes). Core tools are defined as having multiple striking platforms and flake scars but do not have a single dorsal or ventral surface. Core tools include choppers, tested cobbles, and unidirectional and multidirectional cores. Hammer stones are also defined under the core tool category, as they are used as the percussion implement during the reduction of lithic material. Attributes recorded for flaked stone tools included raw material type, modes of reduction, and edge characteristics. In addition, maximum length, maximum width, and maximum thickness were all measured to the nearest millimeter.

Flaked stone debitage was initially sorted by the presence or absence of a single dorsal and ventral surface and the presence or absence of a platform (Andrefsky 1998, 2001; Sullivan and Rozen 1985). Then, it was divided between nonflakes and flakes. Nonflakes, also known as angular shatter, are pieces of raw material that have been broken off during the removal of a flake but do not have the characteristics of flakes. All flakes have a single dorsal and ventral surface, whereas angular shatter may have several surfaces. Flakes are divided into two main categories based on a typological approach in which the artifact is classified based on an inference of the totality of traits observed. These traits include platform type and angle, the amount of cortex and/or flake scars on the dorsal surface, the size and longitudinal curvature of the flake, and the termination type. Two main flake typologies were identified using the above traits: core reduction and biface reduction. Core and biface reduction flakes are further refined by the method of reduction, such as early or late percussion and pressure flakes. Percussion flakes are defined as having partial or complete dorsal cortex, generally larger in size, a plain or cortical platform, a hinged or stepped termination, and a thick bulb of percussion. Pressure flakes are defined as being relatively smaller, pointed single- or multi-faceted platform, a longitudinal curvature, feathered termination, and multiple dorsal flake scars.

The attributes examined during the analysis of debitage included platform type, cortex amount, size class, heat treatment or alteration, and raw material. The five platform types include cortical, plain, faceted (dihedral or multihedral), abraded, and crushed/partial (Andrefsky 1998; Whittaker 1994). Cortical platforms have an unmodified cortical surface, regardless of the cortex amount; plain platforms have a single, smooth continuous plane; faceted platforms are platforms with multiple flake scars or facets; abraded platforms are modified by abrasion or rubbing of a hammer stone or another abrasive stone to smooth the surface or to remove crushable edges and overhangs; and a crushed platform, sometimes referred to as a partial platform, has collapsed during impact of percussion (Crabtree 1982). Cortex amount on the dorsal side of complete flakes was divided into four categories: none, 1–49 percent, 50–99 percent, and 100 percent. The size of the debitage was measured using a template divided into 12 ordinal size ranges. The size ranges start with 0–4.9 mm and 5–9.9 mm, and then proceed in intervals of 10 mm (10–19 mm, 20–29 mm, etc.), ending with artifacts larger than 100 mm. Finally, a determination was made as to whether the raw material was heat-treated prior to flaking. Heated-treated material frequently has a glossy or greasy luster and a soapy feel. Occasionally, small "potlids" are present as concave divots from small pieces of the material detaching while heated (Cotterell and Kamminga 1987; Kooyman 2000). Nonigneous raw material that has been heat-treated generally produces a smoother surface, making it easier to flake.

Ground stone artifacts were first separated into general categories based on morphology and inferred artifact function. Ground stone artifact categories included processing tools (manos, mortars, metates, and pestles), manufacturing tools (axes, polishing stones, and stone discs), and other ground implements such as ornaments (beads, effigies, and pendants) (J. Adams 2002). The ground stone was then subtyped into more specific morphological categories, such as flat, basin, and trough metates. The subtypes help to define the function of the artifacts. As an example, trough metates are frequently associated with the processing of maize, whereas basin metates and grinding slabs are associated with wild-plant processing, particularly seeds with tough outer coverings, or pericarps (Lyon 2000). A flat metate is usually only lightly ground, exhibiting some edge shaping, and creating a slightly concave grinding surface in the longitudinal section (Slaughter et al. 1992). A basin metate usually has some edge shaping but has a deeper concave grinding area than the flat-surfaced, slab metate. The trough metate is generally a rectangular, open-ended metate with steep sides. The sides are created when a mano is used that is smaller than the grinding surface. As the metate is used, the interior grinds away, leaving the steep sides. Manos are also categorized based on these same morphological traits. For instance, a mano used in a trough metate would have ground edges resulting from contact with the interior sides of the metate and would be therefore characterized as a trough mano. Basin manos tend to have a more convex grinding surface resulting from the pattern of grinding, or stroke, specific to a basin metate. A mano used on a flat metate would exhibit a flat grinding surface, similar to that of the metate surface. Further attributes recorded for manos include the direction and type of stroke, which is deduced from circular or reciprocal abrasions observed during analysis. The characterization of manos into morphological categories similar to metates increases our ability to interpret the function of the artifacts as well as the types of plant processing on a given site or feature (J. Adams 2002:99–112).

Personal adornments such as effigies, pendants, and beads are classified as ground stone artifacts owing to their method of manufacture by grinding the material to form the desired shape. Ground stone fragments are broken pieces of ground stone that are too small or nondescript to determine functionality. All ground stone had minimal morphological attributes recorded, such as material type, maximum length, maximum width, and maximum thickness. The observations of each ground surface can aid our understanding of the use life for each particular artifact and can help to infer the intensity of food processing that occurred on a site.

Manuports were minimally recorded due to the lack of any use wear or apparent functionality of the material. The majority of manuports were interpreted as objects imported to the site for later use. Manuports included pieces of usable lithic material that had yet to be modified but were present within meaningful contexts. For the purposes of this study, fire-altered rock was also included with the manuports. Unmodified materials that were native elements or elemental compounds were identified as mineral samples. Mineral samples were thus distinguished from other manuports based on their material type, such as ocher, turquoise, etc. Mineral samples were generally imported to the site prehistorically and curated for special uses. For each manuport, the material types were recorded, as were the maximum length, maximum width, and maximum thickness.

Prehistoric and Native American Ceramic Artifacts

All prehistoric and historical-period Native American sherds were sorted, counted, and entered into the ceramic database by provenience designation. The sherds were first sorted by size. Sherds were then sorted by vessel part: indeterminate, body, rim, shoulder, base, handle, etc. When discernible, vessel form was recorded (e.g., bowl, jar, plate, pitcher, effigy, etc.). Although not exhaustive, an attempt was made to refit sherds within and across adjacent proveniences. Sherds that refit were counted as one in order to minimize the risk of double-counting vessels or inflating sherd counts. Unless too eroded, all painted and unpainted sherds were typed based on the major attributes of surface treatment, decoration, paste, and morphology. For the prehistoric sherds, the standard Tucson Basin typology of wares and types (Di Peso 1956; Heckman et al. 2000; Kelly et al. 1978) was used. The historical-period Native American ceramics were classified using the typology outlined by Fontana et al. (1962), taking into consideration additions and revisions made by others (Bruder 1975; Doelle 1983; Haury 1950; Whittlesey 1997; Wood 1987).

Prehistoric ceramic pastes were assigned to three gross categories based on whether mica, sand, or phyllite was the predominant inclusion. Historical-period Native American ceramic paste analysis included recording paste color (Munsell Color 1994), type of inclusions (organic, sand, and mica), amount of each type of inclusion (sparse <10 percent, moderate 10–30 percent, abundant >30 percent of paste body), and the presence or absence of a carbon core. For both prehistoric and historical-period Native American sherds, large rims (usually Size 3 and above) were described according to rim form, rim angle, lip form, diameter, percent completeness of the rim's diameter, and rim thickness. For both interiors and exteriors, the presence of slip was noted and the presence and type of finish was recorded (e.g., tool polished, hand smoothed, unfinished, etc.), along with the amount of polishing (low, moderate, or high). The slip color was recorded using a Munsell chart (Munsell Color 1994). Any painted decoration was noted and described. The presence and color of fire clouds was recorded along with any burning, warping, or sooting. Wall thickness was recorded when present well below rims and as an average for body sherds. Any modifications such as use wear or repair holes were noted as was any evidence for recycling, refurbishing, or reuse.

Mortuary Artifact Analytical Methods

Like all archaeological remains, historical-period artifacts were analyzed in terms of their cultural context. All historical-period artifacts from the Joint Courts Complex project area were presumed to be highly likely associated with the cemetery, unless they derived from obvious postcemetery contexts. To comply with Pima County's mandate to recover 100 percent of all human remains and funerary objects from the project area, all overburden sediments recovered from mechanical excavations were placed through the mechanical screen. Similarly, grave pits and burial features were hand-excavated, and artifacts from those contexts were mapped and collected by field archaeologists. All artifacts determined to be associated with the cemetery were

analyzed by archaeologists who specialize in mortuary contexts. Ceramic, faunal, lithic, and macrobotanical analyses were conducted on-site by analysts specializing in those types of analysis. Historical-period artifacts that were determined to be unrelated to the cemetery were sent to other historical-period artifact analysts.

When unique or special artifacts from cemetery contexts were discovered by archaeologists, mortuary analysts were consulted so that field photographs could be taken and preliminary identifications could be made. If an artifact was determined to be too fragile to remove for analysis, attempts were made to analyze it in situ. Shoes, clothing, and paint and paper coffin treatments are among the types of funerary objects that were often analyzed in situ. In accordance with the burial agreements, no extraordinary measures were taken to conserve any artifact. Natural materials were used to store artifacts before and after analysis. Objects were wrapped in acid-free tissue paper, contained in natural craft-paper jewelry boxes, and stored in unbleached paper bags.

Once mortuary analysis began, reasonable measures were taken to ensure inventory control and context was maintained, and analysts worked on only a single grave's artifact assemblage at a time. Cleaning was minimal and nondestructive. Soft brushes were used on most objects when they were determined stable enough for such treatment. Washing was rarely conducted. For some copper-based objects, however, a diluted vinegar wash was used to remove calcium-rich soil deposits and prepare the object for cleaning in an ultrasonic cleaner, an electronic device that sends vibrations through a basin filled with distilled water to gently remove corrosion from metal objects. This process was particularly useful for objects with text like coins and religious medallions.

Unlike prehistoric artifacts, attributes for historical-period artifacts are recorded in English units (ounces, pounds, and inches) rather than metric units. This method was used primarily because the majority of historical-period artifact types were manufactured using standardized English measurements. Most mortuary artifacts, with a few exceptions, were counted and measured in three dimensions. Coffin wood and fragmentary nails without heads were weighed. Whole nails and fragmentary nails with heads were counted and measured for length only. Over the course of analysis, approximately 18 months, nearly 75,000 mortuary artifacts were counted and more than 900 pounds of coffin wood and fragmentary nails were weighed.

To facilitate the efficient and effective recording of artifacts, analysts recorded artifact attributes directly into a comprehensive database designed for historical-period artifact analysis. Each artifact was classified into a material class and artifact type. The vast majority of mortuary artifacts fell into five broad material classes: ceramic, glass, metal, modified shell, and modified wood. Other classes were available but seldom needed. Metal types, glass color, ceramic body types, wood species, and other distinctions were made for each material.

Artifact types most often used by the mortuary analysts were ammunition, coffin, coffin hardware, clothing, clothing fasteners, jewelry or personal objects, and shoe parts. As with the material class categories, other artifact types were available but seldom needed. More important were the subtype categories and other descriptive attributes particular to each of these artifact types. Subtypes and other attributes are discussed in detail in Chapters 5 and 6.

Identification of each artifact's function was integral to the categorization and interpretation of the mortuary assemblage. The historical artifact database was designed to allow for primary and secondary function attribute categories. The primary function attribute was intended to define the primary function of a particular artifact. If an item was reused, then this reuse was considered to be the secondary function of that artifact. For example, a coffin handle was categorized with a primary function of "mortuary" and no secondary function. A button in a burial context was categorized with a primary function of "clothing/clothing maintenance" and a secondary function of "mortuary." Interpreting function allowed for refined database queries and facilitated later interpretive analysis.

Mortuary artifacts that were deemed unique or of special interest and quality were photographed in the mortuary laboratory in addition to being field photographed. A detailed photographic log was maintained to track the provenience, and each photograph was entered into a media database linked to the artifact analysis. Artifacts that were associated with individuals determined to be of Native American ancestry were illustrated. Additionally, illustrations were used to record button morphological variability. Approximately 500 scale drawings were made to illustrate material, manufacture, shape, and decoration variations in the button assemblage.

Quality assurance was a constant concern, and quality control was a task undertaken throughout fieldwork and subsequent analysis. Research was ongoing, and new techniques were implemented when reasonable and warranted. As mortuary artifacts became easier to recognize and additional artifact types were established, the database was revised and previous analysis was updated to accommodate the broadening range of artifacts recovered from the cemetery. For detailed interpretative analysis, see Chapters 5 and 6.

Postcemetery Feature Sampling Strategy

Artifact analysis was completed on 8 of the 29 postcemetery feature types identified for the project. This included feature types that were deemed most likely to return substantive information on the historical-period residents of the project area including animal burials, basements, cesspits, fireplaces, privy pits, stairwells, refuse deposits, and refuse pits. The selection of these feature types was based largely on two criteria: (1) level of effort during excavation, and (2) the likelihood of directly associating the feature, or deposits within the feature, to specific residents.

The level of effort for features from these eight feature types usually followed the defined postcemetery excavation strategy. This strategy consisted of the bisection of the feature, with one half excavated in 10–20-cm arbitrary levels and the other half excavated based on the natural stratigraphy of the feature. Features that were grab-sampled and were not subject to the level of effort described above were excluded from the sample.

Besides being subject to an appropriate level of effort, those features chosen for analysis contained discrete deposits that were likely to be temporally and spatially constrained. These constraints increased the likelihood that the features could be associated with specific residential periods, and therefore specific households. In contrast, feature types such as foundations or landscaping pits were not included in the sample of features selected for artifact analysis. Either the associated artifacts were likely to have represented the entire temporal span of the residential period or, in the case of the foundations, were likely to have dated to the commercial period. Few intact foundations were found that dated to the residential period, and it was determined that efforts were better placed on the excavation of residential features such as the refuse deposits and privies/cesspits.

The application of the above criteria left us with 38 postcemetery features on which to perform artifact analysis. Although not all of the 38 features chosen for analysis were excavated using the postcemetery excavation strategy described above, the majority had been, and this strategy provided us with our intrafeature sample. The division of the feature into arbitrarily and stratigraphically excavated units allowed us to prioritize the material from the stratigraphic levels over that from the arbitrary levels. The arbitrary levels were only sampled when there was no division of the feature (e.g., they were mechanically excavated), or when questions arose as to the quality of the natural level excavation. In either case, the sample derived from this strategy usually represented close to 50 percent of the feature.

Postcemetery Feature Volumetric Methods

When excavating by cultural levels, the unique nature of each analytical unit (i.e., Feature, Stratum, or Level) must be accounted for; in particular, each unit will have unique dimensions. Because of this uniqueness, no direct quantitative comparisons can be made between analytical units unless a standardized unit of comparison is provided. For the purposes of this report we chose to use the density of artifacts within the volume of fill associated with an analytical unit as our standard measure (Density of Artifacts [Da] = Artifacts / Unit Volume) for the postcemetery features.

To provide these standard units, the volume of each analytical unit must be known. In some cases this was a fairly straightforward computation. Calculating the volume of a single-use circular refuse pit with a rectangular cross section is as simple as calculating the volume of a cylinder. Likewise, regular plan-view shapes such as triangles, squares, and rectangles pose few difficulties as their areas, and heights are easily calculated. However, not all features have a regular shape in plan view, and very few, if any, strata do. For these irregular units, area approximations were made using a geometric model loosely based on Riemann sums (Hughes-Hallett et al. 2005).

The core principle behind Riemann sums is that the area of an irregular shape can be approximated by using a series of regular shapes. In the case of traditional Riemann sums, these shapes tend to be rectangles, or trapezoids, of a uniform width. In our case, we used squares, rectangles, and triangles as appropriate, sized to efficiently cover the area we were calculating (Hughes-Hallett et al. 2005). We fit these shapes into the irregular area being calculated and then summed their combined areas to provide a close estimate of the irregular area. This shape fitting method of area estimation was used according to the methods outlined below.

The first method we used to calculate volume we called the "direct volume" method. In this method, we used the shape-fitting-method area of the top of the analytical unit and its average depth to calculate a volume. We then took the shape-fitting-method area of the base of the unit and its average depth and calculated a second volume. If the top and the basal areas were unequal, the volume calculated from the smaller area would give us an underestimation of the actual volume, whereas the larger area would give us an overestimation. We therefore used the average of these two volumes as a close estimate of the actual volume of the analytical unit. This method worked well when the shapes of the top and basal areas of a unit were well documented; in situations where these shapes were difficult to discern, however, we had to develop another method of volumetric estimation.

The second method we used to calculate the volume of irregular analytical units we called the "profile area" method. This method used the direct volume method to calculate the total volume for a given portion of a feature (e.g., the north half of Stage I of Feature 3042, etc). We then calculated the area of the related profile and the shape-fitting-method area of the component strata to generate the percent of the profile represented by each stratum. We assumed that the relationships between strata in the profile were generally consistent throughout the excavated volume. Given this assumption, the percent of the total volume represented by a single stratum should be directly related to the percent of the profile that the stratum represented. Clearly, this method is inappropriate when dealing with strata that fail to conform to the given assumption and will therefore overestimate small deposits. However, as was discussed previously, when defining the analytical units, these smaller deposits were generally assumed to represent substrata rather than being strata themselves. Due to this aggregation, there were few, if any, analytical units that were of a sufficiently small size to make the profile area method inappropriate; if the method was deemed inappropriate for a given stratum, that stratum was dealt with using the direct volume method.

Postcemetery Artifact Analytical Methods

The analysis of artifacts recovered from the postcemetery component of Joint Courts Complex was performed by Statistical Research staff at the main office in Tucson, Arizona. Due to the extensive size of the artifact collection from postcemetery contexts, a sampling strategy of key proveniences was employed to obtain the most pertinent information about cultural events that occurred during this time in the project area. The remaining unanalyzed artifacts went through an intuitive selection process to retain usable artifacts for public interpretation, historical-archaeological type collections, and teaching collections.

Standard historical archaeological methods were employed to identify approximately 50,000 artifacts, consisting of glass artifacts, historical-period ceramics, metal artifacts, and "other" historical-period objects representing other material categories. Postcemetery artifacts were categorized on the basis of material and function and entered into the Statistical Research database. Observations regarding diagnostic attributes, function, age, and cultural origin were noted when applicable for each artifact, particularly temporally diagnostic characteristics. Indications of modification, reuse, or use wear were also documented.

A wide range of published sources was used to identify artifact manufacture, function, history, and use life. In addition to printed references materials, these sources included reliable Internet sites, including government, museum, and educational Web sites. For harder-to-identify artifacts, collector, hobby, and auction Web sites were also utilized, with the understanding that these were to be used for initial identification only. Verification was then attempted through more scholarly sources. Common, well-known items were identified without a listing of sources.

Each artifact was assigned a unique catalog number that recorded artifact characteristics and provenience information in our proprietary database. Each part of a composite artifact (a bottle with cork stopper, for example) was analyzed within its own material class. Attention was paid to cross-matched pieces from the same item found in the same provenience, and refits from different proveniences were noted. Due to the extensive size of the analyzed collection, the fragmentary nature of the collection, and the amount of time available for analysis, minimum number of items was only established for glass vessel-type artifacts such as bottles and jars. Therefore, total artifact counts were used for all other material classes.

As was proposed in the treatment plan (Beck et al. 2006), all historical-period artifacts from analyzed postcemetery contexts were initially sorted by material class. Subsequent analysis focused on characteristics within each material class to determine artifact function, point of origin, and period of manufacture. Ceramic analyses focused on body (paste), vessel form, surface treatment, and makers' marks. Glass analyses examined color, technology, mold type, shape, decoration (including labeling), closure, base, finish type, and makers' marks. For metal and other artifacts, analyses depended upon the artifact type. Characteristics pertaining to the particular type were addressed. For example, caliber/gauge, headstamp, and location (centerfire versus rimfire) were the characteristics examined for ammunition.

Glass and ceramic artifacts were described with regard to type of vessel, method of manufacture, and distinguishing marks such as decorative techniques/motifs and makers' marks. Terminology employed for bottle analysis follows Putnam (1965), Fike (2006), Jones and Sullivan (1989) and the Society for Historical Archaeology Bottle Identification Web site (http://www.sha.org/bottle/). Bottle makers' marks were analyzed in reference to Toulouse (1971), Wilson and Wilson (1971), Lockhart (2000, 2004, 2005, 2006a, 2006b), Lockhart et al. (2007, 2008), Peterson (1968), Whitten (2009, www.myinsulators.com), and Munsey (2004, 2006). Terminology for ceramics follows Majewski (1996) and Majewski and O'Brien (1987). Ceramic maker's marks were recorded in reference to Godden (1964), Lehner (1988), www.Marks4Antiques.com, and Kowalsky and Kowalsky (1999).

Artifact measurements were taken of whole vessels and fragments of sufficient dimensions to reveal artifact size. Measurements applied to artifacts in the collection were done in Standard English metrics to correspond with historical specifications. Linear measurements were taken in inches while ounces were used for volumetric calculations. Complete glass artifacts were measured following Fike (2006). Length and rim diameters, when applicable, were taken for certain fragments of bottles and jars. Thickness was measured for window glass. Height, rim, and base diameters were recorded for complete ceramic vessels. A rim chart was applied for measurement of ceramic rim fragments. Weights were recorded for artifact masses such as fabric, wood, and paper. Small fragments of nails, crown caps, wire, cans, ceramic, and glass were not measured. Pennyweight, button line, and ring sizes were applied to whole nails, buttons, and rings.

Notations of postcemetery artifact markings presented in this report are direct transcriptions of wording found on the artifacts (see Chapter 4, Volume 3 of this series). Glass and ceramic embossments, makers' marks, and the like appear in the report enclosed in quotation marks to indicate that the wording is reproduced exactly as it appears on the artifact and without regard to rules of punctuation. Brackets are used in missing, but known portions of a word or words. Ellipsis points are used in cases where missing letters or words remain unknown, and where cursive lettering was present, italics are used. Separate lines of wording are divided by a single slash, and lines of wording appearing on different parts of an artifact are divided by a double slash.

Vertebrate Faunal Analysis Methods

A total of 27,990 bones, bone fragments, eggshell, mollusk and arthropod shell, and shell fragments were analyzed during the Joint Courts Complex project. Prehistoric and historical-period faunal specimens were identified to the smallest taxonomic level possible, and their attributes were entered into a relational database. The bones were analyzed at Statistical Research's Tucson, Arizona, and Redlands, California, laboratories, using a collection of comparative specimens, and the comparative collections in the Arizona State Museum Stanley J. Olsen Laboratory of Zooarchaeology and the Los Angeles County Museum of Natural History, Department of Ornithology. The fish bone was identified by Dr. Kenneth W. Gobalet, Department of Biology, California State

University-Bakersfield. Published osteological references were also consulted (Brown and Gustafson 1979; Gilbert 1980; Gilbert et al. 1985; Goldberg 1999; Hargrave 1972; Hillson 1992, 2005; Lawrence 1951; Olsen 1960, 1964, 1968, 1979; Schmid 1972; Zweifel 1994). The number of identified specimens (NISP) represents the primary analytical unit used in this analysis. Following Grayson (1984:186), a specimen is defined as "a bone or tooth, or fragment thereof," and each specimen is included in the NISP calculation. Some specimens could only be assigned to class or order, but in other instances taxa were identified to the species level.

The most minimal level of identification was size class. All specimens were assigned to six general size classes based on those proposed by Thomas (1969:393) and Wegener (2009). Very small mammals are those weighing less than 100g, such as kangaroo mice and pocket mice. Small mammals are those weighing between 100 and 700g. Most squirrels in the project area are classified as small mammals, as are wood rats. The rabbit-sized mammal category includes those weighing between 700g and 5 kg, and is occupied largely by the leporids (rabbits and hares). Large mammals are those weighing 5 to 25 kg, such as dogs, cats, bobcats, badger, and coyotes, and very large mammals weigh over 25 kilograms, such as sheep, goats, deer, pigs, and pronghorns. Extra-large taxa in our area include cattle, elk, and horse. Unidentified bone from extra-large mammals most likely represents cattle bone, but this study uses the most conservative approach and bone is only assigned to be cattle if it had diagnostic traces. Specimens that were so fragmentary that animal size class could not be confidently determined were designated as indeterminate. Bones that were unidentifiable to taxon were placed in the smallest possible size class. Bird bones were also assigned size classes; very small, small, medium, large. The largest birds in this collection were turkey or goose sized. Chickens and ducks are medium-sized birds; pigeons, most doves, and quails are small birds; and many songbirds fall into the very small size class.

Bones and fragments were counted and identified to skeletal element, side, and to element portion when possible. Fragments were counted separately unless they could be refitted or were broken postexcavation from the same larger piece. Several methods were employed to examine element representation within and between sites. Specimens were placed in categories based on element portion (Wegener 2005:8.3). These categories were used to examine breakage patterns. Long bones represent limb bones. Long bones and long-bone fragments were identified as NISP/whole, NISP/shafts, or NISP/ends, depending on whether the element was intact, or if a specimen was represented by only the shaft or an articular end. Whole and fragmentary cranial bones, vertebrae, scapulae, innominates, carpals, and tarsals were assigned to NISP/flat. Two additional NISP categories were used. The NISP/tooth-enamel category contains teeth and tooth fragments, and NISP/antler-horn indicates antler or horn.

Specimens were categorized as adult, subadult, neonatal, and indeterminate based on the presence or absence of age indicators such as erupting or heavily worn teeth; presence of antler, fused, unfused, or partially fused epiphyses; or spongy fetal appearing bone. A few taxa have easily identifiable sexual characteristics, and so sex was noted when possible.

The overall bone condition was recorded for each specimen. Taphonomic factors include noncultural formation processes such as rodent and carnivore gnawing and weathering, as well as cultural modifications such as cutting, butchering, and burning. Four possible burning stages were recorded. These were based on color: unburned, partial, blackened, and calcined. Unburned bone exhibited no color change. In the present study, partially burned bone fell into two general types. The majority of bone assigned to the partially burned category was blackened in one or more areas but still light colored and unburned on other parts of the bone, and some specimens were dark-brown colored, appeared to have been heated, but were not blackened. Bone becomes black at about 400˚C, a temperature that can be reached in campfires (Lyman 1994:386). As bone heats and organic materials are burned away, there are additional color changes. It begins to be calcined at temperatures over about 600˚C, going from black to blue-gray to gray until it is completely white. Calcination occurs either through increased temperature or longer heating time and can be formed in campfires, forest fires, or cremations (Lyman 1994:386–389).

This study employs the six-stage numerical classification system proposed for weathering by other researchers (Andrews 1990; Behrensmeyer 1978; Lyman 1994:355). Each specimen was classified based on degree of weathering. Stage 0 bone is still greasy, and no specimens fitting this stage were found in the project collection. Large-mammal bone that falls into the Stage 1 category can have longitudinal cracking with mosaic

cracking on articular surfaces, whereas small-mammal Stage 1 bones and teeth can have some splitting (Lyman 1994:355).

When large mammal bones reach Stage 2, their surfaces begin to exfoliate, and the bones continue the cracking that began in Stage 1. The bones of small mammals continue to split, small mammal teeth chip and split, and portions of teeth may fall away in Stage 2. Weathering penetrates deeper into the bone surface in Stage 3, up to 1–1.5 mm, and edges of cracks become rounded. Stage 4 bone develops open cracks and splinters in a rough, fibrous surface (Lyman 1994:355). As a bone goes through the later weathering stages, it becomes progressively more fragile; it splits, cracks, flakes, and becomes fragmented until it reaches Stage 5, at which point it is fragmented, fragile, and splintered. The system was slightly modified to include specimens with surfaces that appeared to be halfway between stages, and so some specimens were designated Stage 1.5 and 2.5. The majority of bone from this project was extremely well preserved and was placed in Weathering Stage 1.

To determine fragmentation, seven ordinal categories characterized the maximum dimension of each specimen (following Wegener 2009): less than 5 mm, 5–15 mm, 15–25 mm, 25–35 mm, 35–50 mm, 50–100 mm, and greater than 100 mm in size. These size classes provide information on fragmentation, which in turn can reflect decisions made during meat processing. Such information can provide useful information concerning butchery and cooking practices, along with postdepositional processes. For example, fragmentation may also come about through trampling or other taphonomic processes.

Crushing and impact marks, breakage, cut marks, saw marks, and other signs of butchery provide clues to human behavior and were recorded when visible. Analysts employed methods proposed by Münzel (1988) to record butchering, in which portions of bones and location of cut marks are described using alphanumeric coding. Sections of bone are numbered longitudinally from 1 through 9, so that, for example, the proximal epiphysis of a femur are Section 1, and the distal end is Section 9. Bones are also assigned the letters A, B, C, and D to identify whether the medial, lateral, dorsal, or ventral portions are present. Münzel's proposed methods did not include all bones for all taxa and so were modified slightly to include fibulae and sacra. A few bird bones were also added as needed.

Finally, various historical sources were consulted to identify meat cuts and interpret foodways. These included cookbooks and newspapers from the early twentieth century. Cookbooks provide an intimate look at some of the decisions encountered in day-to-day life, with information concerning status of certain foods. For example, they often describe how to make less-expensive cuts of meat more palatable. Cookbooks and home economics manuals were consulted to identify the kinds and costs of the meat cuts potentially encountered in the late-nineteenth and early-twentieth centuries, examine processing and cooking methods, and to identify cultural preferences. Several cookbooks were especially relevant, including a handwritten recipe book written and used by Elsie Siewert Brown, whose family owned several rental properties in the project area, and a 1909 cookbook published in Tucson by the St. Anne's Society (both currently housed at the Arizona Historical Society). Several digital archives exist of period cookbooks and home economics manuals. Cornell University's online Hearth electronic archive of historical home economics (http://hearth.library.cornell.edu/h/hearth/) was a particularly useful resource. The University of Arizona Main Library archives Tucson newspapers on microfilm, and these, too, were consulted for any information relevant to foodways. Newspaper advertisements and articles provide useful data concerning costs and availability of game, agricultural products, and other resources. The Joint Courts Complex postcemetery excavations recovered a series of paper grocery receipts from Cess Pit 3040. These receipts provided a unique resource for researchers, giving details concerning the shopping behavior of one household in May and June of 1911. These varied written sources combined with the faunal, floral, and artifactual data to help construct a more nuanced narrative of domestic life and foodways in late-nineteenth- and early-twentieth-century Tucson.

Invertebrate Faunal Analysis Methods

The analyzed invertebrate collection recovered from postcemetery features included a total of 221 pieces of shell representing 81 specimens. Of these, three represented worked shell. Collectively, the analyzed sample

was made up of mostly marine mollusks, consisting of more than 20 marine taxa, as well as a few marine arthropods (e.g., crab, barnacle). Each invertebrate specimen was identified to the most specific taxonomic level possible using standard identification guides (e.g., Abbott 1974; Coan et al. 2000; Keen 1971, Morris et al. 1980; Rheder 2006). All shell pieces were then counted and assigned NISP before converting counts into minimum number of individuals (MNI). To determine MNI, analysts recorded diagnostic elements—in the case of bivalves, whole hinges or hinge fragments that were more than 50 percent complete were counted. When left or right valves could be identified, MNI was based on the greatest number of either left or right valves. For gastropods, each whole shell, columella, and apex was counted and used as the MNI. In the case of arthropods, crab claws that were more than 50 percent complete were divided by 2 to determine MNI, whereas barnacles with plates more than 50 percent complete were each assigned an MNI value of 1.

Invertebrate specimens were then identified as being either unworked or worked. Unworked shells, which lacked clear evidence of modifications, were weighed (in grams), whereas worked shells were measured to the nearest one tenth of a millimeter using digital calipers. Measurements consisted of maximum length, width, and thickness. When a shell was perforated, the minimum perforation diameter was recorded as well as perforation shape (e.g., straight, conical, biconical, punched). Modifications to the shells were also noted and included burning, cutting, grinding, chipping, or a combination of more than one of these alterations. Commercially worked shell in the form of buttons is discussed in sections on clothing and clothing fasteners.

When possible, worked-shell specimens were classified according to previously established regional artifact typologies and chronologies. Worked-shell classifications were based largely on Emil Haury's shell artifact typology derived from his work at Snaketown (Haury 1976). Chronological information was based on comparisons of similar artifact types recovered from sites in Arizona as well as California (e.g., Bennyhoff and Hughes 1987; Gifford 1947; Haury 1976; King 1990; Nelson 1989; Vokes 2001b, 2009).

Macrobotanical Analysis

Analysis of plant remains from the Joint Courts Complex project area was conducted by ethnobotanist Karen Adams. Macrobotanical samples were spread out on a laboratory tray and first examined for any charred non-wood items. Then, all specimens were identified at magnifications ranging from 8× to 50× using a Zeiss binocular microscope and then by comparison to an extensive modern collection of regional native plant materials backed by herbarium specimens deposited in the University of Arizona herbarium (ARIZ). In addition, for this project a large collection of reproductive and nonreproductive parts of historically introduced foods, spices, and ornamentals was acquired from Asian, Hispanic, and organic retailers. This work was facilitated by the recent publication of *Gardens of New Spain, How Mediterranean Plants and Foods Changed America* (Dunmire 2004), which outlines the reported introduction histories of many of the cultivated plants that entered the New World as part of the Columbian Exchange.

Flotation Sample Analysis

Flotation samples were recovered from prehistoric, cemetery, and postcemetery contexts. All flotation samples from prehistoric contexts were analyzed. For mortuary contexts, flotation samples were analyzed for botanical remains and small artifacts. For the postcemetery features, flotation analysis focused on samples from six feature types: refuse pits, refuse deposits, fireplaces, stairwells, privy pits, and cesspits. The majority of the samples came from privies and cesspits and was collected from levels with intact human waste and heavy refuse deposition. Clean fill was not sampled. Although the majority of samples came from privies and cesspits, not all of these samples were analyzed in order to consider other features with heavy deposits of refuse that were also likely to yield culturally relevant botanical materials. Ultimately, the analyzed samples represented the total universe of culturally relevant feature types encountered across the site.

A total of 96 flotation and macrobotanical samples were analyzed from 20 features by ethnobotanist Karen Adams. Sample sediments, containing between 1.2 and 8.5 liters of sediment, were processed with a

water flotation technique that removed the dirt and heavy materials (e.g., lithic debris and rocks) from buoyant organic materials. The skimmed light-fraction materials were collected, dried for analysis, divided by particle size, and examined for seeds and other reproductive parts. All specimens were identified using a binocular microscope and compared to an extensive modern collection of regional native-plant materials. The environmental and historical context of the identified species was conducted using documentary resources. The resulting data was also combined with known historical data to provide insight into the archaeobotanical character of the project area.

Parasite Samples

Samples were taken from hand-excavated privy and cesspit features for parasitological analysis, as well as from a sample of burials. In the privies and cesspits, sampling was focused on levels with evidence of active human waste deposition (green staining, brown crumbly fill, or night soil) because these levels were most likely to contain parasite eggs. In burials, samples were removed from the lower torso area, and control samples were taken from either the foot or head area.

A total of 50 samples were removed from burials and 20 sediment samples were taken from seven postcemetery features. Although preservation condition varied in these samples, three of the postcemetery features contained at least 1 sediment sample with good to excellent preservation. The analysis technique was a refined variation of methods outlined by Warnock and Reinhard (1994) and was conducted by Karl Reinhard. Thirty milliliters of sediment was removed from each sample bag and placed in a beaker of water. In each sample, carbonates were dissolved in hydrochloric acid and silicates were dissolved in hydrofluoric acid. A known number of *Lycopodium* spores were then introduced into the samples and counted upon recovery to assess the accuracy of the retrieval effort. Once dissolved in acid, the samples were transferred to 300-milliliter beakers, and the contents of the beakers were swirled until all particles were in suspension. This solution was passed through 250-micrometer mesh screens into 600-milliliter beakers and washed in distilled water. After another rinse with hydrofluoric acid, the remaining sediment was placed on glass slides and examined with a microscope. Identified parasite eggs and larvae were noted by species and compared with parasites known to infest humans and animals. Parasitological results were used to understand the absence, presence, and level of infection of persons interred in the cemetery and postcemetery residents of the project area and how that compared with contemporaneous populations.

Pollen Samples

Pollen samples were analyzed from a sample of the mortuary contexts in an attempt to identify plants that might have been present in the project area, periods of the year when burials would have taken place, or plant materials used for mortuary purposes. Pollen samples were analyzed for the prehistoric features, as well, but for the postcemetery component, there were only analyzed for the privy/cesspit features that were hand excavated. These were not heavily sampled, with only three samples per feature. These samples were biased toward areas of heavy refuse. Pollen samples were analyzed by palynologists Karl Reinhard (Appendix G, this volume) and Owen Davis (Appendix J, Volume 3 of this series).

After parasitological analyses were completed, the samples were processed for pollen. The tubes were centrifuged and the water poured out. Glacial acidic acid was added to the tubes, which were stirred until all particles were in suspension. Then the tubes were centrifuged, and the acidic acid was safely discarded. An acetolysis solution (8 parts acetic anhydride to 1 part sulfuric acid) was added to each of the tubes, the tubes were stirred, then placed in water baths at 99°C for 3 minutes. The tubes were transferred to cool water baths, 20°C for 3 minutes. This method results in better recovery of degraded pollen than longer treatments in hot solution. The tubes were again centrifuged and the acetolysis solution was safely discarded. The sediments were washed with glacial acidic acid and subsequently with distilled water until the supernatant was clear in each tube. Then microscope slides were prepared and examined at 400× magnification. Pollen types were identified

based on published keys and reference collections. An attempt was made to achieve a 200-grain count for every sample. However, if after counting three slides, it was obvious that obtaining a 200-grain count was impossible, counting was continued until 50 *Lycopodium* tracer spores were found. In this way, a consistent subsample was counted for each sample, even when 200-grain counts could not be achieved.

Mass Spectrometry Methods

Mass spectrometry is a type of instrument-aided analysis that can be used to investigate historical substances at the atomic level. It was conducted on the contents of two medicine bottles recovered from postcemetery contexts in the project area. Mass spectrometry measures the mass-to-charge ratio of charged ions in prepared samples and can be used to identify unknown compounds. In mass spectrometry, ions are charged through various means, and as the charged ions fluoresce, they give off a light spectrum that can be measured by the spectrometer. Compounds are identified because mass spectrometry measures the time the charged ions fluoresced during a scan. Each known ion has a unique signature based on the time it fluoresces during the scan and the light spectrum that is produced. This results in a "fingerprint" that can be compared against ions in a database of known chemical compounds to establish the identity of the fluoresced compounds.

There are currently a number of instruments and techniques that are used for mass spectrometry, three of which were used on samples from the project area. Gas chromatograph mass spectrometry is the most commonly used mass spectrometry technique. It works by vaporizing a sample in order to obtain a detectable spectrograph. Liquid chromatography techniques were also employed on the samples and are useful for the detection of water-soluble components. This technique moves the liquid sample through a column of stationary particles, and the compound is identified by the retention time, or the time it takes for the sample to move through the column. Fourier Transform mass spectrometry was the third type of mass spectrometry used. This method is a very accurate, high-resolution mass spectrometry technique that identifies charged ions by measuring their frequency within a fixed magnetic field (A. Somogyi, personal communication 2009). When used together, all three methods can effectively detect a wide range of components at different resolutions, providing a comprehensive understanding of the analyzed compound. The resulting data collected from historical-period archaeological sites is useful for artifact analysis because it gives archaeologists an idea of what substances have been recovered so that interpretations can be made as to their use. It also provides archaeologists an opportunity to learn what substances were available and used in the past.

Although the measurement of chemical compounds and unidentified substances with mass spectrometry is reliable and valuable for archaeologists, the technique does have some limitations that have implications for archaeological analogy. Some of these limitations are the result of postdepositional processes affecting the physical properties of archaeological materials, which are exposed to erosional forces leading to the natural deterioration of substances contained inside artifacts. Because chemicals in a mass spectrometry comparison database are evaluated as they exist in the present, the technique cannot account for the natural decomposition of chemical compounds over time. Additionally, identifying substances that are water soluble or subject to evaporation, such as opioids and alcohols, is difficult because erosion deteriorates these substances quickly (Schablitsky 2006:15).

Other limitations of mass spectrometry are related to the operation of the instruments and the financial costs of this type of analysis. In order to create a sample that can be read by a gas chromatograph mass spectrometer, samples of the historical-period substance must be created in the laboratory. These samples are primarily made by extracting the historical-period contents and mixing them with a solvent of some type, usually an organic compound such as dichloromethane (CH_2Cl_2) that is useful for volatile compounds or methanol (MeOH) for water soluble substances. Some mass spectrometry techniques destroy the tested samples. For instance, gas chromatograph mass spectrometry essentially vaporizes part of the sample in order to create a spectrum. This favors the identification of volatile compounds that fluoresce during the scan, meaning volatile substances are typically identified whereas other, less volatile chemicals or substances are not. Additionally, it does not always detect a host of residual chemicals that may be present at a lower density (A. Somogyi, personal communication 2009). Liquid chromatography and Fourier Transform mass spectrometry techniques can

detect a larger number of water-soluble chemical compounds, but the resulting data can be daunting. These techniques do not have the same limitations as gas chromatography spectrometry and are able to detect a larger number of chemical compounds, even those that are degraded, but the identification of so many chemicals from an unknown substance requires many hours of additional research. More than 500 chemical compounds were detected in one of the medicines recovered from the Joint Courts Complex project area. Many of these were probably environmental contaminants that infiltrated the bottle's contents. Analysis of this medicine was not fully completed because it would have required more than a month of research by multiple scientists to identify and separate all of the historical-period contents from environmental pollutants, isolate the botanical or natural sources of medicinal compounds, and research their pharmacological uses (A. Somogyi, personal communication 2009).

Although a number of sealed bottles containing liquids or solids were recovered from postcemetery contexts, the contents of two medicine bottles (artifact numbers 08000D1355 and 08000308F) were considered intact enough to be submitted for mass spectrometry analysis. This analysis was conducted by Dr. Arpad Somogyi, Director of the Mass Spectrometry Facility in the Department of Chemistry at the University of Arizona. The contents of the two bottles were subjected to rigorous testing that included analyzing the samples with three separate instruments. A more comprehensive reporting of the results can be found in Volume 3.

Culling and Curation

Because of the potential for recovering human remains throughout much of the project area and the contractual requirement for recovery of all human bone, it was necessary, with only a few exceptions, to excavate every postcemetery feature within the project area. This resulted in the recovery of tens of thousands of artifacts, and more postcemetery historical-period artifacts than could be analyzed. As described above, a sampling strategy was designed at the analytical level to ensure that sufficient data was collected about the postcemetery period that did not require the analysis of all recovered artifacts. Associated with the sampling strategy was a need to cull the postcemetery artifact assemblage for curation purposes. Culling decisions were made cautiously and carefully and were designed to ensure the retention of all diagnostic artifacts and samples of other artifacts that were deemed to have some additional interpretive value. Culled artifact classes included the following:

All indeterminate artifact fragments, regardless of material class

Nail-shaft fragments and unmodified wire

Can-body fragments

Undecorated glass-bottle or jar-body shards

Undecorated-ceramic-vessel body sherds

Window-glass shards

Nondiagnostic metal bars, rods, straps, bands, and pipes

Unmarked bricks

Construction materials, such as concrete, stone, mortar, and wood

Modern (post-1960) materials

Some oversize artifacts were culled from the curation collection, but first they were photographed and recorded. These included, among others, a water pump, large automotive parts, and prehistoric mortars or metates. A large quantity of pipes for the conveyance of water, gas, and sewage were removed from the site without being analyzed, along with most surficial construction debris.

Also culled were postcemetery artifacts that were recovered from disturbed contexts or were found as intrusions into grave shafts. However, artifacts useful for educational kits, museum exhibits, or type collections were retained. Additionally, the nonanalyzed artifact collections from sampled features were cherry-picked

prior to discard for artifacts that either were unique to the site and therefore worthy of analysis outside of the sampling strategy, or for artifacts that would be useful for educational purposes.

Locations of Curated Data

Raw data collected during fieldwork and analysis took a variety of forms; these reside either in SRID, in appendixes to this report series, or, in the case of 3-D laser scanning data, in the native output files that store the processed data (Table 11). All of these data are curated at the Arizona State Museum, where they can be accessed. The majority of data are found in SRID. Data stored in SRID consist principally of metric and nonmetric information related to artifact typologies and attributes; osteological analyses; provenience information, including in-field feature observations; and inventory tracking. Administrative information is also maintained through SRID, allowing for the preservation of links among different kinds of data.

Raw data in SRID is accessed through queries designed to organize and display the data in analytically useful ways; the output created by these queries present the data used in analysis. For example, queries displaying details of historical-period artifacts include corresponding feature and provenience information, so that artifacts and their attributes may be analyzed according to their discovery location.

Some data are housed outside of SRID. Specifically, the data used by outside contributors to this report appear in appendixes. For instance, raw data related to pollen analyses can be found in Appendix G. Similarly, data related to X-ray fluorescence spectroscopy appear in Appendix E of this report. As these data are not integrated into SRID, the reader is cautioned that some of the benefits of a relational data management structure are not immediately available for those data sets.

Finally, a set of highly specialized data is maintained separately in computer files. Skeletal remains from both in situ and laboratory contexts were documented using 3-D laser scanning, which produces extremely large data files. Noncontact laser scans were processed for 838 individuals in situ and for 826 skeletal elements or composite elements in the laboratory. These digital data exist as raw point clouds in RapidForm's proprietary file format (MDL) and as rendered models using the INUS compression format (ICF). A large amount of computer processing power is necessary to manipulate these data in their current format, but it is possible that in the future these data can be converted into 3-D PDF files that use less processing power and would be more widely accessible to researchers for analysis.

Summary

In summary, the Joint Courts Complex project allowed Statistical Research to use cutting-edge technology as a means to thoroughly document and analyze this large, complex, multicomponent site. From the use of sophisticated databases that linked the spatial and aspatial data in real-time applications, through the documentation of the burial features using advanced close-range photogrammetry and 3-D laser scanning, to the use of mass spectrometry to analyze the contents of medical bottles, our goal remained to provide the highest level of documentation and analysis as possible for this unique and important resource. The collection and interpretation of the contextual and osteological data required programmatic, paradigmatic, and procedural improvements to existing and established systems. Analyses were conducted using contemporary and current sources as references, and specialists were consulted as necessary to ensure the highest level of accuracy in our identifications. The combination of available technologies, strict principles of data collection, and relational data systems has provided the means to address defined research questions, as well as the apparatus to perform further explorations in the future.

Figure 3. Mechanically stripping the Joint Courts Complex project area using a specially designed backhoe blade, by Innovative Excavating, Inc., Tucson, Arizona.

Figure 4. Using a TEREX Powerscreen Mark II to recover artifacts and bones from the project area overburden.

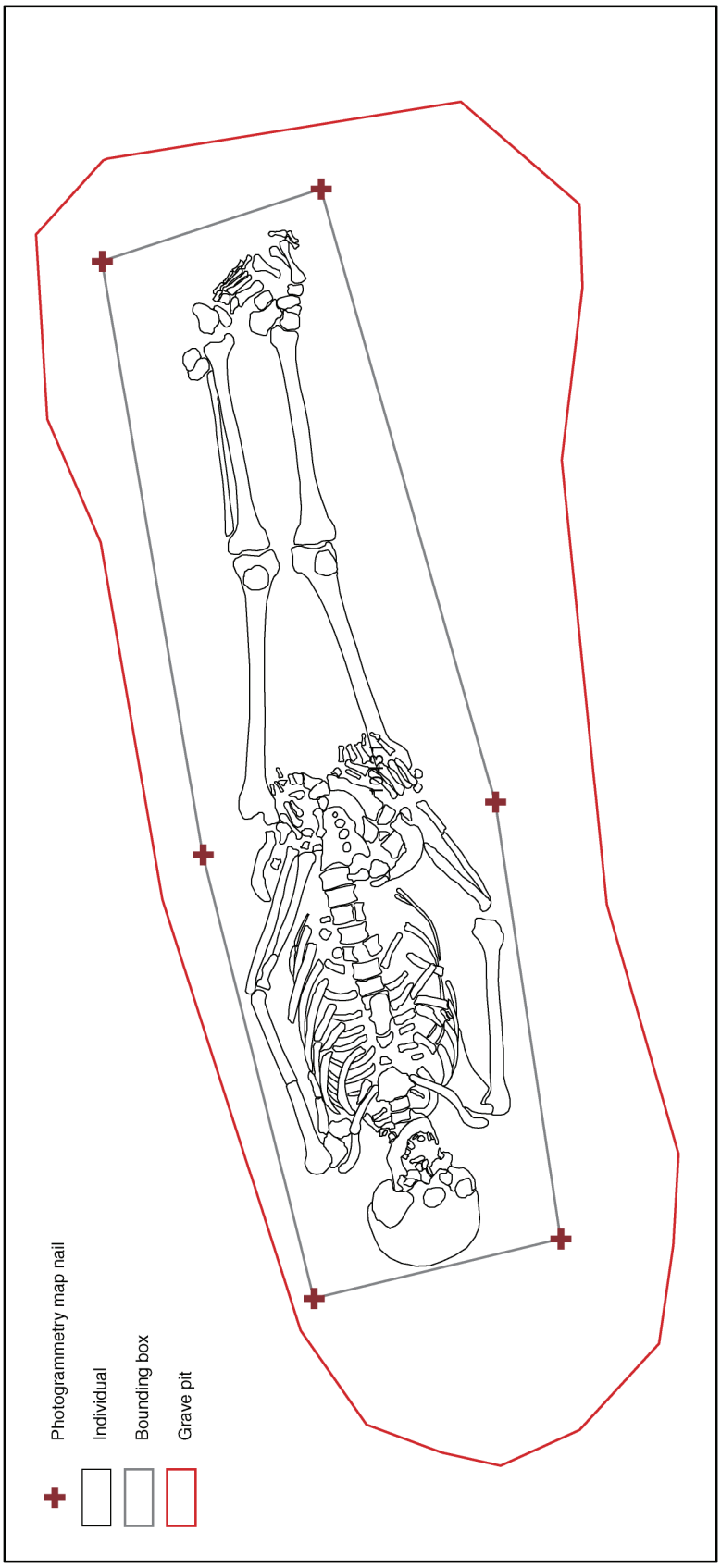

Figure 5. Mapping nails were used to assist in the rectification of photogrammetric images.

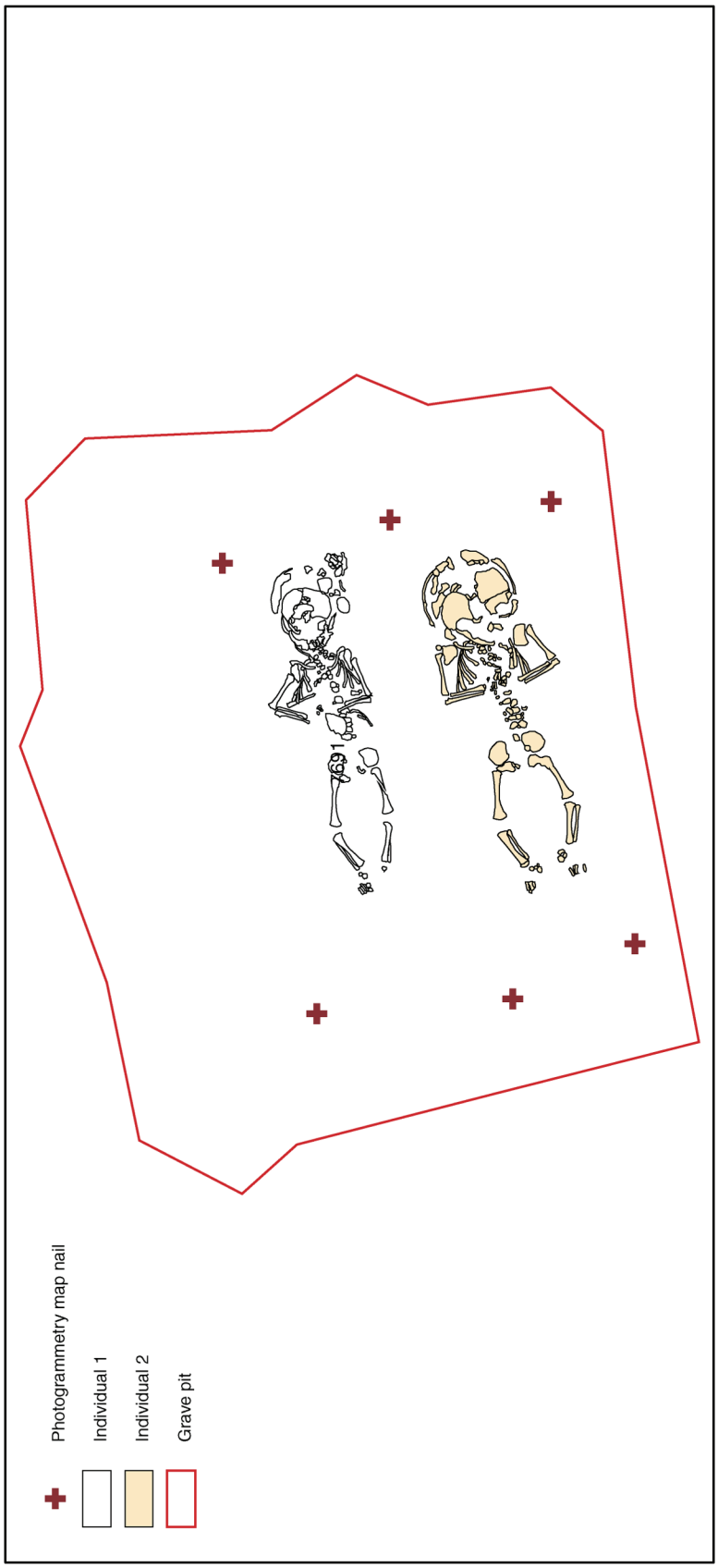

Figure 6. Mapping nails shared by two burials located side-by-side.

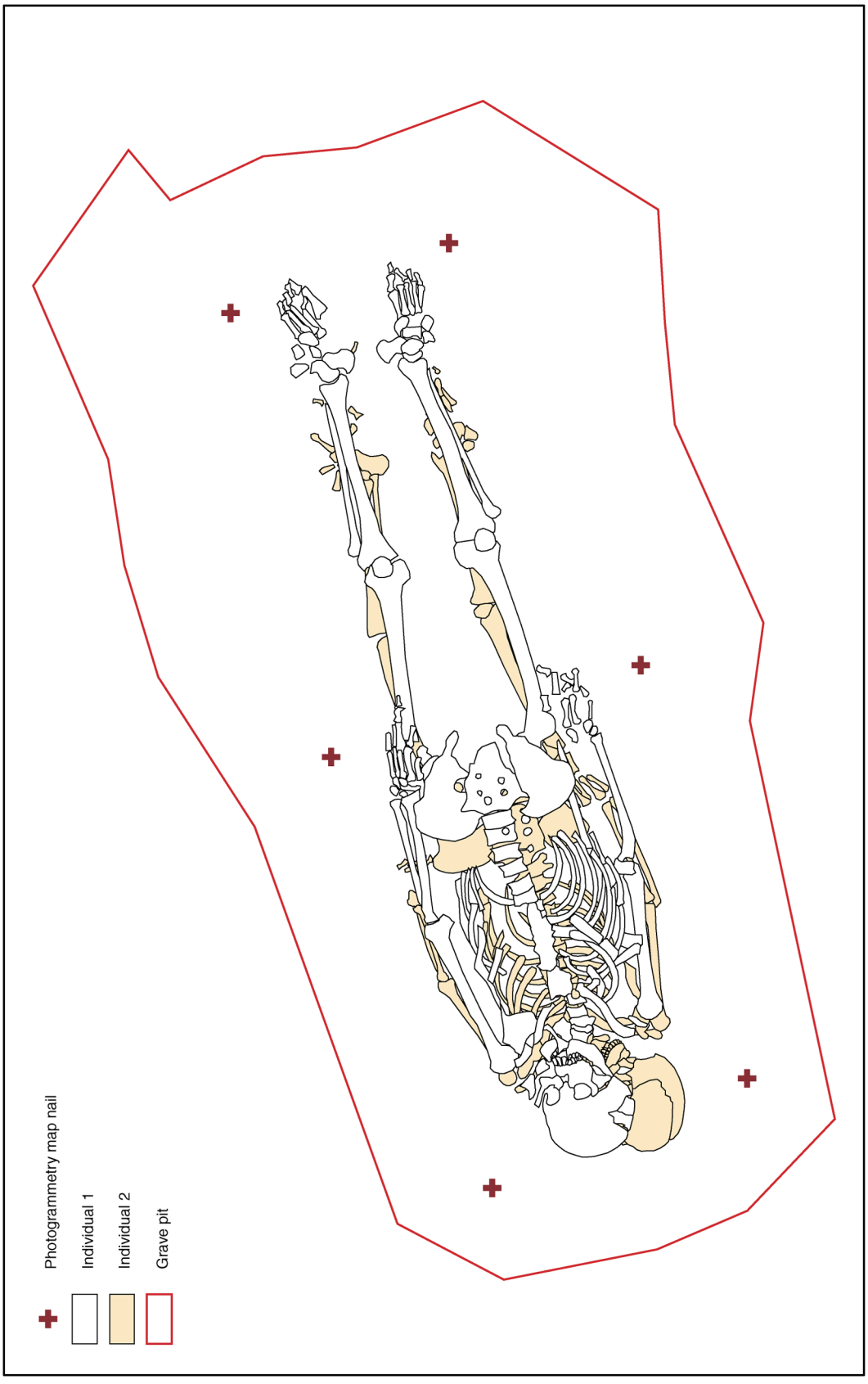

Figure 7. Mapping nails shared by stacked burials.

Figure 8. Grave Pit 13614, Burial 21829, Middle Adult Euroamerican Male: an example of a three-dimensional scanned image.

Figure 9. The MicroScribe G2 contact digitizing tool used to collect coordinate data in three dimensions. (Skull is an anatomic specimen purchased from a biological supply company. Photograph by Michael W. Warren, C. A. Pound Human Identification Laboratory, University of Florida, Gainesville.)

Figure 10. The Konica Minolta Vivid 910 freestanding, noncontact laser line scanner. (Skull is an anatomic specimen purchased from a biological supply company. Photograph courtesy of Mercyhurst Archaeological Institute; taken by Christina Fojas.)

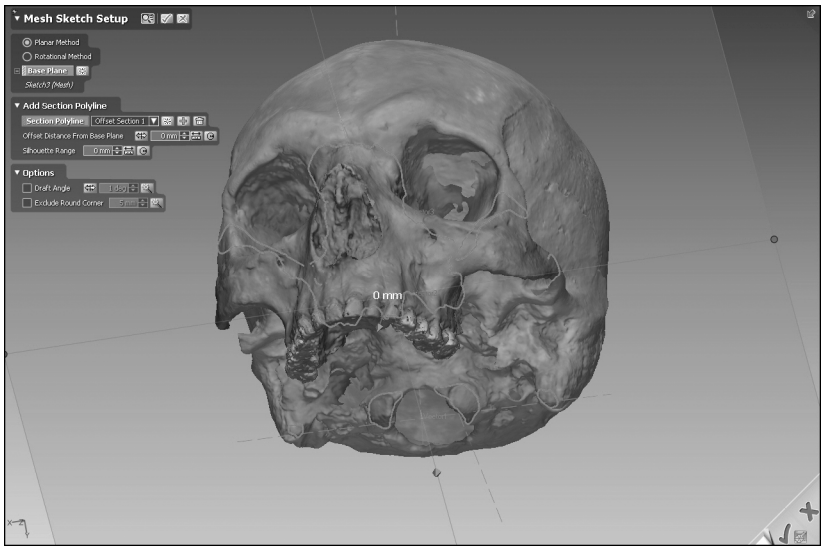

Figure 11. Rapidform XOR2 3-D mesh (showing an element from Individual P, Grave Pit 592, Burial 2595, a middle-adult Hispanic male).

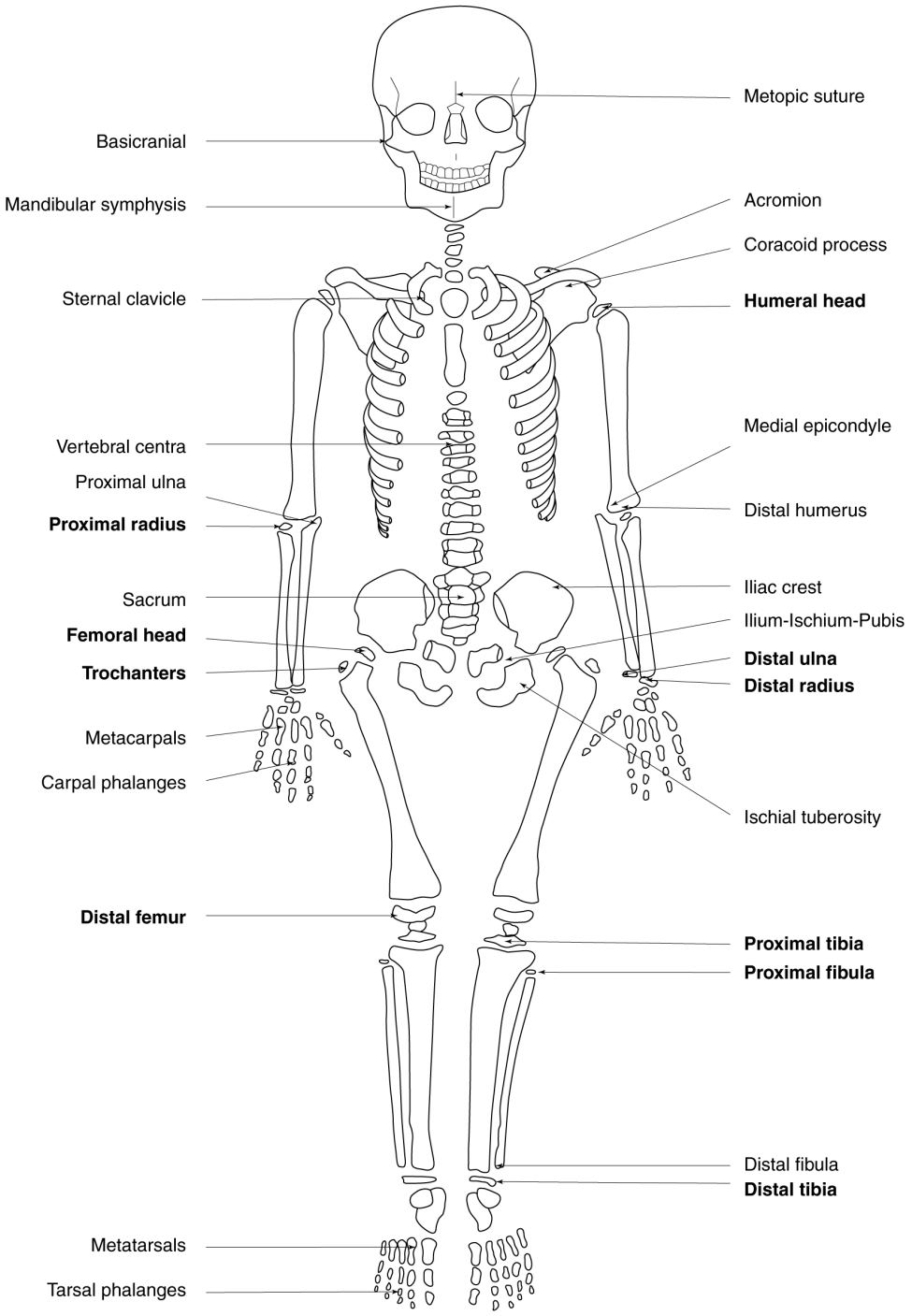

Figure 12. Elements and epiphyses used for juvenile age determination. Epiphyses are labeled in bold type.

Table 2. Composite Elements and Their Constituents

Composite Element	Constituent Elements[a]
Cranium	ethmoid, frontal, inferior nasal concha, lacrimal, maxilla, nasal, occipital, palatine, parietal, sphenoid, temporal, vomer, zygomatic
Cervical vertebrae	1st–7th cervical vertebra
Thoracic vertebrae	1st–12th thoracic vertebra
Lumbar vertebrae	1st–5th lumbar vertebra
Innominate	ilium, ischium, pubis
Carpals	capitate, hamate, lunate, pisiform, scaphoid, trapezium, trapezoid, triquetral
Metacarpals	1st–5th metacarpal
Tarsals	calcaneus, cuboid, intermediate cuneiform, lateral cuineiform, medial cuneiform, navicular, talus
Carpal phalanges proximal	1st–5th digit proximal carpal phalanx
Carpal phalanges middle	2nd–5th digit middle carpal phalanx
Carpal phalanges distal	1st–5th digit distal carpal phalanx
Tarsal phalanges proximal	1st–5th digit proximal tarsal phalanx
Tarsal phalanges middle	2nd–5th digit middle tarsal phalanx
Tarsal phalanges distal	1st–5th digit distal tarsal phalanx

[a] Side is excluded. Elements are listed in alphabetical or numerical order.

Table 3. Adult Age Attributes and Observations

Attribute	Observation[a]
Cranium	spheno-occipital synchondrosis
External cranial vault suture closure	anterior sagittal, bregma, inferior sphenotemporal, lambda, midcoronal, midlambdoid, obelion, pterion, sphenofrontal, superior sphenotemporal
Palatine suture closure	anterior median palatine, incisive suture, posterior median palatine, transverse palatine
Internal cranial vault suture closure	left coronal, left lambdoid, sagittal
Clavicle	sternal epiphysis
Innominate	auricular surface, iliac crest, Suchey-Brooks pubic symphysis, Todd pubic symphysis
Cervical vertebral annular epiphyses	inferior epiphysis, superior epiphysis
Thoracic vertebral annular epiphyses	inferior epiphysis, superior epiphysis
Lumbar vertebral annular epiphyses	inferior epiphysis, superior epiphysis
Sacrum	S1 to S2 fusion
Sternal rib ends	3rd–5th rib

[a] Observations are listed in alphabetical or numerical order.

Table 4. Sex-Assessment Characteristics

Element	Dimorphic Traits
Innominates	greater sciatic notch, ischiopubic ramus ridge, preauricular sulcus, subpubic concavity, ventral arc
Cranium	glabella, mastoid process, nuchal crest, supraorbital margin
Mandible	mental eminence

Note: Traits are listed in alphabetical order.

Table 5. Adult Craniometrics and Landmarks

Measurement	Abbreviation	Cranial Landmarks
Maximum cranial length	GOL	glabella–occipital
Maximum cranial breadth	XCB	euryon–euryon
Bizygomatic breadth	ZYB	zygion–zygion
Basion-bregma height	BBH	basion–bregma
Cranial base length	BNL	basion–nasion
Basion-prosthion length	BPL	basion–prosthion
Maxillo-alveolar breadth	MAB	ectomolare–ectomolare
Maxillo-alveolar length	MAL	prosthion–alveolon
Biauricular breadth	AUB	auriculare–auriculare
Upper facial height	NPH	nasion–prosthion
Minimum frontal breadth	WFB	frontotemportale–frontotemporale
Upper facial breadth	UFBR	frontomalare temporale–frontomalare temporale
Nasal height	NLH	nasion–nasospinale
Nasal breadth	NLB	alare–alare
Orbital breadth	OBB	dacryon–ectoconchion
Orbital height	OBH	vertical bisection of orbit perpendicular to orbital breadth
Biorbital breadth	EKB	ectoconchion–ectoconchion
Interorbital breadth	DKB	dacryon–dacryon
Frontal chord	FRC	nasion–bregma
Parietal chord	PAC	basion–lambda
Occipital chord	OCC	lambda–opisthion
Foramen magnum length	FOL	basion–opisthion
Foramen magnum breadth	FOB	points of most lateral curvature of the foramen magnum
Mastoid length	MDH	superior margin of external auditory meatus to most inferior extension of mastoid process
Chin height	GNI	infradentale–gnathion
Height of the mandibular body	HML	inferior margin of the alveolar process to inferior margin of the mandibular body at the mental foramen
Breadth of the mandibular body	TML	distance perpendicular to long axis of mandibular body, at the mental foramen
Bigonial width	GOG	gonion–gonion
Bicondylar breadth	CDL	distance between most lateral points on mandibular condyles
Minimum ramus breadth	WRB	minimum breadth of ascending ramus, perpendicular to ramus height
Maximum ramus breadth	XRB	distance from most anterior point on coronoid process to most posterior point on condyle
Maximum ramus height	XRH	gonion–most superior point on condyle
Mandibular length	MLT	distance from the most anterior point on the chin to most posterior point of the ascending rami
Mandibular angle	MAN	angle formed by the mandibular body and ascending ramus

Table 6. Epigenetic Traits

Observation	Observed on Infants
Metopic suture	no
Supraorbital notch	yes
Supraorbital foramen	yes
Infraorbital suture	yes
Multiple infraorbital foramina	yes
Zygomatico-facial foramina	yes
Parietal foramen	yes
Epipteric bone	yes
Coronal bone	yes
Bregmatic bone	yes
Sagittal ossicle	yes
Apical bone	yes
Lambdoid ossicle	yes
Asterionic bone	yes
Ossicle in occipito-mastoid suture	yes
Parietal notch bone	yes
Inca bone	yes
Condylar canal	no
Divided hypoglossal canal	yes
Flexure of superior sagittal sulcus	yes
Foramen ovale incomplete	yes
Foramen spinosum incomplete	yes
Pterygo-spinous bridge	no
Pterygo-alar bridge	no
Tympanic dehiscence	no
Auditory exostosis	no
Mastoid foramen location	yes
Mastoid foramen number	yes
Mental foramen	yes
Mandibular torus	no
Mylohyoid bridge location	no
Mylohyoid bridge degree	no
Atlas bridging lateral	yes
Atlas bridging posterior	yes
Accessory transverse foramina in 7th cervical vertebra	yes
Septal aperture	no
Os japanicum	no

Table 7. Morphoscopic Traits

Observation	Observed on Infants
Keeling	no
Post-bregmatic depression	no
Inion hook	no
Venous markings (frontal)	no
Suture complexity	no
Inferior projection of zygomatic/maxilla	no
Zygomatic posterior tubercle	no
Nasal aperture	yes
Nasal depression	no
Nasal spine	yes
Palatine torus	no
Palatine suture	no
Dental arcade	no
Chin shape	no
Mandible lower border	yes

Table 8. Degenerative Joint Disease Joints and Elements

Joint	Elements
Temporomandibular joint	mandible, occipital
Shoulder	clavicle, humerus, scapula
Fingers	distal carpal phalanges, middle carpal phalanges, proximal carpal phalanges
Toes	distal tarsal phalanges, middle tarsal phalanges, proximal tarsal phalanges
Knee	femur, fibula, patella, tibia
Elbow	humerus, radius, ulna
Wrist	carpals, metacarpals, radius, ulna
Hip	femur, innominate
Ankle	calcaneus, fibula , metatarsals, tarsals, tibia
Neck	cervical vertebrae
Trunk	thoracic vertebrae
Lower back	lumbar vertebrae

Note: Elements are listed in alphabetical order.

Table 9. Degenerative Joint Disease Scores

Score	Description
a	normal articular surface
b	appearance of small deposits of bone on articular margins
c	small pits
d	polishing/eburnation
e	other (describe in notes)

Table 10. Individual Attributes and Descriptions

Individual Attributes	Description
Age determination	Synthesized estimation of age at death of the individual based on compiled skeletal age indicators.
Sex determination	Synthesized estimation of sex of the individual based on compiled skeletal sex indicators.
Pathology	Discussion of systemic pathological conditions or compilation of independent elemental conditions.
Morphological variation	Discussion of atypical or remarkable morphological expression independent of pathology or developmental defect.
Behavioral indicator	Discussion of skeletal markers of behavior or occupational stress.
Taphonomy	Description of taphonomic alterations to the remains.
Metrics notes	Metadata concerning cranial or postcranial measurements, including any important notations or comments.
Individual summary	Paragraphical discussion of the individual, summarizing all individual attributes.
DJD notes	Comments relating to the degenerative joint disease for the individual, including metadata and observations beyond the scope of standard DJD data entry.
Trauma notes	Notes for trauma observed on more than one element, suggesting a pattern of injuries, or further description of trauma affecting the individual.
Epigenetics notes	Description of epigenetic metadata, characteristics, or attributes not sufficiently captured by standard epigenetics scores.
Biological group	Description of the determined biological affinity for an individual based on the method of determination, the particular group to which it belongs, a statistical assessment of the confidence level, and a categorical statement of likelihood.
Stature summary	The calculated stature minimum and maximum for the individual, as well as the elements and formulae employed, the selected prediction interval, and the corresponding ranges for each calculation.
Skeletal observer	Identification of the observer responsible for the skeletal examination, or responsible for the greatest portion of the examination.
Skeletal completeness notes	Remarks or comments related to the inventory of completeness elements for the individual.

Table 11. Locations of Curated Data

Data Type	Location of Raw Data
Provenience	SRID (vupProveniencesJCC)
Artifact inventory	SRID (vupInventoryJCC)
Feature type	SRID (vupFeatureTypeSummaries)
Grave-pit feature attributes	SRID (vFeatureGravePitExcavation)
Feature-to-feature relationships	SRID (qryFeatureToFeatureRelationships)
Cemetery areas and grid locations	SRID (vCemeteryAreasByFeature)
Ceramic	SRID (vupInventoryJCC)
Faunal	SRID (vupInventoryJCC; vupFaunalFlattenedFields)
Lithic	SRID (vupInventoryJCC, qryBase_Lithics)
Historic	SRID (vupInventoryJCC, vupHistoricBaseInventory)
Macrobotanical	SRID (vupInventoryJCC)
Pollen	SRID (vupInventoryJCC) Appendix G, this volume
Shell	SRID (vupInventoryJCC; vupFaunalFlattenedFields)
Individual attributes	SRID (vupOsteoIndividualBioProfileByArea)
Indiviual skeletal inventory	SRID (vupOsteoElementCreationSummary)
Adult craniometrics	SRID (vupOsteoIndividualMetrics_AdultCranio)
Juvenile craniometrics	SRID (vupOsteoIndividualMetrics_JuvenileCranio)
Adult postcranial metrics	SRID (vupOsteoIndividualMetrics_AdultPostcranial)
Juvenile postcranial metrics	SRID (vupOsteoIndividualMetrics_JuvenilePostcranial)
Adult age	SRID (vupOsteoIndividualMetrics_AdultAge)
Juvenile age	SRID (vupOsteoIndividualMetrics_JuvenileAge)
Dental morphology	SRID (vupOsteoDentition_Morphology)
Adult sex	SRID (vupOsteoIndividualMetrics_Sex)
Degenerative joint disease	SRID (vupOsteoIndividualDjdByJoint)
Osteophytosis	SRID (vupOsteoIndividualOsteophytosis)
Pathology	SRID (qryOsteoElementPathologies)
Epigenetics/discrete traits	SRID (vupOsteoIndividualEpigenetics)
XRF	Appendix E, this volume

CHAPTER 3

Environmental Setting and Its Influence on the Preservation Potential of Historical-Period Burials and Features

Jason D. Windingstad and John D. Hall

Introduction

This chapter presents the environmental context of the Joint Courts Complex project and its influence on the archaeological record. The first section deals with the general physical setting of the project area and includes discussion of soils, geomorphology, hydrology, vegetation, climate, paleoenvironment, and fauna. The discussion is oriented toward the physical setting during time periods associated with more-intensive human occupation (the middle Holocene through the historical period). The second section of the chapter discusses the taphonomic effects of soil chemical and physical properties on historical-period burials and features. These properties include soil pH, available phosphorus, calcium-carbonate content, particle size, and soil-water characteristics. Although some discussion of postcemetery privy features is presented, the primary focus of the chapter is on the cemetery context, as this was the primary focus of the data recovery efforts. Specific questions concerning how the soil chemical environment surrounding burials and the permeability of the site strata resulted in the preservation of human bone are addressed. This section also addresses specific questions concerning the overall geomorphic processes contributing to the stratigraphy of the project area and the relative ages of the site strata.

Environmental Setting

The following section focuses on the general environmental setting of the Joint Courts Complex project area and includes information on physiography, geology, soils, geomorphology, climate, paleoenvironment, vegetation, fauna, and hydrology. Discussion of how climate, hydrology, and vegetation have changed through time and may have influenced prehistoric and historical-period occupation in the Tucson area is also presented.

Basin and Range

The Tucson Basin is an externally drained structural trough typical of the Southern Basin and Range geologic province. The Southern Basin and Range province is bordered on the north-northeast by the Transition Zone (the physiographic region in Arizona and western New Mexico that separates the Colorado Plateau from the Basin and Range) and on the west by the Mojave Desert and lies almost entirely within Arizona and Sonora, Mexico (Damon et al. 1984). The province is characterized by north-northwest-/south-southeast-trending, discontinuous mountain ranges separated by intermontane structural basins (Morrison 1985). In the eastern Southern Basin and Range province, mountain summits reach elevations of 1,600–3,265 m above mean sea level, and in the west, near the Colorado River, elevations range from 900 to 2,520 m above mean sea level.

The present topography of the Basin and Range province is attributed to deformation in the middle Miocene (12 mya) that marks a transition from andesitic volcanism and thrust faulting to widespread high-angle block faulting, during which large, crustal blocks moved vertically without rotation (Damon et al. 1984). This period of normal faulting resulted in the formation of the basins that separate the numerous mountain ranges in southern Arizona. The newly created basins became major depositional centers for sediment derived from the surrounding highlands via alluvial fans. Deep drilling within many of these basins has revealed basin-fill deposits over 3,000 m (9,840 feet) thick (Damon et al. 1984). Basins were originally internally drained (no through-flowing streams), with external drainage developing as basin-fill elevations exceeded the lowest basin divides (Damon et al. 1984).

Tucson Basin

The Tucson Basin covers a 2,590-km^2 (1,000-square-mile) area bound by the Santa Catalina Mountains on the north, the Rincon and Tanque Verde mountains on the east, the Tucson Mountains on the west, and the Sierrita, Santa Rita, and Whetstone Mountains on the south (Davidson 1973). Erosion since the late Miocene (11 mya) has resulted in extensive piedmont surfaces at the bases of these ranges. The basin is externally drained by the north-northwest-flowing Santa Cruz River and its major tributaries: Rillito River, Tanque Verde Wash, Pantano Wash, and the Cañada del Oro wash. These drainages have formed a gentle northwest-sloping plain with an elevation of 884 m above mean sea level in the south and 610 m above mean sea level at the northwest outlet (Davidson 1973).

Climate

The Tucson Basin is semiarid, with long, hot summers and warm winters. From May through September, summer temperatures commonly exceed 100°F. Between 1951 and 1975, an average of 41 days each year had maximum temperatures over 100°F, with June and July having 14 such days apiece (Sellers and Hill 1974). Mean diurnal temperature changes are about 30°F, and daily shifts of 40° are common. Precipitation is seasonal, with summer and winter rainy seasons separated by short dry periods. The average annual rainfall recorded at the Tucson airport between 1948 and 1970 was 10.98 inches (Sellers and Hill 1974). Based on a 30-year moving average, the annual precipitation is approximately 12 inches. More than 50 percent of the annual precipitation falls between July 1 and September 15, in brief, localized, but heavy, convective storms. Approximately 20 percent of the annual precipitation falls between December and March, during less-intense low-pressure and cyclonic storms originating from the Pacific Ocean (Gelderman 1972).

Winter rains fall as a result of migrating low-pressure systems and low-pressure troughs associated with the southward-shifting jet stream. These systems bring in dark cloud fronts with generally low-intensity precipitation that may last for several days. By contrast, summer monsoons consist of moist winds from the Pacific Ocean and/or the Gulf of California that flow inland to fill the partial vacuum created by the warm continental air mass that rises over the mountains (Ingram 2000). The Pacific High shifts northward to around 40° in latitude by late summer/early fall, allowing moist air from off the coast of Baja, California, to move into Arizona. Summer rains come in the form of violent thunderstorms that may drop more than half the annual rainfall in a single event. The rainy seasons are separated by periods of pronounced aridity, with the driest months being February, May, and June.

The growing season in the Tucson Basin averages 264 days, with the first frost typically occurring in mid- to late November. From 1948 to 1970, the minimum daily temperature usually fell below 32°F on 20 days between November and March. The highest recorded temperature between 1894 and 2007 was 117°F (June 26, 1990), and the lowest was 6° (January 7, 1913) (Western Regional Climate Center n.d.). Precipitation and temperature vary with elevation, with the surrounding mountains receiving as much as 35–40 inches annually (Gelderman 1972). The daily minimum temperature along the Santa Cruz River near downtown Tucson is slightly cooler, compared to more-elevated locations nearby, as a result of cold-air drainage along the channel. Historic weather data for Tucson indicated that the average daily minimum between 1941 and 1970 was 52.8°F at the University of Arizona weather station (elevation 745 m above mean sea level), and at the Tucson

airport (elevation 788 m above mean sea level), the average daily minimum was 54.1°F (Sellers and Hill 1974). The drainage of cold air along waterways results in a shorter growing season and an increase in the number of days in which the temperature falls below freezing.

The earliest climatological data in the Tucson area comes from nearby Fort Lowell. Originally called Camp Lowell (established in 1866), the fort was relocated in 1873, because of malaria outbreaks approximately 7 miles northeast of Tucson, and renamed Fort Lowell. Records of precipitation were kept from 1873 to 1890 and subsequently reported in the *Monthly Weather Review* (Sellers et al. 1985) (Table 12). The data were incomplete for some years (1873, 1881, and 1883–1888) but indicated that periods of increased precipitation (more than 15 inches of annual precipitation) occurred in 1876, 1889, and 1890. Storm reports in the *Monthly Weather Review* indicated intense summer storms were as common then as they are now:

> At Tucson, Arizona Territory, [July 11] 4:45 to 6:30 p.m., heavy thunder and rain-storms; 4:45 p.m. lowest barometric reading this year; total rainfall 5.10 in; damage to the town estimated at from $25,000 to $40,000; buildings completely ruined; west of town one vast lake; arroyos north of town resembled huge rivers. Throughout Arizona TY, from 12th to 14th, very heavy thunderstorms, accompanied by heavy rain and water spouts; houses unroofed and fences blown down. At Agua Fria twenty-seven telegraph poles reduced to fragments. At Phoenix, office struck and portion of battery destroyed. Monthly Weather Report July 1878 [Brazel and Evans 1984].

The U.S. Weather Bureau took over record-keeping responsibilities in July of 1891, and a nearly complete record of daily temperature and precipitation for Tucson is available from 1894 to the present (Sellers et al. 1985). Although annual precipitation can be highly variable over short distances because of the dominant influence of spatially localized thunderstorms on the yearly rainfall total, 5–30-year moving averages can still provide an indication of wet and dry periods. Plots of annual precipitation for Tucson from 1894 to 2005 indicated drought years in which 5 inches or less of precipitation fell (Figure 13) (Western Regional Climate Center n.d.). Drought years occurred in 1894, 1924, 1947, and 1997. Wetter years, in which more than 17 inches of annual precipitation fell, occurred in 1905, 1914, 1919, 1978, 1983, and 1984 (see Figure 13). The longest period of continued drought occurred between 1942 and 1957 across much of the Southwest. The 5-year moving average for Tucson fell below 10 inches of annual precipitation between 1946 and 1955 (see Figure 13). Climate records for Tucson also indicated that the highest annual temperature (the average of the monthly mean temperature) on record from 1894 to 2005 occurred in 1997, with a mean temperature of 75.62°F, and the coolest year was 1898, with an average temperature of 64.71°F (Figure 14). Over the last century, the mean annual temperature has steadily increased in the Tucson Basin (see Figure 14).

Contemporary Vegetation

Vegetation in the Tucson Basin is primarily associated with the Lower Sonoran Life Zone (Lowe 1964:24). The major plant community of this life zone is the creosote-bursage community. This community is found mostly in areas lacking reliable water sources. Creosotebush (*Larrea tridentata*) is the dominant species, but a variety of cacti, including the saguaro (*Carnegia gigantea*), prickly pear, and barrel cactus, abound in this community, especially on higher terraces and piedmont surfaces above floodplains. Major shifts in plant communities occur with increasing elevation above the basin floor, in the surrounding mountain ranges. These various communities would have provided prehistoric period and early-historical-period occupants with a wide variety of resources within a relatively short distance (Gregonis and Huckell 1980:8–10).

Dense riparian communities along the Santa Cruz River and its tributaries have largely been lost over the last century, although riparian areas are preserved along short segments of some drainages, such as along the Tanque Verde Wash in the eastern Tucson Basin. These areas provided critical habitat for many animal and plant species that would otherwise not have been able to survive in this desert environment. This riparian corridor is dominated by cottonwood trees (*Populus fremontii*) and broad mesquite (*Prosopis juliflora*) bosques. Seep willow (*Baccharis salicifolia*), hackberry (*Celtis pallida*), and desert willow (*Chilopsis linearis*) are other major constituents of this ecologically important plant community. Much of this riparian community is likely

to have been present while the cemetery was in use, but later-historical-period land clearing, wood gathering, and erosion have eliminated most of these plant communities in the Tucson Basin. In addition, exotic plant species, such as tamarisk (*Tamarix* sp.), have replaced many of the native riparian plants.

Fauna

The animals that inhabited the project area prior to urban development would have been typical of the desert-adapted species found in the Lower Sonoran Life Zone. Although the focus of this discussion is on vertebrates, several arthropods are worth mentioning, particularly those that can be harmful to humans. These include species of the Arachnida class, such as the bark scorpion (*Centruroides exilicauda*), the black widow spider (*Latrodectus hesperus*), and the brown spider commonly referred to as the brown recluse (*Loxosceles* spp.). Although these species are fairly common in the Sonoran Desert, very few human deaths are actually associated with their bites/stings.

Birds are probably among the most-frequently observed animals in the Sonoran Desert. Familiar Sonoran species include the cactus wren (*Campylorhynchus brunneicapillus*), canyon wren (*Catherpes mexicanus*), phainopepla (*Phainopepla nitens*), mourning dove *(Zenaida macroura*), white-winged dove (*Zenaida asiatica*), Gambel's quail (*Callipepla gambelii*), mockingbird (*Mimus polyglottos*), curve-billed thrasher (*Toxostoma curvirostre*), turkey vulture (*Cathartes aura*), red-tailed hawk (*Buteo jamaicensis*), American kestrel (*Falco sparverius*), roadrunner (*Geococcyx californianus*), common raven (*Corvus corax*), and white-crowned sparrow (*Zonotrichia leucophrys*). Species less frequently observed because of their nocturnal habits include the Western screech-owl (*Otus kennicottii*), great horned owl (*Bubo virginianus*), Ferruginous pygmy-owl (*Glaucidium brasilianum*), elf owl (*Micrathene whitneyi*), burrowing owl (*Athene cunicularia*), lesser nighthawk (*Chordeiles acutipennis*), and common poorwill (*Phalaenoptilus nuttallii)* (Phillips and Comus 2000). Reaches of the Santa Cruz River that historically had perennial flow supported a diverse community of birds that included water birds, such as the Great Blue Heron (*Ardea herodias*).

Common mammalian species of the Lower Sonoran Life Zone include the desert cottontail (*Sylvilagus audubonii)* and the black-tailed (*Lepus californicus*) and antelope (*L. alleni*) jackrabbits. The antelope jackrabbit is most abundant in areas dominated by burroweed, mesquite, and cholla, and the small desert cottontail (*Sylvilagus audubonii*) is probably the most-frequently seen rabbit. Larger mammals in the area historically include the mule deer (*Odocoileus hemionus*), the javelina (*Pecari tajacu*), and the coyote (*Canis latrans*). Less frequently spotted are the gray (*Urocyon cinereoargenteus*) and kit (*Vulpes macrotis*) foxes (mostly nocturnal). Though rarely seen, the common and widely distributed bobcat (*Felis rufus*) and the elusive mountain lion (*Felis concolor*) are both highly adapted predators and important participants in the Sonoran Desert ecosystem. Rodent species include the packrat (*Neotoma albigula),* Harris ground squirrel (*Ammospermophilus harrisii*), kangaroo rat (*Dipodomys* spp.), pocket mouse (*Perognathus* spp.), and deer mouse (*Peromyscus* spp.). A rodent species not typically associated with the desert is the beaver (*Castor canadensis*), but historical accounts of beaver on both the Santa Cruz and the San Pedro Rivers do exist (Logan 2002).

Reptiles, particularly lizards, are abundant in the region. Common species include the whiptail (*Cnemidophorus* spp.), horned (*Phrynosoma* spp.), side-blotched (*Uta stansburiana*), and zebra-tailed (*Callisaurus draconoides*) lizards. The Gila monster (*Heloderma suspectum*) is venomous, but this reptile is so slow and sluggish that bites are extremely rare. Snakes that are potentially dangerous to humans include the western diamondback (*Crotalus atrox*) and Mohave (*Crotalus scutulatus*) rattlesnakes.

Prior to channel adjustment and historical-period disturbance of the Santa Cruz River, several species of fish may have been present, including low-desert fishes that are currently endangered, such as the Gila topminnow (*Poeciliopsis occidentalis*) and the desert pupfish (*Cyprinodon macularius*) (Phillips and Comus 2000).

Historical-Period Hydrology of the Santa Cruz River

The Santa Cruz River is the major drainage that defines the Tucson Basin. The river, in total, drains 22,215 km^2 (8,581 square miles) in southeastern Arizona and northern Sonora, Mexico (Parker 1995:1). It flows northward through the Tucson Basin, fanning out to the Santa Cruz Flats north of Tucson and eventually entering the Gila River in the Phoenix Basin. The Joint Courts Complex project area is approximately 1 km east of the river as it flows immediately west of modern downtown Tucson. Over time, the Santa Cruz River

has undergone numerous alluvial cycles of aggradation (deposition), stability, and erosion. These cycles are generally punctuated by relatively short periods of erosion and arroyo formation followed by longer periods of stability and pedogenesis, or soil formation (Nials and Gregory 2004). The most recent of these cycles began in the late-nineteenth century, dramatically expressed as a deeply entrenched arroyo that began to form in 1871 in the San Xavier reach, south of Tucson. The geomorphic history of the Santa Cruz River since the early Holocene is discussed in greater detail in the Paleoenvironment section of this chapter.

Historically, the Santa Cruz River has undergone major shifts in stream morphology as a result of anthropogenic disturbance and climatic forcing mechanisms. Prior to 1871, the Santa Cruz River was characterized by a shallow, narrow channel with an active floodplain consisting of low ridge-and-swale topography (Parker 1995). *Cienegas* (wetlands) fed by perennial flow were located near the base of Sentinel Peak (A-Mountain) west of downtown Tucson, at the northern end of the Tucson Mountains, and on the San Xavier Indian Reservation south of Tucson (Betancourt and Turner 1990; Freeman 2000; Logan 2002; Parker 1995). Arroyo formation began with the development of headcuts that first appeared in 1871 in the San Xavier area and later in the late 1880s in Tucson (Parker 1995). Headcuts in the Tucson area began as a result of poorly engineered waterworks and high flows associated with summer floods in 1890 (Parker 1993). In the winter of 1914–15, floods resulted in major channel widening and the destruction of the bridge on Congress Street in Tucson. Headcut extension and channel incision as deep as 30 feet below the pre-1890 floodplain continued well into the twentieth century (Parker 1995). Throughout the rest of the twentieth century and into the twenty-first century, the channel of the Santa Cruz River has widened through lateral migration within the arroyo, and its overall length has decreased as a result of avulsions (sudden lateral shifts in which a new channel is formed, primarily occurring when the channel is incapable of carrying all the water and sediment supplied to it) and meander cutoffs (Parker 1993, 1995). Human alteration of the channel through bank armoring and channel filling has created artificial stability within the Tucson reach. Smith (1938:78) observed that, in the Tucson area, "years of moderate to low rain fall causes ephemeral streams to aggrade, while in years of high rainfall, stream channels are deepened and widened." The formation of the incised channel within the Santa Cruz River coincided with arroyo formation across the southwestern United States in the late-nineteenth century, the causes of which are still debated (human caused versus climatically induced) (Bull 1997). Destruction of the riparian zones through land clearing, overgrazing, and wood harvesting undoubtedly played a role in the degradation of the Santa Cruz River over time.

Paleoenvironment (The Last 8,000 Years in Southern Arizona and the Tucson Basin)

After 8,000 years B.P., climatic and vegetational regimes similar to those of the present had largely been established across the Southwest. Although the Holocene is generally characterized as a warm, interglacial period, some climatic deviations took place and are recorded in alluvial, tree-ring, and fossil-pollen records. A warm period from approximately 7,000 to 4,500 years B.P. was originally identified in the Great Basin by Antevs (1962) as the Altithermal. The term Altithermal, itself, suggests a dry and warm period, though atmospheric circulation patterns that result in dry conditions in the Great Basin (characterized by winter precipitation) are unlikely to produce the same result in the eastern Sonoran Desert (Van Devender and Spaulding 1979). This was evident in the fossil-pollen record of the Murray Springs (San Pedro River) and Double Adobe (Whitewater Draw) sites, where the pollen data indicated a period of greater effective moisture and a shift in vegetational zones, downward in elevation, by 300 m (Martin 1970; Mehringer et al. 1967). It is believed that areas characterized by summer monsoons actually had increased summer rainfall as a result of warmer global temperatures that favored the development of the Bermuda High (Van Devender and Spaulding 1979). However, the lacustrine record of Lake Cochise in the Willcox Playa indicated that a lake was not present during the Altithermal from 7,000 to 5,000 years B.P. and did not fill again until the end of this period (5,000–4,000 years B.P.) (Waters 1989). These combined data suggest that the middle Holocene in southern Arizona was characterized by a

warm, dry period from 7,000 to 5,000 years B.P., with a continued monsoonal rain pattern, followed by a period of increased moisture from 5,000 to 4,000 years B.P.

The cycles of erosion, deposition, and stability on the Santa Cruz River in the Tucson Basin are related both to climate and to internal geomorphic thresholds (local stream gradient, fire, and human activity) (Nials 2007). Within the San Xavier reach of the Santa Cruz River, the Holocene alluvial sequence was dominated by aggradation (deposition and accumulation of sediment) within a braided stream until about 8,000 years B.P. The gravels of this braided stream were overlain with a *cienega* clay deposit, indicating a high water table and a more-mesic climate (Spaulding and Graumlich 1986). The Santa Cruz River at that time was characterized by a wide floodplain without a deeply incised channel, at a grade that was 8 m below the current floodplain. From 8,000 to 5,500 years B.P., a major episode of channel widening and erosion took place, forming an erosional unconformity, the alluvial record of which has been almost completely erased. This period of erosion closely correlates with the Altithermal. During this time, water tables would have been low and vegetative cover reduced. These conditions promoted channel incision because there was little vegetation to slow run-off, and the dry, coarse alluvium could be easily eroded. The Santa Cruz River at that time would have been characterized by a wide, incised channel that was increasing in width as a result of lateral migration (Waters 1988a and b). Periods of floodplain stability in the Tucson Basin took place around 4,900 and 4,000 years B.P. (Nials 2007). During times of stability, *cienegas* are more abundant across the floodplain, particularly near reach boundaries (Nials 2007). One of these boundaries lies near the Joint Courts Complex site, at the base of A-Mountain. Water tables are high at this reach terminus because of the presence of a hydraulic barrier (bedrock).

By 4,000 years B.P., modern plant communities associated with the Sonoran Desert had been established. This period, termed the Medithermal (4,500 years B.P. to the present), was characterized by climatic conditions similar to those of the present, although some fluctuations are known to have occurred. Paleoflood chronologies spanning the last 5,000 years, developed from alluvial records on rivers in Arizona and southern Utah, indicated that floods group into distinct time periods (Ely 1997). High-magnitude floods were recorded from 5,000 to 3,600 years B.P. (dendrocalibrated age 3,800–2,200 B.C.), between 1,100 and 900 years B.P., and again after 500 years B.P. These periods of high-intensity flooding were related to an increase in winter northern Pacific frontal storms and Pacific tropical cyclones. These storms increase in frequency when the deep midlatitude troughs steer storm systems toward the southwest. This change in storm tracks is strongly correlated to the frequency of El Niño events (an abnormal warming of surface ocean waters in the eastern tropical Pacific, part of what is called the Southern Oscillation) over the last 3,000 years (Ely 1997). Reconstructions of cool-season precipitation from tree-ring chronologies in south-southeastern Arizona have also been compiled, revealing a climate record that spans the last 1,000 years (Ni et al. 2002). The tree-ring chronology indicated that the driest 10-year periods since A.D. 1000 occurred in 1085–1094, 1245–1254, 1437–1446, 1662–1671, and 1776–1785. This is in addition to long-sustained droughts in the mid-1100s, between 1570 and 1597 (the Great Drought), and in the late 1800s (Swetnam and Betancourt 1998). The wettest 10-year periods took place in 1195–1204, 1331–1340, 1613–1622, 1808–1817, and 1837–1846 (CLAMIS paleoclimatic research project). Several extreme precipitation reversals occurred at the beginning of the twelfth, seventeenth, and nineteenth centuries. These reversals were linked to equatorial Pacific sea-surface-temperature anomalies associated with the El Niño Southern Oscillation (Ni et al. 2002).

The Santa Cruz River in the Tucson Basin continued its cycle of erosion, deposition, and stability during the late Holocene. Arroyo formation (channel incision) in the San Xavier reach took place around 4,000, 2,500, 2,000, 1,000, and 500 years B.P. and again in the late-nineteenth to early-twentieth century (Waters and Haynes 2001). Water tables were apparently high during periods of stability, as they were marked by *cienega* clay deposits. During these stable periods, floodplains would have experienced the reestablishment of the riparian plant communities that likely declined during periods of arroyo formation. From a cultural perspective, the revitalization of the riparian corridor would have provided additional resources and created opportunities for water-table or floodwater farming. Channel incision around 1,000 and 500 years B.P. was closely correlated to periods of extreme flooding of rivers across Arizona, wet periods in the tree-ring chronology, and the El Niño Southern Oscillation. Channel and floodplain erosion would have been pronounced when a wet event followed a period of drought. Periods of drought would have lowered water tables and reduced the vegetation that protects the valley floors from erosion (Waters and Haynes 2001).

Geomorphic Implications for Prehistoric Groups

The cycle of erosion inherent to the Santa Cruz River over the last 4,000 years had several important consequences for prehistoric period cultural groups that occupied the area near the Joint Courts Complex. Periods of channel incision associated with increases in strength and frequency of flooding events are known to have occurred in the San Xavier reach around 4,000, 2,500, 2,000, 1,000, and 500 years B.P. and in the Tucson area around 4,900, 4,000–3,500, 1,850, and 1000 years B.P. (Ely 1997; Nials 2007; Waters 1988a and b). Prehistoric people were generally not discouraged from using and reusing floodplain sites during periods of more-intense flooding, as settlement location is often a product of cultural-formation processes dictated by the population's understanding of local stream activity (Turnbaugh 1978). However, periods of intense flooding would have undoubtedly forced floodplain occupants to relocate to other landscape positions, at least for short periods of time. Episodes of intense flooding between 4,000 and 2,000 years B.P. may have forced some Late Archaic period groups to occupy nearby higher terraces or *bajadas*. Arroyo formation would have had more-serious implications for prehistoric period agricultural societies. Intense floods that damaged irrigation structures and channel entrenchment would have made floodplain farming a much more difficult endeavor (Waters 1988a and b). Channel incision around 1,000 years B.P. took place in many rivers across southern Arizona (the Gila, Santa Cruz, and San Pedro Rivers and Tonto Creek) and corresponds with the abandonment of many large Hohokam villages (Waters and Ravesloot 2001). Conversely, following the early periods of aggradation and during episodes of stability, floodwaters could spread out across the floodplain (water is not confined to a deeply incised channel), expanding the spatial extent of arable land. Floodwaters also contributed inputs of fresh organic matter and deposited finer-grained sediments, enhancing both the fertility and the water-holding capacity of floodplain soils. Also, *cienegas* and riparian areas expanded at these times, providing additional potential resources. Floodplain stability during the early agricultural period in the Tucson Basin segment (between 3,500 and 1,850 years B.P.) is believed to have promoted the adoption of agriculture by providing a riverine environment that supported mixed economies composed of agricultural subsistence augmented by the collection of readily available wild resources (Diehl 1998; Freeman 2000; Wöcherl 2007).

Surficial Geology

Late Quaternary terrace deposits within the Tucson Basin form a thin (10–20-m) veneer that overlies older early Pleistocene basin fill, referred to as the Fort Lowell Formation (McKittrick 1988). The underlying Fort Lowell Formation is composed of a gravel to clayey silt that correlates to early to middle Pleistocene deposits in the San Pedro Valley and the Safford basin, according to magnetostratigraphic-polarity measurements and fossil fauna (Anderson 1987; Davidson 1973). The terrace surfaces in the Tucson Basin are essentially strath terraces (formed as a result of a stream cutting into older valley-fill deposits, also called erosional terraces) cut into the Fort Lowell Formation (McKittrick 1988). Downcutting of the major drainages has resulted in the formation of three Pleistocene terraces and associated piedmont surfaces within the basin (Figure 15). Given that incision was the dominant process throughout the Quaternary, terrace surfaces become progressively younger with decreasing elevation above contemporary channel elevations. Relative dates for the Pleistocene surfaces were obtained through comparison of elevation differences between terrace treads, degrees of rounding on interfluves, scarp sinuosity, and degrees of soil formation (Jackson 1989; McKittrick 1988). Two Holocene terraces along the major drainages within the basin have also been mapped. These terraces have been described in Table 13.

Soils

The degree of postdepositional weathering processes (soil formation) and degradation occurring on the stabilized terrace surfaces is generally a function of the time that has elapsed since stabilization ensued. Older terraces have more-advanced stages of soil development and alteration of their surface topography through localized processes, such as sheetwash, aeolian deposition, infilling of swales, and gully formation along scarps. Pedogenic features most often associated with advanced stages of soil formation include translocation of clay-sized particles into subsurface horizons, horizon thickening, and rubification (development of redder hues associated with the release of iron from the soil parent material). In arid to semiarid environments, the accumulation of secondary carbonates is a major diagnostic feature indicative of the relative age of the associated landforms.

Carbonates accumulate within calcic soils as a result of increased partial pressure (an increase in concentration) of carbon dioxide within the soil environment from biotic processes (10–100 times the partial pressure of carbon dioxide in the atmosphere), increases in soil pH, and high soil ionic concentrations (Birkeland 1999). Carbonates and calcium ions within soils that have developed in noncalcareous parent materials are associated with influxes of atmospheric dust (Gile et al. 1981). Dust-trap data from Las Cruces, New Mexico, suggest that atmospheric carbonates accumulate at a rate of $0.2–0.4 \times 10^4$ g/cm^2 per year (Gile et al. 1981). These factors, combined with limited leaching processes in arid climates, result in the accumulation of carbonates at some depth within the soil.

Soil chronosequence studies in the arid to semiarid Southwest have determined that the buildup of carbonates from a pedogenic origin is related to soil age (Gile et al. 1981). Pedogenic carbonate development has been divided into Stages I–VI and adjusted for gravelly and nongravelly soils. The time required to reach a specific developmental stage is highly dependent upon soil texture, annual precipitation, slope position/aspect, groundwater levels, and rates of dust influx. Stage I is the weakest expression of observable carbonates as thin, discontinuous threads, filaments, and faint coatings on rock fragments or ped faces. In the semiarid climate of southern California, McFadden (1982) determined that Stage I development occurred within 7,000 years. Huckleberry (1997) suggested that Stage I development can be found in late Holocene (<4 ka) soils in the Tucson Basin. Faint carbonate development, however, has also been observed in soils that are less than 100 years in age (Gile et al. 1981). Stage II development has carbonate segregations separated by low-carbonate material, along with few to common nodules. Stage II development is associated with soils that date to the early Holocene to late Pleistocene (8,000–15,000 years B.P.) (Birkeland 1999). In the Tucson Basin, Stage II development can be found in early Holocene soils (Huckleberry 1997). Stage III accumulation consists of essentially continuous plugged horizons with many nodules and fillings. This level of accumulation is associated with late to middle Pleistocene landforms that date to between 25,000 and 400,000 years in age. Finally, Stage IV development consists of cemented laminar horizons overlying plugged horizons. Stage IV accumulation is found in landforms that are middle Pleistocene in age or older (Birkeland 1999; Gile et al. 1981). Machette (1985) added two more stages (Stages V and VI) to indurated calcic soils, focusing on laminae thickness and the presence of multiple generations of laminae formation and pisoliths (subangular to spherical bodies, with many thin layers of carbonate).

Soils in and near the Joint Courts Complex project area are classified within the aridisol or entisol soil order (Gelderman 1972). Aridisols are dry over half the time during most years and are never moist for 90 or more consecutive days (Soil Survey Staff 2003) (see Table 13). According to the U.S. Department of Agriculture soil-classification system, soils classified as aridisols must have diagnostic subsurface horizons, such as an argillic, cambic, nitric, or calcic B horizon. Currently, aridisols and gelisols (permafrost within 2 m of the soil surface) are the only two soil orders defined based on climate. Because aridisols have some type of diagnostic subsurface horizon (e.g., Bw, Bt, Bk, By, Bz, Bq, etc.), this soil order is typically associated with landforms that have been stable since at least the middle Holocene (Huckleberry 1997). The rate of Holocene soil formation in arid environments is generally considered to have been slow, compared to the rate in more humid, temperate regions (Birkeland 1999; Huckleberry 1997). Incipient B (cambic-Bw) horizons in the humid southeastern U.S. can form in less than 1,000 years, whereas cambic horizons in the arid Southwest may take many millennia to form (Foss et al. 1995; Huckleberry 1997).

Aridisols in the Joint Courts Complex project area are classified to the great-group level as Petrocalcids and are mapped as the Cave soil series (Gelderman 1972; Soil Survey Staff n.d.) (Figure 16; see Table 13). This soil developed in the middle to late Pleistocene alluvial deposits of the terrace known as the Cemetery Terrace (T4) (McKittrick 1988), "so named for the Tucson city cemeteries that are present on this terrace" (Smith 1938:58). Petrocalcids are aridisols with a petrocalcic horizon and an upper boundary within 100 cm of the soil surface (Soil Survey Staff 2003). Outside and adjacent to the project area on the late Pleistocene to early Holocene T3 (Jaynes Terrace) surface, soils are classified as Haplocambids in the Yaqui soil series (Gelderman 1972). These are aridisols with incipient subsurface B (Bw) horizons and little to no accumulation of pedogenic carbonate.

Entisols are classified based on their lack of subsurface-horizon development and consist of simple A–C horizonation, although this order may also have an albic horizon (E horizon). These soils have developed in recently deposited sediments, exceedingly dry or wet land surfaces, or inert parent materials (quartz sand) (Buol et al. 2003). Entisols of the Tucson Basin have formed in recent sandy (Torripsamments) or more-loamy (Torrifluvents) alluvial deposits of washes and floodplains. These deposits are generally considered to be recent or middle to late Holocene in age (Huckleberry 1997).

Near the Joint Courts Complex project area, entisols are located on the Holocene T2 surface of the Santa Cruz River (see Figure 15 and Table 13). These soils are classified as Torrifluvents of the Grabe and Glendale soil series (Gelderman 1972; Soil Survey Staff n.d). Torrifluvents are entisols with textures finer than fine loamy sand; they have an irregular decrease in organic carbon with increasing depth caused by periodic flood deposits (Buol et al. 2003). The T2 alluvium is highly stratified and represents alluvial deposition throughout the middle to late Holocene. Other entisols near the project area include Torrifluvents with greater sand contents and are mapped as the Anthony and Comoro soil series (Soil Survey Staff n.d) (see Figure 16 and Table 13). The Comoro series represents the modern floodplain of the Santa Cruz River (T1), and the Anthony series is associated with washes and recent fan surfaces (Soil Survey Staff n.d).

From a prehistoric period land-use perspective, the most-productive soils are those of the Grabe and Glendale soil series. These floodplain soils have thick, organic-rich, fine-textured surface horizons with high water-holding capacities. Coarse-textured floodplain soils with lower water-holding capacities include the Comoro and Anthony series. Based on the modern crop-yield estimates from the Pima County soil survey, the soil-fertility ranking, from highest to lowest, is Grabe, Glendale, Comoro, and Anthony (Gelderman 1972). Water would have been the most critical factor in this arid environment, but floodwater and irrigation farming could have been successfully implemented on these floodplain soils. Many prehistoric period agricultural sites are associated with the low-terrace (T2) Grabe, Glendale, and Anthony soil series along the Santa Cruz River. These include AZ AA:12:111 (ASM) (Las Capas), AZ AA:12:91 (ASM) (Los Pozos), AZ AA:12:746 (ASM) (Santa Cruz Bend), AZ AA:12:503 (ASM) (Costello-King site), and AZ AA:12:90 (ASM) (Wetlands site) (Wöcherl 2007).

Although soils formed on higher terraces may have, in some instances, been relatively fertile, they would have had serious limitations for agricultural use. Irrigation on these landforms would have been extremely difficult, because they lie at a considerable elevation above the floodplain (over 3 m), and floodwaters rarely inundate even the lowest of these terraces (T3, Jaynes Terrace). Additionally, runoff systems (*Ak chin* or alluvial-fan-floodwater systems) would not have been feasible on these low-gradient surfaces. Adjacent *bajadas* and small alluvial fans along terrace scarps would have been more suitable for this type of runoff farming.

Relative Age of Site Stratigraphy and the Influence of Soil Chemical/Physical Properties on Preservation Potential

The second portion of this chapter addresses questions concerning the age of the site stratigraphy and the influence of soil properties on the preservation potential of human bone from cemetery contexts, as well as organic

materials recovered from historical-period privies. Specifically, the following questions are addressed: (1) When did the terrace on which the Joint Courts Complex project area lies form, and how old are the strata into which prehistoric period and historical-period features intrude? (2) How did the chemical and physical properties of the natural soils in the project area contribute to the preservation of human bone, and how do these properties vary across the project area? (3) How did the chemical composition of privy deposits contribute to the preservation of paper? (4) Does the permeability of the Btk (Stratum II) horizon influence the percolation of historical-period privies or the preservation of human bone? (5) Do the current soil conditions in the project area accurately represent conditions that existed when the cemetery was in use?

Geochemical and Physical Analysis: pH, Phosphorus, and Particle Size

This section outlines the analytical background for the geochemical and physical methods used in the study on preservation potential that is to follow. The most-critical aspects of the soil environment in determining the fate of organic remains and the inorganic mineral structure of human bone include soil pH, temperature, moisture content, natural concentrations of specific elements (e.g., phosphorus and calcium), and soil-water characteristics. A secondary, independent factor is the length of time the organic materials have been interred and subjected to soil environmental conditions.

Soil pH

Soil pH is often regarded as the most-influential variable because of its role in many chemical reactions and processes that take place within the soil environment (Sparks 2003). Although pH is of considerable importance in the field of soil fertility, it is also critical to archaeologists, because it strongly influences the potential of the soil matrix to preserve cultural materials and remains (Gordon and Buikstra 1981). The concept of pH is derived from the ion product of water, which slightly dissociates at 25°C:

$$H_20^+ \leftrightarrow H^+ + OH^-$$

$$Kw = [H^+][OH^-] = 1 \times 10^{-14}$$

When $[H^+]$ and $[OH^-]$ are equal, each has a concentration of $(10^{-14})^{1/2}$ or 10^{-7}. Thus, pH is defined as the negative logarithm to base 10 of the hydrogen-ion concentration (or activity).

$$pH = 1/\log[H^+] \text{ or } -\log[H^+]$$

The pH of pure water is then –log of 1×10^{-7}, or 7 (neutral). Based on this, any solution with a pH below 7 is considered to be acidic (H^+ dominates), and solutions above 7 are considered basic (OH^- dominates) (Sparks 2003). Consequently, pH is also an indirect measure of the hydroxide-ion activity, because the product of $[H^+] \times [OH^-]$ must equal 10^{-14}. At pH = 5, the $[OH^-]$ is 10^{-9} ($10^{-5} \times 10^{-9} = 10^{-14}$).

Essentially, soils act as both a buffer and a reserve for hydrogen ions. Contributions of hydrogen ions in soils originate from several main sources, including carbonic acid, acids from biological metabolism (organic acids), the accumulation of organic matter (acid functional groups), oxidation of nitrogen and sulfur (nitric and sulfuric acids), and acid precipitation (Brady and Weil 2002). Carbonic acid is a main contributor of hydrogen ions in most soils, as this weak acid is formed when carbon dioxide from root respiration and decomposition of organic matter dissolves in water.

$$CO_2 + H_2O \rightarrow H_2CO_3 + HCO_3^- \leftrightarrow H^+$$

This chemical reaction dominates because the partial pressure of carbon dioxide in many soils is 10–100 times that of the atmosphere, as carbon dioxide is trapped within pores and voids in the soil. This has the affect of driving the above chemical reaction to the right, producing hydrogen ions. Within the calcic soils of the southwest, however, calcium carbonate acts as a buffer in the following reactions:

$$CaCO_3 + H^+ + HCO_3 \leftrightarrow Ca(HCO_3)_2$$

$$Ca(HCO_3)_2 + 2H_2O \leftrightarrow Ca^{2+} + 2OH^-$$

This reaction tends to maintain soil pH values in calcareous soils at between 7 and 8.4. In soils dominated by calcium carbonate, the pH cannot rise above 8.4, because once the soil solution becomes saturated with calcium ions, the above reaction proceeds to the left, producing hydrogen ions and the formation of carbonic acid, thereby lowering the pH. If other carbonate minerals more soluble than calcium carbonate dominate (e.g., sodium carbonate), pH levels will exceed 8.4, because these carbonates continue to be soluble above a pH of 8.4. This will have the effect of driving the equation to the right, consuming hydrogen ions and increasing the pH. The above reactions are of considerable importance to the preservation potential of organic remains (e.g., bone) in alkaline soils and will be discussed further in the Preservation Potential section.

Phosphorus

Anthropogenic additions, or the enrichment of phosphorus in soils, originate from burials, waste, refuse, animal husbandry, and fertilizer additions (Holliday and Gartner 2007). Once added to the soil, phosphorus is quickly immobilized across a broad pH range, making it a sensitive indicator of human occupation and occupational intensity in many soil types (Terry et al. 2000). A large number of chemical methods have been developed to measure the various forms of soil phosphorus, and some of these have been adopted with some success by archaeologists. Many of these methods were originally implemented in biogeochemical contexts to extract readily soluble forms of phosphorus (inorganic phosphorus) as a test of their availability for plant uptake within a given growing season (Kuo 1996; Mehlich 1978, 1984). These methods utilize various extractants composed of unbuffered salt solutions, dilute concentrations of weak acids or strong acids, buffered alkaline solutions, or simply water to solubilize inorganic phosphates (calcium phosphate, aluminum phosphate, and iron phosphate) (Kuo 1996:890). The liberated phosphorus can then be measured through colorimetric methods. The extractant used is dependent upon natural soil-pH conditions, because alkaline soils will effectively neutralize acid extractants, therefore reducing their effectiveness to extract available phosphorus. Because such a wide variety of methods have been developed to extract various forms of soil phosphorus, a tremendous amount of data has been generated, in both soil science and archaeology. Unfortunately, this situation, combined with the relatively complex nature of soil phosphorus, has led to inappropriate conclusions and inaccurate use of terminology in much of the archaeological literature (Holliday and Gartner 2007).

Archaeological applications of soil-phosphorus analysis have been used primarily to delineate the boundaries of sites prior to excavation (Eidt 1984; Terry et al. 2000), to examine the anthropogenic effects of agriculture on soil quality (Homburg et al. 2005; Sandor and Eash 1995), and to make interpretations regarding activity areas or features (Vizaíno et al. 1999; Schuldenrein 1995). Within these studies, soil-phosphorus levels that exceed natural background-phosphorus concentrations are interpreted as representing enrichment through cultural activities. This "P signal" is usually strong because natural phosphorus levels are low in most soils, with typical total-phosphorus concentrations ranging from 200 to 5,000 mg/kg. A small fraction of this total is available for plant growth at any given time, however, with high available-phosphorus levels ranging from 20 to 30 mg/kg (many soils in Arizona range from 5 to 15 mg/kg) (Hendricks 1985; Kuo 1996). It is noteworthy that anthropogenic influences on soils do not always result in elevated concentrations of soil phosphorus. Certain agricultural practices may, in fact, lower the natural background-phosphorus levels, as soil phosphorus is removed from the system by crop uptake and harvest (or grazing from domesticated animals) and not

replenished through the application of fertilizers. The pattern of soil phosphorus on archaeological sites stems mainly from the removal, transport, and reapplication of phosphorus through cultural activities and is generally a reliable indicator of such processes (Bethel and Máté 1989:9).

Native-phosphorus concentrations are also of interest, because phosphorus can influence the solubility of inhumed human bone. The primary mineral constituent of human bone is hydroxyapatite [$Ca_5(PO_4)_3OH$]. When bone is placed in the soil environment, the concentration of phosphate in the bone will attempt to attain equilibrium with the phosphate concentrations in the surrounding substrate. If natural-phosphorus concentrations are low, phosphorus will leach from the bone, further destabilizing the bone structure and making it more susceptible to weathering.

Particle-Size Analysis

Soil texture greatly influences soil-water characteristics (drainage) and many soil chemical properties, such as pH, as well as the soil's ability to retain basic cations (positively charged ions), such as calcium, potassium, sodium, and magnesium. Particle-size analysis also reveals the textural changes that exist between horizons (or site strata), providing information on how soil water moves, both vertically and horizontally, across the study area.

The overall percentages of sand, silt, and clay used to calculate the particle-size classes are based on the U.S. Department of Agriculture particle-size system, whereas the cumulative plot is based on the Wentworth scale. The differences between these size classes exist within the very fine sand and coarse silt size fractions. In the Wentworth size class, sand-sized particles range from 0.0625 to 2.00 mm, whereas, in the U.S. Department of Agriculture system, sand ranges from 0.05 to 2.00 mm. The Udden-Wentworth scale is most often used by sedimentologists because it is a geometric scale. That is, each value in the scale is twice as large as the preceding value as the scale increases (Boggs 1987:80). This scale can also be easily converted to the phi scale, which facilitates graphical plotting and statistical analysis of grain-size data. The phi scale is simply the $-\log_2$ of the particle diameter (Boggs 1987).

Methods

Field Methods

A large pit-profile wall in the Joint Courts Complex project area was troweled, photographed with a digital camera, and described using standard soil descriptions (Schoeneberger et al. 2002; Soil Survey Staff 1993). Field descriptions included the following: depth below the surface, horizon designation, moist and dry Munsell color, texture and gravel content, structure, coatings, roots, consistence, redoximorphic features, reaction when treated with 10 percent hydrochloric acid, pedogenic carbonate accumulation, and horizon boundary. Pedogenic features, such as the presence or absence of well-defined clay coatings, the degree of structural development, pedogenic carbonate accumulation, rubification, and solum thickness (Birkeland 1999; Huckleberry 1997), were used to estimate the approximate age of the soil. The C horizon designations were used to define sedimentary deposits that lacked evidence of pedogenesis.

Sampling Methods

Bulk soil and sediment samples were collected by horizon/stratum from the profile wall. Soil and sediment was collected from the entire depth of each horizon/stratum to ensure that a representative sample was obtained. In addition, during site excavations, bulk soil samples were collected from privy features and grave pits for geochemical analysis.

Laboratory Methods

Geochemical analyses of the natural soils and anthropogenic sediments within the Joint Courts Complex project area were conducted to evaluate the potential for preservation of archaeological materials and to detect chemical signatures that may be indicative of human behavior associated with historical-period privies. Bulk samples were air-dried and passed through a No. 10 (2-mm-opening) sieve prior to analysis. Soil-pH measurements were conducted in accordance with Method 4C1a2a1 in the U.S. Department of Agriculture–Natural Resource Conservation Service soil-survey laboratory-methods manual (Soil Survey Staff 2004). Soil pH was measured within a 1:1 soil/water slurry to measure the active acidity (hydrogen-ion activity in solution). Extractable phosphorus was measured using the Mehlich 2 extraction solution and quantitatively analyzed with the portable Hach spectrophotometer DR-890. Standard phosphorus solutions with known concentrations were produced, and the absorbance was measured using the Hach colorimeter. Absorbance was then measured for the bulk samples, and extractable-phosphorus concentrations were calculated using the standard curve. It is important to note that, in the alkaline soils of the Joint Courts Complex project area, the Mehlich 2 extractant produced lower amounts of available phosphorus, because higher hydroxide-ion concentrations neutralized the acid. Therefore, within this study, phosphorus levels were extractable-phosphorus, rather than available-phosphorus, concentrations.

Results

Stratigraphy of the Joint Courts Complex Site Area (Stratum Descriptions)

As stated in the treatment plan (Beck et al. 2006:16), the goal of the mechanical excavations was to uncover features in each stripping unit, excavate those features, then continue excavating until "sterile soil" was encountered. This procedure was strictly adhered to during excavation of the project area, and the use of the term *sterile* became synonymous with Stratum II, the layer with strong calcium-carbonate accumulations (Figure 17). For our purposes, *sterile* refers to culturally sterile, meaning that no additional cultural features or remains are expected to exist within or beneath the stratum. Deep excavations, such as the privy excavations in Locus C, allowed archaeologists the opportunity to investigate the buried sediments on the site. The excavations for Privies 3041 and 3042 extended about 9 m below the surface of the site, revealing significant changes in deposition over time. A rough stratigraphic profile was developed over the course of the project, and the following are summaries of the different strata that were encountered (see Figure 17). These strata were numbered sequentially, down from the surface, in the order that they were encountered during excavation.

Stratum I consisted of a possible residual Ap horizon that had been highly disturbed and truncated by historical-period and modern activities (Table 14). This stratum included the "disturbed overburden," which consisted of homogenous silt containing historical-period construction debris and features. Stratum I was approximately 10–50 cm thick (surface to 50 cm below). During the course of the project, this stratum was removed mechanically and sieved through the power screen to recover displaced human remains.

Stratum II was a Btk horizon that consisted of a light-brown (7.5YR 6/4 moist) loam (<10 percent gravel) with Stage III+ calcium-carbonate development (see Table 14). In the Rio Grande Valley of New Mexico, soils with Stage III carbonate accumulation were associated with middle to late Pleistocene (75,000–400,000 years) geomorphic surfaces (Gile et al. 1981). Carbonate morphology in Stratum II can be described as nearly continuous masses with common nodules and internodular fillings. Much of the horizon was weakly to moderately cemented, and many pores were plugged with carbonate. No cultural material existed that was coeval with Stratum II, and it was considered to be a culturally sterile deposit, though almost all cultural features were intrusive into Stratum II deposits. Stratum II had strong coarse subangular blocky to prismatic structure with a very rigid consistence (dry) and common fine tubular pores. The fine-grained texture of Stratum II indicated lower-energy floodplain deposition. The translocation of clay-sized particles also contributed to the

higher clay content of this stratum. Stratum II extended from the surface to about 100 cm below the surface (Figure 18).

Stratum III (2Bk and 2C1 horizons) consisted of a light-reddish-brown (5YR 6/4 moist), stratified, extremely gravelly loamy sand to sandy loam in a slight fining-upward sequence (see Table 14). This soil horizon was distinguished from the overlying Btk (Stratum II) based on a lack of translocated clay and a pronounced increase in gravel. Some pockets of slightly finer sands had developed moderate medium subangular blocky structure; otherwise, there was an overall lack of structural development (massive). The 2Bk horizon had Stage III calcium-carbonate accumulation, with common spherical to irregular masses and filaments with some discontinuous cementation. The 2Bk horizon had an abrupt smooth boundary with the underlying 2C1 horizon. The color and texture of the 2C1 horizon was similar to the overlying 2Bkm (slightly coarser grained with larger gravels), but no pedogenic carbonates were present. At the base of Stratum III, a darker, laterally continuous, 1–3-cm-thick, dark-grayish-brown (10YR 2/2 moist), oxidized manganese lens lay at the contact between the Stratum III gravels and the underlying silt loam deposits of Stratum IV. Stratum III represented high-energy fluvial deposition in a channel environment. The base of the deposit was identified in Locus C during the deep privy excavation.

Stratum IV (3Ckm3 and 3Ck4 horizons) consisted of reddish-yellow (7.5YR 5/6–6/6 moist) fine sandy loam to silt loam with common calcium-carbonate masses and nodules with massive structure (see Table 14). The 3Ckm3 horizon, from 223 to 261 cm below the surface, was weakly to moderately cemented by groundwater carbonates, and the 3Ck4 horizon had horizontal calcium-carbonate masses/bands separated by matrix with lower carbonate content. Common, distinct, irregular, very-dark-brown (10YR 2/2 moist) manganese masses were also present in the lower 3Ck4 horizon. The abrupt upper boundary with Stratum III identified during the deep Locus C privy excavation was discontinuous. Stratum IV continued to a depth of 400 cm below the surface. This stratum represented low-energy floodplain deposition.

Stratum V consisted of a reddish-yellow (7.5YR 6/6 moist) fine sandy loam underlying Stratum IV, with a strong to undulating upper boundary (as observed during the deep Locus C privy excavation). Stratum V was loosely to moderately compact, with no visible calcium carbonate. No other inclusions or larger clasts were observed. The base of this deposit continued beyond 400 cm below the surface and was not identified.

Particle-Size Analysis

Particle-size analysis of Strata II–IV revealed several lithostratigraphic discontinuities due to changing depositional environments during the time when the Cemetery Terrace was the active floodplain of the Santa Cruz River. Stratum II was the most archaeologically significant stratum, because most of the cultural features intruded into this deposit. Particle-size analysis of this stratum revealed that it consisted of 41 percent sand, 35 percent silt, and 24 percent clay—a "loam" in the U.S. Department of Agriculture textural-classification system. Cumulative particle-size plots (Figure 19) of this stratum show the uniform distribution of sand- and silt-sized particles, with no dominant size fraction. The geometric mean of this stratum was 21 microns, or within the coarse-silt size fraction of the Wentworth scale. Some clay in this stratum has been inherited from the overlying Ap horizon through pedogenic processes (Table 15).

The boundary between Strata II and III represented a lithologic discontinuity—that is, a distinct shift in grain size that resulted from a change in depositional environments. The matrix of Stratum III consisted of 70–84 percent sand, 11–19 percent silt, and 4–12 percent clay (see Table 15), which is loamy sand to sandy loam in texture. Gravel content within this stratum was greater than 60 percent by volume. The geometric mean of Stratum III ranged from 127 to 317 microns (very fine sand to medium sand, Wentworth scale) (see Table 15). Sediments of this stratum also contained many round to subround gneiss and quartz gravels in a horizontal to subhorizontal orientation, with some bedding features still evident (including pebble runs) (see Table 14). Stratum III represented a high-energy gravelly sand facies in a near-channel or channel environment. The base of this stratum consisted of a thin lens (>3 cm) of very gravelly loamy sand containing many very dark-brown (10YR 2/2 moist) manganese and reddish-yellow (7.5YR 6/8 moist) iron masses. These postdepositional

features were the result of fluctuating groundwater levels and will be discussed in greater detail in the section on the hydrology of the project area.

The boundary between Strata III and IV, at 223 cm below the surface, represented another lithologic discontinuity (see Figure 19). Stratum IV sediments were composed of fine sandy loams with 52–56 percent sand, 27–34 percent silt, and 14–17 percent clay (see Table 15). This stratum had very little gravel and had an increase in clay- to silt-sized particles and a decrease in grain size within the sand-sized fraction (see Figure 19). The geometric mean particle size for Stratum IV ranged from 36 to 37 microns, or within the very-coarse-silt size fraction (Wentworth scale) (see Table 15). These sediments were deposited in a lower-energy alluvial environment, possibly in a proximal (or near-channel) floodplain environment.

Extractable Phosphorus and pH

Extractable phosphorus averaged 1.83 mg/kg for the privy samples, with a range of 5.26–0.18 mg/kg (Table 16; see Table 14). This stands in sharp contrast to the average extractable-phosphorus concentrations in the natural stratum, which averaged 0.18 mg/kg and ranged from 0.22 to 0.10 mg/kg (see Table 15). Although higher concentrations were obviously expected for the privy samples, the amount of phosphorus extracted from these samples was still considered low. The soil pH for the natural site strata ranged from 7.8 to 8.2, moderately alkaline. As mentioned previously, a pH of 8.2 is near the maximum pH possible for soils dominated by calcium carbonate. The pH of the privy deposits ranged from 7.9 to 8.4, and the grave-pit fill surrounding the burials had a pH range of 6.5–7.6 (Table 17; see Table 16).

Discussion

Relative Age of the Cemetery Terrace and the Joint Courts Complex Deposits

The tread (gently sloping surface) of the Cemetery Terrace is approximately 20 m above the current channel of the Santa Cruz River and is bound by the higher T5 (University Terrace, an early to middle Pleistocene terrace) to the east and the lower Jaynes Terrace (T3) (late to latest Pleistocene) to the west. Soil formation has taken place within an upward-fining sequence of stratified extremely gravelly coarse sand and sandy clay loam alluvium. Scarp sinuosity and incipient ridge-and-valley topography indicate long periods of erosion and degradation of this landform. The soil morphology observed on-site was consistent with the middle to late Pleistocene Cemetery Terrace, or the T4 of Jackson (1989), McKittrick (1988), and Smith (1938). Stage III–IV pedogenic carbonate accumulation existed within the upper Btkm soil horizon, from 0 to 00 cm below the surface (the truncated surface). This horizon displayed nearly continuous calcium-carbonate masses and nodules, with areas of cementation. Carbonates had extended into the underlying extremely gravelly coarse sand stratum to a depth of 129 cm below the surface. Clay films were also present along pore walls, especially in areas surrounding calcium-carbonate pipes in the Btkm horizon. Additionally, 7.5YR to 5YR hues within the Btkm and 2Bkm horizons indicated the release and oxidation of iron from the parent materials over long time spans (Birkeland 1999; Huckleberry 1997).

Soil development since the middle to late Pleistocene has resulted in the formation of A (Stratum I) and Btk (Stratum II) soil horizons. The morphological characteristics of this soil, along with the topographic features of the Cemetery Terrace and its elevation relative to other landforms in the Tucson Basin, indicate that aggradation and stabilization of this terrace occurred prior to human occupation of the landscape. Therefore, deeply buried occupational surfaces are not present on this landform or within the Joint Courts Complex project area.

Geochemical Analysis and Preservation Potential of Inhumed Bone in Alkaline Soils

As noted previously, the primary aim of the geochemical analysis was to assess the influence of soil chemical properties (specifically within the Stratum II Btkm horizon) on the preservation of buried human bone associated with the historical-period burials in the Joint Courts Complex project area. Much work has been conducted concerning pH and bone preservation in acidic soils. It is known that bone is better preserved in alkaline soil and that it decomposes under acidic soil conditions (Gordon and Buikstra 1981; Linse 1992; White and Hannus 1983). Nevertheless, highly alkaline soils are not highly conducive to the preservation of bone—a fact that is less well known to archaeologists (Linse 1992).

Bone is composed of organic (collagen, proteins, and fats) and inorganic (hydroxyapatite) constituents that are influenced differentially by soil-weathering processes (Linse 1992). Three primary soil/sediment characteristics are known to influence the preservation of buried bone: pH, temperature, and moisture content (Whitmer et al. 1989). The latter two factors strongly influence hydrogen-ion activity; therefore, pH is considered to be the primary factor influencing decomposition. All of these processes operate over time, which can be considered a fourth factor. Gordon and Buikstra (1981) studied the effect of soil pH on human-bone preservation and found that pH was strongly correlated with bone decomposition in late Woodland burial mounds of Illinois. They found that, as soil pH decreased, the destruction of osseous material subsequently increased. Interestingly, differences were found in the preservation of immature and mature bone, suggesting that age is an important influence and may result in preservational biases. This was believed to be a function of bone density and thickness, as preservation declined more rapidly with diminishing pH in juveniles (Gordon and Buikstra 1981).

The weathering of bone occurs in recognizable stages whereby the physical makeup of osseous material (both the inorganic and organic constituents) changes over time (White and Hannus 1983). In aerobic soil environments, microorganisms will decompose organic collagen more rapidly than the inorganic hydroxyapatite [$Ca_5(PO_4)_3OH$], given that hydroxyapatite is less soluble at slightly acidic to alkaline pH levels. Collagen, on the other hand, is susceptible to breakdown within this pH range because of proteolyric enzymes (collagenase) that convert collagen into more-soluble substances (Linse 1992). Because hydroxyapatite is the primary constituent of bone, the diagenesis of this mineral is archaeologically significant. For this reason, soil-science research on the solubility of mineral compounds during pedogenesis provides the theoretical framework for most of the research conducted on the chemical weathering of bone.

Of considerable interest is the natural concentration of calcium and phosphate ions in the soil, as these ions will be in equilibrium with those on the surface of the hydroxyapatite [$Ca_5(PO_4)_3OH$]. Essentially, hydroxyapatite will lose or gain calcium and/or phosphate ions, depending on whether the solution contains fewer or more of these ions than can be in equilibrium with the mineral (White and Hannus 1983:316). If the solution contains a large concentration of calcium, then less phosphate can be in solution, and vice versa. Thus, the ratio of these two ions influences the solubility of hydroxyapatite. Acidic soil conditions will decompose hydroxyapatite because protons (hydrogen ions) will replace the calcium within hydroxyapatite, at which point it can be leached from the bone and into solution. Conversely, in soils with high concentrations of calcium, the reverse reaction can replace the hydrogen ions and reconstitute the mineral (White and Hannus 1983). Also of concern in acidic soils is the precipitation of iron and aluminum phosphates that will remove phosphate from solution and promote the loss of phosphate within hydroxyapatite. It has been found that even in nonacidic soils the decomposition of hydroxyapatite can still occur, because the decay of organic tissues surrounding the bone (collagen) creates organic acids that can then react with hydroxyapatite (Linse 1992). Following this initial pulse of decay, the solution surrounding the bone will reach equilibrium with the natural soil environment, and decomposition will either continue or stabilize, depending on the pH. The solubility of hydroxyapatite as a function of soil pH is outlined by Lindsay (1979) (Figure 20).

Hydroxyapatite contains approximately 18.5 percent phosphorus and 39.9 percent calcium, with around 70 percent of the entire bone being mineral. Based on this data, unweathered bone contains 12.95 percent phosphorus and 27.9 percent calcium, at a ratio of 2.15 (Linse 1992:331; White and Hannus 1983:318). The calcium to phosphorus ratio in weathered bone, then, is a good indicator of the degree to which one of these ions has been lost. In some instances, such as at the Oakwood Lake site in South Dakota, ratios of buried bone have exceeded 2.15 and been found to be as high as 6.89 in calcareous soils (White and Hannus 1983). This is

believed to occur because carbon trioxide can replace phosphate ions in hydroxyapatite and actually increase the solubility of the mineral, as a result of the destabilizing effect this ion replacement has on bond structure (Le Geros et al. 1967). This process would increase the calcium to phosphorus ratio. Overall, though, the high concentrations of calcium in solution in calcic soils promote the preservation of bone.

Observations of the remains recovered from the site indicated differential levels of preservation. Poorly preserved bone was generally more friable and displayed surface exfoliation and, in some cases, longitudinal cracking. Some poorly preserved bone was so severely degraded and friable that it could not be picked up without being destroyed. Well-preserved bone, on the other hand, featured little or no degradation, and any observable damage was superficial (Mitchell Keur, personal communication 2009). The condition of the osseous material recovered from the site was recorded as good, fair, or poor during recovery, with *good* suggesting little or no degradation, *fair* indicating the presence of surface exfoliation and longitudinal cracking, and *poor* being very severely degraded.

Several factors contributed to the differential preservation of the human bone recovered from the Joint Courts Complex project area. Factors that led to good preservation included a relatively short period of inhumation (130–150 years), dry soil conditions throughout most of the year, and high concentrations of calcium in a moderately alkaline soil environment. Aridisols, by definition, are never moist for more than 90 consecutive days. The reactions described above take place in solution when the soil is moist and are insignificant when the soil is desiccated. Some hygroscopic moisture may still have been present during dry months, but the overall low-moisture contents would have limited these reactions. It is noteworthy, however, that because most of the historical-period burials were intrusive into a weakly to moderately cemented calcic horizon, permeability may have been an issue, and burials could have remained saturated for longer periods of time. Some redoximorphic features were present around some of the burials, indicating periodic reducing conditions (low oxygen content from saturation). Other factors leading to poor preservation included the fact that fill materials consisted of mixed Stratum II and Stratum I soils. Stratum I consisted of a thin Ap horizon that, as a result of organic-matter content and leaching of carbonates, had a lower pH than the underlying Stratum II calcium-carbonate-rich Btkm soil horizon. Because of this, the ratio of Stratum I to Stratum II material in the grave-pit fill was the overriding factor that determined the fill pH. Analysis indicated that the pH of the grave-pit fill ranged from 6.5 to 7.6 in the areas adjacent to the skeletal remains (see Table 17). The grave-pit sample with a pH of 6.5 was considerably darker, with fewer carbonate fragments, suggesting the fill was composed primarily of Stratum I material. At this pH, bicarbonates, hydrogen ions, and carbon dioxide produced from the breakdown of soft tissue would have continued to react with hydroxyapatite, promoting further dissolution of the bone. Conversely, in grave pits with fill composed of more Stratum II material, a higher pH and greater concentrations of calcium may have resulted in the displacement of the hydrogen ions in hydroxyapatite, with calcium reconstituting the bone as the solution reached equilibrium. Some loss of phosphate from the bone in this situation is likely and would be due both to the low concentrations of phosphorus in Stratum II and to the potential replacement of phosphate with carbonate.

The soil conditions and site stratigraphy of the Joint Courts Complex project area was generally consistent, both vertically and horizontally, across the project area. The soil developed in the Cemetery Terrace alluvium has been forming since the late Pleistocene, and the soil conditions during the time the cemetery was in use had been in place since the early to middle Holocene. Because of postcemetery disturbance (construction, the placement of asphalt and concrete, and storm-water management), it is difficult to assess any natural prehistoric period or historical-period topography that may have influenced site hydrology. Depressions or shallow drainages collect water that, in turn, would promote the chemical weathering of bone in these areas. Burial preservation was more or less random across the project area (Figure 21), except in the area of Council Street (see the Cemetery Area 4 discussion in Chapter 4). Leaky pipes and/or changes in subsurface drainage in this area related to storm-water runoff and utility trenches could have resulted in an increase in moisture, promoting the chemical reactions necessary to break down osseous material. The depth of the remains varied widely in this area, as well, and many individuals had been disturbed by later, intrusive burials. Burials near the surface would have received moisture more frequently and were at a soil depth associated with greater levels of biological activity.

Cultural influences and preservational bias associated with the individuals' ages could have also contributed to the spatial variability of burial preservation (see Figure 21). Several dozen features were treated with lime, which would have greatly influenced both the calcium concentration and the pH of the grave-pit fill. Lime probably limited the acidifying influence of soft-tissue decomposition, and the increased concentrations of calcium may have reconstituted the mineral structure of the bone. Liming would have had the greatest influence on those burials surrounded by Stratum I (Ap horizon) fill material. As noted previously, skeletal fetal and infant remains are often underrepresented, compared to older individuals. Older individuals typically have higher bone densities, making their skeletal remains more resistant to weathering (Gordon and Buikstra 1981). General analysis of age versus bone preservation seems to suggest, however, that younger individuals were well represented and that preservational biases based on age did not exist.

Phosphorus Analysis of Privy Samples

Extractable soil phosphorus was low within the natural strata of the Joint Courts Complex project area. Although low concentrations were expected within the intact soils, artificially low results may have been obtained because of the neutralizing influence of the calcium carbonate on the acid extractant used during the analysis. The relative concentration between strata and within the anthropogenic sediments is believed to be more crucial than obtaining absolute concentrations, however. Although extractable phosphorus was considerably higher in the privy sediments, the concentration is still considered low. This is probably a result of the anthropogenic treatment of privy deposits with lime, to cut down on odor and speed decomposition of organic waste, which effectively locks up much of the phosphorus in calcium-phosphate compounds.

It is important to note that available phosphorus becomes unavailable over time, and vice versa, as chemical reactions take place in the soil and phosphorus bonds with other elements or is released into solution (Holliday and Gartner 2007). The unavailable-phosphorus species (e.g., calcium phosphate, iron phosphate, etc.) present depend on the pH of the soil, as calcium phosphates form in alkaline soils, and iron or aluminum phosphates precipitate in acidic soils (Figure 22). Privies that had additions of calcium carbonate (liming) were moderately alkaline (pH 7.9–8.4) and had a high concentration of calcium. Therefore, most available phosphorus in this environment would have been quickly converted to unavailable calcium phosphates and not extracted by the Mehlich 2 extraction method. It is possible that privy samples with the highest concentrations of extractable phosphorus were limed less frequently.

Site Soil-Water Characteristics

One of the primary questions concerning the preservation potential of human bone and the artifacts recovered from privy deposits centers on the soil-water characteristics of the Joint Courts Complex project area. The ability of the soils on-site to infiltrate and drain surface waters would have influenced the location and duration of moist conditions within the burials and privy pits. The physical properties of concern are the infiltration rate (that is, unsaturated hydraulic conductivity) and permeability of the Btk and 2Btk (Strata II–III) soil horizons. These physical characteristics are determined by soil texture, soil structure, and soil-size continuity and tortuosity (irregular shape of soil pores), as well as the degree of pedogenic carbonate accumulation associated with this horizon.

As noted previously, Strata II and III were composed of loam to very gravelly to extremely gravelly sandy loam to loamy sands with Stage III+ calcium-carbonate accumulation. Machette (1985:5) described Stage III calcium-carbonate morphology in gravelly soils as follows: "there is a massive accumulation of carbonate between clasts (gravels) with the horizon becoming cemented in advanced forms with essentially continuous dispersion of soil carbonate in the matrix (fine-grained material between gravels)." Over time, soil horizons become increasingly infused with carbonate until voids become plugged, severely restricting water percolation (Birkeland 1999:129). Eventually, so much calcium carbonate accumulates that the volume of the carbonate exceeds the volume of the pores, resulting in volumetric expansion (Birkeland 1999). In the advanced form of

Stage III soil-carbonate formation, percolating waters collect on top of the cemented horizon and result in the formation of laminated carbonates (Stage IV soil carbonate).

As stated previously, the soils on-site were mapped as Petrocalcids of the Cave soil series (Gelderman 1972). This series is characterized by a petrocalcic horizon (Stage IV soil-carbonate accumulation) with a thin laminar upper layer. This level of carbonate accumulation indicates an essentially plugged carbonate horizon with extremely low permeability. According to Hendricks (1985), Cave soils have rapid permeability above and very slow permeability through the petrocalcic horizon. Based on the field description, the level of pedogenic carbonate accumulation in Stratum II (Btkm) was characterized as Stage III+ and was therefore not technically a petrocalcic horizon (completely cemented, rock hard). This would have been an important factor when choosing a location for a cemetery, as it would have been extremely difficult to excavate grave pits in a true petrocalcic horizon.

Although Stratum II was not a true petrocalcic horizon, many of the pores were still plugged with carbonate, and the hydraulic conductivity of this horizon was severely limited. Percolating waters would have pooled or accumulated at the top of this horizon and would not have readily infiltrated unless cracks or pipes were present to create preferential flow paths. Pits or features dug into but not through this soil would likely have retained moisture, as percolating waters could not have easily flowed through the moderately cemented calcic horizon. Therefore, following a precipitation event, the privy and grave pits would have remained wet for longer periods of time, as water collected in these features. This environmental factor is of significance because the preservation of organic materials and the inorganic mineral structure of human bone depend on the presence or absence of oxygen and the moisture content of the surrounding substrate (Lillie and Smith 2007).

Another important consideration is the depth of groundwater in the Joint Courts Complex project area. If privy and burial features were constantly being saturated by groundwater, this would have had a dramatic influence on the preservation of the archaeological materials present. Conversely, if the groundwater table rarely came near the surface, archaeological features would have experienced an input of moisture only following precipitation events. Generally speaking, groundwater flow and infiltration of surface water in the Joint Courts Complex project area was complicated by the presence of a partially cemented calcic horizon and lithologic discontinuities with extreme changes in particle size (e.g., shifts from loam to extremely gravelly loamy sand).

The infiltration of water into fine-textured over coarse-textured deposits (Stratum II over Stratum III) was impeded by the lower hydraulic conductivity of the overlying fine-textured deposit and by the presence of a coarse-textured substratum. It is counterintuitive to imagine a coarse-textured (sandy or gravelly) deposit impeding percolating waters, but the macropores of sandy or gravelly sediments have less attraction for water than do the fine pores of the overlying material (Brady and Weil 2002). Following a precipitation event, the wetting front of the percolating water stops when it reaches the coarse deposits because it has a lower matric potential (soil-water potential due to the attractive forces between water and soil solids from capillarity and adsorption). Because water always moves from high to low potential, it cannot move into the coarse deposit until all the pores of the fine-textured overlying deposit are near saturation. At this point, loosely held water will move down into the coarse deposit by gravitational forces (Brady and Weil 2002). Conversely, rising groundwater through capillary action cannot penetrate coarse strata, because the larger pores cannot support capillary movement. The presence of the 3-cm-thick laterally continuous manganese lens at the contact between the finer-textured Stratum IV (3Ckm3 and 3Ck4 soil horizons) and the coarse-textured overlying Stratum III (2C1 and 2Ckm2 soil horizons) emphasized this point. Iron and manganese oxyhydroxides commonly concentrate in soils where a fluctuating water table causes frequent shifts in oxidizing and reducing conditions (Buol et al. 2003). The manganese lens occurred at the lithologic discontinuity because groundwater could not rise appreciably into the coarse-textured Stratum III deposits. Repeated capillary rise of groundwater to this point produced reducing conditions in which manganese and iron were in reduced form and were consequently more mobile (because of their greater solubility). Upon drying, manganese and iron were oxidized to form concretions, masses, or coatings on soil solids. This manganese lens indicated that the water table was predominantly lower than 2.5 m below the soil surface and did not generally influence any intrusive archaeological features within Stratum II or III.

Preservation Potential of Organic Remains in Privy Deposits

The preservation potential of organic materials in situ within the soil environment depends on the speed at which degradation processes take place. These processes are influenced by such factors as temperature, pH, moisture content, redox potential (presence or absence of oxygen), and microbial activity (Lillie and Smith 2007). Environmental conditions that promote biological activity (e.g., warm and moist soil with moderate pH that is well aerated) will promote more-rapid degradation or decay of organic remains. The question of preservation potential within privy deposits has been raised because of the recovery of newspaper that is still legible after having been in the ground for nearly 100 years.

The excellent preservation of these deposits is the result of a poorly oxygenated (anoxic) environment in which decomposition by aerobic bacteria was limited (Kenward and Hall 2000). Anoxic environments in a desert climate are, of course, typically rare and would be unexpected, but the limited hydraulic conductivity of the natural strata in the Joint Courts Complex project area (see above) combined with anthropogenic inputs of moisture in the privies produced an anoxic environment in which decomposition was impeded. Another important factor concerns the presence of other organic materials (human waste) that give off gases as a result of volitization. These gases will displace oxygen, promoting anoxic conditions. This condition is somewhat similar to a marsh or bog environment in which slow, anaerobic decay of organic matter produces methane and/or hydrogen-sulfide gas (swamp gas). It is well known that these wetland environments have ideal conditions for the preservation of organic remains and can, in fact, preserve organic artifacts for thousands of years (Brunning et al. 2000).

Overall, the retention of moisture in the privies, the surrounding alkaline soil, and the additions of neutral to slightly alkaline human waste (urine has a neutral pH, and human fecal matter typically has a pH range of 7–7.5 [Robinson 1922]) produced an anoxic and alkaline environment that inhibited decomposition. It is important to consider, however, that following any change in these environmental conditions, decay of these remains would take place or would have taken place. As privies were abandoned, moisture contents were likely reduced, and the deposits may have become oxygenated, promoting some level of decay. Also, the addition of lime may have sped up decomposition in some privies and resulted in the loss of organic materials that would have otherwise been preserved.

Summary and Conclusion

A combination of environmental factors acting over a time span measured in millions of years has led to the current setting of the Joint Courts Complex project area. The project area lies on a long-abandoned floodplain of the Santa Cruz River known locally as the Cemetery Terrace (T4). This terrace and several others in the Tucson Basin developed as the main axial drainage (Santa Cruz River) incised into Tertiary basin-fill deposits beginning in the late Pliocene (3.6 mya). These terrace surfaces become progressively younger with decreasing elevation above the contemporary channel of the Santa Cruz River. Soil formation on the Cemetery Terrace since the middle to late Pleistocene has resulted in the development of an aridisol with a petrocalcic horizon (hardpan composed of calcium carbonate).

The lower elevations of the Tucson Basin currently lie in the Lower Sonoran Life Zone, an arid-zone plant community consisting predominantly of creosote, bursage, and a variety of cacti, including the saguaro. Dense riparian communities were once present along the major drainages of the basin, providing critical habitat for a diverse range of fauna and an abundance of resources for prehistoric period and early-historical-period groups. Many of these areas have been destroyed since the late-nineteenth century by overgrazing, wood collection, and dropping groundwater tables. Currently the climate of the Tucson Basin is characterized by mild winters and long, hot summers, with an average of 41 days in which the temperature exceeds 100°F. A biannual precipitation pattern exists across the Sonoran Desert in which localized, heavy thunderstorms (monsoons) drop

more than 50 percent of the annual rainfall between July 1 and September 15. Calm winter rains associated with low-pressure troughs usually fall between December and March.

Historically, the Santa Cruz River has undergone major shifts in channel morphology stemming from anthropogenic disturbance and climate change. Headcuts first began to form in the San Xavier reach in 1871 and later, in the late 1880s, in Tucson, signaling the onset of historical-period arroyo formation. Cycles of channel incision, aggradation, and stability have been traced back to the early Holocene on the Santa Cruz River and are correlated to climatic fluctuations and internal geomorphic factors. This alluvial cycle had a profound influence on prehistoric period and historical-period groups because it influenced the abundance and quality of resources available for cultural use. Floodplain stability between 3,500 and 1,850 years B.P. promoted the adoption of agriculture by providing a riverine setting that supported a mixed economy composed of agricultural subsistence and the collection of readily available wild resources. Episodes of intense flooding and channel incision in the Late Archaic and Formative periods likely influenced habitation-site location and subsistence in the Tucson Basin.

The environmental context of the Joint Courts Complex project area has important implications regarding the preservation and interpretation of the archaeological record. The relative age of the Cemetery Terrace, based on soil morphology and its elevation above the modern channel of the Santa Cruz River, indicates this landform aggraded long before humans occupied the Tucson Basin. Therefore, multiple episodes of occupation spanning the Archaic period through the historical period have taken place on or very near the surface of this terrace, and deeply buried surfaces that contain cultural deposits are not expected. Long periods of soil formation have resulted in a well-developed soil with carbonate-rich subsurface horizons. Many of the historical-period remains recovered from grave pits intruding into the calcic horizon of this soil displayed a high degree of preservation; however, some bone was much more friable and highly degraded. Three primary soil/sediment characteristics are known to influence the preservation of buried bone: pH, temperature, and moisture content. Descriptions of the grave-pit fill indicated that its composition was a mixture of Stratum I (Ap horizon) and Stratum II (Btkm horizon) soil materials. The ratio of Stratum I to Stratum II soil would have been the dominant factor controlling the pH of the material surrounding the burial. Geochemical analysis indicated that this pH ranged from 6.5 to 7.6. The mineral component of bone (hydroxyapatite) is relatively insoluble between pH 7.5 and 8.0, and solubility quickly increases above and below this range. Grave pits with more Stratum II material had a higher soil pH. Following the initial pulse of decay and acidification from the breakdown of soft tissue, calcium can replace hydrogen ions in hydroxyapatite, effectively reconstituting the bone and promoting preservation. Grave pits with fill composed primarily of Stratum I material had a lower pH (6.5). Hydrogen ions and carbon dioxide released during the decay of soft tissue would have continued to react with hydroxyapatite, resulting in continued dissolution of the mineral structure.

Several other variables besides soil chemistry must have influenced the preservation of bone in the Joint Courts Complex project area, as there did not appear to be any observable spatial pattern of preservation. A moderate level of cementation in the calcic horizon (Stratum II) had the potential to impede percolating soil water and retain moisture in the grave pits. This would have been accentuated in areas where Stratum II was more highly cemented (generally cementation was consistent across the site). All chemical weathering of bone is highly dependent on moisture, as the reactions only take place in solution. Natural site drainage prior to twentieth-century historical-period modification could have influenced the spatial variability of preservation across the project area, as depressions or shallow drainages collected water. Additionally, grave-pit depth would have greatly influenced the preservation, as shallow grave pits would have received moisture more frequently. Other cultural influences include the application of lime to the burial to cut odor and prevent the spread of pathogens. Grave pits that were limed would have had a higher soil pH surrounding the burial (probably in the 8.0–8.2 range), limiting the acidifying effect of soft-tissue decomposition and probably promoting the preservation of bone. A group of poorly preserved burials was associated with utility trenches under Council Street in Cemetery Area 4. Continued saturation from utility trenches could have played a role in the degradation of these burials. Burial depth was also highly variable, and many grave pits were disturbed by later, intrusive grave pits in this area (see the Cemetery Area 4 discussion in Chapter 4).

Overall, the preservation of historical-period burials in the Joint Courts Complex project area was considered to be fair to good. Although bone preservation was variable across the site, a substantial proportion of individuals displaying a high degree of bone preservation were recovered, and in general, soil chemical and physical properties that enhance the decomposition of osseous material were absent. This fact was also evidenced in the high number of well-preserved juveniles recovered from the site. If poor preservation conditions were present, the lower bone densities typically associated with juveniles would have resulted in a lower proportion of these individuals in the total sample.

The preservation of organic materials (namely newspaper) in postcemetery privy contexts was due to the presence of an anoxic environment produced by the low permeability of Stratum II, continued additions of moisture while the privies were in use, and the volitization of human waste, which produces gas that could displace oxygen. Alkaline pH levels (urine and human fecal matter typically have a pH range of 7–7.5) also limited the chemical breakdown of organic remains. Privies that were frequently limed to reduce odor and promote decomposition had less potential to preserve organic artifacts. Limed privies had a lower extractable-phosphorus concentration, as available phosphorus was tied up in calcium phosphates and not extracted in the Mehlich 2 method.

In conclusion, the noncultural environmental context identified in this investigation has had a profound influence on the archaeological record recovered from the Joint Courts Complex project area. The chemical and physical soil properties across the site have resulted in a high state of preservation in both the historical-period cemetery and the postcemetery privy contexts and have limited potential biases in the sample data. Changes in the local environment since the late Pleistocene have played a critical role in both the historical-period and prehistoric period occupation of the project area. Although most of the cultural record from the Joint Courts Complex is from the historical period, the study of landscape processes that have occurred over a time period measured in thousands of years has provided valuable insight into the context of relatively recent cultural events.

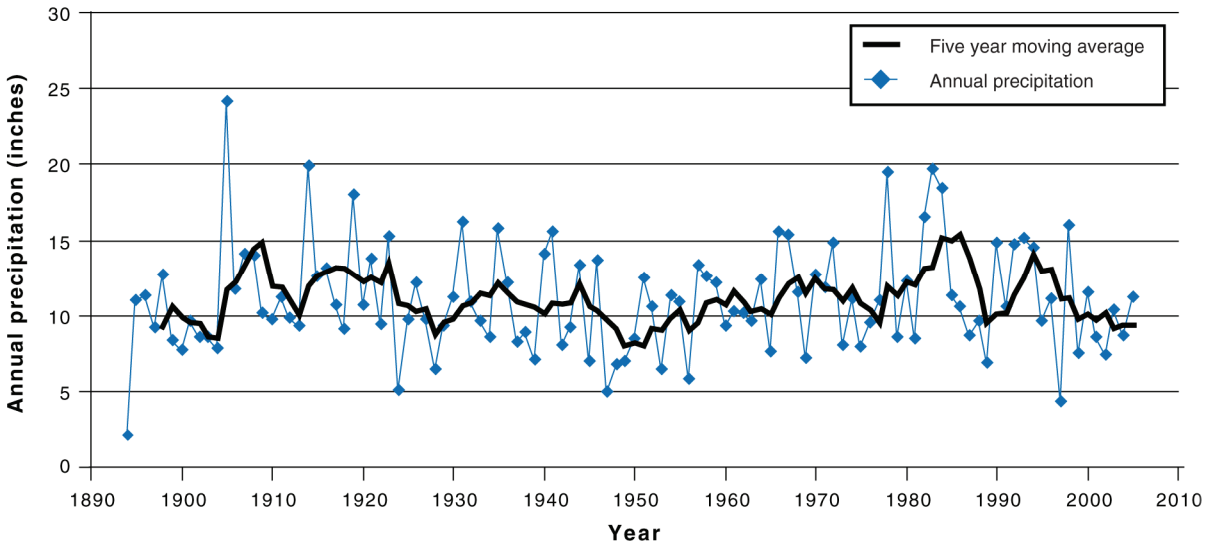

Figure 13. Annual precipitation for Tucson, Arizona, from 1894 to 2005.

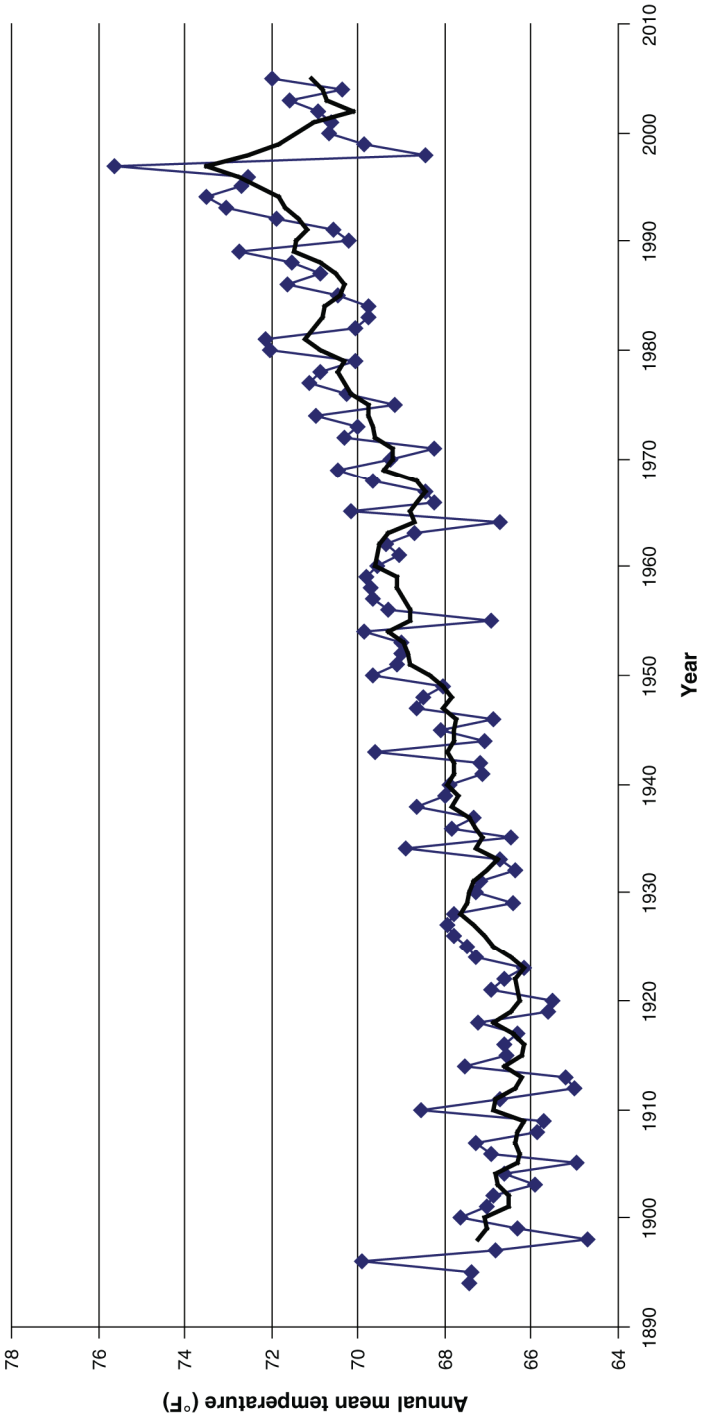

Figure 14. Mean annual temperature for Tucson, Arizona, from 1894 to 2005.

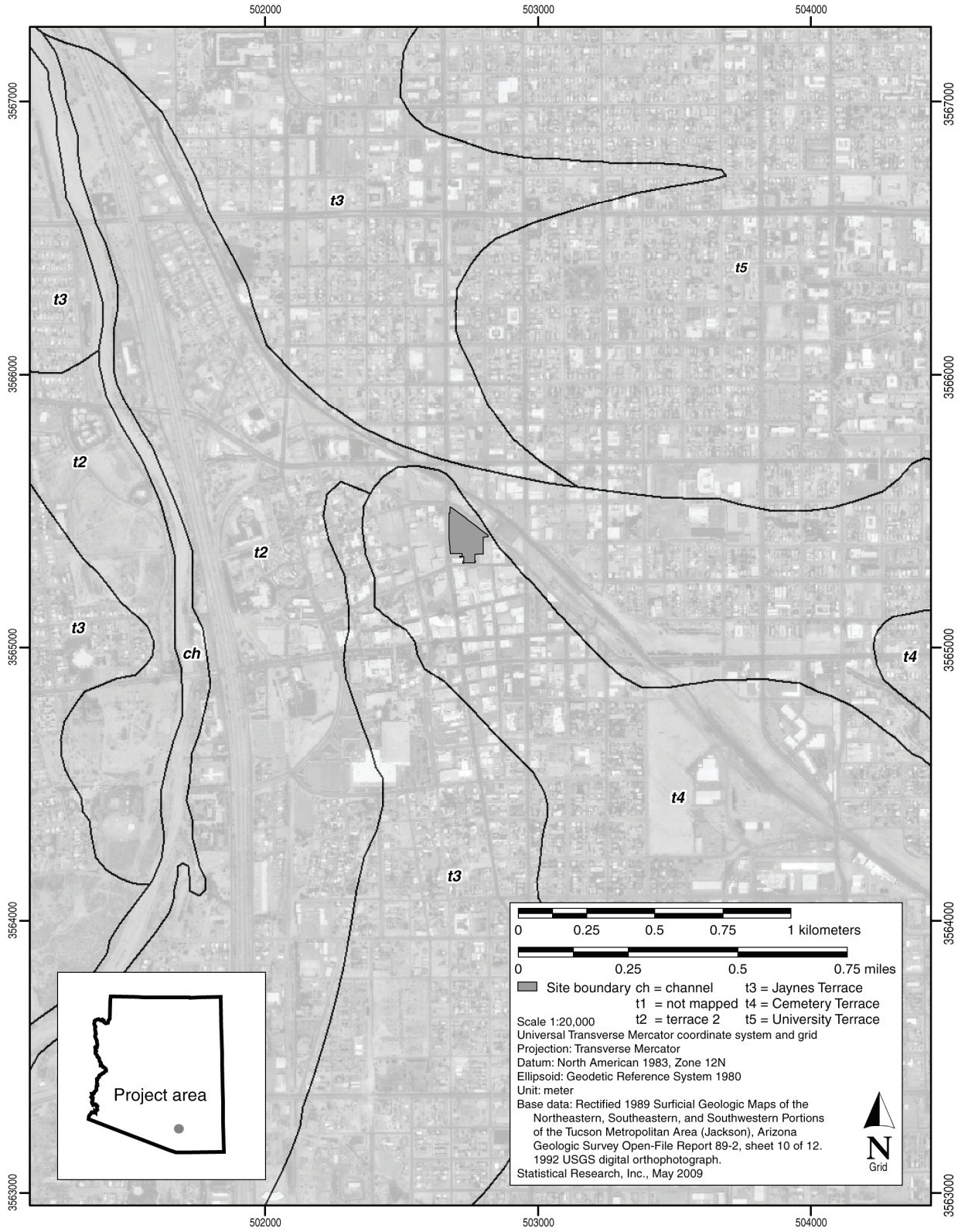

Figure 15. Geomorphic map of the Joint Courts Complex project area showing alluvial terraces.

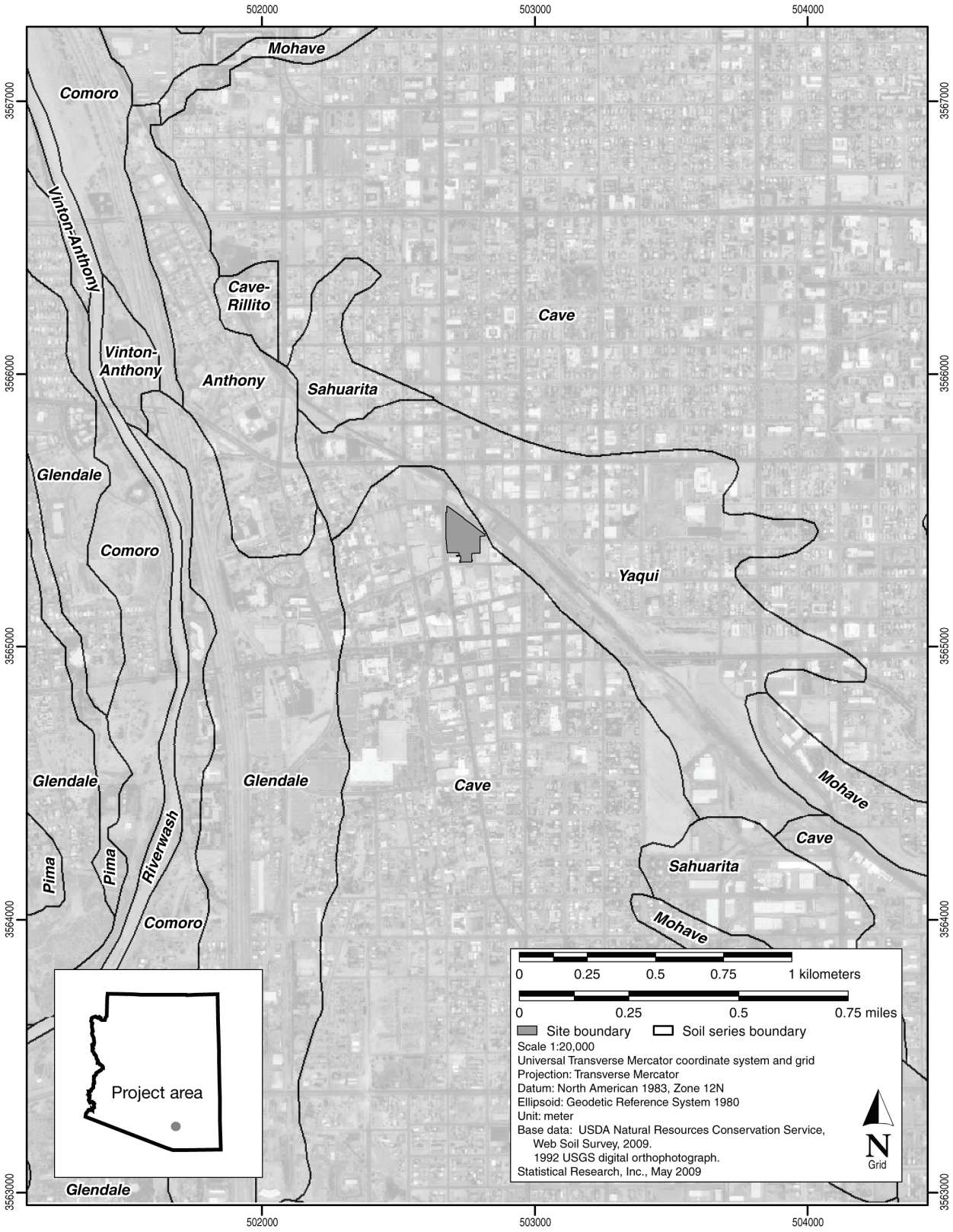

Figure 16. Soil-series map for the Joint Courts Complex project area.

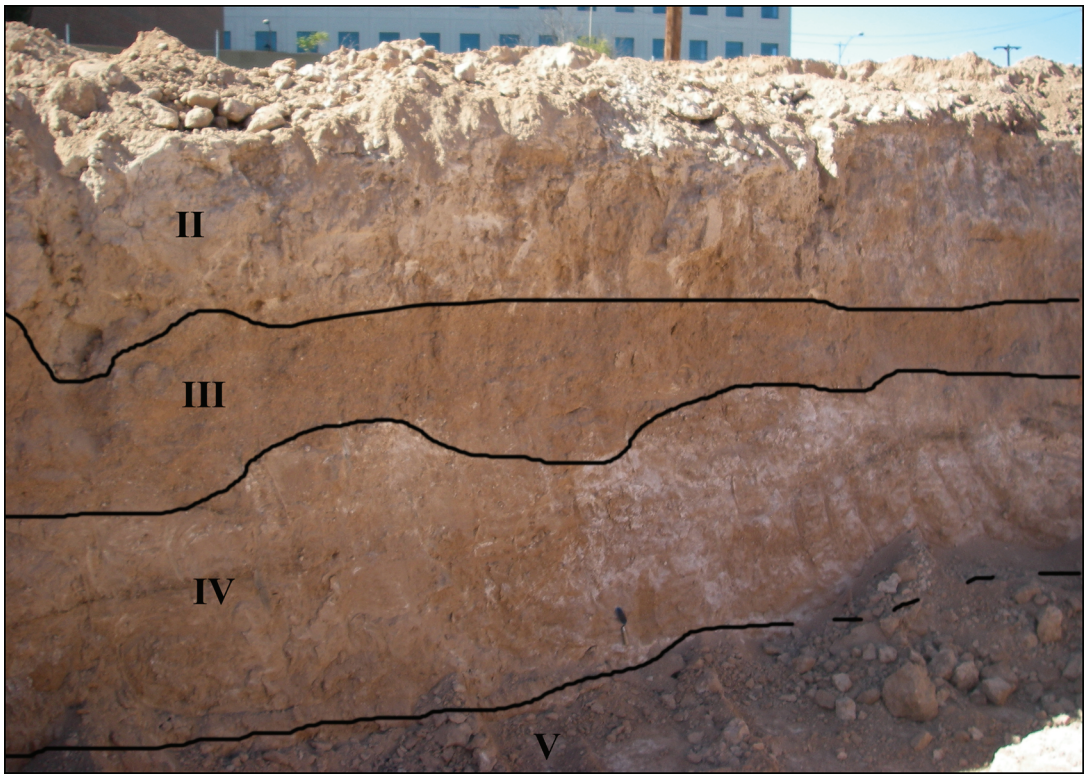

Figure 17. Photograph of a stratigraphic profile in the Joint Courts Complex project area.

Figure 18. Close-up photograph of caliche layer (Stratum II).

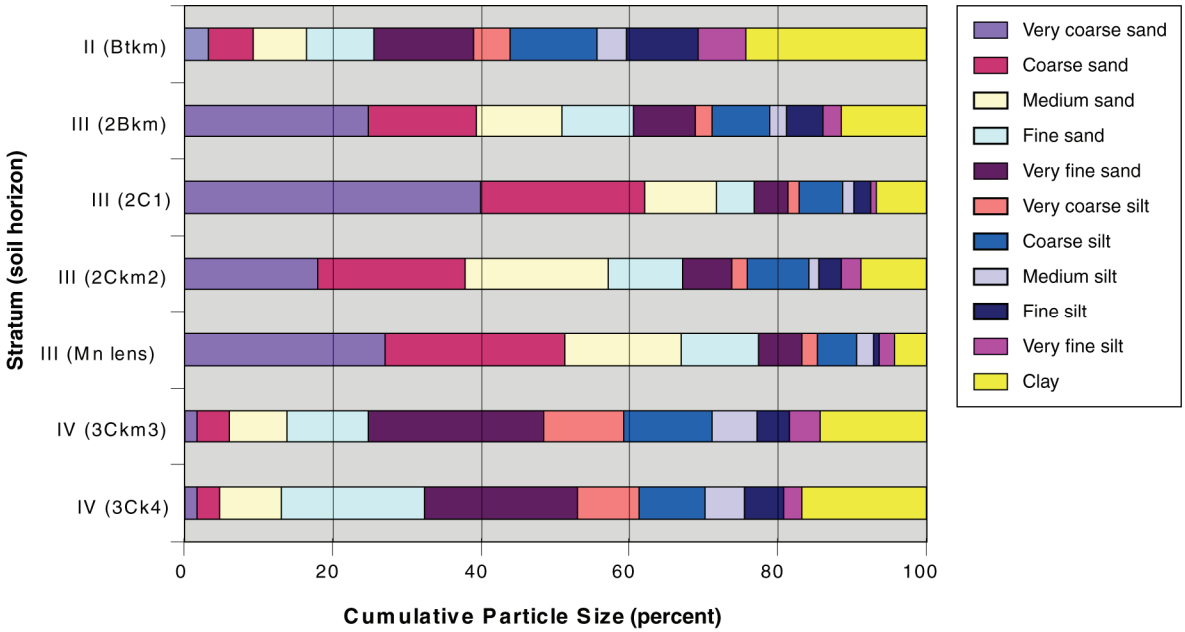

Figure 19. Cumulative particle-size plot of the stratigraphy of the Joint Courts Complex project area.

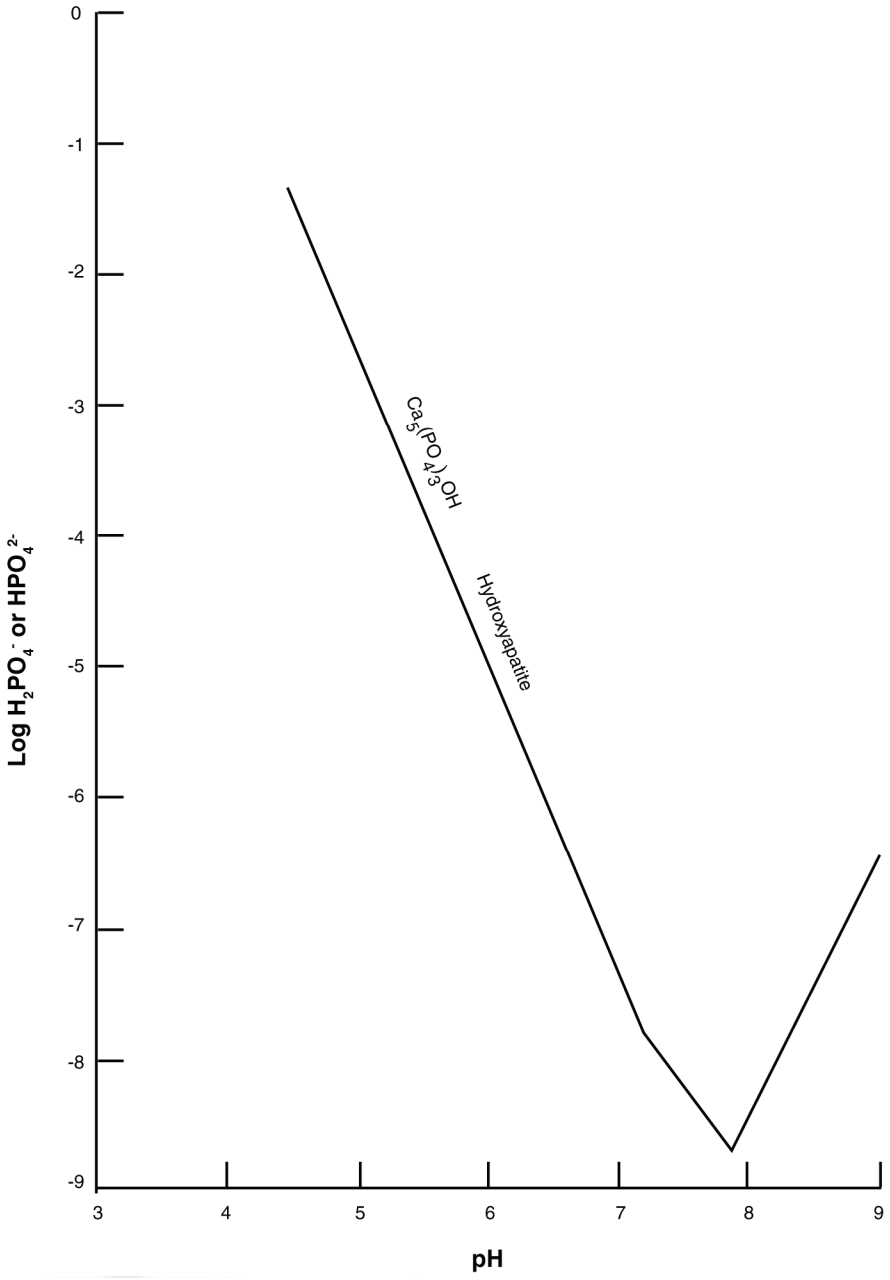

Figure 20. Solubility of hydroxyapatite as a function of soil pH (from Lindsay 1979).

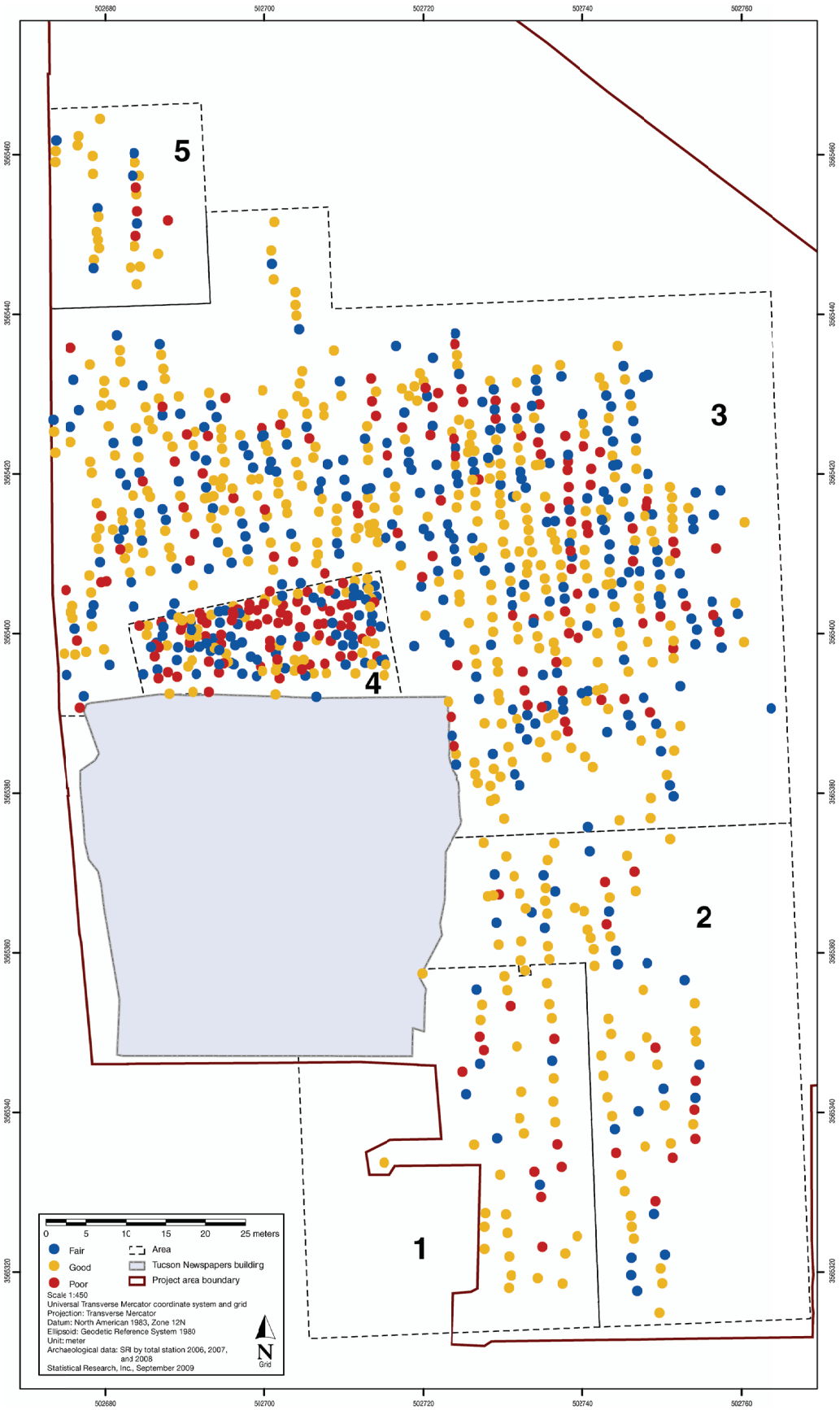

Figure 21. Spatial variability of burial preservation in the Joint Courts Complex project area.

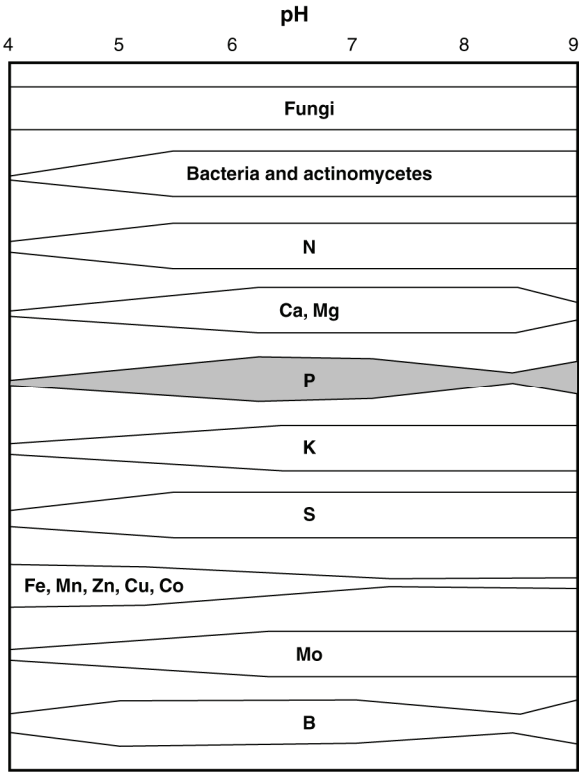

Figure 22. Phosphorus availability versus soil pH (from Sparks 2003:269).

Table 12. Record of Precipitation at Fort Lowell from 1873 to 1890

Year	January	February	March	April	May	June	July	August	September	October	November	December	Annual
1873	—	—	—	—	—	—	0.08	2.73	0.62	—	1.32	0.97	
1874	1.76	1.66	1.19	0.43	0.07	—	4.82	1.93	—	1.08	0.92	0.37	14.23
1875	0.37	1.22	—	0.09	—	0.20	4.22	2.09	2.39	—	0.05	0.53	11.16
1876	0.21	0.27	1.14	—	—	2.05	4.83	2.70	1.95	2.65	0.25	—	16.05
1877	0.95	1.45	0.12	0.88	0.42	—	0.86	0.34	1.76	0.68	—	2.38	9.84
1878	0.12	1.12	1.06	0.48	—	0.16	0.60	7.88	0.14	—	2.30	0.52	14.38
1879	1.54	2.56	0.18	—	—	—	2.50	1.26	1.12	0.80	0.72	0.70	11.38
1880	0.62	—	0.64	0.16	—	0.20	1.88	3.64	0.38	0.12	—	1.06	8.70
1881	0.20	0.12	0.94	0.67	—	—	3.62	—	2.04	1.26	—	0.3	—
1882	2.30	1.90	0.94	0.30	0.32	1.54	1.18	3.6	0.38	—	1.48	0.12	14.06
1883	3.02	1.20	1.06	—	—	—	—	—	—	0.78	0.48	3.18	—
1884	4.74	5.23	2.90	0.08	—	—	—	—	—	—	—	—	—
1886	—	—	1.12	0.14	—	—	—	1.24	1.64	0.12	0.12	0.10	
1889	2.09	0.76	2.46	0.30	—	0.45	3.36	2.07	3.32	0.34	0.19	1.58	16.92
1890	2.09	0.55	0.74	0.75	—	—	6.47	5.58	0.97	0.77	0.83	1.48	20.23

Note: Data compiled from the *Monthly Weather Review*. Years not listed for the specified time period had no data available.

Table 13. Soils and Associated Landforms within and near the Joint Courts Complex Project Area

Soil Series	Soil Taxonomy	Soil Order	Landform	Relative Age
Anthony	Torrifluvent	entisol	T2	middle to late Holocene
Cave	Petrocalcid	aridisol	T4 and T5 (Cemetery and University Terraces)	middle to late Pleistocene
Comoro	Torrifluvent	entisol	T1	historical period
Glendale	Torrifluvent	entisol	T2	middle to late Holocene
Grabe	Torrifluvent	entisol	T2	middle to late Holocene
Sahuarita	Haplocambid	aridisol	T3 (Jaynes Terrace)	late Pleistocene to early Holocene
Yaqui	Haplocambid	aridisol	T3 (Jaynes Terrace)	late Pleistocene to early Holocene

Table 14. Joint Courts Complex Project Area Pit-Profile Description

Horizon	Depth (cmbs)	Description	Archaeological Stratum	Notes
Btkm	0–100	7.5YR 8/2 (dry) 6/4 (moist); fine to medium sandy clay loam; strong coarse subangular blocky to coarse prismatic; few faint irregular discontinuous clay films within pores; common fine to medium tubular pores; slightly sticky; rigid to very rigid consistence (dry); 10–15% round to subround pebbles; strongly to violently effervescent; continuous calcium-carbonate masses, coarse dendritic pipes, spherical nodules, cemented (hardpan); abrupt smooth boundary.	II	Stage III–IV calcium-carbonate accumulation; structural units grade into moderate medium subangular blocky to platy near surface; clay films most noticeable near or within calcium-carbonate pipes.
2Bkm	100–129	5YR 7/2 (dry) 5YR 6/4 (moist); stratified extremely gravelly very coarse sand; some pockets of slightly finer-grained sediments have moderate medium subangular blocky structure, otherwise massive; rigid consistence (dry); few fine to medium tubular pores; strongly effervescent, nearly continuous calcium-carbonate masses, few coarse dendritic masses, few spherical to irregular masses, many fine spherical calcium-carbonate masses, partially cemented; 80% round to subround quartz and gneiss gravels; abrupt smooth boundary.	III	Stage III calcium carbonate; horizontal bedding features still visible.
2C1	129–180	5YR 7/2 (dry) 6/4 (moist); stratified extremely gravelly very coarse to coarse sand; some areas with higher percentage of fines have weak moderate subangular blocky structure, otherwise massive; friable consistence; noneffervescent; few < 3-cm-diameter subround and round quartz gneiss gravels; abrupt smooth boundary.	III	Horizontal bedding features with pebble runs.
2Ckm2	180–220	5YR 7/3 (dry) 6/4 (moist); very gravelly very coarse to coarse loamy sand; massive; common fine to medium pores/voids; slightly effervescent; few medium tabular calcium-carbonate nodules, partially cemented; abrupt smooth boundary.	III	Groundwater carbonates.
Manganese lens	220–223	10YR 4/2 (dry) 2/2 (moist); very gravelly coarse loamy sand; massive; very slightly effervescent; common distinct irregular 7.5YR 6/8 ferric-iron (or oxidized-iron) masses; many distinct irregular manganese masses; abrupt smooth boundary.	III	Manganese lens patchy but continuous around excavated area between 200 and 230 cmbs.
3Ckm3	223–261	7.5YR 7/2 (dry) 6/6 (moist); silt loam; massive; common fine pores; strongly effervescent; continuous calcium-carbonate masses, partially cemented; abrupt smooth boundary.	IV	2-cm-thick sand lens at 250 cmbs; groundwater carbonates.
3Ck4	261–400	7.5YR 7/4 (dry) 5/6 (moist); very fine sandy loam to silt loam; massive; common fine to medium pores; slightly effervescent, few spherical calcium-carbonate masses, horizontal bands of calcium-carbonate nodules; common distinct irregular 10YR 2/2 manganese masses.	IV	Groundwater carbonates.

Note: The profile is of the southwest wall of the pit on the southeast end of the site area. The site is on the tread of the T4 terrace of the Santa Cruz River (Cemetery Terrace) believed to be middle to late Pleistocene in age. The surface gently slopes to the north-northeast. The upper soil horizon (Stratum I) has been removed by mechanical stripping and so has not been described; vegetation has also been stripped. The site appears to be near the proximal edge of the terrace; however, the terrace scarp is difficult to define in this highly urbanized area. Adjacent landforms include a T3 remnant to the west, and a wash mapped as T2 lies to the north and northeast sides of the site. The dark, oxidized manganese lens is a product of fluctuating reduction-oxidation conditions from short-term saturation at a textural boundary.

Key: cmbs = centimeters below the surface.

Table 15. Quantitative Soil Data and Natural Strata for the Joint Courts Complex Project Area

Depth (cmbs)	Horizon	Archaeological Stratum	Extractable Phosphorus (mg/kg)	pH	Sand (%)	Silt (%)	Clay (%)	Geometric Mean (microns)
0–100	Btkm	II	0.10	8.2	41	35	24	21
100–129	2Bkm	III	0.17	8.2	70	18	12	127
129–180	2C1	III	0.19	7.8	82	11	7	317
180–220	2Ckm2	III	0.22	8.1	74	17	9	157
220–223	manganese lens	III	—	8.1	84	12	4	288
223–261	3Ckm3	IV	0.20	8.1	52	34	14	36
261–271+	3Ck4	IV	0.17	8.1	56	27	17	37

Key: cmbs = centimeters below the surface.

Table 16. Mehlich Extractable Phosphorus and pH for Sediment Samples from Privy Pit 734

Sample Provenience No.	Extractable Phosphorus (mg/kg)	pH	Notes[a]
4660	0.57	8.3	10YR 7/3, common calcium-carbonate nodules.
4661	3.40	8.0	10YR 7/2, few calcium-carbonate nodules, few pieces of charcoal.
4662	0.96	8.1	10YR 7/1, common calcium-carbonate nodules, few pieces of charcoal.
4663	1.02	8.2	10YR 6/3, few calcium-carbonate nodules, few pieces of charcoal.
4664	1.44	8.1	10YR 7/2, very few pieces of charcoal.
4665	4.32	7.9	10YR 5/1–4/1, few calcium-carbonate nodules, many pieces of charcoal.
4666	2.69	8.2	10YR 7/2, common calcium-carbonate nodules, few pieces of charcoal.
4667	1.47	8.3	10YR 6/2, few calcium-carbonate nodules, few pieces of charcoal.
4668	5.26	8.1	10YR 6/1, few calcium-carbonate nodules, common pieces of charcoal.
4669	3.29	8.2	10YR 7/1, common calcium-carbonate nodules, few pieces of charcoal.
4670	0.37	8.4	10YR 7/2, common calcium-carbonate nodules, no charcoal.
4671	0.38	8.3	2.5YR 7/2, common calcium-carbonate nodules, no charcoal.
4672	3.42	8.1	10YR 5/1, few calcium-carbonate nodules, common pieces of charcoal.
4673	0.18	8.1	10YR 8/1, many calcium-carbonate nodules, few to common pieces of charcoal.
4674	0.34	8.4	10YR 7/1, very few pieces of charcoal.
4675	0.53	8.3	10YR 7/1, many calcium-carbonate nodules, few to common pieces of charcoal.
4676	1.41	8.1	10YR 6/1, common calcium-carbonate nodules, few pieces of charcoal.

[a] Information given is for dry color.

Table 17. Description and pH of Sediment Samples from Grave-Pit Fill

Sample Provenience No.	Grave Pit No.	Context/Description	pH[a]
4236	3084	Locus C, Level 2, grave pit near distal right femur; 10YR 4/2 (dry) 10YR 2/2 (moist), loam, many calcium-carbonate and wood fragments, hydrophobic.	6.5
5240	6952	Locus C, Level 1, grave-pit control; 7.5YR 6/4 (dry) 7.5YR 4/4 (moist), loam, many calcium-carbonate fragments.	7.6
6684	3038	Locus C, Level 2, grave pit; 10YR 5/2 (dry), 10YR 3/1 (moist), sandy loam, slightly hydrophobic, common calcium-carbonate fragments.	7.4

[a]1:1 soil:water slurry.

CHAPTER 4

The History and Archaeology of the Cemetery: An Overview

Michael Heilen and John D. Hall

Introduction

The Alameda-Stone cemetery appears to have been the only public cemetery in Tucson during the period of its use and was divided minimally into two sections: a military section and a civilian section. The timing of the first interments in the civilian section is unknown; historical records suggest that the first interments in the military section were placed in July 1862. Prior to the use of the Alameda-Stone cemetery, the people of Tucson buried their dead within the Tucson presidio, in a small graveyard adjacent to the presidio chapel (see Chapter 5, Volume 1 of this series) (O'Mack 2005, 2006; Thiel et al. 1995). The presidio graveyard was replaced at some point during the 1850s or early 1860s by the Alameda-Stone cemetery, which was located a few hundred meters to the east of the Presidio, on the outskirts of the small frontier town. The first use of the military section of the Alameda-Stone cemetery coincided with the arrival of the California Column in Tucson in 1862, but what events or processes may have prompted the first use of the civilian section of the Alameda-Stone cemetery is not clear.

In Volume 1, we discuss how, in both Mexico and the United States during the nineteenth century, cemetery reform resulted in the placement of cemeteries on the outskirts of settled areas, outside the control of ecclesiastical authorities, and increasingly under the jurisdiction of municipal authorities, in part because of health concerns and a growing interest in promoting more-egalitarian treatment of the dead (Laderman 1996; Lomnitz 2005; Voekel 2002; Will de Chaparro 2007). The Civil War also had a pronounced effect on American approaches to death and burial, spurring pan-religious or secular approaches to burial treatment and cemetery use (Faust 2008). The establishment of the civilian section of the Alameda-Stone cemetery could have been prompted by any number of events, including (1) a cholera epidemic in Tucson in 1851, which killed a quarter of the population; (2) the Gadsden Purchase of 1854, which made Tucson a part of the United States and initiated the immigration of people into Tucson from diverse parts of the globe; (3) the arrival of French missionaries in the late 1850s, who were accustomed to suburban cemeteries; and (4) the occupation of Tucson by the U.S. Military beginning in 1862, which appears to have resulted in the formation of the military section of the Alameda-Stone cemetery. Unfortunately, no information has survived about exactly when or why the civilian section of the cemetery was first established, and until new information comes to light, the precise beginning of the Alameda-Stone cemetery will remain speculative.

End dates for the use of the cemetery are more certain. The civilian section was officially closed in June 1875. The military section remained open for interment until January 1881, when the last interment was placed in the cemetery. Unofficial interment of a few individuals could conceivably have occurred within the cemetery, on occasion, until the cemetery was completely abandoned for residential development of the property in April 1889, but the vast majority of burials were likely placed in either section prior to the official closing dates (O'Mack 2005, 2006).

When first established, the cemetery was located on the outskirts of town. As the city grew, and after the arrival of the railroad in 1880, the cemetery came to be surrounded by development. In February 1881, the Tucson City Council granted Block 254 to the Trustees of School District No. 1, Pima County. The block, which contained the southwest corner of the cemetery, including the entirety of the military section, was granted on the condition that the city would not be responsible for removing any burials from the parcel (O'Mack 2006:13).

Community members were notified in January 1882 in the local English- and Spanish-language newspapers that they had 60 days to remove the bodies of friends and family from the civilian section (*Arizona Daily Star* [*ADS*], 7 January 1882:3; *El Fronterizo*, 13 January 1882; O'Mack 2006:14). Reburial was to occur at a new cemetery established northwest of town. The new cemetery was referred to as the Court Street Cemetery, because Court Street was extended to meet it. No records have been found that indicate how many individuals were exhumed from the civilian section or how many were reinterred at the Court Street Cemetery (O'Mack 2006:14, 15, 71). Presumably, the cost and compressed schedule for reinterment may have prevented a strong response to the notification to remove remains from the old cemetery. Alternatively, some citizens may have assumed that remaining burials would be removed by authorities, if not removed by friends and relatives.

Interest in abandoning the use of this land as a cemetery increased during the late 1870s and early 1880s. Citizens complained of improper use of the cemetery grounds for illegal dumping, vandalism, and other illicit activities, and the city council became interested in auctioning for development the land containing the cemetery. Much of the discussion at the time centered around the dilapidated state of the military section, which was referred to colloquially at the time as the "National Cemetery.[1]" Under pressure from the city government, the U.S. military contracted in June 1884 to have burials removed from the military section. All known burials remaining within the military section were removed and reburied at a new cemetery at Fort Lowell (O'Mack 2006), although it appears that many of the civilians or former military buried in the western half of the military section were previously removed, as their graves were found to be empty (Heilen et al. 2008). Incidentally, the individuals reburied at Fort Lowell were again exhumed and reburied at the National Cemetery in San Francisco in 1891 (Callender 1998:112–113; Faust and Randall 2002:93).

In April 1889, the Tucson City Council ordered the City Surveyor, John Gardiner, to plat and number lots contained within acreage that encompassed the cemetery. Tucson residents petitioned the city council not to sell the lots, but the petition was denied, and on April 15, lots within the cemetery were sold at auction. Buyers of the lots immediately began developing plans to erect buildings on the former cemetery (O'Mack 2006:16–17). By February 1890, the *Arizona Daily Citizen* reported that contractor A. J. Davidson was preparing "to grade all the lots in the old city cemetery" (*Arizona Daily Citizen*, 8 February 1890:4). Little specific knowledge of the cemetery persisted in official documents in the years to follow, although residents and construction workers repeatedly discovered human remains during ground-disturbing activities after the cemetery was abandoned (O'Mack 2006:Table 6).

O'Mack (2006) discovered several newspaper accounts of disturbances to the cemetery after its closing, the largest of which involved excavation of the Tucson Newspapers building basement in two phases, in 1940 and an addition in 1953. The excavation of this basement disturbed what the Joint Courts Complex project revealed to be a large but unknown number of burials in the southwestern portion of the Alameda-Stone cemetery. A newspaper notice mentioned the discovery of a skeleton during the 1940 excavations (*ADS*, 10 January 1940:5). During the 1953 excavations of the Tucson Newspapers basement, the *Tucson Citizen* reported that 80 individuals were represented in the skeletal remains, "although only 36 individuals were complete enough to study" (*Tucson Citizen*, 9 July 1953). The *Arizona Daily Star* later reported that more than 150 skeletons were found (*ADS*, 24 February 1955); 47 of those individuals were curated at the Arizona State Museum and analyzed as part of this project (Hefner et al. 2008). Archaeological evidence presented in this chapter, although admittedly speculative, suggests that the number of burials disturbed by the excavation for the Tucson

[1] Presumably, this appellation was intended to lend a level of importance to the cemetery that was on par with the national cemeteries that had been established by the federal government to provide permanent resting places for the several hundred thousand Civil War dead (O'Mack 2006:8). Despite use of the term "National Cemetery" by some citizens to refer to the cemetery at Stone Avenue and Alameda Street, it is clear that the military cemetery was not a viable candidate for inclusion in the National Cemetery system because of its association with a relatively isolated and impermanent post. Although in our earlier reports we referred to the entire cemetery as "Tucson's National Cemetery," further review of military documents and information on the National Cemetery system suggests this label for the cemetery is a misnomer. Moreover, the name itself implies a bias toward Euroamerican and military use of the cemetery, although most users of the cemetery were Mexican American civilians, and burials in the military section constituted only a small percentage of all the burials in the larger cemetery. As a result, we refer to the cemetery by its geographic location, as the cemetery at Alameda Street and Stone Avenue, or more simply, the Alameda-Stone cemetery.

Newspapers basement could have been substantially higher than was reported. Other disturbances to the cemetery included utility trenches, tree pits, building foundations, trash pits, roadbeds, privies, and cesspits.

Remarkably, when the cemetery was professionally excavated by Statistical Research, Inc., in 2006–2008, the majority of grave pits and the burials within them were found to have remained largely intact. The result was a wealth of archaeological and osteological data on a historical-period cemetery that contained an unprecedented number of burials, in comparison to other professionally excavated cemeteries, as well as one that was used by an ethnically, religiously, and socioeconomically mixed community. The cemetery was established, used, and abandoned during a crucial period in the American West, when the United States had recently acquired southern Arizona (including Tucson) and migrants from Mexico, other parts of the United States, Europe, Canada, the Caribbean, and South America were converging on Tucson to seek opportunity in a changing land. Other individuals came from families who had lived in the vicinity of Tucson for generations and, in the case of the Tohono O'odham, for centuries. This was a period of conquest and contestation, when cultures clashed, merged, and changed in the face of competing interests, beliefs, and ways of life (see Chapter 5, Volume 1 of this series, for a discussion of the historic context of Tucson while the cemetery was in use).

Archival Research

Prior to fieldwork, Statistical Research, Inc., conducted extensive archival research on the history of the cemetery (O'Mack 2005, 2006). The purpose of the archival research was to seek information on the following topics:

When was the cemetery in use?

Which segments of the community used the cemetery?

How was the cemetery organized according to religious, ethnic, or other affiliations?

How many individuals were likely to have been buried in the cemetery?

Who was buried in the cemetery, and where they were located?

Where were the limits of the cemetery and any documented internal divisions located, with respect to the project area?

How many burials were exhumed historically, and where were they located?

What was the nature and extent of possible disturbances to the cemetery after the cemetery closed? and

What was the burial sensitivity of different parts of the project area?

Conducting archival research prior to fieldwork was crucial to gaining as complete an understanding of the cemetery as could be gleaned prior to excavation. Archival research, for instance, allowed Pima County and Statistical Research, Inc., to know in advance where to expect certain features and which attributes to look for when trying to identify specific features or cemetery areas. Archival research also allowed Statistical Research, Inc., to gauge how many burials could be expected, depending on the level of disturbance and previous exhumation, and to assess the range of variation in cultural affinity and mortuary behavior. Such information provided Pima County with a better understanding of what to expect during data recovery and with advance knowledge of which descendant groups were likely stakeholders in the project. But despite the wealth of information developed regarding some aspects of the cemetery's history and use, archival research left many other questions unanswered. As O'Mack (2006:1) noted, "the most surprising discovery [resulting from the archival research] is how little documentation of the cemetery exists . . . . We have had to rely heavily on scattered, often incidental references to the [cemetery] in a variety of sources, and we can provide only partial or tentative answers to most of the questions we set out to answer."

In this chapter, we outline what has been learned thus far about the history and archaeology of the cemetery in terms of the topics listed above. We rely on archival information developed by O'Mack (2005, 2006), as well as additional archival information gathered by Heilen during visits to the National Archives in Washington, D.C., in July and October of 2008. Archaeological data developed as a result of excavations at the site (Hall et al. 2008; see Appendix H) are presented in this chapter and used to supplement or evaluate the archival evidence. Chapters 5 and 6 describe in greater detail the mortuary archaeology of the cemetery and provide descriptive information on the spatial and demographic distribution of feature and artifact types and attributes from the cemetery portion of the project. Osteological analyses of human remains from the cemetery are described in Chapters 7 through 14 and integrated more thoroughly with historical and archaeological information in Volume 1. Like the rest of the chapters in this volume, this chapter is largely descriptive. In Volume 1, we take a much more synthetic approach to interpreting the organization and use of the cemetery and the lives and deaths of the people who were buried there.

Periods of Use as a Cemetery

Statistical Research, Inc., was unable to uncover archival information that clearly indicated when the cemetery was first used, but it appears that the first burials were likely placed in the early 1860s, or perhaps earlier. We do not know whether the first burials were placed in the military or civilian section or whether the first uses of these two sections were roughly contemporaneous. Currently, as is discussed below, the earliest unambiguous evidence for use of the Alameda-Stone cemetery was the placement of a series of burials in the military section in 1862.

As O'Mack (2005:35–36) discussed, the oral-historical testimony of a few early Tucson residents suggests that the area near what is now the intersection of Stone Avenue and Alameda Street was first used for civilian burials no later than the early 1860s (see also Gallego 1935:76; Lockwood n.d.:8). Prior to that time, Tucson's inhabitants were buried in a cemetery adjoining one or more sides of the small chapel dedicated to San Agustín, located just inside the east wall of the old presidio, near modern Church Street (Thiel n.d.; Thiel et al. 1995:38). The absence of the chapel cemetery on the 1862 map of Tucson, prepared by order of Major David Fergusson shortly after the California Column's arrival in May 1862, suggests that the cemetery at San Agustín may have no longer been in use (Byars 1966; O'Mack 2005:35–36, 2006:7). The Fergusson map does not show the Alameda-Stone cemetery either, though, perhaps because informal use of that area as a burial ground had just begun.

Numerous burials of Native American and Hispanic individuals have been discovered archaeologically along Alameda Street, between Church and Court Avenues, in the area corresponding to the former chapel cemetery (Faught 1992; Thiel et al. 1995:105–118) (Figure 23). Also, a double burial of two adult males was discovered by Statistical Research, Inc., in the north-central portion of Block 180, near Council Street, midway between the cemetery at San Agustín and the Alameda-Stone cemetery. Both individuals appear to have possibly experienced violent deaths outside of Tucson and been subsequently buried together in a shallow grave sometime in the mid-nineteenth century (Ciolek-Torrello and Swanson 1997:140–147). Ciolek-Torrello and Swanson (1997:145) suggested that "the lack of personal artifacts, the shallow nature of the grave, and its location outside of a consecrated cemetery all suggest these were hurried and perfunctory burials." Additional historical-period burial spaces that have been documented archaeologically in Tucson include an early Native American burial ground south of 17th Street that dates to sometime during the seventeenth and eighteenth centuries; the nineteenth-century burial of a cowboy near 7th Avenue and 20th Street; and two graveyard areas within the San Agustín Mission complex dating to the late-eighteenth and early-nineteenth centuries, across the Santa Cruz River from these other burial spaces (Hard and Doelle 1978).

The earliest burials we know of having taken place in the Alameda-Stone cemetery occurred shortly after Tucson was occupied by California volunteer units under the command of Lieutenant Colonel J. R. West (First California Infantry) on May 21, 1862. Prior to that date, Tucson had been occupied by Confederate soldiers

under the command of Captain Sherod Hunter, who had fled the settlement upon word of the Column's advance (Masich 2006). Unless use of the military section was initiated prior to the arrival of the California Column in May 1862, it is likely that the first burials were placed in the cemetery during the late spring or early summer of 1862, after the Column arrived. We discovered no archaeological or historical information that suggested the burial of a Confederate soldier in the military section. We know specific information about some burials in the military section from a series of burial lists discovered at the National Archives (see below). Based on those military records, the earliest known date of death for individuals documented to have been buried in the military section is July 12, 1862, for the deaths of Sergeant John C. McQuade (Company B, Second California Cavalry) and Private James L. Richards (Company H, First California Infantry).

An 1881 record lists the first eight burial numbers as corresponding to the burials of unknown soldiers of the California Column, although the patterns in dates of death suggest that the sequence of burial numbers assigned historically does not correspond closely with the chronological sequence of burials in the military section of the cemetery. All dates of death in the first two rows on the eastern side of the military section (historical-period grave numbers 1–34) (Figure 24) indicate a sequence of burials from north to south. If the first burial was placed in the northeast corner of the military section (i.e., historical-period grave number 16) instead of the southeast corner (i.e., historical-period grave number 1) and subsequent burials in the first row were placed immediately to the south of an existing burial, then there would have been only three burials (historical-period grave numbers 14–16) in the cemetery prior to the burial of Sergeant McQuade and Private Richards in July 1862. Another and perhaps more distinct possibility is that Sergeant McQuade and Private Richards (historical-period grave numbers 12 and 13, respectively) were indeed the first buried in the cemetery and that subsequent burials extended the row in which they were placed in both directions, north (historical-period grave numbers 14–16) and south (historical-period grave numbers 1–11).

At least two individuals eventually buried in the cemetery died prior to the occupation of Tucson by the California Column. Second Lieutenant James Barrett (Company A, First California Cavalry) and Private George Johnson (Company A, First California Cavalry) were killed by gunshot wounds during a skirmish on April 15, 1862, with Confederate troops at Picacho Peak. Private William S. Leonard (Company D, First California Cavalry) died the following morning from a gunshot wound suffered during the skirmish. (*List of the Captured, Missing, Killed and Wounded in Action, of the 1st Regiment of Cavalry Cal Vols,* signed by Lieutenant Colonel E. E. Eyre, First California Cavalry). These individuals were initially buried in an impromptu cemetery at Picacho Peak, but Privates Johnson and Leonard were later exhumed and reburied in the military section in Tucson. In an 1866 report on the condition of cemeteries in southern Arizona, including the cemetery at Tucson and the cemetery at Picacho Peak, Assistant Quartermaster Gilbert Cole Smith reported that the cemetery near Picacho Peak was "Enclosed. Not now in use. Head Boards placed. Bodies can be identified. Area 20 ft by 15 feet . . . . The site is good though it should not be continued as a Cemetery. Is on Public Lands of the U.S. Would be as well to leave bodies where they are" (National Archives and Records Administration, Record Group 92, Entry 225, Box 1159; for a brief description of Smith's military career in Arizona, see Altshuler 1985:8–10). The remains of Privates Johnson and Leonard, however, were moved to the military section in Tucson sometime in 1868, to the south of burials that had been placed in the cemetery late in 1867.

Although we cannot pin down a precise beginning date for the Alameda-Stone cemetery, we do have relatively secure dates for its closing. The civilian section was closed in 1875. O'Mack (2006:10) found that, in April 1875, a committee consisting of city council members R. N. Leatherwood, C. T. Etchell, and S. Hughes was formed to consider the utility of closing the old cemetery and moving it to an area in the northwest part of town (Tucson City Council minutes, 10 April 1875). A few weeks later, the council resolved to set aside 10 blocks of the town site (Blocks 7–16) for a new cemetery (Tucson City Council minutes, 27 April 1875). This new cemetery, which was created on the same day that the previous cemetery was resolved to be closed, came to be known as the Court Street cemetery, because it was bisected by Court Street (also known as Tenth Avenue) when the street was extended north from downtown to the new cemetery in May 1875 (Tucson City Council minutes, 10 May 1875). To ensure immediate use of the new cemetery and abandonment of the old one, the city council "[r]esolved that on and after the last day of May 1875 no more dead be interred in the old burial ground and clear publication be made that on and after the 1st day of June 1875 all dead be interred in

the new cemetery, and that notice be given by publication in conformity with law" (Tucson City Council minutes, 18 May 1875).

A notice to this effect appeared in the *Arizona Citizen* (*AC*) (29 May 1875:4), but a similar notice in a Spanish-language newspaper could not be found, perhaps because of a lack of available issues from that period. O'Mack (2006:10) argued that, along with the fact that the military section was allowed to remain open, "the unambiguous language of the closure resolution and the council's considerable efforts to open the Court Street cemetery on the day after the old cemetery closed strongly suggest that the city council was determined to stop burials in the civilian portion of [the cemetery] after May 31, 1875." No archival or archaeological evidence suggests that people continued to use the civilian section for burials in any regular manner. Instead, the evidence suggests that the Court Street cemetery had effectively taken the place of the Alameda-Stone cemetery.

The city council allowed the military section to remain open until February 1881. In a letter to the post dated February 15, 1881, the City Recorder, Charles H. Meyer, stated that no more burials were to be permitted in the military section (National Archives and Records Administration, Record Group 92, Entry 225, Box 1159). The *Weekly Arizona Citizen* soon reiterated the council's motion, stating that the council had moved "that the commanding officer at Fort Lowell be notified not to allow any more bodies to be buried in the military cemetery" (*Weekly Arizona Citizen* [*WAC*], 20 February 1881:4). The last burial in the military section—that of Corporal John Lyons—was placed just a few weeks earlier, on January 23, 1881, the individual having died 2 days earlier in the post hospital after 2 months of illness (*Arizona Weekly Star* [*AWS*], 27 January 1881:3).

After Corporal Lyons's burial and the city's prohibition on further burial in the military section, a new military cemetery was established at Fort Lowell. The June 1884 reinterment list, which documented the exhumation of remains from the military section in Tucson and their reinterment at Fort Lowell, lists five individuals whose remains were buried in the new Fort Lowell cemetery prior to the transfer of remains from Tucson in June 1884. The date of the first burial at the new Fort Lowell cemetery, a former teamster of the Quartermasters Department, Patrick Scully, is missing. The second burial listed, that of Sergeant George Mitchmoore, Company M, Sixth U.S. Cavalry, was placed on May 12, 1881, the individual having committed suicide the previous day with a Springfield rifle. Assistant Quartermaster G. C. Smith mentioned these two burials in an endorsement dated June 22, 1881, which suggests that Patrick Scully was buried at some point between January and May of 1881. The third burial at the new Fort Lowell cemetery, that of Sergeant Rufus Sumerby, Company E, Sixth U.S. Cavalry (who also committed suicide by shooting himself), was not placed until December 26, 1882 (see also Callender 1998).

Statistical Research, Inc., found no clear archaeological evidence to contradict the idea that the military stopped using the military section after the burial of Corporal Lyons in January 1881. In fact, after the burial of Corporal Lyons, the city council was adamant that the U.S. Army immediately cease to use the military section of the Alameda-Stone cemetery and make immediate preparations for moving the cemetery to Fort Lowell. We did discover the grave of an infant near the northern limit of the military section that could have been placed after the military section had closed, but neither archaeological or documentary evidence indicated when this burial was placed. The infant could have been placed surreptitiously in the cemetery at some point during or after the military section was officially closed; we have no way of knowing when or why the burial of an infant was placed in that particular area.

As far as could be discerned, no artifactual evidence has come to light suggesting use of the civilian portion of the cemetery after 1875 or the military section after 1881. One burial in Cemetery Area 4 had military buttons that could have been made as early as the 1840s or 1850s, but those buttons continued to be used for military attire while the cemetery was still open. Two grave pits contained items that were common only after the arrival of the railroad in May 1880, but at least one correlates to the 1881 grave pit of Corporal Lyons; the other may have been in or adjacent to the military section, depending on where one places the limits of that cemetery, and it could have been placed between May 1880 and January 1881, after the railroad had arrived in town and before the military section was officially closed (see Chapter 5).

Cultural Affinity and Demography

Tucson was a multiethnic and demographically dynamic community during the period the cemetery was in use, with people of many different ethnic and religious backgrounds calling Tucson home. Local Native American groups, such the Tohono O'Odham, had lived in the vicinity of Tucson for centuries prior to the founding of the Tucson presidio in 1775. Apache were also active in the area, including groups of "pacified" Apaches who, during the first half of the nineteenth century, lived near the settlement (Dobyns 1976; Sheridan 1986).

Apache warriors were feared and maligned by Tucson residents, who had for generations endured raiding and warfare on the settlement. Available correspondence and newspaper reports from the period that the Alameda-Stone cemetery was in use are rife with references to Apache "depredations." Outrage over Apache raiding activities erupted in the Camp Grant Massacre of 1871, in which a large group of Tucson residents and Tohono O'odham attacked the Apache camp at Camp Grant and brutally murdered around 100 women and children while the men were away hunting (see Chapter 5, Volume 1 of this series). At the same time, Apache scouts were commonly employed by the U.S. military in Tucson, as were scouts of other Native American and Hispanic backgrounds. For instance, in 1869, Henry K. Durrant, the Assistant Surgeon for Camp Lowell, wrote that "[i]n the immediate vicinity of Tucson, is the Papago tribe of Indians, and a few 'tamed Apaches,' both being friendly, and many of them employed by the military as guides and Scouts against the hostile bands" (National Archives and Records Administration, Record Group 94, Entry 547, Box 13). Yaqui had also begun to migrate into Tucson to escape slaughter in their home communities in Mexico, although larger migrations occurred in the decades following the closing of the cemetery (Spicer 1962, 1980, 1984).

The different Native American groups living in and around Tucson would have held a variety of religious beliefs and performed diverse practices associated with death and burial. The religious life of the Yaqui, for instance, melded Hispanic Catholicism with native beliefs and practices to form a rich and unique religious tapestry. Some Tohono O'odham had likewise adopted Catholicism through almost a century of interaction with Spanish and Mexican influences, although others maintained traditional religious practices. As had happened in many other areas where aboriginal groups were missionized, Tohono O'odham probably developed syncretic or parallel concepts that drew from both native and Catholic religious concepts and traditions, rather than accepting Catholic beliefs and traditions wholesale (Erickson 1994; Underhill 1946) (see Chapter 8, Volume 1 of this series).

The majority of Tucson residents were Mexican American families who practiced a Catholic faith; some families had, by the 1860s, lived in Tucson for several generations. Other Tucson residents were recent migrants from nearby Mexican states, such as Sonora, Sinaloa, and Chihuahua. Mexican Americans had developed a lifeway in the American Southwest that was based on farming and ranching, historically centered on the protection and influence of Spanish presidios and missions. Necessarily, aspects of the lifeways and technologies of Mexican American and Native American communities were intertwined, as these groups had interacted and led parallel lives since the arrival of the Spanish in the mid-sixteenth century (Sheridan 1986).

Other migrants to Tucson during the period the cemetery was in use included non-Hispanic Euroamericans—many of whom were adult males from different parts of the United States, Canada, or Europe—and a small number of African Americans. These individuals were often involved in economic or military pursuits associated with westward expansion of the United States, and though of diverse religious backgrounds, many were likely of Protestant or Catholic faiths and would have been referred to as "Anglo" in historical discussions. Sheridan (1986) shows that, during the period the cemetery was in use, recent Anglo-American migrants to Tucson held most of the real capital in Tucson, most white-collar jobs, and had begun to take control of most political positions in Tucson. In short, Anglo-Americans took advantage of political and economic power to a degree that was well in excess of their population proportion. According to some sources, Asian Americans were not common in Tucson until the late 1870s and early 1880s, many of them having first arrived in Tucson as railroad workers after the civilian section had closed (Lister and Lister 1989; see also Wang 2002). Lister and Lister (1989:1) noted that around 30 Sam Yap speakers from southern China were reported to be in town in September 1879, but many of them left when around 200 Sze Yap speakers from the same province in China arrived in town with the railroad, in March 1880.

Cultural Affinities of the People Buried

In compliance with the *Agreement on Treatment and Disposition of Burial Discoveries Dating After 1775* (Arizona Revised Statute 41-844, Case No. 06-14; see Appendix D), Statistical Research, Inc., assessed the cultural affinity of human remains according to the recognized cultural categories of Native American, Hispanic, African American, and Euroamerican. The term "Euroamerican" was used to refer to individuals who were likely of Euroamerican affinity but not of Hispanic affinity and therefore are referred to in our cultural-affinity efforts as non-Hispanic Euroamericans. Asian Americans were invited to participate as a potential descendant group, but they declined to participate, as they felt the cemetery predated their presence in Tucson. Indeed, no remains were discovered that could be associated with an Asian American affinity, and historical records are silent regarding the presence of Asian Americans in Tucson until a few scattered references to the presence of Chinese individuals in Tucson appear in the latter half of the 1870s (Lister and Lister 1989), after the civilian section had closed. Attempts at more-specific Native American affinities, such as Apache or Yaqui, were made if biological, contextual, and historical information warranted the distinction. Such distinctions were rare, given the inherent difficulties in identifying individuals to the level of tribal affinity (Hefner et al. 2008) (see Chapter 6, Volume 1 of this series).

There can be considerable ambiguity in assessing cultural affinity from osteological and archaeological information. Cultures are fluid and dynamic, and cultural affinity is neither immutable nor timeless. Further, individuals who share a close biological ancestry may not share the same cultural background, because of circumstances like adoption, personal choice, or culture change. In addition, intermarriage among groups confounds the ability to clearly delineate group membership using information on biological ancestry or material culture alone (see Chapter 6, Volume 1 of this series).

The period that the Alameda-Stone cemetery was in use was one of intense cultural, economic, and political change in Tucson (see Chapter 5, Volume 1 of this series). Following a method used by Sheridan (1986) for the Mexican Heritage Project in Tucson, we provisionally classified each individual listed in the 1860, 1864, 1870, and 1880 census data for Tucson according to cultural affinity, sex, and age, in order to gain a better understanding of the demographic composition of the cemetery (Table 18). We did the same for the Tucson Diocese burial records and the 1870 mortality schedule for Tucson for the period in which the civilian section was in use (Tables 19 and 20, respectively).

Ethnic distinctions and labels tend to emerge in contexts, such as these, that involve the interaction of people with distinctive backgrounds, beliefs, languages, and lifeways (Barth 1969; Cohen 1978; Jones 1997). The meaning and significance of ethnic and other cultural distinctions varied through time as well as contextually, as identity is multilayered, complex, and socially contingent. As such, affinity assessments were not intended to essentialize and label groups living in Tucson. Rather, affinity assessments were made to chart the possible ethnic and religious composition of the burial population and to contribute to cultural-affinity assessments made for the human remains recovered during data recovery, in accordance with the burial agreement.

Cultural-affinity designations were made based on first and last names, place of birth, remarks, historically made racial or ethnic distinctions, and, in some cases, close examination of the demographic composition of a particular household. For instance, people with Spanish-language first and last names were inferred to be Hispanic, particularly if they were born in Mexico, California, Arizona, or New Mexico and no other information indicated they were potentially of a different cultural background, such as Yaqui or Tohono O'odham. In a few cases, individuals in census records were identified as Hispanic because they had Spanish first and last names and were born in Spain or in South America, rather than in the American Southwest. Some Native Americans would have been listed in the census record with Spanish names, but without additional information indicating a possible Native American affinity, such individuals were assigned by default to the affinity of Hispanic. As a result, some individuals assessed as Hispanic could have been Native American, and of course, aspects of many individuals' lives could have represented a blending of different cultures. Native Americans were generally identified in historical records in cases where the record specifically indicated an individual was Native American or had a Native American parent or was identified with a specific Native American group. African Americans were identified in the census records based on their racial designation as "Black." People identified as Euroamericans (not including Hispanics) were individuals for which there was no indication of a Hispanic

heritage but who had non-Hispanic Euroamerican first and last names and whose places of birth or former residences were indicated as being in Canada, Europe (not including Spain), or some other area of the United States, such as the northeastern United States. In some cases, an adult male assessed as Euroamerican was identified in the census records as living in a residence with a younger Hispanic female of childbearing age who shared the last name of the household head. The apparent children of such couplings were identified as individuals who shared the man's last name and who were young enough to have been the child of the couple. Interestingly, there was a tendency for mixed-heritage boys to be given a non-Spanish first name and for girls to be given a Spanish first name. The Mexican Heritage Project identified such children as Hispanic because the community they grew up in was largely Hispanic, but we chose to clearly identify the children of these partnerships as Hispanic/Euroamerican to reflect a mixed cultural heritage, should the distinction prove useful in future analysis.

Cultural Affinity and the Tucson Diocese Record

During the archival research, Pima County and Statistical Research, Inc., were provided a photocopy of the Tucson Diocese burial record by Los Descendientes del Presidio de Tucson, a local group dedicated to studying and preserving Tucson's Spanish and Mexican heritage. This record was extremely valuable in understanding who among the Catholic population of Tucson was likely buried in the cemetery, as well as in modeling and interpreting the demography and mortality of Tucson's population during the 1860s and 1870s. We used this record in multiple ways to understand the population in Tucson and to interpret findings from the cemetery (see Chapters 6 and 7, Volume 1 of this series), including in modeling the cultural affinities of the burial population. The span of years covered by the diocese register is 1863–1887, but there are some gaps, apparently reflecting losses of portions of the manuscript. The surviving manuscript has two distinct parts. The first part covers the period May 28, 1863, to January 3, 1880, and consists entirely of handwritten entries on plain paper; this part of the register has 1,772 entries. A second part, covering the period from January 3, 1883, to January 24, 1887, consists of handwritten entries on a commercially printed "Record of Interments" with columns and headings; this part of the register has 542 entries. The reason for the 3-year gap between the two parts of the register is unknown. The change in formats is probably related to the increased availability of commercially printed forms after March 1880, when the Southern Pacific Railroad reached Tucson (O'Mack 2006). O'Mack (2006; see Appendix B) transcribed and summarized the diocese record. The first part of the record is of particular interest to this project, in that it lists burials of interest to the Catholic Church in Tucson during the period that the civilian section of the Alameda-Stone cemetery was in use.

We reviewed the records to determine which burials occurred from the beginning of the record in 1863 until the official closing of the civilian section on May 31, 1875. Because the record does not indicate specifically where each individual was buried, we also determined, based on notes in the record or other documentary evidence, which burials in the record were likely not to have occurred in the civilian section in Tucson. For instance, several burials are noted as having occurred in the cemetery at the San Xavier del Bac Mission, located circa 10 miles south of Tucson, and we know a few other burials were in the military section.

While the civilian section at the Alameda-Stone cemetery was in use, 2 individuals listed in the record—Blas Ayni and Leonor Rosales y Sotelo—appear to have been buried at Tubac, and 17 individuals, who were either Hispanic or "Papago," appear to have been buried at San Xavier del Bac. Based on military records, we know another 6 individuals listed in the diocese record were buried in the military section of the Alameda-Stone cemetery. These were Private Martin Burns (Company E, Twenty-third U.S. Infantry), Sergeant James Carroll (Company E, Twenty-third U.S. Infantry), Private John Finegan (Company C, First U.S. Cavalry), Private Michael Keegan (Company A, Twenty-first U.S. Infantry), Private Peter O'Connor (Company D, First U.S. Cavalry), and Private Lack Tierney (Company D, Eighth U.S. Infantry). All of these individuals were born in Ireland, suggesting they could have been of Irish Catholic background. Perhaps some of these individuals were provided burial services officiated by a Catholic priest. When available, the U.S. Army may have provided Episcopal religious services, rather than Catholic ones, as was the case when the Reverend Preston Nash, U.S. Army, performed Episcopal services for the burial of the Honorable John Titus, which occurred in

the military section in October 1876 (*AC*, 21 October 1876:2). By contrast, Corporal John Lyon, also buried in the military section, was "buried with military honors from the church of San Augustin, Father Antonio officiating" (*WAC,* 30 January 1881:1). Because Corporal Lyon's burial occurred in 1881, during a period for which we have no diocese records, we do not know for certain whether his burial would have been listed in the diocese record, but because it was officiated by a Catholic priest, presumably it would have been.

When constrained according to time and burial location, the diocese record includes 944 individuals who were likely to have been buried in the civilian section (see Table 19). The vast majority of these individuals were assessed as having a Hispanic cultural affinity. The others were either Native American, of a non-Hispanic Euroamerican cultural background, or had a Hispanic mother and non-Hispanic Euroamerican father. Cultural affinities of the individuals listed include Hispanic (n = 855), undetermined affinity (n = 31), Apache (n = 16), Native American (n = 11), non-Hispanic Euroamerican (n = 11), Hispanic/non-Hispanic Euroamerican (n = 9), Yaqui (n = 6), and "Papago" or Tohono O'odham (n = 5). Individuals whose affinities could not be determined were individuals for whom very little information was recorded.

Cultural Affinity Based on Census Data

As discussed previously, the Tucson Diocese burial record is an incomplete one, both temporally and socially. There are a number of gaps in the record while the cemetery was in use, and based on comparison with other records, the record appears to include only those burials of interest to the priests of the Catholic Church. The remaining burials in the cemetery did not make it into this record (O'Mack 2006).

As a result, an alternative method of estimating the cultural affinities of the burial population was needed. We used the 1860, 1870, and 1880 federal census records for Tucson and the 1864 territorial census records to model the cultural affinities of the burial population. It was difficult to get a clear understanding of cultural affinity from the census records for several reasons, however. For instance, in different census years, people were listed according to racial designations that appeared to shift over time, and for at least one census, a limited diversity in racial designations seems to suggest that some groups, such as Native American groups, may have been overlooked. In the 1870 census, for instance, nearly every individual is identified as "White," with the exception of four individuals listed as "Black." Evidently, both Hispanics and non-Hispanic Euroamericans were placed in the same racial category at this time, but we do not know for certain whether all Hispanics were considered the same or "non-White" Hispanics were excluded from the census. By the 1880 census, "Mexican" emerges as a racial label, along with the category of "Chinese," but people born in Mexico and having Spanish first and last names are listed as either "Mexican" or "White" in the census, presumably based on physical or cultural characteristics interpreted by census takers as indicative of either "race." Although we were not surprised that racial categories shifted during the period in question, nor that historical racial designations are not a good index of cultural affinity, the shifting labels and their application suggest the possibility of bias in who was recorded and how they came to be represented in the census records.

Another problem encountered when trying to assess cultural affinity from census records was that some individuals assessed as Hispanic could have been Native Americans with Spanish names. Individuals of clearly Native American affinity are notably absent from the records, as though such individuals were overlooked or their identities masked in the census records. Without a detailed genealogical study, which is beyond the scope of this project, it was impossible to sort out which individuals assessed as Hispanic were actually of a Native American or other cultural affinity.

As a result of these problems, the census records were mostly useful for getting a sense of what percentage of the population was Hispanic, which we gauged to have been around 75–80 percent during the period the civilian section was in use. Another 10–15 percent were probably non-Hispanic Euroamerican, perhaps 5–8 percent were Native American, and a few percent or less were African American. Again, these numbers are crude approximations based on a limited and biased record.

Birthplace Based on Census Data

Another way to think about the demography of the population in Tucson is to consider whether individuals were born within the region or somewhere outside the region. For the purpose of this analysis, we considered the regionally born group to consist of individuals born in Arizona, New Mexico, California, or Mexico. The vast majority of these individuals were born either in Arizona or northern Mexico. The extraregional group consisted of people born everywhere else, which included people born in Canada, the Caribbean, the northeastern United States, the southeastern United States, the midwestern United States, Europe, the Middle East, South America, North Africa, East Asia, and Southeast Asia. The vast majority of individuals from outside the region were from the eastern United States or northern or western Europe (Tables 21–24).

The regionally born population was more likely to be organized around families, with many individuals of Hispanic Catholic or Native American backgrounds and with relatively even age and sex distributions. By contrast, the population born outside the region consisted mostly of adult males, some of whom started families with local brides. Many of the individuals born outside the region spoke English or a northern or western European language as a mother tongue and were probably often of Protestant or, less often, Catholic or Jewish upbringing (see, for example, Grytz 2006). Sheridan (1986) showed that the local Mexican American population during this period in Tucson consisted mostly of blue-collar workers, although some Mexican Americans were prominent merchants or politicians. By contrast and despite their recent arrival, non-Hispanic Euroamericans held most of the white-collar jobs, as well as a greater percentage of skilled and semiskilled blue-collar jobs, and controlled most real capital and many political positions.

People born within the region were more likely to have had cultural and genetic ties with the local community, even if they grew up as children somewhere outside Tucson. By contrast, many of the people who migrated to Tucson from outside the region had, at least initially, few or no cultural or genetic ties with people who grew up in the region and probably affiliated themselves most often with other migrants from outside the region, as well as people who shared the same homeland or a similar upbringing. In interpreting the organization of the Alameda-Stone cemetery, this distinction in place of birth proves to be an important one, as there is compelling evidence that the northern part of the cemetery was representative of the regional, Hispanic Catholic community and the southern part of the cemetery was representative of everybody else, many of whom were probably relatively recent arrivals from outside the region and who shared fewer cultural or genetic ties with the local community (Daughtrey et al. 2008; Heilen et al. 2008).

Estimation of the Number of Burials Placed in the Alameda-Stone Cemetery

There are questions important to understanding the representativeness of the sample of graves investigated archaeologically by Statistical Research, Inc.: How many people were buried in the cemetery, and how does this compare to the number of individuals discovered archaeologically? Although Statistical Research, Inc., did indeed excavate and analyze all of the graves remaining in the project area, there were sections of the project area, most notably the location of the Tucson Newspapers building basement, where the cemetery had been destroyed by later urban development. There are also portions of the cemetery that are presumed to lie outside the boundaries of the project area, most notably in the southwest corner and possibly under Stone Avenue. We estimated the number of individuals interred in the cemetery using both historical and archaeological records. Using historical records, we estimated the number of individuals through (1) comparison of the Tucson Diocese burial record and the 1870 mortality schedule, (2) interpretation of maps and burial lists for the military section, and (3) estimation of population size and mortality, using census data and other records. Archaeologically, we estimated the number of individuals originally interred in the Alameda-Stone cemetery by combining a direct count of discovered grave pits, burials, and individuals with estimates of the number of burials obliterated by major disturbances that occurred historically in the project area.

Comparison of the Tucson Diocese Burial Record and the 1870 Mortality Schedule

By constraining the analyzed portion of the Tucson Diocese record to include only those burials that were not identified as occurring outside Tucson and that dated to before June 1875, when the civilian section was officially closed, we arrived at a figure of approximately 944 burials in the Tucson Diocese record that were likely placed in the cemetery in Tucson (see Table 19). This number corresponds only to those burials that the priests of the Tucson Diocese found to be of interest and is not an all-inclusive list of burials in Tucson during the period of the cemetery's use. Another record of deaths in Tucson during the period the cemetery was in use was the mortality schedule of the U.S. Federal Census of 1870. The mortality schedule is a list of 139 individuals who died in Tucson between around June 1, 1869, and May 31, 1870 (see Table 20). The mortality schedule itself is a biased and incomplete record of death in Tucson, as the accuracy and completeness of the schedule was entirely dependent on the quality of information provided by informants and the abilities of the census takers to accurately comprehend and render the information obtained.

O'Mack (2006) compared the Tucson Diocese record with the 1870 mortality schedule to get a sense of how complete the Tucson Diocese record was in recording burials in Tucson during the period the cemetery was in use. O'Mack (2006:Table 4) was able to find 24 individuals who appeared to have been listed in both the 1870 mortality schedule and the Tucson Diocese record. O'Mack (2006:66) encountered considerable difficulty in comparing the two records because of discrepancies in name spellings and other details between the two. For instance, the date of death was sometimes off by a month or more in the 1870 mortality schedule when compared to the Tucson Diocese burial record, perhaps owing to the way the data was collected. We briefly revisited the two records and were able to add several more individuals who likely appeared in both records. With these additions, the gross reporting rate of the Tucson Diocese burial record is estimated at around 54 percent.

As noted above, however, the Tucson Diocese record is essentially a record of burials that were of interest to the Catholic Church and may include mostly those burials of individuals who were active in the Catholic Church. Over 90 percent of the people listed were Hispanic (94 percent, if individuals of undetermined affinity are removed), when we know from U.S. Federal Census records that the percentage of Hispanics was lower during the period the cemetery was in use. Therefore, an alternate way to compare the two records is in terms of the Hispanic reporting rate. This estimate suggests that the Tucson Diocese burial record reported the burial of approximately 64 percent of Hispanics in 1870.

It must be acknowledged that this estimate suffers from a number of biases, not the least of which is the fact that an outbreak of smallpox in the early months of 1870 killed a large number of individuals in Tucson, many of whom were Mexican American children (see Chapter 7, Volume 1 of this series, for information on epidemics in Tucson). There is also some apparent demographic bias in who was listed in both records. The individuals who appear to be listed in both records were young individuals (mean age = 7.7 ± 3.9 years; n = 36), whereas there were a lot more adults as well as children among individuals listed only in the 1870 mortality schedule (mean age = 17.1 ± 3.3 years; n = 103). This is likely because non-Hispanic Euroamericans, who were mostly adults, appeared most often in the mortality schedule and not in both records, whereas many of the deaths in the diocese record for the period were Hispanic children. There may have been a tendency in the 1870 mortality schedule to remember those deaths that people felt were tragic or that lingered longer in the minds of mourners and their friends, such as those of children taken suddenly by an outbreak of disease, but the ages of individuals listed only in the diocese record for the period between June 1869 and May 1870 (mean age = 9.1 ± 2.9 years; n = 86) are only somewhat higher than those of individuals listed in both records.

In order to estimate the burial population using the diocese record, we first grouped burials into a series of temporal groups, each 12–14 months long, and generally began a temporal group in June of each year. This approach turned out to be very consistent with available date ranges of the records, as well as with the closing of the civilian section in June 1875, and allowed us to analyze the record in terms of relatively uniform temporal units. We then used the number of known burials in a given temporal group to estimate the number of burials in periods where there were gaps in the record. Based on the Hispanic reporting rate, we can estimate that close to 1,600 Hispanic individuals were buried in the cemetery (Table 25). Another 300–500 non-Hispanic

individuals can be posited, based on our understanding of the census data, suggesting a total of perhaps 1,850–2,050 individuals interred in the cemetery.

Estimating the Number of Burials from Population Estimates

As the above section demonstrates, it is difficult, if not impossible, to arrive at a precise estimate of the number of individuals likely to have been buried in the cemetery because of the incompleteness and inherent bias in the available historical records. An alternate way to model the size and composition of the burial population is to estimate population size and mortality rate for each year for different segments of the population. To estimate population size for any given year, we estimated the sizes of the Hispanic population and the non-Hispanic population for each year, using our cultural-affinity assessments as applied to the census record and assuming a linear increase in population size between census years. We then attempted to model the cumulative size of the burial population during the period that the civilian section is inferred to have been in use (1862–1875) by assuming standard mortality rates. Mortality rates were estimated for different segments of the population using the diocese records and the 1870 mortality schedule, which suggested mortality rates could be highly variable, ranging from over 30 percent for Hispanic infants to less than 2 percent for subadults (Table 26).

Rather than make our model overly complicated, we assumed an overall rate of 6.6 percent, based on the comparison of the 1870 mortality schedule and the diocese records. This relatively high mortality rate resulted in a burial population that seemed excessively large, 2,609 individuals (Table 27). Over half of the deaths in the 1870 mortality schedule were from smallpox, which may not have been as much of a factor in other years. By eliminating the smallpox component of the mortality rate, we modeled the burial population again, using a mortality rate of 3.3 percent for years other than 1870 (Table 28). This model resulted in a fairly conservative estimate of around 1,411 individuals in the burial population. A third model of burial population applied a variable mortality rate for each year, by adjusting the number of deaths in the diocese records by a factor of 1.56 for each year (based on a 64 percent reporting rate) and estimating the number of deaths for segments of time when there are gaps in the record. Mortality rates were then calculated using the estimated Hispanic population size for each year that the civilian section was in use. This approach resulted in mortality rates from 2 to 6.6 percent for the Hispanic population. We then applied these rates to estimate the size of the burial population, arriving at a figure of around 2,060 individuals (Table 29). It is difficult to decide which model provides the best estimate, but the model with a uniformly high mortality rate seems to produce too high an estimate, and the model with a smaller, uniform mortality rate seems to produce estimates that may be too low. However, our estimates of the number of individuals buried in the cemetery based on the diocese reporting rate and an alternate model based on archaeological evidence (see below) suggest that there were somewhere between 1,800 and 2,100 individuals buried in the Alameda-Stone cemetery. The result for the model with variable mortality rates falls within that range, suggesting that historical and archaeological models of the burial population size are generally in agreement.

Estimating the Number of Burials in the Military Section

Based on maps and burial lists, we have a reasonably accurate understanding of the number of individuals placed in the military section. The eastern half of the military section contained 65 recorded graves, each originally containing the remains of a single individual. A total of 32 grave pits were documented in the western half of the cemetery, 1 of which (that of the citizen Herbert Lord) only appeared on an 1873 plat map of the cemetery (Heilen et al. 2008). At least 1 grave pit in the western half of the cemetery contained 2 individuals. Harriet Davis and her infant daughter, Hattie, were buried a month apart in the same grave pit, labeled "A7" on the 1884 removal report (National Archives and Records Administration, Record Group 92, Entry 225, Box 1156; see also *AC,* 19 February 1876:2 and 11 March 1876:3). Another grave pit, labeled A28 on the 1884 removal report, may have also contained 2 individuals. The 1884 removal report indicated that the grave was "apparently two graves, or double grave, child," and the previous 1881 burial report indicated that the

grave was one of "Joanna Welisch, child." Reports of deaths in the *Arizona Citizen* indicate that the Welisch's had two infants who died 2 years apart, named Juanita (who may have been Joanna) and Edmund (*AC*, 4 April 1874:3 and 8 April 1876:2). Perhaps these two infants were both buried in the same or adjacent grave pits in the southwestern quadrant of the military section. Altogether, the consolidated records for the military section of the cemetery suggest that at least 99 individuals were buried in that section, although it is certainly possible that several more went undocumented.

Comparison with Archaeological Data

A total of 1,083 individual grave pits were identified during the Joint Courts Complex project. These 1,083 grave pits held a total of 1,006 burials representing 1,386 individuals (see Chapter 7). The total number of individuals includes 47 whose remains were recovered by the Arizona State Museum when the original Tucson Newspaper basement was excavated and 1 individual whose burial was excavated in the project area by Tierra Right of Way in 2001.

In order to determine how many burials may have been disturbed by the excavation of the Tucson Newspapers basement or how many burials could have occurred in other areas not excavated by Statistical Research, Inc., we modeled the original extent of burials in disturbed areas of the cemetery (see below). The estimate we arrived at was a total of between 1,800 and 2,100 burials placed in the cemetery, based on grave-pit density and the extent of areas likely to have been within the cemetery but not subject to professional archaeological investigation. The details of this analysis are presented later in this chapter, in a discussion on the probable effects of impacts on the cemetery during the Tucson Newspapers basement excavations.

Location and Identities of Individuals in the Cemetery

In addition to possessing a unique personal identity, people interact socially according to many different kinds of social identities, depending on the gender, familial, occupational, religious, ethnic, and other roles individuals play in households, communities, and other social networks. Archaeological and osteological information can be used to infer aspects of an individual's identity by examining the skeleton for evidence of labor practices, body-modification practices (such as dental work or cradle boarding), sex, age, trauma, and other factors and by examining mortuary contexts for evidence of mortuary treatments that can be used to infer the various social roles of the deceased or their mourners, including artifact associations, feature characteristics, and spatial relationships among individuals, burials, and grave pits. Of course, archaeologists have to be constantly aware of the fact that many of the characteristics of a burial are characteristics influenced strongly by the aspirations and perspectives of mourners, rather than those of the deceased. In addition, some aspects of burials might speak more to the roles the deceased are intended to play in death, rather than the roles they played in life. These kinds of complex, multilayered social identities are not discussed in any detail in this chapter. Instead, interpretations of the various social identities of individuals buried in the cemetery are reserved for subsequent chapters in this volume and the synthesis volume. In this section, we dwell only on the personal identities of specifically named individuals in the historical record and discuss the kinds of evidence we have for discovering who was buried in the cemetery and, when possible, where within the cemetery they were buried.

Statistical Research, Inc., was able to develop archival information on the personal identities of a substantial number of individuals buried in both the civilian and military sections of the cemetery by compiling information from the Tucson Diocese burial record, the 1870 mortality schedule, obituary notices, newspaper articles, and U.S. military records pertaining to the military section. We were able to develop information on the specific personal identities of around two-thirds of the individuals buried in the military section and of perhaps a little over half of the individuals in the civilian section.

Despite a wealth of information on who was likely or known to have been buried in the cemetery, archival research did not uncover any information on the burial locations of specific individuals within the civilian section. We were only able to develop information on the burial locations of specific individuals in the military section. Notwithstanding these efforts, for legal purposes, we were unable to positively identify any set of remains from the military section with a specific individual because of insufficient biological evidence (Heilen et al. 2008). In other words, although there was compelling evidence from a historical and archaeological standpoint that could lead to the identification of a set of remains in the military section, there was in no case sufficient evidence from a biological standpoint. Below, we discuss the records we examined to learn about who was buried in the cemetery and where they were located. As noted, the records examined included obituaries, mortuary records, the detailed diary of a local citizen (George Hand), the 1870 mortality schedule, the Tucson Diocese burial record, and U.S. military records.

Obituary Records

Obituary records were only occasionally published in area newspapers while the Alameda-Stone cemetery was in use. During the archival research for the project, O'Mack located the obituaries of a number of notable citizens, including those of Ella Stoutenborough Miles (*WA*, 2 October 1869:3), the wife of a Captain Evan Miles; Daniel H. Stickney (*WA*, 25 February 1871:3), president of the Territorial Council; and Mark Aldrich (*AC*, 27 September 1873:3), a prominent businessman and public official. James Ayres also generously supplied Statistical Research, Inc., with cemetery-related references from his Tucson historical-newspaper-indexing project, and each article referenced by Ayres was copied and examined by Statistical Research, Inc., for relevant information (O'Mack 2006:4).

After fieldwork was complete, we obtained from Homer Thiel a systematic compilation of transcribed newspaper articles about deaths in Arizona that occurred anywhere from 1859 through 1880. These included articles from available issues of *The Weekly Arizonian* (and *The Weekly Arizonan*), *The Southern Arizonian*, *The Mesilla Times, Arizona Citizen*, *Arizona Miner, Weekly Arizona Miner*, *Daily Arizona Miner*, *Arizona Free Press*, *Arizona Sentinel*, *Weekly Arizona Citizen, Arizona Weekly Citizen*, *Daily Arizona Citizen, The Daily Bulletin, Arizona Star, Arizona Weekly Star, Arizona Daily Star, Las Dos Republicas, El Fronterizo, Arizona Silver Belt, Tombstone Epitaph, Arizona Gazette,* and *Arizona Mining Index*. A few articles pertaining to deaths in Arizona that occurred between 1859 and 1880 were also found by Thiel in newspapers published outside Arizona by searching www.newspaperarchive.com and www.genealogybank.com in September 2007, using the keywords "Tucson," "Tubac," and "Arizona."

Necessarily, the dates of obituaries or other reports of deaths are restricted to the newspaper runs currently available. A number of the newspapers examined had limited runs, and many issues have not survived. The available newspaper articles included death notices for a number of individuals buried in either the civilian or the military sections of the Alameda-Stone cemetery, but the number reported is by no means comprehensive. In addition to dates of death and some information on a person's background or circumstances of death, a few notices provided additional details on funeral services. Unless the obituary was of a prominent citizen, most notices were relatively brief and often did not clearly indicate where an individual was buried. In Tucson, there was a slight tendency to specify the place of burial if the person was buried in the military section, particularly if the burial location was considered temporary, but in most cases, the precise location of burial was left unmentioned. For instance, the burials of the Honorable Daniel H. Stickney (*AC*, 25 February 1871:3), Peter Conlon (*AC*, 2 November 1872:2), Herbert Lord (*AC,* 8 November 1872:3), Harriet Davis (*AC*, 19 February 1876:2), the Honorable John Titus (*AC*, 21 October 1876:2), and Corporal John Lyons (*WAC,* 30 January 1881:1) were described in death notices as having occurred in the military section, but other contemporaneous deaths reported in the *Arizona Citizen* do not mention the specific places of burial. It may have been the case that the location of burial was implied to be the civilian section of the Alameda-Stone cemetery before June 1875 or the Court Street Cemetery after May 1875, unless otherwise noted.

Overall, the available newspaper articles are a valuable resource, but they also underscore the spotty and sometimes sensationalistic nature of death notices of the period in Arizona. Many reports of deaths pertain

either to prominent citizens or to individuals who died as a result of violent conflict, such as at the hands of Apaches or as a result of a criminal act of homicide. The everyday deaths of regular townspeople, particularly those of Mexican Americans, are notably underrepresented in newspaper articles. Limited newspaper documentation of the deaths of Mexican Americans who died under nonviolent circumstances may have resulted, in part, because most of the available issues are in English-speaking newspapers, and most deaths were those of Mexican Americans.

Mortuary Records

Another potential source of information on burials occurring during the period under investigation would be burial records from local mortuary businesses. We found no evidence of a mortuary business operating in Tucson until the establishment of the Parker Mortuary by Olva Clayton Parker in 1898. The mortuary appears to have kept excellent records of burials but none pertaining to the period the cemetery was in use. Another mortuary was opened in Tucson in 1902, the Reilly Funeral Home (Arizona State Genealogical Society 1976). Statistical Research, Inc., contacted the Evergreen Cemetery and the Holy Hope Cemetery, seeking information on burials removed from the old cemetery to Court Street and, later, to these successor cemeteries. The only records the Evergreen Cemetery has of removals from an earlier cemetery are a few entries in their register that indicate removal from what we interpret as the Court Street cemetery, rather than the earlier Alameda-Stone cemetery, and most of the individuals listed as having been moved are of unknown identity (O'Mack 2006:5–12).

The Evergreen Cemetery does have a section in its northwest corner called the "Pioneer Cemetery" that includes the earliest burials with known identities in the larger cemetery. These include the burials of at least a few individuals from the military section, including Harriet Davis and her infant daughter (O'Mack 2006:52). Another section is dedicated to members of the Grand Army of the Republic, a fraternal organization for Union soldiers who served in the Civil War. This section contains the graves of a number of individuals whose burials were listed in an 1884 Grand Army of the Republic list of individuals buried in the vicinity of Tucson. Based on comparison with military records, at least a few of these individuals would have been originally buried in the military section of the Alameda-Stone cemetery, but others were likely buried in the Court Street cemetery or in other locales before being moved to Evergreen. Captain Robert M. Crandall (Company A, First California Infantry) and Thomas Wallace (Company G, First California Infantry), now buried in the Grand Army of the Republic section of Evergreen Cemetery, were first interred in the military section of the Alameda-Stone cemetery. Other individuals who were indicated by the Grand Army of the Republic in 1884 as buried in the vicinity of Tucson and who came to be buried in the Grand Army of the Republic section of the Evergreen cemetery include August Bogeholz (or Borgholz), John Farquasson (or Furguson) (Company C, First California Infantry), Henry Glassman (Company D, Fifth California Infantry), Private Charles Hardenberg (Company I, First California Infantry), Eli M. Jones (Company I, First California Infantry), James E. McCaffrey (Company F, First California Infantry), Captain John Meredith (Fifth California Infantry), Quartermaster Sergeant Henry Schwenker (Fifth California Infantry), and John L. Stevenson (Company F, Second California Cavalry). These appear to have been burials that members of the Grand Army of the Republic kept a watchful eye on; at least 10 of the 17 burials of Civil War veterans known to the Grand Army of the Republic in 1884 were listed in the diary of George Hand, local saloonkeeper and member of the Grand Army of the Republic.

George Hand's Diary

Another valuable resource for understanding who may have been buried in the Alameda-Stone cemetery was George Hand's diary. Hand was discharged from the Army in 1864 and eventually returned to Tucson in the early 1870s, where he ran a saloon for much of the remainder of his life. Hand kept a diary that he began in 1861 as a new recruit in California (Carmony 1994:1–13). Only portions of Hand's diary survive, and he stopped keeping it for several years after his discharge, but it includes a list he made of people who died in

Tucson and elsewhere during the years of 1872–1887 (Carmony 1994:213–244). The list consists of Hand's abbreviated extracts from his own diary. His original mention of a death in the diary sometimes includes information not included in the corresponding entry in the list, but the list also preserves early entries from a part of the diary that has since been lost. We compiled data from Hand's diary for our previous archival report (O'Mack 2006; see Appendix B); we did not include deaths that obviously occurred outside the region, such as the death of Ulysses S. Grant.

Hand did not indicate in his list whether a burial occurred at the place of death or if the deceased was brought to Tucson for burial, noting the place of burial only occasionally. Many of the deaths listed by Hand appear to have occurred outside Tucson. When he did note that burial took place in Tucson, he did not indicate the specific location of the cemetery. Hand's list is a remarkable source, but the earliest entries are from 1872, and the list shares only 11 of 73 entries with the Tucson Diocese record for the period before the closing of the civilian section in 1875 (O'Mack 2006:Table 5). Another 159 deaths are listed for the period between June 1875 and the last burial in the military section in January 1881, for which Hand simply noted "A soldier's funeral today in the Catholic church" (O'Mack 2006:211). The deaths listed by Hand include a few individuals we know to have been buried in the military section, including Michael Keegan, Reid T. Stewart, Herbert Lord, Mark Aldrich, R. M. Crandall, Michael Ryan, Harriet Davis (wife of W. C. Davis), Hattie Davis (child of Harriet Davis), and John Lyons, as well as several other individuals who had been in the military and could have been buried in the military section of the Alameda-Stone cemetery or in the Court Street cemetery.

Many of the people listed in Hand's diary, particularly during the period the civilian section was in use, experienced violent deaths. Many, also, were non-Hispanic Euroamericans, as opposed to Hispanics or Native Americans. The predominance of violent deaths in Hand's list could be an indication of the level of violence during the period, but it also suggests that Hand was particularly interested, at least early on, in these kinds of events. Hand seems to have shared this fascination with the newspapers, as a good number of the deaths he listed also appeared in newspaper articles, such as the deaths of A. J. Bice and John Petty, who were killed while they were carrying mail to Tucson, and the death of Tom Donovan, who was killed on his way to Texas (*Weekly Arizona Miner* [*WAM*], 10 February 1872:4). Hand's listings are not a perfect reflection of news items, as he listed the death of Michael Keegan, who committed suicide with a needle gun, but not the death of Peter Bus, a private in the U.S. Army who accidentally shot himself 10 days earlier and whose death was listed in the same article in the *Arizona Citizen* (2 March 1872:3) as Keegan's. Perhaps he had not read the *Arizona Citizen*; a similar notice in the *Weekly Arizona Miner* (9 March 1872) listed only Keegan's death.

Hand's later entries seem to be a little more balanced in representing deaths occurring within the community or otherwise of interest to Hand, but a great number of the deaths listed are of non-Hispanic Euroamericans, suggesting a focus on the non-Hispanic Euroamerican segment of the community. Although this indicates some bias in Hand's accounting, it also suggests that the list forms a kind of counterpoint to the burials listed in the diocese register, the vast majority of which were of Hispanic individuals.

1870 Mortality Schedule

The 1870 mortality schedule, discussed earlier in this chapter, provides a record of 139 individuals who died in Tucson. The list contains information on the name, age, sex, occupation, place of birth, marriage status, race, cause of death, and date of death for each of the individuals who died in the 12 months before June 1870. Although an interesting sample of deaths that occurred in Tucson over the course of the year, the list has a number of biases, one of which is that it probably places a somewhat greater focus on non-Hispanic Euroamericans than people of other backgrounds. Although the percentages of non-Hispanic Euroamericans (23 percent) and Hispanics (73 percent) in the schedule are roughly consistent with what we might expect based on our evaluation of the census records, and a few African Americans and Native Americans are represented, 1870 was a year when a large number of Hispanic children died from smallpox.

The February 1870 report in the hospital register for the post hospital at Tucson (National Archives and Records Administration, Record Group 94, Entry 544, Volume 118) indicated that "[t]he Epidemic is confined chiefly to the Mexican population and the percentage of deaths among the children has been very large. It is

impossible to arrive at the exact number of cases at present existing, as nothing but a house to house visitation could effect this—there are probably 25 or 30 cases. The local authorities take no steps to have the infected removed or isolated, and the Epidemic will in all likelihood ~~probably~~ [sic] continue until it has seized upon all who have not suffered previously—or been thoroughly vaccinated. A large number have applied at the Hospital for vaccination and this has in all cases been gratuitously performed." An update in April 1870 indicated "that the disease in the Town has almost disappeared, there only being one or two cases—remnants of the Epidemic—existing. As far as can be ascertained, the whole number of fatal cases which have occurred in Tucson, since the commencement of the Epidemic is about 120 and this estimate is rather under, than over, the exact number." The 1870 mortality schedule lists 78 deaths from smallpox, nearly all of them being those of Hispanic children, but also includes the deaths of 2 Native American children, 2 African American adults, and 7 non-Hispanic Euroamerican adults who died from the disease. However, if we are to accept the post hospital's estimate of at least 120 deaths, mostly of Hispanic children, then there probably should have been perhaps 40 or 50 more deaths from smallpox listed, and many of those would have been Hispanic individuals. Of the deaths from other causes, almost half are non-Hispanic Euroamerican, suggesting that this segment of the community is probably represented more fully in the schedule than were other segments of the community.

Tucson Diocese Burial Record

One of the richest and most complete records that informs on the identity of people likely to have been buried in the Alameda-Stone cemetery is the Tucson Diocese burial record, discussed earlier in this chapter. The diocese record contains information on the names, ages, sex, mothers, fathers, spouses, and dates of burial for many of the people who were likely buried in the civilian section, along with a few notes that indicate the cultural background or cause of death of an individual or the place of burial outside Tucson. We used this record extensively to learn about who was buried in the cemetery and to model various aspects of the burial population. For instance, we used the diocese record to model the age and sex distribution of the burial population in order to compare the demographic distribution of deaths recorded by the Catholic Church with the demographic distribution discovered archaeologically in different areas of the cemetery (see Chapter 7, Volume 1 of this series). Use of the record in this way has provided unique insight into the hazards faced by the population and also has allowed us to interpret which segments of the community used different areas of the civilian section. Although it is a rich record of information on individuals who died within the jurisdiction of the Tucson Diocese during the period that the cemetery was in use, one of the record's major shortcomings is that it does not provide any information on the locations of graves within the cemetery for any burials.

In some Mexican American cemeteries, a local priest would keep a record of placement in his *libro de entierros* (book of burials), with a description of the location of each burial in relationship to the church (Brock and Schwartz 1991:86; Jordan 1990:76). Other than occasionally noting that a burial occurred "in the cemetery of this church," the Tucson Diocese burial record has no mention of the location of burial. Perhaps associated documents, such as a map indicating the locations of burials, have not survived. Alternatively, as O'Mack (2006:43) implies, the increasingly widespread use of grave markers in Mexican American cemeteries during the late-nineteenth century may have replaced the need to record the location of burial in an official document. Ultimately, the diocese record provides information on many individuals buried in the cemetery, nearly all of them buried in the civilian section, but it provides no information on where a specific, historically known individual was buried within the cemetery.

U.S. Military Records on the Military Section

Archival research did uncover information on the relative location of burials within the military section. Statistical Research, Inc., was able to match an 1881 plat map of the cemetery closely with the archaeological distribution of graves in that area of the cemetery. Despite the close spatial match between historically mapped graves and archaeological grave pits, Statistical Research, Inc., was unable to positively identify the remains of

any individual within the military section. In part, the inability to positively identify individuals in the military section stems from the fact that many burials were disturbed in June 1884, when the remains from 74 burials in this section were exhumed and reburied in the new military section at Fort Lowell. As a result, most burials documented archaeologically by Statistical Research, Inc., in the military section consisted of incomplete remains, portions of which could have been redeposited from nearby burials. In addition, because many of the individuals buried in the military section were adult Euroamerican males with similar ages, stature, and life experiences and artifacts in graves could not be used to identify a specific company or rank (see Chapter 6), osteological or contextual information was never specific enough to allow a positive identification (Heilen et al. 2008). Positive identification of remains in the military section was also a problem historically. For instance, in the month preceding the scheduled exhumation, a May 12, 1884, telegraph sent from Whipple Barracks, Arizona Territory, to the Quartermaster General in Washington, D.C., reported that "Post Quartermaster Ft Lowell telegraphs that he has visited cemetery in Tucson about seventy five graves nearly all head boards gone a few left have numbers which might lead to identification." It appears that the military would have had to rely mostly on incomplete burial lists and maps to identify exhumed remains of individuals in the military section and presumably would have used artifacts found within the grave for identification, as well (see for example, Faust 2008). As discussed later in this section, despite an inability to unequivocally link a specific set of remains with a specific individual, we were able to develop fairly comprehensive information on who was buried in the military section and where they were buried in relation to other burials in the military section.

Prior to fieldwork, Statistical Research, Inc., located a list of burials in a National Archives and Records Administration compilation of images from *Burial Registers for Military Posts, Camps and Stations, 1768–1921* (National Archives and Records Administration, Record Group 92, M2014). We also collected newspaper articles, council minutes, photographs, and other documents that provided information on the military section. These documents enabled us to develop a sound approximation of when the cemetery was used, its specific location, the approximate number of burials and their relative locations, attributes of many of the individuals buried in the military section, and other information, such as when the wall around the military section was built. In July and October 2008, we visited the National Archives and Records Administration facilities in Washington, D.C., seeking additional information on the military section. Up until that time, the document that provided the most comprehensive information on the layout, chronology, and organization of the cemetery was the burial list from *Burial Registers for Military Posts, Camps and Stations, 1768–1921.* Contained in two volumes, most of the burial registers in *Burial Registers for Military Posts, Camps and Stations, 1768–1921* record burials that occurred between 1860 and 1890. Volume I began in 1873 and was periodically updated until 1883. After that point, the volume was updated sporadically until 1932. Volume II began in 1883, after the military section at Tucson was closed but prior to the reinterment of burials at Fort Lowell in 1884. The Camp Lowell list, which appears on pages 282, 283, and 326 of Volume I, seems to represent a compilation of burial records from 1873, 1879, and 1882. We have previously referred to this list as the 1881 list (O'Mack 2006), although we now know that a related, but different, list was created in 1881. We therefore refer here to the list found in *Burial Registers for Military Posts, Camps and Stations, 1768–1921* as the 1873–1882 list.

In July 2008, additional burial records were located at the National Archives in the records of the Office of the Quartermaster General (National Archives and Records Administration, Record Group 92). Records specifically related to the military section included an 1866 burial report, an 1873 burial list and plat map, and an 1881 list and plat map (see Figure 24). The records also included a removal report from 1884, when military burials were removed from the military section, as well as an 1884 reinterment report and plat map of the Fort Lowell cemetery, showing locations at the Fort Lowell cemetery where the burials removed from the military section were reinterred.

The 1866 burial report, which described, in general, the attributes of the cemeteries at Tucson and Picacho Peak, was apparently accompanied by a burial list when originally sent from the post at Tucson to the Quartermaster General. The accompanying burial list was not found at the National Archives, but the Honor Roll (Honor Roll XIII, page 119) that was based on that list was located. The 1866 burial report indicates that 20 individuals were thought to be buried in the military section as of May 1866, although the names of only 6 were known at the time. The precise locations of burial for most of those individuals were also not known,

because grave markers survived for only 3 individuals. In addition, records sent to Santa Fe in 1864, when the post was briefly closed, could not be relocated. The author of the report, Assistant Quartermaster Gilbert C. Smith, requested the records from Santa Fe, but apparently those records were never relocated.

We also obtained from Record Group 92 a copy of a letter from the Grand Army of the Republic's post in Tucson, Negley Post No. 35, which included a brief list of military dead who were buried in the vicinity of Tucson prior to June 1884. The letter pleaded with the U.S. Secretary of War "that some action be immediately taken to secure us here a permanent burying plot where the bodies of deceased Comrades may be re-interred, and their graves permanently identified and remembered by all living Comrades who can on each recurring Memorial day 'garland these passionless mounds' in honor of the memory of those who laid down their lives upon the altar of duty." The letter referred to a total of 117 individuals buried in multiple cemeteries in the vicinity, which appear to include the military section in Tucson, the Court Street cemetery, and a cemetery in Tubac. An attachment to the letter listed the names and regiments of 17 individuals, nearly all of whom appear to have been members of the military, and concluded with the statement that there were "also about one hundred unknown" individuals buried in the vicinity, at least some of whom presumably would have been soldiers buried in the military section of the Alameda-Stone cemetery.

Only 4 individuals in the Negley Post No. 35 list—Captain R. M. Crandall (First California Infantry), Thomas Wallace (First California Infantry), Richard Scott (Commissary Sergeant), and Michael Ryan (Eighth U.S. Infantry)—were clearly buried in the military section in Tucson, although it is possible that a few of the remaining 13 named individuals could have been among individuals listed as "unknown" in the military burial records. With the exception of Charles Hardenberg and Hand's good friend, Thomas Wallace, most of the named individuals died between 1876 and 1884 and, if not buried in the military section, would have likely been buried in the Court Street cemetery. One of the individuals listed, C. C. Dodson, is listed as a Confederate soldier; he might be a "Mr. Dodson" listed in George Hand's diary as dying on March 11, 1882. The latest date of death is that of Henry Glassman, who, Hand indicates, died on January 8, 1884, in Tubac, which suggests that the letter from Negley Post was written sometime between January and June of 1884, when the burials were removed from the military section of the Alameda-Stone cemetery. The limited number of named individuals in the list, only 4 of whom were clearly in the military section of the Alameda-Stone cemetery, underscores the point that the graves of only a few individuals in the military section could be identified at the surface in 1884 because of a lack of surviving headboards or other grave markers.

We visited the National Archives again in October 2008, this time focusing on Record Group 94, Records of the Adjutant General's Office. From this record group, we examined the *U.S. Army Register of Enlistments, 1798–1914* (National Archives and Records Administration, Record Group 94, M233); *Field Records of Hospitals, Compiled 1821–1912* (National Archives and Records Administration, Record Group 94, Entry 544); *Medical History of Posts, Compiled 07/1868–1913* (National Archives and Records Administration, Record Group 94, Entry 547); and *Returns From U.S. Military Posts, 1800–1916* (National Archives and Records Administration, Record Group 94, M617). These records revealed some additional deaths and details of deaths that occurred among members of the military in the vicinity of Tucson while the cemetery was in use, and they allowed us to cross-check or supplement many of the personal details provided in the burial lists. To further flesh out and corroborate information on individuals buried in the military section, we also sought information on specific individuals by searching *U.S. Civil War Soldiers, 1861–1865* (National Park Service 2007).

The burial lists and plat maps of the cemetery obtained from the National Archives and Records Administration are largely in agreement with each other in major details, but numerous minor discrepancies were discerned between documents. Comparison and compilation of the records has revealed additional details about the military section that were not apparent or easy to interpret using the 1873–1882 list. For instance, between lists or maps, there are discrepancies in name spelling, date of death, company, regiment, or cause of death for the same individual. Statistical Research, Inc., generated a consolidated burial list based on comparison of the burial lists and plat maps, historical newspaper accounts, enlistment records, post returns, and other sources of information (Heilen et al. 2008). The compilation of these data allowed us to develop additional information on individuals that was used to verify and cross-check records, add missing information, and compare historical, archaeological, and osteological information. These record searches also allowed us to develop information on a substantial number of military-affiliated individuals who died in the vicinity of Tucson while the

military section was in use and who were not listed by name on the surviving burial lists. In all likelihood, these individuals compose most, if not all, of the individuals listed as "unknown" on the burial lists, although we have no way of knowing for certain which ones were placed in the military section or where they were placed. However, if we make some assumptions about the sequence of burials in the earliest two rows of the military section, where most of the unknowns in the portion of the cemetery excavated by Statistical Research, Inc., were located, the number of military-affiliated deaths not listed by name in the burial lists but found in other records closely matches the number of graves listed as unknown during the period those graves were likely to have been placed.

We overlaid the 1881 plat map with cartographic information from our excavations, in an effort to investigate the correspondence between graves on the historical map and those discovered during excavation. Although not a perfect match, individual graves and the overall pattern of graves match quite well between archaeological and historical maps, suggesting a close correspondence between archaeological grave features and historically mapped grave features (Figure 25). Many of the graves appear to correspond uniquely to graves discovered during excavation; some historically mapped graves also fit archaeological mapping information closely in grave size, orientation, or both variables. Distortions in the historical map were expected, depending on how mapping information was measured historically, because both historical maps of the military section are sketch maps. The fit between the archaeological data and the 1881 map, therefore, came as somewhat of a surprise.

Because of the availability of historical information on individuals interred in the military section, Statistical Research, Inc., made a good-faith effort to assess the identities of human remains recovered there during cemetery excavations. Because each grave in the military section contained the remains of no more than one individual and some previously exhumed graves contained no artifacts or osteological remains, the assessment was made per grave. For each grave, the assessment of identity relied on three lines of evidence: context (i.e., where a set of remains was discovered and the items found in association with a grave), osteological indicators (i.e., the physical characteristics of the skeleton), and historical evidence (i.e., research on the identities of the people buried in the military section). After the three lines of evidence were evaluated for consistency, a statement was prepared to indicate whether a positive identification was possible based on the available evidence.

It is important to emphasize that positive identification rests firmly on the weight of unambiguous biological evidence—such as DNA or dental evidence—linking human remains with a known individual. In most cases, the graves in the military section excavated by Statistical Research, Inc., had incomplete osteological remains and few or no burial-associated artifacts. Although the spatial correlation of excavated and historically documented graves was compelling in many cases, from an archaeological and historical standpoint, it was in no case compelling from an osteological standpoint, as no positive correlation could be made with any historically named individual. As a result, we are currently unable to positively identify the grave of any specific named individual buried in the military section. At the same time, we have a pretty strong sense of who was buried in the military section and their original places of burial with respect to other burials in the section.

Grave Markers

Grave markers can provide clues to the identities of the deceased. In addition to indicating the physical location of a burial and sometimes the orientation of a burial, the more-durable grave markers can preserve inscribed information, such as a name, dates of birth and death, family relationships, and other affiliations. The attributes of a marker and its placement with respect to the grave can also provide information on the likely cultural, religious, or temporal association of the burial, should the marker prove to be distinctive along those dimensions (Bell 1987:48–50; Brock and Schwartz 1991; Dethlefsen 1981; Gorman and DiBlasi 1981; Griffith 1992; Jordan 1990; Keister 2004).

Grave markers were used in both the military and civilian sections. Grave markers would have included wooden headboards, inscribed stone slabs, and aboveground vaults, based on historical documentation of the cemetery. We can also assume that there would have been a variety of grave markers in the civilian section, as these had became popular in Mexican American cemeteries in the late-nineteenth century, including wooden

and iron crosses; *cerquitas* (grave fences), *relicaritos* (grave markers with deep recesses to hold items associated with the deceased), *nichos* (smaller versions of the *relicaritos*), grave curbs (low enclosures built close to the ground, often of concrete), decorative piles of field stones placed on top of individual graves, and, infrequently, engraved stone markers (Barber 1993; Brock and Schwartz 1991; Griffith 1992:119; Jordan 1990). Earlier in the century, grave markers were uncommon, and the locations of burials were recorded by a local priest in his *libro de entierros*.

We know that painted wooden headboards, although considered temporary, were used in the military section, and few of them survived during the period that the cemetery was in use, as indicated by descriptions of the cemetery found in military records (see below). Durable grave markers were not made available when burials from the military section were moved to Fort Lowell, as is reflected in an 1887 list of "Soldiers buried in the Post cemetery at Fort Lowell whose graves are unmarked except for wooden headboards" (National Archives and Records Administration, Record Group 92, Entry 576). The War Department adopted the first design for stone markers in 1873, but these were to be permanent markers in national cemeteries. Neither the Camp Lowell nor the Fort Lowell cemetery was considered to be a permanent resting place, and neither ever became a national cemetery; so, it makes sense that the graves therein were never provided permanent markers.

Although personal information was typically recorded on headboards, the information soon became illegible through exposure to the elements, and apparently in the case of the military section, the physical headboard itself did not survive long to indicate the location of a burial. By 1884, only a few headboards had survived, and fewer still contained any legible information on their surfaces. Apparently, at least one marble-slab grave marker remained in the cemetery after it was officially closed, but even it was largely destroyed before burials from the military section were removed to Fort Lowell:

> At the head of one [grave] stood a marble slab (the only one in the cemetery) erected by his company to perpetuate the name of a comrade, a young Englishman, aged twenty three, but it is now broken in pieces and the grave is to be leveled off. In rows on either side, sleep scores of others, who perhaps were not less meritorious or brave but whose mounds, marked only by the regulation board, which time has seamed and worn till not a line remains to tell who they were, how they fought and where they fell . . . ." [*Arizona Weekly Citizen* [AWC], 18 February 1883:4].

We cannot know for certain which individual's grave was marked with the marble slab, but we know of at least one individual buried in the cemetery who fits that basic description: Private James Woods, a carpenter from Liverpool, England, who died in his early twenties on July 17, 1876, from inflammation of the brain. However, a more likely candidate is Corporal John Lyons. Although we do not know his age or place of origin, we do know that his burial was a fairly lavish and well-attended one and that there were at least plans to purchase a headstone for his grave. The *Weekly Arizona Citizen* (30 January 1881:3) reported after his funeral that "[t]he funeral expenses and costs of a suitable headstone for the late Corporal John Lyon have all been generously defrayed by his company—M, Sixth Cavalry. The stone is to be purchased in San Francisco." If the broken headstone mentioned in 1883 was indeed that of Corporal Lyons, who was buried just 2 years prior, then even it was destroyed in short order.

In addition to wooden headboards and at least one headstone, there is also historical evidence for the use of an aboveground vault and, possibly, two adobe grave curbs in the military section. On the undated plat map of the military section, Burial Number 34 in the northeastern quadrant of the military section is indicated as being marked by a "Cement Tomb, Arched." Also, on the 1873 burial list, the graves of Sergeant J. C. McQuade and Private J. L. Richards are indicated as marked with an "adobe mound." If McQuade's and Richards's graves were the first in the military section, as we suspect they were, then it may be that these two graves were originally surrounded with low adobe walls or curbs that had since melted, as the cemetery had not been formally defined or enclosed in 1862, when those burials were placed. The 1870 Lauderdale photograph of the walled military section appears to show a tall grave marker, perhaps made of stone, in what may have been the southwestern quadrant of the cemetery. The detail of the 1880 Carleton Watkins photograph shows a large number of vertical elements within the military section that could be grave markers (or perhaps people standing in the section), as well as possible aboveground vaults or other grave markers in the civilian section.

The civilian section likely contained a variety of different kinds of grave markers. The 1870 Lauderdale photograph appears to show several large monuments just behind the north wall of the military section (which also appear to be visible in the 1880 Watkins photograph) and perhaps one or more markers just east of the military section. Newspaper descriptions of the cemetery after it had closed indicated that there were aboveground vaults in the cemetery that had been "broken open" (*AWC*, 18 February 1883:4), and we can expect there probably would have been *cerquitas, nichos*, and *relicaritos* in areas used by Mexican American Catholics.

Unfortunately, grading of the cemetery shortly after the cemetery was surveyed into lots and sold, along with constant use of the former cemetery area for residential and commercial use for more than a century, resulted in the complete removal or destruction of all previous grave markers. During our excavations, no archaeological evidence of a grave marker was found in any context, making it impossible for us to use grave markers in any fashion to interpret the identities of the deceased and their mourners (Hall et al. 2008).

Internal Organization of the Cemetery

The ethnic, religious, and economic disparities among individuals that made up the Tucson community suggest that the cemetery would have been organized in a manner that reflected divisions among the community. As has been discussed, archival research indicates that the Alameda-Stone cemetery was divided, minimally, into a U.S. military section and a civilian section. Archival research also indicates that, until 1875, when the civilian section was closed and a new city cemetery was opened on Court Street, the Alameda-Stone cemetery appears to have been the only cemetery in Tucson. We therefore expected that anyone who died in or near Tucson between the early 1860s and 1875 and who was not associated with the U.S. military was likely to have been buried in the civilian section; individuals associated with the U.S. military who died in the vicinity would have been buried in the military section until January 1881. Several burial features that included military buttons were found in burial features located outside the military section, however, suggesting that there could have been some individuals associated with the military, perhaps former military, who were buried in the civilian section of the cemetery rather than the military section. No archival evidence revealed information on possible subdivisions of the civilian section, although historical-period plat maps of the military section indicate that the military section was divided into four parts.

Given the diverse demography of Tucson and archaeological clues uncovered during fieldwork, we suspect that the civilian section was probably divided into several distinct areas. We know, for instance, that the later Court Street cemetery was divided into sections according to religion. In May 1875, the city council resolved that Blocks 8, 9, 14, and 15 of the Court Street cemetery be set apart for Catholic burials, that Blocks 10 and 13 be set apart for burials of all other denominations, and that Blocks 7, 11, 12, and 16 be "reserved from use for burials," presumably to reserve them for future use, as the reserved blocks were eventually used for burial (Tucson City Council minutes, 18 May 1875; O'Mack 2006:10). Possibly, the rudimentary organization of the Court Street cemetery into Catholic and non-Catholic sections in some way reflects the organization of the Alameda-Stone cemetery. The city council could have used the former cemetery as a model on which to base the organization of the new cemetery.

An article published in *El Fronterizo* in May 1879 detailing a request to the council from the chief engineer of the Southern Pacific Railroad for a 100-foot-wide right-of-way directly through the town site also suggests the presence of a Catholic section in the cemetery. The article noted, in passing, "El camino cruzará junto al cementerio católico [The road will pass next to the Catholic cemetery]." (*El Fronterizo*, 18 May 1879:2). This statement could mean that at least a portion of the cemetery was associated with the Catholic Church; perhaps northern portions of the cemetery, which would have been closest to the proposed right-of-way (Cemetery Areas 3–5, see below), were used by the Catholic Church, and the remaining areas were used for non-Catholic or military burials.

During the excavation of the Joint Courts Complex project area, Statistical Research, Inc., archaeologists recognized distinct spatial patterns within the distribution of grave pits that suggested the presence of distinct

cemetery areas. Initial demographic information obtained from osteological and mortuary analyses provided further support for our inferences regarding spatial patterning within the cemetery. The first division of the cemetery, the military section, was known prior to the start of fieldwork through our archival research (Heilen et al. 2008; O'Mack 2005:31, O'Mack 2006). This military section was located in the southwestern portion of the project area, which we designated as Cemetery Area 1. Additional archival research for the military section produced an 1881 plat map of this section, and our cartographic specialists were able to match historical grave-pit locations with the features uncovered during our excavations in order to further define the area. Because detailed records for the layout of the civilian portion of the cemetery were lacking, the spatial patterning of grave pits and their attributes became the best avenue for describing and interpreting the internal organization of the civilian section. Four additional cemetery areas (Cemetery Areas 2–5) were identified for the civilian portion of the cemetery during the course of fieldwork and analysis (Figure 26). The following discussion defines the five cemetery areas identified for the Joint Courts Complex project.

Cemetery Area 1

Cemetery Area 1 corresponds to the historically documented military section. The current limits of Cemetery Area 1 are based on our best approximation of the military section, but it must be noted that our understanding of the location and organization of the military section has evolved as a result of fieldwork and additional archival work conducted over the course of the project. In all, 64 grave pits were associated with the military section during the archaeological investigations of the Joint Courts Complex project area. These 64 grave pits held a total of 51 identifiable burials representing 57 individuals (Table 30).

The historical plat maps indicate that the walled military section was divided into four quadrants, separated by walkways. The eastern two quadrants contained 65 documented graves, mostly of enlisted men, but they also contained at least 4 citizens, 1 of whom was formerly a teamster with the Quartermasters Department and another who was listed as a child. The western half of the military section contained at least 32 graves, including the burials of commissioned officers or retired officers, family members, and prominent citizens. The removal list indicates that many of the burials in the western half of the military section had been removed prior to the relocation effort in 1884.

During fieldwork, we identified four north-south-trending rows of grave pits in the area we inferred to be the eastern portion of the military section. The four rows held a total of 60 grave pits. The other 4 grave pits found in Cemetery Area 1 were located west of these four rows and could not be securely associated with other rows in the field. Three of those grave pits, however, appeared to correspond fairly closely in space to grave pits shown in the western half of the cemetery on either the 1873 or the 1881 plat map. The remaining grave pit in Cemetery Area 1 (Grave Pit 26789) was located in what would have been the southern entrance to the cemetery, making its placement ambiguous, with respect to the military section. Although no unambiguous physical evidence of the former military section wall was found, the area of previously exhumed burials associated with the military section was clearly distinct from the area of mostly unexhumed burials found immediately to the east. The archaeological evidence showed a definite spatial break, east of what was presumed to be the military section, between the two areas. This gap, 4–5 m wide, was undoubtedly where the former wall stood. On the north side of the military section, the areas of unexhumed and previously exhumed graves were not separated by any noticeable change in the spacing between grave pits. In fact, the previously exhumed grave pits in the first row were aligned closely with the unexhumed grave pits immediately to the north, which suggests that these grave pits, both the unexhumed and the previously exhumed, had been placed with reference to each other and were already there when the military section wall was built in 1868.

The four rows of grave pits discovered in excavation, although clearly rows, showed irregularities in spacing and alignment. These irregularities can probably be attributed in part to the intermittent, loosely monitored use of the military section and a general lack of durable grave markers (see O'Mack 2006:36). The number of grave pits in each row as given in the 1881 and 1873–1882 lists differs slightly from the number discovered in the field (Table 31), but the generally close correspondence among lists, maps, and field data indicates that

each is a valuable tool for interpreting the other. Some of the discrepancies appear to be accounted for by post-cemetery disturbances that may have obscured traces of previously exhumed graves.

Cemetery Area 2

Cemetery Area 2 is the name given to the portion of the civilian section that was located immediately east of Cemetery Area 1, the military section of the Alameda-Stone cemetery (Figure 27). Cemetery Area 2 encompassed a total of 89 grave pits, which were, for the most part, evenly spaced, similarly to those in the military section. Within these 89 grave pits were 87 identifiable burials representing 96 individuals (see Table 30). The boundary between Cemetery Areas 1 and 2 corresponded to an approximately 4-m gap between rows of grave pits. This conspicuous space between the rows was also the presumed alignment of the adobe wall that once enclosed the military section, as discussed above. The eastern limit of Cemetery Area 2 corresponded with the eastern limit of the cemetery as a whole, and the northwestern limit of Cemetery Area 2 was the eastern margin of the Tucson Newspaper basement excavation, a feature that prevented us from knowing whether the distinctiveness of Cemetery Area 2 continued farther west. As noted in the discussion of Cemetery Area 1, Cemetery Area 2 included an apparent northward continuation of the alignment of the easternmost row of the military section, which may indicate that the adobe wall separating the two areas was not built until after the graves sharing this alignment were already in place.

The northern limit of Cemetery Area 2 was also the southern limit of Cemetery Area 3. This boundary was originally drawn somewhat arbitrarily through an area that marked an apparent change in the density of grave pits, from a relatively sparse distribution on the south to a relatively dense distribution on the north. No neat line was apparent, but a band of mostly open space ran east-west between the two areas, containing a handful of scattered grave pits not clearly associated with either area. The area of open space was in part related to a large pit (Feature 582) that housed an underground fuel tank associated with the gas station located at 55 East Council Street. This large pit obliterated any trace of grave pits in that area, and it should not necessarily be assumed to represent a gap in the cemetery rows.

Our analyses of the contextual and osteological data have further distinguished Cemetery Area 2 from the rest of the cemetery. Demographic data reveal that the majority of individuals in Cemetery Area 2 were adult Euroamerican or Hispanic males (see Chapter 7). Another distinctive quality of Cemetery Area 2 was the orientation of individuals. Eighty-nine percent of the individuals in Cemetery Area 2 had their heads oriented to the east. A general shift in orientation is apparent from Cemetery Area 2 to Cemetery Area 3, with the majority of individuals in the southern portion of Cemetery Area 3 oriented to the west. A demographic shift from Cemetery Area 2 to Cemetery Area 3 was also apparent, with an increased diversity of age, sex, and cultural affinity represented in Cemetery Area 3. For a more in-depth discussion of the demographic diversity in the cemetery, refer to Chapters 7 and 8 of this volume and to Chapter 9, Volume 1 of this series.

Cemetery Area 3

Cemetery Area 3 was by far the largest of the five areas and encompassed a total of 706 grave pits, which held a total of 649 burials representing 753 individuals (Figure 28; see Table 30). This represents over half of the individuals recovered from the entire project area. The eastern and western limits of Cemetery Area 3 were the eastern and western limits of the cemetery as a whole. A small, triangular portion of the cemetery, however, may have extended slightly into the current alignment of Stone Avenue, based on our estimate of the location of a wall that once formed the western limit of the civilian section (see below). The southern limit of Cemetery Area 3 corresponded in part to the northern limit of Cemetery Area 2, but it also surrounded the obviously discrete Cemetery Area 4 on three sides. The original southwestern limit of Cemetery Area 3 is unknown because of the intrusion of the Tucson Newspapers basement. The northern limit of Cemetery Area 3 corresponded with the northern limits of the cemetery, with the exception of Cemetery Area 5, which was situated in the northwestern corner of the cemetery.

An obvious break in the density of grave pits was apparent between Cemetery Areas 3 and 5, from the relatively dense distribution in Cemetery Area 3 to the distinctive distribution of Cemetery Area 5, where a small number of grave pits were grouped in several clusters in the northwestern limit of the cemetery. Interestingly, the evident boundary between Cemetery Areas 3 and 5 also corresponded closely with a property boundary first established in 1890, when the former cemetery was first subdivided by the city and sold off to private parties. This was the boundary between Lots 5 and 6 of Block 252, a line that extended eastward as the boundary between Lot 10 and Lots 11, 12 , and 13 of the same block (see O'Mack 2005:Figure 8). This property boundary actually survived to the start of fieldwork: the same line marked the north edge of the modern parcels that held both the building at 240 North Stone and its parking lot to the east. It is unclear why a line presumably established in 1890 would seem to be reflected in the distribution of graves created at least 15 years earlier.

The large size of Cemetery Area 3 undoubtedly glosses over diversity among the grave pits and burials in the area. In fact, analysis discussed later in this chapter has shown a difference in the placement of grave pits and cemetery rows between the western and eastern halves of Cemetery Area 3. This led to the tentative division of Cemetery Area 3 into Cemetery Area 3a (western half) and Cemetery Area 3b (eastern half) for some comparisons. Demographic information obtained from osteological analysis shows that over half of the individuals in Cemetery Area 3 were under 12 years of age. There was also a roughly equal proportion of males and females in Cemetery Area 3 and a higher diversity of biological affinities, although Hispanic individuals outnumbered all other biological-affinity categories (see Chapter 7).

Cemetery Area 4

In terms of the distribution of grave pits, Cemetery Area 4 was by far the most distinctive of the five areas. In the rest of the cemetery, the general pattern was grave pits spaced more or less evenly in more-or-less-discernible north-south rows, with a single individual in each grave pit and little intrusion by later grave pits into earlier ones. Cemetery Area 4 broke this pattern almost completely. The general east-west orientation of grave pits was still the rule (with a few notable exceptions of north-south-oriented grave pits), but the grave pits were packed tightly together, with little or no intervening space and with frequent and often drastic intrusion by later grave pits into earlier grave pits (Figures 29 and 30). Many grave pits showed evidence of multiple burial episodes; some reuse of grave pits appeared to be intentional, and in others, it appeared to be a consequence of reusing a densely occupied space. The many superimposed grave pits in Cemetery Area 4 greatly complicated the process of archaeological excavation, a situation only made worse by the construction of Council Street over this area during the postcemetery period and the presence of many utility trenches that were excavated below the level of the street (see the Postcemetery Disturbances section, below).

For example, a single grave pit may have been disturbed several times by later grave pits, which were subsequently all disturbed by the construction of a modern utility trench. This sequence of events often dislocated the skeletal elements of one or more individuals. Many of the grave pits in Cemetery Area 4 had numerous skeletal elements that could not be attributed to a particular grave pit or burial feature. Unfortunately, this level of disturbance in Cemetery Area 4 made our efforts to determine the sequence of events very difficult. Furthermore, the natural sediments across the project area were homogenous; therefore, grave pits with multiple intrusions usually did not contain discernable internal stratigraphy. Instances where internal stratigraphy was discernable were limited to postcemetery features, such as utility trenches, where the features contained historical-period or modern refuse and construction material (concrete and asphalt). Grave-pit depth was also an unreliable factor in determining the sequence of interments, so that the overall depth of a grave pit was not indicative of its relative age. For instance, some of the later grave pits that intruded into earlier grave pits were excavated much deeper than the earlier ones they intruded into, whereas others were much shallower. In Cemetery Area 4, archaeologists generally relied upon the position and/or completeness of in situ skeletal remains and coffin wood to determine the sequence of events within a given grave pit. For example, some burials were obviously truncated by later burials, often with the earlier skeletal remains moved aside for the later burial, thus allowing for a determination of which grave pit predated or postdated another. Other factors used

to determine sequence of burials included the walls of the grave pits. Often an intrusive grave pit would be slightly off-set from an existing grave pit, thus removing a portion of the original grave-pit wall. The sum of the above observations was compiled in a feature to feature relationship database, and our attempt to ascertain the sequence of grave-pit excavation in Cemetery Area 4 is provided in the Feature to Feature Relationships section, below.

Cemetery Area 4 was located in the west-central portion of the cemetery and encompassed a total of 193 grave pits, which held a total of 191 burials representing 402 individuals (see Figure 29 and Table 30). The large number of individuals in relation to grave pits and burials was due to the repeated use of Cemetery Area 4, with many overlapping and reused grave pits. The distinctive density of Cemetery Area 4 was sharply circumscribed from the lower density of the surrounding Cemetery Area 3. The west, north, and east sides of Cemetery Area 4 were nearly straight lines, forming nearly right angles at the northwest and northeast corners of the area. Just outside the west, north, and east sides of the area was a band of mostly vacant space, which suggests that a wagon or walking path must have bordered the area. The abruptness of the change from Cemetery Area 4 to the surrounding Cemetery Area 3 strongly suggests that Cemetery Area 4 was once enclosed by a fence or wall. Several pieces of archaeological evidence support the presence of an enclosure around Cemetery Area 4. For example, several postholes (Features 10154–10156 and 10158), which were aligned north-south in the same general orientation as the grave pits, were identified along the eastern boundary of Cemetery Area 4, and these postholes may have represented where an original fence or wall once stood. At the northwest corner of Cemetery Area 4 was another pit (Feature 7738) that may have held a corner post for a fence or wall that surrounded Cemetery Area 4. Feature 7738 was intruded upon by another posthole associated with a possible wooden curb that ran the length of Council Street, or Miltenberg Street, as it was originally named. This wooden curb would have been associated with the early alignment of Miltenberg Street; therefore, the fact that this wooden-curb posthole intruded upon Feature 7738 suggests that Feature 7738 was created before the construction of Miltenberg Street. This temporal relationship supports the argument for Feature 7738 as contemporaneous with the cemetery. Other possible evidence for a fence or wall around Cemetery Area 4 was the presence of a distinctly linear alignment of grave pits along the northern edge of the area and several north-south-oriented grave pits located along the east and west margins of the area. These included Grave Pits 13616 and 26908 on the east end of Cemetery Area 4 and Grave Pits 7743 and 28110 on the west end of Cemetery Area 4. The presence of densely packed grave pits lining the margins of the area suggests that space became a premium within the walled or fenced area and that a few people were forced to find room for grave pits along the edges of the area, presumably along the inside edge of the enclosure. Unfortunately, no historical evidence was uncovered to support the existence of a wall or fence surrounding Cemetery Area 4. The original southern limit of Cemetery Area 4 is also unknown, because of the intrusion of the Tucson Newspapers basement, which undoubtedly destroyed a large number of grave pits originally placed within this cemetery area.

The significance of Cemetery Area 4's uniquely dense distribution of grave pits is not entirely clear, given a lack of historical information on the use of the area, but the dense distribution of grave pits in Cemetery Area 4—along with frequent intrusion into earlier burial features to make way for new ones, with disturbed remains placed to the side of newly placed remains—bears a striking resemblance to earlier burials in the Tucson presidio graveyard, the San Agustín Mission complex graveyards, and other early Hispanic burials in Mexico and the American Southwest (Di Peso 1958; Hard and Doelle 1978; Tennis 2002; Thiel et al. 1995; Will de Chaparro 2007). Essentially, these burial traditions reflect an interest in burying individuals in consecrated ground, often in churchyards or beneath church floors, and preferably within spaces associated with particular saints or other sacred vestiges (see Chapters 5 and 8, Volume 1 of this series). Despite the strong resemblance of some aspects of burial in Cemetery Area 4 to earlier Hispanic Catholic traditions practiced in Mexico and the American Southwest, differences in other variables between Cemetery Area 4 and the adjacent Cemetery Area 3, where many of Tucson's local Hispanic population appear to have been buried, have apparently been minor or subtle, suggesting an overarching similarity between Cemetery Areas 3 and 4 in cultural backgrounds and in some aspects of burial treatment.

Among the possible explanations for the characteristics of burial in Cemetery Area 4 is that the area represents the earliest version of the civilian section. In this case, the area would have been used intensively until a much larger cemetery parcel was set aside in the 1872 town-site survey. Another possibility is that Cemetery

Area 4 was used by a particular segment of the Tucson population (for example, an ethnic or religious group or a large extended family) at the same time that the larger civilian section was in use. As discussed in Chapters 5 and 8, Volume 1 of this series, it may be the case that Cemetery Area 4 represents a more religiously conservative segment of the community than Cemetery Area 3, with burials in Cemetery Area 4 placed according to earlier traditions and expectations for a good burial and burials in Cemetery Area 3 placed in accordance to the new tenants of cemetery reform, which promoted the placement of burials in distinct and identifiable, individual graves and discouraged the disturbance of previous graves to make way for new ones. In this regard, Cemetery Area 4 may represent consecrated ground associated with the Catholic Church that was set apart from the rest of the civilian section. An area of consecrated ground was established in the later Court Street Cemetery, which served as the official Tucson cemetery from 1875 until 1909. Historical accounts of the use of consecrated ground in the Court Street Cemetery suggest that there would have been a similar area within the Alameda-Stone cemetery (O'Mack 2006:39–40).

Cemetery Area 5

Cemetery Area 5 encompassed the smallest number of grave pits for the five cemetery areas, with a total of 31 grave pits, including a total of 28 burials representing 30 individuals (see Table 30). Cemetery Area 5 was located in the northwesternmost portion of the former cemetery. As can be seen in the overall map of graves (Figure 31), Cemetery Area 5 appears to have been a distinct grouping of grave pits along Stone Avenue. Initial inspection of Cemetery Area 5 suggested that this area may have represented a later use of the cemetery area, as evidenced by the isolated nature of the grave pits in this northernmost portion of the cemetery. Another hint of the possibly later date of Cemetery Area 5 was the overall orientation of the grave pits. Most grave pits elsewhere in the cemetery had an east-west orientation that was slightly off a true east-west line, but in Cemetery Area 5, most of the grave pits had a more precisely east-west alignment. One possible interpretation of this difference is that the grave pits in Cemetery Area 5 were placed with reference to the truly north-south alignment of Stone Avenue, which was incorporated into the regularized street grid of Tucson with the 1872 town-site survey. Before the town-site survey, there were few, if any, visual references that reflected a true east-west alignment, which meant that any attempt to lay out grave pits with an east-west orientation was inevitably approximate, as witnessed by the alignment of the inferred military section wall, as well as the orientation of Cemetery Area 4, as a whole. Demographic information shows that Cemetery Area 5 was composed mostly of Hispanic individuals, with a relatively even distribution of ages and sexes. Even if used late in the history of the civilian section, beginning in 1872 when the regularized street grid was created, Cemetery Area 5 could not have contained more than a small percentage of the graves likely to have been placed during that period, suggesting that the area was reserved for some special purpose. In addition, a number of the graves in the northwestern portion of that section line up well with our hypothesized alignment of the civilian section wall, which does not appear to have been aligned with the regularized street grid but, instead, with the former alignment of Stone Avenue. Given the sparse and somewhat distinct and removed location of Cemetery Area 5, one possibility is that it was an area reserved for outcasts, strangers, or individuals who suffered unusual circumstances of death.

Walls and Other Boundaries

The first record describing the overall cemetery boundary comes from an 1872 town-site survey map of Tucson, which shows a large area bounded by Stone Avenue, Cemetery Street, Sixth Avenue, and Seventh Street designated for use as a cemetery (Figure 32). By 1880, the cemetery parcel had been divided in half diagonally, with the northwestern half used to accommodate Toole Avenue, the Southern Pacific Railroad, and a series of lots between Toole Avenue and the railroad. As indicated in a map of Tucson by Pattiani (1880) (Figure 33), the railroad bisected the original cemetery plot from southeast to northwest. Eventually, a road that paralleled the railroad tracks was established and named Toole Avenue. Toole Avenue bordered the cemetery

along the north and east, thus making the new cemetery parcel triangular in shape. No historical documents suggested concern over the impact of these developments on the cemetery.

The entirety of this large area was unused through the use life of the cemetery, however, and the excavations for the Joint Courts Complex project have demonstrated a convincing boundary for the cemetery as a whole. Archaeological information based on the locations of grave pits and other disturbances suggests that only the southwestern corner of the area officially designated as a cemetery was used as such. Our excavations show that the cemetery was bounded by Stone Avenue to the west, Alameda Street to the south, Toole Avenue to the north, and what later became Grossetta Avenue to the east.

Apart from the land allocated for the cemetery, there is also archival evidence that walls were erected for both the military and civilian portions of the cemetery. Examination of an 1880 photograph by Carleton Watkins (courtesy of the Arizona Historical Society, Tucson, Accession No. 18233) shows two distinct walls associated with the cemetery (Figure 34). The smaller military section to the south appears to have been completely enclosed, and the civilian section appears to have been walled on the west and north but left open to the south and east. A more detailed photograph of the military section wall was taken by John Vance Lauderdale in 1870 (Figure 35).

The Military Section Wall

Based on prefieldwork archival research, we extrapolated that the former military section measured about 108 by 108 feet, sat more or less along the north edge of modern Alameda Street, and was set back about 50 feet from the east edge of modern Stone Avenue (O'Mack 2006:22–32). Shortly after our second background report was finalized, however, we learned more about the wall of the civilian section from a series of early newspaper articles (*The Weekly Arizonan* [*WA*], 7 May 1870:3, 7 May 1870:2, 14 May 1870:3, 14 May 1870:2). These brief articles announced a request by the county for bids to build an adobe wall around the civilian section that would incorporate the existing military section wall (which we know from other documentation to have been built around 1868). The wall specified in the request was apparently never built, at least not in the proposed configuration (the actual civilian section wall, known from other sources, probably resulted from a modification of the same proposal), but the description allowed us to infer the dimensions of the military section as 150 by 150 feet. However, more recently discovered plat maps of the cemetery indicate that the cemetery was 120 feet east-west by 150 feet north-south. The discrepancy in the east-west dimension of the cemetery cannot be easily reconciled at this time, because most of the western portion of the military section was not excavated, either because it lay outside the project area or was disturbed through construction of the newspaper basement. Therefore, no archaeological information could be used to define or verify the military section's western limit. However, if we use the boundaries of the cemetery as indicated in the overlaid plat map as a guide, the southwestern corner of the military section would have been located within 15 feet of the northern edge of modern Alameda Street and around 87 feet from the east edge of modern Stone Avenue. Based on the distribution of grave pits and the plat map, the orientations of the walls of the cemetery were clearly not aligned with true north but, instead, shifted slightly to the west.

During our excavations, we discovered two segments of adobe wall that we inferred to possibly be remaining portions of the military section wall. One was located along the eastern edge of the military section (Feature 968), and another (Feature 27038) was located at what we inferred to be the southeastern corner of the military section. The possible wall segment located along the eastern limit of the military section may have been part of the original cemetery wall, given its location and orientation. The eastern limit of the military section also appears to have been fairly neatly defined by an extended gap between grave-pit rows, corresponding to the division between the military section (Cemetery Area 1) and Cemetery Area 2 of the civilian section to the east.

The precise northern and southern limits of the military section are not entirely clear, however. Despite our original interpretation of one wall segment as the southeast corner of the cemetery wall, the overlay of the historical and archaeological mapping information appears to indicate that the orientation and location of the cemetery walls do not closely match that feature. The wall segment may instead correspond to the property

boundary for a later residence. Moreover, the northern limit of the military section, as indicated by overlay of historical and archaeological mapping information, places six additional grave pits within the possible limits of the military section (Grave Pits 3286, 3287, 3288, 3289, 3315, and 3438). Three of these grave pits would have been completely or partially overlapped by the historically mapped cemetery wall.

The six grave pits in question could not be correlated with any historical mapping information or otherwise-documented burial in the military section; so, it was ultimately decided not to include them in the military section, based on a lack of information, although there remains a distinct possibility that some or all of those individuals were deliberately placed in the military section. Unfortunately, the interpretation of the osteological and contextual information did not allow us to unambiguously determine whether any of these six individuals were deliberately placed within the limits of the military section. Five grave pits contained the unexhumed remains of adult males, several of whom suffered trauma during their lifetimes or had conditions indicative of strenuous physical activity. Another grave pit contained the remains of an infant whose burial is not listed in any of the burial records for the military section. Only one of the six individuals, an African American individual in Grave Pit 3315, had military-associated artifacts deposited in the burial, but military-associated artifacts were also discovered in burials clearly located outside the military section. We believe our current definition of the military section to be fairly conservative, as it is based on the balance of available archaeological, historical, and osteological data. In this scenario, the extent of the military section was defined by rows of grave pits but not necessarily by the cemetery wall itself, as the wall was built after the military section had been in use for 6 years and may have been built over grave pits considered to be outside the military section. This definition of the military section also suggests that, when the wall was built, it may have been built in such a way as to provide a fairly regular spacing of around 5–7 feet between the outermost grave pits in the military section and the military section wall.

The Civilian Section Wall

Prior to fieldwork, it proved difficult to infer the extent of the wall at the western and northern limits of the civilian section as shown in the 1880 Watkins photograph, in part because of uncertainty about the dimensions of the military section. Although we were unable to confirm the western limit of the military section because it lay outside the project area, we were able to use the dimensions of the military section as depicted on the 1881 plat map to infer the possible dimensions of the wall along the western and northern edges of the civilian section. To do this, we simply measured the relative lengths of the western and northern walls of both the military and civilian section as shown on the detail of the 1880 Watkins photograph. We then used the historically recorded dimensions of the military section to estimate that the civilian section wall may have measured approximately 332 feet north-south by 260 feet east-west. To place the wall in space, we noted that the north-south civilian section wall in the 1880 photograph appears to have been aligned in a more northwesterly direction than the north-south wall of the military section, which still deviated from true north by several degrees. We have a reasonably good idea of how the military section was aligned and can infer the alignment of the boundaries of Cemetery Area 4 based on the distributions and orientations of graves and rows in that area. Assuming that the north-south wall of the civilian section was aligned roughly perpendicular to rows in Cemetery Area 4 and the grave pits in the western half of Cemetery Area 3, we positioned the hypothesized location of the north-south wall to enclose grave pits on the western limit of Area 3 and to line up with grave pits on the south edge of Cemetery Area 3. Assuming also that the two wall segments on the north and west sides of the civilian section were perpendicular, we then simply extended the east-west wall a distance of 260 feet, perpendicular from the northern end of the north-south wall. However, this scheme extends the northwest corner of the cemetery under Stone Avenue, and we found no archaeological evidence that indicated that grave pits continued under Stone Avenue. An alternative model would place the civilian section wall in a more strictly north alignment, but we have no clear archaeological evidence that could be used to infer precisely where the wall would have begun and ended, as no remnants of this wall were found.

Numbers and Kinds of Grave Pits and Burial Features

Within the cemetery, the archaeological evidence indicates a consistent morphology for grave pits. Most grave pits were rectangular in plan view and cross section, with straight, vertical walls. Some recognizable differences in the size, shape, and construction techniques of grave pits were identified, including the presence of head niches, vaulting, and variations in orientation (see Chapter 5). The lengths of the bottoms of grave pits also tended to conform to the ages of the individuals interred within the grave pits. For example, an adult individual would be placed in a relatively large grave pit, and a juvenile would be placed in a relatively small grave pit. A comparison of grave-pit size and age supports this general trend (Figure 36). The size distribution shows that, on average, adult individuals were interred in grave pits greater than 1.9 m in length, subadults were interred in grave pits between 1.5 and 1.9 m in length, children were interred in grave pits 1.2–1.5 m in length, and infants were interred in grave pits less than 1.2 m in length. However, there was also some variation among cemetery areas in grave-pit dimensions according to age and sex (Table 32). These trends were used to assess the possible ages of individuals whose remains were found to lack sufficient osteological evidence for age estimation.

The original, historical-period excavation of grave pits also amounted to a tremendous amount of effort during the use life of the cemetery. Grave-pit excavations were arguably the most pervasive ground-disturbing activity within the Joint Courts Complex project area boundary. A sample of 1,075 grave pits (excluding 8 grave pits with missing volumetric data) was used to calculate the volume of sediment excavated during the use of the cemetery. From the 1,075 grave pits, a total of 1,275.5 m^3 of sediment were excavated. This is an average of 1.19 m^3 of sediment per grave pit (Figure 37). The largest calculated volume was from Grave Pit 3244, which held the remains of three individuals placed side-by-side in a large, rectangular grave pit and had a total volume of 5.44 m^3. The smallest measure of volume was from Grave Pit 22299, representing an infant interred within a very shallow grave pit with a total volume of 0.025 m^3. Some of the variation of grave-pit volume came from truncated and disturbed grave pits, for which we could not record the maximum dimensions.

To examine variation in grave-pit depth between cemetery areas, Statistical Research, Inc., cartographers modeled the elevation of the original ground surface (Figure 38). We then estimated the depth of each grave bottom from the elevation of the original ground surface, as modeled. There are a number of drawbacks to this approach, not the least of which is that our understanding of the elevation of the original ground surface is limited, at best, for some parts of the project area because of disturbances and a low density of recorded surface elevations. Nonetheless, the modeled ground surface appears, in general, to conform to our expectations of a gradual decrease in elevation as one moves north across the project area. The modeled surface also shows a curvilinear contour in the southern part of Cemetery Area 3 that conforms well to the alignment of grave pits in that area, suggesting that the grave pits in the southern portion of Cemetery Area 3 may have been oriented somewhat differently from other grave pits, simply because their alignment was influenced by topography rather than some other factor.

In any case, grave-pit depth showed considerable variation among cemetery areas. A lot of variation was probably statistical noise that was introduced by the many disturbances to the project area after the cemetery period, resulting in anomalously shallow depths for some grave pits in some cases. We thus modeled the top 10 percent of grave-pit depths in each cemetery area in an attempt to identify values that would have been most similar to the original grave-pit depths in those areas. A drawback of this approach was that only three grave pits make up the upper 10 percent sample for Cemetery Area 5, but the results were consistent with the overall pattern of grave-pit depths as can be discerned from rank-size analysis (Figure 39). The deepest grave pits were found in Cemetery Area 4, followed by Cemetery Area 1, with the deepest 10 percent of grave pits averaging 115 cm (3.8 feet) and 100 cm (3.5 feet) in depth in those areas, respectively. Grave pits in Cemetery Areas 2 and 3 had fairly similar depths, around 90 cm (3 feet) in depth for the deepest grave pits, whereas the shallowest grave pits were found in Cemetery Area 5. It is possible that the depth of a hard, restrictive layer, such as caliche, varied among the cemetery areas and thus formed a practical limit on the depth of grave pits in each area. Another possible explanation for this pattern is that there was a different level of investment in grave digging among cemetery areas. It makes sense that at least some of the grave pits in Cemetery Area 4 would

have been especially deep, as they needed to be larger, volumetrically, to accommodate multiple burials. It might also make sense that burials were most shallow in Cemetery Area 5, if that area contained the burials of individuals who were strangers or outcasts. It is not entirely clear, however, why Cemetery Areas 2 and 3 would be similar in grave-pit depth, as grave pits were generally larger in Cemetery Area 2, to accommodate the larger number of adults.

Cemetery Use and Growth Patterns

Its short time frame and community-wide use has made the Alameda-Stone cemetery a unique snapshot of Tucson during a crucial period in the history of the settlement. At the same time, the brief period of use also limits the potential for using material culture to infer temporal change. There were very few contexts in which was found a temporally diagnostic artifact or feature information of sufficient resolution to infer a sequence of burial (see Chapters 5 and 6). Moreover, stratigraphic relationships that could be used to infer a sequence of burial or to document change in artifact types or burial treatments were rare. With the exception of some grave pits in Cemetery Area 4, most grave pits within the cemetery were placed individually to the sides of previous grave pits and did not intrude into earlier grave pits. As discussed above, a sequence of burial could be discerned for grave pits or burial features that disturbed earlier features, and these represent the best archaeological information we have for documenting change through time during the short period the cemetery was in use. These feature to feature relationships are discussed below.

Because archaeological data that could be used to temporally distinguish grave pits was rare, it was difficult to definitively discern how the cemetery grew over time. Our suspicion is that Cemetery Areas 1 and 4 were likely established first, although we do not know whether Cemetery Area 1 was established before, after, or roughly at the same time as Cemetery Area 4. It seems reasonable to assume that the presence of either area triggered the establishment of the other.

During the period the cemetery was in use, a long period of sectarian reform in Mexico was taking place, during which time "reformers promoted the construction of suburban cemeteries to end 'vain' funereal displays" (Voekel 2002:74). Earlier Catholic cemeteries in Mexico were often located within the church building itself or in the yard surrounding the church. To churchgoers, it was of utmost importance to be buried in sanctified ground. There were also areas within church graveyards that were more coveted than others and that were generally reserved for individuals of higher status. However, during the late-seventeenth century and into the eighteenth century, the state began to wrest control from the church over such matters as burial grounds and public health and began to push for the secularization of burial grounds. Government officials in Mexico insisted that cemeteries were a health hazard and that, as a matter of public health, cemeteries needed to be placed on the outskirts of town rather than within or adjacent to churches closer to the center of town (Lomnitz 2005; Voekel 2002). Religious authorities were opposed to these stipulations because they stripped authority from the church over the matter of death. Churchgoers were also deeply concerned by the reforms, because they placed the dead farther away from their loved ones, in locations where their graves could not be visited and maintained as regularly as those at the church. Placing the dead farther away also prevented the burial of people close to loved ones who had previously been buried in the church or churchyard. People of high social status were also horrified by the possibility of being thrown together with the masses in the cemetery, according to the new vision of "egalitarian, atomized cemetery plots in individual boxes (nichos)" and being denied their rightful place in the "corporate hierarchy of the sanctuary floor" (Voekel 2002:217). These reforms also may have had the added effect of establishing cemeteries that were not sanctified in the same way as those on church property. In other words, they were not continuously blessed and watched over by the church and maintained in direct association with the sacred space of the church and churchyard. In some areas, opposition to cemetery reforms led to protests and riots, as well as efforts to subvert or sidestep new regulations (McCrea 2007). This growing trend toward secularization of burial grounds coincided with a new spiritual perspective among Hispanic intellectuals "that proffered an internal, individual, and direct spirituality that exalted moderation, reason, and discipline over all other

Christian virtues. In doing so, the new piety challenged baroque techniques of rule and the divine sanctification of ossified social hierarchies and enshrined individual moral moderation as the true justification for social rule" (Voekel 2002:44). This new spirituality promoted individual self-reflection and the development of a direct relationship with God over the previous baroque spirituality in which an individual's relationship with God was mediated and controlled by the Church.

It is unclear if and to what degree these reforms had reached Tucson before the settlement was absorbed by the United States in 1854 or how citizens felt about such matters. However, it seems plausible that a church burial ground may have been placed on the outskirts of town, in keeping with the spirit of these reforms or simply because of the need to find more space for burials in the growing town.

We suspect that Cemetery Area 4, which appears to have been enclosed by a wall or fence, was an area that was established early on for burial by the church. Previous burials had taken place at the presidio and apparently at one or more locations between Church Street and Stone Avenue (Ciolek-Torrello and Swanson 1997). Graves at the presidio appeared to have been disturbed frequently as a result of emplacing new burials, with skeletal materials gathered up and placed back in the ground in order to make room for new burials. This is the kind of pattern that we might expect to have occurred in sacred ground where space was limited and the main intent was to ensure that a person's remains were placed into sacred ground.

Indeed, the first 35 entries in the diocese burial register, signed by Pastor Aloisius M. Bosco, S. J., all end with the Latin phrase *in coemeterio hujus Ecclesiae*, meaning "in the cemetery of this church." Those 35 burials, which date from May 28, 1863, to July 19, 1864, are followed by no entries until some point early in 1866, when J. B. Salpointe signed the burial record for a Papago woman buried at San Xavier. After that point, François Boucard began signing entries, the first of which recorded the burial of Angel, the 3-month-old child of Juan Lopez and Maria Rivera, on April 4, 1866. These later entries do not mention anything about being buried "in the cemetery of this church," which could simply be a matter of style, or it could mean that there was a change in where people were buried. However, if the earlier burials occurred in the civilian section of the Alameda-Stone cemetery, and not at San Agustín chapel or some point in between, it seems possible that Cemetery Area 4 could have been an area that was specially sanctified by the church for use as a burial ground. Perhaps, as that area began to fill in with burials, burials also were placed in Cemetery Area 3, and later still in Cemetery Area 5. A similar process may have happened with the military section. The military section may have been established first and Cemetery Area 2 established at some point shortly afterward for individuals who were not directly affiliated with the Catholic Church or with the U.S. military. No archaeological evidence has come to light suggesting that the cemetery was used before the early 1860s or after the military and civilian sections were officially closed for interments (see Chapters 5 and 6).

The Sequence of Burials in the Military section

Dates of death compiled from multiple historical sources indicate that the military section was filled in by row and quadrant according to a somewhat regular chronological sequence, with the easternmost row in the eastern half (historical-period grave numbers 1–16; see Figure 24) being the earliest row and each new row in the eastern half of the military section placed to the west of a preceding row. The apparent sequence of burials as could be reconstructed from historical-period documents, however, suggests no overall design or prior planning, as the sequence of burials is not consistent from row to row. Instead, the way in which rows were filled in changed over time, perhaps as different individuals became involved in deciding where to place the next grave.

We have archival information on only 3 of the 16 individuals placed in the first (or easternmost) row (historical-period grave numbers 1–16; see Figure 24), but Assistant Quartermaster G. C. Smith seems to have been under the impression that the many unknown soldiers in the easternmost row were California Volunteers, who would have been among the earliest U.S. military dead in Tucson. The dates of death and placement of the 2 earliest burials in the cemetery suggest a southward burial sequence (historical-period grave numbers 12 and 13). If these 2 burials were indeed the earliest in the cemetery, however, taking place in July 1862, at least 3 subsequent burials would have been placed to the north of those 2 burials, and the remaining 11 graves in

that row, placed to the south. One burial was placed in the walkway along the same row alignment, probably in April 1867, several years after the row had been completed.

Dates of death in the next row to the west (historical-period grave numbers 17–34; see Figure 24) were arranged in time from north to south for the entire row for all datable graves, with the exception of two graves. The graves of Private Michael Murphy (Company C, Thirty-second U.S. Infantry; historical-period grave number 26) and Sergeant John King (Company I, Fourteenth U.S. Infantry; historical-period grave number 27), were placed on either side of the walkway after the row was continued farther to the south, in the southeast quadrant. The southernmost grave pits in the sequence were those of Private George Johnson (Company A, First California Cavalry; historical-period grave number 20) and Private William S. Leonard (Company D, First California Cavalry; historical-period grave number 21), who were killed at Picacho Peak in 1862 but reburied later in Tucson, a fact that remains consistent with a southward-trending burial sequence in that row of the military section.

Burials in the next row to the west (historical-period grave numbers 35–52; see Figure 24), for which we have a large number of dates of death, clearly indicate a different pattern from that of the preceding row to the east. Beginning at the walkway separating the northeast and southeast quadrants, the row was filled according to a northward sequence in the northeast quadrant and a southward sequence in the southeast quadrant. It is not known what logic, if any, dictated the decision to place each new burial in the northeast or southeast quadrant in this row, as the dates of the burials do not seem to clearly alternate between quadrants, nor do burials appear to cluster in either quadrant according to a variable, such as regiment.

The sequence of burials in the final row in the eastern half of the military section (historical-period grave numbers 53–63; see Figure 24) appears to have been northward for the entire row, starting with the grave of Private Martin Burns (Company E, Twenty-third U.S. Infantry; historical-period grave number 53) near the southern edge of the cemetery. The last two grave pits placed in the eastern half of the cemetery were recorded on the 1881 burial list but do not appear on the 1881 plat map, which could mean that the map itself was produced prior to July 1880, before those last two burials were placed. Statistical Research, Inc., did find two grave pits (Grave Pits 28076 and 28077) immediately to the north of the last grave represented on the plat map, suggesting that the row was continued to the north after the map was produced. Altogether, dates of death and grave placement for individuals buried in the eastern half of the military section suggest some attempt at maintaining a regular sequence of burial locations within each row and the formation of a new row to the west as each row was filled in. However, several graves were placed close to or within the walkway, out of sequence, and temporal patterning in grave placement suggests that the sequences of burials in previous rows may have been unknown or disregarded as new rows were initiated and subsequent burials placed.

We have dates of death for only around a third of the individuals who were buried in the western half of the military section. Also, the bulk of the western half of the military section fell outside the project area investigated by Statistical Research, Inc., leaving us with little archaeological information concerning the western half of the military section. The few dates of death available do not show any clear patterning as to where graves were placed. The historical plat maps indicate that graves in the western half of the military section were placed in rows, possibly starting with the westernmost row, but unlike the eastern half of the cemetery, rows do not appear to have been filled in completely before another row was started. The difference in the sequencing and placement of burials between the western and eastern halves of the military section suggests that the western section may have been subject to less oversight and planning than the eastern half of the military section.

Civilian Section Row Analysis

In order to further differentiate potential patterning within the civilian section, we identified possible rows of grave pits within the cemetery (Figure 40). At first, cursory examination of the pattern of grave pits with respect to possible rows suggested that the identification of rows within many areas of the cemetery would be difficult, at best. One need only look at a map of grave-pit locations to see that grave pits were not placed in evenly spaced or straight rows. Instead, there was a fair amount of variation in the spacing and precise alignment of grave pits, and possible rows of grave pits appeared to follow curvilinear rather than straight paths.

When we began to examine the placement of grave pits in more detail, however, it became clear that many grave pits appeared to be aligned in roughly north-south rows. In some cases, grave pits also appeared to be aligned in east-west rows. As is discussed by Sewell (see Chapter 5), the vast majority of grave pits are oriented along an east-west axis, with heads placed either to the west or east, a fact that also supports the notion that grave pits were deliberately placed in rows.

In order to assign grave pits to hypothetical rows, we first gathered together our mortuary specialists, field director, and principal investigators involved with the cemetery portion of the project. Each was given a map showing the distribution of grave-pit polygons and was asked to delineate rows on the map. The results were remarkably similar, particularly for north-south rows, suggesting some validity to the idea that the cemetery was organized in rows. Using these maps as a guide, we then assigned grave pits to rows in GISs, using a set of arbitrary rules following Goldstein (1980). Our first attempt at assigning north-south rows was made for the cemetery as a whole, without respect to cemetery areas. Rows were allowed to traverse the entire cemetery from north to south, if possible, with row numbers assigned sequentially from west to east. The purpose of this row-numbering scheme was to begin the preliminary identification of rows according to a numbering scheme that was uniform across the cemetery. With this scheme, analysts had the potential to examine variation between rows while preserving the relative placement of rows anywhere in the cemetery. Of course, grave pits with the same row number in two adjacent cemetery areas may not represent parts of a contiguous row. We address this problem below.

We also tried to define east-west rows but could not arrive at consistent results. For east-west alignments, it appears that there were a few clusters of four or more grave pits aligned along an east-west axis, but they did not appear to follow any consistent patterning across the cemetery. It was concluded that apparent east-west alignments may have been a natural consequence of placing grave pits in north-south rows, wherein the attempt was made to align graves in a north-south row with existing graves in adjacent rows. As such, the effort to define east-west rows was abandoned.

Using the relative sequence of north-south rows defined for the cemetery at large, we developed additional numbering schemes internal to each cemetery area, so that the westernmost row in each cemetery area began with the number 1 and numbers increased sequentially within each cemetery area, from west to east. Grave pits within rows were also numbered, with the southernmost grave pit in each row numbered 1 and each successive grave pit to the north numbered sequentially. This row- and grave-pit-numbering scheme allowed us to track variation within and among cemetery areas in basic dimensions related to the placement and digging of grave pits, such as the size and spacing of grave pits within and between rows.

When mapped according to rows, it is clear that grave pits within the cemetery were organized routinely in north-south rows, with grave pits placed in rows and oriented along an east-west axis (see Figure 40). As O'Mack (2006) hypothesized, grave pits were likely aligned perpendicular to the orientation of Stone Avenue at the time the cemetery was in use, which may explain the northwesterly alignment of rows, particularly in areas of the cemetery closer to Stone Avenue. It may also be the case that the more-northerly orientation of rows in Cemetery Area 5 reflected the realignment of Stone Avenue and thus suggests that grave pits were first placed in this area later than in Cemetery Areas 3 and 4 (O'Mack 2006). The row analysis also makes it clear that there was a fair amount of deviation from any apparent organizational scheme; most of the rows followed curvilinear paths, as though they were not laid out on a grid but, instead, were placed as necessary and with their precise alignments varying according to topography and vegetation. For instance, based on our reconstruction of the original ground surface, a series of atypically aligned grave pits in the southeasternmost portion of Cemetery Area 3 may reflect that grave pits were placed to follow the contour of the ground surface (see above).

Variation in the alignment and spacing of rows and grave pits suggests that the placement of grave pits within the civilian section did not follow any overarching, explicit plan, with grave pits and rows laid out according to a predefined design. Instead, the variation in grave-pit spacing and alignment suggests that grave pits were probably added as needed when a death occurred or more were expected in the near future. This suggests, further, that, at least within cemetery areas, growth in the cemetery probably expanded outward from where it first began, within the limits of the plot allotted to the cemetery. It thus appears that the civilian section could have expanded from west to east, in general, but it also seems likely that the placement of a new grave pit in the cemetery did not necessarily follow any rigid, formal rules. This may conform to a situation

wherein either the families of deceased persons or the persons contracted to do the grave digging were responsible for choosing where to locate a new burial, rather than a sexton or cemetery administrator, and new burials were placed respective to their neighbors, without rigid conformity to the overall cemetery layout.

Grave-Pit and Row Spacing

We also used rows identified within the cemetery to analyze variation across the cemetery in the spacing of rows and grave pits within rows. This information allowed us to evaluate differences among the cemetery areas, as well as to identify patterning in grave-pit placement that might lead to further subdivision of the cemetery according to time, demography, or other factors. We estimated row spacing for each grave pit and row by calculating, in GISs, the shortest distance between grave pits in adjacent rows (eliminating cases for which there were no adjacent grave pits). Spaces between grave pits within rows were calculated by measuring the shortest distance between the centroids of each grave pit and the next grave pit to the north in the same row. To model grave-pit spacing for each cemetery area, we subtracted the average top length of grave pits from the average spacing between rows to arrive at an average spacing between grave pits (Table 33). We performed a similar exercise to model the average spacing between grave pits within rows, by subtracting the average grave-pit top width from the average spacing between grave pits in each row (Table 34). A more precise estimate could be arrived at by performing a similar equation for each pair of adjacent grave pits, but this proved to be cumbersome for this exercise. An estimate of the length of each row was made by summing the centroid to centroid distance between adjacent grave pits within a row.

This analysis showed that the longest rows were in Cemetery Areas 1 and 3, followed by Cemetery Areas 2 and 4 (Table 35). The shortest rows were in Cemetery Area 5. Obviously, the length of rows in Cemetery Area 4 is underestimated, because that area was truncated by the excavation of the Tucson Newspapers building basement in 1940 and 1953. We might expect rows to have originally been two or more times longer in Cemetery Area 4 if the area were relatively square in size and a similar distribution of grave pits occurred throughout the area. On average, rows tended to include around 11–13 grave pits, regardless of cemetery area, but rows in the western half of Cemetery Area 3 (Area 3a) contained nearly double the number of grave pits in comparison to rows in other areas of the cemetery, and these rows were substantially longer than rows in any other part of the cemetery.

We also monitored differences in the mean and coefficient of variance for individual rows within cemetery areas, in an attempt to detect change in these variables as one moved from west to east across the cemetery. This analysis showed that Cemetery Areas 3 and 4 appeared to mirror each other in the spacing between rows, as if grave pits were roughly aligned with each other in Cemetery Area 4 and the western half of Cemetery Area 3. This analysis also showed an apparent break in grave-pit and row spacing east of Row 21 in Cemetery Area 3. Grave-pit and row spacing were highly variable in the western half of Cemetery Area 3 (Cemetery Area 3a), between Rows 1 and 21, but became more standardized in the eastern half of Cemetery Area 3 (Cemetery Area 3b). The general alignment of rows also appeared to shift to a more northerly alignment in the western half of Cemetery Area 3. These data suggest that there may have been a fundamental difference between the two parts of Cemetery Area 3, in terms of how these areas were used or when they were used, or both. One possibility discussed in Chapters 7 and 9, Volume 1 of this series, is that the eastern half of Cemetery Area 3 represents the use of that area for the burial of people after epidemics, as a large number of young juveniles, as well as older adults, were buried there.

Feature to Feature Relationships

We have no historical information on the sequence of burials for any burials in the civilian section. Therefore, the only avenues we had for investigating the sequence of burials were sequences of grave pits that intruded into previous grave pits and sequences of burials within grave pits that could be determined from indicators of disturbance or stratigraphic positioning and other clues. When grave pits or burials were superimposed or

intruded on other grave pits or burials, these feature to feature relationships were recorded in the field by determining which feature was earlier. These relationships allowed us to develop Harris (1989) matrices (see Appendix I) that delineated the temporal relationships between groups of features in cemetery areas where such relationships occurred. Feature to feature relationships between grave pits occurred only in Cemetery Areas 2, 3, and 4 and were absent in the other two cemetery areas.

Because the Alameda-Stone cemetery was established on the eastern edge of town, one hypothesis is that burials were placed in rows first on the west side and that, as rows filled in, additional rows of grave pits were placed immediately to the west of earlier rows. Each grave pit in a sequence of grave pits may have been placed immediately to the north or south of the preceding grave pit, a pattern which may have alternated as rows were filled in. Obviously, we do not expect such a formal pattern to have been universally carried out with each new grave pit. On the contrary, archaeological and osteological evidence suggest that some grave pits were squeezed between existing grave pits or rows, in order to bury an individual near an earlier grave pit or cluster of grave pits (see discussion on exhumation and row analysis). Also, as in the military section, it is possible that the first rows were set back some distance from Stone Avenue and some subsequent rows were placed to the west of earlier ones as the cemetery began to fill.

Feature to feature relationships for grave pits and burials were analyzed for Cemetery Areas 2, 3, and 4; the vast majority were in Cemetery Area 4 (Table 36). The few relationships in Cemetery Area 2 do not warrant major discussion, but it is worth noting that, for each of the four relationships in this area, the later grave pit was either placed immediately to the north or east of the feature it intruded upon, suggesting that Rows 2, 3, and 4 in Cemetery Area 2 may have been filled in from south to north and that rows were placed from west to east (see Table 36). The pattern, however, is based on limited evidence and could easily be broken if temporal relationships were known for additional burials.

In Cemetery Area 3, there were 13 "earlier-than" relationships that could be discerned for grave pits and 8 "earlier-than" relationships that could be discerned for burials within grave pits. There were also 2 "equal-to" relationships between burials. Of the relationships between grave pits, 8 relationships each involved a grave pit that was intruded upon by a later grave pit placed immediately to the north of the earlier grave pit; 4 grave pits were each placed immediately south of an earlier grave pit; and 1 was placed immediately east of an earlier grave pit. Unfortunately, none of the relationships occurred in the same row, and they were scattered across Cemetery Area 3. Two of the 4 grave pits each placed to the south of an earlier grave pit involved a grave pit's being sandwiched between 2 preexisting grave pits or 2 later grave pits' being placed on both the north and south sides of an earlier grave pit. The other 2 grave pits placed to the south of an earlier grave pit occurred on the far-east side of Cemetery Area 3.

Remarkably, 9 of the 13 feature to feature relationships in Cemetery Area 3 involved at least 1 grave pit that appears to have been previously exhumed (see section on exhumations). This suggests the possibility that the appearance of a temporal relationship was created during the process of exhumation, that some features identified as grave pits were not actually grave pits, or that some grave pits intruded on earlier grave pits because there was an attempt to bury someone close to a previous burial. Many of the grave pits involved in feature to feature relationships appear to have been fit snugly against one another, as if there was an attempt to bury someone adjacent to a previously buried friend or relative. This pattern also contradicts the idea that, in Cemetery Area 3, the position of the later feature in a feature to feature relationship (whether north or south of the earlier feature) can be considered representative of the direction in which rows were filled in with each new grave. Rather, the directionality of placements might be random, or there might have been a tendency to place subsequent grave pits to the north of a loved one's grave pit.

Feature to feature relationships in Cemetery Area 4 were most numerous, in comparison to other cemetery areas, and were complex, owing to the tendency in that area to disturb earlier grave-pit or burial features in the process of placing a new burial (see Appendix I). In Cemetery Area 4, there were 95 "earlier-than" relationships between grave pits and 15 "earlier-than" relationships between burials within grave pits. There were another 8 "equal-to" relationships between burials in Cemetery Area 4 grave pits. The data suggest that, unlike other cemetery areas, there was a frequent effort to place burials within the same grave pit, either at the same time or at a later time. In addition, many grave pits were dug so that they substantially intruded into previous grave pits. In other words, unlike in Cemetery Area 3, there was not a consistent effort to place intruding grave

pits immediately north or south of existing grave pits. Instead, grave pits appear to have often been placed, perhaps deliberately, to overlap with a previously existing feature, often on multiple sides of the earlier feature. In addition to grave pits' intruding into earlier grave pits, a number of the grave pits in Cemetery Area 4 involved in feature to feature relationships had multiple burials within them. Many of the temporal relationships between grave pits or burials in Cemetery Area 4 involved 1 or 2 grave pits' being earlier or later than another 1 or 2 burials, but a few temporal sequences were more extended, involving 10 or more burials and grave pits. Three or four tiers of temporal relationships could be recognized in these sequences, although we have yet to notice any clear temporal patterns in burial treatment or artifact use in examining these sequences. Nonetheless, because they involved multiple burials and extended temporal sequences, burial sequences in Cemetery Area 4 could be a rich source of data on temporal change in mortuary or other behaviors for future analysis.

There was also some possible spatial clustering of grave pits with multiple burials in Cemetery Area 4. For instance, on the far-west side of Cemetery Area 4, two overlapping features (Grave Pits 12276 and 7737) contained multiple burials and appeared to be two of the earlier grave pits in a complex sequence of grave-pit intrusions. A linear cluster of four almost-contiguous grave pits (Grave Pits 7768, 12802, 7782, and 7790) was distributed along the northern edge of Cemetery Area 4. There was another cluster of four grave pits with multiple burials near the center of the area (Grave Pits 13643, 13663, 28095, and 13653). Finally, there were also three pairs of closely situated grave pits with multiple burials (Grave Pits 7777 and 7765; 13647 and 13666; and 8078 and 13705) in Cemetery Area 4. This clustering suggests that there may have been specific areas within Cemetery Area 4 that were more highly sought after for burial.

The patterning of burials in Cemetery Area 4 suggests that there was a consistent effort to bury people in close physical proximity to each other and that, although apparent rows were recognized in Cemetery Area 4, there was no real concern for maintaining a neat or orderly pattern in the placement of grave pits. The emphasis instead seems to have been to ensure that some individuals were buried in overlapping and closely adjoining spaces. Perhaps these clusters of overlapping and intruding grave pits represented extended family groupings or other social groupings that encouraged mourners to want loved ones to be buried in the same focused area. In any case, although we could recognize apparent rows in Cemetery Area 4, mourners may have been more concerned with placing new burials in areas that they considered important or that were in proximity to loved ones that had been buried earlier. In some cases, this involved placing burials in the same grave pit. In other cases, this involved intersecting a previous grave pit with a new one. Possible results of this behavior in Cemetery Area 4 were clumps or clusters of grave pits separated by empty space.

Previous Exhumations

The archival research left a big question unanswered: How many burials were exhumed in the civilian section? Historical records were relatively silent on the subject, although a large number of burials were left in the ground, as evidenced by the archaeological investigation. Historical evidence indicated that burials in the military section were exhumed, but at the time the second archival report for the project was completed (O'Mack 2006), it was unclear why only 74 bodies had been exhumed by the U.S. military in June 1884 when it was apparent that a larger number were buried in the military section. The following discussion makes it clear, based on additional records discovered at the National Archives and Records Administration, that most of the remaining burials in the military section had apparently been exhumed prior to the military's final efforts, thus explaining the disparity between numbers exhumed and numbers interred. The following discussion provides historical information relevant to exhumation in the civilian and military sections, followed by discussion of the archaeological evidence for exhumation.

Historical Evidence for Exhumation in the Civilian Section

After the civilian section closed in 1875, no concerted effort was made to exhume burials from the Alameda-Stone cemetery and rebury them at the Court Street cemetery. Some citizens, however, complained of the continued presence of the cemetery in the midst of the growing settlement, citing sanitation issues and health concerns as a justification for removing the bodies. An October 1878 article in the *Arizona Star* stated,

> While our city Council is entitled to much credit for the energy and care displayed in sanitary affairs of our town, there are two matters of importance which should be attended to: one is the disinterment of the remains lying in the old cemetery and their removal to the new grounds. It has been almost three years since the new cemetery was established, and we hear many of our citizens inquire why it is the old one still remains. We think, as a sanitary measure alone, something ought to be done in the premises. Let the city council give out the work of disinterment to be done by contract, sale of the ground now occupied by the old cemetery would go far toward defraying the expenses of removal [*Arizona Star,* 3 October 1878:3].

The other matter had to do with the need for "vaults or earthen closets" (i.e., privies) at most Tucson residences, which lacked such sanitary facilities.

Complaints were again made the following year:

> Our city council is generally prompt to act in all matters beneficial to the health and improvement of the city; but in the matter of action in regard to the removal of the old cemetery, they act slow. This is a matter of so much importance to our growing city that prompt action ought to be had in the premises. The council has full jurisdiction to remove, or contract to remove, the bodies there-from and to dispose of the ground now occupied as the cemetery. A great many of our people are interested in this subject [*AWS*, 3 April 1879:3].

A subsequent article sarcastically remarked that the city council apparently had "no time to consider the subject of the removal of the remains of the interred, from the old cemetery" (*AWS*, 19 June 1879:3) and a list of "Things Desirable" included the following item: "The remains in the old cemetery removed to the new cemetery" (*AWS*, 29 January 1880:3).

It was not until 1882 that the city council took measures to encourage the removal of burials from the cemetery, and evidently, the city council did not appear to have been interested in paying for removals with public funds (O'Mack 2006). At the time, citizens had petitioned the city council to have Council Street (originally known as Miltenberg Street) opened between Stone and Toole Avenues (Tucson City Council minutes, 7 November 1881 and 4 January 1882.). Based on a report by Councilman Levin on the subject, the council recommended the opening of the street and

> the removal of the bodies to the new cemetery within sixty days from date, and that the Recorder give notice in an English and Spanish paper published in the city, to the effect that all bodies not removed by relatives or friends of those interred within the designated time, be removed and reinterred under supervision of the municipal authorities. The report was adopted and the Recorder instructed to act accordingly [Tucson City Council minutes, 4 January 1882].

The *Arizona Daily Star* and the Spanish-language *El Fronterizo* published brief notices informing citizens that they had 60 days to remove friends and relatives buried in the cemetery. Exhumed bodies were to be reburied in the new Court Street cemetery. The notice published in the *Arizona Daily Star* was relatively brief and failed to mention that this was an order from the city council: "Persons having relatives and friends buried at the old cemetery between Stone and Toole avenues, must remove them within sixty days" (*ADS*, 7 January 1882:3). Unlike the notice in the *Arizona Daily Star*, the notice in *El Fronterizo* identified the notice as an order of the city council and, curiously, stipulated that "Todos los cuerpos que no sean exhumados durante este tiempo, serán removidos y enterrados bajo el cargo de las autoridades competentes [All of the bodies not

exhumed at this time will be removed and buried under the supervision of competent authorities]" (*El Fronterizo*, 13 January 1882). This statement, signed by City Recorder Charles Meyer, implied that the city would see to it that any remaining burials were removed from the cemetery, although this contingency clearly did not occur. In fact, based on what we know now, the systematic removal of any remaining burials in the civilian section did not happen for another 124 years, when Pima County had the remaining burials professionally removed by Statistical Research, Inc.

In response to the city's notices in January 1882, undertaker E. J. Smith advertised his exhumation services in *El Fronterizo* and on February 4, 1882, *El Fronterizo* reported that E. J. Smith "will to-day commence the removal of bodies from the old to the new cemeteries" (O'Mack 2006:14). As exhumations were underway, the *Arizona Weekly Citizen* complained about

> too much indiscriminate and irresponsible digging done in the old Cemetery. When time or neglect has effaced the marks of a required grave, its whereabouts then becomes a matter of mere speculation and on that principle much of the digging is done. On Saturday last not less than six or seven remains were unearthed before finding the supposed one wanted. The bones were widely scattered . . . and on their reinterment they were heaped into a common hole without regard as to where they came from, rendering it impossible for others to identify any particular remains buried in the same locality" [*AWC*, 12 February 1882:4].

Statistical Research, Inc., encountered at least one possible instance of this practice. Grave Pit 7967 contained the partial, disarticulated remains of five individuals, intermixed with faunal bone. The remains were placed in a small, rectangular box constructed differently from the coffins from other graves at the site. No artifacts, other than cut nails used to construct the box holding the remains, were found. This could have been an instance of someone gathering up scattered remains from multiple graves opened during the historical exhumations and reburying them together in an available grave pit. Alternatively, the reburial of these remains could have occurred during construction of the Old Pueblo Bowling and Billiard Parlor in 1929, as that building's foundation intruded into the grave pit. The use of cut nails in construction of the box, however, suggests the disturbance occurred at an earlier date, as it may have been more likely for wire nails to have been used in 1929. The grave pit was located near a cluster of grave pits that appear to have been exhumed (Grave Pits 7972, 7983, 7984, 10118, 10119, and 10120), providing some support for this interpretation.

Exhumations in the Military Section

As with the civilian section, moving the military section was motivated by the fact that the city wanted the land for other purposes, and the cemetery was considered to be in a dilapidated condition that was both unsanitary and disrespectful of the dead. Apparently, the cemetery was not always in such poor condition. For instance, an October 1869 news item reporting on the burial of the wife of Captain Miles described the military section as "a beautiful resting place" (*WA*, 2 October 1869:3). That same year, Assistant Surgeon Durrant stated that the "military section is one third of a mile from Camp Lowell, on the extreme northeastern edge of the Town. It is surrounded by a high Adobe wall, and numbers at present about 50 graves. It is well kept, but the sandy nature of the soil prevents any attempt at beautifying by means of grass or trees" (National Archives and Records Administration, Record Group 94, Entry 547, Box 13). By February 4, 1881, however, Captain Gilbert Cole Smith of the Quartermaster's Department described the cemetery as "in a dilapidated condition, the walls having been knocked down and injured in some places by parties unknown and that it is being used in a sacrilegious manner presumably by the inhabitants in its immediate vicinity for the same purposes as a privy and as a depository for all sorts of filth" (National Archives and Records Administration, Record Group 92, Entry 225, Box 1156).

By the late summer of 1881, the city council began insisting that the U.S. military exhume all the burials in the military section to make way for development. They even offered to set aside an area of the Court Street cemetery for reburial, although the authorities at Fort Lowell did not take the city's offer. In an August 30, 1881, letter addressed to Captain C. B. McLelland, Fort Lowell's Commanding Officer, Tucson's Mayor wrote:

> In my last letter, I offered, under instructions from the Council, to the proper military authorities to set aside a portion of the present [Court Street] cemetery, for the use of the military department—to which they could transfer the bodies from their present places. Since which, I have not been advised of any action in the matter. We are anxiously waiting the removal of the bodies, as we need the land—it being constantly sought after for building purposes [National Archives and Records Administration, Record Group 92, Entry 225, Box 586].

A few days later, the Mayor again wrote Captain McLelland, this time responding to a question regarding whether "there has been any objection to the bodies [in the military section] remaining where they are, and if the graves are safe from disturbance" (National Archives and Records Administration, Record Group 92, Entry 225, Box 586). Tucson's Mayor responded that

> the bodies are not safe in their present location—the graves are exposed and liable to be dug up by dogs and coyotes. I have in my previous communications, made known the objections to the bodies remaining where they now are. The City needs the ground and as soon as the military authorities commence moving the bodies from their present place, the City will move those bodies lying on the outside of the plot in which the soldiers have been buried. It is urgently requested that prompt action will be taken in the matter [National Archives and Records Administration, Record Group 92, Entry 225, Box 586].

Part of the city's position demanding removal of the burials rested on the council's belief that the city owned the patent to the land, although G. C. Smith wrote in an endorsement dated June 22, 1881, that "I understand from good authority [that the patent] was not given until 1871, so that, the Mayor is in error in his implication in regard to 'City officials at the time the land was appropriated till its present use etc.' I built the cemetery myself and got no permission either written or 'verbal' from any party to use the land as a cemetery."

It was not until June 1884 that the U.S. military contracted with Dr. W. J. White to remove the burials in the military section, for the amount of $500. Exhumations were done very quickly over the course of 2 days on June 23 and 24, 1884, and, given the short period, must have involved the use of hired laborers to carry out much of the work. After the exhumations and reburial had been completed, a July 7, 1884, letter to the Quartermaster General in Washington, D.C., reported that the cost paid by the U.S. military included "the disinterment of remains; refilling of old graves; the furnishing of boxes; digging of new graves; removal of bodies to and reinterment in the Post cemetery at Fort Lowell, A.T." (National Archives and Records Administration, Record Group 92, Entry 225).

The exhumations were made with the benefit of the 1881 plat map and burial list, which enabled the government to identify many of the exhumed individuals, despite the lack of surviving or legible headboards. The removal report indicated that the remains of 74 individuals had been exhumed and that burials from a total of 17 of 31 known grave pits in the western half of the cemetery had been previously removed. These included the graves of Mark Aldrich, the infant son of Carr, Harriet Davis and her daughter, Minnie Isabella Duffield, Nellie Haslett, Frank Lenard, George M. Newsom, J. P. Prentice, Reid T. Stewart, Joanna Welisch, and 7 unknown individuals. According to the removal report, "The remains of Thomas Wallace Citizen [numbered] 24 on Capt Smiths plat were claimed and removed by Mr. Mann. Clerk of the Court in Tucson A.T." George Hand, who had enlisted and served alongside Wallace in the California Column and later entered a business partnership with his friend, had been Wallace's chief mourner when he was originally buried. Hand, who was executor and beneficiary of Wallace's will, had Wallace's remains removed in 1884 at his own expense (*AWC*, 12 July 1884:4; Hayden n.d.). Another individual buried in the military section who appeared only on the 1873 plat map, and whose grave does not appear to have been sought after by Dr. White's team, was listed on the undated (circa 1873) plat map as having been disinterred. The *Arizona Citizen* reported that, after his death, his "remains are temporarily placed in the military cemetery in Tucson" (*AC,* 8 November 1872:3).

All told, historical documents indicate that a total of 93 (74 + 17 + 1 + 1) of the 99 individuals documented to have been buried in the military section were exhumed. Some or all of the remaining 6 burials could have also been removed but simply overlooked by Dr. White's team, as they were clearly working with an imperfect set of records and grave markers were missing for nearly all burials. Archaeological evidence for exhuma-

tion, discussed below, suggests that White's team missed 4 graves in the portion of the military section excavated by Statistical Research, Inc., as 4 of the 64 graves excavated within the section contained the remains of complete or nearly complete individuals.

Archaeological Evidence of Exhumation

Prior to excavation, Statistical Research, Inc., had no solid information about the number of burials that had been exhumed in the civilian section in 1882 or afterward. Other than newspaper articles decrying how exhumations were performed, no records were found that documented exhumations from the civilian section or reburials in the Court Street cemetery. As could be gleaned from archival evidence, the greatest percentage of exhumations occurred in the military section. We had a reasonable idea of how many burials were exhumed from the military section, but we had no idea what the effects of these historical excavations had been on grave features and their contents.

One of the most interesting aspects of the military section is the evidence we found for the previous exhumations of burials. In the portion of the military section excavated by Statistical Research, Inc., only 4 of the 64 excavated grave pits contained nearly complete or complete skeletons. The primary evidence for historical exhumation in the other 60 grave pits was, in every case, either the complete absence of a skeleton in what was clearly a grave pit or the presence of only the partial skeleton of a single individual within a grave pit. Complete exhumation was actually rare and occurred in only a single instance. Partial exhumation was more common, with the skeletal elements left behind ranging from a few small bones to more than half a skeleton. Complete removal of all burial-associated artifacts was also rare. Nearly every grave pit held at least a few burial-associated artifacts (coffin wood or nails, coffin hardware, clothing remnants, or personal or religious items), and some held as many artifacts as the typical unexhumed burial in the civilian section.

A similar pattern was noted at the contemporaneous Fort Craig cemetery in New Mexico, where soldiers' burials were exhumed in 1876 and 1886. In comparing archaeological patterns of exhumation for the two cemeteries, Spurr et al. (2008) found that elements commonly left behind during excavation were bones that might not be recognized by someone unfamiliar with human anatomy, such as the hyoid, patella, coccygeal vertebrae, twelfth ribs, and small bones of the hands and feet. Larger, more recognizable bones were also left behind, however, such as scapulae, central ribs, or portions of the pelvis. Long bones left behind were usually the fibula or lower arm bones but also included one femur in Tucson's military section. Crania were not found in any of the exhumed graves, nor were most long bones, suggesting that these elements were the sine qua non for recovering human remains during such exhumations.

This insight allowed us to seek out possible cases of exhumation in the civilian section. We were able to identify possible exhumations in the civilian section by (1) identifying grave pits with no archaeological evidence for a burial and (2) identifying grave pits that contained only limited remains according to a pattern similar to that seen in the military cemetery. In other words, we searched the database for grave pits that contained few long bones (excluding the fibula) and no crania (with the exception of some of the smaller and less-recognizable cranial elements) or fewer than 50 elements total, not including teeth. This left us with a total of 111 grave pits lacking burials and another 117 grave pits with limited osteological remains (Table 37). Disturbances other than exhumation, of course, could create the appearance of an exhumation; so, we then removed all cases of possible exhumation in grave pits for which there was recognizable evidence in the field of intrusive disturbance. This reduced the number of potential exhumations to a total of 168 grave pits of all those excavated by Statistical Research, Inc. Our method for identifying possible exhumations in the database resulted in the independent detection of 57 of the 60 grave pits that were likely to have been exhumed in the military section. Remains in the 3 military grave pits that were not captured in our database-query method were more complete than remains in the 57 other grave pits. The relatively close approximation suggests that our method worked reasonably well and was conservative.

Based on the number of grave pits excavated by Statistical Research, Inc., we can estimate that, for the military section, burials from roughly 9 of 10 graves were exhumed; in the civilian section, burials from roughly 1 of every 10 graves were removed (see Table 37). The highest rate of removal, of course, was estimated

for Cemetery Area 1 (the military section), where we know there was an effort to remove all burials. With disturbances controlled for, the next-highest rate of exhumation appears to have occurred in Cemetery Area 4. Burials in nearly 1 of every 5 graves in Cemetery Area 4 were potentially exhumed, although the rate could be somewhat inflated because of disturbances. If not merely the result of more-intensive disturbance, the apparent greater number of exhumations in Cemetery Area 4 may indicate that this cemetery was sought after by the local Catholic community and that more attention was paid to grave pits in this area owing to a somewhat elevated status for the dead or their mourners. An alternative explanation is that exhumations in the civilian section focused to a greater degree on the proposed alignment of Council Street. Although the notices in the local papers did not specify areas of the cemetery requiring removal of burials, the impetus behind the order was the opening of Council Street. If citizens became aware of the more-precise purpose behind the order, they may have been more motivated to remove a burial of interest to them if it occurred within the alignment of Council Street. Indeed, the largest number of grave pits with evidence of potential exhumation occurred along Council Street, although subsequent disturbance made it difficult to discern whether these graves were truly exhumed or adversely affected by construction of utility trenches in Council Street. The lowest exhumation rates were estimated for Cemetery Areas 2, 3, and 5.

A chi-square test using the numbers of exhumed and unexhumed graves in Cemetery Areas 2, 3, and 4 (Cemetery Area 5 was not included because there were less than five possible exhumations) suggests that the differences between these areas were significant ($\chi^2 = 5.92$, $df = 2$, $p = 0.0518$). There were fewer than expected exhumations in Cemetery Area 2 and more than expected in Cemetery Area 4. A problem with this analysis, however, was that many of the grave pits without burials in Cemetery Area 4, as well as some in the southeastern portion of Cemetery Area 3, occupied a small, irregular footprint and appear to have possibly been truncated by the many utility trenches dug beneath Council Street. If we remove these grave pits as possible cases of exhumation, then we end up with smaller percentages of potential exhumations in Cemetery Areas 3 and 4, with the rate of exhumation dropping by half in Cemetery Area 4 and by a small percentage in Cemetery Area 3. The result is very similar rates of exhumation in Cemetery Areas 2, 3, and 4, and the differences between areas become insignificant ($\chi^2 = 0.79$, $df = 2$, $p = 0.6737$). If this model of exhumations is correct, a relatively uniform rate of exhumation in the civilian section can be suggested—burials from roughly 1 in 10 graves were exhumed. However, if the possible exhumations along Council Street reflect a concentrated effort, historically, to target burials in the proposed area of impact, then a higher percentage of burials were exhumed in Cemetery Areas 3 and 4 in comparison to the other cemetery areas.

Overall, an exhumation rate of 1 in 10 burials and our estimates of the number of burials disturbed by the Tucson Newspapers basement excavations (see below) suggest that burials from perhaps 100 graves were exhumed in the whole of Cemetery Area 4, including areas not excavated by Statistical Research, Inc. If perhaps a thousand grave pits had been placed in the remainder of the civilian section, then we might expect burials from an additional 100 or so graves to have been exhumed in the remaining areas of the civilian section. We know from historical records that burials from 93 graves were exhumed historically in the military section. Altogether, these estimates suggest that on the order of 300 individuals were removed from the cemetery, with perhaps three-quarters of the exhumations paid for by private citizens. This could mean that a substantial number of citizens of Tucson who had the wherewithal to pay for one or more exhumations actually did so, although the majority of burials were left in the ground.

Interestingly, the spatial distribution of grave pits that potentially had exhumed burials was clustered; many of these occurred in clusters of two or more adjacent or closely placed grave pits (Figure 41). In some cases, these clusters appeared along utility trenches, suggesting that other disturbances created the false impression of an exhumed burial, but even in these cases, other adjacent grave pits along the same section of trench appear to have been left intact. In many other cases, by contrast, no cultural disturbances were noted nearby, and the clusters of grave pits that potentially had exhumed burials appear to be valid. In most cases, these clusters consisted of two adjacent grave pits in the same row, and most often, these grave pits were found to contain no burials, suggesting the possibility that remains within the grave pits were carefully and completely removed.

Postcemetery Disturbances

With any cultural deposit, varying degrees of disturbance are possible. When an archaeologist interprets cultural deposits or features, a consideration must be made of the natural and cultural transformations that have occurred over time (Schiffer 1987). Features identified within the Joint Courts Complex project area were affected by numerous disturbances, but for the following discussion, the main consideration will be the cemetery component of the project. The disturbances to cemetery features (e.g., grave pits and burials) became a crucial consideration in making certain determinations, such as temporal associations and cultural affinity, as well as in the mortuary and osteological analyses.

Natural disturbances were relatively limited in the project area, likely because of the stable geologic surface where the site was situated (see Chapter 3). For instance, there were no major erosional events, such as in an alluvial environment, or colluvial deposition, such as in a *bajada* environment. For the Joint Courts Complex project, the most common natural disturbances reported for the grave pits were from rodents, roots, and insects, which are ubiquitous for most archaeological excavations (Table 38). Burials were also affected by these disturbances, but few suffered significant damage from rodents, insects, or root growth.

In general, most grave pits and burials in the project area maintained a moderate to high level of preservation (see Chapter 3). In most instances, human-bone preservation was considered high throughout the cemetery. Similarly, coffin wood was preserved in situ, although not normally, as well as human bone. In most grave pits, coffin wood only preserved enough to indicate the presence of the coffin, such as a stain of wood to delineate the top or side boards of the coffin. Only on rare occasions were whole or substantial pieces of coffin wood recovered. The natural substrate across the project area included a dense, lightly colored caliche layer. This hard stratum aided in the preservation of grave pits, with virtually no instances of grave-pit-wall collapse prior to our excavation of the cemetery.

An interesting phenomenon witnessed during the excavations of the Alameda-Stone cemetery was ground collapse within a grave pit. Occasionally, during the initial exposure of a grave pit by mechanical excavations, the ground within the grave pit would collapse and leave a void. This phenomenon was attributed to the prior collapse of the coffin. When an individual was placed in a grave pit, a certain amount of empty space existed within the coffin. Through natural decompositional processes and ground pressure, the coffin would eventually collapse, and sediment above the coffin would cover the skeletal remains. This would create a void within the grave pit. This coffin collapse was often responsible for disturbing the skeletal remains, particularly the cranium.

Cultural disturbances affecting the cemetery were predominantly from postcemetery features. Examples of postcemetery features included concrete foundations, utility trenches, and basements (see Volume 3). Understandably, over 100 years of urban development transformed the cemetery, from its closing in 1875 to the excavation of the site by Statistical Research, Inc., beginning in 2006. Fifty-two percent (n = 560) of the grave pits identified in the cemetery were intruded upon by postcemetery features, to one degree or another. This number does not take into account the historical-period surface modifications that occurred once the cemetery was abandoned and the land was sold for residential development, nor does it account for the overall footprint of historical or modern buildings in the project area. Concrete foundations, on the other hand, were considered in this calculation, as these building foundations were purposefully excavated to a certain depth below the surface to stabilize the building itself. In most instances, a postcemetery feature, such as a posthole or concrete foundation, only intruded into the upper portion of a grave pit but was not deep enough to disturb the burial. In other cases, the postcemetery features would impact the burial or remove it entirely. The largest and most pervasive disturbance to the cemetery was the two-story basement of the Tucson Newspapers building, constructed during the 1940s and 1950s and then demolished in 1974 (O'Mack 2005). This extensive basement obliterated an unknown number of grave pits.

During our excavations of the cemetery, we also discovered that there were not only postcemetery features overlapping grave pits but also grave pits overlapping other grave pits. In the dense area of the cemetery (Cemetery Area 4), we found that multiple grave pits were reused several times. In most instances, the original burial was moved out of the way for the new burial, or sometimes the burials were placed on top of each other. This displaced a fair amount of bone, but the displaced bone was always limited to the confines of the grave pit. Unfortunately, this dense area was also beneath Council Street, where numerous utility trenches were dug

beneath the street over several decades, further disturbing the burials. In particular, an underground high-power electrical line, which was set in a large concrete corridor, ran the entire length of Council Street. This utility trench, called the Tucson Electric Power trench, was several feet thick and was laid several feet below the street, destroying an unknown number of grave pits.

One particularly intriguing instance of disturbance involved the apparent removal of crania from intact burials during construction of a building foundation (Feature 13511) in Cemetery Area 3. Statistical Research, Inc., osteologists discovered that a series of seven grave pits contained individuals whose remains were largely intact, with the exception that each was missing a cranium. All seven grave pits were located within the footprint of the commercial building at 240 North Stone Avenue (see Volume 3), which served as a temporary laboratory during fieldwork for the project before the building was demolished (Figure 42). Four of the grave pits were located along a part of the building's foundation wall (Features 20511, 17825, 17826, and 17867), and one grave pit (Feature 24495) was located along a utility trench (Feature 13632) that was underneath the building; Feature 13607 (at the southeast corner of Figure 42) was also part of the building foundation. Two other grave pits with burials missing crania (Features 10122 and 13351) were located near these other grave pits with burials missing crania and were underneath the building at 240 North Stone Avenue. Archaeological evidence suggests that construction of the foundation was too shallow to intrude deeply into the disturbed grave pits. Perhaps, construction workers or other interested individuals may have noticed parts of the crania poking out from beneath the surface during construction of the building or noticed areas of soft or disturbed sediment corresponding to a grave pit, in stark contrast to the hard caliche that persisted across the project area, and selectively removed the crania that were visible, leaving the remainder of the skeleton intact. Because similarly disposed grave pits were not found in other parts of the project area and all those with intact skeletons and missing crania appear to be associated with a single building, it is at least plausible that the removal of the crania could have occurred over the course of a single construction episode, although the motivation behind such removals is a matter of speculation.

Differential Grave and Burial Preservation

As stated in the Environmental Context (see Chapter 3), a number of geomorphological conditions allowed for a high level of preservation of human bone in the Joint Courts Complex project area. The alkalinity of the sterile site sediments were tested, resulting in an average pH of 8, a value considered very suitable for the preservation of human bone. Moisture was also a determining factor in the preservation of skeletal remains. During the excavation of the cemetery in 2007, heavy summer rains ensued and flooded the entire project area more than once. These flooding events were quite informative as to the magnitude to which atmospheric conditions had affected the site over time. Prior to the urban development of the project area, before concrete and asphalt covered the cemetery, the grave pits were certainly inundated by similar flooding episodes. Extended periods of exposure to moisture would have created a poor environment for bone preservation; however, the normally dry conditions of the Sonoran Desert likely limited the amount of moisture exposure to the skeletal remains. Areas where postcemetery features intruded upon grave pits, such as utility trenches, likely increased the ability of moisture to reach the human remains, therefore creating unfavorable conditions for bone preservation in those areas (see Chapter 3, Figure 21).

Statistical Research, Inc., evaluated the integrity of each burial as low, medium, high, or no integrity, based on the degree of disturbance to the burial (Table 39). Using the same categories of low, medium, high, or no integrity, we also evaluated the articulatory integrity of each individual skeleton, based on the degree to which the skeleton remained articulated and in correct anatomical position (Table 40). For each assessment, a small number of individuals in each cemetery area were not assessed, resulting in no determination regarding integrity. Across cemetery areas, the assessments of integrity for both the burial and the skeleton mirrored each other generally, in part because the evaluation of burial integrity was based on the assessment of articulatory integrity. For obvious reasons, low burial integrity and low articulatory integrity were most frequent in Cemetery Area 1, where most burials had been previously exhumed. Articulatory integrity was fairly similar in Cemetery Areas 2, 3, and 5, with the remains of around 6 of every 7 individuals well articulated. Burial integrity

was similar for Cemetery Areas 2 and 3 but was highest in Cemetery Area 5, where all 30 primary individuals were found in burials of high integrity. Burial and articulatory integrity were relatively low in Cemetery Area 4, which was expected because of the amount of disturbance that had occurred both during and after the cemetery was in use. In Cemetery Area 4, only around three-quarters of the individuals were well articulated, and around two-thirds of the burials were of high integrity.

Estimations of Numbers of Burials That Were Disturbed by the Tucson Newspapers Basement or That Occurred Outside the Project Area

Upon completion of the prefieldwork archival research, a question remained regarding disturbance: How many burials were disturbed by the Tucson Newspapers building excavations? Historical newspaper accounts indicated the graves of upwards of 150 individuals may have been disturbed, but given the limited recording of skeletons and the relatively heavy-handed approach of the excavation company, we suspected the number to be substantially higher. In order to estimate the number of individuals whose burials may have been disturbed during previous excavations, we first approximated the limits of different areas of the cemetery that were either disturbed by the Tucson Newspapers basement or fell outside the Joint Courts Complex project area. The Tucson Newspapers building construction appears to have obliterated the southern half of Cemetery Area 4, portions of Cemetery Area 3, and undocumented areas of the cemetery that would have been immediately north and west of the western half of the military section. We used our estimate of the location of the wall on the northern and western edges of the civilian section to approximate which additional areas of the cemetery may have fallen outside our excavations. The southern half of Cemetery Area 4 was modeled as though it had originally been roughly square in shape.

To estimate the number of individuals who may have been interred in the potential areas of the cemetery not excavated by Statistical Research, Inc., we used grave-pit densities and individual densities from comparable areas of the cemetery to generate low and high estimates (Table 41). Grave-pit density was calculated for each cemetery area as the number of archaeological grave pits per square meter, and individual density was calculated as the most likely number of individuals per square meter (Adams and Konigsberg 2004) (see Chapter 7). We then used the density estimates for areas that we felt to be most similar to what might have been the grave-pit and individual densities in previously disturbed or unexcavated areas of the cemetery. Because most grave pits in the cemetery contained one individual, grave-pit and individual densities were markedly different only for Cemetery Area 4, which was the most disturbed area.

These estimates suggest that the grave pits of somewhere between 421 and 722 individuals may have been disturbed by previous construction projects or fallen outside of areas excavated by Statistical Research, Inc. As many as 90 percent of the grave pits in this estimate would have fallen within the area disturbed by the Tucson Newspaper basement. One possible explanation for the discrepancy between historical (about 150 individuals) and archaeological (somewhere between 387 and 653 individuals) sources in estimates of the number of individuals within the Tucson Newspapers building basement area is that the disturbed area may have included an area for children, or *los angelitos* (see, for example, Will de Chaparro 2007), and those remains would have been less obvious because of preservation issues. Although not beyond the realm of possibility, we have no evidence to support this hypothesis, other than the fact that Hispanic Catholic cemeteries of the period often contained such an area, and no such area was found in our excavations. There was a large concentration of juveniles in several rows of grave pits in the western portion of Area 3, but their grave pits did not occupy a discrete space and were interspersed, to some degree, with grave pits containing older individuals. It remains possible that the large number of juveniles in this area corresponded to a catastrophic event, such as the 1870 small pox epidemic, which selectively took the lives of a large number of children over a short period of time. Of the 47 individuals whose remains were curated at the Arizona State Museum (from the 1953 Tucson Newspaper basement excavations), only 6 were younger than age 11 at death, and very few were teenagers.

The basement excavations would have disturbed the graves of the number of individuals indicated in the newspaper (~150) only if we assume a low density of graves and individuals in the disturbed area, that burials occurred in only a small portion of the disturbed area, or both. A more likely scenario is that many more grave

pits were disturbed than were reported. As stated earlier in this chapter, when we modeled the effects of the Tucson Newspapers building disturbance and estimated the number of burials placed within the cemetery but outside the project area, we arrived at an estimate of between 1,800 and 2,100 individuals interred within the Alameda-Stone cemetery, which is consistent with our estimates of the burial-population size arrived at through other methods.

Burial Sensitivity Revisited

As part of the archival research, O'Mack (2006:Figure 20) hypothesized the burial sensitivity, or likelihood of discovering burials archaeologically, of different portions of the project area. O'Mack identified an area of very low sensitivity at the southeast corner of Stone Avenue and Council (Miltenberg) Street that corresponded to the area disturbed by excavations for the basement of the Tucson Newspapers building in 1940 and 1953. North and east of the zone of very low sensitivity was a large zone of high sensitivity, undisturbed by basement excavations and corresponding to what O'Mack suspected were the practical limits of the cemetery. The northern limit of O'Mack's high-sensitivity zone corresponded to the general location of the east-west adobe wall visible in the 1880 Watkins photograph (Figure 43). The area north of the hypothesized wall alignment was interpreted as beyond the limits of the civilian section and was considered to be of low sensitivity. Because of a lack of information on how far east the civilian section extended, O'Mack defined a zone on the eastern side of the project area as medium sensitivity, based on the assumption that areas closer to Stone Avenue and Alameda Street, and hence closer to the settled part of Tucson in the nineteenth century, were likely to hold more burials than areas farther east.

In order to test how well O'Mack's burial-sensitivity model worked, we first revised the extent of his sensitivity zones, because of small modifications in the project area boundary that were made after the publication of the 2006 report. Fortunately, the slight adjustments in the project area boundary presented no new areas with sensitivity levels that could not be interpreted unambiguously using O'Mack's original model. Although based on limited and fairly tentative information, O'Mack's predictions turned out to be remarkably accurate, if not precise. Only 3 of 1,083 grave pits fell outside the high-sensitivity zone, which composed approximately 60 percent of the project area (Table 42). In addition, the 3 grave pits that fell in lower-sensitivity zones either intersected or were within a few meters of the boundary of the high-sensitivity zone. In GISs, we created a convex hull polygon around grave-pit centroids to estimate the size of the area in which grave pits were found. Grave pits were found in an area covering approximately 1.6 acres. If we include areas disturbed by the Tucson Newspapers basement, another 0.7 acres could have been used for burials, although the actual extent of the area used was not confirmed archaeologically.

The eastern and northern portions of the predicted high-sensitivity zone contained few or no grave pits, indicating that the high-sensitivity area was substantially larger than the area in which burials were actually located. A little over 60 percent of the high-sensitivity zone contained grave pits. Interestingly, because O'Mack's model was based in part on the assumption of 1,800–2,000 burials' occurring at a regular density in this area of the cemetery, part of the reason his high-sensitivity zones extended beyond the discovered distribution of grave pits was that he did not account for the unusually high density of grave pits in Cemetery Area 4, as the density of grave pits in that area had come as a surprise.

Our excavations provided no indication that any grave pits had ever occurred in areas to the east and north of where burials were found. Based on historical evidence, it seems likely that the cemetery did not extend into Alameda Street and that the Joint Courts Complex excavations likely encompassed the southern limit of the cemetery in Cemetery Areas 1 and 2, but we do not know the southern limit of the cemetery west of Cemetery Area 1, outside the project area, as the area has not been excavated archaeologically. All the available evidence suggests that the northern, eastern, and southern limits of the archaeological distribution of grave pits do in fact represent the northern, eastern, and southern limits of the Alameda-Stone cemetery. We could not confirm unequivocally the western limit of the cemetery archaeologically, but given the extent of disturbance in the Tucson

Newspapers basement area and underneath Stone Avenue, where some grave pits in the northern part of the cemetery may have conceivably occurred, it is likely that few of the original burials still remain below the surface in those areas. One estimate, based on our archaeological modeling of the number of individuals in the cemetery as a whole, suggests that there could be around as many as 74 graves in the southwestern and western portions of the cemetery that were not investigated by Statistical Research, Inc.

Conclusions

The Alameda-Stone cemetery was a relatively large and complex one, originally containing the graves of 1,800–2,100 individuals. Most of these individuals were buried in the civilian section sometime between 1862 and June 1875. Around 100 other individuals were buried in the military section between July 1862 and January 1881. Statistical Research, Inc., recovered the remains of 1,386 individuals, including 1,044 primary individuals whose remains were found in 1,083 grave pits, as well as in secondary, disturbed contexts. Perhaps 90 percent of the remaining burials in the cemetery were likely destroyed by excavation of the Tucson Newspapers building basement. A small number of additional remains, if not destroyed by other disturbances, likely were placed in a few areas outside the western limits of the project area, based on our reconstruction of the limits of the civilian and military sections. In all likelihood, the northern, eastern, and southern limits of the cemetery were captured in our excavation and are described by the archaeological distribution of grave pits in those parts of the project area.

With the exception of the military section, we have no specific information on where any named individual was buried, nor do we know with absolute certainty which named individuals were buried in the cemetery. Nonetheless, triangulation of a number of different records has allowed us to arrive at a reasonable first approximation of who was buried in the cemetery and how the cemetery was organized. Prior to fieldwork, we knew from archival information that the cemetery was organized into military and civilian sections, but we did not know specifically how these sections articulated with each other or how the civilian section was organized.

The large majority of individuals interred in the cemetery would have been Hispanic, perhaps 75–80 percent, but a substantial number would have been non-Hispanic Euroamerican, with smaller numbers of Native American and African American individuals. Because many Hispanic individuals would have practiced a Catholic faith and Hispanic Catholics of the time expected to be buried in ground consecrated by the Church, we suspected that there would likely be one or more areas specifically devoted to Catholic uses. For instance, Hispanic Catholic cemeteries of the time often had an area devoted to *los angelitos*, or children whose innocence precluded the need for them to visit purgatory on their way to heaven. In addition, the burial of individuals who had not been baptized or were not in good standing in the church would likely not have been allowed in consecrated ground and would have been placed in other, less desirable areas (O'Mack 2006:39; Will de Chaparro 2007).

We expected from our modeling of historical data that the demographic composition of different segments of the community would help us to identify different areas of the cemetery reserved for specific groups or uses. The age and sex distribution of Hispanic individuals interred in the cemetery, for instance, would have been broader than other groups. The Hispanic segment of the community was substantially larger than other segments and was organized into families and households consisting of related individuals of both sexes and all ages. Non-Hispanic Euroamericans, by contrast, would have been mostly adult males, as would individuals interred in the eastern half of the military section. Recent Hispanic migrants to Tucson, also, would have tended to be adults, although both sexes would have been more evenly represented. Many Hispanic individuals would have practiced a Catholic faith, but the burials of individuals of Protestant, Jewish, and Native American faiths would have occurred in the cemetery, as well.

Non-Hispanic Euroamerican individuals came from many different parts of the United States, Europe, Canada, the Caribbean, and the Middle East and would have brought with them diverse religious, cultural, and linguistic heritages, but at the same time, they would have lacked the community or institutional support in

death that they may have experienced in their homelands. Hispanic individuals, if not born locally, would have come from parts of northern Mexico, as well as other parts of the southwestern United States. Native Americans are poorly represented in the official documents, making it difficult to understand their presence in Tucson during this period. Nonetheless, we know from a variety of sources that Apaches, O'odham, Yaqui, and other Native American groups were living in or visiting Tucson and that at least some of these individuals were likely to have been buried in the cemetery. As is discussed in Volume 1 of this series, our basic understanding of the cultural affinity of Tucson residents during the period that the Alameda-Stone cemetery was in use matches fairly well our assessment of the cultural affinity of individuals whose remains were recovered during the course of the project, despite the many difficulties and uncertainties involved in interpreting historical, contextual, and osteological evidence to determine cultural affinity.

A basic understanding of the cultural and demographic diversity of Tucson was crucial in allowing us to develop a preliminary understanding of the organization of the cemetery. We knew from archival records that the cemetery was divided minimally into military and civilian sections, but further division of the civilian section was expected, based on the factors just discussed. The strongest clues to the spatial organization of the civilian section were provided by archaeological information. Archaeological excavation and preliminary analysis of the spatial distribution of grave pits, skeletal demography, and mortuary treatment enabled us to initially define a total of four areas within the civilian section, as well as to define the limits of the military section. Based on further analysis of row and grave-pit spacing in different areas of the cemetery, we were able to suggest another division within Cemetery Area 3 that may possibly reflect the use of the eastern half of Cemetery Area 3 to bury individuals who died during epidemics.

Although a larger percentage of juveniles were interred in the western half of Cemetery Area 3 than in other areas of the cemetery, this area does not appear to have been one consisting exclusively of juveniles, and no discrete area consisting exclusively of juveniles was located. If there was an area reserved for *los angelitos*, we did not find it. Possibly, if Cemetery Area 4 was an area of consecrated ground, it could have included such an area. In all likelihood, more than half of the area originally represented by Cemetery Area 4 was destroyed by excavation of the Tucson Newspapers basement, but no information on that disturbance, limited as it is, indicates that a large number of juveniles were encountered in the disturbed area. We also have no clear evidence for an area of the cemetery reserved for unconsecrated burials, such as those of individuals who committed suicide or were unbaptized, but it seems at least plausible that such burials may have occurred in either Cemetery Area 5, where grave pits were sparsely located, shallow, and distant from other graves, or Cemetery Area 2, which may have been an area where the burials of outsiders were sometimes placed.

Preliminarily, it appears that Cemetery Areas 3 and 4 likely represent the local Hispanic community, many of whom would have been Catholic, whereas Cemetery Areas 1 and 2 are more representative of recent migrants to Tucson, many of whom would have been non-Hispanic Euroamericans from outside the region but would probably have also included Hispanic or Native American individuals who either affiliated themselves more with the extraregional migrants or lacked community or institutional support in their burials. The significance of Cemetery Area 5 remains unclear, but it seems at least possible that this area may have been reserved for a special use. Given the more-strictly east-west orientation of some burials in Area 5, the area may have been used late in the history of the cemetery, but it would not seem to represent anywhere near the hundreds of burials that would have been placed in the cemetery between 1872, the year the city streets were surveyed into grids, and 1875, the year the civilian section of the cemetery closed. The significance of these areas is further explored in the following chapters on mortuary artifacts and features and human osteology, as well as in a more integrative and comprehensive manner in Chapter 9, Volume 1 of this series, where we synthesize all the available historical, contextual, and osteological data to understand the organization of the cemetery in a more holistic manner.

In contrast to the civilian section, archival information provided clues to the dimensions and organization of the military section, which appears to have been 120 feet (east-west) by 150 feet (north-south) and organized into four quadrants that were filled in by row from east to west in the eastern half of the cemetery. We were able to identify the location and extent of the military section on the ground by evaluating artifactual and osteological contents of grave pits in that area and by correlating an 1881 plat map of the cemetery with the archaeological distribution of grave pits. The sequence of burials and the organization of grave pits into rows in

the west half of the military section was less well structured than in the eastern half, suggesting less oversight or a different set of protocols for burial in that area of the cemetery.

Temporal information on the growth of the cemetery is limited, from both archival and archaeological sources. We were able to reconstruct the use of the military section through time using dates of death and other information for individuals reported as interred in that cemetery, but even in this case, the exact pattern of use through time is unclear owing to missing information. Archaeologically, very few grave pits contained artifact types or attributes that could be used to differentiate them according to time. Instead, we used feature to feature relationships in Cemetery Areas 2, 3, and 4 to infer possible growth patterns, but the available information proved to be relatively sparse and could only be used to arrive at tentative and weakly supported conclusions. Despite their limitations, feature to feature relationships, particularly those in Cemetery Area 4, may prove useful in future analyses in attempting to evaluate change through time in mortuary practices.

Analysis of grave-pit distributions according to rows suggests that the cemetery was filled in according to rows, which may have advanced, in general, from west to east across the cemetery as the cemetery expanded, but the validity of this pattern is in no way clear. There is evidence that grave pits were placed in close proximity to previous ones, perhaps in an effort to place an individual close to a friend or relative in a row that had already been filled. Also, some rows, particularly in the western half of Cemetery Area 3, were relatively short, irregular, and unevenly filled, suggesting that multiple rows may have been initiated at more or less the same time, with gaps left to accommodate the future burial of loved ones. By contrast, rows in the eastern half of Cemetery Area 3 appear to have been more regular and standardized, with more-evenly spaced grave pits; this could indicate a different strategy in placing grave pits, such as a tendency to place a new grave pit in the next available space within the latest row, rather than close to a relative or friend. The apparent attempt to bury individuals close to preexisting grave pits appears to have been most dramatic in Cemetery Area 4, where many grave pits intruded into previous ones or burials were placed in preexisting grave pits. In other areas of the cemetery, by contrast, burials appear to have been placed in adjacent, rather than overlapping, grave pits in most cases. We suspect that Cemetery Areas 1 and 4 may have been the first areas used in the cemetery, with the use of Cemetery Areas 2, 3, and 5 initiated later in time, while Cemetery Areas 1 and 4 continued to be filled.

Analysis of feature to feature relationships suggests a possible link with evidence for exhumation, as characteristics of exhumed grave pits sometimes gave the appearance of a temporal relationship that did not exist, or grave pits that intruded on each other tended to be those of individuals who were collectively exhumed. Using our understanding of the effects of exhumation from studying the military section, we generally identified as exhumed those grave pits that either lacked osteological materials or that contained sets of remains consistent with the osteological correlates of exhumation seen in the military section. When controlled for disturbance, analysis of possible cases of exhumation suggested a small percentage of individuals interred in the civilian section (perhaps a total of 200 or so individuals in the civilian section as a whole, including areas not excavated by Statistical Research, Inc.) were exhumed. Based on a combination of historical and archaeological evidence, the burials of over 90 individuals were exhumed from the military section. Many possible cases of exhumation in the civilian section occurred in the area of Council Street or along utility trenches in other nearby areas, suggesting that disturbance could still account for some of the possible cases. Other cases, however, tended to appear in clusters in areas where no intrusive disturbance had occurred, suggesting minimally that multiple grave pits were opened during the course of exhumations. This pattern may, in some cases, represent a haphazard attempt to locate a single burial by digging in multiple grave pits, as was suggested in one historical account (*AWC*, 18 February 1883:4), but in other cases, the pattern could represent the attempt to recover the remains of multiple friends or loved ones whose burials were clustered together.

All told, a large variety of disturbances, most of which were cultural, affected the Alameda-Stone cemetery after its abandonment. The largest of these, involving the excavation of the Tucson Newspapers basement, could have destroyed at least several hundred burials, and many other burials were impacted in some way by utility trenches, building foundations, tree pits, trash pits, privies, and other disturbances. Natural disturbances, by contrast, were relatively rare, perhaps owing to the relatively stable and ancient character of the land surface on which the cemetery was placed. Despite disturbances, preservation and burial integrity were relatively good in most grave pits, with the exception of some grave pits in Cemetery Area 4, where both burial practices and

postcemetery disturbances conspired to disturb the largest percentage of burials; half of all individuals in Cemetery Area 4 were discovered in secondary contexts.

In summary, archival research was able to produce some very useful information about the Alameda-Stone cemetery, but as O'Mack (2006) remarked before excavations were underway, the information about the cemetery that was not recorded or retained in existing archival sources is substantial. Archaeological information, although not definitive for a number of important questions, turned out to complement archival information fairly handily and helped to clarify issues for which the archival record proved to be either confusing or silent. Together, burials from the cemetery form a remarkably informative sample for these and future analyses and for comparison with other cemeteries. Yet what has been discussed in this chapter is still fairly basic and preliminary, only scratching the surface of what can potentially be learned through more in-depth analysis of the remains and their distribution. This chapter has dwelled mainly on presenting the historical and archaeological data that can be used to establish basic parameters for how and when the cemetery was used and by whom. Subsequent chapters in this volume and in Volume 1 of this series explore in greater depth the historical, contextual, and osteological data developed for this project, providing further insight into the organization and use of the Alameda-Stone cemetery and the life of a community.

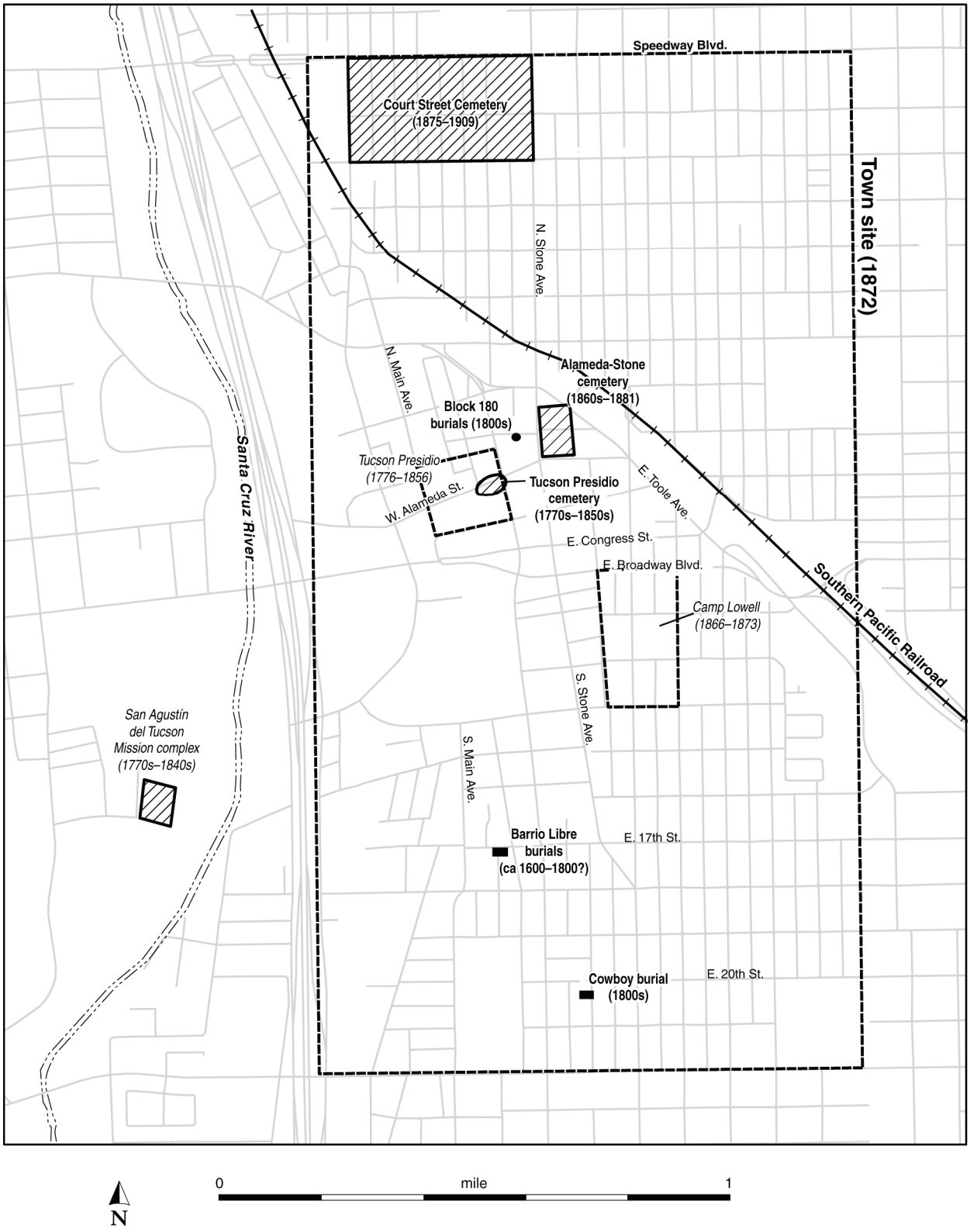

Figure 23. Burial spaces in Tucson.

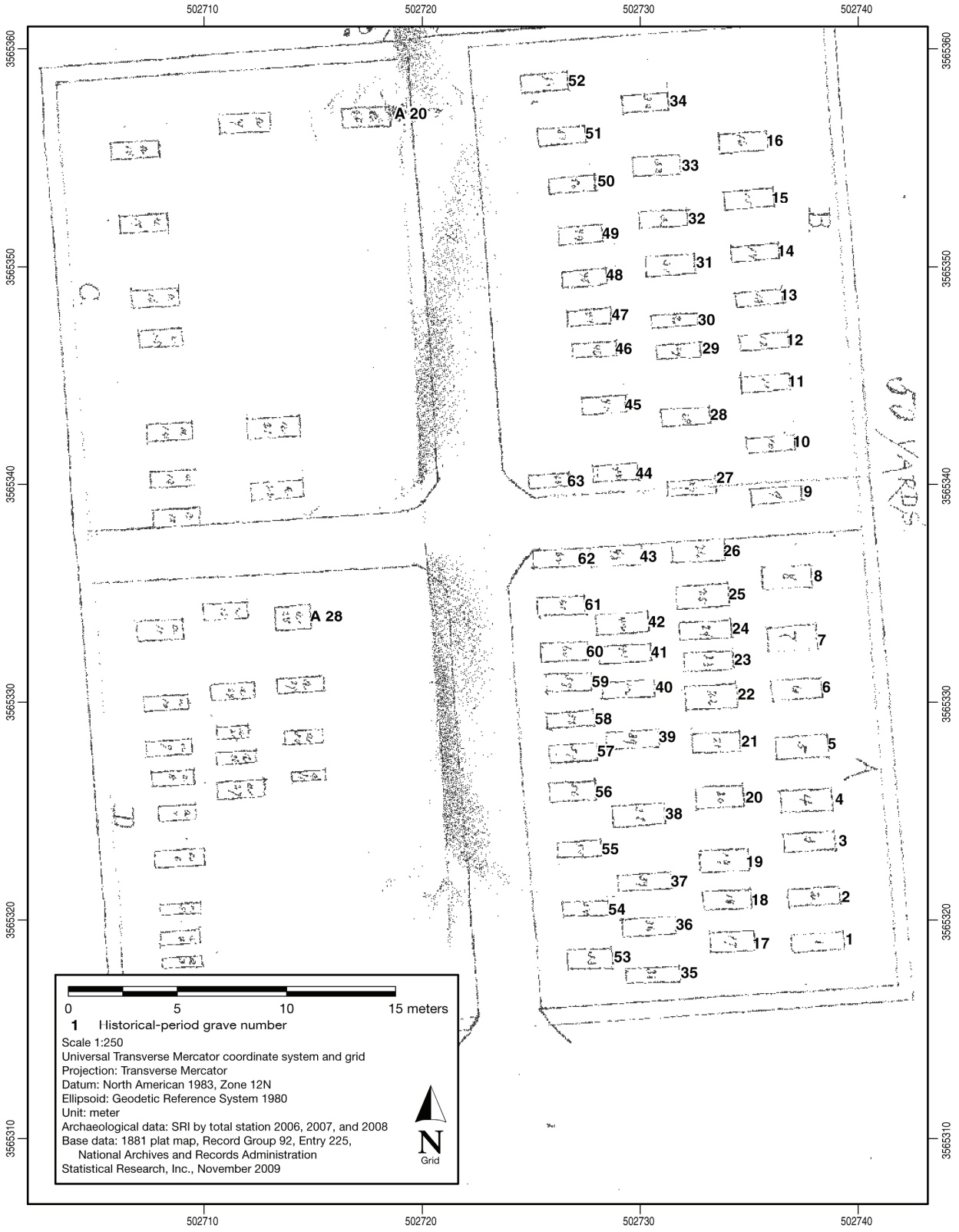

Figure 24. 1881 plat map of Military Cemetery.

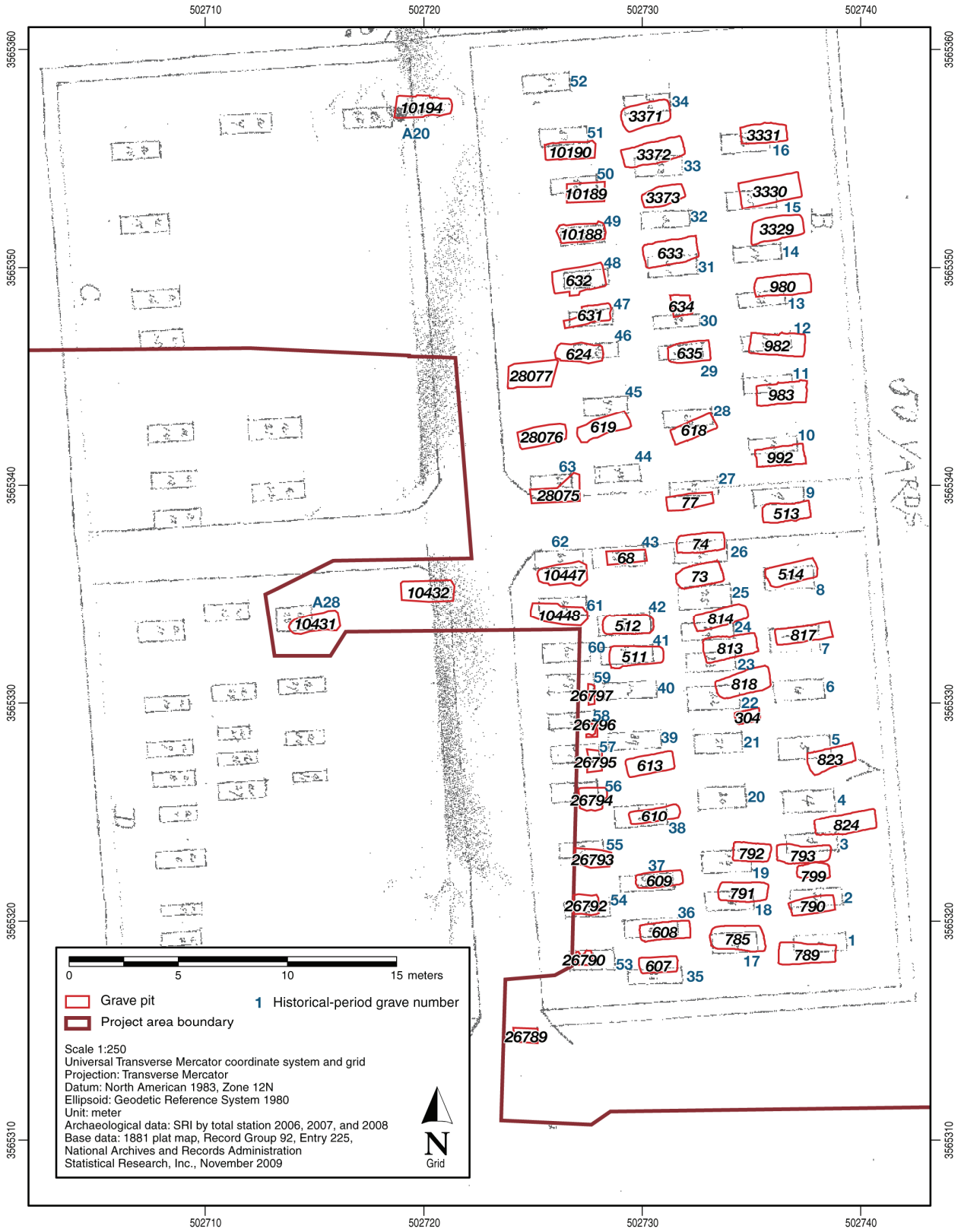

Figure 25. 1881 plat map overlay with Cemetery Area 1.

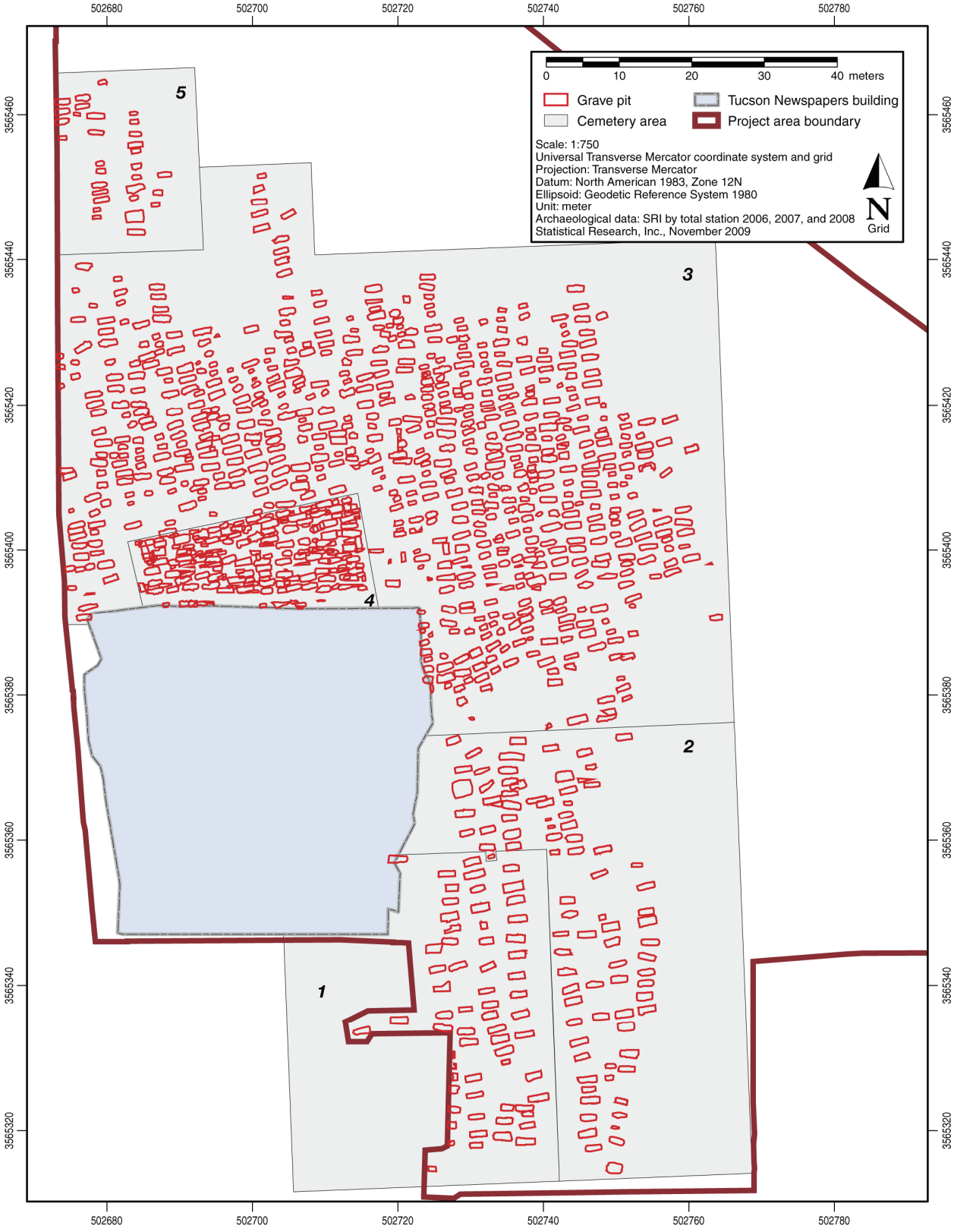

Figure 26. Cemetery area map.

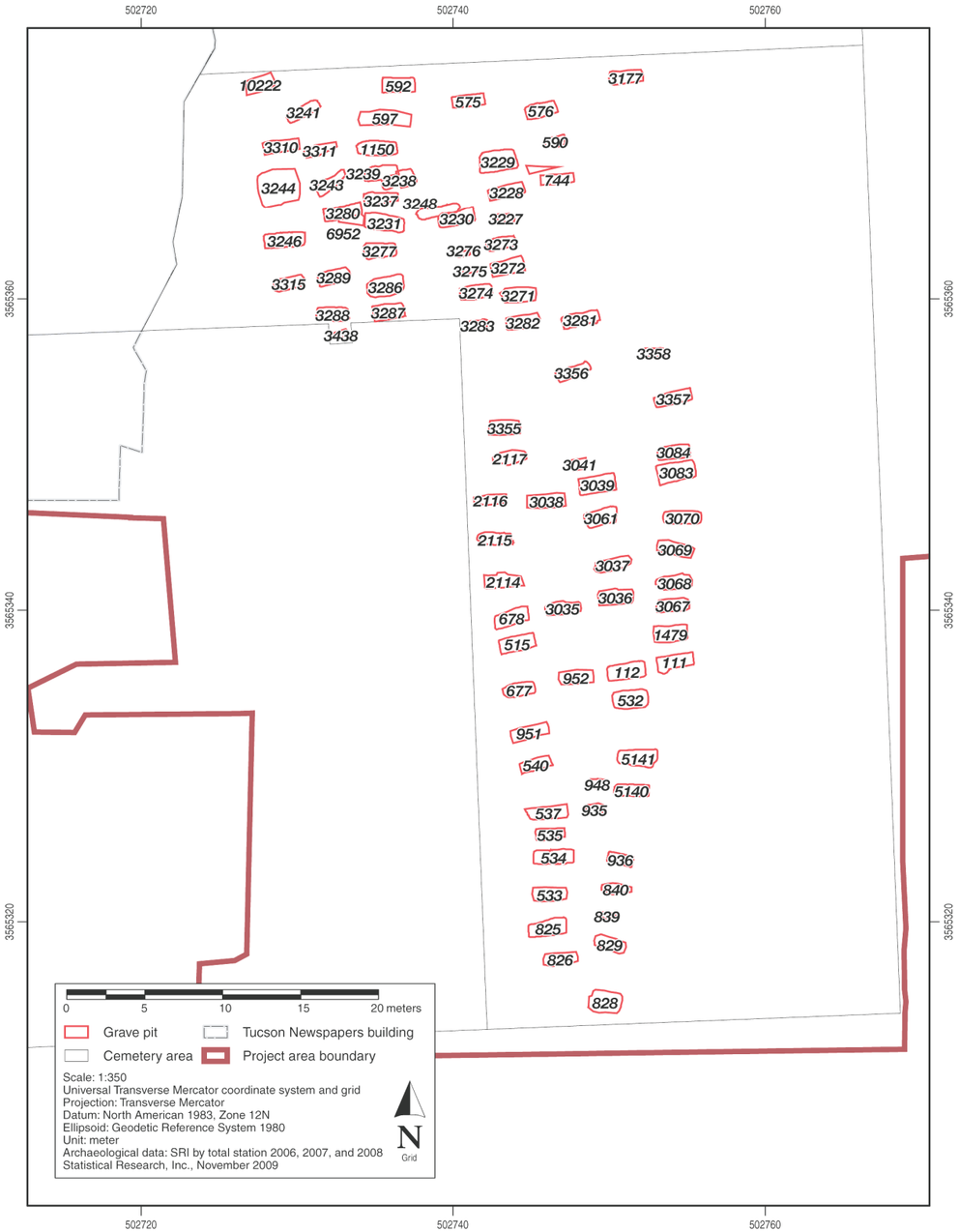

Figure 27. Cemetery Area 2 map.

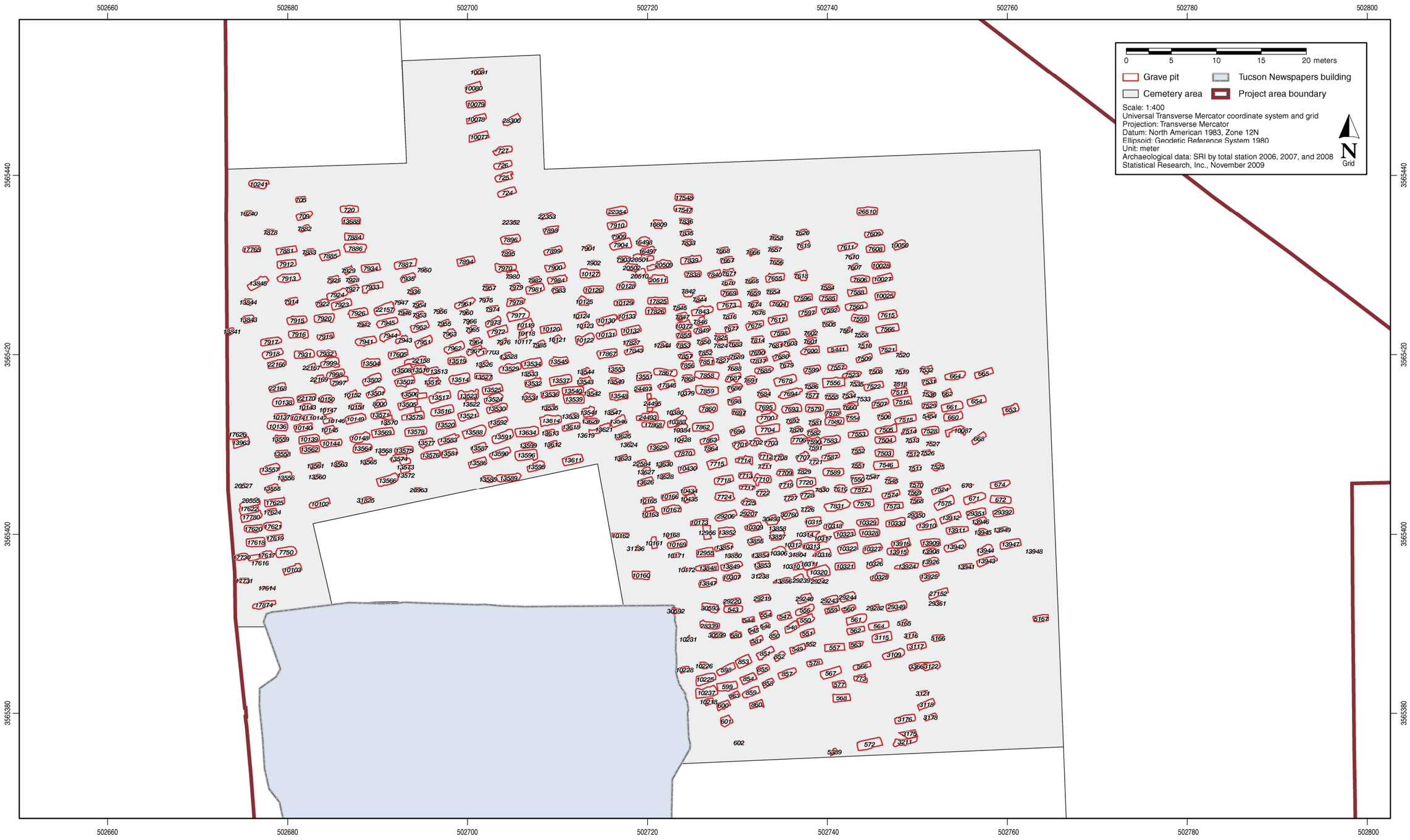

Figure 28. Cemetery Area 3 map.

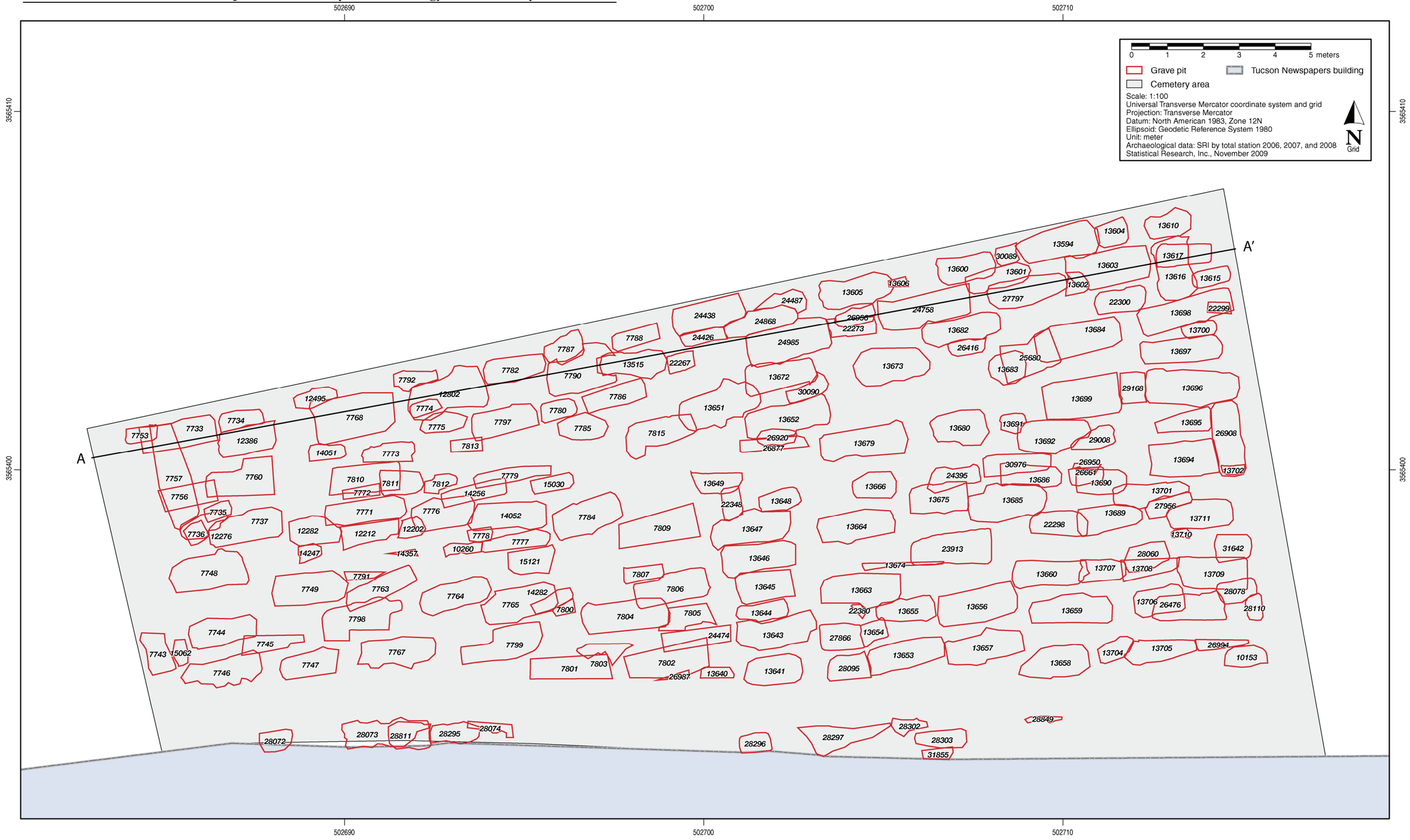

Figure 29. Cemetery Area 4 map.

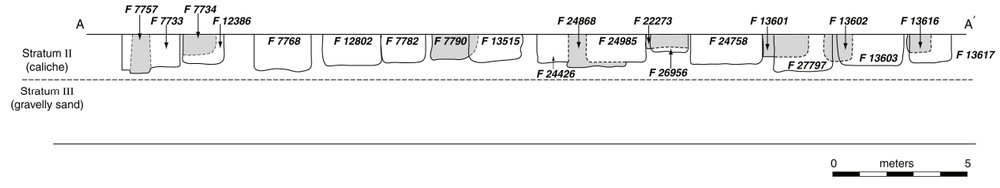

Figure 30. Cemetery Area 4 cross section.

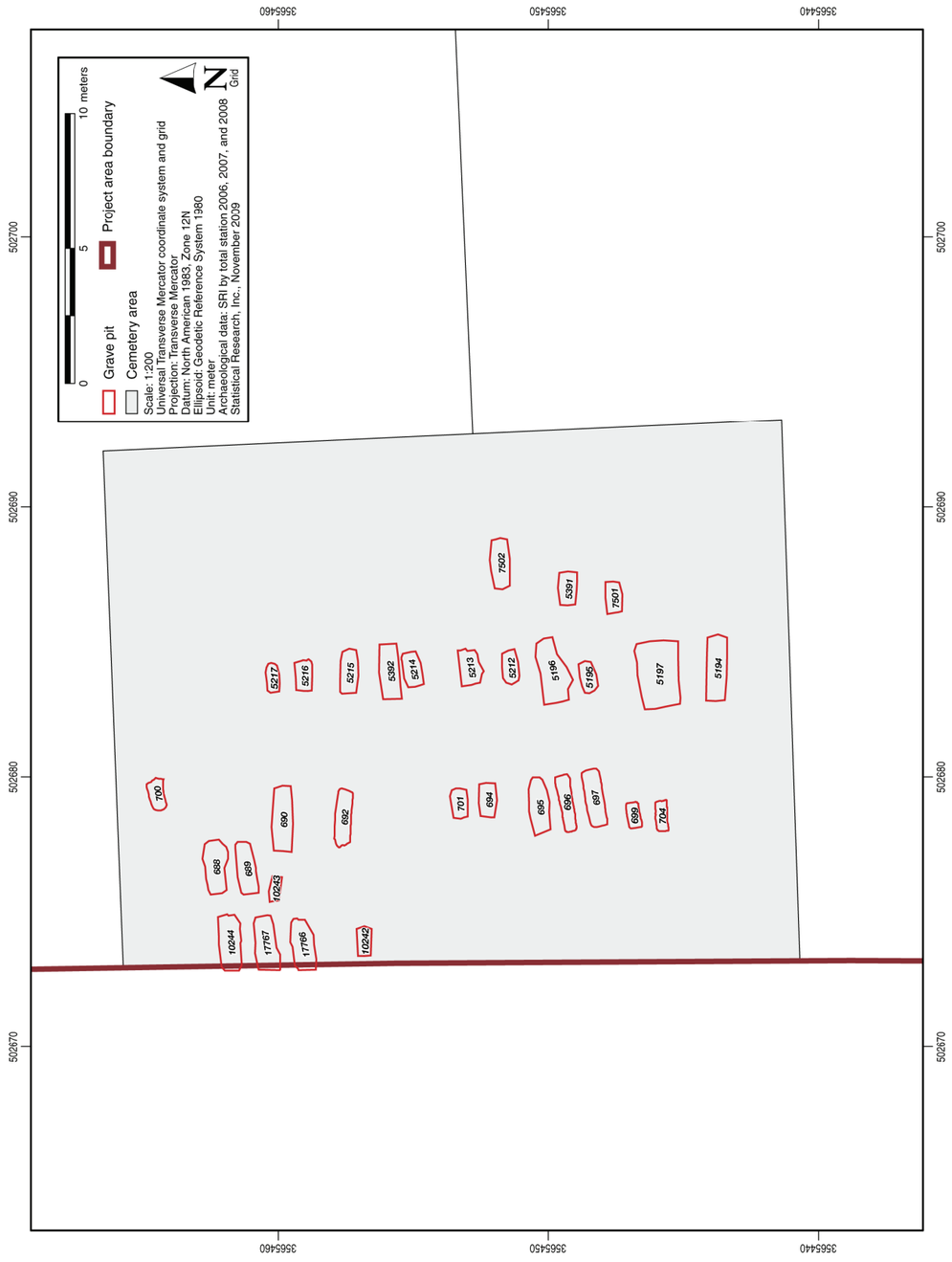

Figure 31. Cemetery Area 5 map.

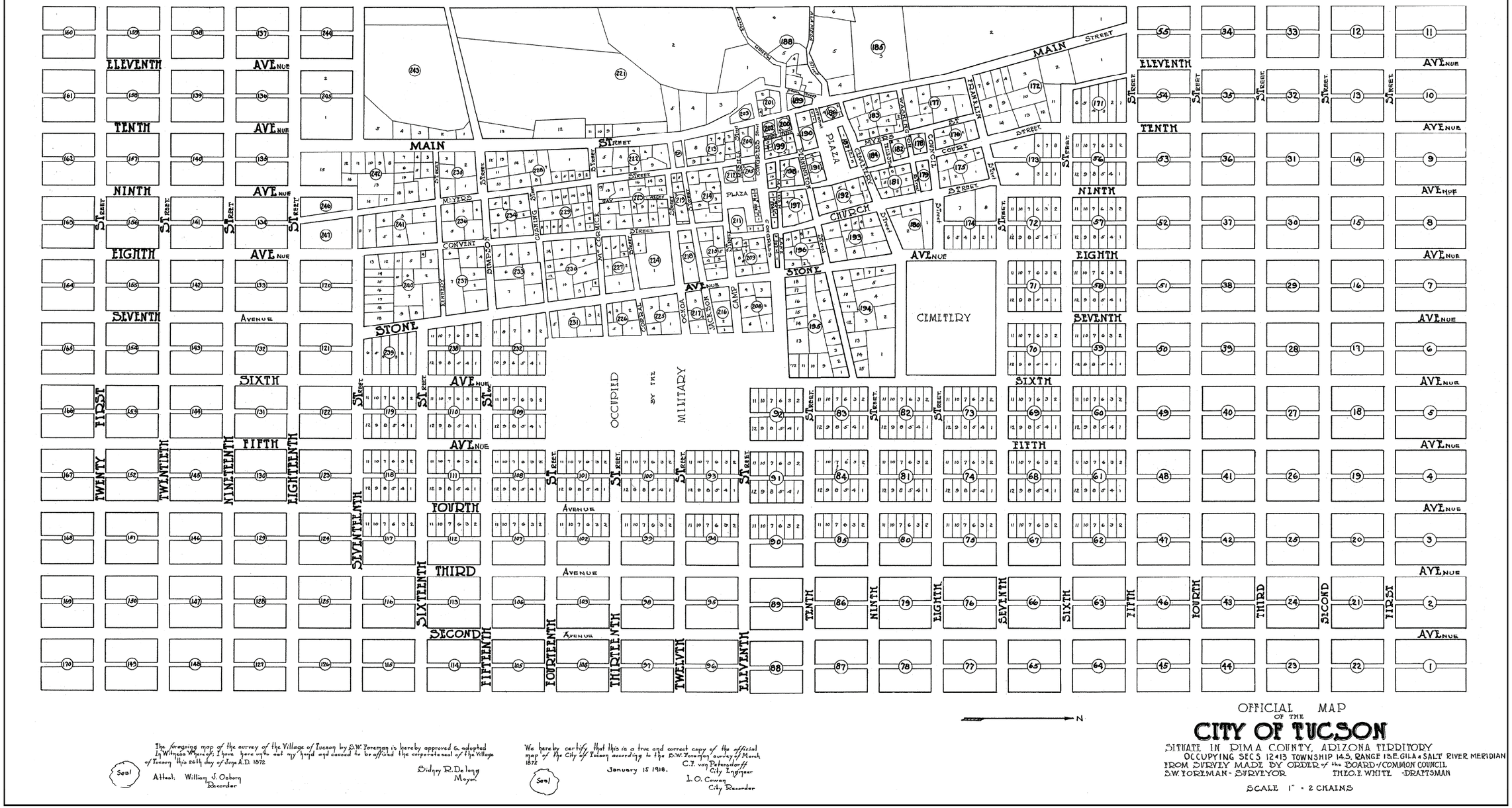

Figure 32. Official map of the 1872 survey of the town site of Tucson by S. W. Foreman (certified copy of 1918). Maps and Records Section, Engineering Division, Department of Transportation, City of Tucson.

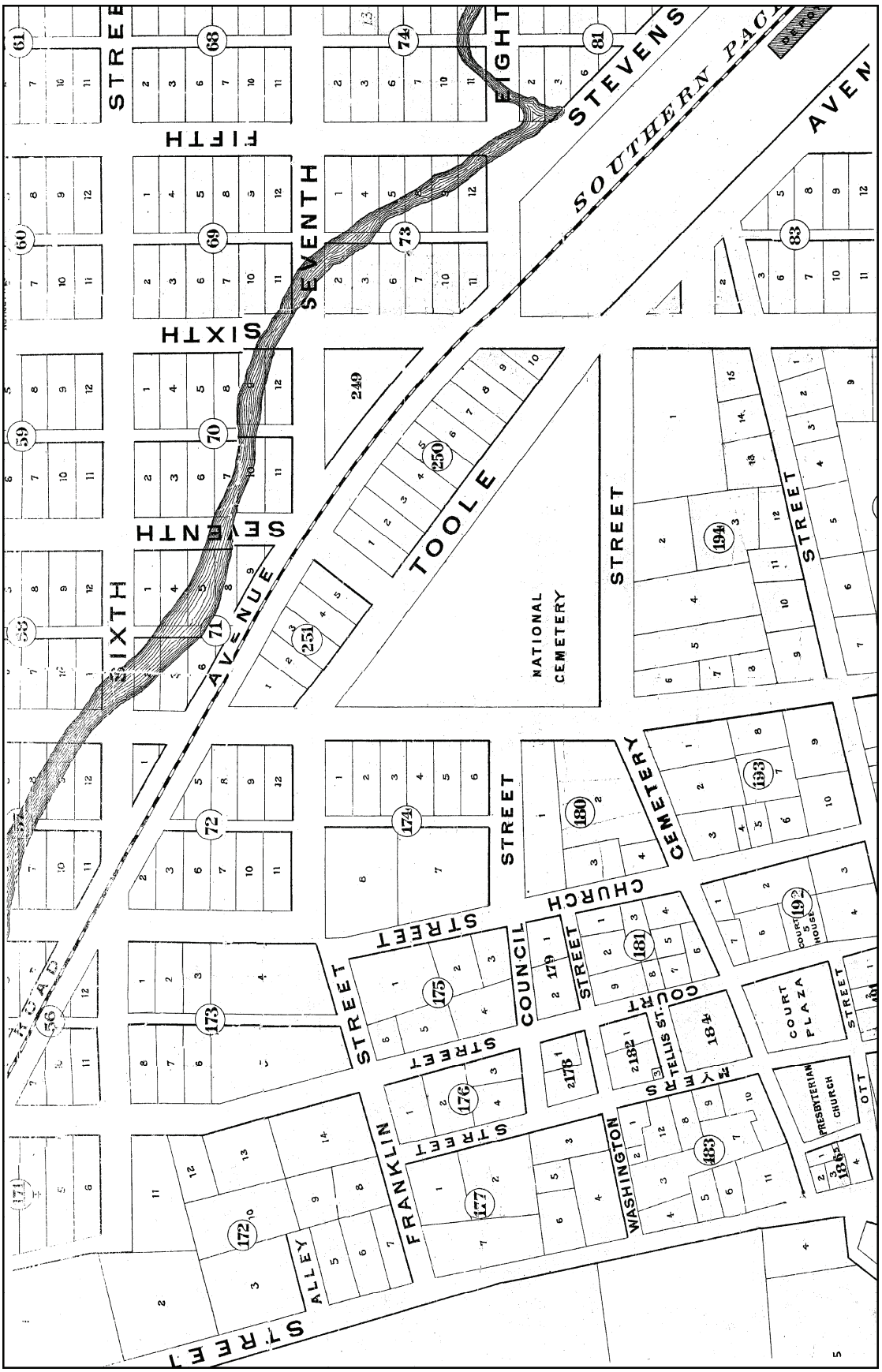

Figure 33. Portion of a map of Tucson prepared in 1880 showing the "National Cemetery"; recently built Southern Pacific Railroad; newly surveyed Blocks 249, 250, and 251; and Toole Avenue (Pattiani 1880).

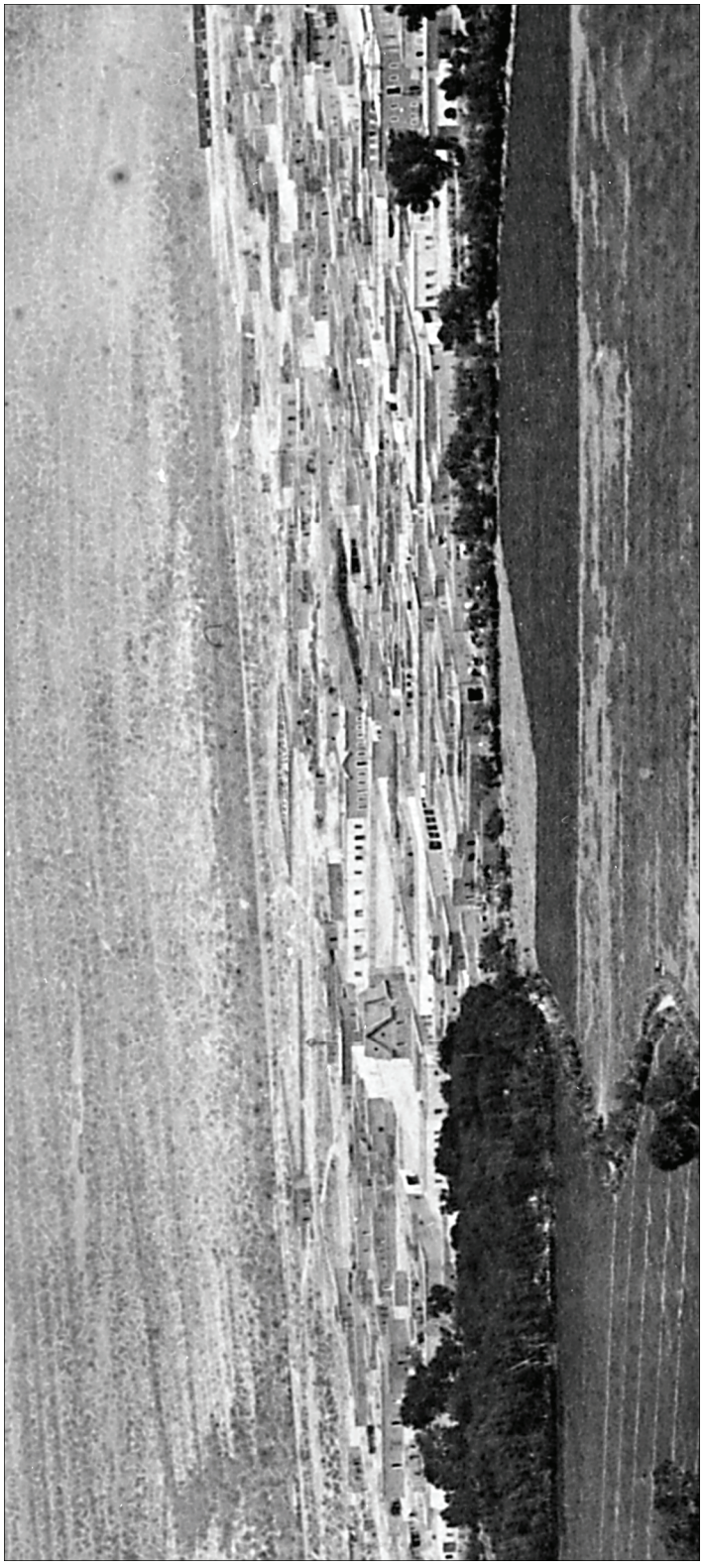

Figure 34. Detail from the 1880 Carleton Watkins photograph of Tucson (courtesy of the Arizona Historical Society, Tucson, Accession No. 18233).

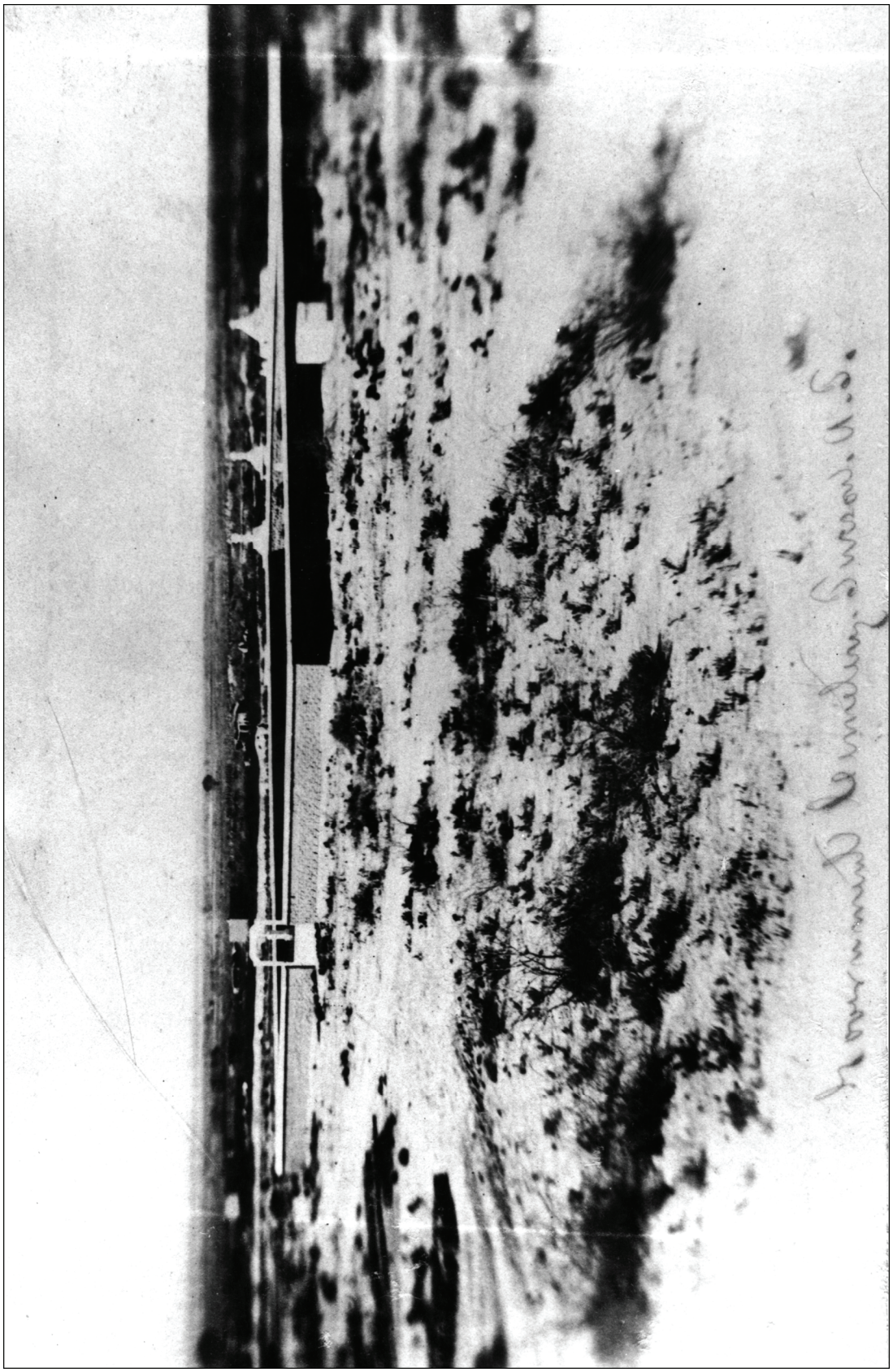

Figure 35. The "government" cemetery at Tucson, 1870. (Photograph by John Vance Lauderdale. John Vance Lauderdale Papers, Yale Collection of Western Americana, Beinecke Rare Book and Manuscript Library, Yale University, New Haven, Connecticut. Courtesy of the Beinecke Rare Book and Manuscript Library.)

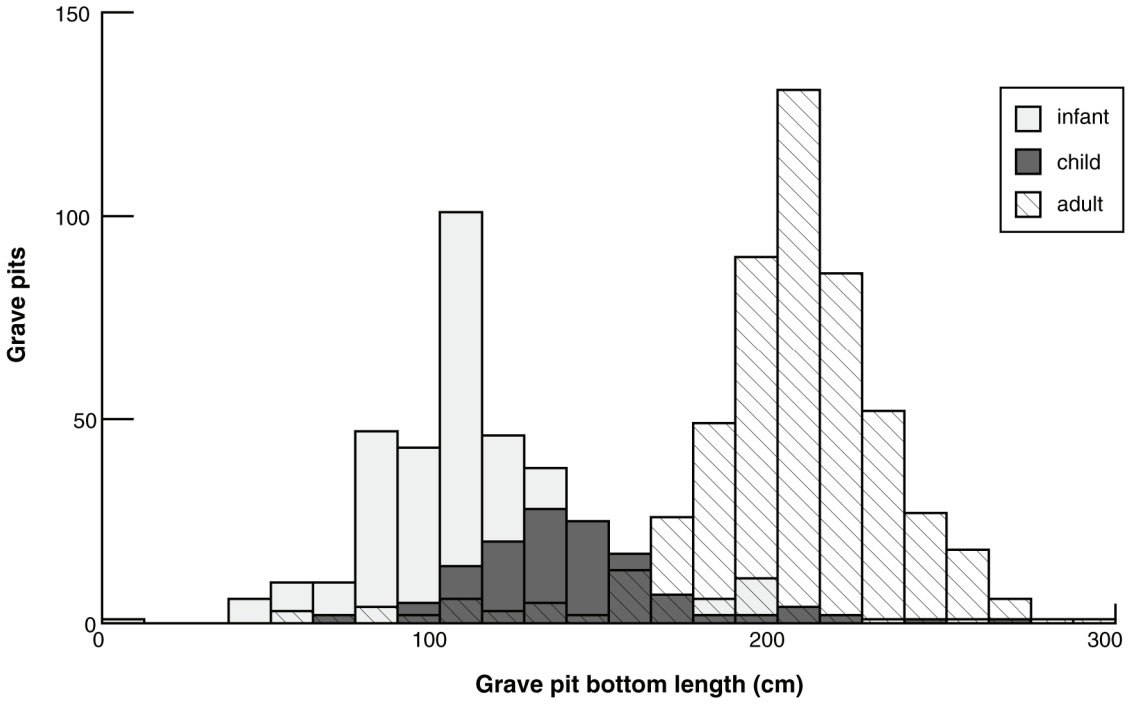

Figure 36. Grave-pit size by age.

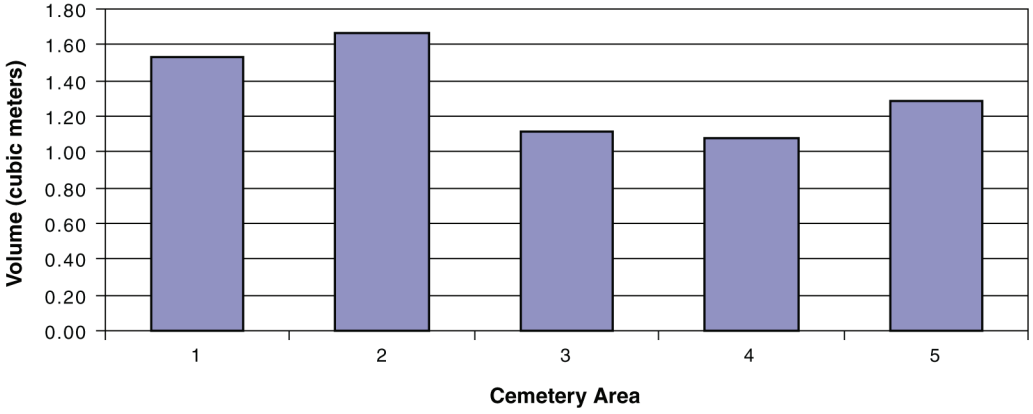

Figure 37. Average grave-pit volume by cemetery area.

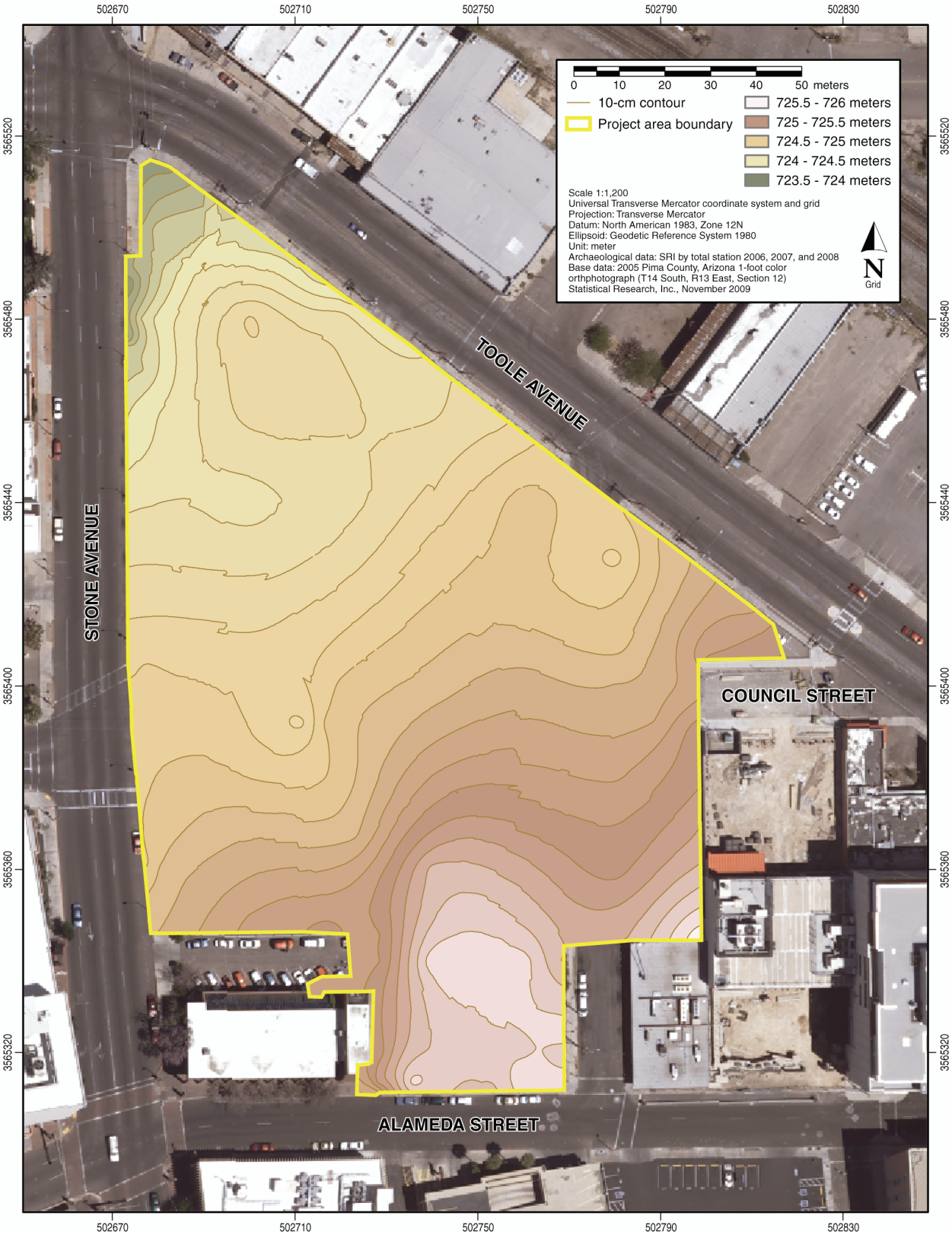

Figure 38. Model of surface elevation for the project area.

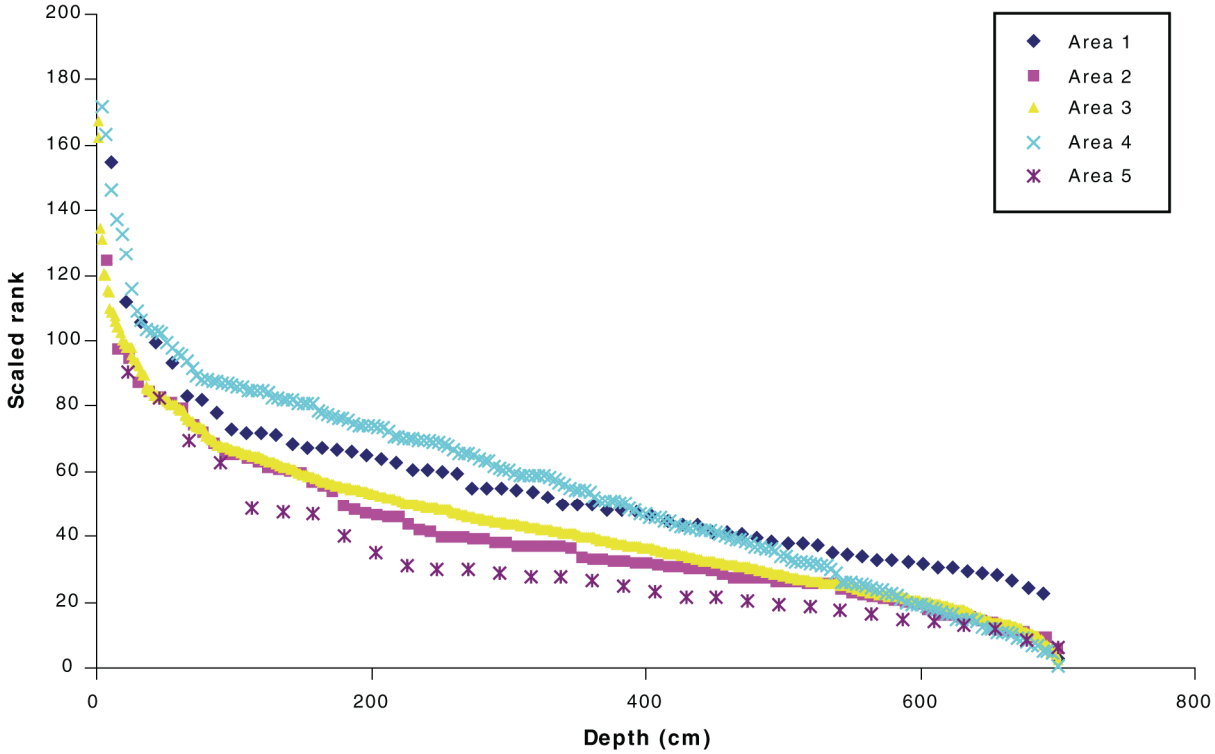

Figure 39. Rank-size distribution of grave pit depth, per cemetery area.

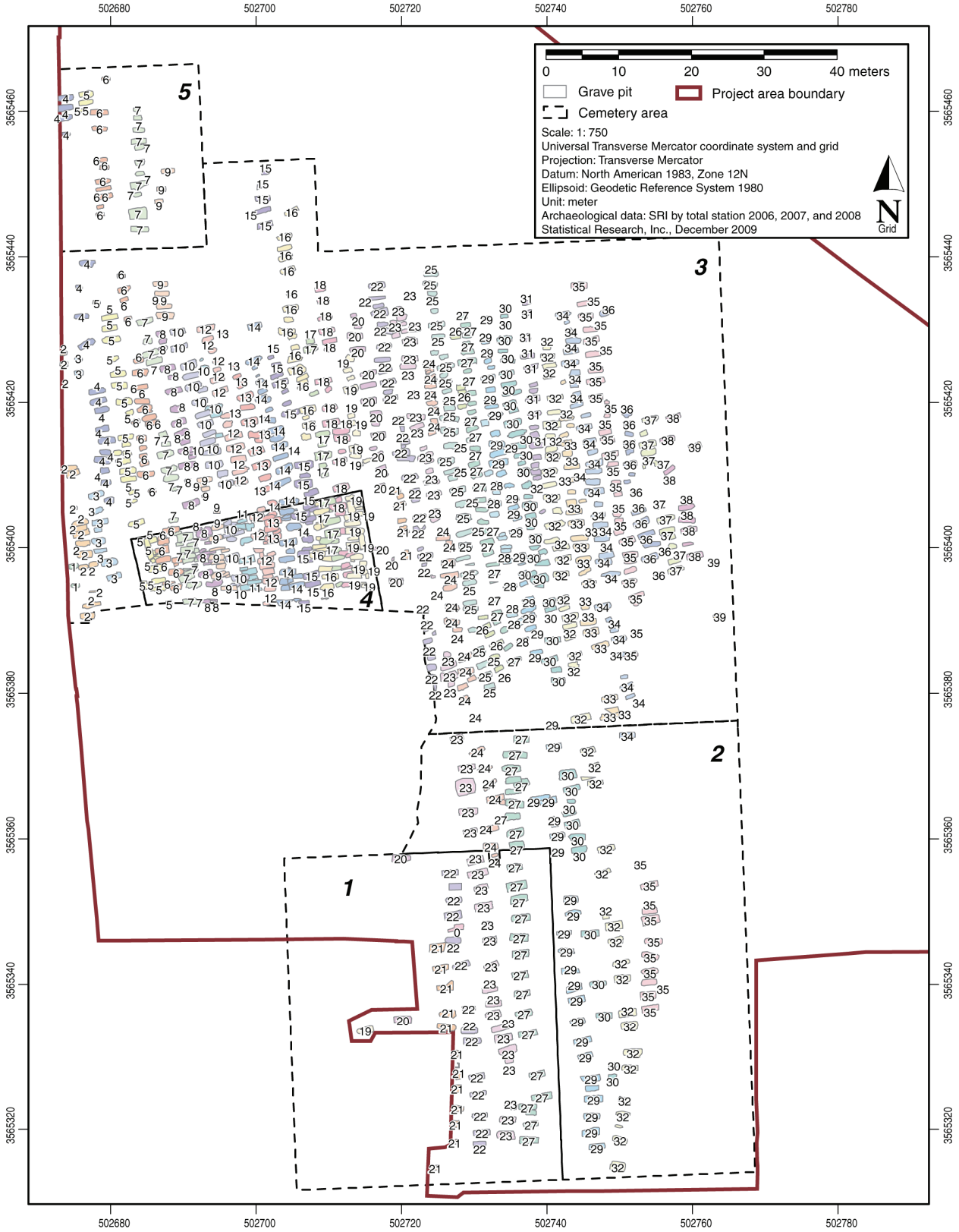

Figure 40. Map showing possible rows in the cemetery.

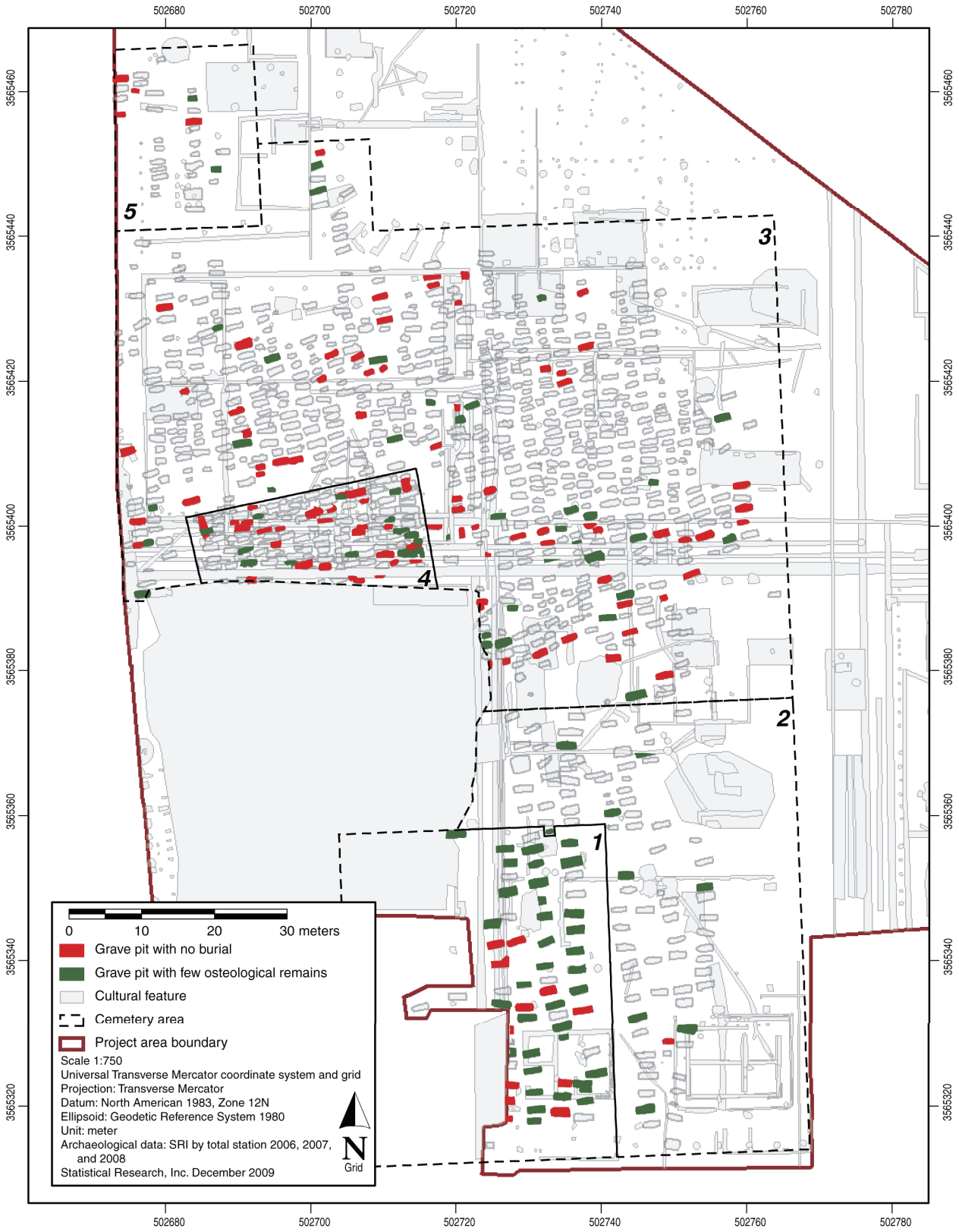

Figure 41. Map of exhumed burials in project area.

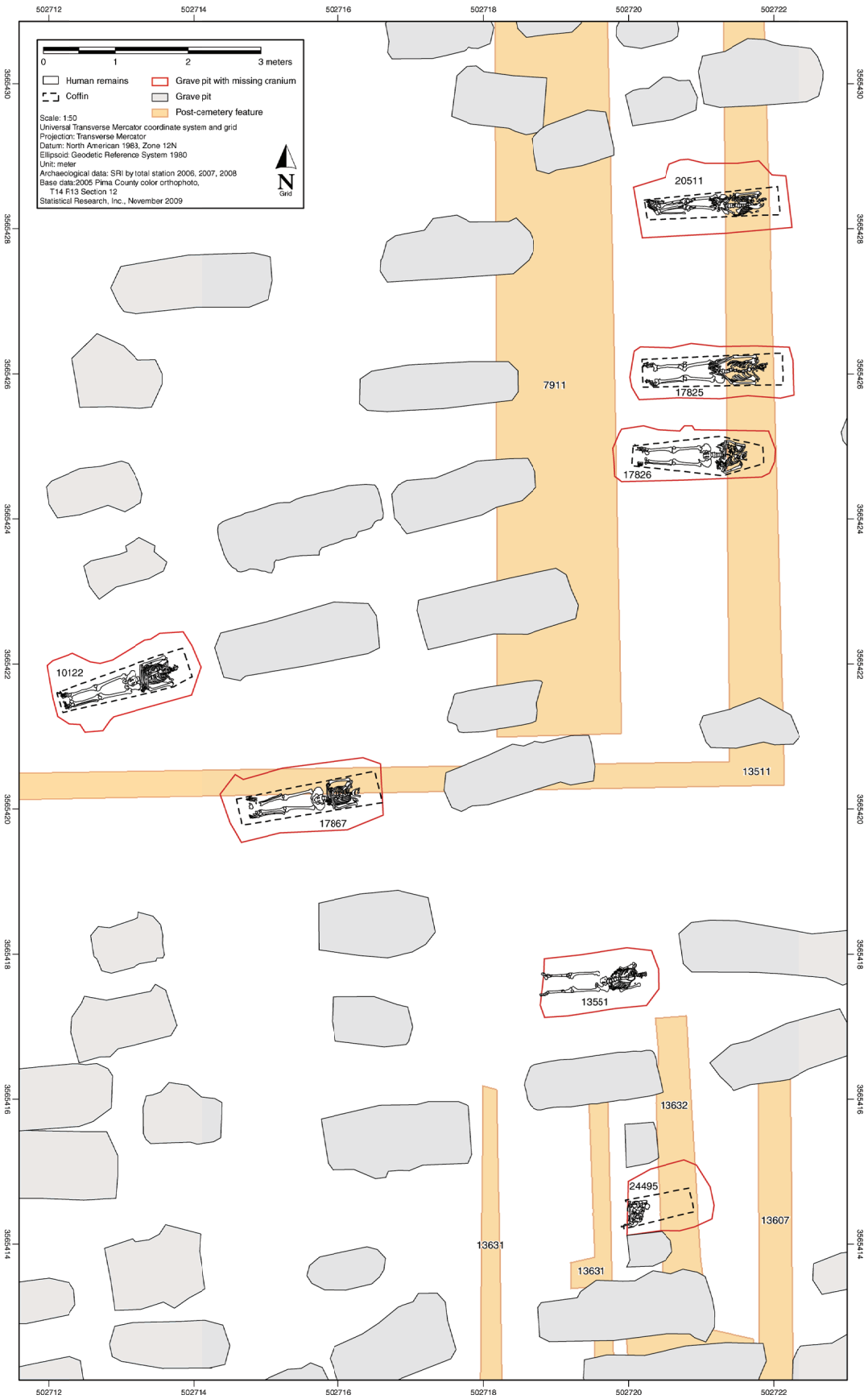

Figure 42. Map of burials missing crania.

Figure 43. Portion of detail from the 1880 Carleton Watkins photograph of Tucson (courtesy of the Arizona Historical Society, Tucson, Accession No. 18233).

Table 18. Cultural Affinity by Age, Sex, and Census Year from U.S. Census Data for Tucson, 1860–1880

Age Category	Sex[a]	African American or African American/Euroamerican				Asian American	Asian American/Hispanic	Hispanic				Hispanic/Non-Hispanic Euroamerican				Native American		Non-Hispanic Euroamerican				Total			
		Census Year				Census Year	Census Year	Census Year				Census Year				Census Year		Census Year				Census Year			
		1860	1864	1870	1880	1880	1880	1860	1864	1870	1880	1860	1864	1870	1880	1860	1880	1860	1864	1870	1880	1860	1864	1870	1880
Infant	f	—	—	—	—	—	1	18	24	56	29	1	1	3	2	5	—	—	—	8	8	24	25	67	40
Infant	m	—	—	—	—	—	—	27	31	56	32	3	3	3	7	1	1	—	2	5	9	31	36	64	49
Infant	n	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—
Child	f	—	—	—	—	—	—	70	131	261	375	4	9	15	54	4	7	—	2	11	73	78	142	287	509
Child	m	1	—	—	—	—	—	73	136	286	395	1	4	9	48	4	12	1	5	26	86	80	145	321	541
Subadult	f	1	—	—	—	—	—	37	76	183	184	—	—	2	17	1	10	2	—	7	18	41	76	192	229
Subadult	m	2	—	—	—	8	—	42	72	161	185	—	—	—	20	4	3	—	2	2	34	48	74	163	250
Adult under 35	f	2	—	—	1	3	—	131	253	490	595	1	1	1	10	26	9	4	4	28	176	164	258	519	794
Adult under 35	m	—	—	3	5	115	—	132	265	660	635	1	1		6	23	37	116	147	244	859	272	413	907	1,657
Adult under 35	n	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	2	—	—	—	2	—
Adult over 35	f	—	—	—	1	—	—	47	81	237	417	—	—	—	—	13	2	2	1	6	73	62	82	243	493
Adult over 35	m	2	—	1	3	35	—	64	102	293	480	—	—	—	1	3	14	42	53	163	861	111	155	457	1,397
Adult, nonspecific	m	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	103	—	—	1	103	—	—
Total, by sex	f	3	—	—	2	3	1	303	565	1,227	1,600	6	11	21	83	49	28	8	7	60	348	369	583	1,308	2,065
	m	5	—	4	8	158	—	339	606	1,456	1,727	5	8	12	82	35	67	159	312	440	1,849	543	926	1,912	3,894
	n	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	2	—	—	—	3	—
Total		8	—	4	10	161	1	642	1,171	2,684	3,327	11	19	33	165	84	95	167	319	502	2,197	912	1,509	3,223	5,959

Note: Individuals for whom no age was given in the census records are not included in this table.
[a] f = female; m = male; n = not specified

Table 19. Cultural Affinity and Age for Individuals in the Diocese 3 Record Likely to Have Been Buried in the Cemetery

Age Category	Hispanic	Non-Hispanic Euroamerican	Non-Hispanic Euroamerican/ Hispanic	Apache	Tohono O'odham	Yaqui	Native American, Nonspecific	Not Determined	Total
Infant	316	1	7	3	2	—	2	5	336
Child	156	1	1	4	2	1	3	9	177
Subadult	23	—	—	—	—	1	—	—	24
Young adult	168	4	1	7	—	2	3	11	196
Middle adult	88	2	—	—	—	1	—	—	91
Old adult	57	3	—	2	—	—	—	2	64
Not specified	47	—	—	—	1	1	3	4	56
Total	855	11	9	16	5	6	11	31	944

Table 20. Cultural Affinity, by Age and Sex, from the 1870 Mortality Schedule

Age Category/Sex	African American	Hispanic	Native American	Non-Hispanic Euroamerican	Non-Hispanic Euroamerican/ Hispanic	Total
Infant						
Female	—	14	—	—	1	15
Male	—	14	—	1	—	15
Child						
Female	—	31	—	—	—	31
Male	—	21	1	2	—	24
Subadult						
Female	—	1	1	—	—	2
Male	—	2	—	—	—	2
Adult under 35						
Female	—	3	—	4	—	7
Male	1	7	—	14	—	22
Adult over 35						
Female	—	4	—	—	—	4
Male	1	5	—	11	—	17
Subtotal						
Female	—	53	1	4	1	59
Male	2	49	1	28	—	80
Total	2	102	2	32	1	139

Table 21. Region of Birth for Tucson Residents Listed in the 1860 Federal Census, by Age Category

Region/Sex	Infant	Child	Subadult	Young Adult	Middle Adult	Older Adult	Total
Canada							
Male	—	—	—	3	—	—	3
Caribbean							
Male	—	—	—	1	—	—	1
Europe							
Female	—	—	—	—	1	—	1
Male	—	—	—	28	6	—	34
Northeastern, southern, or mid-western United States							
Female	—	—	3	6	—	1	10
Male	—	2	2	86	29	11	130
South America							
Male	—	—	—	—	1	—	1
Mexico							
Female	4	13	13	60	12	9	111
Male	3	15	17	67	22	12	136
Southwestern United States							
Female	20	65	25	97	25	13	245
Male	28	63	29	86	18	12	236
Subtotal							
Female	24	78	41	163	38	23	367
Male	31	80	48	271	76	35	541
Total	55	158	89	434	114	58	908

Note: Four individuals of either undetermined place of birth or age were not included in the table.

Table 22. Region of Birth for Tucson Residents Listed in the 1864 Territorial Census, by Age Category

Region/Sex	Infant	Child	Subadult	Young Adult	Middle Adult	Older Adult	Total
Canada							
Male	—	—	—	5	—	—	5
Europe							
Female	—	—	—	1	—	—	1
Male	—	—	1	33	19	2	55
Northeastern, southern, or mid-western United States							
Female	—	2	—	1	—	—	3
Male	—	1	1	103	27	5	137
Mexico							
Female	3	43	26	114	18	11	215
Male	4	30	28	154	40	10	266
Southwestern United States							
Female	22	97	50	142	38	15	364
Male	32	114	44	114	34	17	355
Subtotal							
Female	25	142	76	258	56	26	583
Male	36	145	74	409	120	34	818
Total	61	287	150	667	176	60	1,401

Note: The place of birth and age were not determined for 103 individuals in this census who appeared to be associated with the U.S. military post at Tucson. Those individuals are not listed in the table.

Table 23. Region of Birth for Tucson Residents Listed in the 1870 Federal Census, by Age Category

Region/Sex	Infant	Child	Subadult	Young Adult	Middle Adult	Old Adult	Total
Canada							
Female	—	—	—	1	—	—	1
Male	—	—	—	13	2	—	15
Caribbean							
Female	—	—	—	1	—	—	1
Male	—	—	—	3	—	1	4
Europe							
Female	—	—	—	6	4	—	10
Male	—	—	—	83	51	4	138
Northeastern, southern, or midwestern United States							
Female	—	4	4	13	1	—	22
Male	1	6	1	146	93	16	263
South America							
Male	—	—	—	—	3	—	3
Mexico							
Female	13	161	137	415	137	41	904
Male	4	172	116	587	193	48	1,120
Southwestern United States							
Female	54	122	51	83	39	20	369
Male	59	143	46	75	28	18	369
Subtotal							
Female	67	287	192	519	181	61	1,307
Male	64	321	163	907	370	87	1,912
Total	131	608	355	1,426	551	148	3,219

Note: Four individuals of either undetermined place of birth or sex were not included in the table.

Table 24. Region of Birth for Tucson Residents Listed in the 1880 Federal Census, by Age Category

Region/Sex	Infant	Child	Subadult	Young Adult	Middle Adult	Old Adult	Total
Australia							
Male	—	—	—	1	1	—	2
Canada							
Female	—	3	1	8	2	—	14
Male	—	1	—	25	26	3	55
Caribbean							
Female	—	—	—	—	1	—	1
East Asia							
Female	—	—	—	2	—	—	2
Male	—	—	8	106	27	5	146
East Indies							
Male	—	—	—	—	—	1	1
Europe							
Female	—	1	1	44	19	4	69
Male	—	—	3	269	199	60	531
Middle East							
Female	—	—	—	1	—	—	1
Male	—	—	—	—	1	1	2
North Africa							
Male	—	—	—	1	—	—	1
Northeastern, southern, or midwestern United States							
Female	1	17	12	85	41	5	161
Male	1	23	13	506	424	146	1,113
Northwestern United States							
Female	—	1	—	—	—	—	1
Male	—	—	—	2	—	—	2
South America							
Male	—	—	—	3	3	2	8
Mexico							
Female	5	181	139	520	251	124	1,220
Male	8	177	154	543	315	116	1,313
Southwestern United States							
Female	34	306	76	132	30	14	592
Male	39	339	72	195	43	16	704
Subtotal							
Female	40	509	229	792	344	147	2,061
Male	48	540	250	1,651	1,039	350	3,878
Total	88	1,049	479	2,443	1,383	497	5,939

Note: Twenty individuals of undetermined place of birth and 123 individuals of undetermined age were not included in this table.

Table 25. Number of Hispanic Burials in the Cemetery, based on Multiple Diocese and Census Records

Temporal Group	Date Range	Months	Infant Burials	Child Burials	Subadult Burials	Young-Adult Burials	Middle-Adult Burials	Old-Adult Burials	Burials, Unspecified Age	Total Burials	Hispanic Population Estimate	1870 Adjusted Deaths	Mortality Rate (%)	Adjusted Mortality Rate (%)	Estimated Total Hispanic Burials
1[a]	May 1862–April 1863	12	—	—	—	—	—	—	—	28	1,038.25	44.3	2.7	4.1	44
2	May 1863–July 1864	14	10	6	1	1	1		16	35	1,171.00	54.7	2.9	4.5	54
3[a]	Aug 1864–March 1865	8	—	—	—	—	—	—	—	19	1,423.00	29.6	1.3	2.0	29
4[a]	April 1865–April 1866	12	—	—	—	—	—	—	—	28	1,675.00	44.3	1.7	2.6	44
5	April 1866–April 1867	13	6	3	1	9	3	3	4	29	1,927.00	45.3	1.5	2.3	45
6	Jun 1867–May 1868	12	9	9	1	2	1	2	6	30	2,179.00	46.9	1.4	2.1	46
7	Jun 1868–May 1869	12	26	20	2	17	9	9	19	102	2,431.00	159.4	4.0	6.2	159
8	Jun 1869–May 1870	12	44	48	2	17	2	3	6	122	2,683.00	190.6	4.3	6.6	190
9	Jun 1870–May 1871	12	36	18	4	31	20	8	4	121	2,755.80	189.1	4.2	6.4	189
10	Jun 1871–May 1872	12	43	18	6	35	14	10	—	126	2,828.60	196.9	4.3	6.5	196
11	Jun 1872–May 1872	12	38	13	3	25	8	7	—	94	2,901.40	146.9	3.1	4.8	146
12	Jun 1873–May 1874	12	66	15	2	19	14	6	2	124	2,974.20	193.8	4.0	6.1	193
13	Jun 1874–May 1875	12	58	27	2	40	19	16	—	162	3,047.00	253.1	5.0	7.7	253
Total		155	336	177	24	196	91	64	57	1,020					1,588

[a] Total numbers of burials during these periods were estimated based on the burial rates for adjacent temporal groups, as these temporal groups represent gaps in the record.

Table 26. 1870 Mortality Estimates, by Cultural Affinity

Deaths	Age Class																			Total
	Infant			Child			Subadult		Adult under 35			Adult over 35		Not Specifed			Total			
	Sex			Sex			Sex		Sex			Sex		Sex			Sex			
	F	M	N	F	M	N	F	M	F	M	N	F	M	F	M	N	F	M	N	
African American																				
Diocese only	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
1870 only	—	—	—	—	—	—	—	—	—	1	—	—	1	—	—	—	—	2	—	2
Overlap	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Total	—	—	—	—	—	—	—	—	—	1	—	—	1	—	—	—	—	2	—	2
1870 population	—	—	—	—	—	—	—	—	—	3	—	—	1	—	—	—	—	4	—	4
Death rate (%)										25			50					33.33		33.33
Hispanic																				
Diocese only	13	17	1	18	13	1	—	1	6	8	—	2	1	—	3	1	39	43	3	85
1870 only	11	6	—	24	13	—	—	1	3	6	—	4	4	—	—	—	42	30	—	72
Overlap	3	8	—	7	7	—	—	1	1	1	—	—	—	—	1	—	11	18	—	29
Total	27	31	1	49	33	1	—	3	10	15	—	6	5	—	4	1	92	91	3	186
1870 population	56	56	1	261	286	—	183	161	490	660	—	237	293	—	—	—	1,227	1,456	1	2,684
Death rate (%)	32.53	35.63		15.81	10.34			1.83	2	2.22		2.47	1.68				6.97	5.88		6.48
Native American																				
Diocese only	—	1	—	—	1	—	—	—	—	—	—	1	—	—	—	—	1	2	—	3
1870 only	—	—	—	—	1	—	1	—	—	—	—	—	—	—	—	—	1	1	—	2
Overlap	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Total	—	1	—	—	2	—	1	—	—	—	—	1	—	—	—	—	2	3	—	5
1870 population	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Death rate (%)																				
Non-Hispanic Euroamerican																				
Diocese only	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
1870 only	—	—	—	—	2	—	—	—	4	13	—	—	10	—	—	—	4	25	—	29
Overlap	—	1	—	—	—	—	—	—	—	1	—	—	1	—	—	—	—	3	—	3
Total	—	1	—	—	2	—	—	—	4	14	—	—	11	—	—	—	4	28	—	32
1870 population	8	5	—	11	26	—	7	2	28	244	2	6	163	—	—	—	60	440	2	502
Death rate (%)		16.67			7.14				12.5	5.43			6.32	—	—	—	6.25	5.98		5.99
Hispanic/Non-Hispanic Euroamerican																				
Diocese only	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
1870 only	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	1
Overlap	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Total	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	1
1870 population	3	3	—	15	9	—	2	—	1	—	—	—	—	—	—	—	21	12	—	33
Death rate (%)	25																4.55			2.94

Deaths	Age Class																			Total
	Infant			Child			Subadult		Adult Under 35			Adult Over 35		Not Specifed			Total			
	Sex			Sex			Sex		Sex			Sex		Sex			Sex			
	F	M	N	F	M	N	F	M	F	M	N	F	M	F	M	N	F	M	N	
Not Determined																				
Diocese only	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	1	—	1	1	2
1870 only	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Overlap	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Total	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	1	—	1	1	2
1870 population	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Death rate (%)																				
Total																				
Diocese only	13	18	1	18	15	1	—	1	6	8	—	3	1	—	3	2	40	46	4	90
1870 only	12	6	—	24	16	—	1	1	7	20	—	4	15	—	—	—	48	58	—	106
Overlap	3	9	—	7	7	—	—	1	1	2	—	—	1	—	1	—	11	21	—	32
Total	28	33	1	49	38	1	1	3	14	30	—	7	17	—	4	2	99	125	4	228
1870 population	67	64	1	287	321	—	192	163	519	907	2	243	457	—	—	—	1,308	1,912	3	3,223
Death rate (%)	29.47	34.02		14.58	10.58		0.52	1.81	2.63	3.20		2.8	3.59				7.04	6.14		

Key: F = female; M = male; N = not specified.

Table 27. Projected Burial Population Based on Data from the 1860, 1870, and 1880 U.S. Federal Census Records and the 1864 U.S. Territorial Census Record, Assuming a Constant Death Rate of 6.6 Percent

Census Year	Living Population (Projected)			Deaths per Year (Projected)			Cumulative Burials			Hispanic (%)	Non-Hispanic (%)	Total (%)
	Hispanic	Non-Hispanic	Total	Hispanic	Non-Hispanic	Total[a]	Hispanic	Non-Hispanic	Total[a]			
1860	640.0	272.0	912.0	42	18	60	—	—	—			
1861	772.8	288.5	1,061.0	51	19	70	—	—	—			
1862	905.5	305.0	1,211.0	60	20	80	60	20	80	74.8	25.2	100
1863	1,038.3	321.5	1,360.0	69	21	90	128	41	169	75.6	24.4	100
1864	1,171.0	338.0	1,509.0	77	22	99	206	64	270	76.4	23.6	100
1865	1,423.0	371.67	1,795.0	94	25	119	299	88	387	77.3	22.7	100
1866	1,675.0	405.33	2,080.0	111	27	138	410	115	525	78.1	21.9	100
1867	1,927.0	439.0	2,366.0	127	29	156	537	144	681	78.9	21.1	100
1868	2,179.0	472.7	2,652.0	144	31	175	681	175	856	79.5	20.5	100
1869	2,431.0	506.3	2,937.0	160	33	193	841	209	1,050	80.1	19.9	100
1870	2,683.0	540.0	3,223.0	177	36	213	1,019	244	1,263	80.7	19.3	100
1871	2,755.8	753.1	3,508.9	182	50	232	1,200	294	1,494	80.3	19.7	100
1872	2,828.6	966.2	3,794.8	187	64	251	1,387	358	1,745	79.5	20.5	100
1873	2,901.4	1,179.3	4,080.7	191	78	269	1,579	435	2,014	78.4	21.6	100
1874	2,974.2	1,392.4	4,366.6	196	92	288	1,775	527	2,302	77.1	22.9	100
1875	3,047.0	1,605.5	4,652.5	201	106	307	1,976	633	2,609	75.7	24.3	100
1876	3,119.8	1,818.6	4,938.4	206	120	326	—	—	—			
1877	3,192.6	2,031.7	5,224.3	211	134	345	—	—	—			
1878	3,265.4	2,244.8	5,510.2	216	148	364	—	—	—			
1879	3,338.2	2,457.9	5,796.1	220	162	382	—	—	—			
1880	3,411.0	2,671.0	6,082.0	225	176	401	—	—	—			

[a]Numbers are rounded.

Table 28. Projected Burial Population Based on Data from the 1860, 1870, and 1880 U.S. Federal Census Records and the 1864 U.S. Territorial Census Record, Assuming a Constant Death Rate of 3.3 Percent

Census Year	Living Population (Projected)			Deaths per Year (Projected)			Cumulative Burials			Hispanic (%)	Non-Hispanic (%)	Total (%)
	Hispanic	Non-Hispanic	Total	Hispanic	Non-Hispanic	Total[a]	Hispanic	Non-Hispanic	Total[a]			
1860	640.0	272.0	912.0	21	9	30	—	—	—			
1861	772.8	288.5	1,061.0	26	10	36	—	—	—			
1862	905.5	305.0	1,211.0	30	10	40	30	10	40	74.8	25.2	100
1863	1,038.3	321.5	1,360.0	34	11	45	64	21	85	75.6	24.4	100
1864	1,171.0	338.0	1,509.0	39	11	50	103	32	135	76.4	23.6	100
1865	1,423.0	371.7	1,795.0	47	12	59	150	44	194	77.3	22.7	100
1866	1,675.0	405.3	2,080.0	55	13	68	205	57	262	78.1	21.9	100
1867	1,927.0	439.0	2,366.0	64	14	78	269	72	341	78.9	21.1	100
1868	2,179.0	472.7	2,652.0	72	16	88	341	88	429	79.5	20.5	100
1869	2,431.0	506.3	2,937.0	80	17	97	421	104	525	80.1	19.9	100
1870	2,683.0	540.0	3,223.0	177	36	213	598	140	738	81.0	19.0	100
1871	2,755.8	753.1	3,508.9	91	25	116	689	165	854	80.7	19.3	100
1872	2,828.6	966.2	3,794.8	93	32	125	782	197	979	79.9	20.1	100
1873	2,901.4	1,179.3	4,080.7	96	39	135	878	236	1,114	78.8	21.2	100
1874	2,974.2	1,392.4	4,366.6	98	46	144	976	282	1,258	77.6	22.4	100
1875	3,047.0	1,605.5	4,652.5	101	53	154	1,077	334	1,411	76.3	23.7	100
1876	3,119.8	1,818.6	4,938.4	103	60	163	—	—	—			
1877	3,192.6	2,031.7	5,224.3	105	67	172	—	—	—			
1878	3,265.4	2,244.8	5,510.2	108	74	182	—	—	—			
1879	3,338.2	2,457.9	5,796.1	110	81	191	—	—	—			
1880	3,411.0	2,671.0	6,082.0	113	88	201	—	—	—			

[a]Numbers are rounded.

Table 29. Projected Burial Population Size Based on Data from the 1860, 1870, and 1880 U.S. Federal Census Records and the 1864 U.S. Territorial Census Record, Assuming a Variable Death Rate

Census Year	Living Population (Projected)			Estimated Death Rate	Deaths per Year (Projected)			Cumulative Burials					
	Hispanic	Non-Hispanic	Total		Hispanic	Non-Hispanic	Total[a]	Hispanic	Non-Hispanic	Total[a]	Hispanic (%)	Non-Hispanic (%)	Total (%)
1860	640.0	272.0	912.0		—	21	21	—	—	—			
1861	772.8	288.5	1,061.0		—	22	22	—	—	—			
1862	905.5	305.0	1,211.0	4.0	37	13	50	37	13	50	74.8	25.2	100
1863	1038.3	321.5	1,360.0	4.1	43	13	56	80	26	106	76.4	23.6	100
1864	1,171.0	338.0	1,509.0	4.5	52	15	67	132	41	173	77.6	22.4	100
1865	1,423.0	371.7	1,795.0	2.0	29	8	37	161	48	209	79.3	20.7	100
1866	1,675.0	405.3	2,080.0	2.6	43	10	53	204	59	263	80.5	19.5	100
1867	1,927.0	439.0	2,366.0	2.3	44	10	54	248	69	317	81.4	18.6	100
1868	2,179.0	473.7	2,652.0	2.1	46	10	56	294	79	373	82.2	17.8	100
1869	2,431.0	506.3	2,937.0	6.2	150	31	181	444	110	554	82.8	17.2	100
1870	2,683.0	540.0	3,223.0	6.6	178	36	214	622	146	768	83.2	16.8	100
1871	2,755.8	753.1	3,508.9	6.4	177	48	225	799	194	993	78.5	21.5	100
1872	2,828.6	966.2	3,794.8	6.5	184	63	247	983	257	1,240	74.5	25.5	100
1873	2,901.4	1,179.3	4,080.7	4.8	140	57	197	1,123	314	1,437	71.1	28.9	100
1874	2,974.2	1,392.4	4,366.6	6.1	182	85	267	1,304	399	1,703	68.1	31.9	100
1875	3,047.0	1,605.5	4,652.5	7.7	234	123	357	1,538	522	2,060	65.5	34.5	100
1876	3,119.8	1,818.6	4,938.4		—	140	140	—	—	—			
1877	3,192.6	2,031.7	5,224.3		—	156	156	—	—	—			
1878	3,265.4	2,244.8	5,510.2		—	173	173	—	—	—			
1879	3,338.2	2,457.9	5,796.1		—	189	189	—	—	—			
1880	3,411.0	2,671.0	6,082.0		—	206	206	—	—	—			

[a]Numbers are rounded.

Table 30. Graves per Cemetery Area

Cemetery Area	Graves	Burials	Primary Individuals	Individuals (MLNI)	Size (m^2)	Grave Density	Primary Individual Density	MLNI Density	Individuals in Secondary Context (%)
1	64	51	51	57	1,032.5	0.06	0.05	0.06	10.5
2	89	87	89	96	1,938.8	0.05	0.05	0.05	7.3
3	706	649	673	753	5,006.7	0.14	0.13	0.15	10.6
4	193	191	201	402	407.4	0.47	0.49	0.99	50.0
5	31	28	30	30	491.0	0.06	0.06	0.06	0.0
1 and 2	153	138	140	153	2,971.3	0.05	0.05	0.05	8.5
3–5	930	868	904	1185	5,905.1	0.16	0.15	0.20	23.7
Total	1,083	1,006	1,044	1,338	8,876.4	0.12	0.12	0.15	22.0

Key: MLNI = most likely number of individuals.

Table 31. Number of Burials per Row in the Military Section, Based on Historical and Archaeological Data

Row (Beginning on East)	Number of Graves in the 1881 List	Number of Grave Pits
1	16	16
2	18	17
3	18	15
4	13	12

Table 32. Average Grave Bottom Length (cm) and Confidence Interval, by Cemetery Area, Age, and Sex

Age Category	Sex	Cemetery Area						
		1	2	3a	3b	4	5	Total
Infant or fetal	indeterminate	109.5 ± 1	105 ± 22.8	106.5 ± 5.5	111.8 ± 5.1	125.2 ± 10.4	110.6 ± 13.8	112.6 ± 3.6
Child	indeterminate	166 ±	157.7 ± 46.5	130.6 ± 8.4	140.7 ± 5.6	139.8 ± 19.2	120 ± 7.6	138.8 ± 5.3
Subadult	female			181 ± 9.8	161.6 ± 19	201.5 ± 6.9		174.8 ± 15.2
Subadult	male		170 ± 176.4	190 ±	177 ± 25.5			176.8 ± 56.9
Adult	female		209.3 ± 14.9	200.1 ± 6.4	198.2 ± 5.9	184 ± 13.9	193.5 ± 17.2	196.4 ± 4.3
Adult	male	209.2 ± 17.6	214 ± 6.3	205.7 ± 6.7	209 ± 7.6	199.8 ± 11.1	214.3 ± 13.4	208 ± 3.8

Table 33. Grave Spacing, by Cemetery Area

Cemetery Area	Grave Spacing within Rows (cm)				Grave Top Width (cm)				Modeled Grave Spacing (cm)
	Average	sd	CV	No. of Observations	Average	sd	CV	No. of Observations	
1	212.7	49.6	23.3	45	87.1	17.3	19.9	64	125.6
2	197.4	48.1	24.3	61	81.7	24.9	30.4	89	115.7
3	156.3	46.2	29.6	595	67.6	15.5	23.0	706	88.7
4	122.9	54.9	44.7	178	67.4	24.6	36.6	193	55.5
5	159.2	52.2	32.8	24	66.9	20.9	31.2	31	92.3
Total	155.4	53.2	34.2	903	69.9	19.5	27.9	1,083	85.5

Key: CV = coefficient of variation; sd = standard deviation.

Table 34. Row Spacing, by Cemetery Area

Cemetery Area	Nearest-Neighbor Distance between Rows (cm)				Grave Top Length (cm)				Modeled Row Spacing (cm)
	Average	sd	CV	No. of Observations	Average	sd	CV	No. of Observations	
1	359.0	80.2	22.3	61	210.8	51.6	24.5	64	148.2
2	349.0	87.7	25.1	89	212.0	47.5	22.4	89	137.0
3	247.0	70.4	28.5	692	163.1	52.4	32.2	706	83.9
4	150.0	43.9	29.3	161	157.6	57.6	36.6	193	-7.6
5	352.0	110.0	31.3	22	160.6	52.6	32.8	31	191.4
Total	251.0	92.8	37.0	1,025	168.9	55.7	33.0	1,083	82.1

Key: CV = coefficient of variation; sd = standard deviation.

Table 35. Row Attributes, by Cemetery Area

Cemetery Area	Grave Pits	Rows	Grave Pits per Row	Average Row Length (m)	sd	CV
1	64	6	10.7	23.9	5.0	20.9
2	89	8	11.1	17.2	11.2	64.9
3	706	39	18.1	24.5	14.5	59.2
3a	280	21	13.3	16.8	7.3	43.4
3b	426	18	23.7	33.9	15.7	46.3
4	193	15	12.9	14.6	4.4	30.1
5	31	5	6.2	7.6	5.7	74.0
Total	1,083	73	14.8	20.3	12.8	62.7

Key: CV = coefficient of variation; sd = standard deviation.

Table 36. Numbers of Feature to Feature Relationships between Grave Pits, by Cemetery Area

Feature Type	Relationship	Cemetery Area					Total
		1	2	3	4	5	
Burial	earlier than	—	—	8	15	—	23
	equal to	—	—	2	8	—	10
Grave pit	earlier than	—	4	13	95	—	112
	equal to	—	—	—	3	—	3
	indeterminate	—	—	13	20	—	33
Total		—	4	36	141	—	181

Table 37. Exhumed Grave Pits

Cemetery Area	No Osteological Remains	No Osteological Remains (disturbance controlled)	Limited Osteological Remains	Limited Osteological Remains (Disturbance Controlled)	Potentially Exhumed (Minimum)	Potentially Exhumed (Maximum)	Potentially Exhumed (%) (Minimum)	Potentially Exhumed (%) (Maximum)
1	13	13	44	44	57	57	89.1	89.1
2	2	2	6	6	8	8	9.0	9.0
3	67	55	38	25	80	105	11.3	14.9
4	26	9	28	10	19	54	9.8	28.0
5	3	3	1	1	4	4	12.9	12.9
1–2	15	15	50	50	65	65	42.5	42.5
3–5	96	67	67	36	103	163	11.1	17.5
Total	111	82	117	86	168	228	15.5	21.1

Table 38. Grave Disturbance, by Cemetery Area

Cemetery Area	Graves	Disturbed Graves (Any Level of Disturbance)		Graves Affected by Intrusive Disturbances		Graves Affected by Slumpage or Collapse		Graves Affected by Bioturbation	
		n	%	n	%	n	%	n	%
1	64	46	71.9	39	60.9	4	6.3	4	6.3
2	89	82	92.1	13	14.6	68	76.4	14	15.7
3	706	592	83.9	80	11.3	522	73.9	83	11.8
4	193	159	82.4	77	39.9	133	68.9	11	5.7
5	31	23	74.2	2	6.5	20	64.5	1	3.2
1–2	153	128	83.7	52	34.0	72	47.1	18	11.8
3–5	930	774	83.2	159	17.1	675	72.6	95	10.2
Total	1,083	902	83.3	211	19.5	747	69.0	113	10.4

Table 39. Burial Integrity, by Cemetery Area

Cemetery Area	None		Low		Medium		High		Not Determined	
	n	%	n	%	n	%	n	%	n	%
1	5	9.8	35	68.6	1	2.0	8	15.7	2	3.9
2	—		4	4.5	8	9.0	76	85.4	1	1.1
3	2	0.3	40	5.9	63	9.4	558	82.9	10	1.5
4	1	0.5	23	11.4	33	16.4	129	64.2	15	7.5
5	—		—		—		30	100.0	—	
1–2	5	3.6	39	27.9	9	6.4	84	60.0	3	2.1
3–5	3	0.3	63	7.0	96	10.6	717	79.3	25	2.8
Total	8	0.8	102	9.8	105	10.1	801	76.7	28	2.7

Table 40. Articulatory Integrity, by Cemetery Area

Cemetery Area	None		Low		Medium		High		Not Determined	
	n	%	n	%	n	%	n	%	n	%
1	6	11.8	31	60.8	7	13.7	5	9.8	2	3.9
2	1	1.1	2	2.2	7	7.9	78	87.6	1	1.1
3	2	0.3	31	4.6	60	8.9	571	84.8	9	1.3
4	2	1.0	10	5.0	20	10.0	156	77.6	13	6.5
5	—		1	3.3	3	10.0	26	86.7	—	
1–2	7	5.0	33	23.6	14	10.0	83	59.3	3	2.1
3–5	4	0.4	42	4.6	83	9.2	753	83.3	22	2.4
Total	11	1.1	75	7.2	97	9.3	836	80.1	25	2.4

Table 41. Estimates of the Number of Graves and Individuals Disturbed by the Tucson Newspapers Basement or Otherwise Falling Outside the Project Area

Cemetery Portion	Area (m^2)	Estimated Grave Density	Estimated MLNI Density	Graves Estimate	Individuals Estimate
Southern half of Area 4, disturbed by Tucson Newspapers basement	566.8	0.47	0.99	267	562
Possible portion of Area 3 disturbed by Tucson Newspapers basement	569.0	0.14	0.15	80	86
Remaining area not excavated in the southwest corner of the cemetery	1,469.0	0.05	0.05	74	74
Total	2,604.8	0.16	0.28	421	722

Key: MLNI = most likely number of individuals.

Table 42. Predicted and Actual Burial Sensitivity of Project Areas

Burial Sensitivity	Original Acres	Percent of Total	Revised Acres	Percent of Total	Number of Burials	Percent of Total	Area with Burials	Percent of Zone with Burials
Very low	0.45	10.8	0.50	11.5	2	0.2	0.003	0.5
Low	0.50	11.9	0.51	11.8	1	0.1	0.001	0.1
Moderate	0.72	17.1	0.69	15.8	—			
High	2.52	60.2	2.64	60.9	1,080	99.7	1.627	61.6
Total	4.19	100.0	4.34	100.0	1,083	100.0	1.631	37.6

CHAPTER 5

Graves, Burial Containers, and Undertaking

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Introduction

How a grave pit is dug, the construction and placement of a burial container, the placement of offerings, and the preparation and placement of the body within a burial container or grave pit contribute to an understanding of burial traditions, identity, and attitudes towards death and burial. In this chapter, we describe the characteristics of grave pits, body placement and preparations, offerings, burial container construction, and evidence of behaviors related to funeral and undertaking services in order to understand variation and change in mortuary practices as they were implemented in the Alameda-Stone cemetery.

As is discussed in Chapter 4, the cemetery contained both military and civilian sections and represents a cross section of a diverse, multiethnic community. Variation in grave-pit and burial characteristics are described in this chapter in terms of sex, age, cultural affinity, and location within the burial feature, grave pit, and cemetery in order to interpret how demographic and spatial factors related to variation in burial practices. In this chapter, we identify basic patterns in the distribution of grave and burial characteristics and propose some preliminary hypotheses about how inferred behaviors relate to demographic variation within the community. The following chapter describes in detail apparel and personal artifacts associated with interred individuals. In Chapter 9, Volume 1 of this series, these data are integrated with other information in order to more fully understand mortuary behavior in Tucson during the period the cemetery was in use.

This chapter is organized into sections according to the basic dimensions of burial listed above. In the section on grave-pit preparation, we discuss aspects of the pit itself with regard to shape and excavation techniques employed by the original grave digger. We examine elements of the vaulting complex and methods used to protect the coffin and its contents from disturbance. This section is followed by a discussion on orientation and the placement of individuals in the cemetery. In most cases, individuals were oriented on a generally east-west axis, and typically, a single individual was interred in a single grave pit. This section examines variation in orientation and examines the burials that deviate from these patterns. In a few instances, there is artifactual evidence of funerary activities, including professional undertaking tools and treatments. In the section on undertaking, we describe artifacts used by the undertaker, including tools, lime, and decorative floral arrangements. The last section explores aspects of coffin construction, including coffin shape, interior and exterior treatments, coffin hardware, and coffin decoration. These are first described in terms of the types observed and their relevance to current understandings of coffin construction. In each discussion, a brief historical context is given, types are described, and type counts are provided. Additionally, we compare demographic distribution and variation and explore patterns; make inferences; and, when possible, offer hypothetical explanations. Thorough research, although not exhaustive, was conducted to compare the findings in the Alameda-Stone cemetery with other American cemeteries (Table 43). Unfortunately, few archaeological investigations of historical-period cemeteries in the American Southwest have been reported. As a result, only a limited comparative sample exists. Despite these limitations, this chapter attempts to place funerary behavior in the Alameda-Stone cemetery in context with greater American deathways. In the exploration of these topics, we hope to provide a more holistic understanding of variation in the funerary practices throughout the cemetery, laying the foundation for more in-depth interpretation presented in Chapter 9, Volume 1.

Grave-Pit Preparations

As outlined in the introduction to this chapter, this section describes the characteristics of the grave pits in the Alameda-Stone cemetery. There were 1,083 grave features excavated. These features held the remains of 1,386 individuals. Each pit was generally rectangular in shape. Depth for each grave varied throughout the site. As discussed in Chapter 4, grave-pit depths were highly variable across the site because of postcemetery disturbance, with much of the variation across the cemetery appearing to be random. Analysis of the deepest grave pits suggested that grave pits tended to have been excavated to a depth of 3–4 feet, with the deepest grave pits found in Cemetery Areas 1 and 4. The horizontal dimensions of grave pits varied directly with the age and sex of interred individuals, with the smallest grave pits used for infants and the largest used for adult males. For more on grave-pit dimensions and variability, see Chapter 4. The following discussion details aspects of the grave with regard to age, sex, cultural affinity, spatial location within the cemetery, and burial practices in the Tucson community.

Vaulting is characterized by a primary shaft, in this case rectangular in plan view, with a secondary shaft excavated to fit the shape of the coffin (Figure 44) (Sprague 2005; Swauger 1959). The shelves created by the secondary shaft are then used to support loose planks placed perpendicular to the long axis of the shafts (Figure 45). Several terms have been used to describe this and similar types of vaulting, including "coffin board" (Plume [ca. 1890] in Mainfort and Davidson [2006]), "vaulted lid" (Mainfort and Davidson 2006), and "grave arches" (Bell 1987; Bybee 2002:7). The practice of reinforcing the grave shaft in this manner dates in the United States to the colonial period and has been documented in historical-period cemeteries throughout the United States, including Kentucky (Bybee 2003a, 2003b, 2004), West Virginia (Bybee 2002, 2003c, 2007a), Georgia (Blakely and Beck 1982), Alabama (Shogren et al. [1989] in Mainfort and Davidson [2006]), Tennessee (Matternes [1998b] in Mainfort and Davidson [2006]), Texas (Davidson 1999), Arkansas (Mainfort and Davidson 2006), Pennsylvania (Swauger 1959), central Appalachia (Crissman 1994), and Massachusetts (Bell 1987, 1990, 1994). Somewhat different forms of vaulting have been used in Europe and Africa, as well (Plume [ca. 1890] in Mainfort and Davidson [2006]).

Vaulting serves a dual purpose. Grave arches temporarily protect the coffin and its contents from collapse and aids in preventing soil from slumping. Vaulting serves a psychological purpose in addition to its practical function, however. The added labor and time involved in excavating the secondary shaft and applying the grave arches suggests additional care taken in preparation of the grave and may indicate greater respect for the individual in the grave (Mainfort and Davidson 2006:100). There may also have been an added psychological benefit for mourners in that the additional architectural reinforcement of the grave may have offered perceived protection from the grave walls and soil.

Typically, vaulting includes the presence of shelves and grave arches, but when viewed as a means of protecting a burial from collapsing soil, this definition may be broadened to include other grave-pit preparations. The vaulting complex includes at least two stepped shelves on opposing walls of the grave pit with transverse planks of wood, although these do not always preserve archaeologically. The shipping crates for the coffin were sometimes reused as vaulting once coffins were able to be mass-produced and transported across the country. In this type of vaulting, the crate was placed in the grave as an outer box around the coffin. In the Alameda-Stone cemetery, however, shipping crates used in this manner were extremely rare. This suggests most burial containers were manufactured locally. Further discussion on the construction of burial containers will be presented later in this chapter.

Additionally, we have included niches excavated into the short axis of the grave-pit wall as part of the vaulting complex (Figure 46). Morphology was highly variable, and their presence was sometimes difficult to determine. All of the grave pits with possible niches were examined according to a set of criteria. Physical characteristics of the niche, such as size, shape, and location, were used to identify niches. Proximity of human remains to the niche was an essential element to determining function and ultimately to establishing the presence of the niche. Conservatively, only niches that met all criteria were determined to serve a vaulting function. Only the head niches that were interpreted as serving this funerary function are discussed here.

The precise function of head niches is unknown, although one explanation could simply be that it serves to protect the individual, particularly the head. In an environment in which wood is a scarce commodity, carving a protective space in the wall of the grave may have been the most effective solution. Head niches may also have been an adaptation of a practice used by Native Americans in the Southwest. Loendorf (2001:128) described grave pits in which one or more sides of the pit were undercut and the entire individual was placed in the excavated space. Wood was sometimes placed vertically across the undercut portion of the grave as added protection.

Soil conditions in Tucson were optimal for the preservation of vaulting elements. The hard caliche layer present at depth throughout the site allowed for a clear distinction between sterile and disturbed soils (see Chapter 3). There were six vaulting scenarios observed at the cemetery (Table 44). Vaulting Type 1, of which there was only 1 instance, was characterized by the presence of shelves, arches, and niches. Vaulting Type 2, of which there were 12 instances, consisted of having only shelves within the grave pit. Vaulting Type 3, of which there was also only 1 instance, included the presence of arches only. Vaulting Type 4 was characterized by the presence of a niche, and there were 27 of these grave-pit types in the cemetery. Vaulting Type 5, of which there were 12 instances, exhibited both shelves and arches. Vaulting Type 6 included both niches and shelves; there was 1 such grave pit. Vaulting was present in a total of 54 grave pits—5 percent of the total number of grave pits (Table 45; see Appendix J.1). There were two grave pits that had both shelves and a head niche; one of the grave pits had arches, and the other did not. The rest of the grave pits had shelves, arches, a head niche, or a combination of the three elements. Arches are reported when wood preserved, although they were likely present with grave pits bearing shelves. Preservation of the wood of the grave arch varied from excellent to poor, depending on soil condition. The shelves and grave arches were present more often in the southern portion of the cemetery (Cemetery Areas 1 and 2) with a few exceptions. The head niches were exclusive to the northern portion (Cemetery Areas 3, 4, and 5) of the cemetery (Figure 47). All of the grave pits with shelves or arches had a burial with a single individual. Some of the grave pits had only one shelf or three shelves. Grave pits with an odd number of shelves may represent a useful step carved by the grave digger for better access to the bottom of the grave pit.

There were 26 grave pits with shelves in the cemetery—just over 2 percent of the grave-pit features. Of these, half had grave arches. Two of the grave pits were empty so no demographic information is available for them. Of the remaining grave pits with shelves, 70 percent held adult interments. Almost 80 percent of the adults were male. Euroamerican and Hispanic individuals were interred more often with shelves, although Grave Pit 7674 was also determined to have shelves and held Burial Feature 14654 with Individual P, an infant of Hispanic or Yaqui cultural affinity. Slightly more grave pits containing Euroamericans than Hispanics had shelves. Grave Pit 3243/Burial Feature 3422 had arches, but there were no shelves. A Hispanic, male adult was interred in the grave.

Twenty-nine of the 1,083 grave pits at the cemetery also had a head niche—less than 3 percent. Seventy percent of the individuals interred with head niches were adults, with the majority determined to have been young adults (Table 46). Of the juveniles present, there were none between the ages of 2 and 12 years old and no fetuses. A slight majority of the adults were male. There were equal numbers of Euroamerican and Hispanic adults (five each), along with two Native American adults.

The grave pits with head niches had several other characteristics. None of the individuals in the grave pits with head niches was interred in a coffin, making up approximately 13 percent of the total number of burial features without coffins. Grave Pit 13556 held two burial features (Burial Features 22000 and 21901), but only Burial Feature 22000 was in proximity to the head niche. Both individuals were infants. The burials differed in that the infant in Burial Feature 22000 was buried without a floral crown that would indicate Catholic religious affinity. The rest of the grave pits with head niches were single inhumations. Most of the grave pits with niches were large enough to accommodate the entire length of the inhumation, suggesting that niches were not created in an effort to fit an individual in the grave pit in the event that body length exceeded the length of the grave pit.

No ethnographic documentation has been discovered and no other archaeological evidence has been found to explain this type of grave preparation. Head niches may be a Native American adaptation as described by Loendorf (2001:128), although the head niches at the cemetery were not used exclusively by Native Americans or any other cultural group. Head niches were also not restricted to any age group or sex. There appears to

be no spatial correlation between features with this type of preparation, as well. Thus, they may not have had any cultural affiliation to the individual in the grave pit. Because a small percentage of grave pits had head niches, around 3 percent, and all of the grave pits with head niches held individuals buried without coffins, this type of grave preparation may have simply served a psychological function by limiting contact between the grave-pit soil and unprotected remains, particularly the face of the individual. Head niches may simply represent idiosyncratic behavior on the part of a grave digger.

Orientation, Position, and Multiple Interments

Many variables that describe aspects of orientation and position were recorded for each grave pit and burial feature at the cemetery. Variables included the major axis of the grave pit, container orientation, burial orientation, burial position, and burial head-facing direction. Grave-pit, container, and burial orientation refer to the long axis of the grave pit, container, or skeleton, respectively, with regard to cardinal and ordinal directions. Burial position refers to the posture of the individual (e.g., flexed, semiflexed on side, or extended supine, etc.). Burial head facing describes the position of the individual's face (e.g., up, down, north or south, and so on). Drawing on the combination of these variables, we were able to arrive at a clear picture of the orientation of grave pits, burial features, and individuals within the cemetery.

The major axis of the grave pit was defined as the cardinal direction in which the long axis of the grave pit rested (see Appendix J.2). Many of the 1,083 grave pits did not lie on a precisely east-west axis and were instead skewed somewhat toward a southwest-northeast axis. We generalized these grave orientations to generally head to the west or head to the east in order to facilitate analysis. Further, nine of the grave pits were on a north-south axis. Six grave pits were of indeterminate orientation. Variation in orientation may have been a result of changes in the alignment of prominent landscape features, such as roads or buildings, or result from cultural variation in religious traditions. Graves, for instances may have been oriented with respect to sacred places or directions. Four of the grave pits oriented on a north-south axis were along the edges of Cemetery Area 4 and may have been oriented to accommodate or align with a now non-existent wall. The remaining two north-south grave pits were located to the east of Cemetery Area 4, in Cemetery Area 3.

Burial container orientation is the axis from the foot to the head of the container and identifies the cardinal direction of the head end (see Appendix J.2). Obviously, the container orientation is limited by the major axis of the grave pit within which it rested. Just fewer than half (n = 528) of the containers were oriented with head of the container to the east, 31 percent were oriented with head of the container to the west (n = 337), 14 percent did not have a burial container (n = 231), and the rest were oriented north, south, or indeterminate. During data recovery, container orientation was documented independently of burial orientation so the two orientations could later be compared for concordance. For the most part, the two orientations agreed with each other with the exception of several cases (less than 1 percent) in which the field archaeologist may have misinterpreted the shape of the container and inferred container orientation based on incorrect assumptions about shape. There was slight variability in the precise direction of burial orientation throughout the cemetery, but the vast majority of the individuals were oriented along a generally east-west axis. Almost two-thirds of the burial features (n = 635) were oriented with their heads to the east and feet to the west. About 35 percent of the burial features (n = 371) were oriented head to the west. Less than 1 percent of the burial features were oriented with head to the north or south, and for 3 percent of the burial features, burial orientation could not be assessed because of poor preservation or heavy postcemetery disturbances. Burial orientation shifted from generally head-to-the-east orientation in the northern half of the cemetery to generally head-to-the-west orientation in the southern half of the cemetery, where more than two-thirds of burial features were oriented with head to the east (Figure 48).

There was some interesting variation in orientation in Cemetery Areas 3, 4, and 5, however (Table 47). Around 90 percent of burial features in Cemetery Area 4 were buried with head to the east, with a few buried with head to the west, north, or south. In Cemetery Area 3, many of the burial features in the westernmost rows

(Rows 1–10) (see Chapter 4) were buried with head to the west, and multiple clusters of burial features throughout the remainder of Cemetery Area 3 (Rows 11–39) were also oriented head to the west. Nearly all burial features in Rows 1–9 of Cemetery Area 3 were oriented with head to the west and began to shift to a generally head-to-the-east orientation at Row 10, in which there was a mixture of opposing orientations, followed in subsequent rows by a generally eastward orientation. Perhaps the scattered clusters of burial features oriented with head to the west in Rows 11–39 of Cemetery Area 3 were placed close in time or were placed according to a tradition that differed from the one applied to most nearby burial features. In Cemetery Area 5, more than half of burial features were oriented with head to the west, and several clusters of adjacent burial features appeared to alternate between head-to-the-west or head-to-the-east orientation, suggesting a fundamentally different approach to burial orientation than was evident in the other cemetery areas.

One explanation for the generally head-to-the-east orientation for burial features in Cemetery Areas 3 and 4 could be that the generally Hispanic Catholic population of Tucson during the cemetery's period of use may have elected to bury their loved ones oriented with their feet pointed toward the nearest Catholic church, San Agustín, or another religious landmark. This is particularly the case for Cemetery Area 4, where nearly all burial features were oriented with head to the east, but it does not explain the predominance of burial features oriented in the opposite direction in the westernmost rows of Cemetery Area 3. The predominance of burial features oriented with head to the east in Cemetery Area 4 provides some support for the notion that this area may have been an area consecrated by the church early on (see Chapter 4). In the southern half of the cemetery, populated mostly by Euroamerican or Hispanic males who may have immigrated to Tucson from the eastern United States or California, individuals were oriented with their feet pointed to the east. Some Christian traditions hold that upon resurrection, Christ will rise in the east, and the dead will rise to greet him. The San Agustín church, situated west of the cemetery, may have acted as a mediator between God and the traditional Catholic population oriented toward it. That is, there is some flexibility in the "rules" of orientation.

Orientation, when considered in isolation, is an unreliable indicator of religious affinity because it may be complicated by a number of factors, including landscape configuration, space limitations, or the agency of the grave digger and mourners. Other historical-period cemeteries in Tucson, including Tucson's secular Evergreen Cemetery, Holy Hope Catholic Cemetery, and San Xavier del Bac Mission Cemetery, illustrate this point. Evergreen Cemetery's graves are oriented more or less east-west with the head end of the grave in either direction. Holy Hope Catholic Cemetery's graves are oriented in all four cardinal directions with some in intermediary directions to accommodate roads and pathways. San Xavier del Bac Mission Cemetery, a Tohono O'odham community Catholic cemetery, is organized with all graves oriented with head to the west, facing due east toward the Mission church.

Burial position refers to the posture of the interred individual within the grave pit (Appendix J.3). Nearly 90 percent of the individuals (n = 930) were in supine position, meaning they were positioned on their backs. The burial positions for most of the rest could not be determined because of poor preservation or disarticulation. The following were the few that were not in an extended supine position. One older adult Hispanic female (Grave Pit 7952/Burial Feature 19541) was prone, positioned on her stomach. This individual was unlike the majority of the cemetery population not only because of this unusual burial position, but because there were no clothing fasteners or grave inclusions. The only artifacts recovered were juniper wood and construction materials related to the unadorned trapezoidal coffin in which she was buried. The absence of artifacts did not aid in the explanation for the prone burial, as many individuals, primarily infants and children, were similarly buried without artifacts although supine. Additionally, two individuals were positioned on their sides: Grave Pit 7673/Burial Feature 14607 on the left side and Grave Pit 7655/Burial Feature 13133 on the right side, a fetus and an infant, respectively. These data indicate that there was a consistent effort throughout the cemetery to bury individuals on their back, except in a few rare cases.

Head facing describes the direction the face of the individual was turned when discovered archaeologically (see Appendix J.3). The head-facing direction could not be determined for 274 of the individuals because of skeletal disarticulation and disturbances. When head-facing direction could be determined, the largest percentage were facing up (18 percent) or west (18 percent), followed in descending order by east, north, south, southeast, southwest, northwest, and northeast.

In order to gain some understanding of the relevance of these data, we first grouped all head-facing directions into northward (north, northeast, northwest) or southward (south, southeast, southwest) under the assumption that the head of an individual oriented along a generally east-west axis, if placed to face up, would generally remain facing up or become displaced during or after burial to face in either a northerly or southerly direction based on random chance. This hypothesis turns out indeed to be the case, as the number of northward or southward head-facing directions was almost exactly equal for all cemetery areas except Cemetery Area 3, where there was a slight predominance of southward head-facing directions over northward ones. The slight tendency toward a southward head-facing direction in Cemetery Area 3 was, however, not significant and deviated only slightly from the expected distribution (chi-square = 0.56, $df = 2$, $p = 0.7558$). Only Cemetery Areas 3, 4, and 5 were compared statistically because of sparse values for Cemetery Areas 1 and 2.

We performed a similar test by grouping head-facing directions per cemetery area in eastward (east, northeast, southeast) or westward (west, northwest, southwest) directions. It should be noted that this calculation reuses some of the values used to arrive at northward or southward counts. Interestingly, this comparison showed a clear difference in head-facing directions between Cemetery Area 2 and Cemetery Areas 3 and 4. Head-facing values were sparse for Cemetery Area 1 (many of these burials had been exhumed historically), and although also sparse, head-facing values were fairly evenly split for Cemetery Area 5 between eastward and westward directions. Head-facing directions in Cemetery Area 2 were predominantly eastward (eastward = 25; westward = 4) but predominantly westward in Cemetery Area 3 (eastward = 114; westward = 184) and Cemetery Area 4 (eastward = 18; westward = 55). Given what we know about orientation in these areas of the cemetery, these data are consistent with a generally head-to-the-west orientation in Cemetery Area 2 and a head-to-the-east orientation in Cemetery Areas 3 and 4, suggesting that the heads of individuals buried in these areas were somewhat pitched forward, perhaps as a result of being elevated on pillows or other materials or because of the natural settling of the skeleton during decomposition. Altogether, head-facing data suggest that heads were generally placed to face up, were possibly elevated, and rotated to the left or right sides randomly during or after burial.

There were 58 grave pits containing multiple interments (see Appendix J.4). This describes grave pits that were used for multiple consecutive burial events or grave pits that were used for multiple simultaneous burial events. This number does not include grave pits in which nonprimary remains or elements were recovered. There were 130 primary individuals represented in the 58 grave pits. Thirty-two of the grave pits held multiple simultaneous burials with as many as 5 individuals interred within. The remaining 25 grave pits held consecutive burials. Two grave pits demonstrated combinations of these two scenarios. Grave Pits 13507 and 13698 each held 3 individuals, 2 interred simultaneously and 1 interred in a separate burial event. Of the 130 individuals, 84 (65 percent) were juveniles. There were as many adult males as adult females. Fewer than half of the 130 individuals could be assessed for cultural affinity, in part because juvenile individuals could not be assessed for biological affinity and contextual information was not sufficient alone to determine cultural affinity. When cultural affinity could be determined, it was found that 40 individuals were of Hispanic, Hispanic or Yaqui, or Native American affinity. Most of the multiple interments were located in Cemetery Areas 3 and 4. Only 3 grave pits were located elsewhere.

Across cemetery areas, grave pits with multiple interments contained on average two individuals, although as many as five individuals were discovered in individual grave pits in Cemetery Areas 3 and 4 (Figure 49). Around 40 percent of the grave pits containing multiple interments contained only individuals under the age of 12, and half contained at least one individual under the age of 12 and one adult. Three contained only adults; one contained a subadult and two adults; and another contained an infant, a subadult, and an adult. In Cemetery Area 3, there was a slight tendency for multiple interments in a single grave to contain only young individuals (n = 16, 55 percent), and in Cemetery Area 4, a mixture of both individuals under the age of 12 and adults interred in the same grave was more common (n = 17, 65 percent). The difference in the age distribution of multiple interments is not significant at the 95 percent confidence level, but is significant at the 90 percent confidence level (chi-square = 2.86, $df = 1$, $p = .0908$). Grave pits with multiple interments were too few in Cemetery Areas 2 and 5 to discern any clear patterns.

The complexities of the cemetery's feature relationships are discussed in greater detail in Chapter 4. Evaluation of grave pits with multiple interments played an important role in the project's cultural affinity

assessment and repatriation. Although it is likely that economics was a factor in multiple-use grave pits, it is also highly likely that many of these scenarios represented family relationships. Family relationships, however, were often obscured by an inability to establish biological affinity for many of the juvenile individuals and may have been complicated by economic factors for Tucson's less than affluent population during a period of high mortality. That is, during periods of epidemic disease, families may have pooled resources to share funeral costs by burying their loved ones together. In Cemetery Area 3, there may have been a tendency to bury siblings or close kin of the same age cohort together, or perhaps, simply to bury juveniles who died around the same time together. In Cemetery Area 4, there may have been more of a tendency to bury juveniles with adult relatives, which might represent a somewhat different approach to the treatment of burial space (see Chapter 4), but again the inability to assess biological relationships among potential kin complicated our ability to arrive at definitive conclusions.

Evidence of Funerals and Undertaking

Information derived from both historical and archaeological sources is available to understand funerals and undertaking in historical-period cemetery settings of the U.S. West. Fortunately, this historical and archaeological information can be complementary in that the archaeological evidence resides in the material realm, whereas the archival or literary sources focus more on process and ceremony. Knowledge of the historical element, as mentioned above, underscores the fact that many components of the funeral have no archaeological signature in burial context, and oftentimes specific evidence of undertaking is also absent, except where evidence of the profession is indicated by embalming or burial container construction and trimming. Therefore, it is only through the merger of the historical and the archaeological that a more complete understanding of the cultural aspect of funerals is possible.

Most of this chapter describes material aspects of the recovered mortuary material culture and observable burial practices; therefore, that data will not be repeated here. However, a description of two possible archaeological examples of the undertaking profession does fall within the purview of this section.

Undertaker Tool Type 1 consisted of an oval ferrous ring, found in only one burial (Grave Pit 951/Burial Feature 7017) with wood grain present on the interior of the ring (Figure 50). Screws, or some other type of metallic objects, were attached to the ends of the ring and pointed inward. It was initially (and prematurely) called a cuff or shackle because it was found near the ankles of the male individual in the associated coffin. In addition to this cuff were two large iron bolts, about 4 inches long and $^{1}/_{2}$ inch in diameter. It was concluded that these objects were perhaps related to an abandoned or broken tool of the undertaker or grave digger during the burial event.

The second example of a burial practice that could suggest or implicate the presence of an undertaker consisted of four bricks systematically placed below the coffin in Grave Pit 28076/Burial Feature 28559 (Figure 51). Four working hypotheses exist to explain the presence of these bricks. Based on the physical characteristics of the grave pit, the excavators hypothesized that the bricks may have been used to level the coffin within the pit. Another hypothesis posits that the bricks were used to elevate the coffin from the bottom of the shaft to prevent damage from accumulated rainwater and mud likely to wash into an open grave pit during a heavy rain. The use of bricks to elevate the coffin from the floor of the grave pit would also have facilitated easy removal of lowering straps or ropes (Sprague 2005:118). Finally, it is noteworthy to mention that the coffin in this grave pit was the only one in the cemetery that included double-lug, tipped, swing bail handles with Masonic emblems. It was posited that the bricks might have significance to the fraternal order. Whatever the reason for the inclusion of these bricks, they and their context remain unique in the cemetery excavations.

Burial Shrouds and Winding Sheets

Burial shrouds are funeral robes or gowns and consist of a piece of cloth draped over the body from neck to feet (Beaudry 2006; Crissman 1994; Howson 2006). Common in the United States through the colonial period to the early nineteenth century, shrouds were sometimes used in conjunction with a winding sheet and held in place with straight pins in such a manner as to allow the face of the deceased to be seen prior to burial (Richardson 2000:20). Winding sheets consist of a strip of fabric, usually linen or wool, which were wrapped around the individual. The edges of the cloth were pinned or stitched closed, and the ends of the sheet were usually tied. Bell (1987:88) noted some of the Almshouse burials in Uxbridge, Massachusetts had straight pins but no clothing fasteners. These burials likely had shrouds or winding sheets. Similar associations were recorded at the New York African Burial Ground (Perry et al. 2009) and the St. Luke's Church Burial Ground in London (Boston and Boyle 2005).

Although a variety of burial clothing may have been used at the Alameda-Stone cemetery, including shrouds or winding sheets, evidence of their use was scant and ambiguous. For this study, we examined burials in which no clothing fasteners were found and straight pins were directly associated with the human remains (Figure 52). We found this strategy to be somewhat flawed in that straight pins may have been used in a variety of ways. In the Alameda-Stone cemetery, straight pins were used to fasten or repair garments, to affix floral arrangements to hair and clothing, and to fasten trim or floral garlands to the perimeter of the coffin. Location of straight pins could not be relied upon for determining the presence of burial shrouds or winding sheets. There was only one instance of shrouding that could be determined with any confidence. This single example violates both criteria for our study in that this individual was undoubtedly buried in clothing, and evidence for shrouding was not based on the presence of straight pins, as no pins were discovered in the burial feature.

Grave Pit 3315/Burial Feature 6941 held an African American adult male. This male was buried in pants, a shirt, and a jacket, as evidenced by the variety and position of buttons recovered from the remains, including brass military buttons. The regiment could not be determined. Additionally, two metal coins were located on or near the head of the individual. The coins appear to have been placed over the eyes prior to interment. One coin appears to have slid off of the eye and was recovered from under the cranium. The other coin was recovered just below the right eye orbit. It is this coin that bears evidence of burial shrouding. As the copper coin degraded, cuprous material attached to and leached through fine cotton fabric, creating a thin sandwich of metal around the fabric, preserving it. The presence of this fabric on the face of the deceased suggests the presence of a covering, such as a shroud. The individual was buried in clothing, with his face covered by a cloth and two coins.

Straight pins were the only fasteners found for a large number of infants and small children (see Appendix J.5). Many of these infants may have been wrapped tightly in swaddling blankets rather than shrouded, as strictly defined here. The use of shrouds and swaddling clothes would appear similar archaeologically. Here we discuss only those burials for which the use of burial shrouds was most likely.

Thirty-seven individuals, apart from the individual mentioned earlier, appeared to have been interred with a shroud or winding sheet, and 92 percent of them were less than 3 years of age (Table 48). This is only 3 percent of the total number of individuals in the cemetery. Cultural affinity could not be established for most of the juveniles in the cemetery. From the 37 individuals discussed here, however, 13 were determined to be of Hispanic or Yaqui affinity, largely based on the presence of floral crowns. The presence and location of straight pins compared to the relative absence of clothing fasteners was an indication of possible shrouding. Pins indicative of shrouding were found in anywhere from one to four locations on the body and were located most often (in decreasing order) near the torso, cranium, pelvis, legs, feet, ribs, and abdomen. The use of straight pins for other purposes, however, often obscured the interpretation of this mortuary practice. Infants' clothing, such as christening gowns that may have been tied closed, would have left no indications. Altogether, these data indicate that shrouding was primarily reserved for a small percentage of the very young, perhaps as a way to conserve cost, and was not a common practice at the Alameda-Stone cemetery (Figure 53).

Lime

Lime, or "lime capping," was used in historical-period burial contexts primarily for the purposes of sanitation. Lime was used to disinfect the body and the materials associated with the corpse, to neutralize odors, and to increase the rate of decomposition (Leaney 1989; Will de Chaparro 2007). This last use, however, was misguided. Lime has mistakenly been thought to increase the rate of decomposition of soft tissue. In fact, lime kills the bacteria that cause decomposition and actually decreases the rate of decay. Laudermilk (1932) explained the misconception may have originated with the observation that lime acts as a desiccant causing the tissue to shrink, decreasing the total volume of tissue and contributing to the illusion of decomposition. This misconception persists as evidenced by disposal policies for animal carcass in several states according to the National Biosecurity Resource Center (2009).

Lime was found with 53 interments or about 5 percent of the total number of individuals (Figure 54). Around 60 percent of the individuals with lime were under the age of 12. The majority of the individuals under 12 years old were not able to be sexed and nor could biological group be determined. Of the 20 adult individuals who could be sexed, 15 were male or probably male and 5 were female. These demographics are listed by area in Appendix J.6.

Cultural affinity was only able to be determined for 28 of the individuals interred with lime. There were 4 Euroamericans, 9 Hispanics, 13 Hispanic or Yaqui, and 2 Native Americans. The remaining 25 individuals were of an indeterminate affinity. Lime was present in Cemetery Areas 2, 3, and 4, the areas with the largest population of burials, and no patterns or correlations were evident to suggest any spatial or demographic relationship among these individuals. The fact that most individuals who could be assessed for cultural affinity were Hispanic or Hispanic or Yaqui may not point to any cultural tendencies, given the large number of Hispanic individuals in the cemetery. However, the fact that the majority of adults who could be sexed were males could suggest, if only weakly, that these were individuals who suffered death away from town and were exposed to the elements more than other individuals prior to burial.

Floral Arrangements

Flowers play an integral role in funerary customs the world over. Whether they are fresh, paper, ceramic, fabric, or otherwise, flowers provide comfort for those in mourning and serve as an offering to the deceased. Fresh flowers may represent the fragility of life and inevitability of death. Aromatic flowers may play a palliative role, adding a pleasant fragrance during the funeral service. This was a particularly important role during the nineteenth century before embalming became a common practice (Seaton 1995). The deceased were often kept in the home for several days to allow for ceremonies and burial preparation. Fragrant flowers, herbs, and incense helped to mask the foul odors associated with the body and made the viewing of the dead a more pleasant experience (Crissman 1994). During the nineteenth century, specific etiquette and traditions of the Beautification of Death movement were followed as death was viewed as romantic, beautiful, and melancholic rather than somber and gruesome. Showy displays of floral arrangements were common for the deceased individual as well as for the immediate family who were in mourning (Bell 1987; Houlbrooke 1989; see Chapter 8, Volume 1 of this series, for a description of the Beautification of Death movement). According to Catholic beliefs, the death of a child and his or her immediate ascendency to heaven is cause for celebration rather than mourning. These little angels (*los angelitos*) were dressed for burial in white, with garlands of flowers placed upon their heads. Unwed males and females were often treated in a similar fashion. The coffins were decorated with floral arrangements in a display of celebration and tribute (Kelly 1975; Marino 1997; Toor 1985; Will de Chaparro 2007).

In the Alameda-Stone cemetery, funerary floral arrangements were often composed of artificial flowers made from twisted paper or fabric on copper wire and complemented with small "buds" crafted from ceramic

paste or glass (Figure 55). Although botanical flowers decomposed beyond recognition, the man-made elements of artificial floral arrangements preserved well. Artificial floral arrangements were associated with approximately one-quarter of the total number of primary individuals (Appendix J.7). Of the 130 individuals for whom age could be determined, 95 percent of the floral arrangements were with individuals under 12 years of age. A large portion of the remainder of the individuals associated with floral arrangements consisted of young adults. Of the adult individuals associated with floral arrangements, there were slightly more female than male; however, the majority of individuals associated with floral arrangements were subadults and were unable to be assessed for sex through skeletal analysis.

Cultural affinity is also difficult to discern for children and infants; therefore, most of the individuals associated with floral arrangements were of indeterminate affinity. The individuals who were buried with floral arrangements and whose cultural affinity could be determined were most often Hispanic, followed by Euroamerican and then Native American. No floral arrangements were associated with individuals of African American or Apache cultural affinity.

Remnants of floral arrangements had several locations within the grave pit. They were placed in the hands, around the head, on the torso and pelvis of the individual, and around the perimeter of the coffin. They may have been affixed to the edge of the coffin, as some wire fragments were found wrapped around metal straight pins and collected with the coffin materials. The overall scope and presence of floral arrangements using fresh flowers was difficult to assess, although we do know variations of them were used and adorned on many of those laid to rest in the Alameda-Stone cemetery. The presence of floral arrangements may denote the following of the Catholic tradition celebrating the ascent to Heaven of innocent children and unwed adults, rather than mourning their passing.

Pollen Analysis

Pollen samples were submitted for analysis to Dr. Owen Davis and the University of Arizona in an attempt to identify botanical species used during funeral ceremonies. Of the 50 grave features submitted, only 7 of them had both cultural artifacts (i.e., floral wire, glass, bulbs, pins, etc.), suggesting flower arrangements of some kind, and pollen indicative of flowers (Figure 56).

Burial Containers

In the colonial period, coffin making was a task occasionally undertaken by the local carpenter, cabinetmaker, or wheelwright as an ancillary service, one which was vitally important in the cultural expression in the treatment of the dead (LeeDecker 2001:1; Perry et al. 2009: 251; Rauschenberg 1990:26; Remsberg 1992:4). In some rural areas where skilled craftsmen were in short supply, friends, relatives, or other members of the community would be enlisted to aid in the construction of the coffin, although likely with limited resources compared to their professional counterparts (Lawrence et al. 2009:108).

No particular need exists to bury people in burial containers; nonetheless, this practice has developed in some cases out of the desire for protection, that is protection from the physical and spiritual contaminants of the corpse, or protection of the corpse from the elements, animals, and the process of decomposition (Habenstein and Lamers 1985:162–163). Burial containers do not serve purely utilitarian functions, however; changes in burial container forms and styles tend to reflect basic concepts about and attitudes toward death (Bromberg et al. 2000:145). Such changes in the nineteenth century were inextricably linked to changes in the economic base with increases in industrialization, mass production, and the development of a specialized funeral industry (Bell 1987, 1990; Farrell 1980).

The Beautification of Death movement, as discussed by Bell (1987, 1990, 1994) and Pike and Armstrong (1980), has been characterized by an increased sentimentality in funerals that created a market for elaborate burial containers, trimmings, and other funeral-related materials. Furthermore, the progress of the Industrial Revolution improved manufactory technologies and transportation, which enabled mass-produced materials to become affordable and available to most segments of the population. This, in turn, perpetuated the acceptance of the underlying ideology (Bell 1990:57; Lang 1984; see Chapter 8, Volume 1 of this series, for a description of the Beautification of Death movement).

Burial Container Morphology

In many of the cemetery excavation reports consulted, authors often used the terms "coffin" and "casket" interchangeably without consideration for the different styles of burial container to which the terms referred and cultural meanings associated with them. This confusion has been further propagated in popular literature and even period mortuary catalogs through ambiguous use of the terms. Oster et al. (2005:161) cite the *Columbia Guide to Standard American English* as stating that the term "coffin" is generic, and that "casket" has been a euphemism for "coffin" in the United States for more than a century. Nonetheless, there are important technological and cultural differences between the two.

Coffins are generally hexagonal in plan view (Figure 57) and are narrower at the head, extending to the widest point at the shoulders before tapering to the foot. They have been referred to by many different names in the archaeological literature, such as "toe-pincher" (Burnston and Thomas 1981:II-5; Parrington et al. 1989:144; Trinkley and Hacker-Norton 1984:4), "pigeon-toed coffin" (Blakely and Beck 1982:188), "truncated diamond coffin" (McReynolds 1981:15), as well as the "shouldered coffin" (LeeDecker et al. 1995:50). Mainfort and Davidson (2006:104) have suggested that this shape most clearly fits the form of the human body.

There are two main types of hexagonal coffins: the bent-shoulder coffin and the mitered shoulder coffin (Mainfort and Davidson 2006:104). The mitered shoulder is the simplest of the forms, with the side of the coffin being made out of two boards joined together at the shoulder with a miter joint. A miter joint merely refers to the joining of two boards, the ends of which have been cut at an angle at the meeting point much like a picture frame (Peter et al. 2000:269). The bent-shoulder form involves much more complex carpentry. The side of the coffin is made from a single board that is bent along the bottom coffin form to meet the head and foot boards. This bending is facilitated by one of two methods: kerfing or steam-bending. Kerfing involves cutting a series of narrow slits on the interior of the shoulder and then pouring water over the wood to aid in bending. Steam-bending involves heating and steaming the side boards to create the rounded curved result (Mainfort and Davidson 2006:104–105; Peter et al. 2000:269–270). Mainfort and Davidson (2006:106) contended that a mitered shoulder coffin could be constructed with simple tools by anyone, whereas a bent-shouldered coffin required specialized tools and skill to construct. Therefore, the prevalence of mitered shoulder coffins may reflect a reliance on local journeyman carpenters rather than skilled, professional cabinet or coffin makers.

Although the hexagonal form was the most common type of coffin from the sixteenth through the mid-nineteenth century, other forms of coffins did exist. Illustrating the ambiguous nature of the term, in some areas of the country a trapezoidal form of coffin was produced, one which tapers gently from the head to the foot (see Figure 57). This type, also known as the "tapered box," has been found in archaeological excavations of cemeteries throughout the United States from Florida to California. It has never been illustrated in known period trade catalogs and is likely only a locally constructed container. From archaeological descriptions, Mainfort and Davidson (2006:106) have concluded that the presence of tapered coffins vs. hexagonal coffins in the eighteenth and nineteenth centuries reflects a distinction in mortuary practices between Catholic, specifically those of French (First Cemetery in New Orleans, Louisiana [Owsley et al. 1985]), Spanish (St. Augustine, Florida [Koch 1983]), and Russian Eastern Orthodox (Fort Ross, California [Osborn 1997]) who predominantly used tapered boxes, and Protestant/English-speaking peoples, who preferred the hexagonal form. Aside from the apparent cultural distinction between tapered and hexagonal forms, the main function of the coffin is the encasement of the corpse, with the explicit purpose of providing a protective container for burial (Lang 1984:30).

The casket, on the other hand, represents a fundamental shift in terminology and construction that coincides with and represents changing attitudes toward death and burial in the late-nineteenth-century United States. Derived from French, the term "casket" refers to a jewelry box, or a box used to store valuables (Farrell 1980:10; Habenstein and Lamers 1985:168; Lang 1984:31). Its utilization as a name for a type of burial container was interpreted by Tharp (1996:199) to mean that the container "held not an ugly corpse, but the valuable remains of a loved one and the mourners experienced a 'beautiful' death." Hence, function of the burial container shifted from mere encasement to presentation (Lang 1984:31).

Generally rectangular, or parallel-sided (see Figure 57), in plan view, the casket had several different variants, such as the elliptical or oval-ended casket, as well as the canted-corner casket, also known as an "octagonal casket" (Mainfort and Davidson 2006:107) or the "chamfered casket" (Oster et al. 2005). Caskets, as they have been defined, reflect an aesthetic manifestation of the "beautiful death" (Tharp 1996:199, 201). They therefore are further defined not by form but by elaborate construction and embellishment (Mainfort and Davidson 2006:107).

Some researchers have attempted to define specific dates for the introduction of caskets as a means of temporally differentiating nineteenth-century burials with rectangular or hexagonal burial containers. This is problematic because the introduction of the rectangular casket is not a definite point in time; rather it occurred at different times in different regions of the country and with different cultural groups or communities (Mainfort and Davidson 2006). Although use of hexagonal or other forms of coffins waned in the late nineteenth century, hexagonal forms were still advertised in period catalogs at least into the 1920s, according to Mainfort and Davidson (2006:109–110), and were in use in some areas at least into the 1930s. Furthermore, it has been noted that rectangular burial containers were already in use prior to the nineteenth century (Koch 1983) for all demographics, and primarily for the interment of infants and young children in the early nineteenth century (Bybee 2002; Davidson 1999).

Burial Container Typology

In most cases, coffins were observable based on the presence of a stain of coffin wood that delineated the top or sideboards of the coffin. In only rare cases were larger fragments of coffin wood preserved that could be used to infer construction techniques. Basic shape was observable is most cases, however, and coffin wood types—consisting of juniper, pine, or a combination of the two wood types—could often be inferred based on macrobotanical analysis of the wood fragments. As discussed in the section below on Burial Container Shape and Construction, coffins appear to have been constructed locally using locally available woods and according to idiosyncratic, vernacular construction techniques, suggesting their construction by nonprofessionals. Differential preservation throughout the Alameda-Stone cemetery, as well as differential recording of individual burial features, makes it impossible to create a full typology of all burial containers encountered during excavations (see Appendix J.8). There were approximately 909 burial containers recorded during excavations. Of those containers recorded, roughly 384 were hexagonal in shape, 265 were rectangular, 190 were trapezoidal, and 70 were classified as shape undetermined due to poor physical preservation or a lack of grave/burial integrity (Table 49). Further observations of well-preserved extant containers, nail patterns, and wood grain orientations allowed for the classification of a representative sample of burial containers. Although each burial container presents a different set of data to the researcher, an understanding of the carpentry involved in the construction of various types of containers may aid in the analysis and classification of this special type of material culture (Riordan 2009:85). In this regard, it is important also to include available historical and sometimes archaeological descriptions of construction processes in order to shed light on current data sets.

Leaving aside the lid, which can come in a variety of forms, a simple coffin consists of five pieces of wood—a base, two sides, and two ends. In the case of a mitered hexagonal coffin, the count would increase by two. The base is prepared first because it gives shape and form to the rest of the box. The sides are then affixed to the base, and the head and foot boards are attached to the sides and bottom. Some scholars (Litten 1991:92; Riordan 2009:83) have argued that the sides of burial containers would always have been nailed to the bottom from the side rather than sitting on top of the base and being nailed from underneath. They assert that this

practice would have increased the risk of the bottom falling out when the container was lifted. Although this is a reasonable assumption, it is one that has proven to be false in the case of the Alameda-Stone cemetery as evidenced by the construction variants discussed below.

Each component of the coffin is generally made of a single wood board positioned parallel to the long axis of the burial container, perpendicular in the case of the head and foot boards (Noël Hume 1982:38). However, there are exceptions to this principle, such as at the African Burial Ground in New York, where narrower boards were used for bottoms and lids and then were cross-braced (Perry et al. 2009:265). This same pattern was observed in the Alameda-Stone cemetery. In regard to head and foot boards, many relatively well-preserved burial containers in the Alameda-Stone cemetery showed wood grains indicating that the end boards were positioned in a vertical pose rather than being affixed horizontally. In fact, nearly all of the identified burial-container types discussed below shared this variation with both horizontal and vertical end boards present. Since this was a minor variation and did not significantly affect the overall construction of the container, the end board variation did not factor into the developed classification scheme. A typology of burial containers from the Alameda-Stone cemetery is presented in Table 50.

Three clear types of burial containers were present in the Alameda-Stone cemetery: hexagonal, trapezoidal (tapered), and rectangular. Each of these three types was given a type number (e.g., Burial Container Type 1 for the basic hexagonal form). For instance, where there were multiple construction techniques used for the same basic form (i.e., mitered shoulder hexagonal vs. bent-shoulder hexagonal) numerical suffixes were designated (e.g., Burial Container Type 1.1). Within each of these larger type categories there were sometimes numerous construction variants (e.g., a foot or head board inserted with the side boards vs. abutting the ends of the side boards). For each variant, an alphabetical suffix was given (e.g., Burial Container Type 1.a or 1.1.a).

It should be noted that classification of the basic types of burial containers was merely an analytical exercise to discern categories to which construction variants could be assigned. There is no "correct" way to produce a burial container, there is only the vernacular; therefore, each has a possibility of being unique. In most cemetery investigations, burial containers have not been studied at the level of detail necessary to discern fine-scale variation in their manufacture. In part, this is because the level of preservation and other factors prohibit the observation of discrete construction details, such as how individual container components were fashioned and joined. However, variation in the construction of burial containers has the potential to inform on the source or sources of burial containers used in a cemetery, the availability and cost of construction materials, chronology, and differences in the selection and use of container types by different communities or segments of a community. For this project, we were able to develop enough information on these details of coffin construction to identify a large degree of variation in the construction of burial containers. Of the 27 burial containers whose construction we examined in detail, 24 were unique in some aspect of their construction. The sample of coffins used to create this typology can in no way be considered representative, as it consisted of the limited number of burial containers for which it was possible to develop detailed information on construction techniques. As a result, it is not possible to say with accuracy how often any particular construction technique was used to make the burial containers used in the cemetery, although other sections of this chapter examine the distribution of container manufacture according to variables such as shape, material, and hardware type. This condition limits the ability to interpret variation across the cemetery in container construction techniques. This analysis does show, however, that despite the relatively brief period during which the cemetery was used, a wide variety of idiosyncratic construction techniques were used in burial container construction, within a general mental template for coffin design. At least some of the techniques suggest makers who did not make burial container construction their regular profession. Most containers were probably made by carpenters or laymen and were probably not the product of professional cabinetmakers or casket makers.

Plank Burials

In the Alameda-Stone cemetery excavations, there were at least three individuals recovered who appeared to have been buried on single boards, planks, or platforms (see Appendix J.9). In one instance (Grave Pit 17703/ Burial Feature 19900), after having been placed on the plank, both the infant and plank were wrapped with

fabric and then the fabric was tacked down on the underside and painted before being placed in the grave pit. The other two plank burials were seemingly unembellished. Although not technically burial containers, these plank burials are included in this section because of the cultural implication and purpose the platforms played in supporting and thus containing the corpse.

Although it is not a common practice, plank burials have been noted in one known archaeological context. The Seven Rivers Cemetery, a late-nineteenth-century pioneer cemetery in New Mexico, contained both Euroamerican and Hispanic interments. Two plank burials were recorded in this context: one in association with a 7-year-old female and the other with a 24–30-year-old male (Ferguson et al. 1993:IV-22, IV-36). Two of the Alameda-Stone cemetery plank burials were infants and one was that of a young child. All were located in Cemetery Area 3. Because of the small sample size, it is statistically impractical to associate plank burials with any specific demographic, yet it would seem that there is a tendency for plank burials to be associated with children.

It is possible that single boards were used because of limited physical access to wood for the construction of a proper burial container, or possibly because of limited financial resources, which would end with the same result. Yet there could also be cultural motivations behind the practice. Toor (1985[1947]:163) recorded that people in Tepoztlán, Morelos, Mexico, were just as likely to be buried wrapped in cloth or placed on a board as to be buried in a coffin. It is unknown, however, what cultural significance this practice held in Mexico, in New Mexico, or in Tucson.

Burial Container Shape and Construction

As was discussed in the earlier part of this section on burial container shape, often a particular shape might speak to the temporality of the burial, as well as the religious or social aspects of the individual or population. The cultural patterns behind the production and construction of burial containers can also be elucidated through a demographic and geographic analysis. For example, when addressing temporality in a cemetery context, the growth of a cemetery often can be charted through the geographic distribution of certain burial attributes. Additionally, an understanding of the nature of burial container construction can inform economic, technological, and transportation concerns.

The characterization of nineteenth-century Tucson as a southwestern frontier community weighs heavily on the aforementioned concerns. In most similar contexts, little formality existed in the undertaking industry. Local tradesmen, handymen, or family members were enlisted to construct burial containers. Ferguson et al. (1993) reproduced portions of a letter written in 1882, by Frank Rheinboldt, just after he moved to Seven Rivers, New Mexico. Rheinboldt described how the locals coerced him into becoming the coffin maker for a number of burials in the rural Seven Rivers Cemetery:

> Soon after I was there, an aged lady died in the neighborhood and I was called to make the coffin. It was a surprise to me and I told them I never made a coffin. They asked me if I had a saw, a hammer, and a square and I told them "yes". They answered, we will rustle the boards and you use the tools. So I rushed in and made the coffin. In the store, we had black calico and unbleached domestic muslin and I lined it with that. When I finished they complimented me, and from that time on for many years, I had to make all of the coffins. Fortunately our section was a healthy one—few deaths occurred [Katz and Haynes (1986:18), as cited by Ferguson et al. (1993:V-8)].

Ferguson et al. (1993) show particular interest in Rheinboldt's comment about the family's need to "rustle" the boards. They conclude that the lumber used for burial containers was whatever material was readily available to the families either through physical or economic access.

The coffins assumed to have been constructed by Rheinboldt showed a characteristic bent-shouldered, hexagonal form with splayed sides and ends. This form of burial container may have been his personal choice, developed in response to the desires of family members, adhered to strictures of coffin makers at large, been dictated by the materials available, or maybe was developed over time as he learned more through experience.

Whatever the reason, this account makes it clear that even on the frontier, burial containers requiring complex carpentry (e.g., bent-shouldered hexagonal coffins) were sometimes fashioned by relatively inexperienced craftsmen.

The burial containers recovered from the excavations at the Alameda-Stone cemetery showed a similar type of patterning in construction techniques. No information has been located that might shed light on coffin makers of late-nineteenth-century Tucson. What has been learned from this investigation is that local woods (i.e., pine and juniper) were used to construct the containers (see Appendixes J.10 and J.11). Many burial containers were unique in the construction techniques employed and used narrow, wide, long, and short boards, suggesting that available construction materials were sometimes scarce. The use of a variety of construction hardware such as iron plates, straps, and hinge straps as devices to join multiple boards also suggests local manufacture. Lack of uniformity of nail sizes used in the construction of the burial containers further corroborates this hypothesis. The presence of burial containers requiring specialized tools and complex carpentry techniques, as well as knowledge (i.e., bent-shouldered forms), alongside roughly constructed containers of all shapes, indicates that a number of local individuals (e.g., professional coffin makers, novice handymen, or family members) were constructing these containers.

Of the three main coffin shapes, hexagonal coffins were most common in all cemetery areas. Hexagonal coffins formed the majority of coffins in Cemetery Areas 1 and 2 and were followed in frequency by rectangular coffins. Slightly more than half of coffins in Cemetery Area 5 with determinable shapes were also hexagonal, with most of the remainder of coffins in that area being rectangular in shape. Trapezoidal coffins were observed in only one instance each in Cemetery Areas 1, 2, and 5. In Cemetery Areas 3 and 4, by contrast, hexagonal coffins were only slightly more common than rectangular or trapezoidal shapes, with these three types being relatively evenly distributed in number. Some of this variation in container shape relates to age, as hexagonal containers were most common among adults. For juveniles, rectangular containers were most common, but hexagonal or trapezoidal shapes were also used.

There was also variation in container shape according to age between cemetery areas. In Cemetery Areas 1 and 2, most adults were buried in hexagonal containers, whereas juveniles were buried in either hexagonal or rectangular containers. In Cemetery Area 5, the pattern of burial container shapes for adults closely followed the pattern in Cemetery Areas 1 and 2, but all three shapes were used for juveniles, with rectangular containers the most prevalent shape for juveniles. In Cemetery Areas 3 and 4, around one-half of adults were buried in hexagonal containers, as were around a third of juveniles, but both rectangular and trapezoidal containers were used for adults and juveniles to varying degrees.

For the cemetery as a whole, there was a tendency for more males to be buried in hexagonal containers, but this pattern seems to relate almost entirely to the apparent preference for hexagonal burial containers in Cemetery Areas 1 and 2 and the large number of males in those two cemetery areas. Otherwise, there appears to have been no difference in burial container shape between sexes, with one possible exception. Males in Cemetery Area 4 were most often buried in a hexagonal or a rectangular container, whereas females in Cemetery Area 4 were most often buried in a hexagonal container. Given the relatively small sample size of burial containers that had both recognizable shape and were associated with sexed individuals in Cemetery Area 4 ($n = 40$), this pattern may simply be random.

There was some apparent patterned variation in the spatial location of burial container shapes within cemetery areas. For instance, in Cemetery Area 2, most of the burials with rectangular containers were in the northern portion of the area. In Cemetery Area 3, the three basic shapes for burial containers were found throughout the area but tended to cluster according to shape within rows. Often, two or more adjacent grave pits in Cemetery Area 3 held burial containers of the same shape. The significance of this pattern is unclear, but the clustering of shapes within rows suggests that similar coffin styles may have been used for burials that occurred either closely in time or among socially related individuals who were buried in close proximity to each other. In Cemetery Area 4, trapezoidal containers were found throughout the excavated area, but rectangular shapes clustered in the west half of the area and trapezoidal shapes clustered in the east half. The significance of this pattern is also unknown, but if not demographic in nature, it is possible that variation in disturbance across different areas of the cemetery contributed to variation in the identification of container shapes. For instance, a rectangular container that was disturbed may have appeared to excavators to have been trapezoidal, or vice versa.

To further understand the specific distributions of burial container shapes an analysis of the demographic patterns of individuals contained within the burial containers may prove useful. Table 51 shows frequencies of burial container shapes across cemetery areas in comparison to ASM age categories and biological sex. In general, both adult males and adult females were three times more likely to have been buried in a hexagonal coffin as compared to a trapezoidal coffin or a rectangular coffin. Juveniles were almost equally likely to have been buried in a hexagonal or a trapezoidal coffin, and they were slightly more likely to have been buried in a rectangular coffin. Roughly equal numbers of hexagonal and trapezoidal burial containers appeared with infant and fetal remains. Infants were, however, 36 percent more likely to have been buried in a rectangular coffin. Fetuses were 50 percent more likely to have been buried in rectangular burial containers. This general trend is supported by similar comparisons in other historical-period cemetery settings (i.e., Ferguson et al. 1993:V-8–V-9).

Nails

Nails are an essential and ubiquitous form of construction hardware used in the production of coffins and caskets. There were three general types of nails in use in various regions and times in the nineteenth century: handwrought, square cut, and wire. Handwrought nails were commonly used during the seventeenth and eighteenth centuries until the introduction of the cut nail around 1800 (Mainfort and Davidson 2006:115–116). Cut nails declined in use toward the end of the nineteenth century as wire nails hit the market and become more widely used in the casket industry.

A vast literature exists on the subject of nails and nail dating (W. Adams 2002; Baackes 1896; Benson 1983; Edgerton 1897; Edwards and Wells 1993; Epstein 1981; Fontana 1965; Fontana and Greenleaf 1962; Jurney 1987; Loveday 1983; Michael 1974; Nelson 1963, 1968; Phillips 1989; Priess 1970, 1973; Wells 1993, 1998; Young 1991). For a detailed discussion of the problems associated with using nails as a chronological determinant, see Mainfort and Davidson (2006:115–120). Based on Fontana (1962, 1965), Edgerton (1897), and other reliable sources, Mainfort and Davidson (2006) have placed the introduction of wire nails to common usage in the funeral industry between 1890 and 1900. In estimates of burial chronology, this date has been conventionalized to ca. 1895. The period prior to this date is characterized by the exclusive use of cut nails in the funeral industry. This dating has held true for comparable dated burials from Arkansas (Cande 1995:161–168, 249–251); Freedman's Cemetery in Dallas, Texas (Peter et al. 2000); and Meadowlark Cemetery, Kansas (Pye 2007).

The literature suggests that the most common sizes of nails used in the construction of coffins and caskets were smaller nails (i.e., 4d, 6d, and 8d), whereas larger nails (i.e., 10d and above) were more likely to be used in shipping containers for the transport of mass-produced burial containers (Davidson 1999; Mainfort and Davidson 2006). It is reasonable to expect that there would be a certain degree of uniformity in the sizes of nails used for mass-produced coffins and caskets, and in fact, the most common nails listed in the archaeological literature have been 6d and 8d cut nails with a bias toward the use of 6d nails in both the cut and wire varieties through time (Mainfort and Davidson 2006:101).

No in-depth analyses of nails from the excavations at the Alameda-Stone cemetery were conducted, mainly because of the poor preservation of the excavated ferrous materials. It was possible to note that there was a mixture of cut and wire nails. This can be attributed to the heavy postcemetery disturbance to the site overall. In most cases, it was clear that all wire nails encountered during burial excavations were intrusive to those burial features. The combination of the suggested introduction date of wire nails and the known terminal use of the cemetery bolsters this observation.

In the sample of cut nails recovered from burial contexts, there was a predominant reliance on 6d and 8d nails for coffin and casket construction, although sizes ranged from 2d to 20d. The variety of nails of different sizes recovered in burial contexts suggests a greater likelihood for local manufacture by individuals who did not have ready access to a standard source of uniform nail sizes.

The term "clinched" nail refers to nails that have been intentionally bent at roughly a 90 degree angle toward the distal end. Nails are often intentionally bent in this manner when used to secure bracing or runners connecting multiple boards. The nail is driven through the two boards and then the protruding end is bent over.

Mainfort and Davidson (2006:101) have suggested that clinched nails would not have been used in the construction of primary burial containers, even those manufactured locally. Instead, clinched nails would have been more commonly used in the construction of an outer shipping crate, or sometimes in a vaulted lid (Mainfort and Davidson 2006:101). Although the roughness of outer shipping crates would typically require this type of construction, the presence of clinched nails should never be used as a proxy for an outer box or commercial manufacture. Their presence only indicates the functional aspect of their use in the construction of a container.

Screws

Mainfort and Davidson (2006:144–145) report that wood screws in some form have been around since the time of the ancient Greeks; however, prior to the nineteenth century, most screws had blunt points and could not self-start. The introduction of the gimlet wood screw, a screw that has a tapered body and a pointed tip, has been attributed to Thomas J. Sloan, who was issued a U.S. Patent (No. 4,704) in 1846. The mass production of these gimlet screws was initiated the same year by Sloan's introduction of the machine capable of producing said screws (U.S. Utility Patent No. 4,864). Although technically a gimlet form had been introduced 10 years earlier by Thomas W. Harvey of Poughkeepsie Screw Company, as well as a machine capable of producing wood screws in 1834, most early gimlet and blunt-tip forms had to be hand turned and therefore were more costly to consumers than later machine-made screws (Mainfort and Davidson 2006:145).

Plain gimlet screws were commonly employed as lid closures for burial containers in the nineteenth century, although the earliest mention of some type of screw used in mortuary contexts dates to 1748 (Mainfort and Davidson 2006:145; Tharp 1996:226). In the known sample of general hardware and mortuary catalogs available for comparison, flat, round, oval, and fillister-headed gimlet screws were prominently advertised for sale in the 1865 Russell & Erwin Mfg. Co. hardware catalog. Mainfort and Davidson (2006:145) conclude after critical examination of archaeological literature of pre-1850 cemeteries that the presence of screws, particularly gimlet screws, was relatively rare. Additionally, in those burial containers where utilitarian gimlet screws were used as primary means of lid closure, there was an absence of formal coffin hardware such as coffin screws or thumbscrews. Forms of ornamental tacks, however, were often used to mask the use of ordinary screws (Mainfort and Davidson 2006:146).

Seventy-four burials recovered in the Alameda-Stone cemetery excavations had utilitarian screws or fragments of screws present. Most of these screws were corroded and fragmentary. Among those that were in a suitable condition for analysis, there seemed to be two varieties of gimlet screws, the flat-headed and the oval-headed forms. Twenty-two of the 74 features contained $^{3}/_{4}$–1-inch-long, small-gauge, oval-headed screws used to attach coffin hardware such as handles or ferrous joining plates and/or straps. Therefore, 52 burial features contained the remains of screws used in the primary construction of the burial container or as lid closures. The context of all screws and screw fragments was not consistently noted; therefore, no further interpretations about the relationship between utilitarian screws, lid closure, and formal coffin hardware can be made. It should be noted, however, that at least in a few instances utilitarian gimlet screws were used in conjunction with formal coffin screws, as well as being used alone. In all cases, except in the application of coffin hardware such as handles and ferrous plates and straps, few utilitarian screws were used in burial container construction, being limited to one to three screws (see Appendix J.8).

Miscellaneous Construction Hardware

The term miscellaneous hardware refers to any types of hardware used in the construction of a coffin or casket that were unique to certain burial or grave features or that did not fall into the other categories of decorative or utilitarian construction hardware. The cemetery excavations yielded six miscellaneous types of construction hardware.

Miscellaneous Hardware Type 1

Miscellaneous Hardware Type 1 as a group refers to thin, rectangular, ferrous metal plates used to join two boards together in the construction of the burial container (see Appendix J.12). They were recovered in 20 grave pits in Cemetery Areas 1, 2, and 3 of the Alameda-Stone cemetery. There were no dimensions recorded nor were any mold markings evident in association with Hardware Type 1. There is no known design patent or period catalog matches for Hardware Type 1, and there are reportedly no known matches from contemporary cemetery excavations. Typically, single wood boards that were wide enough to perform the function would have been used in construction. Narrow boards were cheaper and often more accessible; therefore, a way to join the boards together was required. Joining plates that were large enough to bridge the boards were used for this function.

Identification of joining plates speaks to construction technique and skill of the coffin maker, availability of resources for coffin construction, and cost of burial container. Joining plates would have been used on a coffin when more than one board needed to be employed for the construction of any one part, particularly the lid. Litten (1991:103) notes that often coffin makers could not obtain 2-foot widths of wood, which he suggests would have been the suitable size for coffin construction; in such a cases, 12-inch or 6-inch planks were used, and the poor craftsmanship was masked by cloth covering. In this technique, multiple boards could be used along the long axis, or numerous transverse boards could have been used in the construction of the burial container. Judging by the orientation of recovered joining plates and the direction of remaining wood grains on the underside of said plates, both types of construction were present in the Alameda-Stone cemetery.

Miscellaneous Hardware Type 2

Miscellaneous Hardware Type 2 consisted of one type of ornamental hinge plate or hinge strap recovered in one burial in Cemetery Area 3 (see Appendix J.12). They tapered toward the ends, which were in the form of broad triangular points with curved corners. They were roughly similar in form to hinge plates depicted in P. & F. Corbin's 1931 catalog, *Colonial and Early English Hardware,* and the hinge straps or dummy straps depicted in the ca. 1932 Russell & Erwin Mfg. Company's *Catalogue of Hardware*. These types of straps were manufactured for use as decorative elements on doors, cabinetry, or other appropriate types of furniture or architectural locations. There were no mold markings evident in association with Hardware Type 2. Dimensions included a total strap length of 6 inches, a strap midline width of 1 inch, and a strap thickness of 0.125 inches. There is no known match among design patents or period catalogs or from excavations of contemporary cemeteries for Hardware Type 2.

The straps recovered in cemetery excavations were used as joining plates and did not serve a decorative purpose. The presence of fabric or fabric impressions on each of the straps within the burial that contained Miscellaneous Hardware Type 2 suggests that the straps were on the coffin beneath cloth covering and therefore would not have been visible. Their use on the coffin in burial contexts implies opportunistic or need-based use.

Miscellaneous Hardware Type 3

Miscellaneous Hardware Type 3 consisted of a type of ornamental hinge plate or hinge strap recovered in the same burial as Miscellaneous Hardware Type 2 above (see Appendix J.12). It was a smaller version of the same tapered strap design as Miscellaneous Hardware Type 2, with one end in the form of a broad triangular point with curved corners. Dimensions included a total strap length of 5 inches, a strap midline width of 1 inch, and a strap thickness of 0.125 inches. Only a portion of the midsection and one side taper remained, so it was not possible to determine whether the artifact once contained both extremities, like Miscellaneous Hardware Type 2.

Miscellaneous Hardware Type 4

Miscellaneous Hardware Type 4 consisted of roughly 1-inch-wide rectangular ferrous straps of various lengths from seven burials, all of which were discovered in Cemetery Area 3 (see Appendix J.12). These straps were affixed to the burial container via screws or nails, and they were used to aid in the joining of boards, much like the miscellaneous hardware types mentioned above. The straps recovered from Grave Pit 7526 were found wrapped around the entire coffin at both the head and foot ends, seemingly holding the coffin together. In all cases, these straps were not decorative and were placed beneath a cloth covering, as evidenced by the presence of fabric or fabric impressions on the exterior surfaces. There were no mold markings evident in association with Hardware Type 4. Dimensions included an average strap length of 1 inch and an average strap thickness of 0.13 inches. There is no known match among design patents or period catalogs or from excavations of contemporary cemeteries for Hardware Type 4.

Such straps have been used in the construction of historical-period burial containers in at least one other recorded cemetery, the Seven Rivers Cemetery in New Mexico (Ferguson et al. 1993). They are not known to have been used in other regions of the country, but no concrete cultural or regional correlation could be made because of the small sample size.

Miscellaneous Hardware Type 5

Miscellaneous Hardware Type 5 consisted of a metal hasp recovered to the left of the first and second lumbar vertebrae in one burial in Cemetery Area 2 (see Appendix J.12). The hasp tapered to form the solid end to the slotted end, which had rounded corners. There were no mold markings evident in association with Hardware Type 5. Dimensions measured 4.9 inches in length, and the widest width measured 1.4 inches and the tapered end was 1.1 inch. The hasp thickness was 0.125 inches. There is no known match among design patents or period catalogs or from excavations of contemporary cemeteries for Hardware Type 5.

The positioning of the hasp in relationship to the burial would suggest that the hasp had been affixed to the lid of the coffin as a closure or locking mechanism. However, the lid of this coffin did not appear to have been hinged, and there was no viewing panel to suggest that it had served as a window or panel latch. Furthermore, only the body of the hasp was recovered with no evidence that the hinge plate had been present. Both lengthwise edges of the hasp had evenly spaced nails hammered through the metal, suggesting that the object had been used as a joining plate in the construction of the coffin. This hypothesis is further supported by the presence of coarse, white cotton, balance-weave fabric on the obverse face of this hasp, which indicates that the coffin had been covered by cloth.

Miscellaneous Hardware Type 6

Miscellaneous Hardware Type 6 consisted of a ferrous ring with a screw (or other fastener) on one side, found in Grave Pit 699/ Burial Feature 8696 in Cemetery Area 5 (see Appendix J.12.). Dimensions measured 4.53 inches in length by 2.43 inches in width. It was recovered from atop the lid of a child's coffin and was interpreted as a handle or some sort of lid lifter. Although it is possible that this object may have served in such a capacity, its context was not clear enough to positively identify its function or purpose in relationship to the burial or burial event. There is no known match among design patents or period catalogs or from excavations of contemporary cemeteries for Hardware Type 6.

Construction Hardware

All burial containers recovered in the Alameda-Stone cemetery were constructed using common cut nails, and therefore no demographic conclusions can be drawn from investigating them. Similarly, the use of utilitarian

screws follows a seemingly typical demographic distribution. Miscellaneous Hardware Types 2, 3, 5 and 6 were found in only one burial each within the cemetery, and therefore did not produce a pattern (see Appendix J.13). Joining plates (Miscellaneous Hardware Type 1) were recovered in 21 burials. Iron straps (Miscellaneous Hardware Type 4) were collected from 7 burials. Both types of hardware were recovered from burials cutting across demographic boundaries, multiple types of burial containers, and burial contexts.

Coffin Hardware

The analysis and historical study of coffin hardware is crucial in establishing a useful discourse between multiple lines of evidence recorded and recovered in historical-period cemetery investigations. Coffin hardware conveys multiple social and aesthetic meanings. For some affluent members of society, ornate and expensive coffin hardware was used as a marker of social status (Burgess et al. 2007). Others used coffin furniture as a means of masking social realities and presenting the illusion of wealth (Little et al. 1992). These various types of hardware in and of themselves held religious and ideological symbolic value in the development of the outward expression of the Victorian Beautification of Death movement (Bell 1987, 1990). The nineteenth- and early-twentieth-century perspective viewed the ornamentation of the funeral and the coffin or casket as an extremely important part in the expression of sentiment and community restructuring.

Coffin hardware holds great value for the archaeologists just as it did for the mourners who chose to include decorative hardware on a coffin or casket. Exact identification of types and styles of hardware is important in defining the chronology of burial, particularly in the absence of dated grave markers. Moreover, variations in styles, hardware forms, and materials of manufacture, in tandem with temporality, speak volumes about economic expenditure and therefore indirectly reflect aspects of socioeconomic class status and/or community involvement in the funeral process (Bell 1987, 1990; Davidson 1999, 2004; Little et al. 1992; Pye 2007). Nearly all of the historical-period cemetery reports, investigated for hardware types comparable to the materials recovered from the Alameda-Stone cemetery (see Table 43), have used coffin hardware as a means to place undated burials within a temporal context. However, as Buchner et al. (1999:28), Davidson (1999), and Mainfort and Davidson (2006) note, there are serious dangers and limitations in the uncritical application of past hardware analyses to excavated materials.

Prior to the work by Mainfort and Davidson (2006) and Davidson (1999), the most widely used authoritative manuals on dating coffin hardware were Hacker-Norton and Trinkley (1984) and Trinkley and Hacker-Norton (1984). These reports were among the first to employ period hardware catalogs to establish their chronologies. Although this was innovative for the time, the number of hardware catalogs used for comparison was small. These works did succeed in illustrating one very important point—that various types of coffin hardware were stocked by stores throughout the country and may have remained on the shelf for some time before being used. Therefore, just because one hardware type appears and declines in appearance in the hardware catalogs very early does not mean that it cannot be introduced into the archaeological record at a later time period. Buchner et al. (1999:28) equate this type of lag to the demonstration of local cultural sequences, which should be researched in each specific region independent of possibly inaccurate dates from other areas of the country.

The methods established by Davidson (1999) for the classification of hardware from the Freedman's Cemetery Project, Dallas, Texas, have been applied to the Alameda-Stone cemetery materials. Essentially, a new type number was designated when a new hardware type (or combination of elements) was encountered. Mainfort and Davidson (2006:120–121) give the example, "the first thumbscrew . . . was given the type designation Thumbscrew Type 1 . . . if the next burial excavated uncovered a thumbscrew with an even slightly different design motif, [then] it was assigned a new type number (e.g., Thumbscrew Type 2)." Size variants (i.e., adult-sized handles vs. child-sized handles) were designated by numerical suffixes (e.g., Handle Type 12.1).

The burial excavations revealed a relatively small sample of coffin hardware, consisting of nine handle types, five coffin screw types, and eight ornamental tack types. The total counts of decorative hardware are given via grave feature and burial feature number in Appendix J.13. Numerous cut nails, lining tacks, gimlet

screws, and other miscellaneous utilitarian/functional hardware were also recovered from the excavations but will not be specifically discussed in this hardware schema.

Following Davidson (1999) and Mainfort and Davidson (2006:121), it is acknowledged that these pieces of coffin hardware should be dated and contextualized through three lines of evidence: patent dates, dates derived from period hardware catalogs, and known dates of cemetery use. A fourth line of evidence can be included but must be critically analyzed based on the previous lines of evidence—the estimated interment ranges of burials from previously excavated cemeteries. The fact that the cemetery was in use for a relatively short period, 1862–1881, would seem to negate the utility of such a chronological exercise; however, there are important observations to be made about the interplay of chronology with consumerism and economics in Tucson. Specifically, what types of meanings and value were applied to these artifacts displayed on the coffin during the funeral, prior to the arrival of the Southern Pacific Railroad and easier access to mass-produced materials in 1880 (O'Mack 2005:40)?

When information is available, identical matches to each hardware type are listed, as shown in the following tables. In some instances, similar matches may be mentioned, and it should be noted that even although they are not listed, most pieces of hardware have contemporary similar forms. Care should be taken in future studies to identify exact stylistic matches and not matches of simple morphological similarity. An attempt will not be made in this report to describe the history and various iterations of all hardware forms. For more descriptive information about each hardware type, see Davidson (1999, 2004) and Mainfort and Davidson (2006). However, for general purposes, a brief contextual discussion of each hardware form encountered during the cemetery excavations will be presented followed by descriptive discussions of each hardware type as constructed within the current typology.

Handles

Furniture Pull

Furniture pulls were made for use on pieces of wooden furniture, such as chests of drawers, curio cabinets, and table drawers (Ormsbee 1951, 1952). They could be found for sale in general hardware catalogs such as the 1865 Russell & Erwin catalog and the late-nineteenth-century and early-twentieth-century Sears, Roebuck and Co. catalogs. However, sometimes furniture pulls and other types of utilitarian hardware were used in the construction of coffins and caskets in the nineteenth century and found their way into the archaeological record of historical-period cemeteries, as is evidenced by the presence of one such artifact type in the Alameda-Stone cemetery assemblage.

Handle Type 1

Handle Type 1 (Figure 58a) was represented by six items recovered from one burial (see Appendix J.14). All of these artifacts were made of stamped, nonferrous metal and were heavily corroded. The corrosion obscured any possible design pattern; however, the general form appeared to be a type of furniture pull, pocket handle. Considering the condition of the artifacts, no matches could be made to general hardware catalogs of the period, such as the 1865 Russell & Erwin Catalogue or the Sears, Roebuck and Co. catalogs.

Swing-Bail Handles

Single-Lug, Swing Bail Handles

Single-lug, swing-bail handles are a variant of the general swing-bail type and were in common use by the 1850s. This type of handle consists of a single lug and a single bail. According to Davidson (2004:410), these types of handles were more frequently associated with child coffins or caskets even into the 1950s. It should be noted, however, that it is certain stylistic motifs, such as the "lamb" handles, that were almost exclusively made for children. This type of handle could be found on coffins across demographic categories.

Handle Type 2

Handle Type 2 (see Figure 58b) was represented by only two artifacts from one burial (see Appendix J.14). These items were made of a nonferrous metal and were likely silver plated. These single-lug, swing-bail coffin handles showed heavy corrosion; however, the elements were clear enough to discern stylistic motifs. The bail and outer inch of the lug had floral patterns evident through corrosion. Both the bail and lug were hollow backed, stamped metal. No mold numbers were evident on the pieces, although they may have been obscured. A recessed cross appeared on a convex central disk within the floral border. The lug was attached to the coffin using an estimated six ferrous metal gimlet screws. These pieces were exact matches to the "silver plate on brass handle" depicted as No. 240 "Cross Center Piece and Handle" in the 1871 Sargent & Co. catalog (Figure 59a). This handle was located in five hardware catalogs dating from 1865 to 1884, thus bracketing the cemetery's known period of use (Table 52). No other cemetery's collections consulted for this report contained matches to this handle; however, there is a U.S. design patent, Patent No. 1571, granted to J. B. Sargent on April 29, 1862, that effectively determines this hardware type's terminus a quo.

Handle Type 3

Handle Type 3 (see Figure 58c) was represented by only two artifacts from one burial (see Appendix J.14). These items were made of a nonferrous metal and were likely silver plated. These single-lug, swing-bail coffin handles showed very little corrosion. The handle was made from silver-plated brass with the lug in the form of an ornate cross with hearts and sunbursts. All four ends of the cross had spade- or heart-shaped cutouts (three each, pointing up, down, and out) with the screws at the center used to secure the lug to the coffin. Each cross bar also had sections cut out along its length, although the bulk of the cross was solid. Below the horizontal bar sat the pin of the bail; above the horizontal bar and stemming from the intersection of the two bars were rays. The top of the vertical bar was bent up slightly off of the original plane. The pin of the handle fell just below the horizontal bar of the cross. The pin likewise fit to the precise width of the plain section of the horizontal bar and was held in place by a cascading floral arrangement on the body of the cross and by short, raised notches on the bail; these raised notches also limited the degree of rotation of the handle to less than 75 degrees. The front of the bail was decorated in the following manner: a central four-petal cutout and what looked to be alternating pairs of bisected horizontal ovals and complete vertical ovals ("zeros") arranged around the length. Although there was a slightly raised border around most of the bail, the alternating pair of bisected horizontal ovals were part of the border. The back of the bail was concave but was not the negative image of the front (e.g., molded rather than stamped). This hardware type was an exact match to the silver-plated brass handle No. 58 depicted in the 1866 Sargent & Co. catalog (see Figure 59b and Table 52). This was the only match to period hardware catalogs, and this type has not been reported in any of the comparison cemetery reports consulted for this project. Furthermore, no design patents have been located that might better identify when this handle type was manufactured.

Double-Lug, Swing-Bail Handles

The double-lug, swing-bail handle is one variant of the general swing-bail form. It is composed of three elements: two lugs, which are affixed via screws to the side of the coffin, and the bail, which form the gripping portion of the handle. The bail is mounted into the lugs by the insertion of two metal pins (of iron or steel wire) at either end. Davidson (1999, 2004:407) reports that swing-bail handles have been in production from the eighteenth into the twentieth century, when the short-bar and, later, the extended bar handles became more popular.

Handle Type 4

Handle Type 4 (see Figure 58d) was a double-lug, swing-bail handle represented by nine artifacts from two burials (see Appendix J.14). Handles of similar styles have been recorded in three cemetery excavations across the United States and Canada (Table 53). These items were made of a high-quality, nonferrous, white metal and were likely silver plated. The handle consisted of two simple oval-shaped lugs with a U-shaped bail attached. No design motifs were present on either the bail or the lugs. These artifacts were more or less in an excellent state of preservation, attesting to good quality of materials. There are eight period hardware catalogs

that advertise handles of this stylistic type that range from 1857–1874 (see Table 52). Exact identification of item number within many of the catalogs was difficult for two reasons: (1) size grades that were somewhat ambiguous, and (2) the presentation of multiple material types that might appear very similar when encountered in the archaeological record. For example, the 1865 Markham & Strong catalog advertised five variations on this type of handle: Numbers 10–12 are white metal handles; Number 101 is referred to as "argentine metal"; and finally, Number 210 is silver plated (white metal). Each different material classification was sold for different prices and reflected levels of material quality.

It is probable that the handles classified in the category Handle Type 4 were the handles numbered 210 in Markham & Strong and 100 in the 1871 and 1874 Sargent & Co. catalogs (see Figure 59a and c) based on the apparent presence of silver-plating on some of the recovered artifacts. No mold numbers were evident on either the bail or the lugs. This handle type seems to be stylistically similar to those artifacts groups under Handle Type 5, but because of the poor preservation of that type, it was difficult to make concrete conclusions.

Handle Type 5

Handle Type 5 (see Figure 58e) was represented by 26 artifacts from five grave features containing six individuals (see Appendix J.14). This double-lug, swing-bail handle type was by far the most common type of handle recovered from excavations. These items were made of a nonferrous, white metal plated on a ferrous inner wire. Only fragments of lugs remained, but they appeared to have been roughly oval in shape. The bails were roughly similar in size, shape, and apparent style as those handles within Handle Type 4. Handle Type 5, however, was characterized by its poor preservation. By contrast, Handle Type 4 showed excellent preservation. The surfaces of the handles within Handle Type 5 were flaky and fragmented, suggesting that they were made of poor-quality materials. Because they were found in multiple burials throughout the cemetery, differential preservation was unlikely a factor in their condition. No mold numbers were evident on the bail through the fragmentation and corrosion.

All handles of this type were very fragmentary and corroded. Based on the similarity of degradation, it can be reasonably assumed that within this cemetery, the handles included in this type category were of the same or similar form and material composition. It was not possible to prove any definitive match to other archaeological artifacts or period hardware catalogs. However, if speculation is correct, they may possibly represent the plain white metal handles listed as Numbers 10–12 in the 1865 Markham & Strong and the 1871 and 1874 Sargent & Co. catalogs (see Table 52).

Handle Type 6

Handle Type 6 (see Figure 58f) consisted of double-lug, swing-bail handles represented by only six artifacts from two burials (see Appendix J.14). These items were made of a nonferrous, white metal, and were likely silver plated. No mold numbers were evident on either the lugs or the bail, although there was some corrosion and fragmentation. Both the bail and the lug were decorated with floral and vine motifs accenting small oval elements at the terminal arcs of the lugs and a larger oval element in the center of the bail. This exact bail and lug combination appears as "silver-plated," No. 1160 coffin handle in the 1874 *J. L Wayne & Sons Catalogue* (see Figure 59d). There were nine exact bail/lug combination matches in the period catalog comparative collection (see Table 52). There was one instance where only the lug matched. Further, there are four catalogs depicting handles that show striking similarities to the handles in question but perhaps do not reflect exact matches. The hardware catalogs in which this handle type is depicted range in date from 1865 to 1902. This handle was also encountered in four cemetery excavations from Georgia; Texas; Illinois; and Ontario, Canada (see Table 53). There are no known patent records for this particular handle type; therefore, it is not clear when this style entered the market. However, it is clear from the dates associated with the hardware catalogs and dates attributed to the comparison cemeteries that the use of this type of handle bracketed the use life of the Alameda-Stone cemetery.

Handle Type 7

Handle Type 7 (see Figure 58g) consisted of double-lug, swing-bail handles represented by only four artifacts from one burial (see Appendix J.14). These items were made of a nonferrous, white metal. No mold numbers

were evident on either the lugs or the bail, although there was some corrosion and fragmentation. Both the bail and the lug were decorated with floral and vine motifs accenting a fan of raised ridges opening outward across the outer portion of the lugs. This exact bail and lug combination appears as "white metal handle," No. 540 in the 1874 *J. L Wayne & Sons Catalogue* (see Figure 59d). Only three period hardware catalogs showed exact matches to this type of handle, and there have been only two cases of them being recovered from archaeological excavations (see Table 53). The hardware catalogs in which this handle type was advertised range in date from 1865 to 1874 (see Table 52). This time range would seem to restrict the period of possible interment of this burial. There are no known patent records for this particular handle type; therefore, it is not clear when this style entered the market. Moreover, the lack of matched, dated catalogs might be a product of the small sample size of comparative material.

Handle Type 8

Handle Type 8 (see Figure 58h) was represented by 12 artifacts from three burials (see Appendix J.14). These items were made of a nonferrous, white metal and were possibly silver plated. This handle type consisted of a cross/tassel lug motif with a U-shaped bail with a rope motif. This type of handle has been recovered in 10 cemetery excavations throughout the United States and Canada, with a range from Texas up to Ontario (see Table 53). The first known appearance of this lug/bail combination is illustrated in the ca. 1871 *Miller Brothers & Co. Catalogue* (Mainfort and Davidson 2006:129). It was also offered for sale in nine other coffin hardware catalogs ranging in date from 1871 to 1905 (e.g., the 1875 H. E. Taylor catalog) (see Figure 59f and Table 52). This time range would seem to restrict the lower end of the period of possible interment of these burials to after 1871. However, there are no known patent records for this particular handle type; therefore, it is not clear exactly when this style entered the market.

Double-Lug, Swing-Bail Handle with Tips

Double-lug, swing-bail handles with tips are a special variant of the general swing bail design produced to mimic the qualities of the more expensive and then-modern short-bar handle in the 1860s and 1870s (Davidson 1999, 2004:408–409). Although the exact introduction date of this type of artifact is unclear, it is known that C. Strong was granted a U.S. patent for this type of handle on May 13, 1873 (U.S. Letter Patent No. 138768). The bail of Strong's handle consists of five parts: two arms molded to insert into the sides of swing-bail handle lugs, but also molded to accept a handle bar; a hollow metal (although wood was also used) handle bar; and two finials or tips to cap either end and secure the bar to the arms. On December 24, 1872, W. M. Smith was granted a U.S. design patent, Design Patent No. 6324, for finial elements similar to those of Strong, so it is clear that these types of handles were present at least by the early 1870s. Davidson (1999, 2004:409) posited that only a limited number of different styles were available by the turn of the century and were available until around 1915.

Handle Type 9

Handle Type 9 (see Figure 58i) consisted of a double-lug, tipped, swing-bail handle represented by only four artifacts from one burial (see Appendix J.14). The lugs, arms, and tips of this handle were made of a nonferrous, silver-plated, white metal. The lugs bore Masonic symbols (e.g., letter "G," compass, square, trowel, hourglass, and keystone), as well as an open book (possibly a Bible) sitting atop a pulpit formed by the pin housing. The lower portion of the lug below the pin housing bore crossed sprigs of leaves. These lugs were exact matches to those pictured in No. 72 in the 1876 Meriden Britannia Co. hardware catalog (see Figure 59g). The bail of this handle consisted of a hollow, cuprous metal bar with four parallel bands of decorative work running lengthwise across the handle. It was capped by urn-shaped finials/tips. The finials were similar to those depicted in No. 660 "Satin Bar" on page 11 of the same catalog mentioned above. There were no mold numbers evident on the backs of the lugs or anywhere else on the handle.

There are only two period hardware catalogs that show exact matches to this type of handle; there are no known instances where this handle type has been recovered archaeologically. The hardware catalogs that include this handle type range in date from 1876 to ca. 1880 (see Table 52). This time range would seem to restrict the period of possible interment of this burial to the later period of cemetery use; however, there are no

known patent records for this particular handle type. Therefore, it is not clear when this style entered the market. Moreover, the lack of matched, dated catalogs might adversely restrict the perception of this handle's use life.

Ornamental Tacks

Ornamental tack refers to a general class of artifact that includes a number of different forms and is referred to by several different terms, such as coffin tack, dummy screw, stud, diamond tack, etc. These items usually have floral or geometric motifs, but they also can be representational ornaments of sorts (such as the cross-shaped stud). The more substantial coffin tacks (dummy screws) are made of a white metal, whereas the stud forms are made of thin, light-weight, pressed metal. In all instances, a ferrous tack shaft is affixed to the underside of the main body. These ornamental tacks are usually placed along the perimeter of the coffin lid or on the sides of the coffin itself. As a general artifact class, the ornamental tack is commonly found in catalogs from the 1850s to ca. 1920+ (Davidson 1999, 2004:419–420; Mainfort and Davidson 2006:153).

Coffin Tacks (Dummy Screws)

The term coffin tack refers to a specific kind of ornamental tack with a white metal screw head affixed to a small ferrous tack shaft. They are commonly used in conjunction with true coffin screws to give the illusion that more true screws were used in the construction of the coffin. For this reason, coffin tacks are often referred to as dummy screws (Davidson 1999, 2004:402–403). Coffin tacks were available for sale in some locations from the 1850s well into the 1900s but were most popular between the 1850s and the 1880s. Although the exact introduction date of this type of artifact is unclear, it is known that W. H. Nichols was granted a U.S. patent for this type of tack on July 26, 1859 (U.S. Letter Patent No. 24911). However, no specific design patent is known to exist for the ornamental tack types recovered at the Alameda-Stone cemetery. Because coffin screws were common starting in the 1850s, the known catalog matches discussed below do not necessarily limit the temporal range for the use of the ornamental tacks.

Ornamental Tack Type 1

Ornamental Tack 1 was represented by 55 artifacts from two burials (see Appendix J.15). It consisted of a domed, cylindrical, slotted, nonferrous, white metal head with a ferrous tack shaft. The tack had a double filigree decorative form with the sides of the dome slightly slanted and the lower filigreed collar squared. This artifact type, or at least a similar version, was recovered in five cemetery excavations throughout the United States and Canada (Table 54). The first definite appearance of this tack was illustrated in the 1875 *H. E. Taylor & Co. Catalogue*. It was also offered for sale in four known coffin hardware catalogs ranging in date from 1875 to ca. 1890 (Table 55).

Ornamental Tack Type 1.1

Ornamental Tack Type 1.1 was a diminutive form of Ornamental Tack Type 1 and was represented by 130 artifacts from two burials (see Appendix J.15). This tack type consisted of a domed, cylindrical, slotted, nonferrous, white metal head with a ferrous tack shaft. It had a double filigree decorative form with the sides of the dome slightly slanted and the lower filigreed collar squared. It, or at least a similar version, has been recovered in three cemetery excavations throughout the United States (see Table 54). The first definite appearance of this tack was illustrated in the 1865 *Markham & Strong Catalogue*. It was offered for sale in five known coffin hardware catalogs ranging in date from 1865 to ca. 1890 (see Table 55).

Ornamental Tack Type 2

Ornamental Tack Type 2 was represented by 85 artifacts from seven burials (see Appendix J.15). This tack type consisted of a domed, cylindrical, slotted, nonferrous, white metal head with a flanged, filigreed brim and a ferrous tack shaft. This type had a brim with a filigreed decorative band along the outer three-fourths of the brim. The sides of the dome were relatively straight, curving slightly at the interface with the brim, and the

dome was gently curved. It, or at least a similar version of tack, has been recovered in two cemetery excavations in the United States (see Table 54). The first definite appearance of this tack was illustrated in the 1865 *Markham & Strong Catalogue.* It was offered for sale in three known coffin hardware catalogs ranging in date from 1865 to ca. 1880 (see Table 55).

Ornamental Tack Type 3

Ornamental Tack Type 3 was represented by 42 artifacts from three burials (see Appendix J.15). It consisted of a domed, cylindrical, slotted, nonferrous, white metal head with a ferrous tack shaft. This type had a double filigree decorative form; the sides of the dome were slightly slanted and the lower filigreed collar squared. The dome was slightly flatter than Ornamental Tack Types 1 and 1.1. This tack, or at least a similar version, has been recovered in three cemetery excavations throughout the United States (see Table 54). The first definite appearance of this tack was illustrated in the 1861 *Sargent & Company Catalogue*. It was offered for sale in six known coffin hardware catalogs ranging in date from 1861 to 1874 (see Table 55).

Ornamental Tack Type 4

Ornamental Tack Type 4 was represented by 30 artifacts from two burials (see Appendix J.15). This tack type consisted of a domed, cylindrical, slotted, nonferrous, white metal head with a ferrous tack shaft. It had a double filigree decorative form, with the sides of the dome slightly slanted and the lower filigreed collar mirroring the very slight slant of the side. The tops of these tacks were almost totally flat in comparison to other forms present. This type, or at least a similar version of this tack, has been recovered in two cemetery excavations, one in the United States and one in Canada (see Table 54). It appears in only two period hardware catalogs between 1861 and ca. 1880 with the first definite appearance of this tack illustrated in the 1861 *Sargent & Company Catalogue* (see Table 55).

Decorative Studs

Decorative studs are a specific type of ornamental tack, which include geometric forms, such as diamond- and star-shaped studs, as well as representational forms, such as flowers, lambs, bells, crosses, etc. (Davidson 1999, 2004:420). These types of decorative studs, like the larger ornamental tack category, are commonly found in catalogs from the 1850s to ca. 1920+; however, many of these forms appear in the latter portion of this time range (Davidson 1999, 2004:419–420; Mainfort and Davidson 2006:153).

Ornamental Tack Type 5

Ornamental Tack Type 5 was represented by 35 artifacts from five burials (see Appendix J.15). This artifact type falls into the descriptive category of diamond stud because its overall shape was that of a diamond. It further functioned much like the dummy coffin screw in that its form mimicked the appearance of a coffin screw atop a diamond-shaped escutcheon. There was floral design on the top of the dome (somewhat corroded on all examples), as well as a vine or tendril extending outward from the edge of the dome toward the points of the diamond. The top of the dome was hemispherical and corroded, but halfway down the dome the diameter increased slightly, and the overall dome shape became octagonal and had parallel, vertical "edging" lines. The edge of the flat pressed base was slightly raised, which formed a border for the floral tendrils. Simple diamond studs were made of a pressed, cuprous foil, and they were reportedly manufactured beginning in the mid-1800s (Davidson 2004:420). However, Ornamental Tack Type 5 appears in six period hardware catalogs ranging in dates between 1871 and 1923 (see Table 55). This type of tack is known to have been recovered in only one cemetery excavation (see Table 54). The first definite appearance of this tack in a period catalog was illustrated in the 1871 *Sargent & Company Catalogue*. It was also recorded by Trinkley and Hacker-Norton (1984) in the A. L. Calhoun Collection recovered from the Calhoun General Store in South Carolina, which dated between 1894 and 1926. No specific design patent is known to exist for this ornamental tack type to further define when this form was introduced.

Ornamental Tack Type 6

Ornamental Tack Type 6 was represented by 10 artifacts from two burials (see Appendix J.15). This tack type consisted of a cross-shaped decorative stud made of pressed, cuprous foil. There was a floral image at the center point of the cross, and vines/tendrils emanated from that point and extended down each of four portions of the cross. A pair of leaves appeared at the edge of the flower on all but the lower sides. Each end of the cross was rounded and terminated with a smaller rounded point. This artifact type is not known to have been recovered in any of the other cemetery excavations used as comparisons in this research. The first definite appearance of this tack was illustrated in the 1871 *Sargent & Company Catalogue*. This exact item was offered for sale in two known coffin hardware catalogs with dates of 1871 and 1875. There are two more catalogs, dated 1874 and 1884, with extremely similar items (see Table 55).

China Nails

Used much in the same way as other decorative tacks, china nails are used in conjunction with china nail disks to decorate the outside of the coffin. The china nail consists of a brass or ferrous tack affixed to a domed ceramic/china head. This artifact type does not have a clear temporal range. They appear in only a few known catalogs in the 1880s and 1890s, but the fact that both elements of this artifact type were present in the United States much earlier than the use of the Alameda-Stone cemetery does not lend itself to clear temporal restriction.

Ornamental Tack Type 7

Ornamental Tack Type 7 was represented by 84 artifacts from two burials (see Appendix J.15). It consisted of a small brass tack affixed to a domed, ceramic head made of smooth, white paste with a clear glaze. The ceramic heads were adhered to the heads or shafts of the brass tacks with a white colored adhesive. This type of tack is not known to have been recovered in any other cemetery excavations used for comparison in this research. The first known appearance of this tack was illustrated in the *Illustrated and Descriptive Catalogue of Hardware, Showing a Standard Selection of Salable Goods in General, Building, and House Furnishing Lines* published by Thatcher W. Root in 1883. This exact item was offered for sale in two known general hardware catalogs with dates of 1883 and 1898, as well as the 1888 catalog of Sargent & Company, which carried coffin hardware (see Table 55).

Coffin Screws

The general hardware category of coffin screws consists of a form of hardware with a white metal screw cap affixed to a ferrous screw shaft. The top of the white metal cap has a slot to accept a screwdriver for mounting (Davidson 1999, 2004:400). Mainfort and Davidson (2006:141) note that coffin screws were commonly used in sets of four or six, with one screw placed at each corner of the coffin, with the possibility of an extra set mounted at either the shoulder or waist of the coffin. It can be noted, however, that in cases where only a set of two is present, these screws are often mounted at the head and the foot ends of the coffin.

Coffin screws were in common usage by the 1850s; they made their first known appearance in the 1853 Peck and Walter Manufacturing Company catalog. A U.S. patent was granted to W. H. Nichols for this type of screw on July 26, 1859 (U.S. Letter Patent No. 24911). However, no specific design patent is known to exist for the coffin screws recovered at the Alameda-Stone cemetery. Coffin screws were replaced by thumbscrew forms in large part in the 1870s and 1880s and, by the late 1880s, were carried only by general hardware suppliers and jobbers (Mainfort and Davidson 2006:141). Because coffin screws were common starting in the 1850s, the known catalog matches discussed below do not necessarily limit the temporal range for the use of these screws. The overall temporal range of coffin screws ranges from about 1850 to 1910.

Coffin Screw Type 1

Coffin Screw Type 1 (Figure 60a) was represented by 68 artifacts from 11 burials (see Appendix J.16). This screw type consisted of a domed, cylindrical, slotted, nonferrous, white metal head with a flanged, filigreed brim and a ferrous screw shaft. It had a wide filigreed decorative band along most of the brim. The sides of the dome were slanted slightly and the dome was gently curved; the brim was also slanted. This item, or at least a similar version of this screw, has been recovered in four cemetery excavations throughout the United States (Table 56). It appears in eight period hardware catalogs ranging in dates between 1874 and 1882e (Table 57).

Coffin Screw Type 2

Coffin Screw Type 2 (see Figure 60b) was represented by 50 artifacts from 10 burials (see Appendix J.16). This artifact type consisted of a domed, cylindrical, slotted, nonferrous, white metal head with a ferrous screw shaft. The sides of the dome were slanted slightly and the dome was gently curved. The filigreed collar was slanted slightly mirroring the slant of the sides. This type of screw, or at least a similar version of it, has been recovered in three cemetery excavations throughout the United States (see Table 56). It appears in only two period hardware catalogs ranging in dates between 1865 and 1895 (see Table 57).

Coffin Screw Type 3

Coffin Screw Type 3 (see Figure 60c) was represented by 19 artifacts from five burials (see Appendix J.16). This screw type consisted of a domed, cylindrical, slotted, nonferrous, white metal head with a ferrous screw shaft. The sides of the dome were slanted, and the dome was curved. The filigreed collar was squared. It, or at least a similar version, has been recovered in five cemetery excavations throughout the United States and Canada (see Table 56). This screw type appears in six period hardware catalogs ranging in dates between 1865 and 1874 (see Table 57).

Coffin Screw Type 4

Coffin Screw Type 4 (see Figure 60d) was represented by 25 artifacts from six burials (see Appendix J.16). This artifact type consisted of a domed, cylindrical, slotted, nonferrous, white metal head with a flanged, filigreed brim and a ferrous screw shaft. It had a filigreed decorative band along the outer three-fourths of the brim. The sides of the dome were slanted slightly, and the dome was gently curved; the brim was slanted slightly. This type of screw, or at least a similar version of it, has been recovered in three cemetery excavations throughout the United States and Canada (see Table 56). It appears in only three period hardware catalogs ranging in dates between 1857 and ca. 1890 (see Table 57).

Coffin Screw Type 5

Coffin Screw Type 5 (see Figure 60e) was represented by three artifacts from two burials (see Appendix J.16). This screw type consisted of a domed, cylindrical, slotted, nonferrous, white metal head with a ferrous screw shaft attached. This artifact had a double filigree decorative form, with the sides of the dome slightly slanted and the lower filigreed collar mirroring the very slight slant of the side. The top of this screw was almost totally flat in comparison to other forms present. This type, or at least a similar version of this type of tack, has been recovered in three cemetery excavations throughout the United States and Canada (see Table 56) It appears in only seven period hardware catalogs dating between 1865 and 1895 (see Table 57).

Decorative Hardware

Approximately 38 burial containers in the Alameda-Stone cemetery were adorned with some form of decorative mortuary hardware, such as handles, coffin screws, and ornamental tacks. Appendix J.13 reveals the total number of artifacts per hardware type. The presence of decorative mortuary hardware in this period in Tucson history is a clear economic indicator. The railroad did not enter Tucson until May 1880, 5 years after the civilian section of the cemetery had been closed for burials. The military section remained open until February 1881, but only two burials were recorded as having taken place in the military section during the interval between the arrival of the railroad and the closing of the military section, those of Hospital Steward Charles Knaeble in July 1880 and Corporal John Lyons in January 1881. Both of the grave pit features (Features 28076 and 28077) correlated with the historically recorded graves of these two individuals contained decorative mortuary hardware which, given the timing of burial, suggests that the decorative hardware in these graves could have been transported to Tucson via the railroad. By contrast, the hardware that was documented throughout the remainder of the cemetery would have had to travel by stage from the manufacturers in the eastern United States or from a port city where goods had been shipped at least part of the distance by sea. As no records have been located for general hardware distributors in Tucson, the actual retail cost that would have been incurred with the addition of decorative hardware on burial containers is unknown. Wholesale costs of the hardware types documented in the Alameda-Stone cemetery can be gleaned from period hardware catalogs (Table 58).

If the inclusion of decorative hardware reflects on the apparent wealth of the families of the individuals interred, then one might expect the members of the same family to have been buried with similar embellishment. As family members were often buried nearby one another in historical-period cemeteries, a look at the geographic distribution of decorative hardware might elucidate patterning. First, no pieces of decorative hardware were recorded in Cemetery Area 4. Second, Grave Pit 3083/Burial Feature 3421 and Grave Pit 3084/ Burial Feature 3980 were immediately adjacent to one another, and although both contained decorative hardware, the hardware style types did not overlap. Without a clear indication of overlap, it is difficult to make a correlation between the two. Grave Pit 28076/Burial Feature 28559 and Grave Pit 28077/Burial Feature 28535, on the other hand, share proximity and several decorative hardware types. One explanation may be that these two graves held later interments, were contemporaneous to each other, and were the sites of burial for two prominent citizens. Although there is insufficient evidence to positively identify these remains, Heilen et al. (Appendix K suggest the two graves spatially correlate to the graves of Hospital Steward Charles Knaeble (Grave Pit 28076) and Corporal John Lyons (Grave Pit 28077), both of whom died after the arrival of the transcontinental railroad in Tucson. A wider range of goods and services may have been readily available and may explain the evidence of professional undertaking and ornate coffin treatments.

No types of handles or ornamental tacks were found in Cemetery Area 5, but this is understandable when one considers the relatively few number of burials in this area compared with other areas.

Overall, most pieces of decorative hardware were found on the burial containers of adults, however, decorative hardware was documented for each ASM age category. Additionally, hardware appeared on the burial containers of individuals who exhibited cultural, religious, and biological affinities of all types. Differences in frequencies within each category seem to reflect general differences in cemetery area, as well as total cemetery population.

Surface Treatments for Burial Containers

Relatively little has been systematically presented in the published archaeological literature about the types of surface treatments encountered during historical-period cemetery or burial excavations. This is largely because surface treatments rarely preserve. Degree of physical preservation does indeed limit the scope of observation, but absence of evidence does not necessarily indicate absence of practice. For example, paint or cloth may not

preserve except in association with metal hardware. It is up to the excavators and artifact analysts to piece together enough of the extant information to make accurate, data-informed hypotheses about burial practice.

There are two surfaces of a burial container that need to be discussed, the exterior and the interior. When surface treatments have been addressed in the previous literature, primacy has been given to the exterior surface treatments. However, both exterior and interior treatments played a role in the social presentation of the deceased during the funeral, and both contribute important information to interpretation of mortuary behavior. It is important to note that there is little agreement or synthesis about the presence or social importance of variable surface treatments.

Although the social importance of surface treatments may be somewhat ambiguous, the economic impact of certain practices can be more easily determined. In 1831, the Columbia Cabinetmaker's Society published a price list for various wooden items, which included coffins. The price list recorded the price paid for labor involved in the production of certain types and sizes of coffins, and also for extra services such as finishing. This price list attests to the fact that different woods, different sizes of containers, and different types of surface treatments influenced the price of the burial container, and thus the material representation of the funeral. Furthermore, the materials with which the cabinetmaker, in this case, was working may require different types of surface treatments such that lighter-colored softwoods would appear similar to the darker-colored hardwoods. For instance, the mahogany coffins were to be oiled, whereas poplar coffins were to be stained and then oiled. Poplar was not stained because of a physical requirement; instead, the practice developed through a process of socially elevating negotiation whereby the lighter-colored softwood was transformed into something more reminiscent of an expensive hardwood.

A few consistencies in exterior surface treatments were noted in the Alameda-Stone cemetery sample. Approximately 219 cloth-covered burial containers were recorded (see Appendix J.8). The majority (n = 185) of these were found in Cemetery Area 3. Cloth coverings were present with burial containers of all shapes in roughly the same proportions. Juveniles, particularly infants, were the ones most commonly associated with cloth-covered burial containers. However, expensive types of fabrics such as velvet were almost exclusively associated with adult males.

There were similar tendencies in the presence of certain types of paints with regard to patterning along the age and sex categories. The use of green and blue paints was identified for graves associated largely with infants and children. Although it is difficult to assign biological or cultural affinity to the remains of juveniles, the overall sample of individuals with burial containers covered with green and blue paints showed a tendency toward Hispanic origins. White paint was also in elevated numbers but did not show any distinction between sex or age categories, although it tended to be present on more hexagonal coffins. Table 59 lists other cemetery excavations that encountered evidence of paint on the exterior of coffins.

Interior surface treatments followed similar strictures as those described above with relationship to paints. Interior fabric linings, however, were common, being identified with 475 burial containers in all cemetery areas, across demographic boundaries. Again, however, as with the exterior fabrics mentioned above, velvets were seen with a couple of adult males, whereas fine cotton, silk, or satin fabrics were associated with females and juveniles.

The presence of fine fabrics in burials, such as velvet, silk, and satins, are in some cases indications of wealth. Silk, for example, was produced in limited quantities in the United States during the mid- to late nineteenth century. Most silk garments and textiles were imported from Europe at that time and therefore would have been more costly than locally produced materials (Buikstra et al. 2000:68). Acquisition of fine imported fabrics would have been that much more difficult for Tucson residents because of their location on the frontier.

Exterior Treatments

Mainfort and Davidson (2006:113) state that there are generally three ways to finish the exterior of a coffin or casket's outer surface: (1) staining—including blackening with soot—to which will be added varnishing and waxing; (2) painting; and (3) fabric or cloth covering. Each of these types of surface treatments are discussed here so there might be a contextual base with which the archaeological data derived from the Alameda-Stone

cemetery excavations can be compared. Exterior treatments of burial containers at the Alameda-Stone cemetery included painting, possible lacquering, cloth covering, and possibly decorating with tacks. Appendix J.8 lists all of the burial containers recovered as well as the type of exterior treatment encountered.

Coffins and caskets have historically been constructed of many different types of materials. In cabinet or furniture making, it is less expensive to use light-colored softwoods for the construction of unseen parts of cabinets or furniture. In the same way, the bases or bodies of burial containers were sometimes constructed of cheaper materials, whereas more visible parts, such as the lid, were constructed of dark hardwood. Historically, stains, waxes, and varnishes have been used to create a fine finish on the exterior surface of burial containers, with dark stains being used on light-colored wood to mimic dark woods, such as walnut or mahogany, which were more expensive (Bastis 2006:44; Coffin 1976:103; Lang 1984; LeeDecker et al. 1995; Mainfort and Davidson 2006:114). Many have suggested that the practice of emulating expensive woods is the poor and middle-class attempt to symbolically or superficially rise to the socioeconomic appearance of the elite (Bybee 2007a:86–87). Status shuffling aside, dark woods, or their simulated counterparts, were fashionable during the late nineteenth century and may have been an aesthetic extravagance used to express respect and adoration for the deceased. A black or dark-colored lacquer or resin was also identified on the burial containers of two infants and one middle adult male. No stains or waxes were identified during excavation and analysis.

Painting was a very common surface treatment for coffins and caskets in the late nineteenth century. Many of the period catalogs sold burial containers with white painted exteriors, known as "gloss white" (Chappell, Chase, Maxwell & Co. 1884; Cleveland Burial Case Co. 1882; Hazelton Coffin and Casket Co. 1883; National Casket Co. 1899; Paxson, Comfort & Co. 1884, 1898; St. Louis Coffin Co. 1901). Mainfort and Davidson (2006:114) posit that this gloss white was likely made of an organic material, possibly a milk-based or casein-based paint. Casein is a prominent phosphoprotein in cow's milk and was used commonly as an ingredient in paints in the nineteenth century (Davidson, personal communication 2009). It is also possible, however, that this gloss white paint, rather than an organic paint, was made with a white mineral pigment, such as zinc white, which was a popular late-nineteenth-century pigment. Whatever the nature of the paint composition, Mainfort and Davidson (2006:114) assert that this white, painted coffin was the most common color advertised, especially for children's burial containers; however, it would seem that in the catalogs mentioned, there were just as many gloss white containers for adults as there were for children.

Other colors, such as red, yellow, and blue have also been noted in the popular funeral literature. Coffin (1976:103–104) noted that some softwood coffins were painted. One "old-timer" in Coffin's (1976:103–104) discussion is said to have stated:

> The old red paint? Gosh, the kind they put on cheers[sic] and coffins and light stands? That was the plain yellow ochre got out of the ochre pits and roasted or burned into a soft clinker. Same as they get darker ends on the bench bricks 'cause they're laid nearest the fire, you get red instead of yellow ochre after this extry roasting. Then they ground it up. 'Twas awful cheap so they used it on most everything. I seem to have forgot but I reckon this was the old Venetian Red that folks bought for two cents a pound and mixed with oil or milk. Those that lived down Maine way and was handy to fish, used fish oil to stir it up with, and it kept the powder from flying off. Yes, they was uncommon generous with that old paint.

Yellow ochre was also mentioned by Hasson (2001) in the production of yellow paints. Plume discusses the use of blue pigments in the exterior treatment of children's coffins in England, "it is usual to cover, or colour small coffins with blue . . . pigment, indigo, or ultramarine blue" (Plume ca. 1890:39, 41).

The paint that was once present on the coffin or casket does not generally preserve well in most archaeological settings. The paint has a higher probability to be preserved on the underside of hardware or near other metal artifacts. A number of historical-period cemeteries excavations across the United States and Canada have revealed paints of various colors, including red, green, yellow, orange, pink, blue, gold, brown, white (organic), white (lead), gray, and black (see Table 59). In other cemetery settings in the southwestern United States, colors such as blues, greens, yellows, reds, and whites dominate. However, Mainfort and Davidson (2006:114) suggest that what is most often seen archaeologically is the primer layers and not the paint itself. Although this may be true in some cases, the instances where layered pigments are present clearly represent

actual paint layers. For instance, at Meadowlark Cemetery in Manhattan, Kansas, two types of color combinations were notably used as exterior surface treatments (Pye 2007:134–135).

It is wise to follow the advice of Welsh (1982:30) who suggests the use of the Munsell color charts in the identification of paints to gain conformity in paint analysis. However, merely noting the presence of some color does not reveal the meaning behind those colors and their importance in creation of design elements on the surface of burial containers through the application of social traditional knowledge. For example, the Pennsylvania Dutch at Voegtly Cemetery used a wide variety of colors on their coffins and on the furniture produced in the community at large. For them, bright colors represented nature and the use of such colors to be a celebration of God's universe, with death being an integral part of life (Beynon 1989:108). Future research should focus on the identification of elements of surface treatments with respect to certain culture-specific associations of certain treatments, wood types, and demographics, and how these would preserve archaeologically as a comparison to those that are recovered in historical-period cemetery settings. It is unclear what importance colors of paint may have played in the embellishment of the burial containers in the Alameda-Stone cemetery.

At least 165 burial containers had, at one point, been painted on the exterior surfaces. Colors encountered included green, blue, white, black, yellow, pink, red, and gray. Approximate frequencies of total counts of colors are as follows: green (n = 114), blue (n = 26), black (n = 7), yellow (n = 4), pink (n = 3), red (n = 2), and gray (n = 1). In a number of cases, however, multiple colors were noted on the same burial container. Layered pigments included green over white (n = 2), green over yellow (n = 1), green over black (n = 1), green over blue (n = 9), and green over blue over yellow (n = 2). In other instances, multiple colors were present, but it was not clear whether they had been layered or applied to different parts of the burial container. These color combinations included yellow and black (n = 1); blue and white (n = 1); pink and red (n = 1); and green, pink, and blue (n = 1). There were at least 98 burial containers that exhibited only green paint, 19 white, 13 blue, 5 black, 1 pink, 1 red, and 1 gray. No yellow pigment was apparently used as a stand-alone surface treatment. As suggested by other cemetery excavations (i.e., Mainfort and Davidson [2006] and Pye [2007]), it is likely that the yellow and gray pigments, and possibly the red pigments, were primer layers rather than true paint coatings.

Decorative patterns of paint were also encountered. One burial container (Grave Pit 7816/Burial Feature 14653) seemed to have been painted green and then embellished with yellow swirl patterns. One burial container (Grave Pit 7929/Burial Feature 18676) seemed to have been decorated with green floral/leaf patterns on the top of the lid. Finally, one burial container (Grave Pit 7708/Burial Feature 16588) had a green cross painted on the foot board. All of these decorated burial containers contained fetal or infant remains.

Although no formal chemical analyses of paint were undertaken, it is possible to make some general observations and hypotheses about the compositions of the paints documented in the Alameda-Stone cemetery. The green and blue paints, although distinct at their extremes, had a great deal of color variation in the blue-green range. It is possible that this was the result of mineral pigments used. Some grades of emerald-green pigment tend to have a bluish cast, whereas paints produced with cobalt blue pigments have a tendency to turn green under certain conditions. Yellow and red paints were likely produced using some form of ferric oxide. The white paints in the cemetery were possibly produced using mineral pigments but were more likely formed from organic components, such as casein. Pink paints would have been produced using a combination of a base white and an additive such as blood or some other red substance (Coffin 1976). The black paints would have been produced using a mineral such as lamp black or some other carbon-cased pigment.

Cloth coverings evolved out of the pall or mort cloth, which was draped over the burial container or body prior to interment (Mainfort and Davidson 2006:114). A British guide to coffins and coffin making by Sable Plume published in *The Undertakers' Journal*—and later reprinted in book form likely sometime in the 1880s—details the process of covering a coffin with cloth. In this source, a common black (broad) cloth and velvet are mentioned as the most common types of cloth covering. This method of covering was useful because the wood could be of lower quality and left relatively rough (Litten 1991:103). If the cloth was wide enough to cover both sides, it was divided in such a way as to cover the sides of the coffin. Both pieces would then be tacked at the foot end going in the same direction. The first piece was brought around one side until it reached the head, and the second would be folded back over the tacks hiding them from view, and then brought around the opposite side until it met the end of the first piece at the head of the coffin. In this way,

only a few tacks at the head would be visible (Plume ca. 1890:64). The bottom edges of the material would be folded under and tacked or glued on the bottom of the coffin. In the same way, a piece of material was cut for the lid and folded to attach to the underside of the lid (Plume ca. 1890:65).

One of the earliest recorded cloth-covered coffins was that of Queen Elizabeth I, who died in 1603 (Mainfort and Davidson 2006:114). The practice was carried over from Europe to the Americas during the colonial era. Coffin (1976:109–110) records excerpts from the daybooks of David Evans, a Philadelphia cabinetmaker from 1774–1811. In one entry dated March 7, 1793, Evans states, "Daniel Rundle, making a coffin for his wife Ann Rundle, covered in black cloth, lined with white flannel. Inscription plate, flowerpots, cherubs, handles and full lace, £15" (Coffin 1976:109–110). Mainfort and Davidson (2006:114) state that in the early nineteenth century, people in the United States commonly covered coffins and caskets with broadcloth of various colors. It was not until 1872 that a specific line of cloth-covered caskets was patented by Samuel Stein of Stein Manufacturing Company, Rochester, New York (U.S. Utility Patent No. 132,605) (Habenstein and Lamers 1955:277; Mainfort and Davidson 2006:114).

Stein specialized in cloth-covered caskets, and later, founded the National Casket Company, known for its cloth-covered caskets developed out of the Stein cloth-covering department (Habenstein and Lamers 1985: 173–174). A variety of fabrics and colors could be ordered from the 1899 *National Casket Company, Pocket Edition Price List of Casket Catalogue D*. Included in this list are broadcloths, plushes, piqués, crape, momie cloth, satin, sateen, and velvet.

Although Stein was the first known individual to have been issued a patent mentioning cloth covering, his specific invention was for improvements in casket design rather than being primarily focused on cloth covering. The practice of cloth covering was already well developed; other coffin and casket manufactures began to advertise cloth-covered caskets at least by the early 1880s and likely even earlier. Hamilton, Lemmons, Arnold & Company produced a line of cloth-covered coffin and caskets as early as 1882. Types of cloth-covered caskets available in the 1884 *Hamilton, Lemmons, Arnold & Company, Revised Price List of Varnished & Cloth-Covered Burial Cases and Caskets*, included broadcloth, brocatelle, piqué, and velvet, in several different colors or combinations of fabrics and trimmings.

Archaeologically, it is very difficult to make observations on cloth covering because in most cases fabrics do not preserve. Unless some form of protective vault was used, cloth coverings on coffins or caskets are particularly vulnerable to processes of decomposition because of their immediate contact with the soil. Evidence of cloth coverings may be preserved, however, on certain types of coffin hardware, or in special circumstances where preservation is good (Mainfort and Davidson 2006:114).

There were approximately 219 burial containers in the Alameda-Stone cemetery that showed clear evidence of having been covered with some sort of cloth. This evidence most often took the form of fabric impressions on the heads of nails or on the surfaces of other metal hardware. Small pieces of actual fabric were preserved in some instances, however.

At least five burial containers had been covered with velvet. Of these five, at least one had been covered with black velvet, and one had been covered with scarlet velvet that had faded to a dull reddish brown. Colors of the other three velvet samples were not noted by analysts or excavators.

The rectangular burial container in Grave Pit 7953/Burial Feature 18926 was covered with an off-white, floral-patterned, embossed felt. This material was labeled as felt because it had no discernible thread or weave structure. It was the only clear case of felt being used as a covering for a burial container in the cemetery. The felt had been embossed with floral patterns, likely as a result of being passed through a calendaring process.

Three other features contained small fragments of white cotton, plain/balance-weave fabrics with thread structures preserved to the extent that the ends and picks per inch (epi/ppi) of material could be reasonably estimated. Grave Pit 13529/Burial Feature 21667 had material with an epi/ppi of 64. Grave Pit 10309/Burial Feature 28677 had two pieces of fabric preserved, one with an epi/ppi of approximately 60 and the other 40. Grave Pit 840/Burial Feature 6772 contained fabric with an estimated 40 epi/ppi. There are a number of possible fabric types that could match these characteristics. The two that seem to be more likely are muslin and piqué. A larger sample would be needed for a definitive identification.

Other fabrics or fabric impressions noted during excavations were not as easily identified because of poor preservation. Colors noted in this category were cream, tan, brown, black, and green. Approximately 26 burial

containers appeared to have been covered with a plain or balance-weave fabric. The texture of such fabrics ranged from very fine varieties (possibly silk or satin), fine, medium-coarse, and coarse. The burial container in Grave Pit 13942 had both white cotton and coarse wool fibers in the preserved fabric sample. Because of the state of preservation, it was not clear if this was one fabric constructed of two types of materials or whether the burial container had a combination cover.

One final covering needs to be mentioned. On one burial container in Grave Pit 22157/Burial Feature 21848, there was a small fragment of a coarse, grass fiber mat. This mat appeared to have been brown in color and woven in a plain-weave fashion. It is unknown what the complete product looked like or what function it served. It was located atop a fine, ribbed, fabric (possibly the backing of velvet) on the exterior of a metal joining plate.

Metal lining tacks are discussed in greater detail in the sections on interior surface treatments below. However, brief mention needs be made here because there were at least 50 burial containers at the Alameda-Stone cemetery that were constructed with tacks on the exterior of the surface of the container, 25 of which only showed tacks on the exterior. The exterior tacks were likely used to affix cloth coverings to the burial container as evidenced by the presence of extant fabric or fabric impressions on the heads of nails and/or on other hardware. Not all burial containers with exterior tacks showed additional evidence of cloth covering, however. At least 2 burial containers had brass tacks affixed to the exterior surface but showed no indication of cloth covering. This could reflect poor preservation or could suggest that the tacks were used for a decorative rather than a functional purpose.

In 60 cases, there was both paint and fabric present. Green was the most common paint associated with fabric (n = 39). There were also 4 blues, 5 whites, 2 blacks, 5 blue/green combinations, 1 green/yellow combination, 1 green/pink/blue combination, and 2 green/blue/yellow combinations. In all of these instances, it appeared that the paint was applied to the outer surface of the fabric. It is possible that the paint and fabric were applied to different portions of the exterior of some burial containers. Grave Pit 709/Burial Feature 13422 held a burial container that exhibited green and black paint as well as cloth covering. According to the excavator's notes, the green and black paint were found only on the exterior surface of the lid, whereas fabric impressions were located on nails on the sides of the container. This could suggest that only the body of the container had been cloth covered and the lid had been painted.

Interior Treatments

For the local craftsmen, cabinetmakers, undertakers, and commercial coffin and casket manufacturers, just as much time, energy, and for the consumer, money, went into treating the interior of burial containers as treating the exterior. The interior of a coffin or casket could have been left bare for various reasons, but more often than not, the interior received some form of treatment. The most common interior treatment was simple cloth lining, although occasionally the interior surfaces were painted, as discussed earlier in this chapter.

Just like the construction of the burial container itself and the exterior treatment, the interior treatments of coffins and caskets carried certain social meanings and reflected cultural traditions and beliefs. Coffin (1976: 102) states:

> Traditionally, old-time carpenters brushed together all of the sawdust and shavings accumulated from making a coffin and placed these scraps inside it. Superstition taught that if these bits of leftover wood were tracked into a house or carelessly shaken from clothing, they would endanger whomever they touched, and that person might become death's next victim.

These wood shavings, while having a social reason for inclusion in the coffin, also served a functional purpose. After construction of the burial container, the cracks were filled with pitch as a sealant, and the sawdust was used for extra padding to prevent shifting of the body, but primarily to absorb the fluids resulting from primary decomposition (Janaway 1998:23; Litten 1991:92, 1998:11; Stock 1998:148). In some cases, newspapers, bran, straw, or cotton waste were also used to make linings appear more luxuriant, full, and textured (Hasson 2001; Plume ca. 1890:21).

In the late nineteenth century, the development of the coffin and casket industry and the perception of the burial container as a bed-like vessel prompted the further elaboration of coffin and casket linings. Mattresses developed out of the layer of sawdust or other absorbent material upon which the linings were placed. Mattresses covered the entire bottom of the burial container and consisted of plain woven covers or cloth embellished with frills or rosettes (Janaway 1998:22) Pillows were also often included in the burial container. Sets of linings could often be purchased from period catalogs that sometimes included both mattresses and pillows of the same decorative style (Janaway 1998:22).

Burial Container Liners

Davidson (2004:417) has asserted that "except in the cheapest of burials, all coffins were once upholstered and then lined in cloth." In fact, one of the more substantial portions of the total cost of a funeral, or at least of a coffin or casket, would have been the lining. The 1899 *Pocket Edition Price List for Casket Catalogue D* issued by the National Casket Company lists the prices associated with lining a coffin with materials such as muslin, satin, merino, and canton flannel (Table 60). This price list shows that prices varied considerably for different materials and for lining burial containers of different dimensions.

At the very least, coffins required only a simple inside lining or heading. This could be a single piece of fabric depending on the width of the material or could be composed of side wall pieces and a bottom piece. Plume (ca. 1890:21–23) details the process of lining a coffin (for a description of lining a casket, see also Hohenschuh [1900:126–132]). After placing the pitch around the inside of the coffin to seal the container, a layer of sawdust was used to stabilize the body. Over this sawdust was placed a piece of cloth cut to the shape of the bottom. This bottom piece of fabric would later earn the title of "mattress." The side pieces were cut from a cloth long enough that the pieces might reach along one side, across the head, and 4 inches over, matching the shape of the side of the coffin. The lining could either be tacked near the top edge of the coffin, thus allowing the wood to show, or the fabric could be pulled over the edge and tacked down from the top, covering the wood.

To this most basic level of coffin lining, it was possible to add several varieties of trimming, including a top, fringe, lace, tassels, cords and gimp—a flat trimming made from twisted silk, worsted wool, or cotton yarns. The development of the hinged half lid on the coffin, and later the full or half-hinged lid of the casket, prompted the introduction of the skirt and the overskirt. A glance through the 1882, 1884, and 1886 price lists of burial robes and linings of the Hamilton, Lemmons, Arnold & Company reveals that in the near 200 types of linings offered for sale, a variety of trimmings could be purchased in different combinations and colors. These trimmings were made of various materials sometimes at greater cost.

Lining and trimming materials were also sold individually as piece dry goods. Table 61 shows the descriptions and costs of such items as they were advertised in the 1884 *Revised Price List of Burial Robes and Linings*, published by the Hamilton, Lemmons, Arnold & Company. Analysis of these tables suggests that buying the full range of materials needed to line a coffin or casket piece-meal would incur a greater total cost than purchasing combination sets of linings.

Lining Tacks

As the name implies, the primary function of a lining tack is to tack down the fabric lining on the interior of a coffin or casket. There are a variety of small tacks that fall into this broad category, including both ferrous and cuprous flat-headed cut tacks; ferrous or cuprous domed-headed gimp tacks; as well as 7-line to 14-line, silk-headed lining tacks. Davidson (2004:417) reported that the most common type of tack found in excavations at Freedman's Cemetery in Dallas, Texas, were composed of two parts: a short iron shank and a plain, domed, lead head.

Table 62 shows the listings of lining tacks in the 1884, Hamilton, Lemmons, Arnold & Company price list. As the names of the tacks sometimes imply, certain types of tacks were often used for certain functions.

The gimp tack, for instance, would have commonly been used to tack down the gimp around the upper margin of the coffin perimeter. The lace tack would have been used to secure the lace, and the tufting tack the tufting. Although it is true that certain types of tacks were more commonly used as lining tacks, other varieties of tack could also have been used, including upholstery tacks or French nails. In fact, any simple steel, iron, or brass tack, and even small brads or nails may have been used in certain situations to tack down interior coffin lining or exterior cloth covering.

Davidson (1999; 2004:417) suggested that any number of small tacks recovered from a burial likely served as lining tacks. Furthermore, the presence of these supposed lining tacks could act as a proxy indicator for the presence of lining materials in cases of poor preservation of organic materials. Evidence of coffin lining, in most cases, exists on the underside of tack heads, or in association with other metal coffin elements or metallic personal items, such as cuprous medallions or crosses. It is often very difficult, if not impossible, to distinguish between coffin lining material and articles of clothing. Nonetheless, the presence or absence of a coffin or casket lining is an important economic observation. The recovery and accurate analysis of lining tacks serves to give greater assurance to the presence of a coffin lining (Davidson 2004:418).

A note of caution is warranted, however. One should not be too quick to assume the presence of coffin lining based on the mere identification of lining tacks or other types of tacks without consideration of the archaeological context. Small tacks were also used to secure cloth covering on the exterior of the coffin or casket or to secure other decorative elements such as tassels or cordage. Beynon (1989) reports the presence of serpentine, copper wire rickrack tacked around the outside perimeter of some cloth-covered coffins at the Voegtly Cemetery in Pennsylvania. As evidenced by excavations from earlier cemeteries, such as the New York African Burial Ground (Perry et al. 2009) and the Bulkeley Tomb, in Colchester, Connecticut (Bastis 2006), small tacks were often placed on the lids of coffins in order to give information, such as dates of death or names, or merely as aesthetic elements (Bromberg et al. 2000:162; Lang 1984:23; Rauschenburg 1990:41). Careful attention must be paid to the context of recovered tacks if accurate interpretations are to be made.

Pillows

One other aspect of interior coffin treatment yet to be discussed is the presence of a pillow, or some object upon which the head of the deceased was laid. During the late-nineteenth-century's Beautification of Death Movement, as discussed by Bell (1990, 1994) and elsewhere in this report, the deceased was often characterized as sleeping, a conception that acted to normalize the view of the coffin or casket as a bed. Pillows likely appeared in period catalogs since the first mortuary supply company expanded production beyond hardware; however, only three known listings or advertisements for pillows appear in the sample of comparison catalogs.

Pillows can be made from a variety of materials and come in many different styles. Page 161 of the ca. 1890, Paxson, Comfort & Company catalog, *Wholesale Pricelist of Burial Robes, Wrappers, Dresses, Suits, Habits,* advertised "very fine artistic hand-embroidered pillows made from coburg, sateen, cashmere, wool merino, silk and satin." Those fabrics could be produced in colors such as white, cream, drab, steel gray, pink, blue, and black to match the style and color of associated Paxson, Comfort & Company coffin/casket linings. Several styles mentioned include puffed, plaited, and honeycomb, although it is mentioned that other popular designs could be ordered for a cost ranging between $0.25 and $25.00.

Satin was by far the most popular material for manufacturing pillows as evident in the available catalogs. The November 1, 1886, *Price List of Wrappers, Robes, Linings, Trimmings, & Etc.* manufactured by Hamilton, Lemmon, Arnolds & Co. lists six types of satin pillows for adult-sized caskets with three different levels of product quality ranging in price from $2.00 to $6.00 and three types of satin pillows for children's caskets ranging in price from $0.80 to $1.75. Unfortunately, no illustrated catalogs were available for comparison matches to be made with the Hamilton, Lemmon, Arnold & Company price lists.

Interior Treatments at the Alameda-Stone Cemetery

Interior treatments of burial containers at the Alameda-Stone cemetery included pillows and linings, as well as painting. Appendix J.8 lists all of the burial containers recovered as well as the type of interior treatment encountered. A brief description of the materials and frequencies is given below.

Because of the lack of preservation for most of the fabrics and other organic materials included in the burials at the Alameda-Stone cemetery, it is difficult to determine whether most individuals were interred with pillows, and if so, what type of pillows. Only three individuals are known to have been buried with their heads resting on some type of object. Grave Pit 24985/Burial Feature 25351 contained an adult female buried in a trapezoidal coffin and interred with an adobe brick below the head. Grave Pit 13578/Burial Feature 25064 held the remains of a middle adult female of Yaqui cultural affinity. The head of the this decedent was resting on a degraded satin-covered pillow filled with a sawdust material. Grave Pit 7748/Burial Feature 25054 had a possible pillow below the cranium. This pillow appeared to have been stuffed with cotton or wool and was covered with a now-degraded wool fabric. No other clear indications of pillows were encountered during excavations. Two of these graves were in Cemetery Area 4, and Grave Pit 13578/Burial Feature 25064 was in Cemetery Area 3.

Burial container linings were just as elusive. Approximately 500 burial containers in the Alameda-Stone cemetery appeared to have been lined with some sort of fabric. This was suggested either by the presence of interior lining tacks or remnants of lining fabric. Because it is difficult to distinguish between remnants of clothing and lining fabric, interior lining tacks are a better indicator of burial container linings.

In those situations where fabric was preserved, there was a range of colors and materials. Colors of fabrics encountered were brown, yellow/brown, white/cream, white, green, black, and pink/green. All fabrics were somewhat degraded, and colors may not have represented the original fabrics. Types of fabrics ranged from finely woven silks; fine cottons; pleated cottons; medium-coarse, woven fabrics; coarse, grass fiber matting; coarse, twilled fabric; possible felts; and velvet. Because of the lack of overall organic preservation, little can be said regarding the overall demographic pattern of burial container linings. That said, there are some observations that can be made. Velvets, or possible velvets or felts, were found with at least two adult males and one subadult. Satin, silk, or other finely woven fabrics seemed to be present with the burials of infants and adult females.

In one burial (Grave Pit 7802/Burial Feature 25210), a noteworthy portion of the interior container treatment was preserved, the gimp (Figure 61). The gimp consisted of dark green and yellow/white yarns interwoven so that the dark green strands formed distinct vertical bands and the white threads were visible on the face forming "X" patterns horizontally across the gimp. This material had been tacked to the upper margin of the interior of the burial container. This was the only instance of preserved gimp in the Alameda-Stone cemetery, and it was found in association with an adult burial of unknown sex and cultural affiliation. This grave was located in Cemetery Area 4.

Some form of lining tack was recovered from approximately 510 burials in the Alameda-Stone cemetery. There were five types of tacks present: silk-head lining tacks, which appeared in 28 burials; domed-head ferrous tacks, found in 21 burials; flat-head ferrous tacks, recovered in 456 burials; flat-head brass tacks, included in 7 burials; and decorative French nails/upholstery tacks found in only 1 burial. All flat and domed-head brass and ferrous tacks were cut with sheared, pointed tips. The silk-head tacks and upholstery tacks appeared to have rounded, pointed shafts.

Approximately 485 burial containers had lining tacks on the interior, indicating that they had been used to affix cloth lining to the wood. Tacks varied in size both in head diameter and length. For example, there were two sizes of silk-head lining tacks present: 7-line and 10-line. Most of the tacks used in burial contexts were $^{1}/_{2}$ or $^{3}/_{4}$ inches long, although there were also some that were 1 inch long.

In several cases, multiple types of tacks were used in the same burial container. As was discussed previously in the lining tack section, some types of tacks were used for different functions. Unfortunately, contextual information about the placement of lining tacks was not usually recorded beyond noting whether the tacks appeared to be on the interior or the exterior of the burial container.

There was a wide range of colors of paints used on the interiors of 72 burial containers recovered during the Alameda-Stone cemetery excavations, including green, blue, white, brown, black, pink, and red. In most cases, paint was only preserved in small patches on wood or associated with metal hardware. Because the evidence of paint was scant, it is difficult or impossible to say whether the entire interior surface had been painted or only certain portions. In one burial container, two types of paint were identified: green paint was found on the bottom of the container, and a dark-gray paint was applied to the underside of the lid. This observation allows for the possibility of multiple paints within the same burial container in other burials in the cemetery. There were also two cases in which blue and green paints were layered.

The presence of paint on the interior of a burial container did not preclude the presence of lining. In 26 cases, both paint and fabric were present. In most cases, as with the paint/fabric combinations on the exterior surfaces, the paint was applied to the outer surface of the fabric. It is unknown to what extent the paint and fabric were applied together or applied to different portions of the interior, such as paint on the underside of the lid and fabric on the bottom and side walls. None of the burial containers observed suggested that paint and fabric were used for separate portions of the interior surface, but it is a possibility.

Summary and Conclusions

In this chapter, we have described a number of feature attributes and artifact types that can be used to understand spatial and demographic variation in grave-pit preparation, burial container design and construction, and body preparation. In doing so, a number of patterns in the distribution of these dimensions of mortuary practice have been noted and preliminary hypotheses have been presented to explain their distribution. The most distinctive patterns observed were those that distinguished mortuary practices between the northern and southern areas of the cemetery. However, interesting differences were also occasionally noted between Cemetery Areas 3 and 4, which along with similar patterns noted in the following chapter, should allow us to understand the behavioral factors that distinguished the use of those two areas.

Grave-pit preparations, vaulting, and head niches were divided by type between the northern and southern halves of the cemetery. Vaulting complexes with grave arches and shelves appeared more often in the southern half of the cemetery in Cemetery Areas 1 and 2. Head niches appeared more often in the northern half of the cemetery in Cemetery Areas 3 and 4. The cemetery was divided in a similar fashion according to burial orientation, with the northern half of the cemetery population more often buried with head to the east and the southern half buried with head to the west. The few graves with artifactual evidence of professional undertaking—apart from the presence of mass-produced coffin hardware—were located in the southern half of the cemetery in Cemetery Areas 1 and 2. This included bricks, lowering tools, and floral arrangements. In contrast, floral arrangements with a specific Hispanic cultural meaning—floral crowns—were found in large numbers only in the northern portions of the cemetery. There seems to be a similar division among burial container shapes, as well. More coffins were recovered from Cemetery Area 3 than any other area merely because the largest number of burials was recovered from this area. However, when each cemetery area is examined separately, we find that hexagonal coffins were more popular than any other shape in Cemetery Areas 1 and 2, whereas all three shapes tended to be more or less evenly divided in Cemetery Area 3. Differences were also observed between Cemetery Areas 3 and 4 in the spatial distribution of burial containers according to shape, suggesting possible differences in how these areas were used or who was using them. Burial containers were constructed of locally available woods according to a variety of idiosyncratic construction techniques, suggesting that they were constructed as needed by kin or local craftsmen, rather than by professional coffin makers. Fewer than 50 burial containers displayed decorative coffin hardware, and these appeared in near equal numbers in both the northern half and southern half of the cemetery. Decorative coffin hardware is often seen by mortuary archaeologists as an unmistakable marker of the Beautification of Death movement (see Chapter 8, Volume 1 of this series). The paucity of decorative coffin hardware in the Alameda-Stone cemetery was most likely the

result of limited access during the cemetery's period of use. The amount present, however, suggests some Euroamerican influence taking shape in Tucson during the same period.

Archaeological interpretation of mortuary behavior has seen many transformations in recent years. Early studies of identity in archaeology relied on the concept of essentialized and fixed identities and posited direct correspondence between identity and sets of diagnostic artifacts and features. Recurring sets of artifact and feature types were interpreted as markers for a particular ethnic or cultural group, for instance. More recently, archaeologists have begun to consider identity from an instrumental or constructivist perspective and have investigated the intersections and tensions among different components of identity, such as gender, status, age, religion, occupation, or family roles. These approaches stress that identities are never fixed or immutable but are instead hybridized, multivalent, porous, and situationally contingent. Identities are formed in relation to other identities and vary according to social context.

The funeral ceremony is now seen as an opportunity to negotiate, display, obscure, or transform identity through the agency of the living. As such, cemeteries can be used to interpret the negotiations of community, status, and individual identity.

Few accounts exist to describe funerary practices of the Tucson citizens during the period that the cemetery was in use (see Chapter 8, Volume 1 of this series). Those that were located describe the ceremonies from a Euroamerican perspective. John Vance Lauderdale, a doctor with the U.S. Army who was stationed at Camp Lowell from July 1869 to September 1870, recorded in his diary:

> August 6, 1869—A funeral procession of a child passed this evening attended by a brass band of three instruments. I went to the grave and the coffin was a box of this shape [drawn a four-sided, trapezoidal coffin], as seen in which I find to be the one commonly used and it was covered with dark red cloth, and fringed about with white edging. When the coffin was laid in the grave, the children and all as if ambitious to throw their handful of earth, scarcely waited for the man who got into the grave to fix the coffin to get out again, before they shoveled with their hands the dirt from all sides, kicking up a great dust, and left but little for the grave digger to do to cover up and make the usual mound. But the most singular and interesting part of this ceremony is the fact that the earth takes the place of flowers which are usually thrown upon the graves of deceased friends, as with us at home where they are plenty [John Vance Lauderdale Papers, Reel 5].

In a later entry—September 17, 1869—Lauderdale compared the funerals of a soldier's child with the funeral of a Mexican child. The soldier's child was in the "neatest little coffin, covered with black cloth and spangled with silver headed screws." The funeral of the Mexican child was prefaced by the dinging of the church bells. The open coffin was carried by a young girl with its lid carried by another child. The body of the dead child was covered with a napkin and all who attended threw a handful of earth into the grave. These two accounts describe relatively modest funerals and may represent the typical funeral ceremony of Tucson's Hispanic population, most of whom were Catholic.

The Beautification of Death trend, at its height during the reign of Queen Victoria, spread rapidly during the second half of the nineteenth century, as the transcontinental railroad laid its tracks across the United States. Beautification of death, as characterized by Bell (1987), Buikstra et al. (2000), Little et al. (1992), and Dockall, Powell, et al. (1996), among numerous others, describes a change in the ideational view of death as grisly or gruesome to sentimental and romantic. This primarily Euroamerican trend was marked by displays of grief and high mourning and has been the focus of many recent studies of mortuary behavior. Archaeologically, this trend is represented by bucolic park-like cemeteries, ordered cemetery rows, elaborate headstone design, the presence of mass-produced coffins, decorative coffin hardware, and the remains of fine clothes included in the burial. The trend is subtly evident in the Alameda-Stone cemetery. As discussed in Chapter 4, and illustrated again here, we see a division between the northern and southern portions of the cemetery. Further, as discussed in detail in Chapter 4, we identified in Cemetery Area 3 an east/west organizational shift in cemetery rows. We did not, however, find mass-produced coffins. The coffins in the cemetery appear to be idiosyncratic, vernacular coffins crafted by nonprofessionals. As discussed earlier, rectangular caskets are a hallmark of the Beautification of Death and the desire to display the dead as a sentimental gesture of mourning.

Most of the rectangular burial containers in the Alameda-Stone cemetery had butted joints and made use of scrap lumber. They were likely a result of unskilled coffin makers assembling a simple box for burial rather than for display. Again, we find most of these containers in Cemetery Area 3, in the northern half of the cemetery. It appears the living population of Tucson appropriated some of the accessible material culture of the Beautification of Death for their funerals but did not adopt the trend wholesale (see Chapter 9, Volume 1 of this series for additional discussion of the influence of the Beautification of Death movement on the cemetery).

The cemetery in Tucson represents a transition period in Tucson culture in which the community began its move away from long-held Hispanic and Native American traditions to a European-influenced manner of practicing death and burial. As the cemetery neared its terminal end, the Euroamerican influence gained a foothold, and elements of the Beautification of Death movement were appropriated and slowly incorporated into native Tucsonan culture. We see this influence most prominently in Cemetery Area 3. It is in this area that we began to see linear organization of cemetery rows, as discussed in Chapter 4. Decorative coffin hardware began to appear in modest amounts. We see more flexibility in burial orientation. The Alameda-Stone cemetery seems to have been less an example of beautification and more illustrative of the concept of the "good death," in which the dying were given fortification for the spiritual journey ahead through preparation for death and the administration of ritual by the Roman Catholic church (Will de Chaparro 2007:12–13). Despite the influence of newly arrived Euroamericans, the population maintained its Catholic traditions and may have found new ways of expressing identity through religion, clothing fasteners, and other mundane objects. The following chapter discusses in detail the artifacts of personal adornment, religious objects, and other grave inclusions.

Figure 44. Shelves from Individual P, Grave Pit 597, a middle adult male of Hispanic cultural affinity.

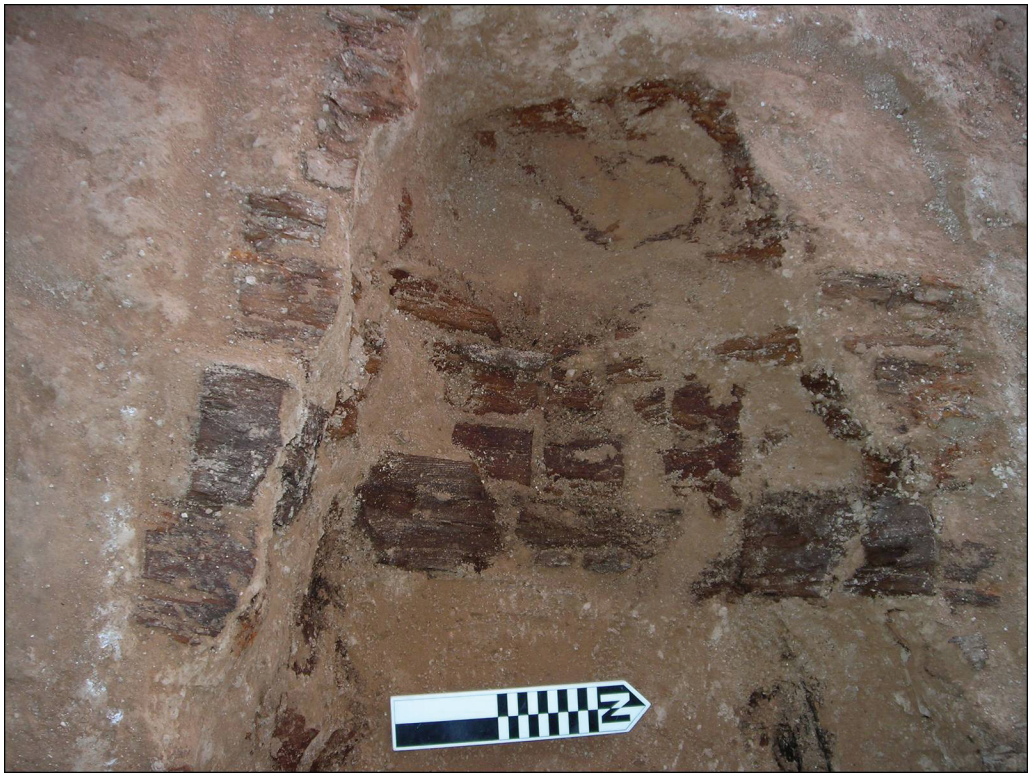

Figure 45. Grave arches from Individual P, Grave Pit 3228, a middle adult male of Euroamerican cultural affinity.

Figure 46. Head niche with human remains from Individual P, Grave Pit 7798, a middle adult male of Euroamerican cultural affinity.

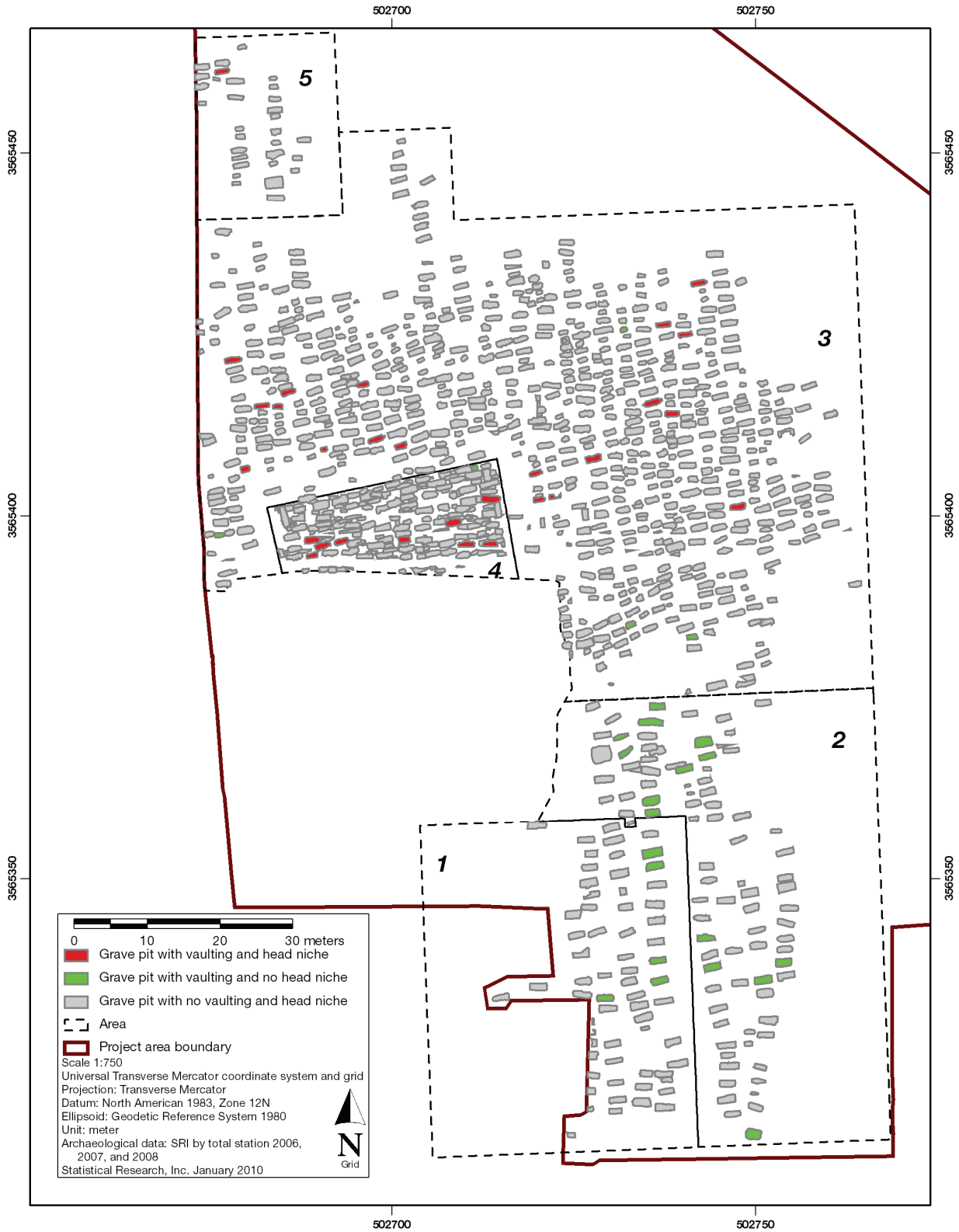

Figure 47. Distribution of graves with head niches.

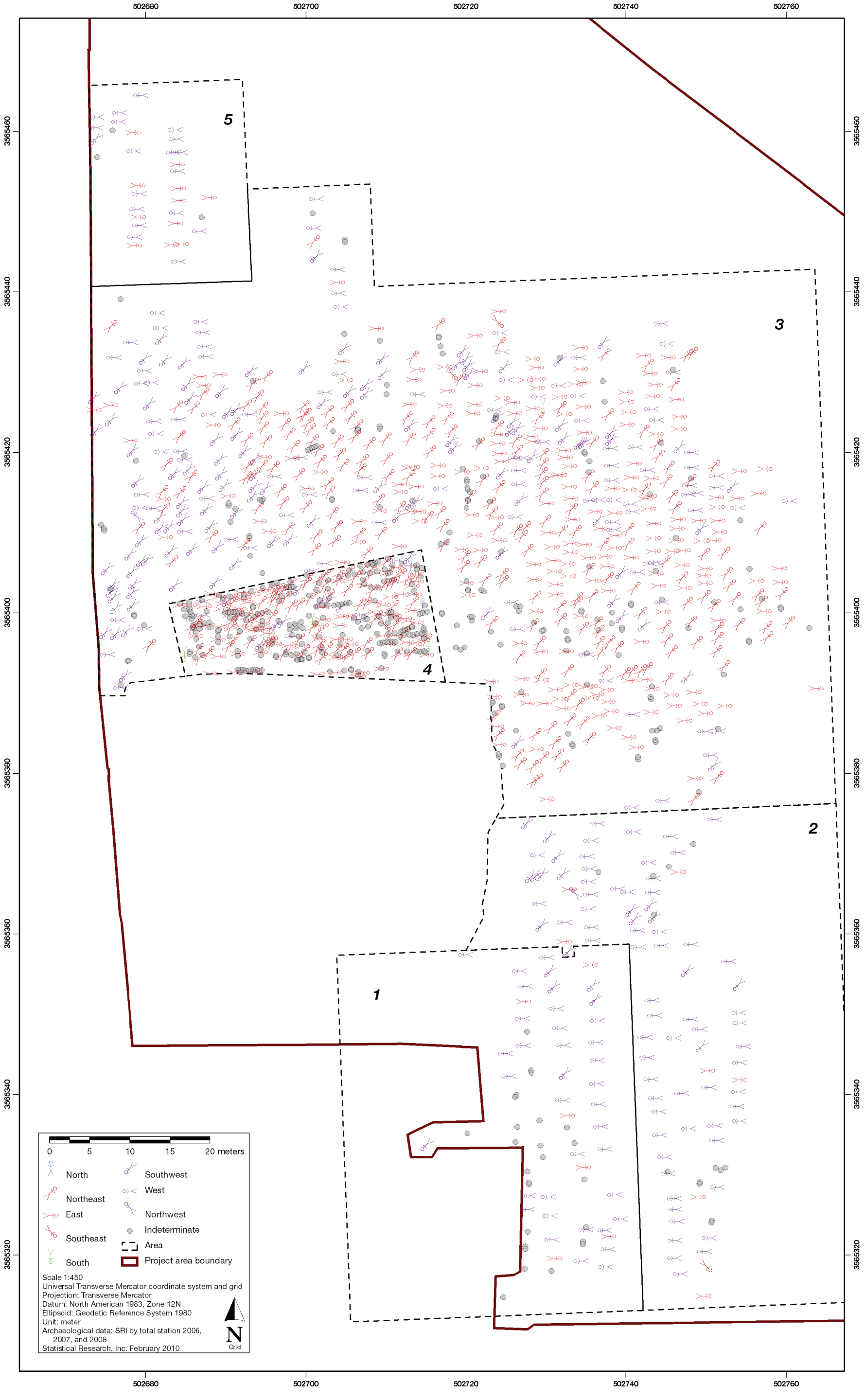

Figure 48. Burial orientation.

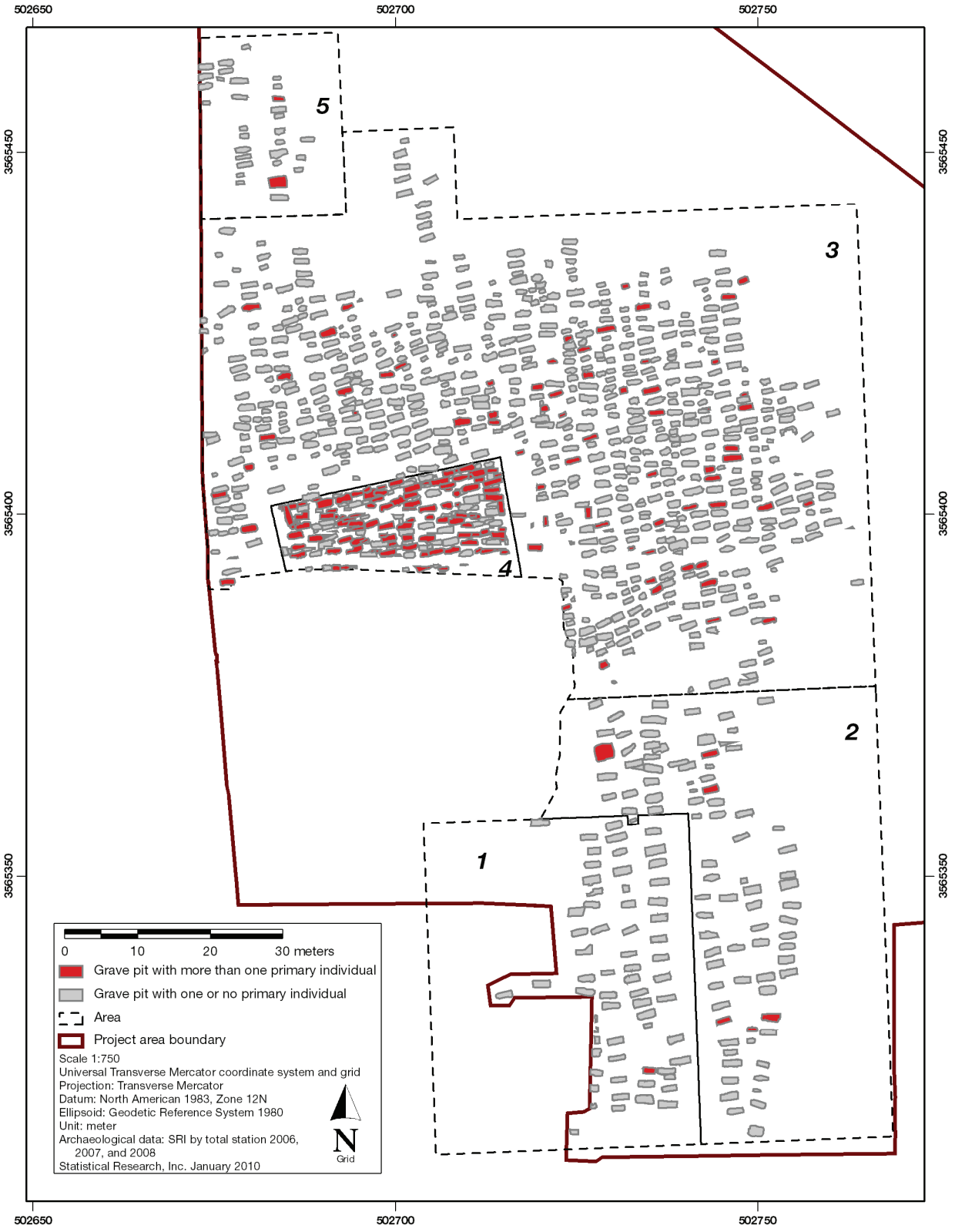

Figure 49. Distribution of graves with multiple interments.

Figure 50. Undertaking hardware from Individual P, Grave Pit 951, an older adult male of Euroamerican cultural affinity.

Figure 51. Brick placed under the coffin from Individual P, Grave Pit 28076, an adult male of indeterminate cultural affinity.

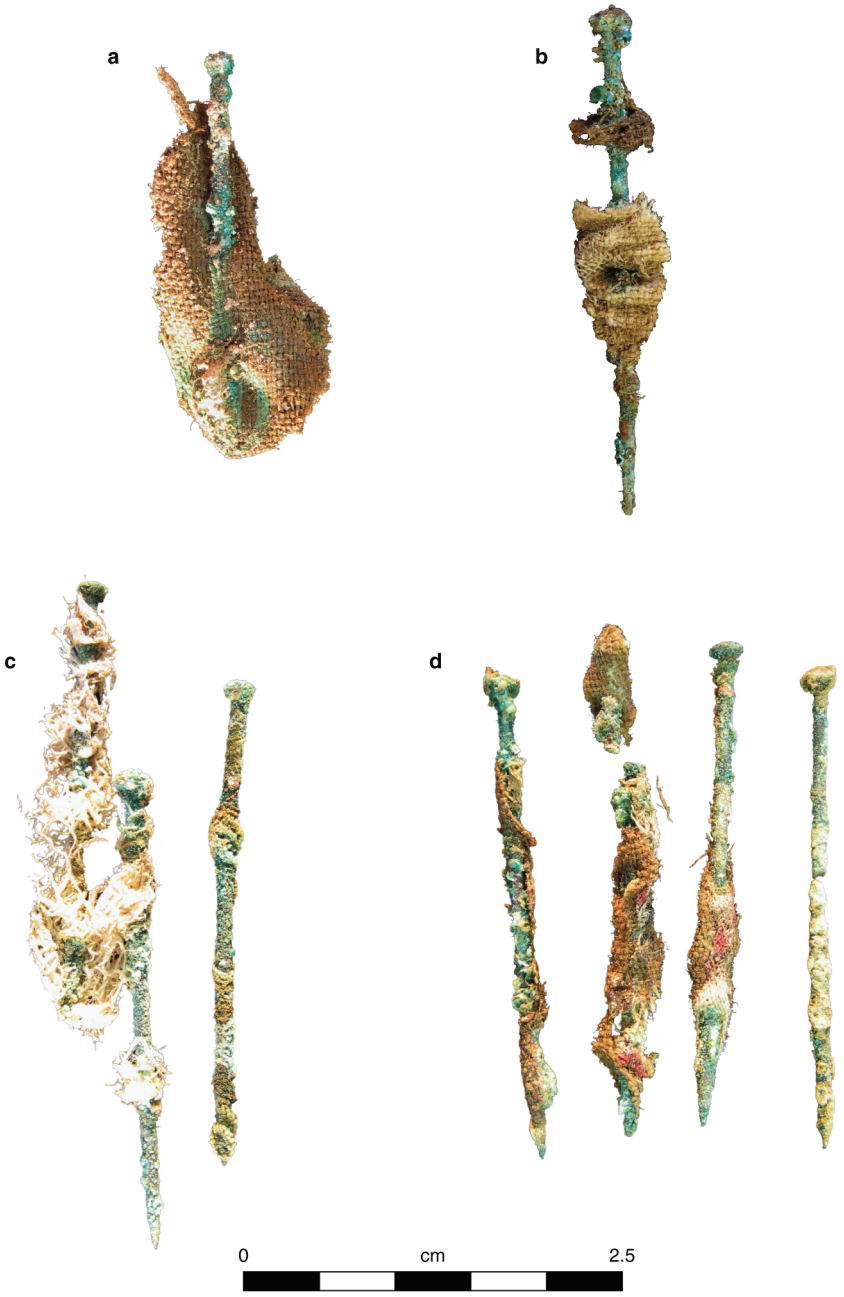

Figure 52. Straight pins with small fragments of fabric from burials with possible shrouding.

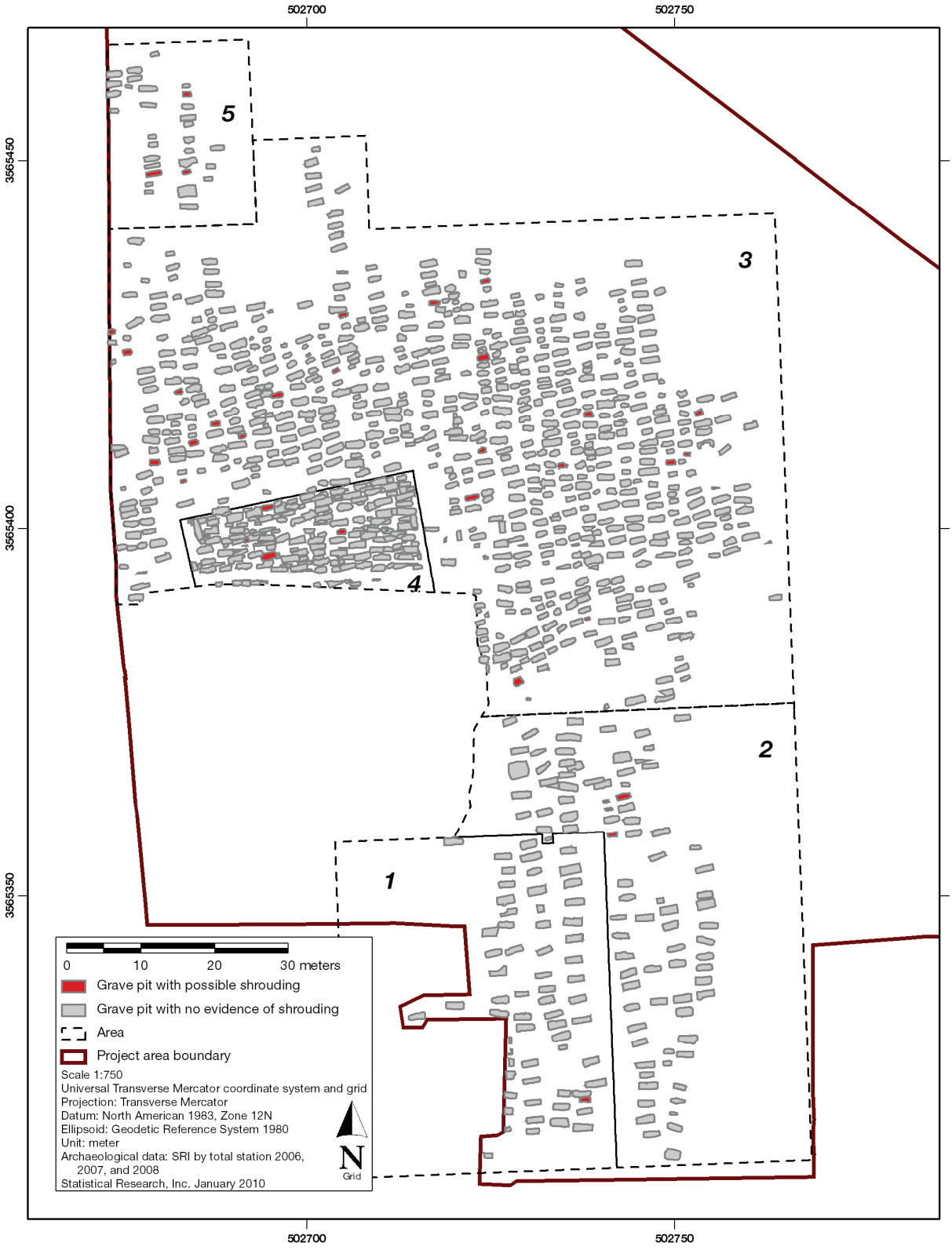

Figure 53. Graves with possible shrouding.

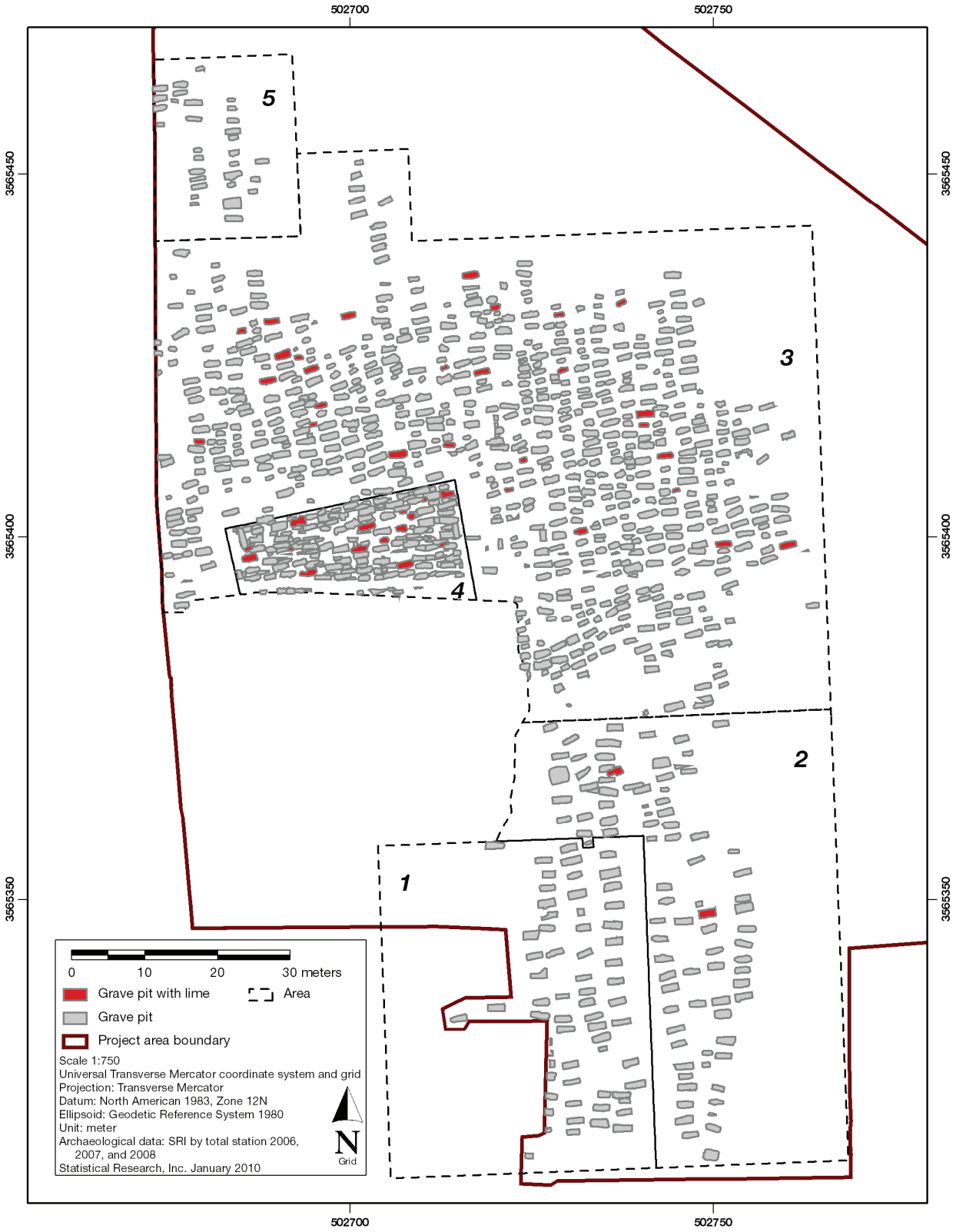

Figure 54. Graves with lime.

Figure 55. Fragments of floral arrangements.

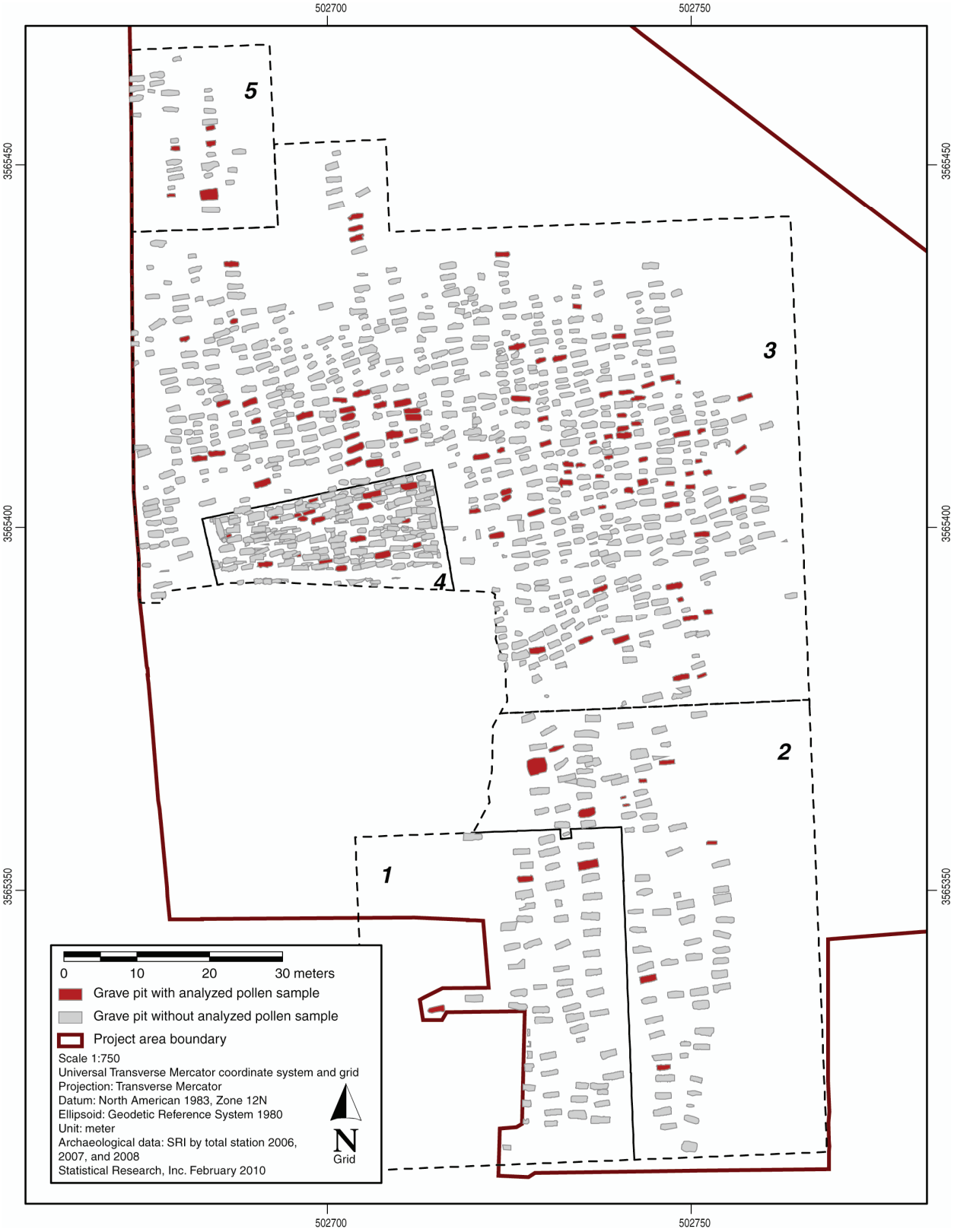

Figure 56. Graves sampled for pollen analysis.

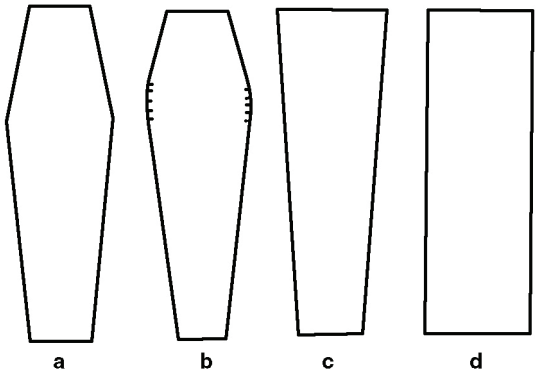

Figure 57. Coffin shapes from the Alameda-Stone cemetery.

Figure 58. Coffin handle types: (*a*) Handle Type 1; (*b*) Handle Type 2; (*c*) Handle Type 3; (*d*) Handle Type 4; (*e*) Handle Type 5; (*f*) Handle Type 6; (*g*) Handle Type 7; (*h*) Handle Type 8; (*i*) Handle Type 9.

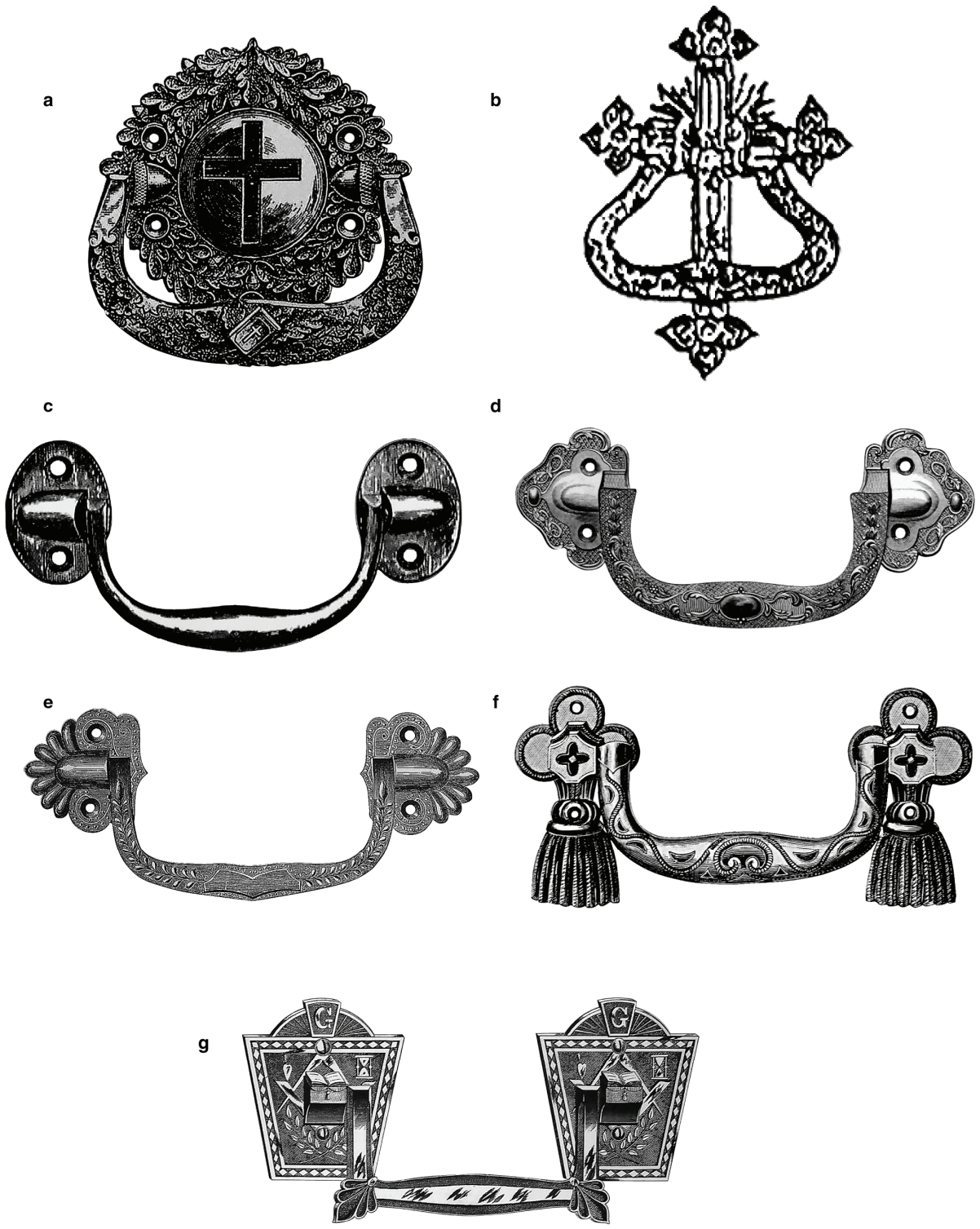

Figure 59. Coffin handles from the Alameda-Stone cemetery as depicted in nineteenth-century coffin hardware catalogs: (*a*) Sargent & Co. 1871; (*b*) Sargent & Co. 1866; (*c*) Sargent & Co. 1874; (*d*) J. L. Wayne & Sons 1874; (*e*) J. L. Wayne & Sons 1874; (*f*) H. E. Taylor 1875; (*g*) Meriden Britannia & Co. 1876.

Figure 60. Coffin screw types: (*a*) Coffin Screw Type 1; (*b*) Coffin Screw Type 2; (*c*) Coffin Screw Type 3; (*d*) Coffin Screw Type 4; (*e*) Coffin Screw Type 5.

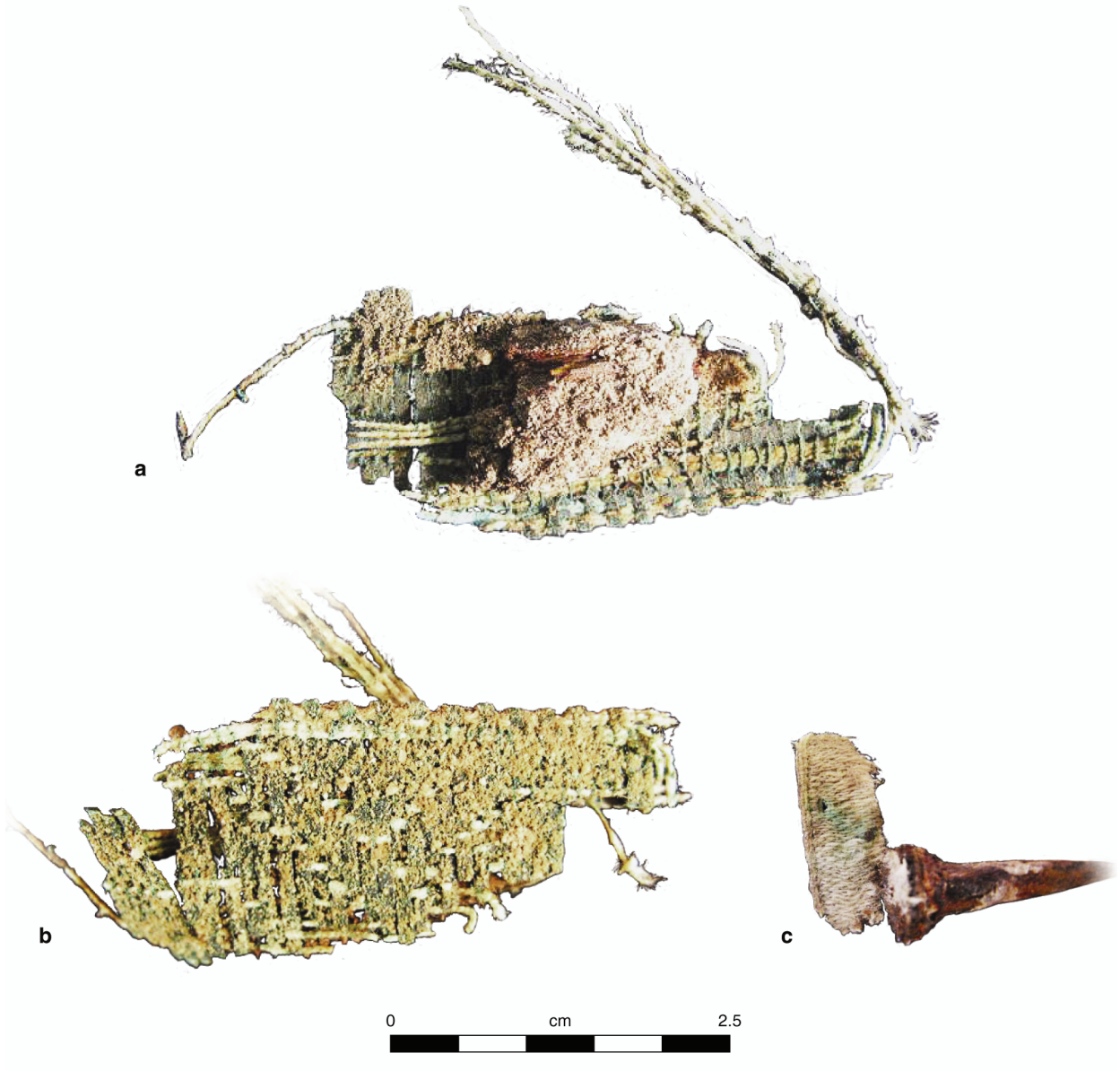

Figure 61. Fragments of fabric from Individual P, Grave Pit 7802, an adult of indeterminate sex and cultural affinity.

Table 43. Historical-Period Cemetery Reports Consulted for Project, by Year Excavation Took Place

Project	Affiliation	Temporal Range[a]	No. of Burials Exhumed	No. of Individuals Exhumed	Location	Year Excavated	Reference
Ravenscraft Cemetery	Euroamerican	1800–1825	7	7	Pennsylvania	1954	Swauger 1959
Las Vegas Gravel Pit Cemetery, New Mexico	Euroamerican and Hispanic	1880s–1940s[a]	17	17	New Mexico	1972	Mills 1979
Oakland Cemetery	African American	1866–1884	17	17	Georgia	1978	Blakely and Beck 1982
St. Andrew's Roman Catholic Cemetery	Euroamerican	Pre-1900	1	1	Ontario, Canada	1979	Heringer and Haywood 1980
Catoctin Furnace Cemetery	African American	1790–1840	35	35	Maryland	1979–1980	Burnston and Thomas 1981
Applegate Lake Project (two cemeteries)	Euroamerican	1886–1914	13	13	Oregon	1980	Brauner and Jenkins 1980
Laredo Cemetery	Euroamerican	1880–1920	22	23	Texas	1980	McReynolds 1981
Fort Brooke's Cemetery	Euroamerican	1825–1838	126	126	Florida	1980	Piper and Piper 1982
Millwood Plantation Cemetery	Euroamerican	1880–1930	263	263	South Carolina	1980–1981	Orser et al. 1987
First African Baptist Church (8th and Vine)	African American	1823–1842	140	140	Pennsylvania	1981	Parrington et al. 1989
Choke Canyon Project (five cemeteries)	Euroamerican	ca. 1860–1911	34	34	Texas	1981–1982	Fox 1984
Stirrup Court Cemetery	Euroamerican	1840–1890	27	27	Ontario, Canada	1982	Woodley 1992
Cedar Grove Cemetery	African American	1900–1915	79	80	Arkansas	1982	Rose 1983, 1985
Scisson Family Cemetery	Euroamerican	1862–1911	3	3	South Dakota	1982	Berg 1990
McGee Creek Cemetery	Euroamerican	ca. 1900–1924	11	11	Oklahoma	1983	Ferguson 1983
First African Baptist Church	African American	1823–1842	140	140	Pennsylvania	1983–1984	Parrington et al. 1989
Mount Pleasant Cemetery	Euroamerican	1850–1910	35	37	South Carolina	1984	Trinkley and Hacker-Norton 1984
Nancy Creek Cemetery	African American	1850s–1979	56	56	Georgia	1984	Garrow et al. 1985
Morgan Chapel Cemetery	Euroamerican	1891–1924	21	21	Texas	1984	Taylor et al. 1986

continued on next page

Project	Affiliation	Temporal Range[a]	No. of Burials Exhumed	No. of Individuals Exhumed	Location	Year Excavated	Reference
Mount Gilead Cemetery	Euroamerican	1832–ca. 1900	31	31	Georgia	1984	Wood et al. 1986
Rincon Cemetery	Euroamerican	1889–1935	4	4	California	1984	Brock and Schwartz 1991
First Cemetery (New Orleans)	Euroamerican	1721–1789	32	32	Louisiana	1984	Owsley et al. 1985
Blackburn Cemetery	Euroamerican	1818–1910[a]	10	10	Tennessee	1985	Atkinson and Turner 1987
Blackburn Cemetery (early graves: Nos. 5, 6, 8, 9)	Euroamerican	1818–1850	4	4	Tennessee	1985	Atkinson and Turner 1987
Blackburn Cemetery (later graves: Nos. 1, 2, 3, 4)	Euroamerican	ca. 1900–1925	4	4	Tennessee	1985	Atkinson and Turner 1987
Uxbridge Almshouse Burial Ground	Euroamerican	1831–1872	31	32	Massachusetts	1985	Elia and Wesolowsky 1991; Bell 1987, 1990
Talbot County (Big Lazer Creek) Cemetery	Euroamerican	1825–1900	6	6	Georgia	1986	Garrow and Symes 1987
Tucker Cemetery	Euroamerican	1880–1942	16	16	Texas	1986	Lebo 1988
Battle of Glorieta Pass	Euroamerican	1862	31	31	New Mexico	1987	Owsley 1994
Voegtly Cemetery	Euroamerican	1833–1861	727	727	Pennsylvania	1987	Beynon 1989
Elko Switch Cemetery	Euroamerican	1850–1920	56	56	Alabama	1987–1988	Shogren et al. 1989
Cedar Keys Lions Club Lot	Euroamerican	Pre-1895	2 (historic burials)	2 (historic burials)	Florida	1988	Jones 1992
Seven Rivers Cemetery	Euroamerican and Hispanic	1873–1899	54	54	New Mexico	1988	Ferguson et al. 1993
Harvie Family Burying Ground	Euroamerican	1825–1894	15	15	Ontario, Canada	1988	Saunders and Lazenby 1991
Wise Family Pioneer Cemetery	Euroamerican	1815–1858[a]	6	6	Ontario, Canada	1988–1989	Pearce 1989
Weir Family Cemetery	Euroamerican	1830s–1907	24	24	Virginia	1989	Little et al. 1992
Madam Felix/Hettick Cemetery	Euroamerican	1852–1900	3	3	California	1989	Costello 1991
Sinclair Cemetery	Euroamerican and African American	1850s–1880s	16	16	Texas	1989	Winchell et al. 1992
O.H. Ivie Reservoir (Boothill Cemetery)	Euroamerican	1870s–1880s	11	11	Texas	1989–1990	Earls et al. 1991

Project	Affiliation	Temporal Range[a]	No. of Burials Exhumed	No. of Individuals Exhumed	Location	Year Excavated	Reference
O.H. Ivie Reservoir (Coffey Cemetery)	Euroamerican	1870s–1880s	2	2	Texas	1989–1990	Earls et al. 1991
Spartanburg County, S. C. (38Sp105)	Euroamerican	1870–1910	15	15	South Carolina	1989–1990	Joseph et al. 1991
Spartanburg County, S. C. (38Sp106)	Euroamerican	1830s–1880s	61	61	South Carolina	1989–1990	Joseph et al. 1991
Patuxent Point (18CV271)	Euroamerican	1658–1680s	18	18	Maryland	1989–1990	King and Ubelaker 1996
Sandy Creek Cemetery	Euroamerican	1841–1920s	13	13	Georgia	1990	Garrow 1990
Piggery Point Burials	Euroamerican	1840–1890	28–37	28–37	Massachusetts	1990	King and Miller 1991
First African Baptist Church (10th Street, 36PH72)	African American	1810–1822	89	89	Pennsylvania	1990	Crist et al. 1996
Seccombe Lake Park Cemetery	Euroamerican	ca.1830–1900	11	11	California	1990–1991	Marmor et al. 1990, 1991
Cheyne Cemetery	Euroamerican	1844–1906	3	3	Ontario, Canada	1991	Archaeological Services, Inc. 1992
African Burial Ground	African American	seventeenth century– ca. 1795	more than 400	more than 400	New York	1991–1992	Blakey and Rankin-Hill 2009; Perry et al. 2009
Phillips Memorial Cemetery	African American	1884–1927	53	53	Texas	1991–1992	Dockall, Powell, et al. 1996
Freedman's Cemetery	African American	1869–1907	1150	1157	Texas	1991–1994	Condon et al. 1998; Peter et al. 2000
Freedman's Cemetery (Early Period)	African American	1869–1884	64	64	Texas	1991–1994	Condon et al. 1998; Peter et al. 2000
Freedman's Cemetery (Middle Period)	African American	1885–1899	170	171	Texas	1991–1994	Condon et al. 1998; Peter et al. 2000
Freedman's Cemetery (Pre-1900 Period)	African American	1869–1899	37	37	Texas	1991–1994	Condon et al. 1998; Peter et al. 2000
Freedman's Cemetery (Late Period)	African American	1900–1907	878	884	Texas	1991–1994	Condon et al. 1998; Peter et al. 2000

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Project	Affiliation	Temporal Range[a]	No. of Burials Exhumed	No. of Individuals Exhumed	Location	Year Excavated	Reference
Milwaukee County Poor Farm Cemetery	Euroamerican	1882–1925	1649	1649	Wisconsin	1991–1992	Richards and Kastell 1993; Richards 1997
Deepstep A.M.E. Church	African American	1860s–1920s[a]	79	79	Georgia	1992	Braley 1992
Deepstep A.M.E. Church	African American	1860s–1900[a]	39–40[a]	39–40[a]	Georgia	1992	Braley 1992
Deepstep A.M.E. Church	African American	1900–1920s[a]	39–40[a]	39–40[a]	Georgia	1992	Braley 1992
Sussex City Cemetery (site 7SF68)	Euroamerican	1752–1799	9	9	Delaware	1992	LeeDecker et al. 1995
Cross Family Cemetery (Springfield, Illinois)	Euroamerican	1829–1849	29	29	Illinois	1992	Craig and Larsen 1993
Cemetery 2, Colorado Mental Health Institute	Euroamerican	1879–1899	131	131	Colorado	1992	Painter et al. 2002
St. James Episcopal Church Cemetery (Brandy Station)	Euroamerican	1862–1900s[a]	7	7	Virginia	1992[a]	Owsley et al. 1992
Venable Lane Cemetery	Euroamerican	1860–1900	12	12	Virginia	1993	Grey et al. 1993
Fowler Street Cemetery (U.S. Military Cemetery 1851	Euroamerican	1841–1865	20	17	Florida	1993	Deming et al. 1993
Former Wesleyan Methodist Church Cemetery	Euroamerican	1821–1900	135 grave shafts	157	Ontario, Canada	1993	Kogon and Mayer 1995
Old Pioneer Cemetery	Euroamerican	ca.1850–1900?	1	1	Arkansas	1993	Spears et al. 1996
Dement Family Cemetery, Arkansas	Euroamerican	1890, 1896	2	2	Arkansas	1993	Cande 1995
Quaker Burying Ground	Euroamerican	1784–1890s	66 impacted (159 identified)	66	Virginia	1993–1995	Bromberg et al. 2000
Redfield Cemetery	Euroamerican	1875–1930	80	80	Georgia	1994	Braley and Moffat 1995
Henry Lehman Family Cemetery	Euroamerican	1844[a]–1862	15	15	New York	1994	Raemsch and Bouchard 2000
Texas State Cemetery (Confederate Section)	Euroamerican	1884–1951	57	57	Texas	1995	Dockall, Boyd, et al. 1996
Grafton Cemetery	Euroamerican	1834–1873	252	252	Illinois	1995	Buikstra et al. 2000
Cool Branch Cemetery	Euroamerican	1800–1830	5	5	Tennessee	1996	Matternes 1998a, 1998b
Fuller Cemetery	Euroamerican	1856–1920	46	46	Georgia	1997	Wilson and Holland 1998

Project	Affiliation	Temporal Range[a]	No. of Burials Exhumed	No. of Individuals Exhumed	Location	Year Excavated	Reference
Pine Ridge Cemetery	Euroamerican	1800–1850[a]	14	14	Georgia	1997	Wilson 1998a
Oliver Family Cemetery	Euroamerican	1831–1865[a]	11	11	Virginia	1997	Wilson 1998b
Turner Cemetery	Euroamerican	1840–1900[a]	12	12	Mississippi	1998	Wilson 1998c
Ridley Cemetery	African American	1885–1940	47	47	Tennessee	1998	Buchner et al. 1999
Third New City Cemetery (Allen Parkway Village)	African American	1875–1905[a]	355[a]	355	Texas	1998	Foster and Nance 2002
Brunson-Sisson Cemetery	Euroamerican	1836–1892	17	19	Illinois	1998	Cobb 1999
Sam Goode Cemetery	African American	1840–1920s	155	155	Virginia	1999	Crist et al. 2000
Pioneer Cemetery (Dallas, Texas)	Euroamerican	1880–1910	15	15	Texas	1999	Cooper et al. 2000
Brassell Cemetery	Euroamerican	1872–1874[a]	4	4	Georgia	1999	Gresham and Martin 1999
Connally I. S. D. School Tract Abandoned Cemetery	Euroamerican	Late 1800s–Early 1900s[a]	4	4	Texas	1999	Bradle et al. 2002
Howard Cemetery (39MN7)	Euroamerican	1850s–1920s[a]	5	5	South Dakota	1999–2000	Boen and Taft 1999
Manzanar National Historic Site Cemetery	Asian American	1942–1945	15	6	California	1999–2000	Burton et al. 2001
Cemetery 2, Colorado Mental Health Institute	Euroamerican	1879–1899	31	31	Colorado	2000	Painter et al. 2002
Kniseley Family Cemetery	Euroamerican	1830s–1850s[a]	6	6	Ontario, Canada	2000	Garner et al. 2001
Trinity Anglican Church Cemetery	Euroamerican	ca. 1870	1	1	Ontario, Canada	2000	Archaeological Services, Inc. ca. 2000
Craddock Cemetery	Euroamerican	1860–1911	6	6	Texas	2000	Turpin and Bement 2002a
Lucy Kimball Mead Tomb	Euroamerican	1822–1852	3	3	Massachusetts	2000–2003	Sutherland 2006
Elmbank Roman Catholic Cemetery (Fifth Line Cemetery)	Euroamerican[a]	1832–1937	634	622	Ontario, Canada	200–2001	Lipovitch et al. 2003
St. Paul's Pioneer Cemetery	Euroamerican[a]	ca. 1870	1	1	Ontario, Canada	2001	Miklavcic 2001
Matagorda Cemetery	Euroamerican	1850–1880	6	6	Texas	2001	Thoms 2001; Crow 2004

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Project	Affiliation	Temporal Range[a]	No. of Burials Exhumed	No. of Individuals Exhumed	Location	Year Excavated	Reference
Anderson Cemetery (41RT350)	Euroamerican	1875[a]–1902	4	4	Texas	2001	Turpin and Bement 2002b
Nisbett Cemetery (41RT189)	Euroamerican	1870[a]–1882	10	10	Texas	2001	Turpin and Bement 2002b
Varnell Family Cemetery	Euroamerican	1860s–1880s[a]	20	20	Texas	2001	Gadus et al. 2002
Manslick Road Cemetery, Burial #34	Euroamerican Euroamerican	1907–1910	1	16	Kentucky	2001	Spencer 2002
Reynolds Cemetery (46Ka349)	Euroamerican	1832–1900	31	31	West Virginia	2001	Bybee 2002
Eddy Cemetery	Euroamerican	1870–1900	16	16	Arkansas	2001	Mainfort and Davidson 2006
Becky Wright Cemetery	Euroamerican	1870–1900	10	10	Arkansas	2001	Mainfort and Davidson 2006
Potter's Field/Greenwood Cemetery	Euroamerican	1878–1911	14	14	Texas	2001	Tiné et al. 2002
Burning Springs Branch Cemetery	Euroamerican	1795–1818	9	8	West Virginia	2002	Bybee 2003a
Unmarked Historic Cemetery (15CP61)	Euroamerican[a]	1830–1900	15	15	Kentucky	2002	Bybee 2003b
Bulkeley Tomb	Euroamerican	1775–1832	27	21	Connecticut	2002	Bastis 2006
15Mm137	Euroamerican and African American[a]	ca.1830–1900	17	17	Kentucky	2002	Bybee and Richmond 2003
Hosier Family Cemetery	Euroamerican	1846–1870	4	4	Ohio	2002	Lee 2002
The Soldier's Plot, Emmanuel Lutheran Church Cemetery	Euroamerican	ca. 1897[a]	5	5	Virginia	2003	Owsley et al. 2003
Michigan City Old Graveyard (12LE348)	Euroamerican	1835–1864	15	15	Indiana	2003	Strezewski 2003
Pioneer Cemetery (41BO202)	African American	Late 1800s–early 1900s[a]	4	4	Texas	2003	Tiné and Boyd 2003
Oscar Abstein Cemetery	African American	1850s[a]–1884	3	4	Texas	2003	Broehm et al. 2004
St. Peter's Anglican Church Cemetery	Euroamerican	1828–ca.1850	25	29	Ontario, Canada	2003	Crawford 2003

Project	Affiliation	Temporal Range[a]	No. of Burials Exhumed	No. of Individuals Exhumed	Location	Year Excavated	Reference
Providence Baptist Church Cemetery (40SY619)	African American	1899–1933	65	65	Tennessee	2003	Oster et al. 2005
Samuel Robinson Cemetery	Euroamerican	1830–1900	12	12	Kentucky	2003	Bybee 2003c
Upper Prater Cemetery	Euroamerican	1830–1920	8	8	Kentucky	2003	Bybee 2003c
Old Branham Cemetery	Euroamerican and African American[a]	ca. 1825–1900	24	24	Kentucky	2003	Bybee 2004
St. Mary's Cemetery	Euroamerican	1868–ca. 1870	13	13	Louisiana	2003–2004	Williamson 2005
Pea Hill Site	Euroamerican	1860–1900	2	2	Ontario, Canada	2004	Archaeological Services, Inc. and Gary Warrick 2005
Former Sacramento County Hospital Burying Ground	Euroamerican	1891–1927	78	72	California	2004	Edwards et al. 2005
Meadowlark Cemetery	Euroamerican	1860–1900	14	14	Kansas	2004	Pye 2007; Pye et al. 2004, 2007
Dove Cemetery	Hispanic, Euroamerican and Native American	1860–1900	18	18	California	2005	Sewell and Stanton 2008
St. Clair County, Alabama (1SC320)	Euroamerican	1840s–1880s	19	19	Alabama	2005	Matternes and Serio 2005
Neal (Big Cove) Cemetery	Euroamerican	1880s–1920s	68	68	Alabama	2005	Trudeau 2005
Pepper Hill I (Site 22LO998)	African American	ca. 1850–1956	17	17	Mississippi	2005	Hogue and Alvey 2006
Lone Fir Cemetery (Morrison Lot)	Asian American	1866–1910	1	1	Oregon	2005	Smits and Reese 2005
Williams-Green Cemetery	Euroamerican	ca. 1800–1880	34	32	Virginia	2005–2006	Ezell and Huston 2006a
Quantico Corporate Center Tract Burials (Site 44ST0623)	Euroamerican	1850–1900	5	5	Virginia	2006	Ezell and Huston 2006b
Historic Los Angeles Cemetery (HLAC)	Asian American	1880s–1922	118	131	California	2006	Gust et al. 2006

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Project	Affiliation	Temporal Range[a]	No. of Burials Exhumed	No. of Individuals Exhumed	Location	Year Excavated	Reference
Evans Cemetery	Euroamerican	1875–1988	106 (15 archaeologically recovered)	106 (15 archaeologically recovered)	West Virginia	2006	Bybee 2007a
Tallyns' Reach Burial	Euroamerican	ca. 1850	1	1	Iowa	2006	Schermer et. al 2006
Alderson-Jackson Cemetery	Euroamerican	1833–1834	2	2	Kentucky	2007	Bybee 2007b
Rudy Cemetery	Euroamerican	1836–1850	1	1	Kentucky	2007	Bybee 2007c
Don Jail Cemetery	Euroamerican	1872–1930	3	3	Ontario, Canada	2007	Veilleux and Robertson 2008
Don Jail Cemetery	Euroamerican	1872–1930	15	15	Ontario, Canada	2007–2008	Crawford et al. 2008
Church of the Assumption of Our Lady Cemetery	Euroamerican	1861–1967	2	2	Ontario, Canada	2008	Hutcheson et al. 2008

[a] Indicates that the data are unknown or questionable for various reasons.

Table 44. Vaulting Scenarios

Type	Vaulting Element	Presence	Description	No. of Graves
1	shelves	yes	Characterized by the presence of shelves, arches, and niches.	1
	arches	yes		
	niches	yes		
2	shelves	yes	Characterized by the presence of shelves but no arches or niches.	12
	arches	no		
	niches	no		
3	shelves	no	Characterized by the presence of arches but no shelves or niches.	1
	arches	yes		
	niches	no		
4	shelves	no	Characterized by the presence of niches but no shelves or arches.	27
	arches	no		
	niches	yes		
5	shelves	yes	Characterized by the presence of shelves and arches but no niches.	12
	arches	yes		
	niches	no		
6	shelves	yes	Characterized by the presence of shelves and niches but no arches.	1
	arches	no		
	niches	yes		

Table 45. Demographic Distribution of Vaulting

Age Category	Cemetery Area					Total
	1	2	3	4	5	
Juvenile	—	1	9	3	—	13
Adult female	—	1	5	1	1	8
Adult male	2	13	6	5	—	26
Adult, indeterminate sex	2	—	—	1	—	3
Indeterminate age and sex	—	—	—	—	—	—
Total	4	15	20	10	1	50
Adult/juvenile		14.0	1.2	2.3		2.9
Males/females		13.0	1.2	5.0		3.3

Table 46. Demographic Distribution of Head Niches

Age Category	Cemetery Area					Total
	1	2	3	4	5	
Juvenile	—	—	6	2	—	8
Adult female	—	—	5	1	1	7
Adult male	—	—	6	5	—	11
Adult, indeterminate sex	—	—	—	1	—	1
Indeterminate age and sex	—	—	—	—	—	—
Total	—	—	17	9	1	27
Adult/juvenile			1.8	3.5		2.4
Males/females			1.2	5.0		1.6

Note: This table represents the demographic distribution of head niches among individuals in the cemetery. The total number of individuals presented here may differ from the total number of grave features with head niches.

Table 47. Demographic Distribution of Burial Orientation

Age Category	Cemetery Area					Total
	1	2	3	4	5	
	General Eastward Burial Orientation					
Juvenile	1	1	257	88	5	352
Adult female	—	2	83	30	3	118
Adult male	1	5	84	44	3	137
Adult, indeterminate sex	4	—	10	11	—	25
Indeterminate age and sex	—	—	—	—	—	0
Total	6	8	434	173	11	632
Adult/juvenile	5	7	0.69	0.97	1.2	0.80
Males/females		2.5	1.01	1.47	1	1.16
	General Westward Burial Orientation					
Juvenile	2	12	114	8	8	144
Adult female	—	5	49	2	5	61
Adult male	10	58	47	4	6	125
Adult, indeterminate sex	26	3	12	1	—	42
Indeterminate age and sex	—	—	—	—	—	0
Total	38	78	222	15	19	372
Adult/juvenile	18	5.5	0.95	0.88	1.38	1.58
Males/females		11.6	0.96	2	1.2	2.05

Table 48. Demographic Distribution of Shrouds and Winding Sheets

Age Category	Cemetery Area					Total
	1	2	3	4	5	
Juvenile	1	4	24	4	2	35
Adult female	—	—	—	1	1	1
Adult male	—	—	—	—	—	—
Adult, indeterminate sex	—	—	—	1	—	—
Indeterminate age and sex	—	—	—	—	—	—
Total	1	4	24	5	3	37
Adult/juvenile				0.25	0.50	0.06
Males/females						

Note: This table represents the demographic distribution of possible burial shrouding among individuals in the cemetery. It does not represent the distribution of straight pins associated with other functions.

Table 49. Totals of Burial Container Shapes

Burial Container Shape	Cemetery Area					Total
	1	2	3	4	5	
Hexagonal	44	65	218	45	12	384
Rectangular	4	18	191	42	10	265
Trapezoidal	2	1	157	29	1	190
Shape undetermined	7	3	38	20	2	70
Total	57	87	604	136	25	909

Table 50. Typology of Burial Containers

Type	Cemetery Area	Grave Pit No.	Burial Feature No.	Burial Container Shape	Joinery	Construction Methods
1.1.a						
	3	7870	18511	hexagonal	butted	The bottom was nailed to all sides from underneath. The sides were nailed to the head and foot boards. Both were inserted between the sides.
	3	10079	13777	hexagonal	butted	The head and foot boards were inserted between the sides and butted against the end of the bottom. The sides were nailed to the end boards from without, and the bottom sat within the sides. The head and foot boards were nailed to the bottom from the ends.
	3	705	13419	hexagonal	butted	The head and foot boards were inserted between the sides and butted against the end of the bottom. The sides were nailed to the end boards from without, and the bottom sat within the sides. The head and foot boards were nailed to the bottom from the ends.
	3	7666	14557	hexagonal	butted	The head and foot boards were inserted between the sides and butted against the end of the bottom. The sides were nailed to the end boards from without, and the bottom sat within the sides. The head and foot boards were nailed to the bottom from the ends.
1.1.c						
	3	7677	14611	hexagonal	butted	Steam-bent shoulders and the sides and end boards splayed slightly, meaning that the bottom dimensions were smaller than those at the top of the coffin.
1.1.d						
	3	709	13422	hexagonal	butted	The bottom board was inserted between the sides and nailed from without. The foot board nailed to the bottom from the end and was inserted between the sides and nailed from the side. The head board was nailed to one side from the end and the side was nailed to the head board from without on the other side. The bottom was nailed to the head board from below. The combination of these closure techniques and the insertion of the bottom between the sides left a notch in the right bottom corner of the coffin produced because the side was wider than the head board. In order to alleviate this problem, the bottom was cut with a protrusion on that corner the same size as the notch. The sides and ends of were splayed. This meant that the bottom dimensions of the coffin were smaller than the top.
1.2.a						
	1	10431	16943	hexagonal	mitered	The bottom of the container was inserted between all sides and nailed from without. Both the head and foot boards were inserted between the two head-end side panels, nailed to the bottom from the ends and to the sides from the side.
	1	10188	16817	hexagonal	mitered	
1.2.b						
	4	12276	13001	hexagonal	mitered	The bottom was placed within the sides of the container and the head and foot boards were inserted between the side boards and nailed from the sides. The bottom was nailed to the head and foot boards from underneath.
	4	12276	12781	hexagonal	mitered	

Type	Cemetery Area	Grave Pit No.	Burial Feature No.	Burial Container Shape	Joinery	Construction Methods
1.2.c						
	3	7677	14888	hexagonal	indeterminate	The sides of the coffin were splayed with the dimensions narrowing toward the bottom.
1.2.d						
	3	10144	21881	hexagonal	mitered	At least three boards were used to form the bottom of the container. At least one longitudinal board covers one half of the container length straddling the middle of the container, while at least one transverse board makes up the difference in length at the both the head and foot ends of the container. The bottom boards were nailed to the ends and sides from underneath. The head and foot boards were inserted between the sides and nailed from without.
1.2.e						
	2	3246	6899	hexagonal	indeterminate	At least two boards, running along the long axis of the coffin, were used to form the bottom. Two transverse boards were affixed to the bottom of the coffin for bracing, one at the apex of the shoulder, and the other across the knee region of the coffin. The bottom boards were nailed to the ends and sides from underneath. The sides were nailed to the head and foot boards from the side.
2.a						
	3	7970	19501	trapezoidal	indeterminate	The side boards were nailed to the bottom. The head and foot boards were then inserted between the side boards at either end. The bottom was nailed to the head and foot boards from below.
2.b						
	3	7712	16694	trapezoidal	indeterminate	The bottom of this container was nailed to the sides from underneath. The head and foot boards were inserted between the sides and nailed from the side while the bottom was attached from underneath.
2.c						
	3	29244	28289	trapezoidal	butted	Both the head and foot boards were butted against the sides and bottom and were nailed to the other pieces from the end.
2.d						
	3	7952	19541	trapezoidal		The head board was nailed to the sides from the end, while the foot board was nailed to the side on one corner and nailed from the side on the other. The bottom was then nailed to all sides from underneath.
2.e						
	3	7943	18966	trapezoidal	butted	The bottom sat within the side boards and was nailed from all sides. The head board was nailed to the sides from the end, and the foot board was inserted between the side boards and nailed from the side.

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Type	Cemetery Area	Grave Pit No.	Burial Feature No.	Burial Container Shape	Joinery	Construction Methods
2.f						
	3	7936	18857	trapezoidal	indeterminate	At least two boards were used to form the bottom container. At least one longitudinal board covered one-third of the container length, and at least one transverse board made up the difference in length at the head end of the container. One side panel was constructed from three boards, one that ran the full length of the burial container, and the other two affixed to the first board and sitting flush with each end forming a ¾-inch-wide notch in the middle.
3.a						
	4	7787	13390	rectangular	butted	The bottom was nailed from within all of the sides. The head and foot boards were both inserted within the sides and nailed from the side.
3.b						
	3	7929	18676	rectangular	butted	After insertion of the head and foot boards between the sides, the bottom was nailed to them from underneath. The bottom was placed between the side boards and nailed in place.
3.c						
	3	7885	18799	rectangular	butted	The lid was constructed of two longitudinal boards joined together by ferrous metal plates along the midline. The bottom of the container was made up of five to six transverse planks which were nailed to the sides from underneath.
3.d						
	3	7864	18521	rectangular	butted	The head and foot boards abutted the ends of the sides and were nailed from without. The bottom lay within all sides and was nailed from the sides and from the ends.
3.e						
	3	7951	19542	rectangular	butted	One side was constructed out of two thin boards that were pressed together and nailed from the side into the bottom of the container. The bottom was constructed entirely with narrow transverse planks which were nailed from underneath on the opposite side.
3.f						
	3	7523	9624	rectangular	butted	At least two boards were used. At least one longitudinal board covers one third of the container length, while at least one transverse board makes up the difference in length at the head end of the container. The bottom boards were nailed to the ends and sides from underneath.
3.g						
	3	10126	19954	rectangular	butted	Two transverse boards only 1.25 inches wide were found at the foot of the container, while at least one transverse board covered a 9.45 inch area at the head. All transverse boards, as well as the sides of the one longitudinal board were nailed to the sides and ends from underneath.

Type	Cemetery Area	Grave Pit No.	Burial Feature No.	Burial Container Shape	Joinery	Construction Methods
3.h	3	7674	14654	rectangular	indeterminate	The shape of the burial container was presumed to be elliptical, or oval-ended, by the outline of the sides, and one smoothly curved end board. The fact that one end appeared to be uniformly curved tends to support the assumption, however, one cannot rule out the possibility of distortion caused by soil pressure and collapse. Due to the poor preservation and lack of concrete evidence, this container has been classified as rectangular. If, indeed, this container was an elliptical form, the curved ends would have been produced by a method of steam bending before being attached to the sides and the bottom.

Table 51. Demographic Distribution of Burial Container Shapes by Cemetery Area

Age Category	Cemetery Area					Total
	1	2	3	4	5	
Hexagonal coffins						
Juvenile	2	5	96	21	2	126
Adult female	—	6	57	6	5	74
Adult male	11	51	50	11	5	128
Adult, indeterminate sex	29	2	10	4	—	45
Indeterminate age and sex	2	—	4	2	—	8
Total	44	64	217	44	12	381
Adult/juvenile	20.0	11.8	1.2	1.0	5.0	2.0
Males/females		8.5	0.9	1.8	1.0	1.7
Rectangular coffins						
Juvenile	2	7	138	25	7	179
Adult female	—	1	18	4	—	23
Adult male	—	9	24	10	2	45
Adult, indeterminate sex	2	1	7	—	1	11
Indeterminate age and sex	—	—	3	2	—	5
Total	4	18	190	41	10	263
Adult/juvenile	1.0	1.6	0.4	0.6	0.4	0.4
Males/females		9.0	1.3	2.5		2.0
Trapezoidal coffins						
Juvenile	—	—	96	23	1	120
Adult female	—	—	30	4	—	34
Adult male	—	1	23	—	—	24
Adult, indeterminate sex	1	—	4	1	—	6
Indeterminate age and sex	—	—	4	1	—	5
Total	1	1	157	29	1	189
Adult/juvenile			0.6	0.2		0.5
Males/females			0.8			0.7

Note: This table represents the demographic distribution of the shape of burial containers among individuals in the cemetery. The total number of individuals presented here may differ from the total number of grave features associated with specific shapes of burial containers.

Table 52. Catalog Matches for Handle Types

Catalog	Page (Item No.)	Source
	Handle Type 2	
Russell & Erwin Mfg. Co. (1980 [1865])	335 (No. 240)	Library of Congress
Sargent & Co. (1866)	115 (No. 240)	Davidson Collection
Sargent & Co. (1871)	264 (No. 240)	Library of Congress
Sargent & Co. (1874)	(No. 240)	Library of Congress
Hawley Bros. Hardware Co. (1884)	405 (No. 240)	Davidson Collection
	Handle Type 3	
Sargent & Co. (1866)	111 (No. 58)	Davidson Collection
	Handle Type 4	
Peck & Walters, and Sargent, Bros. & Company (1857)	51 (No. 17)	Davidson Collection
J. B. Sargent & Co. 1861	106 (No. 9-12)	Davidson Collection
Markham & Strong (1865)	12 (Nos. 10, 12, 101, 210)	Connecticut Historical Society
Russell & Erwin Mfg. Co. (1980 [1865])	333 (No. 10, 12)	Library of Congress
Sargent & Co. (1866)	118 (No. 49)	Davidson Collection
Miller Bros. Co. (ca. 1870)	3, 4 (Nos. 10, 12)	Winterthur Museum
Sargent & Co. (1871)	265 (Nos. 10, 12, 100)	Library of Congress
Sargent & Co. (1874)	396 (Nos. 10, 12, 100)	Library of Congress
	Handle Type 5	
see comment in report		
	Handle Type 6	
Russell & Erwin Mfg. Co. (1980 [1865])	335 (No. 1160)	Library of Congress
Sargent & Co. (1866)	119 (No. 1160)	Davidson Collection
Miller Brothers & Co. (ca. 1870)	16 (No. 120)	Winterthur Museum
Sargent & Co. (1871)	274 (No. 1160)	Library of Congress
Sargent & Co. (1874)	416 (No. 1160)	Library of Congress
J. L. Wayne & Sons (1874)	16 (No. 641)	Ohio Historical Society
H. E. Taylor & Co. (1875)	6 (No. 2)	Library of Congress
C. Sidney Norris & Co. (ca. 1880)	31 (No. 68)	University of Delaware
Crane, Breed & Co. (1877)	36 (No. 21)	Library of Congress
Zanesville Coffin Co. (1880)	9 (No. 27)	Davidson Collection
Harrisburg Burial Case Co. (ca. 1890)	17 (No. 1413)	Hagley Museum, Delaware
W. B. Belknap & Co. (1895)	968 (No. 116)	Davidson Collection
W. B. Belknap & Co. (1901)	1090 (No. 116)	Library of Congress
Simmons Hardware Company (1902)	1172 (No. 2102)	Library of Congress
	Handle Type 7	
Markham & Strong (1865)	13 (No. 7)	Connecticut Historical Society
Miller Bros. & Co. (ca. 1870)	3 (No. 8)	Winterthur Museum
J. L. Wayne & Sons (1874)	5 (No. 540)	Ohio Historical Society

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Catalog	Page (Item No.)	Source
	Handle Type 8	
Miller Brothers & Co. (ca. 1870)	13 (No. 41)	Winterthur Museum
Sargent & Co. (1874)	414 (No. 450)	Library of Congress
J. L. Wayne & Sons (1874)	25 (No. 1458)	Ohio Historical Society
H. E. Taylor & Co. (1875)	35 (No. 47)	Library of Congress
C. Sidney Norris & Co. (ca. 1880)	57 (No. 96)	University of Delaware
Warfield & Rohr (ca. 1890)	7 (No. 440)	University of Delaware
W. B. Belknap & Co. (1895)	969 (No. 450)	Library of Congress
W. B. Belknap & Co. (1901)	1090 (No. 450)	Library of Congress
Simmons Hardware Company (1902)	1172A (Nos. 4404, 4504)	Library of Congress
Chattanooga Coffin & Casket Co. (1905)	94 (No. 450)	Library of Congress
	Handle Type 9	
Meriden Britannia Co. (1876)	5 (No. 72)	Davidson Collection
Meriden Britannia Co. (ca. 1880)	9 (No. 72)	Winterthur Museum

Table 53. Cemetery Matches for Handle Types

Cemetery	No. of Burials	Dating	Citation
	Handle Type 4		
Elmbank Cemetery, Ontario, Canada	8	1832–1933	Lipovitch et al. 2003
Grafton Cemetery, Illinois	4	1865–1873	Buikstra et al. 2000:69
Former Wesleyan Methodist Church Cemetery, Ontario, Canada	1	1821–1900	Kogon and Mayer 1995:137
	Handle Type 6		
Grafton Cemetery, Illinois	2	1834–1873	Buikstra et al. 2000:66
Nancy Creek Primitive Baptist Church Cemetery	1	1884	Garrow et al. 1985:19
Freedman's Cemetery, Texas, Handle Type 134	1 (B1026)	1885–1899	Davidson 2004:512
Elmbank Cemetery, Ontario, Canada	3	1832–1933	Lipovitch et al. 2003
	Handle Type 7		
Grafton Cemetery, Illinois	1 (bail only)	1834–1873	Buikstra et al. 2000:66
Elmbank Cemetery, Ontario, Canada	1	1832–1933	Lipovitch et al. 2003
	Handle Type 8		
Eddy Cemetery, Arkansas, Handle Type 2	1	1885	Mainfort and Davidson 2006:129
Grafton Cemetery, Illinois	2	1865–1873	Buikstra et al. 2000:67
Freedman's Cemetery, Texas, Handle Type 66 (lug only)	1	1902	Davidson 1999
Former Wesleyan Methodist Church, Ontario, Canada (lug only)	1	pre-1871	Kogon and Mayer 1995:138
Elmbank Cemetery, Ontario, Canada	2, 4 (lug only)	1832–1933	Lipovitch et al. Inc. 2003
Stirrup Court Cemetery, Ontario, Canada	1	1840–1890	Woodley 1992:55
Third New City Cemetery, Texas	6	1875–1883	Foster and Nance 2002:F-141
Laredo Cemetery, Texas	1	1890–1920	McReynolds 1981:47
Mount Pleasant Cemetery (38CH778), South Carolina	2	1850–1910	Trinkley and Hacker-Norton 1984:6–7
Howard Cemetery, South Dakota	1	1850–1920	Boen and Taft 1999

Table 54. Cemetery Matches for Tack Types

Cemetery	No. of Burials	Dating	Citation
		Ornamental Tack Type 1	
Eddy Cemetery, Arkansas, Ornamental Tack Type 1	1	1880–1900	Mainfort and Davidson 2006
Freedman's Cemetery, Texas, Ornamental Tack Type 55	2	1869–1884	Davidson 1999
Freedman's Cemetery, Texas, Ornamental Tack Type 58	2	1869–1884	Davidson 1999
Meadowlark Cemetery, Kansas, Coffin Tack Type 1	1	1860–1900	Pye 2007
Mount Pleasant Cemetery, South Carolina, Type IV	1	1850–1910	Trinkley and Hacker-Norton 1984:8
Elmbank Cemetery, Ontario, Canada	5	1832–1933	Lipovitch et al. 2003
		Ornamental Tack Type 1.1	
Becky Wright Cemetery, Arkansas, Ornamental Tack Type 1.1	2	1873–1900	Mainfort and Davidson 2006
Freedman's Cemetery, Texas, Ornamental Tack Type 55	2	1869–1884	Davidson 1999
Freedman's Cemetery, Texas, Ornamental Tack Type 58	2	1869–1884	Davidson 1999
Quaker Burying Ground, Virginia, Type C-1	2	1784–1890s	Bromberg et al. 2000:468
		Ornamental Tack Type 2	
Mount Pleasant Cemetery, South Carolina, Type IV	2	1850–1910	Trinkley and Hacker-Norton 1984:8
Freedman's Cemetery, Texas, Ornamental Tack Type 33	4	1869–1884	Davidson 1999
		Ornamental Tack Type 3	
Becky Wright Cemetery, Arkansas, Ornamental Tack Type 4	1	1873–1900	Mainfort and Davidson 2006
Freedman's Cemetery, Texas, Ornamental Tack Type 56	2	1869–1884	Davidson 1999
Elmbank Cemetery, Ontario, Canada	1	1832–1933	Lipovitch et al. 2003
		Ornamental Tack Type 4	
Quaker Burying Ground, Virginia, Type C-1	2	1784–1890s	Bromberg et al. 2000:468
Elmbank Cemetery, Ontario, Canada	3	1832–1933	Lipovitch et al. Inc. 2003
		Ornamental Tack Type 5	
Howard Cemetery	1	1850–1920	Boen and Taft 1999

Table 55. Catalog Matches for Ornamental Tack Types

Catalog	Page (Item No.)	Source
	Ornamental Tack Type 1	
H. E. Taylor & Co. (1875)	129 (No. 2x)	Library of Congress
H. E. Taylor & Co. (1879)	145 (No. 2x)	University of Delaware
Warfield & Rohr (ca. 1880)	69 (No. 30)	University of Delaware
Warfield & Rohr (ca. 1890)	61 (No. 2)	University of Delaware
	Ornamental Tack Type 1.1	
Markham & Strong (1865)	6 (No. 24)	Davidson Collection
Sargent & Co. (1871)	281 (No. 30)	Library of Congress
Sargent & Co. (1874)	417 (No. 30)	Library of Congress
Warfield & Rohr (ca. 1880)	69 (No. 30)	University of Delaware
Warfield & Rohr (ca. 1890)	61 (No. 2)	University of Delaware
	Ornamental Tack Type 2	
Russell & Erwin Mfg. Co. (1980 [1865])	331 (No. 17)	Library of Congress
Markham & Strong (1865)	6 (No. 34)	Davidson Collection
Warfield & Rohr (ca. 1880)	69 (No. 34)	University of Delaware
	Ornamental Tack Type 3	
J. B. Sargent & Co. (1861)	125	Yale University Library
Russell & Erwin Mfg. Co. (1980 [1865])	332 (No. 8)	Library of Congress
Markham & Strong (1865)	6	Davidson Collection
Sargent & Co. (1869)	152 (Nos. 16, 24)	Yale University Library
Sargent & Co. (1871)	281 (No. 24)	Library of Congress
Sargent & Co. (1874)	417 (No. 24	Library of Congress
	Ornamental Tack Type 4	
J. B. Sargent and Co. (1861)	109 (Nos. 26, 28, 30)	Yale University Library
Warfield & Rohr (ca. 1880)	69 (No. 30)	University of Delaware
	Ornamental Tack Type 5	
Sargent & Co. (1871)	278 (No. 72)	Library of Congress
Sargent & Co. (1874)	422 (No. 72)	Library of Congress
Columbus Coffin Co. (1882)	31 (No. 29)	Winterthur Museum
Harrisburg Burial Case Co. (ca. 1890)	50 (No. 72)	Hagley Museum, Delaware
Bliss-Holbrook Co. (ca. 1905)	3 (No. 17)	Pye Collection
Schmidt Mfg. Co. (1923)	3 (No. 17)	Davidson Collection
	Ornamental Tack Type 6	
Sargent & Co. (1871)	No. 94	Library of Congress
J. L. Wayne & Sons (1874)	48 (No. 31) similar	Ohio Historical Society
H. E. Taylor & Co. (1875)	126 (No. 24)	Library of Congress
Hawley Bros. Hardware Co. (1884)	408 (No. 90) similar	Davidson Collection
	Ornamental Tack Type 7	
Thatcher W. Root (1883)		Library of Congress
Sargent & Co. (1888)	919 (No. 136)	Library of Congress
Rice, Lewis & Son (1898)	679 (No. 4)	Davidson Collection

Table 56. Cemetery Matches for Screw Types

Cemetery	No. of Burials	Dating	Citation
		Coffin Screw Type 1	
Eddy Cemetery, Arkansas, Coffin Screw Type 1	1	1880–1900	Mainfort and Davidson (2006)
Freedman's Cemetery, Texas, Coffin Screw Type 5	15	1869–1884	Davidson (1999)
Vardeman Cemetery, Kentucky, Coffin Screw Type 1	1	1861	Davidson (n.d.)
Michigan City Old Graveyard, Indiana	1	1835–1864	Strezewski 2003:22
		Coffin Screw Type 2	
Eddy Cemetery, Arkansas, Coffin Screw Type 2	3	1880–1900	Mainfort and Davidson 2006
Meadowlark Cemetery, Kansas, Coffin Screw Type 1	2	1860–1900	Pye 2007
Freedman's Cemetery, Texas, Coffin Screw Type 2	1	1900	Davidson 1999
		Coffin Screw Type 3	
Eddy Cemetery, Arkansas, Coffin Screw Type 3	1	1882	Mainfort and Davidson 2006
Freedman's Cemetery, Texas, Coffin Screw Type 11	2	1869–1884	Davidson 1999
Meadowlark Cemetery, Kansas, Coffin Screw Type 1	2	1860–1900	Pye 2007
Varnell Cemetery, Texas	1	1860–1880	Gadus et al. 2002:41
Former Wesleyan Methodist Church Cemetery, Ontario, Canada	unknown	pre-1871–post-1881	Kogon and Mayer 1995:148 (Figure 14e)
		Coffin Screw Type 4	
Eddy Cemetery, Arkansas, Coffin Screw Type 4	2	1890	Mainfort and Davidson 2006
Freedman's Cemetery, Texas, Coffin Screw Type 1	1	1900	Davidson (1999)
Former Wesleyan Methodist Church Cemetery, Ontario, Canada	unknown	pre-1871–post-1881	Kogon and Mayer 1995:48 (Figure 14d)
		Coffin Screw Type 5	
Elmbank Cemetery, Ontario, Canada	1	1832–1933	Williamson 2003
Reynolds Cemetery, Texas	1	1832–1900	Bybee 2002:116
Sinclair Cemetery, Texas	unknown	1850–1880	Winchell et al. 1992

Table 57. Catalog Matches for Screw Types

Catalog	Page (Item No.)	Source
	Coffin Screw Type 1	
J. L Wayne & Sons (1874)	43 (No. 36)	Ohio Historical Society
Crane, Breed & Co. (1877)	168 (No. 34) best match located	Library of Congress
H. E. Taylor & Co. (1875)	129 (No. 2s) similar	Library of Congress
H. E. Taylor & Co. (1879)	145 (No. 1s) similar	University of Delaware
C. Sidney Norris & Co. (ca. 1880)	9 (No. 36) similar	University of Delaware
Warfield & Rohr (ca. 1880)	69 (No. 34)	University of Delaware
Cincinnati Coffin Co. (1881)	72 (No. 3)	University of Delaware
Cincinnati Coffin Co. (1882)	80 (No. 3)	University of Delaware
	Coffin Screw Type 2	
Markham & Strong (1865)	6 (No. 30)	Davidson Collection
W. B. Belknap & Co. (1895)	969 (No. 30)	Davidson Collection
	Coffin Screw Type 3	
Markham & Strong (1865)	6 similar	Davidson Collection
Sargent & Co. (1866)	125 similar	Davidson Collection
Sargent & Co. (1869)	152 (Nos. 16–24) similar	Davidson Collection
Sargent & Co. (1871)	281 (Nos. 16, 18) similar	Library of Congress
Sargent & Co. (1874)	417 (Nos. 16, 18) similar	Library of Congress
J. L. Wayne & Sons (1874)	43 (No. 30)	Ohio Historical Society
	Coffin Screw Type 4	
Peck & Walter, and Sargent Bros. & Company (1857)	51 (Nos. 22, 24)	Davidson Collection
Russell & Erwin Mfg. Co. (1980 [1865])	332(No. 17)	Library of Congress
Warfield & Rohr (ca. 1890)	61 (No. 3)	University of Delaware
	Coffin Screw Type 5	
Russell &Erwin Mfg. Co. (1980 [1865])	332(No. 8)	Library of Congress
Sargent & Co. (1866)	125 (No. 24)	Davidson Collection
Sargent & Co. (1871)	281 (No. 24)	Library of Congress
Sargent & Co. (1874)	417 (No. 24)	Library of Congress
J. L. Wayne & Sons (1874)	43 (No. 20)	Ohio Historical Society
Warfield & Rohr (ca. 1880)	69 (No. 30)	University of Delaware
W. B. Belknap & Co. (1895)	969 (No. 30)	Davidson Collection

Table 58. Wholesale Costs of Excavated Decorative Mortuary Hardware

Hardware Type	Catalog Match	Catalog	Page (item no.)	Given Cost ($)	Cost per Unit ($)
Coffin Screw Type 1	no price list available, refer to general costs of screws	Hamilton, Lemmon, Arnold & Co. 1884		.90–1.00 per gross	0.007
Coffin Screw Type 2	similar	Markham & Strong 1865	6 (No. 30)	1.43–1.52 per gross	0.01
Coffin Screw Type 3	similar	Sargent & Co. 1871	281 (Nos. 16, 18)	1.23–1.26 per gross	0.009
Coffin Screw Type 4	no price list available, refer to general costs of screws	Hamilton, Lemmon, Arnold & Co. 1884		.90–1.00 per gross	0.007
Coffin Screw Type 5	similar	Sargent & Co. 1871	281 (No. 24)	1.30 per gross	0.009
Ornamental Tack Type 1	no price list available, refer to general costs of tacks	Hamilton, Lemmon, Arnold & Co. 1884		0.50–0.55 per gross	0.003
Ornamental Tack Type 1.1	similar	Sargent & Co. 1871	281 (No. 30)	0.62 per gross	0.004
Ornamental Tack Type 2	similar	Markham & Strong 1865	6 (No. 34)	0.62 per gross	0.004
Ornamental Tack Type 3	similar	Sargent & Co. 1871	281 (No. 24)	0.56 per gross	0.003
Ornamental Tack Type 4	no price list available, refer to general costs of tacks	Hamilton, Lemmon, Arnold & Co. 1884		0.50–0.55 per gross	0.003
Ornamental Tack Type 5	identical	Sargent & Co. 1871	278 (No. 72)	1.10 per gross	0.008
Ornamental Tack Type 6	identical	Sargent & Co. 1871	279 (No. 94)	1.40 per gross	0.01
Ornamental Tack Type 7	identical	Sargent & Co. 1888	919 (No. 136)	0.70 per thousand	0.0007
Handle Type 1	no match found				
Handle Type 2	identical	Sargent & Co. 1871	264 (No. 240)	10.25 per dozen	0.85
Handle Type 3	identical	Sargent & Co. 1866	111 (No. 58)	10.75 per dozen	0.89
Handle Type 4	identical	Sargent & Co. 1871	265 (No. 100)	3.80 per dozen	0.31
Handle Type 5	no positive match				
Handle Type 6	identical	Sargent & Co. 1866	119 (No. 1160)	5.60 per dozen	0.46
Handle Type 7	identical	Markham & Strong 1865	13 (No. 7)	4.22 per dozen	0.35
Handle Type 8	identical	C. Sidney Norris & Co. ca. 1880	57 (No. 96)	4.50 per dozen	0.38
Handle Type 9	identical	Meriden Britannia Co. ca. 1880	9 (No. 72)	7.00 per dozen	0.58

Table 59. Selected Archaeological Excavations of Cemeteries Showing Evidence of Painting

Project/Cemetery	Temporal Range	Location	Surface Treatments	Reference
African Burial Ground	late seventeenth century–ca. 1795	New York	Paint: red	Perry et al. 2009
Bulkeley Tomb	1775–1832	Connecticut	Shellac: red or brown, black stain	Bastis 2006
Sussex City Cemetery	1752–1799	Delaware	Stain: dark	Leedecker et al. 1995
Burning Springs Branch Cemetery	1795–1818	West Virginia	Pigment: light green	Bybee 2003a
Reynolds Cemetery	1830–1900	West Virginia	Layered Paints or Pigments: red over black over white	Bybee 2002
			Layered Paints or Pigments: red over white over black, black over red over black over white over brown	
15Cp61	1830–1900	Kentucky	Paints and Pigments: white and Layered Pigments	Bybee 2003c
15Mm137	1830–1900	Kentucky	Varnish: black, Pigments: white, and Paint: black	
			Layered Pigments: white over black over red (interior)	
Evans Cemetery	1875–1988	West Virginia	Paint: white	Bybee 2007a
Providence Baptist Church Cemetery	1899–1933	Tennessee	Paint: white, light blue, red (exterior/interior), gold leaf or gold, red viewing lid, white top	Oster et al. 2005
Voegtly Cemetery	1833–1861	Pennsylvania	Paint: pink or red most common, but also white, green, yellow, orange, blue, and black	Beynon 1989
Elmbank Cemetery	1832–1937	Ontario, Canada	Varnish: red and yellow	Lipovitch et al. 2003
Quantico Corporate Center Tract Burials	1850–1900	Virginia	Paint or Varnish: dark	Ezell and Huston 2006b
Williams Green Cemetery	ca. 1800–1880	Virginia	Paint: yellow	Ezell and Huston 2006a
Don Jail Cemetery	1872–1930	Ontario, Canada	Paint: light color	Crawford et al. 2008
Old Branham Cemetery	ca. 1825–1900	Kentucky	Pigment: light green and white	Bybee 2004
Quaker Burying Ground	1784–1890s	Virginia	Varnish or wax: white, off-white/yellowish	Bromberg et al. 2000
First African Baptist Church Cemetery	1823–1842	Pennsylvania	Paint: red	
Becky Wright Cemetery	1870–1900	Arkansas	Paint: red and white	Mainfort and Davidson 2006
Eddy Cemetery	1870–1900	Arkansas	Paint: red and white	Mainfort and Davidson 2006
Freedman's Cemetery	1869–1907	Texas	Primer: red	Peter et al. 2000
Meadowlark Cemetery	1860–1900	Kansas	Layered: yellow ochre over white (lead-based) over white-gray primer over black over yellow ochre	Pye 2007
			Layered: yellow ochre over black over red over black over yellow ochre (exterior/interior)	

Table 60. Prices for Lining Coffins and Caskets as Advertised by the National Casket Co. (1899)

Description	Dimensions	Unit of Cost	Cost ($ per Unit)
Lining with Muslin	2-0 to 4-0	each	0.50
	4-3 to 4-9	each	0.75
	5-0 to 6-3	each	1.00
Lining with Canton Flannel	2-0 to 4-0	each	0.75
	4-3 to 4-9	each	1.15
	5-0 to 6-3	each	1.50
Satin mattress for bottom	—	per yard	1.00
Merino mattress for bottom	—	per yard	0.75
Cashmere mattress for bottom	—	per yard	0.65
Bottoms lined with Spanish satin			0.25 extra
Bottoms lined with satin			1.50 extra
Full satin plaited Adult caskets			from 9.00 to 15.00 according to quality
Full satin plaited Children's caskets			from 4.00 to 10.00 according to size and quality

Table 61. Descriptions and Costs of Piece Dry Goods Listed by Hamilton, Lemmon, Arnold & Company (1884)

Material	Item No.	Width (inches wide)	Description	Cost ($ per yard)
Broadcloth	1	52	black	1.50
	2	54	black	2.20
	3	54	black	2.50
	4	54	black	2.80
	5	54	white	2.00
	6	54	white	2.80
Velvet	1	22	black	0.50
	2	22	black	0.62
	3	22	black	0.85
	4	22	black	3.25
	5	22	white	0.62
	6	22	purple	0.77
Merino	1	40	white or cream	0.90
	2	40	black	0.95
	3	40	brown	0.95
Cashmere, 1st Quality	1	40	white or cream	0.45
	2	40	black	0.50
	3	40	brown	0.50
Cashmere, 2nd Quality	1	40	white or cream	0.25
	2	40	black	0.27
	3	40	brown	0.27
Satins	C	24	white	0.55

Material	Item No.	Width (inches wide)	Description	Cost ($ per yard)
	M	20	white	0.78
	G	24	white	1.00
	B	22	white	1.25
	A	24	black	0.67
	A	—	black, with embossed flower	1.00
	P	—	black, with embossed stripe	1.00
	L	20	pale blue	0.85
	D	20	navy blue	1.00
	W	19	light brown	1.15
	H	19	black	1.20
	F	—	white, with embossed flower	0.80
	S	—	white, with embossed stripe	0.80
Muslins	1	36	"Rival" muslin	0.07
	2	42	"Cabot" muslin	0.11
	—	36	white cambric muslin	0.06
Lawns	1	40	white	0.15
	2	40	black	0.16
	3	40	brown	0.16
Corded Serge	—	40	black	0.35
Satin de Chine	1	27	white	0.50
	2	32	white	0.60
	3	32	white	0.70
	4	32	white	0.80
Striped Italian Cloth	—	32	cream	0.65
Brocade Cloth	—	27	white (same as 41 lining)	0.30
Watered Sateens	—	40	white (same as 38 lining)	0.40
China Gauffer	—	25	white	0.40
Spanish Satins	1	20	black	0.08
	2	20	black	0.08
	3	20	white	0.08
	4	20	white	0.08
	5	20	white	0.08
	6	20	brown	0.08
	7	20	brown	0.08
	8	—	white, extra heavy to order	0.10
Corded Silk	—	24	white	1.12
Pique	—	27	white	0.30
Cotton Gimp				per bolt (24 yards)
	1	narrow	white	0.20
	2	medium	white	0.25
	2.5	medium	white	0.25
	3	wide	black and white	0.50

continued on next page

Material	Item No.	Width (inches wide)	Description	Cost ($ per yard)
	3.5	wide	black and white	0.50
Silk Gimp				per piece (24 yards)
	4	narrow	white	0.90
	4.5	medium	black and white	1.40
	5	medium	white	1.40
	5.5	medium	black and white	1.40
	6	wide	white	1.40
	6.5	narrow	black and white	0.90
	7	wide	white	2.00
	7.5	wide	black and white	2.00
	8	wide	white	4.00
	216	—	—	2.30
	999	—	—	2.75
	1013	—	—	0.80
	1013	—	brown	1.00
	1018	—	brown	1.25
	1018	—	—	1.25
	1021	—	—	1.50
	1021	—	black	1.50
	1021	—	brown	1.50
	1033	—	—	1.60
	1043	—	—	1.55
Silk Cord				per piece (18 yards)
	10	—	white chenille	1.00
	20	—	white	0.60
	20	—	brown	0.70
	30	—	brown	0.80
	30	—	white	0.75
	30	—	black	0.75
	40	—	black	0.90
	40	—	white	0.90
	60	—	black	1.15
Silk Tassels				per dozen
	1	—	black (for draped caskets)	5.60
	2	—	black (for draped caskets)	8.50
	3	—	white (for draped caskets)	6.30
	4	—	white, or black, for lining	0.20
	6	—	white, or black, for lining	0.30
Silk and Cotton Fringe				per bolt (24 yards)
	—	0.5	white silk	1.00
	—	1	white silk	1.60
	—	1.5	white silk	2.00

Material	Item No.	Width (inches wide)	Description	Cost ($ per yard)
	—	2	white silk	3.00
	—	1	black and white silk	1.60
	—	1.5	black and white silk	2.00
	—	1	black and white cotton	0.40
	—	1	white cotton	0.40
Lace				per dozen yards
	1	1	white	1.00
	2	1.5	white	1.50
	3	1.5	white	2.00
	4	2.5	white	3.40
	5	3	white	5.00
	6	1	black	1.00
	7	1.25	black	1.50
	8	2.5	black	3.40

Table 62. Descriptions of Tacks Listed by Hamilton, Lemmon, Arnold & Company (1884)

Description	Weight (oz.)	Unit of Cost	Cost ($ per Unit)
Blue Tacks	1.5	per pound	0.70
	1.5	per paper	0.04
	2.0	per pound	0.70
	2.0	per paper	0.05
	12.0	per paper	0.10
	2.5	per pound	0.60
	2.5	per paper	0.05
	4.0	per paper	0.06
Gimp Tacks, round head	2.0	per paper	0.06
	3.0	per paper	0.07
	4.0	per paper	0.08
Gimp or Lace, flat head	20.0	per paper	0.06
	2.5	per paper	0.06
Bright Lining Tacks, oval head	2.5	per paper	0.09
Bright Tufting Tacks, oval head	12.0	per paper	0.09
Silver Cast Head		per box of 144	0.10
Small Silk Head Lining Tack, 7 lines		per M	2.40
Large Silk Head Lining Tack, 10 lines		per M	2.50
Silver Silk Head Lining Tack		per M	2.50
Gold Silk Head Lining Tack		per M	2.50
French Nails		per M	1.00
Large Silk Head Lining Tacks, 14 lines		per M	3.50

CHAPTER 6

Adornment, Religious Objects, and Grave Inclusions

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Introduction

Artifacts corresponding to personal adornment, religious objects, and other grave inclusions contribute to the understanding of identity, spiritual devotion, socioeconomics, and community organization. In this chapter, we discuss jewelry, hair adornment, beads, clothing and clothing fasteners, shoes, religious and ceremonial artifacts, and other personal items interred with the dead.

Similar to Chapter 5, variation in apparel, personal adornment, religious objects, and other grave inclusions are described in terms of sex, age, cultural affinity, and location within the burial feature, grave pit, and cemetery. In this chapter, we identify basic patterns in the distribution of artifacts associated with interred individuals and propose some preliminary hypotheses about how inferred behaviors relate to demographic variation within the community. In Volume 1 of this series, these data are integrated with other information in order to more fully understand identity and mortuary behavior in Tucson during the period when the cemetery was in use.

This chapter is organized into sections according to the basic artifact categories listed above. In the first section, on apparel and personal adornment, we discuss jewelry, hair adornment, beads, fabric and textiles, buttons and other fasteners, and footwear. From this discussion, it becomes clear that there was substantial variation in personal adornment and apparel according to demography and cemetery location, much of which probably related to differences in the kinds and styles of apparel and adornment that were used by different segments of the community to dress and adorn deceased individuals for burial. This section is followed by a discussion of religious and ceremonial artifacts. A remarkable finding related to religious and ceremonial artifacts is that they were almost exclusively located in the northern portion of the cemetery (Cemetery Areas 3, 4, and 5), suggesting a fundamentally different approach to the use of religious objects in different portions of the cemetery. This observation provides some support for our hypothesis that the northern section of the cemetery represents the local and mostly Hispanic and Catholic segment of the community, which included families who were living in Tucson before the formation of the cemetery or who recently migrated from nearby areas of northern Mexico. The subsequent section discusses other grave inclusions, including bottles, smoking pipes, tools and toys, coins and tokens, frames, and ammunition. Most of these artifact types were relatively rare within the cemetery, although a number still had demographic and spatial associations that could be tied to different segments of the community. Frames, for instance, which may have been used to hold and display photographs, drawings, or other mementos, were exclusively found in the northern portion of the cemetery. Although a variety of uses for frames were possible, it seems plausible that many of the frames could have held religious images. The distribution of ammunition is also interesting, as few ammunition artifacts were found and many were probably intrusive to grave pits. The small number of ammunition artifacts positively associated with a burial feature seems to belie the general historical understanding of Tucson, during the period when the cemetery was in use, as a town rife with gun violence (see Chapter 7, Volume 1 of this series for an integrated discussion of ammunition artifacts and skeletal evidence for trauma).

In each discussion, a brief historical context is given, types are described, and type counts are provided. Additionally, demographic distribution and variation are compared and described. The findings are also compared in general to the findings in other American cemeteries (see Table 43). The limited number of archaeological investigations of historical-period cemeteries in the U.S. Southwest has curtailed our ability to compare

the Alameda-Stone cemetery to other closely aligned contexts, but the data in this chapter should be useful for future comparisons among Hispanic Catholic cemeteries and cemeteries of the frontier American West.

Apparel and Personal Adornment

In this section, we discuss artifacts interpreted as relating to apparel and personal adornment, including jewelry, hair adornment, beads, fabric and textiles, buttons and other fasteners, and footwear.

Jewelry

Forty-two individuals were interred with jewelry (see Appendix L.1). Jewelry consisted of earrings, lockets, pendants, necklace fragments, pins, brooches, and rings (Figure 62). Each piece of jewelry was unique: no identical items of jewelry were found in more than one burial feature or grave pit. Artifacts associated with jewelry included 4 pairs of earrings and 3 single earrings recovered with seven individuals in five graves, a single nonreligious pendant recovered with a subadult, fragments of 3 necklace chains recovered with three individuals, 13 beaded necklaces (discussed below in the section on beads), brooches associated with five individuals, and 12 rings with eight individuals. All metal jewelry appeared to have been made from cuprous materials. One ring appeared to have had the stone removed from its setting (Grave Pit 7913/Burial Feature 19628).

Artifacts associated with pieces of jewelry were located in all five cemetery areas (Table 63). They were found in 2–4 percent of burials in any given area. More types and the larger proportion of jewelry artifacts were found in Cemetery Areas 3 and 4, but this result is probably the result of the larger sample of burials from these two cemetery areas. Although it is unclear whether the distribution of jewelry types pertains to a clear behavioral signal, only rings and a locket were found in Cemetery Areas 1 and 2, whereas, in addition to rings, jewelry in Cemetery Areas 3 and 4 included earrings, necklaces, pins, a buckle, a pendant, and a jewelry setting. Only a necklace and a ring were found in Cemetery Area 5 burials. Females were interred with jewelry more often than males, and juveniles were interred with jewelry slightly more often than adults. Only one adult male individual in Cemetery Area 2 (Grave Pit 3177/Burial Feature 3738) was interred with a piece of jewelry, a cuprous ring, which was located on the right hand and had a flat surface on which may have been an emblem or other engraving. The other individuals interred with jewelry were either juveniles, adults of indeterminate sex, or adult females. The evidence, although inconclusive, suggests that jewelry as a form of personal adornment was reserved for females and juveniles, although it is unclear whether male juveniles would have been buried with jewelry. Rings were the only jewelry type recovered only with adults. Other jewelry types were found with adults and juveniles alike, although earrings seemed to have been more prevalent among children. Six juvenile individuals were interred with an earring or earrings, whereas only one adult individual was interred with an earring. The prevalence of juveniles with earrings could be explained, however, by the high proportion of children in the cemetery population and the small sample size of individuals interred with jewelry.

Hair Adornment

Few individuals had adornments in their hair that could be discerned archaeologically (Figure 63). There were six individuals with hair combs, one with a barrette, and one with a braided cord (see Appendix L.2). Of the seven combs recovered, six were used to hold a hairstyle in place; an example was the comb recovered with the child from Grave Pit 10166/Burial Feature 18637. It was a headband used to pull the hair off the child's face. All combs but one were recovered on or near the cranium of each of the four individuals with which they were found. A fine-tooth dressing comb was recovered under the torso of a Native American male (Grave Pit 10329/Burial Feature 28765) and appeared to have been a tool for hair maintenance. Additionally, one Hispanic female (Grave Pit 678/Burial Feature 407) was interred with a braided cord entwined in her hair.

The cord was made of a green, braided textile interwoven with fine copper thread. A single barrette, or clip, was located with an adult male (Grave Pit 3035/Burial Feature 6985). The clip was recovered from the upper back and may have been used to tie back the male's long hair. Hair adornments were located in only two areas of the cemetery, Cemetery Areas 2 and 3 (Table 64). Combs were found in Cemetery Area 3, whereas the barrette and the braided cord were both found in Cemetery Area 2.

Beads

Approximately 16,600 beads were included among the interments in all areas of the cemetery with the exception of the military section, where no beads were discovered (see Appendix L.3). The smallest beads may be underrepresented in the sample because of the diminutive size of many beads and the use of $^{1}/_{8}$-inch mesh to screen burial soils. Beads were classified using a modified version of the system developed by Karkins (1985), which was itself based on the classification developed by Kidd and Kidd (1970). It should be noted that although mortuary analysts took care to accurately identify and document the attributes of all beads associated with the burials at the cemetery, none of the analysts specializes in the analysis of beads, and errors in identification may have occurred (Figure 64).

Beads were categorized by material class, shape, decoration, color, size, and function. Beads may be manufactured from one material or combinations of materials, including bone, botanical seeds, ceramic, glass, metal, shell, stone, and wood. Only ceramic, glass, juniper-seed, stone, wooden, metal, and rubber beads were associated with the Alameda-Stone burials (Table 65). Bead shapes were described as doughnut, spherical or round, faceted round, tubular, hexagonal, teardrop, figural, or indeterminate (Table 66). Bead decoration was limited to painted beads and was rarely present, although a variety of colors were recorded (Table 67). Each bead was measured for length, width, and height, and size groupings were developed using the largest dimension taken (Table 68). The most common size was the very small "seed" bead (see Table 68).

Finally, contextual function was established. The beads at the cemetery had two functions: beads used as personal adornment (sewn onto clothing or worn as jewelry) and beads used in the funerary and religious ceremonies (part of a rosary or decorative element on a floral crown). Beads that could not be confidently placed in either of these categories were recorded as of indeterminate function (Table 69). Most of these, however, were probably related to funerary floral arrangements. Function was determined primarily by location within the grave and spatial relationship to other artifacts and skeletal elements. Beads located near wire were identified as part of a floral arrangement. When the beads and wire were recovered on or under the cranium, the floral arrangement was further identified as a floral crown, a ceremonial element used in Catholic and Native American burial traditions. Beads were sometimes recovered in clusters in which some beads retained a small fragment of knotted thread. These beads were identified as apparel related.

Seven individuals were interred with apparel-related beads (Table 70). These individuals were two young adult females, two children, and three infants. One of the young adults (Grave Pit 7886/Burial Feature 18668) was determined to have a Native American cultural affinity. All three infants were determined to be either Hispanic or Yaqui. All of the apparel-related beads were recovered in Cemetery Areas 3 and 4. Fifteen individuals were buried with beaded jewelry: 13 necklaces, 1 buckle, and 1 glass bead in a setting. All of the beaded necklaces were recovered with adult females or juveniles in Cemetery Areas 3 and 4.

Seventeen individuals were buried with beaded floral crowns, a religious artifact indicative of Catholic burial traditions (Table 71). Of these, 1 was a young adult Native American female (Grave Pit 665/Burial Feature 8604). Three children, 12 infants, and 1 fetus were buried with beaded floral crowns. These floral crowns represent a small fraction of the total number of floral crowns recovered from the cemetery. Seventy-eight individuals—25 juveniles, 35 adult females, 17 adult males, and 1 adult of indeterminate sex—were buried with rosary beads (Table 72). Although rosary beads were recovered from all areas of the cemetery except Cemetery Area 1, most were recovered from the three areas in the northern half of the cemetery. Notably, the only grave pit with rosary beads in Cemetery Area 2 was Grave Pit 3280/Burial Feature 7383, located just south of Cemetery Area 3. Floral crowns, rosaries, and other religious artifacts are discussed further in subsequent sections of this chapter.

Fabric and Textiles

Contact with copper-alloy metals proved to be an effective preservative for textiles. Because of the use of brass hooks and eyes, and pants and coat buttons, clothing materials were recovered from many burials (see Appendix L.4). The most common textile types recovered from the cemetery were cotton and wool, although fragments of silk and velvet were also recovered. Quantifying the textiles from the cemetery has proven difficult, as most fragments were observed during excavation and failed to survive to be identified by an analyst. Other fragments were noted by analysts in association with artifacts (e.g., "This is a brass uniform button with trace amounts of cotton thread attached to the shank.").

Rarely, large amounts of fabric were recorded. Most noteworthy was the large shawl located with Grave Pit 7843/Burial Feature 16989 (Figure 65). The garment was evaluated by textile analyst Laurie Webster, Ph.D. The shawl appeared to have been made of commercially spun wool yarn and was commercially woven. It was trimmed in wool fringe on at least two edges. The fringe elements appeared to have been made of yarns that were folded and plied. The shawl was a brownish green color, which suggests that it was treated with a copper-based dye. A dye of this type would have acted as an antimicrobial agent and may explain the shawl's excellent preservation. The adult female, 35–50 years old, was wrapped in the traditional style for wearing the garment, around the back, covering the top of the head to the forehead, and draped over and tucked under the arms.

One large wool fragment was recovered from the Euroamerican male, 20–25 years old, in Grave Pit 1479/Burial Feature 2506. This fragment appeared to have been the remains of a coat with brass buttons attached. It was fairly common for brass buttons to bear the remains of the garments to which they were fastened. Most of the brass coat buttons from the cemetery had trace amounts of wool adhering to the backs.

Velvet and dyed cottons were found with the child interred in Grave Pit 7597/Burial Feature 16520. The Hispanic child, 10–12 years old, was buried in a red or pink calico print blouse or dress, cinched at the waist with a belt bearing an ornate buckle. The fabric of the garment was trimmed in red velvet.

Altogether, 155 cases of textile fragments were noted in association with the burials of 137 individuals. Around 64 percent of fragments were made of cotton, and approximately another 29 percent were made of wool. The rest were made of silk or velvet. Cotton was found with males and females in roughly equal proportions; silk was associated with females or individuals of indeterminate sex; wool was found most often with males, although not exclusively so. Velvet was found only in association with two males and two individuals of indeterminate sex. Most individuals with wool fragments were adults, whereas silk was found more often with juveniles as well as two adults. Cotton was found with individuals of all ages, as was velvet. Occasionally, multiple textile fragments made of multiple fabrics were found in association with a single individual. Most often, when multiple kinds of fabric were found in association with a single individual, both wool and cotton fragments were found, and these were associated mostly with adult males or individuals of indeterminate sex.

Buttons and Other Clothing Fasteners

Clothing fasteners were often the only remaining artifacts that represented the garments worn by the deceased. Therefore, these mundane objects were tremendously valuable to archaeological interpretation of mortuary behavior and also contributed to answering questions about chronology and variation in socioeconomic stratification within the cemetery and within Tucson's living population during the late nineteenth century. Many resources were used for identifying clothing-fastener types, including period catalogs, collector's guides, and reports from archaeological investigations. More than 7,000 clothing fasteners and buttons were recovered from the cemetery.

Buttons

Whenever possible, common terms were used to describe button shapes, colors, and styles; however, the range of buttons recovered was far greater than expected. For this reason, it is beyond the scope of this report to provide differential distribution of the many combinations and sorts of button types. Basic types, descriptions, and their distribution are discussed here. Buttons types included Prosser porcelain sew-through buttons, shell sew-through buttons, metal sew-through buttons, bone sew-through buttons, coat buttons, military coat buttons, glass-shank buttons, and gaiters. Buttons were measured in inches and converted to the English system of "line" measurements used in the historical button manufacturing industry (Table 73). Buttons of all types ranged in size from the diminutive 10-line shell and Prosser buttons to 40-line brass uniform-coat buttons.

Prosser Porcelain Sew-Through Buttons

The question of ceramic vs. glass button material has been the subject of a great deal of discussion, made more confusing by an array of inconsistent terminologies. The confusion is, in part, the result of the fact that milk glass and ceramic Prosser porcelain, both opaque white materials, were attempts to mimic Chinese porcelain (Albert and Kent 1949:50) and porcelain buttons imported from Bohemia (Ziesing 1989:144). In North American colonial contexts, ceramic buttons began as very expensive imports from Europe. Into the 1800s, they were hand molded from wet clay (Hughes and Lester 1991:31; Ziesing 1989:147), until in 1840 the "Prosser" method of ceramic-button manufacture was introduced. Developed in Birmingham, England, by Richard Prosser, the relatively simple process consisted of compressing powdered clay in a mold, which created a solid, uniform blank that was then fired at high temperatures in order to create a glassy appearance. The process, initially patented in 1840, was quickly sought by French manufacturers, who exported huge quantities of the buttons to the United States in the mid- to late nineteenth century (Hughes and Lester 1991; Odland 2006: 11; Sprague 2002:111–118; Ziesing 1989:147). At the same time, U.S. manufacture of these buttons was established, although it came nowhere near to eclipsing French imports (Hughes and Lester 1991:31).

Prosser buttons were often difficult to distinguish from their porcelain predecessors because the typical "orange peel" texture (Sprague 2002) on the reverse of the button can be difficult to detect. Therefore, "Prosser" here may include porcelain buttons of the same color (milk-white) and general morphological style. Odland (2006:11) suggested that porcelain buttons were "always small and sew-through, while glass buttons can be quite large and are usually domed, faceted, and fastened with a wire shank." For the purposes of this study, the term "Prosser" is used to describe buttons of the general Prosser style but may include porcelain buttons manufactured before the innovation that lends its name to the general type (i.e., white-bodied ceramic sew-through buttons). Additionally, the terms used here to describe shape or profiles of the Prosser buttons recovered at the Alameda-Stone cemetery are commonly used by collectors and are consistent with terms adopted for use in other archaeological studies and cataloguing systems. They are not, however, period terms.

There were nearly 1,400 Prosser buttons in line sizes 10–28. Approximately 75 percent of Prosser buttons were between 14 and 18 lines. Prosser buttons were categorized as either plain undecorated or decorated. There were six plain undecorated Prosser types (Figure 66). Types were determined by cross section—dish, saucer, inkwell—and number of attachment holes (Figure 67). Four-hole plain Prosser buttons with a dish profile far outnumbered the other plain Prosser types (see Appendix L.5). Approximately 200 decorated Prosser buttons were recovered from the cemetery. Decorated Prosser buttons are described as molded, painted, or transfer-printed. Fifty-two decorated buttons had a molded design (see Appendix L.6).

Nine molded button types, including the birdcage variety, were identified among the recorded buttons (Figure 68). Sixty-eight buttons with painted designs were found in a total of 33 graves (see Appendix L.7). Molded Prosser buttons were found only in Cemetery Areas 2, 3, and 4; most of them were found in Cemetery Area 3. Buttons with piecrust shapes were found mostly in Cemetery Area 3. Molded Prosser buttons were interred more often with adults, as opposed to juveniles, as well as more often with adult males, as opposed to adult females (Table 74). Perhaps, preservation was for poor for individuals with molded Prosser buttons for some unknown reason.

Painted designs were categorized into five painted button types determined by button mold and the area painted (Figure 69). All except one were four-hole Prosser buttons. Many painted buttons were of indeterminate color, but others were red, black, green, orange, blue, lilac, yellow, brown, or light blue (in decreasing

order of abundance). There was variation in where painted Prosser buttons were found in the cemetery. Of the 32 individuals with painted Prosser buttons, 26 were found in Cemetery Area 3. None was found in Cemetery Area 1, and small numbers were found in a few burials in Cemetery Areas 2, 4, and 5. Painted Prosser buttons tended to be found with infants and younger children and with middle or older adults but were relatively evenly distributed between sexes. They were also more commonly found with Hispanic individuals or with Hispanic or Yaqui individuals but were also found with Euroamericans. The restricted use of painted Prosser buttons within the cemetery and among certain age groups suggests they may have served a special purpose or were used by a specific group, such as an extended family or families (Table 75).

Seventy transfer-printed Prosser buttons were recovered from the cemetery (see Appendix L.8), representing 26 unique transfer-printed patterns (Figure 70). These patterns are referred to as calicos or ginghams by collectors. Calico buttons were meant to complement fabric patterns on dresses, blouses, or shirts. Most of these patterns at the cemetery were transferred onto dish-shaped Prosser button blanks. Calicos were present with approximately 3 percent of the cemetery population and were recovered from all areas of the cemetery with the exception of the military section (Table 76). Like painted Prosser buttons, transfer-printed Prosser buttons were common only in Cemetery Area 3, where most of them were found. Of the 45 individuals with transfer-printed Prosser buttons, 34 were in Cemetery Area 3. Transfer-printed Prosser buttons were discovered in several burials in Cemetery Area 4, but in only 1 burial each in Cemetery Areas 2 and 5. They were not found in Cemetery Area 1. Transfer-printed Prosser buttons were found in the burials of males more than twice as often as in those of females. However, they were also found more often with younger juveniles than with adults and, like the painted Prosser buttons, tended to be found with infants and young children and with adults, a number of whom were advanced in age.

Plain Prosser buttons were recovered from all areas of the cemetery (Table 77). Cemetery Area 1, the military section of the cemetery, had the fewest (n = 47), and Cemetery Area 3, the most heavily populated portion of the cemetery, had the most plain Prosser buttons (n = 1,193). Across cemetery areas, the average number of plain Prosser buttons found within a burial feature was roughly the same (2–4 buttons per burial). However, plain Prosser buttons were found in slightly lower numbers per burial in Cemetery Areas 1 and 2. Plain Prosser buttons in Cemetery Areas 1, 2, and 5 were larger than those in Cemetery Areas 3 and 4, and the greatest variability in size was found in Cemetery Area 2. The somewhat smaller average size of buttons in Cemetery Areas 3 and 4 may relate to the larger number of juvenile individuals in those areas—their garments may have made use of smaller buttons than those of adults.

Males were associated with plain Prosser buttons two, sometimes three, times as often as females throughout the cemetery. In Cemetery Areas 1 and 2, plain Prosser buttons were located with males 11 times more often than with females, largely because of the high numbers of males represented in the southern half of the cemetery. Plain Prosser buttons were usually associated with the torso of the individual and were probably used for fastening underwear, shirts, or dresses.

Shell "Pearl" Sew-Through Buttons

Shell sew-through buttons were another common button type: approximately 1,200 shell buttons were discovered in the cemetery. Shell buttons, or pearl as they are sometimes called, were not mass-produced domestically until late in the nineteenth century and were relatively expensive compared to their Prosser counterparts (Claassen 1994:6–7, 66–69). Shell buttons in the cemetery (see Appendix L.9) were usually not decorated and were associated with the upper torso and pelvic region. Plain shell buttons were also used to fasten underwear, shirts, or dresses. In addition to the undecorated variety, there were 154 engraved shell buttons showing a total of 34 unique designs (see Appendix L.10). Like the Prosser buttons, engraved shell buttons were found most often in burials in Cemetery Area 3. They were found much less often in the other cemetery areas, albeit at a slightly higher frequency in Cemetery Area 4 than in the other areas with few shell buttons. Engraved shell buttons had a strong association with adult males and with infants or young children and were on average larger for adults than they were for juveniles. Of the males in the cemetery, 18 percent had engraved shell buttons; engraved shell buttons were more than six times more common among males than among females. They were most commonly found with Hispanic and with Hispanic or Yaqui males but were found nearly as often with Euroamerican males. Individual buttons (Figure 71) were unique and appear to have been carved by

hand; they were often stylized in idiosyncratic patterns such as sunbursts, loops, circles, and, in one case, the Star of David pattern (Grave Pit 7894/Burial Feature 19926) (Figure 72). These buttons may have been carved as an expression of identity, as with the Star of David, or as a way to personalize an otherwise nondescript article of clothing. Given their association with Hispanic and Euroamerican adult males and young children and infants in Cemetery Area 3, they must have had multiple specific applications in funerary attire. At this time, further interpretation of these designs and their meaning awaits additional analysis. Demographic distribution tables are presented here (Tables 78 and 79).

Metal Sew-Through Buttons

Approximately 1,200 metal sew-through buttons were located with 257 individuals (see Appendix L.11) (Figure 73). These metal discs were usually made from brass, iron, or both and were manufactured in the United States as early as 1845. Although there is some disagreement among collectors and archaeologists as to the earliest date of manufacture, these buttons were certainly widely available by the mid-nineteenth century (Mainfort and Davidson 2006). These buttons were often recovered from near the waist or pelvic region and were used for fastening trouser-fly closures or suspenders. More than half of all adult males were interred with this type of button, whereas only 5 percent of females were interred with them (Table 80). Size ranged from 14 to 26 lines. Most were medium-sized, averaging around 24.5 lines in size. One to 25 metal sew-through buttons were found in individual burial features, with an average of 4.7 per burial feature. When the number of individuals in each cemetery area was accounted for, more than 40 percent of individuals in Cemetery Areas 1 and 2 were associated with metal sew-through buttons, whereas around a quarter of individuals in Cemetery Areas 3 and 5 were associated with these buttons. Metal sew-through buttons were associated least often with individuals in Cemetery Area 4, around 13 percent. Part of this pattern could be explained by the fact that most metal sew-through buttons were associated with adult males, who were 17 times more likely than females to be buried with metal sew-through buttons. Metal sew-through buttons were also more commonly associated with adults, who were associated with them around twice as often as juveniles. Adults with metal sew-through buttons also tended to have, on average, around twice as many metal sew-through buttons recovered per burial than juveniles. The discovery of metal sew-through buttons did not appear to pattern according to cultural affinity, as these artifacts were found in association with individuals of all cultural affinities.

Bone Sew-Through Buttons

Approximately 430 bone buttons were located with 157 individuals (see Appendix L.12). These buttons were manufactured from cattle bones, which were widely available and relatively inexpensive (Hughes and Lester 1991; Luscomb 1992). There were at least five styles of bone buttons observed in the cemetery. Unfortunately, types were not recorded systematically and cannot be accurately reported here. The differences observed in the styles of bone buttons were subtle and related primarily to the button profile and presence of an incised design (Figure 74). Sizes were similar to those of metal sew-through buttons, ranging from 12 to 32 lines and averaging 24.5 lines. Bone buttons were usually medium-sized, sew-through, irregularly shaped, concave discs associated with the pelvic region of the individual. A few had one hole, but most had four or five holes; four-hole buttons were most prevalent. Most bone buttons were used to fasten underwear or trousers (McChristian 1995). One button, however, had a single drilled hole and was probably covered in fabric and used as a coat fastener (Grave Pit 3287/Burial Feature 7380). Bone underwear buttons were associated with juveniles and adults alike, although adults were buried with these buttons more than twice as often as juveniles (Table 81). Bone sew-through buttons were discovered in all cemetery areas; when the number of individuals in each area was accounted for, relatively similar percentages of individuals were associated with bone sew-through buttons (14–20 percent of individuals per cemetery area). Around 2.7 bone sew-through buttons were found per burial throughout the cemetery; the highest counts per burial were in Cemetery Areas 2 and 5. The lowest average number of bone sew-through buttons per burial was calculated for Cemetery Area 1.

Because many individuals in Cemetery Area 1 were exhumed, bone buttons used to fasten underwear or trousers may have been removed from grave pits along with the other remains. Although there were a few females—approximately 5 percent—associated with bone buttons, males were far more likely to have been interred with this button type. Males tended to have more bone sew-through buttons per burial and were interred

in articles of clothing fastened with these buttons almost nine times more often than females, underscoring the typical use of these buttons in fastening underwear and trousers.

Cloth-Covered and Metal Coat Buttons

Approximately 400 coat buttons were recovered from the cemetery (see Appendix L.13). These buttons were identified by their attachment method and their spatial relationship to the human remains. They were most often found at mid-torso and were used for fastening coats or jackets. Cloth buttons were usually made of a central core of iron or brass and covered by an outer fabric fastened with a shank at the back. Approximately 7 percent of the cemetery population was buried with coat buttons (Table 82). Adult males and children were buried with coat buttons more often than females. Males were buried with coat buttons three times more often than females; adults were buried with coat buttons more often than juveniles were. All individuals with coat buttons in Cemetery Areas 1, 2, and 5 were adults, and more than three-quarters of individuals with coat buttons in Cemetery Area 4 were adults. The largest number of juveniles with coat buttons was in Cemetery Area 3, but they still formed the minority of individuals with coat buttons in that area. Sixteen percent of all males, approximately 4 percent of all children, and fewer than 7 percent of all females were recovered with coat buttons. Coat buttons tended to be somewhat larger in Cemetery Areas 1 and 2; those recovered with Euroamericans were also larger than those recovered with other affinities.

Military Uniform-Coat Buttons

One hundred eighty-five military uniform-coat buttons recovered from the cemetery. Like other coat buttons, uniform buttons were usually recovered near the torso, although in some cases, smaller versions were also associated with the wrists of the individual, presumably at the cuff of the jacket. Uniform buttons at the cemetery were made of brass and featured a large federal eagle bearing a shield, arrows, and olive branches (see Appendix L.14). Only nine military buttons bore the shields with the letters I, C, D, or A for officers in the Infantry (n = 6), Cavalry (n = 5), Dragoons (n = 4), or Artillery Corps (n = 9), respectively. More common was the striped federal shield for general servicemen (n = 71). Many of the military buttons, however, were poorly preserved and could not be identified for regimental association (n = 90).

In the United States, the design of uniform buttons has been strictly regulated since the Revolutionary War (1775–1783). Advancements in button manufacture during the nineteenth century, competition among button distributors, and Civil War–era changes to federal regulations created a record by which to date the buttons of the period. However, dating the military uniform buttons from the Alameda-Stone cemetery was often impeded by poor preservation. When stamps were visible, dating was also complicated by the long period when the buttons were in use compared to the relatively short period when the cemetery was in use. For instance, Grave Pit 13501/Burial 25029 held the well-preserved remains of a young male aged 12–13 years. This individual was buried with a garment fastened by nine Artillery Corps coat buttons (Figure 75). The buttons were two-piece brass devices with "A" stamped on the front shield and "Superior ★ Quality ★" stamped on the back. The mark was used "from 1845 and lasted beyond the Civil War" (Tice 1997:120–124) but would have been reserved for officers after 1854. After 1854, General Service buttons without the letter A were specified for enlisted men of all artillery. In 1902, the Great Seal was adopted for use by all regiments and ranks. This collection of military buttons is an example of the problem encountered when attempting to establish a chronology for any of the graves with military buttons. Most uniform buttons from the cemetery date to the early 1860s but were in use well beyond the Civil War. In the case of the male interred in Grave Pit 13501/Burial Feature 25029, given his age, it is most likely that he was enlisted and buried after 1854. This date is consistent with the dates when the cemetery was in use and is not useful for establishing cemetery chronology.

Military uniform buttons were distributed across four areas of the cemetery (all but Cemetery Area 5); the largest concentration was in Cemetery Area 1, the military section of the cemetery (Figure 76). Cemetery Area 1 held 64 graves, 60 of which had been exhumed and relocated in 1884 (Heilen et al., Appendix K). Uniform buttons were among the few personal effects left behind by the nineteenth-century excavators and were found in 17 graves in this section. Cemetery Areas 2 and 3 had a fair number of military buttons as well. Eight graves in both Cemetery Areas 2 and 3 had military buttons. Cemetery Area 4 had only 1 grave with military buttons.

Uniform buttons were generally found with adult males, although, surprisingly, two infants were buried with military uniform buttons. The infant recovered from Grave Pit 7851/Burial Feature 18632 in Cemetery Area 3 was found with two General Service buttons and four brass military buttons of an indeterminate regiment, presumably also General Service. The infant recovered from Grave Pit 13686/Burial Feature 28707 in Cemetery Area 4 was found with nine General Service military uniform buttons and one indeterminate button, probably also a General Service button. Both of these infants were determined to have Catholic religious affinity by means of the evidence of Catholic burial traditions present in both burials. These two features were relatively clear examples of the reuse of garments, and the implicit reuse of the clothing fasteners attached to them, and should be considered exceptional in the context of military burials in the cemetery. Bearing in mind the extended period of use of military buttons after the Civil War and the potential for the reuse of buttons, it was not possible to develop a burial chronology based on the analysis of military buttons.

Glass Shank Buttons

Approximately 56 glass buttons with shanks were located with 13 individuals (see Appendix L.15). Sixteen styles of glass buttons were recognized. Many of the buttons were fragmentary or otherwise poorly preserved. Several of the better-preserved glass buttons are shown here (Figure 77). Glass buttons were found in Cemetery Areas 1 and 3, although of the 13 individuals with glass buttons, all but 1 grave (Grave Pit 789/Burial Feature 3800) was from Cemetery Area 3 (Table 83). Most of the glass buttons were recovered with adult females of all age categories or juveniles whose sex could not be determined. Additionally, one older adult male in Cemetery Area 3 was interred with 2 glass buttons. These may have been used as coat fasteners.

Gaiters

Gaiters were distinguished from their glass counterparts by their ceramic body and looped-wire shank attachment. Presumably used to fasten shirts, blouses, and children's garments, these buttons were often recovered under the remains or around the torso. One hundred and fifteen gaiters were recovered from the cemetery (see Appendix L.16). A little more than 3 percent of the cemetery population was buried with gaiters. Males and females were buried with gaiters in proportionally comparable numbers (Table 84). Approximately 4 percent of males and females were buried with gaiters, whereas around 3 percent of juveniles were buried with gaiters. Gaiters were located in Cemetery Areas 2, 3, and 4 and were most common in Cemetery Area 3. There was some variation in who was buried with gaiters between cemetery areas. Gaiters were more common among females than among males in Cemetery Area 3 but were found exclusively with males in Cemetery Areas 2 and 4. Also, with the exception of the burial of one infant in Cemetery Area 4, gaiters were found with juveniles only in Cemetery Area 3. Gaiters were found buried with individuals of Hispanic, Hispanic or Yaqui, and Euroamerican cultural affinities.

Other Fasteners

In addition to buttons, other kinds of clothing fasteners were discovered in burial contexts in the cemetery. These included riveted pants studs, buckles, hook-and-eye fasteners, and safety pins.

Riveted Pants Studs

Approximately 200 riveted pants studs were recovered from the Alameda-Stone cemetery. These fasteners consisted of a button and a post that snapped together through cloth (Luscomb 1992:191). One form of this pants fastener was marketed in period catalogs as a sew-free alternative for bachelors (Montgomery Ward & Company 1969:86). Approximately 180 metal pants studs were recovered from the cemetery (see Appendix L.17). Of the 33 individuals with pants studs, around 60 percent were in Cemetery Area 3. Each of the other four areas had a few individuals with pants studs. Almost all pants studs were recovered with adult males, who tended to be Hispanic or Native American somewhat more than would be expected on the basis of the distribution of cultural affinities in the cemetery. Pants studs do not appear to have been found exclusively with younger or older adults but were instead found with adults ranging in age from 18 to 75 years. Five individuals with pants studs were of indeterminate sex, and one was a female (Table 85).

Buckles

Cinch buckles (see Appendix L.18) are devices designed to slide along a strap of fabric or leather such that the teeth on the fastener would catch on the material to hold it in place, causing a cinched waist (Figure 78). The enormously successful design was patented in 1855 (Mainfort and Davidson 2006). Ninety-nine cinch buckles were recovered with adult males, 5 with females, 27 with individuals of indeterminate sex, and 2 from empty graves. Most of buckles of this type were located with adults, although 9 juveniles were interred with this type of fastener (Table 86). Cinch buckles were usually recovered from beneath the remains at the lower back and are associated with vests and pants. Cinch buckles were associated with slightly more than 15 percent of the adults in the cemetery. Of the males, approximately 30 percent had cinch buckles. Of the females, more than 2 percent had this type of pants or vest buckle. Cinch buckles were recovered from all areas of the cemetery.

Sixteen other buckles recovered from the cemetery (Figure 79). None of these buckle types were repeated anywhere else in the cemetery (see Appendix L.19). Eight adult males were interred with unique buckles; only two females and seven juveniles of indeterminate sex had unique buckles (Table 87). They were located in Cemetery Areas 2, 3, and 4. Additionally, one military buckle was recovered (Figure 80). Grave Pit 13697/ Burial Feature 25396, located in Cemetery Area 4, held an adult male 35–40 years old.

Hook-and-Eye Fasteners

Hook-and-eye fasteners at the cemetery were constructed of brass wire looped around to form a loop and a hook that could then be sewn into opposite sides of a garment and hooked together for closure (Figure 81). Approximately 525 hooks and 450 eyes from hook-and-eye fasteners were recovered with 179 individuals. Approximately 160 hook-and-eye fastener parts could not be accurately identified because of fragmentation (see Appendix L.20). These were often recovered as a single fastener at the throat of the individual or in a line of multiple hooks and eyes down the front of the chest or down the back and were associated with dresses or blouses. Hook-and-eye fasteners were the only clothing fasteners that had an obvious correlation to females (Table 88). Approximately 10 percent of the cemetery was associated with these fasteners. Almost 40 percent of the females in the cemetery were associated with hook-and-eye fasteners. Children were the other segment of the population with this type of fastener. A small percentage (5 percent) of the male population was also associated with hook-and-eye fasteners. Most individuals with hook-and-eye fasteners were found in burials in Cemetery Area 3, followed by Cemetery Area 4. Only 1 individual, an adult female, was buried with a hook-and-eye fastener in Cemetery Area 5; 1 adult male was buried with hook-and-eye fasteners in Cemetery Area 1; and no individuals in Cemetery Area 2 were buried with hook-and-eye fasteners. There was some variation between Cemetery Areas 3 and 4 in who was associated with hook-and-eye fasteners. In Cemetery Area 3, 11 times more females than males were associated with hook-and-eye fasteners, whereas in Cemetery Area 4 the number of females with hook-and-eye fasteners was only slightly greater than the number of males with these artifacts. Also, hook-and-eye fasteners were somewhat more common among adults than among juveniles in Cemetery Area 4, whereas the opposite pattern held in Cemetery Area 3. At this time, the meaning behind these differences is unclear, but perhaps hook-and-eye fasteners tended to be used in different kinds of garments between Cemetery Areas 3 and 4. Hook-and-eye fasteners were particularly prevalent among Hispanic and among Hispanic or Yaqui individuals but they were also found with Euroamericans and Native Americans, including 1 Yaqui individual.

Safety Pins

Three safety pins were recovered in three different graves. Two of the pins could be identified and dated. The safety pin from Grave Pit 694/Burial Feature 8781, recovered with a small child, was fragmentary and could not be identified. The second safety pin was recovered from upper grave fill from Grave Pit 10173/Burial Feature 28614, which held an adult female. This pin was a Butler Safety-Pin, patented in 1878 (U.S. Patent No. 198,912), with a smooth shield head. The safety pin postdated the supposed terminal end of use for the cemetery, and because of the location of this grave near construction and other postcemetery activity, its association with the human remains was tenuous. The safety pin recovered from Grave Pit 7590/ Burial Feature 9724, which held an infant, was a Stewart Diaper Pin patented in 1870 (U.S. Patent No. 106,422). The diaper pin was located at the infant's abdomen. All three safety pins were located in the northern half of

the cemetery. The two pins that could be identified were located in Cemetery Area 3; the indeterminate safety pin was located in Cemetery Area 5.

Footwear

Early-nineteenth-century shoes were little more than cloth or leather booties stretched and sewn to hard leather soles. The left shoe was indistinguishable from the right until the wearer forced the shape through use. Before the nineteenth century, U.S. shoemakers did little more than their predecessors to conform to the demands of the complicated human foot. Around 1860, curved lasts, or soles, for left and right shoes were developed (Anderson 1968). Crude manufacturing methods, however, provoked complaints from Arizona Territory soldiers during the Civil War (1861–1865). Ill-fitting boots, sewn threads that broke under stress, and wooden pegs that contracted and became loose plagued countless foot soldiers (Brinkerhoff 1976:3). Before and during the Civil War, problematic footwear was charged to the soldier's company clothing allowance. After the Civil War, however, soldiers were expected to buy their own shoes. Soldiers took matters into their own hands by rejecting boots manufactured and sold by the federal government, opting instead to purchase privately (Brinkerhoff 1976:4). Cobblers purchased high-quality leather from Mexico rather than following the government's lead by using leather remnants. One soldier described breaking in his unyielding Spanish leather boots: "These [shoes] were very uncomfortable, but I solved the fit by walking through the creek until the uppers were thoroughly soaked, walked the whole day in them and so got a foot form and comfort" (Brinkerhoff 1976:9).

Improvements in shoe manufacture progressed rapidly during the war. By 1862, power-driven stitching replaced hand sewing, and nailing replaced wooden pegs. Despite the innovation and general availability of brass screws for fastening the sole to the upper as early as 1862, the brass standard screw machine was not perfected until 1880. In 1876, the Quartermaster Department's investigation into complaints about brass screws found that screw-machine operators often ran the machine too fast; this procedure allowed the brass screws, upon wear, to push through the leather, making direct contact with the wearer's foot (McChristian 1995). In addition to the problem of screws' causing puncture wounds, soldiers complained that the copper screws conducted heat through the sole of the shoe. As a remedy, the army returned to hand-sewn soles and offered sheepskin to guard against the brass screws (Brinkerhoff 1976:15). Despite these problems, brass screws remained popular into the twentieth century. It was not until 1888, after the cemetery closed, that shoe sizes were standardized and soldiers and civilians alike could measure their feet and order sized shoes through a catalog (Anderson 1968:59).

Shoes in cemetery contexts may have multiple meanings. The obvious explanation for the overwhelming absence of shoes in the cemetery can be explained by economics. Around 1862, shoe prices ranged from $3.00 to $4.00 (Store Ledger 1862–1868, Arizona Historical Society Tucson, Arizona). By comparison, at the same Tucson shop, three shirts could be purchased for $1.50 and a suit of clothes could be purchased for $6.50 (Store Ledger 1862–1868, Arizona Historical Society Tucson, Arizona). In 1871, the cost of a soldier's pair of boots was $2.07 (Brinkerhoff 1976:4). The exclusion of shoes with burials may be considered in socioeconomic terms, but shoes have eschatological meanings as well. Mainfort and Davidson (2006) suggested in their discussions of the Eddy and Becky Wright cemeteries in Arkansas and the interments at Freedman's Cemetery in Dallas that shoes may have been included in those burials to provide a magical element to the wearer as he or she began a new journey. A similar custom has been observed in Oaxacan funeral rites. Men were shod in sandals made especially for the journey of the dead on the rocky road to paradise (Toor 1985). Regardless of the reason for inclusion, economic or spiritual, shoes are extremely personal.

Evidence for shoes was relatively rare among the Tucson interments: approximately 5 percent of the cemetery population buried with artifacts was associated with some kind of footwear (see Appendix L.21). Many of the shoes recovered from the cemetery bore the wearer's footprints—signatures of the lives passed that provide a unique metaphor for a travelling soul. Shoes were identified by the presence of leather shoe uppers, leather soles, or leather heels; exfoliated leather; leather stains; copper eyelets; copper aglets; or cotton lacing (Figure 82) usually at or on the feet of the individual in the grave. Fifty-five individuals were buried in footwear. These graves were located in all five areas of the cemetery, but evidence for shoes was

proportionally most common in Cemetery Area 3, where more than 6 percent of individuals were interred with shoes. By contrast, around 3.5–4 percent of individuals in Cemetery Areas 1, 2, and 4 were buried with shoes, and only 1 percent of individuals in Cemetery Area 5 were interred with shoes (Table 89).

Footwear at the Alameda-Stone cemetery was categorized into nine different types. Juveniles were buried in three different types of footwear: lace-up booties, lace-up ankle boots, and lace-up ankle boots with brass toe-covers. There were 9 infants or children aged 6 months–2.6 years presumably buried in booties constructed of an indeterminate textile material. These booties were represented by trace amounts of textile, aglets, and a few eyelets near the feet of each individual. All of these individuals were located in Cemetery Areas 3 or 4. There were 18 infants or children aged 6 months–7 years buried in lace-up leather boots. These individuals were recovered from Cemetery Areas 2 or 3. The third type of children's shoe was the lace-up ankle boot with brass toe-covers (Figure 83). There were 8 infants or children aged 6 months–7 years buried in this type of shoe. These individuals were buried in Cemetery Areas 3, 4, and 5.

Adults were buried in footwear of six different types: lace-up booties, lace-up ankle boots, ladies' boots, pull-up work boots, riding boots, and men's buckle shoes. There were 2 adults buried in lace-up booties; both of these individuals were buried in Cemetery Area 3. Like the booties recovered with children, these booties may have been a simple foot covering used for sleeping or may have been made specifically for burial. There were 14 adults buried with lace-up ankle boots. These individuals were buried in all cemetery areas except Cemetery Area 2. Three adults were buried in ladies' boots. These boots had adornments such as decorative buckles, buttons, or silk lining. These 3 burials were located in Cemetery Areas 3 and 4. There was 1 adult buried in pull-on work boots (Figure 84). This individual was located in Cemetery Area 1. There was 1 adult buried in what appear to have been riding boots. These boots were badly deteriorated but seem to have been constructed of black leather and were fitted up to the knee. This burial was located in Cemetery Area 2. The last type was a single shoe or bootie with a buckle fastener. This shoe was located in Cemetery Area 1 and was recovered from a grave that had been partially exhumed, presumably during the 1884 removals conducted by the U.S. Army. Skeletal evidence suggested that this grave was occupied by an adult male.

There were 13 females and 8 males buried with footwear. The remaining 35 were juveniles of indeterminate sex. Grave Pit 28077 contained lace-up boots but no human remains. Footwear distribution by sex suggests that, proportionally, adult females were buried with footwear relatively more often than adult males, but interpretation of this apparent pattern is complicated by a small sample size of sexed adults with footwear. Six percent of the adult female population was buried with footwear, compared to 2.5 percent of the adult male population. Four percent of all adults were buried in shoes. Despite their seemingly high numbers, only 5.4 percent of juveniles were buried with footwear. Juveniles were somewhat more likely than adults to have been buried with shoes.

Five Euroamerican individuals were buried with footwear. Footwear types buried with Euroamericans included riding boots, ladies' boots, and children's lace-up boots with copper toe-covers. Thirteen Hispanic individuals were buried with footwear that included lace-up booties, ladies' boots, pull-up work boots, and lace-up boots for adults and children. One adult male of Native American ancestry was identified with lace-up boots.

Most of the footwear at the cemetery was poorly preserved; however, some manufacturing techniques were observed. All manufactured footwear was constructed of leather, as opposed to vulcanized rubber. When soles were intact, it was observed that all but one pair of shoes had curved lasts, suggesting that nearly all observed shoes with intact soles would have been manufactured after 1859, when curved lasts were introduced. The small child from Grave Pit 30599/Burial Feature 28705 was buried in leather boots with straight soles that were interchangeable between the right and left foot. There were eight graves with footwear using brass screws to attach the sole to the upper shoe; this construction unambiguously signified a mass-produced shoe. All others used iron shoe nails. These were also probably mass-produced; however, they may have been produced using older technology, given that brass screws were introduced around 1862 (Anderson 1968). Although shoe length and width measurements were recorded, we were unable to infer probable shoe size from the skeletal remains. All of the shoes were observed to be more or less the correct size for the individual. That is, there were no adult shoes with children or vice versa.

Interestingly, not all footwear was located on the individuals' feet. There were three burials in which footwear was loose at the foot end of the coffin. Grave Pit 30599/Burial Feature 28705 held a small child whose

shoes were not fitted to its feet. The boots were placed between the legs in the lower half of the coffin. The footwear in Grave Pit 3211/Burial 3713 was also placed between the legs of the young adult male who was buried there. In this case, one shoe was placed between the legs and the other shoe was placed over the right leg. Grave Pit 7689/Burial Feature 14655 held a small child with the left boot near the left foot and the right boot positioned under the left knee. These inclusions do not have any obvious spiritual correlation and may simply have been a result of difficulty in preparing the deceased. The shoes may have been included with the individual rather than discarded or reused.

Religious and Ceremonial Artifacts

Religious or ceremonial artifacts recovered from graves at the Alameda-Stone cemetery signify some of the influence that Catholicism had on the population. Items such as jewelry included crosses, crucifixes, medallions, beads and other elements of fragmented rosaries, and wire from funerary floral crowns. Symbolically, the cross represents the crucifixion of Jesus Christ and devotion to Christianity, but among pre-Christian indigenous people it symbolized the intersection of life and death as it brought together the four cardinal points (Davis 2006). More than 225 graves held at least one religious object.

There were 42 crosses, 21 crucifixes, and approximately 70 medallions and other religious objects located in 108 graves (see Appendix L.22). The most common cross was of a simplistic style (Figure 85). Thirty-one variations of this style, averaging 1.1 inch in length by 0.7 inches in width, were recovered. Three were wooden with stamped-metal Christ figures attached (Figure 86). The basic design or depth of detail ranged from simple to ornate. The letters "INRI" were inscribed on 3 of the crucifixes; they constitute a Latin acronym for "IESVS•NAZARENVS•REX•IVDÆORVM," which translates to "Jesus of Nazareth, King of the Jews." The text was inscribed on 3 different brass plaques that were probably positioned above the body of Jesus on the cross; one was in the shape of an open scroll (Figure 87; see Figure 85).

Nine medallions had discernible motifs depicting saints (Figure 88). These included five variations of the Virgin Mary, one St. Catherine Laboure, one Virgin of Guadalupe, and two French Catholic Sacred Heart medallions. The discovery of French motifs is consistent with the cultural backgrounds of religious specialists working for the Tucson Diocese during the period when the cemetery was in use (O'Mack 2005, 2006). Corrosion and fragmentation were factors in the inability to identify more of the probable figures and text on the other items. There were fragments of string, twine, or wire and chain links associated with seven of the medallions. As discussed earlier, rosary beads were constructed of a variety of materials and shapes (Figure 89).

Half of the artifacts associated with a religious affinity consisted of wire fragments, probably associated with floral crowns (see Appendix L.23). Floral crowns, consisting of wire wrapped with paper or ribbon and adorned with paper or fabric flowers, were recovered with 115 of the cemetery's juveniles (Table 90). In a Catholic tradition practiced by Hispanics and some Native American tribes, the bodies of children are dressed in clothes to resemble angels with wreaths of real or imitation flowers and are referred to as *los angelitos* (Marino 1997; Toor 1985; Will de Chaparro 2007). Spicer described a similar practice in Yaqui-Catholic burials in which the "child is decked with many-colored paper-flowers a crown is made of them and placed on the head." The Yaqui tradition included unmarried adults who received this treatment as well (Spicer 1976). These decorations are an outward expression of the ritual celebrating the passage of an innocent child to heaven and continue to be a tradition integral to Mexican celebrations of death even today (Marino 1997:37–38) (Figure 90).

One brass reliquary pendant holding a distal finger bone was recovered from Grave Pit 7528/Burial Feature 8965 (Figure 91). The inside cover of the reliquary had a cross engraved on it. There was a small amount of fine fabric impressed on the front; there was a bail for the chain, and a hinge on the right side of the pendant. Additionally, the solitary Star of David button located in the throat area of the older adult male buried in Cemetery Area 3 (Grave Pit 7894/Burial Feature 19926) was recovered with a rosary and may have been a gesture of clandestine faith or a cryptic symbol of kinship.

Religious objects were found in Cemetery Areas 2, 3 4, and 5, but more than 95 percent of them were located in Cemetery Areas 3 and 4. Adults were twice more likely to have been buried with rosaries than juveniles, and juveniles were more likely to have been buried with floral crowns, although neither artifact type was exclusive to one age group (Table 91). There were important differences between Cemetery Areas 3 and 4 with respect to the inclusion of rosaries. In Cemetery Area 3, more than twice as many adult females as adult males were buried with rosaries; in Cemetery Area 4, adult females were around 50 percent more likely than adult males to have been buried with rosaries.

Other Grave Inclusions

In this section, we discuss grave inclusions that did not unambiguously fall into other categories reserved for personal adornment, religious expression, or undertaking activities. Objects may be included in burials for a variety of other reasons. Some objects may have been used as talismans, charms, or mementos from the deceased's life (Perry et al. 2009:146; Toor 1985:160–163). These objects may have been placed in the burial by prior request of the deceased or by close friends and family who may have prepared the body and included the objects for sentimental reasons. Cannon (1989) noted that inclusion or, conversely, exclusion of grave goods is not necessarily an indication of status and "varies independently of religious or emotional concern for the dead." There is no direct correspondence between mortuary display and socioeconomic status.

In a review of historical-period cemetery excavations—Arkansas (Mainfort and Davidson 2006), California (Sewell and Stanton 2008), Illinois (Buikstra et al. 2000), Kansas (Pye 2007), Kentucky (Bybee 2003a, 2003c, 2004), New Mexico (Toll 2006), New York (Perry et al. 2009), Texas (Davidson 2004; Peter et al. 2000), West Virginia (Bybee 2003b), England (Boston and Boyle 2005), and Ontario (Lipovitch et al. 2003)—it is apparent that grave inclusions apart from the limited types mentioned above are relatively uncommon. Becky Wright Cemetery in Arkansas had a large proportion of graves with inclusions of this type. Of the 10 burials, 3 had grave inclusions—a wooden pencil fragment, a spur, a shoe placed on top of a coffin, and a tablespoon. Mainfort and Davidson (2006) suggested that the placement of some of these objects may represent folk practices in which the last items used or touched by the deceased were included in the grave. Some believed objects "touched by death" would taint the living (Mainfort and Davidson 2006:200). This could have included any number of artifacts, such as eating utensils, dinnerware, toys, and tools, among other common items. Shoes in this context may represent an acknowledgement of a spiritual journey the deceased has undertaken.

Of course, it is worth mentioning that the archaeological absence of these sentimental objects from grave contexts may simply be a result of poor preservation. Sentimental objects may include jewelry, photographs, favorite toys, or items used in the deceased's favorite recreation. Cloth dolls, photographs, and letters are unlikely to preserve well. One hallmark of the Victorian Beautification of Death movement, a primarily Euroamerican trend, was the inclusion of mementos and personal effects with the body before burial (Bell 1987, 1990). This trend probably had a relatively limited impact on Tucson during most of the cemetery's period of use, although parallel trends could have emerged in Mexico, and may not have had as much of an impact on mortuary behavior as it had in other areas of the United States.

Bottles

Three small bottles were recovered from infant burials. Bottle Type 1 was a perfume bottle (Figure 92a) and was recovered from Grave Pit 7520/Burial Feature 5476. The bottle's stopper was intact and was holding back liquid in the vessel. The liquid was not tested, and it is unknown if the fluid was perfume, water, or another liquid. The bottle was embossed with the words "Lubin Parfumeur Paris." A paper label on the opposite side of the bottle read "Helio[trope]." Lubin first advertised its products in the United States in the mid-1840s. The perfume would probably have been available to U.S. consumers from 1865 to 1895, according to the current

owner, Gilles Thevenin (personal communication 2007). Bottle Type 1 was recovered from an infant burial. The newborn infant was interred in a hexagonal coffin. No clothing fasteners were recovered. A small amount of fabric was recovered in the cranial matrix and may represent the remnants of a shroud or burial gown. No overtly religious objects were recovered with the burial. Because of compression and deterioration of the burial, it is unclear whether the bottle was inside the coffin or in the grave fill. If the bottle was placed in the coffin with the infant, it may have represented a sentimental inclusion or perhaps a vessel containing holy water used during the funeral ceremony.

Bottle Type 2 (see Figure 92b) was recovered from Grave Pit 13526/Burial Feature 21614. The bottle body was embossed with a woven basket design. A bow with the ends trailing down is embossed on the opposite side of the body. No stopper was recovered with the bottle. The neck of the bottle was slim but would not have functioned well as a natural stopper for whatever liquid was contained inside. Bottle Type 2 was recovered from an infant burial. The infant was approximately 1 year old and was interred in a hexagonal coffin. The remnants of shoes and clothing were recovered. No overtly religious artifacts were recovered. The bottle was located in the coffin at the infant's left side and may have contained holy water used during the funeral ceremony, although its precise function is unknown.

Bottle Type 3 (see Figure 92c) was recovered from Grave Pit 17764/Burial Feature 19779. It was a small, oval bottle with 13 white stripes that swirled vertically around the body of the vessel. The neck of this bottle was slim and would have required vigorous shaking to release the contents and could have easily functioned as a vessel for holy water. The burial was of a newborn infant interred in a rectangular box. No clothing fasteners were recovered, although several straight pins were found. The presence of straight pins could indicate the use of a shroud or the use of a floral arrangement, which the pins would have secured. Floral wire was recovered at the infant's torso and from around the cranium. The bottle was located in the coffin near the infant's left arm.

All three infant burials were in Cemetery Area 3, presumably the section of the cemetery in which most of Tucson's Catholic population was buried. Floral arrangements, floral crowns, and the types of burial clothing recovered with these three burials were fairly common in the Alameda-Stone cemetery. Most infant burials were located in Cemetery Area 3. Apart from the spatial correlation, no clear relationships among the burials with bottle inclusions could be determined.

Smoking Pipes

Clay smoking pipes may arguably be one of the most common items found archaeologically at historical-period sites in the United States. Tobacco, and the pipes used to smoke it, were introduced to Europeans through contact with American Indians during the American colonial period (Ayto 2002; Bradley 2000; Dunhill 1969; Rafferty and Mann 2004). Use of smoking pipes was most common among men, although women indulged in smoking tobacco as well, albeit to a lesser degree. By the nineteenth century, pipe smoking had become virtually ubiquitous in America (Bradley 2000). In the west, clay pipes have been found at nineteenth-century army encampments in Colorado, Montana, South Dakota, Wyoming (Wilson 1971), and Arizona (Herskovitz 1978). Pipes are found less often in mortuary contexts. One pipe stem was recovered from a nineteenth-century burial in Manhattan, Kansas (Pye 2007); one pipe was recovered from a burial in the Elmbank Cemetery (Lipovitch et al. 2003); and several pipes were found in the Milwaukee County Poorhouse Cemetery (Richards and Kastell 1993). Despite underrepresentation in numbers, their significance should not be discounted. Like many grave inclusions, smoking pipes can be very personal. Many nineteenth-century clay smoking pipes display idiosyncratic designs or engraved initials and bear symbols of home and country (Bradley 2000). As sentimental symbols of identity, smoking pipes make fitting contributions to the grave.

There were two clay smoking pipes associated with two individuals in the Alameda-Stone cemetery. Pipe Type 1 was recovered with a Euroamerican young adult male (Grave Pit 112/Burial Feature 1497). The fragmentary pipe consisted of a whole clay bowl with etched images of a harp and chalice (Figure 93a and b). The pipe bowl was fitted with a brass ferrule and was located near the male's left foot.

Pipe Type 2 consisted of a fragmentary clay smoking-pipe bowl (see Figure 93c) with fragmentary stem and heel located with a young adult of indeterminate sex and biological ancestry (Grave Pit 609/Burial Feature 1348). This pipe most resembled the Irish style manufactured in England from 1850 to 1900 (Ayto 2002:8),

although its country of origin and manufacturer are unknown. The young-adult burial was located in the military cemetery and was partially removed during the 1884 exhumations contracted by the U.S. Army. The location of the pipe in relationship to the individual is unknown because of heavy disturbance.

Both burials were located in the southern portion of the cemetery. Pipe Type 1 was in Cemetery Area 2, and Pipe Type 2 was in the military section of the cemetery to the west, Cemetery Area 1. The populations of these two areas were predominantly male and Euroamerican. Both individuals had complete or nearly complete sets of teeth; however, neither exhibited any use wear typical of long-term daily pipe smoking. The lack of wear probably reflects the individuals' ages at the time of death. Only 10 individuals discovered in the cemetery had pipe facets in their teeth. All but 2 were Euroamerican, and these Euroamerican individuals were located in the southern portion of the cemetery, Cemetery Areas 1 and 2. For more information on pipe faceting in the cemetery, see Chapter 13.

Tools and Toys

Tools and toys recovered from the cemetery included a graphite stylus, a colorless glass marble, and an iron pair of scissors.

A stylus (Figure 94a) was recovered from upper fill of Grave Pit 591/Burial Feature 1148. The grave was that of a small child of approximately 2 years of age. The feature was heavily disturbed and was intruded upon by a clay sewage pipe; therefore, the stylus may have been introduced during postcemetery construction activities. Barring that, however, this artifact may represent a memento or artifact sentimentally placed with the deceased child.

A pair of scissors (see Figure 94b) was recovered from Grave Pit 690/Burial Feature 8877, a Hispanic young adult male. The scissors were located beneath the individual's pelvis as if they had been in a back pocket. The iron scissors were heavy and large, and it seems unlikely that the object would have been overlooked or unintentionally included unless the scissors were misplaced by the person who prepared the individual for burial. If this object was intentionally placed in the coffin, the scissor may be an indication of the deceased's trade or avocation.

A marble was recovered from Grave Pit 7912/Burial Feature 18723, that of an older adult Hispanic male. The marble was recovered from grave fill surrounding the coffin. The grave was relatively intact; however, the possibility exists that this artifact was a result of postcemetery disturbance. More likely, though, the marble may have been included during the funeral ceremony. Whether it was intentionally placed in the grave with the coffin as a sentimental gesture or was scooped up with soil as the grave was filled is unknown.

Coins and Tokens

The belief in the need for valuables, including currency, in the afterlife is a widespread and long-held belief in many cultures from antiquity to the present day. The ancient Greeks, accustomed to heavy taxation, prepared the deceased with coins to pay for safe passage across the River Styx (Puckle 1926). The Chinese placed a coin in the mouth of the dead so that it might be easily retrieved for the payment of otherworldly tolls (Crissman 1994; Puckle 1926). These customs continued into Christianity with the placement of coins directly on the eyes of the dead so that the dead will "no longer look upon this imperfect life" (Muret 1683 in Puckle 1926:51). Additionally, coins prevented the eyes from opening, effectively mitigating the superstition that the dead may look for a travel companion among the living (Perry et al. 2009:425), and gave the appearance of peaceful sleep (Chiñas 1992).

The practice of including coins persisted in America, Europe, and Britain well into the 1900s (Merrifield 1988:67 in Davidson 2004:350; Puckle 1926:51). During the late eighteenth century, the placement of coins in burials was adopted by individuals of African American ancestry, as well. In the United States, coins have been recovered archaeologically in Euroamerican and African American burials, including those in New York's African Burial Ground (1650–1795) and Dallas's Freedman's Cemetery (1869–1907), among others.

Davidson (2004) reported, in his dissertation on Freedman's Cemetery, that coins were located at the head, hips, and hands, and loose in the coffin fill. These locations were consistent with those in other African American cemeteries (Davidson 2004), including the New York African Burial Ground (Perry et al. 2009). According to Davidson's report, relatively few burials included more than 2 coins, although one Late Period burial (Burial 1002) at Freedman's Cemetery included 7 coins, all recovered near the left hip. In Euroamerican cemeteries, coins were most commonly located near the head and shoulders or in the eye orbits. Pittsburgh's Voegtly Cemetery excavations recovered 18 burials with coins placed over the eyes (Beynon 1989:147), and Grafton Cemetery in Illinois had 4 burials with coins near the eyes or in pants pockets (Buikstra et al. 2000). There were 13 coins recovered from 6 different burials at the Alameda-Stone cemetery.

Six coins were located with a single Hispanic male (Grave Pit 13591/Burial Feature 21840), located in a pile at the right hip. These six coins included five Mexican *reales* coins—all with illegible dates—and one 1859 U.S. Seated Liberty half dollar (Figure 95b–f). The individual with the U.S. coin was placed in a coffin that was not long enough to accommodate an extended position. The head of the individual was turned at an awkward angle and the legs were flexed and crossed at the ankles. Additionally, the remains were covered with lime indicating contagion or an attempt to conceal putrefaction. If this burial was performed hastily, it is more likely that the coins were in the individual's pants pocket and were an accidental inclusion.

A Euroamerican adult male (Grave Pit 534/Burial Feature 1278) and an African American adult male (Grave Pit 3315/Burial Feature 6941) had two coins each near their heads. The Euroamerican had two Mexican pesos (see Figure 95a), one on each side of his head. Crissman (1994) described Appalachian burial customs in which coins are placed on the eyes of the dead and pushed off to the sides upon interment. The location of the coins included with this burial could be explained by this custom, or the coins might simply have fallen off during lowering into the grave. The Euroamerican also had osteological trauma consistent with a self-inflicted gunshot wound through the mouth and a fractured left forearm. Fourteen of the individual's teeth had gold fillings within the crown.

The coins with the African American male were too degraded to identify (see Figure 95g). One coin was on the nasal bone, and the other coin was near the side of the head. There was cuprous staining on the face of the individual from where the coins rested. It appears that the coins were placed on cotton fabric and as the copper coins oxidized, cuprous material leached through the fabric, sandwiching a disc of cotton between the two layers of copper. This may represent some form of shrouding, although this individual appeared to have been dressed in a military uniform jacket and pants. If this individual was shrouded, the evidence suggests that only his face was covered.

There were three additional individuals associated with the remaining three illegible coins. One individual was an infant with a single coin near the head (see Figure 95h). The other two individuals were adults, one Hispanic male and the other of indeterminate biological ancestry and sex. The Hispanic male had a single coin on the torso along with a metal crucifix. The other adult was a previously removed individual in the military cemetery. There were several buttons remaining in the grave along with the coin.

A single token was recovered in the Alameda-Stone cemetery. The dark gray or black ceramic poker chip, inscribed "Poker Check 50" (see Figure 95i), was located underneath the torso of a Hispanic adult male (Grave Pit 533/Burial Feature 1113). The poker chip may have been an accidental inclusion, a sentimental placement, or a token of spiritual belief similar to the inclusion of other currency recovered from the cemetery.

The individuals associated with coins and tokens did not seem to have a spatial correlation. They were located in Cemetery Areas 1 through 4, although the individuals within Cemetery Area 3 were limited to the southern portion of that area. The Hispanic male in Grave Pit 13591/Burial Feature 21840 was the northernmost individual, located in the northernmost portion of Cemetery Area 4. The Euroamerican and the African American with coins at their heads were both located in Cemetery Area 2.

All of the individuals associated with coins or tokens were either male or indeterminate. The adult of indeterminate sex was associated with masculine artifacts and was probably male. All of the individuals except for the Hispanic male with the crucifix (Grave Pit 7767/Burial Feature 13322) had indeterminate religious affinity. The Hispanic with the crucifix was determined to be Catholic.

Frames

There were 19 frames recovered from 18 separate burials. Five basic styles could be determined: large rectangular, rectangular, square, oval, and oval bale (Figure 96a–e).

There was 1 large rectangular frame measuring approximately 5 by 7 inches, consisting of a ferrous metal frame with glass insert (see Figure 96a), and 15 smaller rectangular frames (see Figure 96b). Smaller rectangular frames were roughly 1½ by 2 inches and consisted of a ferrous metal frame with a glass insert. One of the small rectangular frames preserved well enough to discern an image. The image was in black ink and depicted three figures; the central figure had its right hand raised. There were 2 square frames (see Figure 96c) measuring roughly 1½ by 1½ inches. These were also constructed of a ferrous metal frame with glass insert. There was 1 oval frame (see Figure 96d) constructed of a ferrous metal frame with glass insert and 1 oval frame with bale (see Figure 96e) constructed of a cuprous metal frame and glass insert with a loop at one end for hanging.

The distribution of frames was exclusively in the northern half of the cemetery, Cemetery Areas 3, 4, and 5. They were predominantly in Cemetery Areas 3 and 4, presumably where Tucson's Catholic citizens were buried. Six of the individuals with frames were determined to have had a Catholic religious affiliation based on the presence of rosary beads or other artifacts associated with Catholic burial traditions. All age categories were represented. Euroamerican, Hispanic, and Native American individuals and individuals of both sexes were buried with frames.

It is not known whether smaller rectangular frames contained photographs or other mementos. One hypothesis is that these frames contained religious images. The frame from Grave Pit 13689/Burial Feature 30678 (Figure 97) did not hold a photograph but an ink drawing of three figures, one of whom appears to be crossing himself or gesturing a blessing. It is impossible to know if the other small rectangular frames contained similar illustrations.

Ammunition

Arizona in the early nineteenth century was still part of Mexico and did not become part of the United States until the Gadsden Purchase in 1854. Tucson was founded in 1775 and was built to withstand a possible offensive attack from the British to the northeast, from the Russians to the north, and from Native Americans, specifically the Apaches, from all directions (Sheridan 1986:10). The railroad did not arrive until 1880, making Tucson a far frontier in the west. Tucson was considered by many Euroamericans to be a rough town, home to "bandits, con men, [and] lawless riffraff from both sides of the border" (Sonnichsen 1987:45). The lawmen from neighboring areas like California also encouraged the movement of rough characters away from their own towns and toward Arizona. Guns were a common and necessary tool for survival in the American West.

During the period when the cemetery was in use, negative views of violence and lawlessness in Tucson had spread across the country. For instance, John C. Cremony, a Boston journalist, described Tucson as having been "cursed by the presence of two or three hundred of the most infamous scoundrels it is possible to conceive. Innocent and unoffending men were shot down or bowie-knifed merely for the pleasure of witnessing their death agonies" (Cosulich 1953:120). J. Ross Browne, a journalist from *Harper's Magazine*, reported similar views of Tucson in the nineteenth century. Some individuals tried to uphold the law, but most of the population ignored criminal activity, not wanting to become involved, making prosecution for crimes difficult. Judge Aldrich, in fact, resigned his position in the criminal court of Tucson on October 30, 1860, in disgust at the people of Tucson and their unwillingness to report criminal activity (Cosulich 1953).

Tucsonans and the people of the neighboring areas also had to contend with hostile Apaches, who were notorious for raiding settlements in the region. There were weekly accounts of murder printed in the local newspapers. The Tucsonans were allied with some of the O'odham, who helped protect them from the Apaches and without whose help survival would have been tenuous. Various treaties with the Apaches led to decreased raiding activities, but never for long (Sheridan 1986). There were a few soldiers stationed at nearby Camp Lowell, but they were not enough to deter the Apaches from attacking. Before the railroad arrived in 1880, transportation of people, mail, and goods was accomplished by horseback, wagons, and stagecoaches.

These wagon and stagecoach trains were frequently attacked, and many people feared leaving or entering Tucson (Cosulich 1953; Sonnichsen 1987). More than 160 U.S. and Mexican individuals were killed in 3 years on the Butterfield Mail route from Fort Yuma, California, to Stein's Peak in New Mexico (Wagoner 1975:355).

Acquiring guns and ammunition was probably difficult in Tucson during the nineteenth century, as most of the factories were in New England, and only a few in the south (Lewis 1959). The military had priority and with the advent of the Mexican War and then the Civil War, the military had a constant need for new firearms. Tucson's isolation from the railroad made shipments all the more challenging to receive. The military encampment of Camp Lowell, nearby, may have boosted the supply of the latest-model weapons in Tucson, but many Tucsonans would probably have made do with any firearm that was handy, regardless of age or durability.

A total of 89 ammunition artifacts was collected from the cemetery (see Appendix L.24). Five types of ammunition were recovered: bullets, pellets, cartridge cases, percussion caps, and shotgun shell bases, each in several different sizes (Figures 98–101). The ammunition was fairly well preserved and was composed of nonferrous metals such as brass, copper, and lead. Maker's marks could not be identified on any of the ammunition, and manufacturers were not determined. Ammunition was classified and grouped into four contextual categories: intrusive, personal objects, weaponry, and unknown.

Ammunition was collected from 43 graves in Cemetery Areas 1 through 4. Twenty-four individuals, or 2 percent of the total number of individuals in the cemetery, were directly associated with ammunition. In 22 of the graves, ammunition was present that could not be directly associated with the individual and was interpreted as intrusive (i.e., relationships to funerary activities was tenuous at best). Three of the graves had a combination of intrusive ammunition and ammunition that could be directly associated with a burial. Of the 24 individuals associated with ammunition, 88 percent were adults and 12 percent were children. Of the 21 adult individuals associated with ammunition that could be analyzed for sex, all were male.

There were 25 intrusive ammunition artifacts associated with 19 graves: 6 bullets, 7 cartridge cases, 3 pellets, 8 percussion caps, and a shotgun shell base. Ammunition was deemed intrusive if it was collected outside the coffin and therefore was not associated with the interred individual. One newspaper account described the north wall of the cemetery as being used as "a screen for a combat of some kind, which served to attract a large part of the population in that neighborhood" (*Daily Arizona Citizen*, 1 April 1879:3). Additionally, some firearms may have been used during funeral services, as described in the newspaper accounts of Corporal John Lyon's funeral (*AWS,* 27 January 1881:3, "The Military Cemetery"): "The troops formed in the enclosure; the coffin, wrapped in the American flag, was then taken from the hearse to the grave, and three volleys were fired; the band played a dirge, and the ceremonies were over." The use of firearms in and around the cemetery during its use probably left spent ammunition scattered on the ground surface, some of which could have been incorporated into grave-pit fill as graves were dug and filled.

Associated with four adult individuals were 39 ammunition artifacts that probably were personal effects or mementos placed with the deceased. All of the ammunition was in the hip area of each individual as if in a pocket or pouch attached to the pants or belt. A Euroamerican male (Grave Pit 515/Burial Feature 1461) had 11 unfired and 2 fired percussion caps in a mass at his right hip. A Hispanic male (Grave Pit 564/Burial Feature 3626) had 4 unfired pellets. Another Euroamerican male (Grave Pit 7887/Burial Feature 18922) had a fragmented cartridge case with thick fabric stuffed inside it, along with an unidentified metal object; portions of a fragile fabric were wrapped around all of these artifacts. A bundle of fabric fragments, newspaper fragments, a cartridge case, and 20 percussion caps were also collected with a Native American male (Grave Pit 10329/Burial Feature 28765). The Native American and the Euroamerican may have had a separate pouch containing their ammunition.

Three individuals exhibited skeletal evidence of gunshot wounds in addition to the presence of ammunition. A Euroamerican adult male (Grave Pit 3288/Burial Feature 7199) had a gunshot wound to the abdomen. The pellet was lodged in the fourth lumbar vertebra. There was little to no healing, indicating that he died around the time when the gunshot wound was inflicted. A Euroamerican child (Grave Pit 7529/Burial Feature 8941) of indeterminate sex had a pellet located near the right upper arm, and the right shoulder blade had a mostly healed gunshot wound, demonstrating that the child survived the gunshot and the pellet was never removed. An adult male (Grave Pit 13539/Burial Feature 21747) of indeterminate cultural affinity had a gunshot wound in the right hip. A fired bullet was resting on the pelvic bone where the trauma was located; there was

little to no healing of the wound. There does not appear to be any spatial correlation for these individuals. Two were located in Cemetery Area 3 and the other was located in Cemetery Area 2.

Some ammunition was collected with coffin fill and was therefore associated with the individual, but there were no obvious indications that the ammunition was a sentimental inclusion, and there was no skeletal evidence of trauma. The cartridge cases and percussion caps were more likely to be personal objects because they were not ammunition that would have entered the body of an individual that was shot. Contextual evidence for interpreting the bullets and pellets is unclear. Thus, the bullets and pellets may have been from nonfunerary activities or could be personal effects.

There were 22 ammunition artifacts associated with 17 separate individuals: 6 bullets, 8 pellets, 3 cartridge cases, and 5 percussion caps. The ammunition was of various sizes. There was 1 Native American, 1 Euroamerican, 7 Hispanic individuals, and 7 individuals of indeterminate biological affinity. Most were adults; 1 was a child and 1 was an individual of indeterminate age.

There is an obvious disparity between the many newspaper and personal accounts of violence in 1860s–1870s Tucson and the realities of the cemetery's artifactual evidence and signs of weapons trauma discovered through analysis of the skeletal remains. Of the 1,386 individuals recovered from the cemetery, there were only 18 individuals recovered with any kind of weapons trauma; 11 of these individuals had evidence of gunshot wounds (see Chapter 12, this volume, and Chapter 7, Volume 1 of this series). Several factors may account for this disparity. First, gunshot trauma does not often appear osteologically. Second, the sampling strategy for this type of analysis may have precluded observation of gunshot-trauma cases. Third, personal accounts should be viewed with moderate skepticism. George Hand's diary, although rich in detail and a valued source for historians, may skew the perception of Tucson's past. Hand was a saloonkeeper and may have been exposed to more violence than the average Tucsonan. Additionally, newspaper accounts may have sensationalized violence or exaggerated stories of gunslinging settlers fending off Apache raids, thus romanticizing the inherent danger of life in the Wild West.

Conclusions

Chapters 4 and 5 discussed cemetery organization, physical aspects of the graves, and burial traditions represented in the cemetery. We learned the Alameda-Stone cemetery had two major sections divided more or less into two geographical halves. In this chapter, we examined the artifactual remains and personal effects of the 1,386 individuals interred in the cemetery. Consistent with the two previous chapters, the artifactual evidence suggests there were two major sections of the cemetery, the more populous Hispanic Catholic section in the north and the secular section in the south.

In general, artifacts of personal adornment—apart from clothing fasteners—were most likely to be located in Cemetery Areas 3 and 4 than in any other area of the cemetery. This can be attributed largely to the high numbers of women and children interred in the northern half of the cemetery compared to the southern half, which consisted mostly of adult males. Clothing fasteners were distributed throughout the cemetery, although there were noteworthy differences between clothing-fastener types and age or sex. Decorated Prosser buttons (e.g., painted, transfer-printed, or molded) and engraved shell buttons were more frequent in Cemetery Areas 3 and 4 than in other areas of the cemetery, suggesting there was a preference for decorated buttons in the northern half of the cemetery. Transfer-printed Prosser buttons, molded Prosser buttons, and engraved shell buttons were more common among adult males than adult females. Glass shank buttons and hook-and-eye fasteners were more popular among adult females. Military buttons, riveted studs, coat buttons, and cinch buckles were more popular among adult males. As a group, juveniles were interred with more painted Prosser buttons, gaiters, and hook and-eye fasteners than adults. Footwear was more common among juveniles. Among adults, females were more likely to have been interred with shoes. Again, footwear was more common in Cemetery Area 3.

Religious objects were almost exclusively restricted to the northern half of the cemetery in Cemetery Areas 3, 4, and 5. There were only two religious artifacts recovered in the southern half of the cemetery, in Cemetery Area 2. One was a cross located with an adult female in a grave just south of Cemetery Area 3, and the other was cruciform coffin hardware decorating the coffin of an adult male (see Chapter 5). Catholicism was more frequently represented in the cemetery than any other religious affinity. Adults were more likely to have been buried with rosaries, whereas children were more likely to have been buried with traditionally Catholic floral crowns. Additionally, all of the funerary-related bottles were located in Cemetery Area 3. These may have held holy water and may have been used in the funeral ceremonies for each of the three infants with which they were found. Frames, which in some cases may have held religious images, were also confined to the northern portion of the cemetery.

Coins and tokens—those that were unambiguously included in burials—were all located in Cemetery Area 2. Two individuals were interred with coins over their eyes, and one individual was buried with a poker chip in what was presumably his back pocket. Other individuals with coins were located in Cemetery Area 3; however, the coins recovered from these burials cannot be directly associated with funerary activities. Ammunition was located in adult male or juvenile graves exclusively, although ammunition was located in all areas but Cemetery Area 5. The three males with bullets recovered from their remains were located in Cemetery Areas 2 and 3—two of them in Cemetery Area 3. This is consistent with osteological analysis showing that most of the 18 weapons-trauma cases were recovered from the northern half of the cemetery (see Chapter 12), although it scarcely supports romantic tales of the Wild West or Tucson's legendary violent past.

The distribution of ammunition was also interesting. In only three burials was an ammunition artifact probably associated with a gunshot wound, and in a large proportion of cases, ammunition artifacts were determined to have been intrusive and probably not associated with any trauma to an interred individual. The few associations of individuals with fired ammunition artifacts seem to contradict historical descriptions of Tucson as a town overwhelmed with gun violence, although it remains possible that projectiles were removed from affected individuals before death or burial as a result of medical procedures.

Temporal changes in artifact types were not noted, in part because of the short period during which the cemetery was in use and a lack of clear information on the sequence of burial for most areas of the cemetery. As discussed in Chapter 4, further analysis of feature-to-feature relationships could reveal possible changes in mortuary treatment and artifact use, although even in those cases, the sample size that could be used to infer possible temporal change in artifact use and deposition would be limiting.

In conclusion, artifacts associated with personal adornment, apparel, religious objects, and other personal artifacts found in burial contexts within the project area were relatively abundant and diverse. The specific meaning or function of many artifacts was often difficult to determine, but variation in multiple artifact types according to demography and spatial location suggests that further analysis of artifact distributions—including analysis of covariation in multiple artifact types and feature characteristics—could contribute to a deeper understanding of cemetery organization. Burial-associated artifacts associated with individuals, in combination with other evidence, should also provide a basis for understanding social and religious variation in mortuary practices as implemented in the cemetery and in other cemeteries of the period, particularly those associated with Hispanic Catholic religious traditions.

Figure 62. Examples of the jewelry from the Alameda-Stone cemetery: (*a–d*) brooches and pins; (*e–f*) chain links; (*g–h*) pendants; (*i–o*) earrings; (*p–s*) finger rings.

Figure 63. Artifacts of hair adornment recovered from the Alameda-Stone cemetery: (*a*) braided cord from Individual P, Grave Pit 678, an adult female of Hispanic cultural affinity; (*b*) combs from Individual P, Grave Pit 7525, an adult female of indeterminate cultural affinity; (*c*) headband from Individual P, Grave Pit 10166, a child of indeterminate sex and Hispanic cultural affinity; (*d*) combs from Individual P, Grave Pit 727, an adult female of Hispanic cultural affinity; (*e*) drawing of a fine-tooth comb from Individual P, Grave Pit 10329, a middle adult male of Native American cultural affinity.

Figure 64. Examples of beads from the Alameda-Stone cemetery.

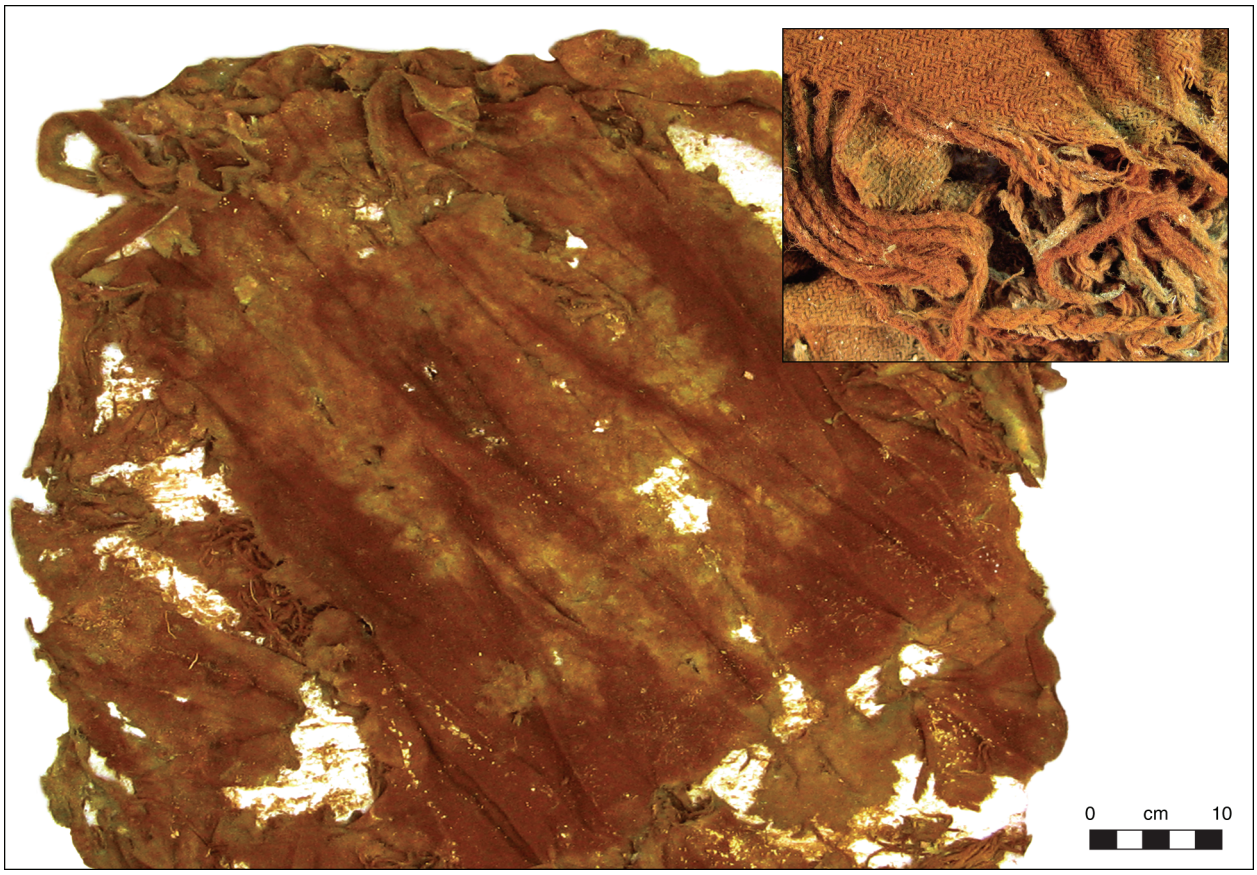


Figure 65. Wool shawl with fringe (inset) from Individual P, Grave Pit 7843 an adult female of Hispanic or Euroamerican cultural affinity.

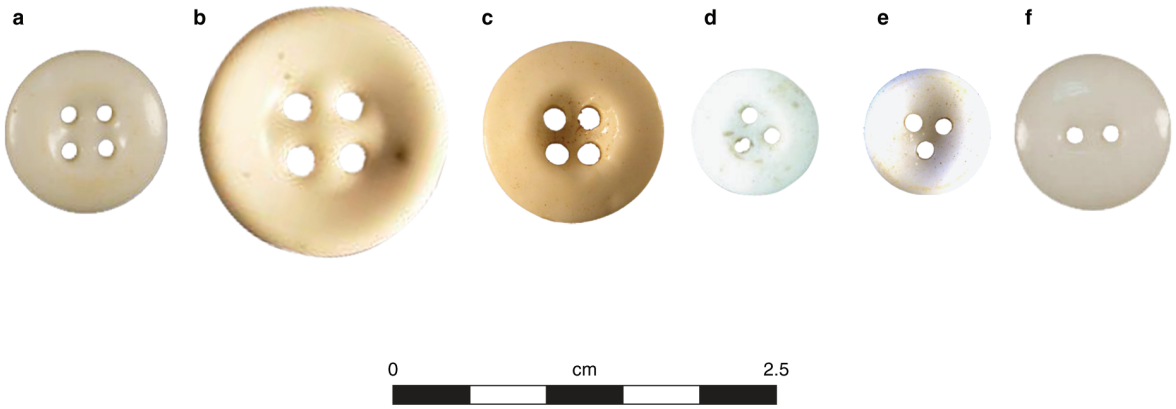


Figure 66. Prosser button types: (*a*) four-hole dish; (*b*) four-hole saucer; (*c*) four-hole inkwell; (*d*) three-hole dish; (*e*) three-hole saucer; (*f*) two-hole dish.

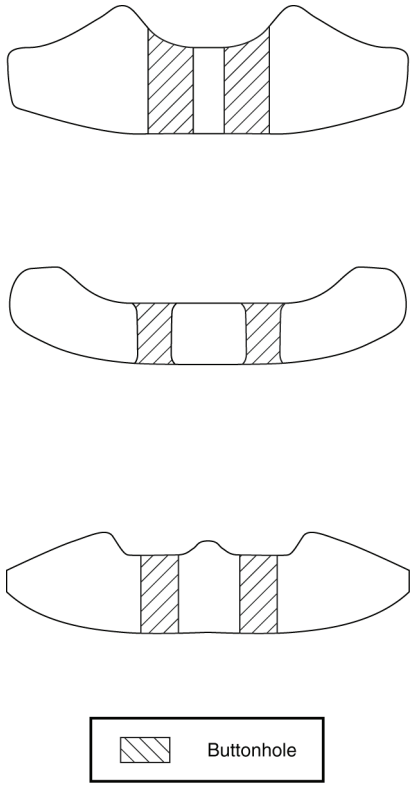


Figure 67. Basic Prosser button profiles: *top*, dish; *middle*, saucer; *bottom*, inkwell.

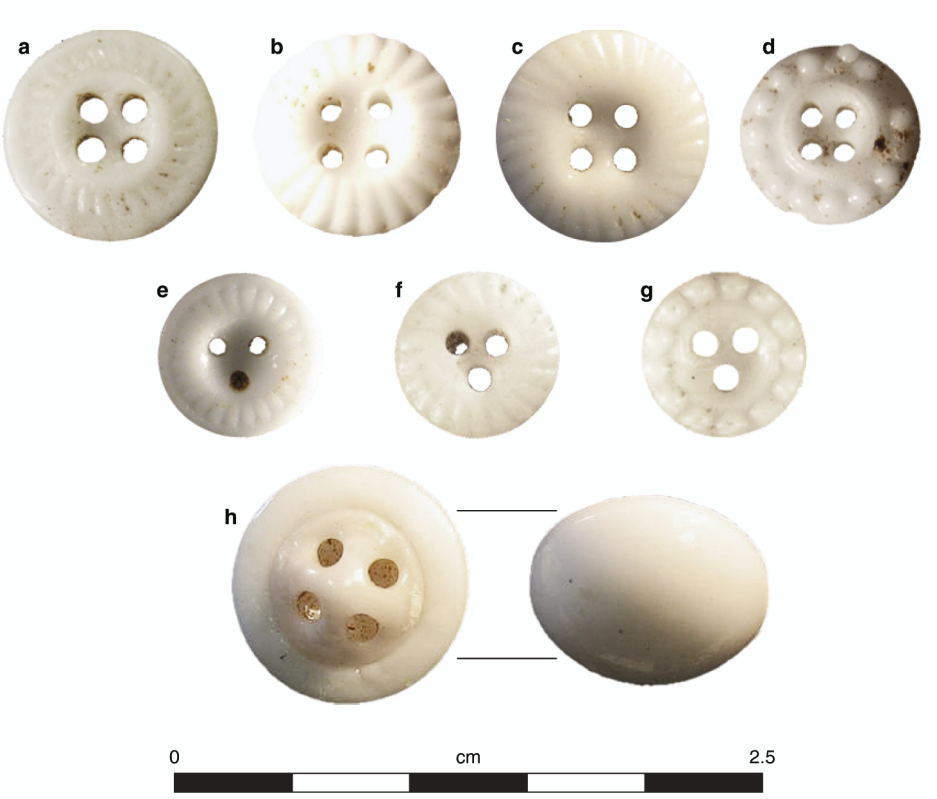


Figure 68. Molded button types: (*a*) four-hole piecrust; (*b*) four-hole sawtooth; (*c*) four-hole swirling piecrust; (*d*) four-hole hobnail; (*e*) three-hole pie crust; (*f*) three-hole swirling piecrust; (*g*) three-hole hobnail; (*h*) birdcage.

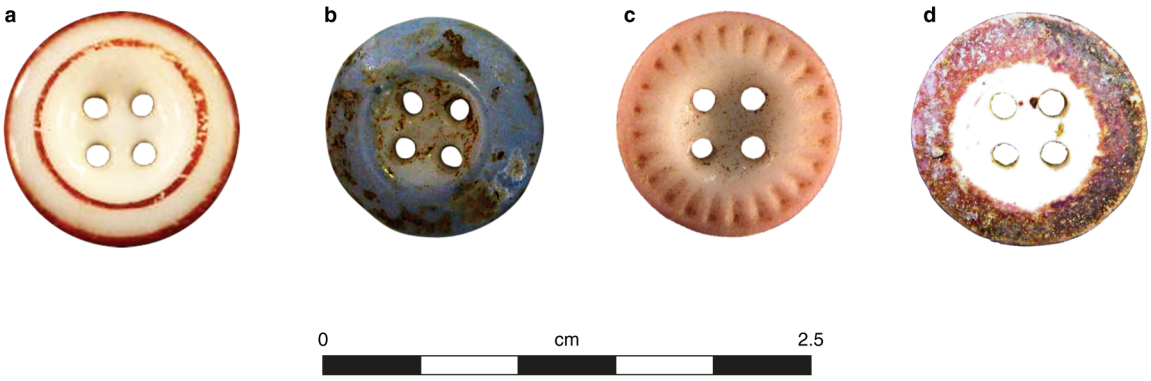


Figure 69. Painted button types: (*a*) two stripes front, one stripe back; (*b*) rim-painted inkwell; (*c*) two stripes piecrust; (*d*) rim-painted dish.

Figure 70. Examples of transfer-printed buttons from the Alameda-Stone cemetery.

Figure 71. Examples of engraved shell buttons from the Alameda-Stone cemetery.

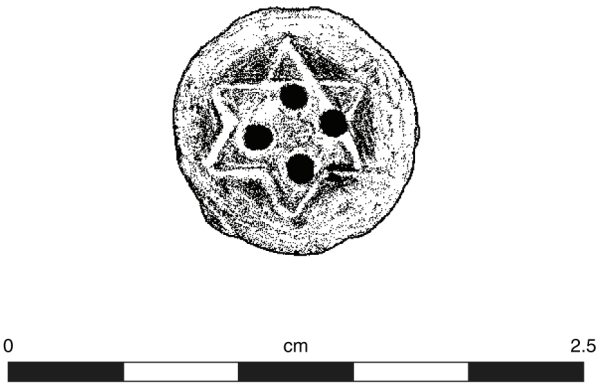


Figure 72. The Star of David button from Individual P, Grave Pit 7894, an older adult male of Hispanic or Yaqui cultural affinity.

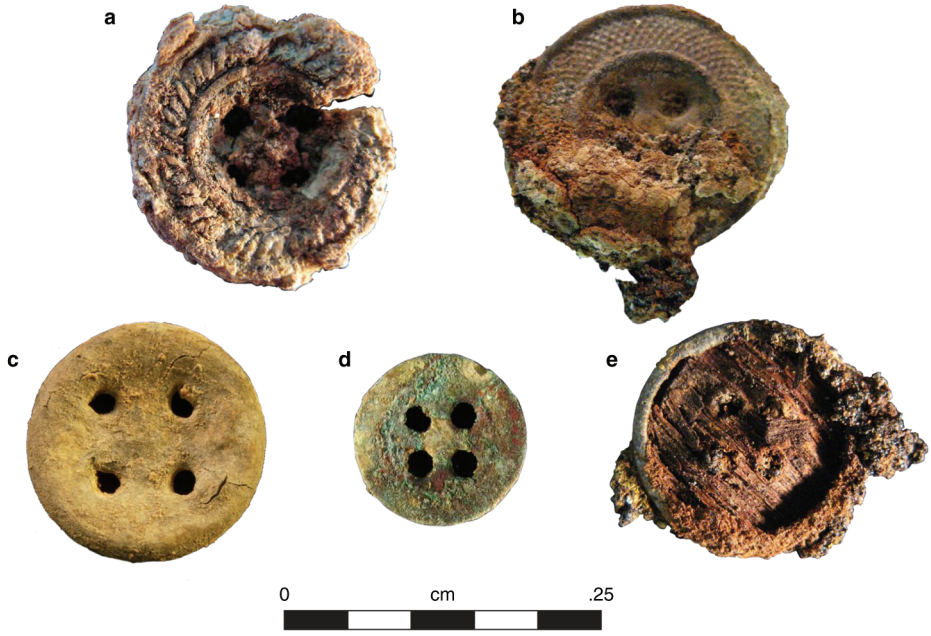


Figure 73. Examples of metal sew-through pants buttons from the Alameda-Stone cemetery.

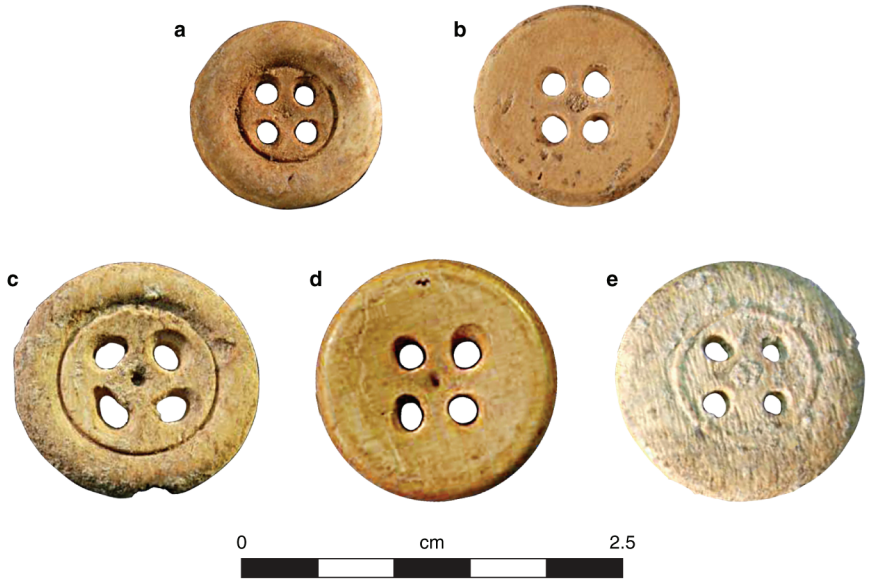


Figure 74. Bone buttons from the Alameda-Stone cemetery.

Figure 75. Military uniform buttons: (*a*) Artillery Corps; (*b*) Cavalry; (*c*) Dragoon; (*d*) General Service; (*e*) Infantry.

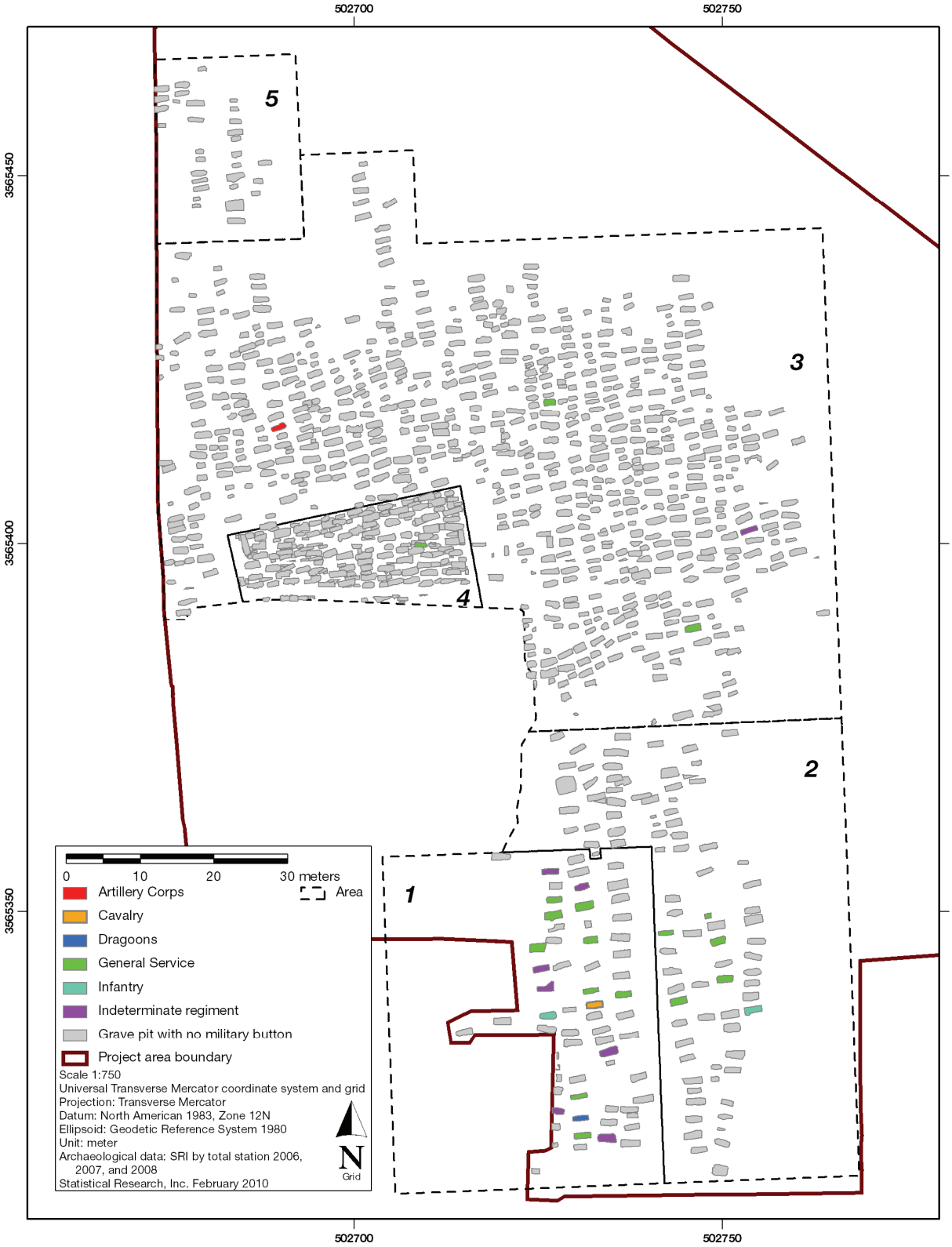


Figure 76. Distribution of military uniform buttons.

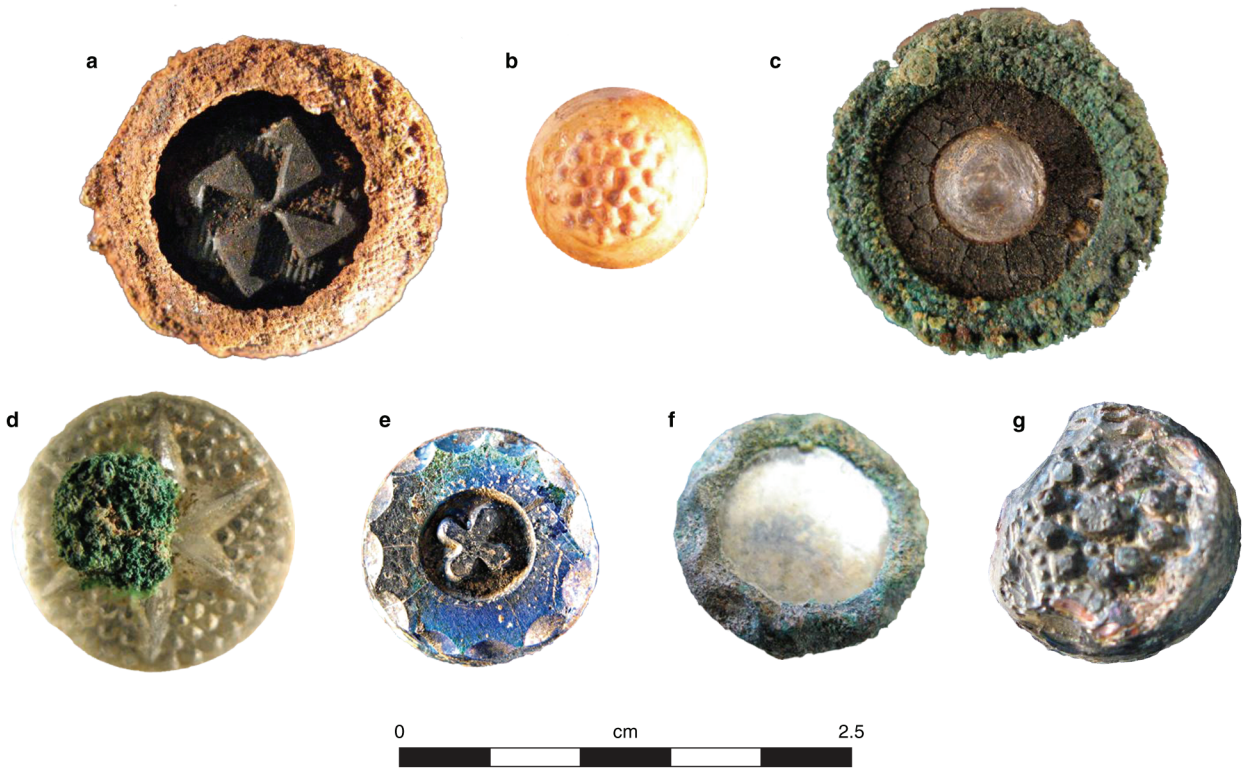


Figure 77. Examples of glass shank buttons from the Alameda-Stone cemetery.

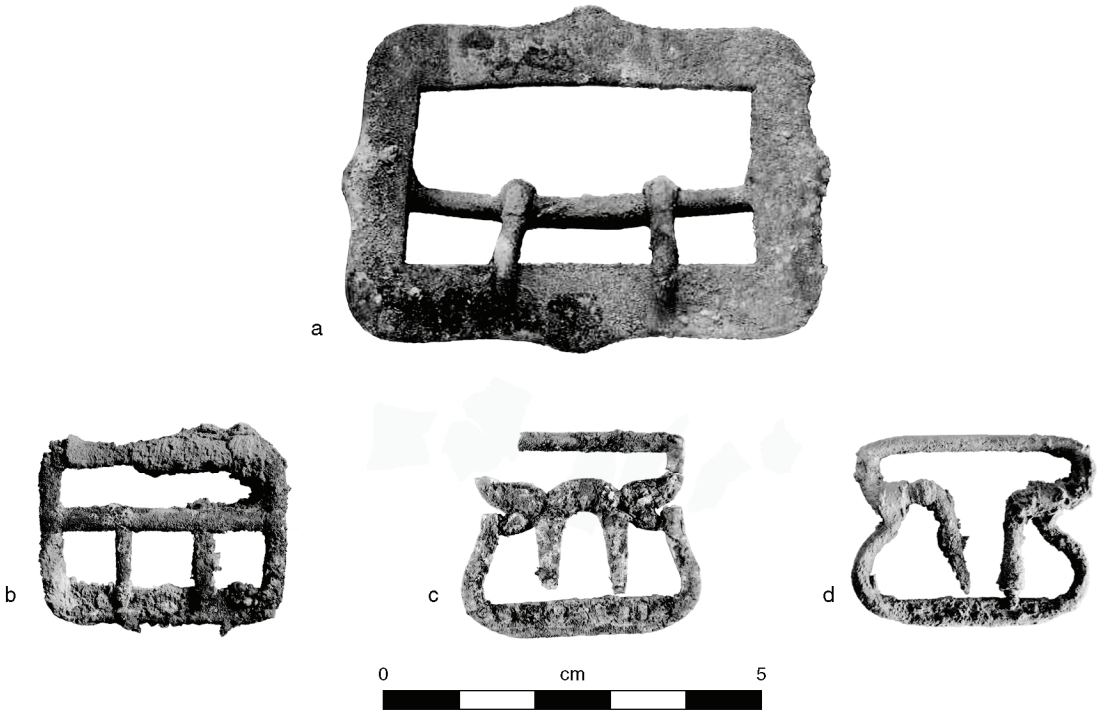


Figure 78. Examples of cinch buckles from the Alameda-Stone cemetery.

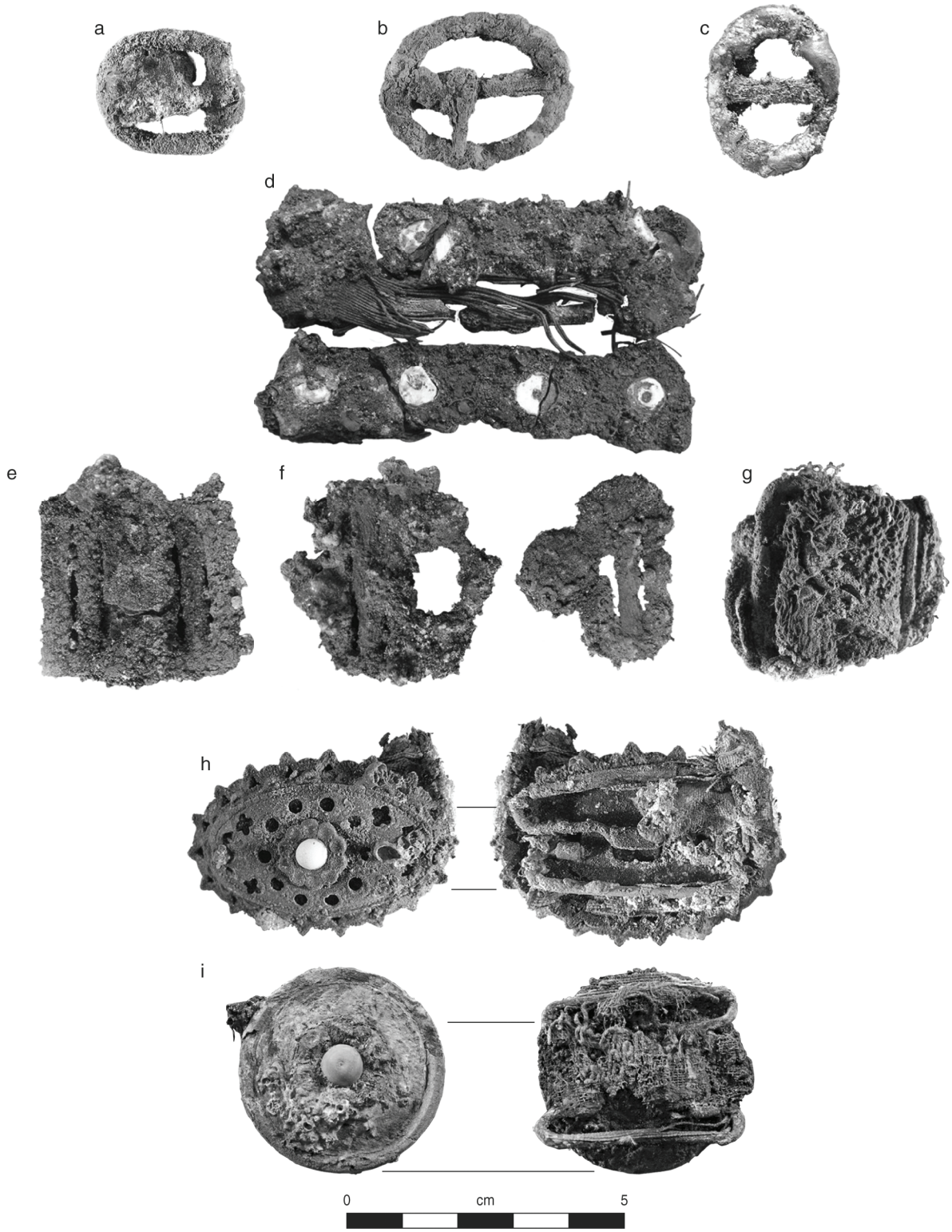


Figure 79. Examples of other buckles from the Alameda-Stone cemetery.

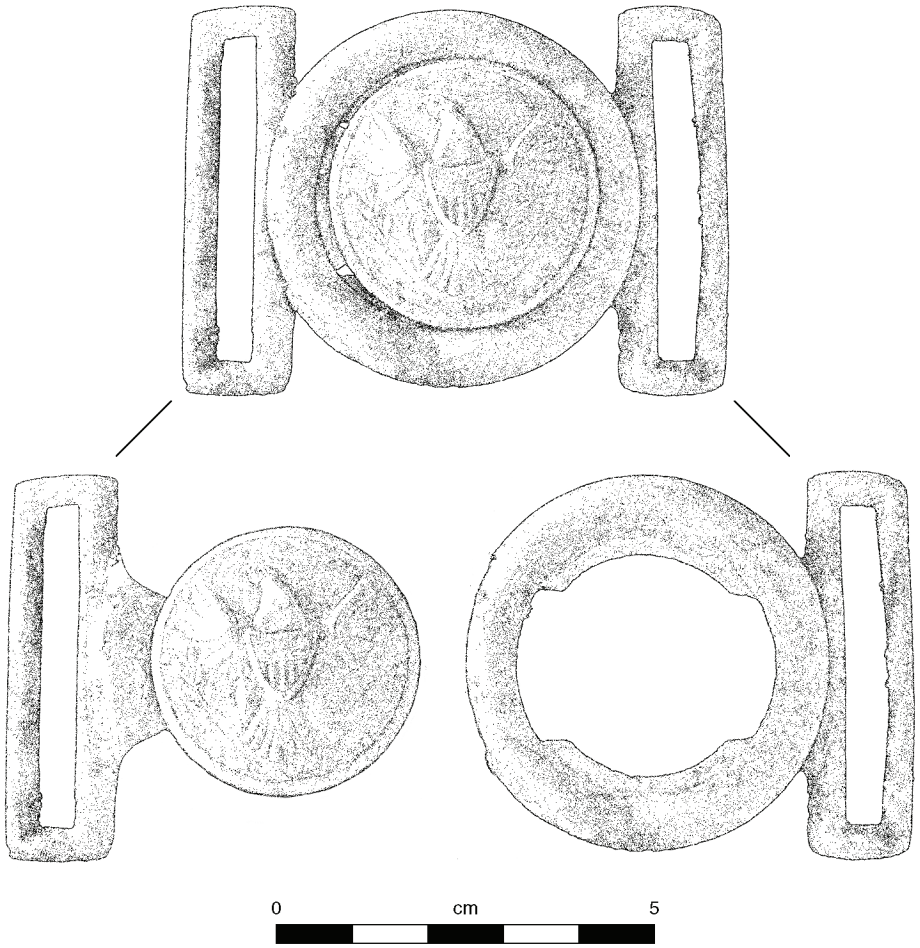


Figure 80. Military buckle from Individual P, Grave Pit 13697, a middle adult male of Hispanic or Yaqui cultural affinity.

Figure 81. Examples of hook-and-eye fasteners from the Alameda-Stone cemetery.

Figure 82. Shoe parts: (*a*) shoe lacing; (*b*) leather soles; (*c*) eyelets; (*d*) copper toe-cover; (*e*) lace plate; (*f*) aglet; (*g*) shoe buckle.

Figure 83. Child's copper-toe-covered boot from Individual P, Grave Pit 7698, a child of indeterminate sex and Euroamerican cultural affinity.

Figure 84. Workboot refit from Individual P, Grave Pit 7896, an older adult female of Hispanic cultural affinity.

Figure 85. Examples of crosses from the Alameda-Stone cemetery.

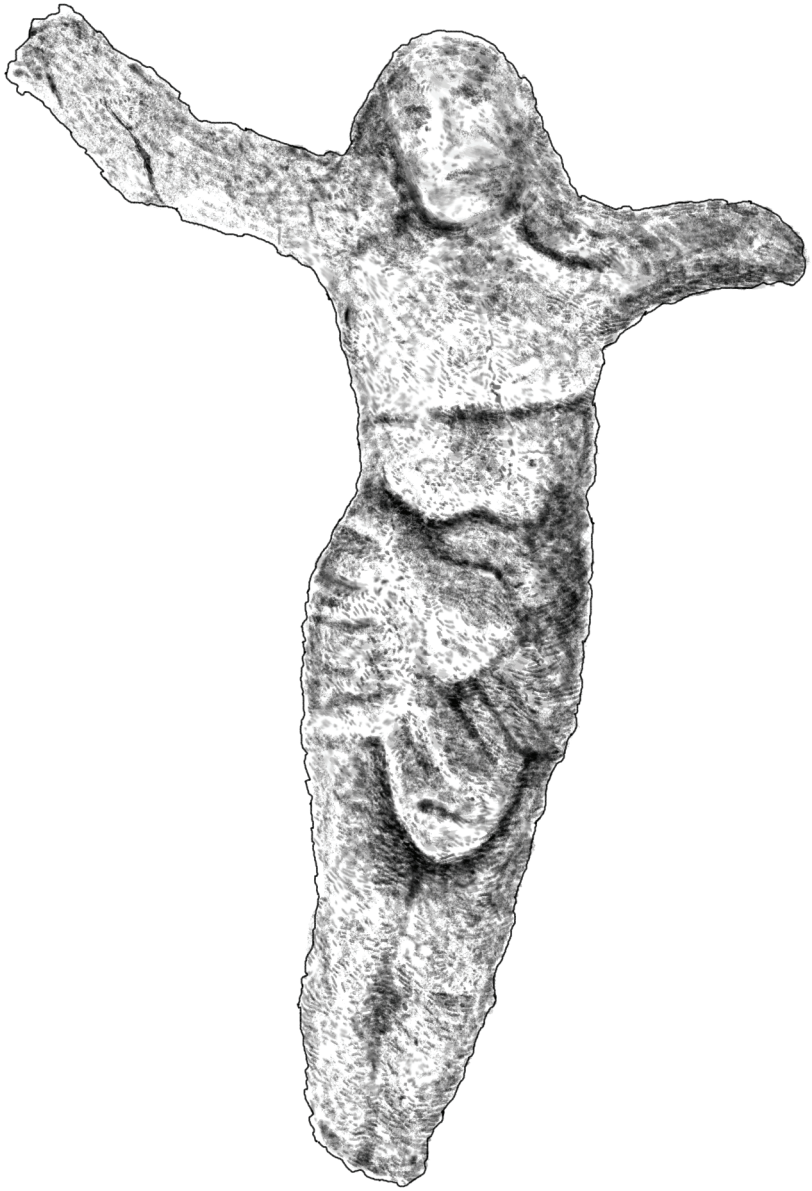


Figure 86. Christ figure from the crucifix of Individual P, Grave Pit 13520, a middle adult female of Apache cultural affinity.

Figure 87. Examples of crucifixes from the Alameda-Stone cemetery.

Figure 88. Examples of medallions and religious pendants from the Alameda-Stone cemetery.

Figure 89. Examples of rosaries from the Alameda-Stone cemetery: (*a*) rosary from Individual P, Grave Pit 10163, an older adult male of Hispanic cultural affinity; (*b*) rosary from Individual P, Grave Pit 13516, an older adult female of Hispanic cultural affinity.

Figure 90. Postmortem photograph ca. 1916 of a mother holding her deceased child wearing a floral crown (photograph courtesy of the Arizona Historical Society, Tucson, Accession No. B89855).

Figure 91. A distal phalanx was found inside this reliquary from Individual P, Grave Pit 7528, a subadult of indeterminate sex and Euroamerican cultural affinity.

Figure 92. Bottles from the Alameda-Stone cemetery: (*a*) from Individual P, Grave Pit 7520; (*b*) from Individual P, Grave Pit 13526; (*c*) from Individual P, Grave Pit 17764. All three bottles were from the graves of infants of indeterminate sex or cultural affinity.

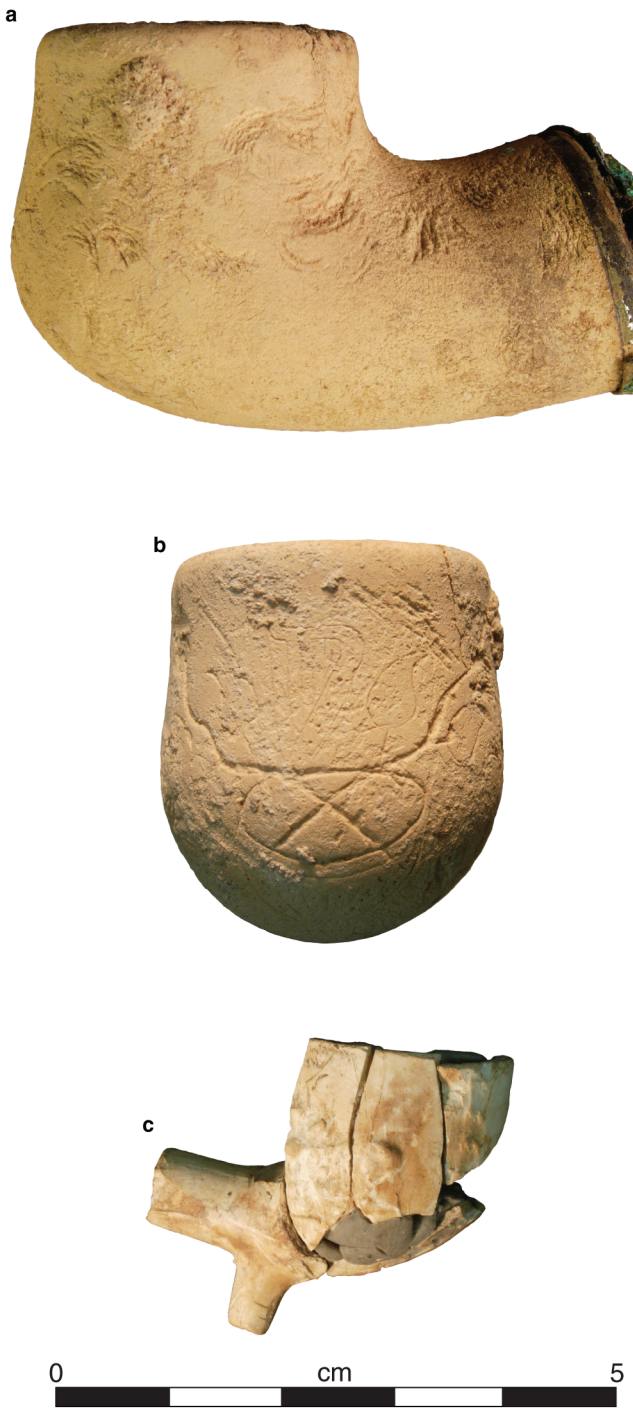


Figure 93. Pipes from the Alameda-Stone cemetery: (*a*) profile of the pipe from Individual P, Grave Pit 12, a young adult male of Euroamerican cultural affinity; (*b*) harp and chalice etched into bowl of pipe shown in *a*; (*c*) fragmentary pipe from Individual P, Grave Pit 609, a young adult of indeterminate sex or cultural affinity.

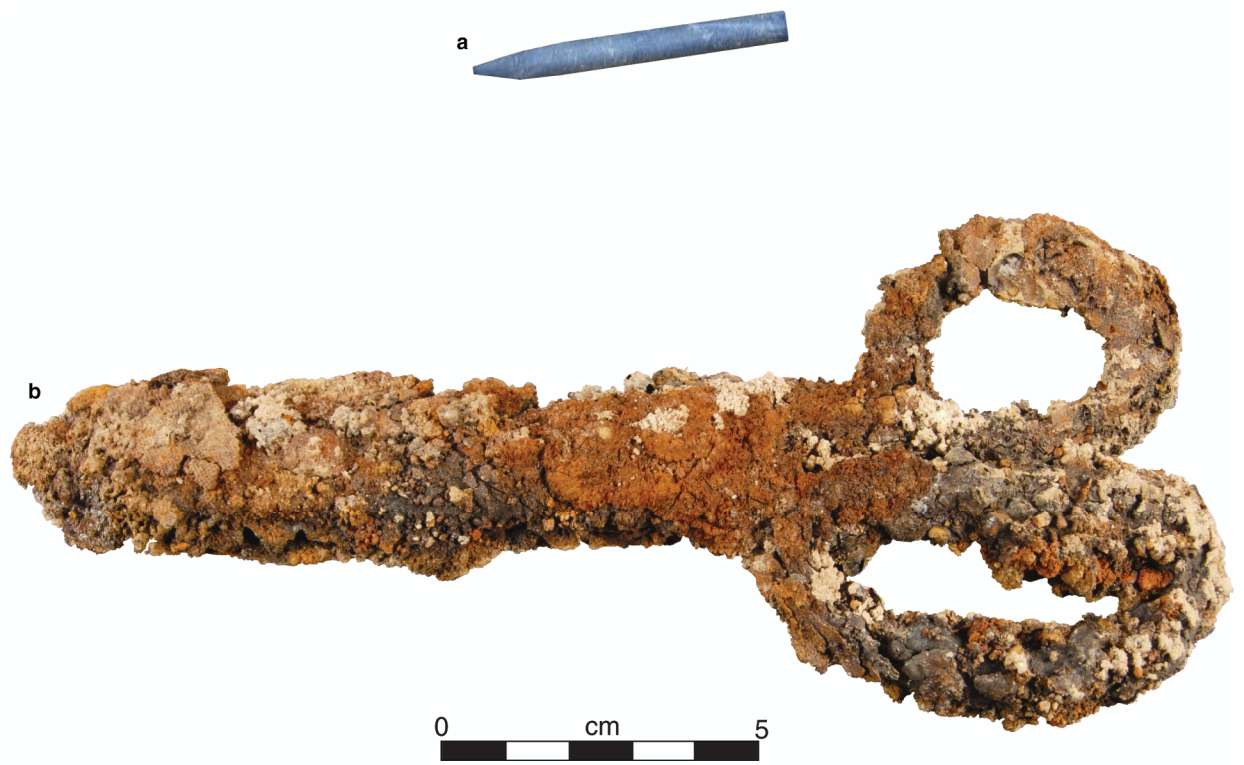


Figure 94. Tools and toys from the Alameda-Stone cemetery: (*a*) a stylus from Individual P, Grave Pit 591, a child of indeterminate sex or cultural affinity; (*b*) a pair of scissors from Individual P, Grave Pit 690, a young adult male of Hispanic Cultural Affinity.

Figure 95. Coins and tokens from the Alameda-Stone Cemetery: (*a–h*) examples of coins; (*i*) the 50-dollar poker check from Individual P, Grave Pit 533, a middle adult male of Hispanic cultural affinity.

Figure 96. Examples of frames from the Alameda-Stone cemetery.

Figure 97. A frame with drawing from Individual P, Grave Pit 13689, a middle adult female of Native American cultural affinity.

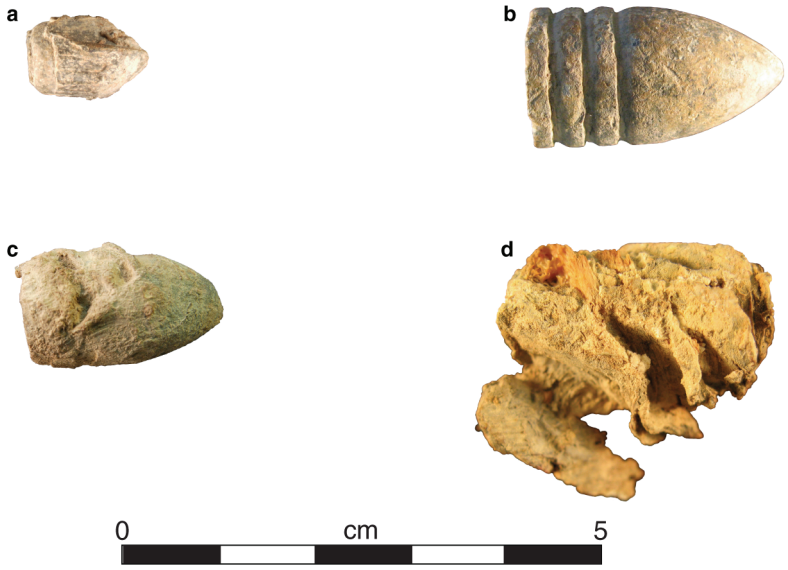


Figure 98. Examples of bullets from the Alameda-Stone cemetery.

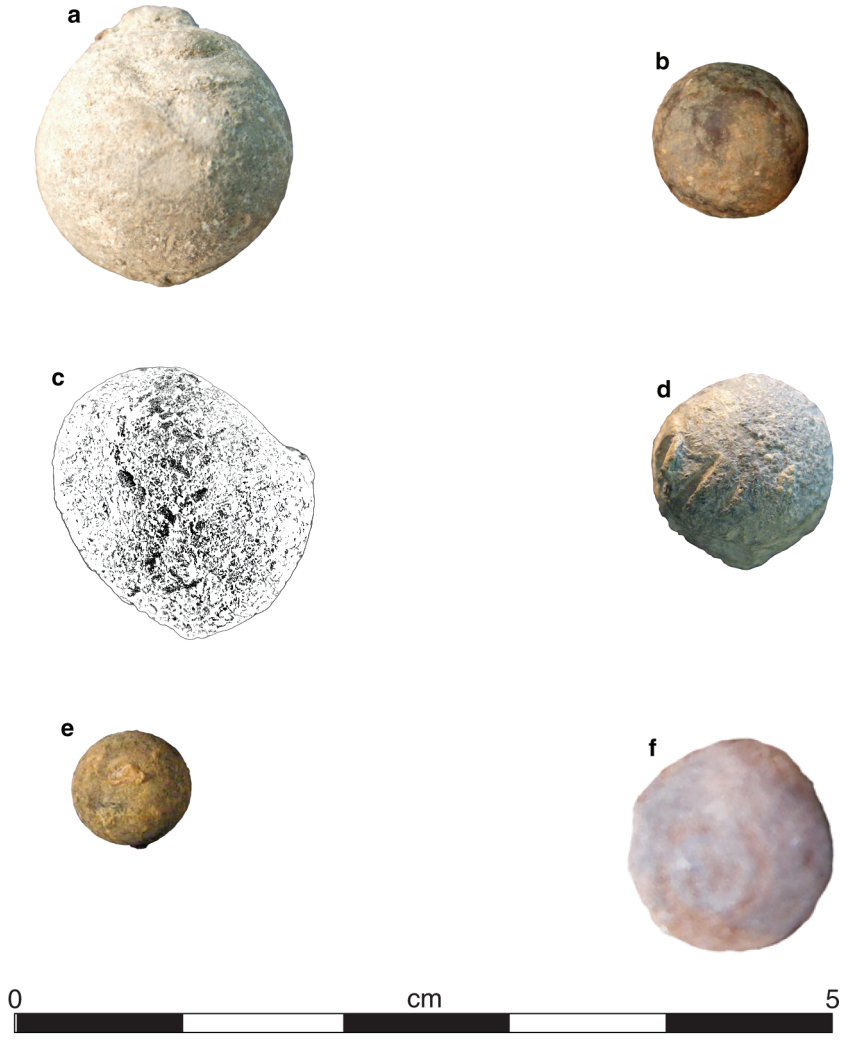


Figure 99. Examples of balls from the Alameda-Stone cemetery.

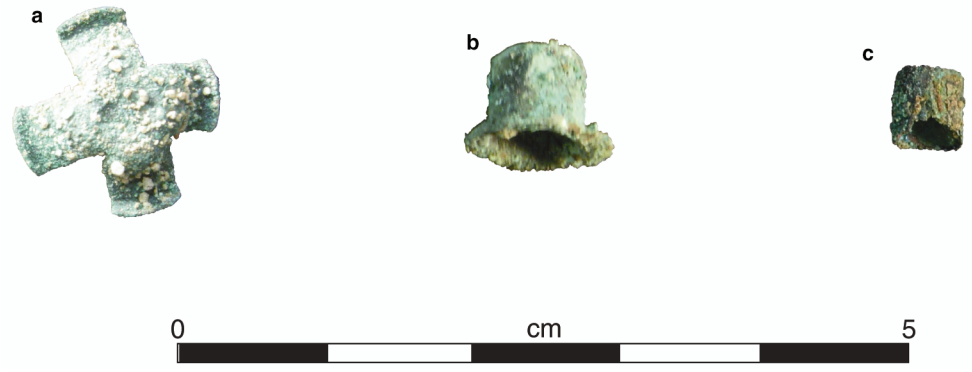


Figure 100. Examples of percussion caps from the Alameda-Stone cemetery.

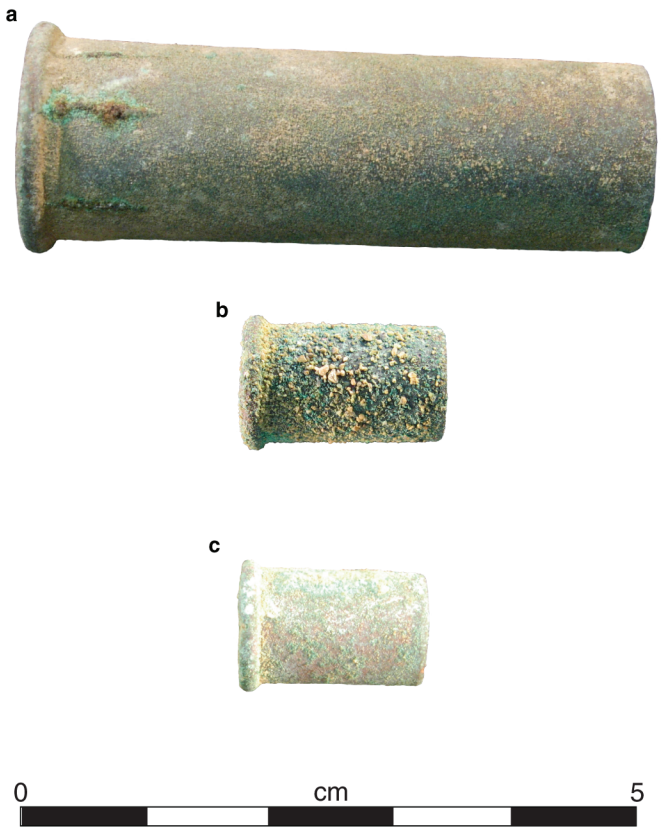


Figure 101. Examples of shell casings from the Alameda-Stone cemetery.

Note: For tables showing the demographic distribution of individuals in the cemetery associated with specific artifacts, the total number of individuals noted in the table may differ from the total number of grave features associated with those artifacts.

Table 63. Demographic Distribution of Jewelry

Age Category	Cemetery Area					Total
	1	2	3	4	5	
Juvenile	—	—	17	5	—	22
Adult female	—	1	14	—	1	16
Adult male	—	1	—	—	—	1
Adult, indeterminate sex	2	—	—	1	—	3
Indeterminate age and sex	—	—	—	—	—	—
Total	2	2	31	6	1	42
Adult/juvenile ratio	—	—	0.82	—	—	0.91
Male/female ratio	—	1	—	—	—	0.06

Note: Three pendants and one ring were recovered in the grave fill of several grave pits, but could not be associated with an individual

Table 64. Demographic Distribution of Hair Adornments

Age Category	Cemetery Area					Total
	1	2	3	4	5	
Juvenile	—	—	1	—	—	1
Adult female	—	1	3	—	—	4
Adult male	—	—	1	—	—	1
Adult, indeterminate sex	—	—	—	—	—	—
Indeterminate age and sex	—	—	—	—	—	—
Total	—	1	5	—	—	6
Adult/juvenile ratio	—	—	4	—	—	5
Male/female ratio	—	—	0.33	—	—	0.5

Table 65. Bead Counts, by Material Class

Material Class	Count
Glass	13,816
Ceramic	2,136
Botanical (wood)	431
Stone	156
Botanical (juniper seeds)	50
Metal	10
Rubber	1
Total	16,600

Table 66. Bead Counts, by Shape

Shape	Count
Doughnut	9,938
Hexagonal tube	3,977
Spherical	1,019
Indeterminate (not described)	656
Tubular	529
Faceted round	389
Teardrop (juniper seeds)	50
Figural	39
Teardrop	3
Total	16,600

Table 67. Bead Counts, by Color

Color	Count
Black	6,081
White	3,806
Blue	2,763
Colorless	1,394
Green	726
Natural (brown)	401
Pink	283
Indeterminate	248
Yellow	229
Cobalt blue	216
Other	91
Multiple	70
Red	68
Light blue	67
Brown	65
Dark green	33
Light green	28
Purple	16
Olive	8
Amber	6
Gold	1
Total	16,600

Table 68. Bead Counts, by Size

Size Category	Size Range (inches)	Count
Very small	<0.10	8,706
Small	0.10–0.19	5,977
Medium	0.2–0.39	1,381
Large	>0.40	128
Indeterminate		408
Total		16,600

Table 69. Bead Counts, by Function

Function	Count
Apparel-related	6,660
Indeterminate	3,863
Rosary	2,545
Floral (other)	1,643
Floral (crown)	1,097
Jewelry (necklace)	790
Jewelry (buckle)	1
Jewelry (other)	1
Total	16,600

Table 70. Demographic Distribution of Apparel-Related Beads

Age Category	Cemetery Area					Total
	1	2	3	4	5	
Juvenile	—	—	4	1	—	5
Adult female	—	—	2	—	—	2
Adult male	—	—	—	—	—	—
Adult, indeterminate sex	—	—	—	—	—	—
Indeterminate age and sex	—	—	—	—	—	—
Total	—	—	6	1	—	7
Adult/juvenile ratio	—	—	0.5	—	—	0.4
Male/female ratio	—	—	—	—	—	—

Table 71. Demographic Distribution of Floral-Crown Beads

Age Category	Cemetery Area					Total
	1	2	3	4	5	
Juvenile	—	—	12	4	—	16
Adult female	—	—	1	—	—	1
Adult male	—	—	—	—	—	—
Adult, indeterminate sex	—	—	—	—	—	—
Indeterminate age and sex	—	—	—	—	—	—
Total	—	—	13	3	—	17
Adult/juvenile ratio	—	—	0.1	—	—	0.1
Male/female ratio	—	—	—	—	—	—

Table 72. Demographic Distribution of Rosary Beads

Age Category	Cemetery Area					Total
	1	2	3	4	5	
Juvenile	—	—	14	8	3	25
Adult female	—	1	25	9	—	35
Adult male	—	—	11	6	—	17
Adult, indeterminate sex	—	—	1	—	—	1
Indeterminate age and sex	—	—	—	—	—	—
Total	—	1	51	23	3	78
Adult/juvenile ratio	—	—	2.64	1.88	—	2.12
Male/female ratio	—	—	0.44	0.67	—	0.49

Table 73. Button Sizes

Size	Line Size																
	8	10	12	14	16	18	20	22	24	26	28	30	32	34	36	38	40
Diameter (inches)	3/16	1/4	5/16	11/32	13/32	7/16	1/2	9/16	5/8	21/32	11/16	3/4	25/32	27/32	28/32	30/32	1
Diameter (cm)	0.47	0.64	0.79	0.87	1.03	1.11	1.27	1.42	1.59	1.67	1.82	1.91	1.98	2.14	2.29	2.38	2.54

Table 74. Demographic Distribution of Molded Prosser Buttons

Age Category	Cemetery Area					Total
	1	2	3	4	5	
Juvenile	—	—	13	2	—	15
Adult female	—	—	3	1	—	4
Adult male	—	1	12	—	—	13
Adult, indeterminate sex	—	—	4	2	—	6
Indeterminate age and sex	—	—	—	—	—	—
Total	—	1	32	5	—	38
Adult/juvenile ratio	—	—	1.46	1.5	—	1.53
Male/female ratio	—	—	4	—	—	4.33

Table 75. Demographic Distribution of Painted Prosser Buttons

Age Category	Cemetery Area					Total
	1	2	3	4	5	
Juvenile	—	—	14	1	1	16
Adult female	—	—	7	—	—	7
Adult male	—	2	5	2	—	9
Adult, indeterminate sex	—	—	—	—	—	—
Indeterminate age and sex	—	—	—	—	—	—
Total	—	2	26	3	1	32
Adult/juvenile ratio	—	—	0.86	2	—	1
Male/female ratio	—	—	0.71	—	—	1.29

Table 76. Demographic Distribution of Transfer-Printed Prosser Buttons

Age Category	Cemetery Area					Total
	1	2	3	4	5	
Juvenile	—	—	21	6	—	27
Adult female	—	—	5	—	1	6
Adult male	—	1	8	3	—	12
Adult, indeterminate sex	—	—	—	—	—	—
Indeterminate age and sex	—	—	—	—	—	—
Total	—	1	34	9	1	45
Adult/juvenile ratio	—	—	0.7	1.5	—	0.8
Male/female ratio	—	—	1.6	—	—	2.0

Table 77. Demographic Distribution of Plain Prosser Buttons

Age Category	Cemetery Area					Total
	1	2	3	4	5	
Juvenile	1	4	170	34	6	215
Adult female	—	4	56	10	2	72
Adult male	2	39	97	36	6	180
Adult, indeterminate sex	9	1	9	4	—	23
Indeterminate age and sex	5	—	—	—	—	5
Total	17	48	332	84	14	495
Adult/juvenile ratio	11	11	1.0	1.5	1.3	1.3
Male/female ratio	—	9.8	1.7	3.6	3	2.5

Table 78. Demographic Distribution of Plain Shell Buttons

Age Category	Cemetery Area					Total
	1	2	3	4	5	
Juvenile	—	3	142	10	6	161
Adult female	—	2	33	5	2	42
Adult male	4	36	93	23	6	162
Adult, indeterminate sex	9	1	10	3	—	23
Indeterminate age and sex	—	—	—	—	—	—
Total	13	42	278	41	14	388
Adult/juvenile ratio	—	13	1.0	3.1	1.3	1.4
Male/female ratio	—	18	2.8	4.6	3	3.9

Table 79. Demographic Distribution of Engraved Shell Buttons

Age Category	Cemetery Area					Total
	1	2	3	4	5	
Juvenile	—	—	39	3	3	45
Adult female	—	—	8	—	1	9
Adult male	—	7	39	10	3	59
Adult, indeterminate sex	1	—	6	—	—	7
Indeterminate age and sex	—	—	—	—	—	—
Total	1	7	92	13	7	120
Adult/juvenile ratio	—	—	1.4	3.3	1.3	1.7
Male/female ratio	—	—	4.9	—	3.0	6.6

Table 80. Demographic Distribution of Metal Sew-Through Buttons

Age Category	Cemetery Area					Total
	1	2	3	4	5	
Juvenile	1	—	45	5	1	52
Adult female	—	1	10	—	—	11
Adult male	7	35	102	19	7	170
Adult, indeterminate sex	15	2	6	1	—	24
Indeterminate age and sex	—	—	—	—	—	—
Total	23	38	163	25	8	257
Adult/juvenile ratio	22.0	—	2.6	4.0	7.0	3.9
Male/female ratio	—	35.0	10.2	—	—	15.5

Table 81. Demographic Distribution of Bone Buttons

Age Category	Cemetery Area					Total
	1	2	3	4	5	
Juvenile	—	—	33	7	1	41
Adult female	—	1	8	2	—	11
Adult male	3	16	48	22	5	94
Adult, indeterminate sex	4	1	5	1	—	11
Indeterminate age and sex	—	—	—	—	—	—
Total	7	18	94	32	6	157
Adult/juvenile ratio	—	—	1.8	3.6	5.0	2.8
Male/female ratio	—	16.0	6.0	11.0	—	8.5

Table 82. Demographic Distribution of Cloth-Covered and Metal Coat Buttons

Age Category	Cemetery Area					Total
	1	2	3	4	5	
Juvenile	—	—	23	4	—	27
Adult female	—	—	11	1	2	14
Adult male	4	10	24	13	2	53
Adult, indeterminate sex	1	2	2	1	—	6
Indeterminate age and sex	—	—	—	—	—	—
Total	5	12	60	19	4	100
Adult/juvenile ratio	—	—	1.6	3.8	—	2.7
Male/female ratio	—	—	2.2	13.0	1.0	3.8

Table 83. Demographic Distribution of Glass Shank Buttons

Age Category	Cemetery Area					Total
	1	2	3	4	5	
Juvenile	—	—	6	—	—	6
Adult female	—	—	5	—	—	5
Adult male	—	—	1	—	—	1
Adult, indeterminate sex	1	—	—	—	—	1
Indeterminate age and sex	—	—	—	—	—	—
Total	1	—	12	—	—	13
Adult/juvenile ratio	—	—	1.0	—	—	1.2
Male/female ratio	—	—	0.2	—	—	0.2

Table 84. Demographic Distribution of Gaiters

Age Category	Cemetery Area					Total
	1	2	3	4	5	
Juvenile	—	—	20	1	—	21
Adult female	—	—	9	—	—	9
Adult male	—	7	5	3	—	15
Adult, indeterminate sex	—	—	1	—	—	1
Indeterminate age and sex	—	—	—	—	—	—
Total	—	7	35	4	—	46
Adult/juvenile ratio	—	—	0.8	3.0	—	1.2
Male/female ratio	—	—	0.6	—	—	1.7

Table 85. Demographic Distribution of Riveted Pants Studs

Age Category	Cemetery Area					Total
	1	2	3	4	5	
Juvenile	—	—	—	1	—	1
Adult female	—	—	1	—	—	1
Adult male	1	3	16	3	3	26
Adult, indeterminate sex	1	—	4	—	—	5
Indeterminate age and sex	—	—	—	—	—	—
Total	2	3	21	4	3	33
Adult/juvenile ratio	—	—	—	3	—	32
Male/female ratio	—	—	16	—	—	26

Table 86. Demographic Distribution of Cinch Buckles

Age Category	Cemetery Area					Total
	1	2	3	4	5	
Juvenile	—	—	8	1	—	9
Adult female	—	—	4	1	—	5
Adult male	3	17	42	12	5	79
Adult, indeterminate sex	7	2	6	1	—	16
Indeterminate age and sex	—	—	—	—	—	—
Total	10	19	60	15	5	109
Adult/juvenile ratio	—	—	6.5	14	—	11
Male/female ratio	—	—	10.5	12	—	15.8

Table 87. Demographic Distribution of Other Buckles

Age Category	Cemetery Area					Total
	1	2	3	4	5	
Juvenile	—	1	6	—	—	7
Adult female	—	1	—	1	—	2
Adult male	—	3	4	1	—	8
Adult, indeterminate sex	—	—	—	—	—	—
Indeterminate age and sex	—	—	—	—	—	—
Total	—	5	10	2	—	17
Adult/juvenile ratio	—	4	0.7	—	—	1.4
Male/female ratio	—	3	—	1	—	4

Table 88. Demographic Distribution of Hook-and-Eye Fasteners

Age Category	Cemetery Area					Total
	1	2	3	4	5	
Juvenile	—	—	76	11	—	86
Adult female	—	—	72	7	1	80
Adult male	1	—	5	5	—	11
Adult, indeterminate sex	—	—	4	1	—	5
Indeterminate age and sex	—	—	—	—	—	—
Total	1	—	157	24	1	182
Adult/juvenile ratio	—	—	1.1	1.2	—	1.1
Male/female ratio	—	—	0.1	0.7	—	0.1

Table 89. Demographic Distribution of Footwear

Age Category	Cemetery Area					Total
	1	2	3	4	5	
Juvenile	—	1	29	3	2	35
Adult female	—	1	10	2	—	13
Adult male	1	1	3	2	—	7
Adult, indeterminate sex	—	—	—	—	—	—
Indeterminate age and sex	—	—	—	—	—	—
Total	1	3	42	7	2	55
Adult/juvenile ratio	—	2	0.4	1.3	0.5	0.6
Male/female ratio	—	1	0.3	1.0	—	0.6

Table 90. Demographic Distribution of Floral Crowns

Age Category	Cemetery Area					Total
	1	2	3	4	5	
Juvenile	—	—	101	13	1	115
Adult female	—	—	—	1	—	1
Adult male	—	—	—	—	1	1
Adult, indeterminate sex	—	—	—	—	—	—
Indeterminate age and sex	—	—	—	—	—	—
Total	—	—	101	14	2	117
Adult/juvenile ratio	—	—	0.0	0.08	1.0	0.02
Male/female ratio	—	—	0.0	0.0	—	1.0

Table 91. Demographic Distribution of Crosses, Crucifixes, and Medallions

Age Category	Cemetery Area					Total
	1	2	3	4	5	
Juvenile	—	—	20	8	4	32
Adult female	—	1	46	11	3	61
Adult male	—	—	20	16	1	37
Adult, indeterminate sex	—	—	3	—	—	3
Indeterminate age and sex	—	—	—	1	—	1
Total	—	1	89	36	8	134
Adult/juvenile ratio	—	—	3.5	3.4	1.0	3.2
Male/female ratio	—	—	0.4	1.5	0.3	0.6

CHAPTER 7

Paleodemography

Willa Trask

Introduction

This section discusses the paleodemography of the skeletal assemblage excavated as part of the Joint Courts Complex project. General descriptions of the demographic makeup of the recovered skeletal sample are considered, as well as various demographic models. Additionally, calculations of the minimum number of individuals recovered from the project area are addressed.

During the latter half of the nineteenth century, Tucson was a dynamic city, composed of individuals of Hispanic, European, and Native American ancestry, as well as a limited number of individuals from other parts of the world. During the 20 years between the 1860 and 1880 censuses, the population of Tucson increased from 925 to over 7,007 inhabitants (Sheridan 1986:3). As the population increased, the demography of Tucson changed radically. Tucson had been a predominantly Mexican-American settlement since the foundation of the Presidio in 1775, growing steadily in size through time. The signing of the Gadsden Purchase in 1854 and the entrance of Tucson into the Union brought changes in the composition of Tucson's population (Sheridan 1986: 37). "In a sense Tucson in 1860 was a dual, almost schizophrenic, settlement, one divided between Mexican families rooted in the land and male Anglo immigrants seeking fame and fortune on the Apache frontier. This demographic duality in large measure determined Tucson's destiny for the next 20 years" (Sheridan 1986:38).

Keeping this historical framework in mind, various comparative and statistical methods will be employed to investigate the demography of the skeletal remains excavated from the cemetery.

Theoretical Foundations

Paleodemography is "the field of inquiry that attempts to identify demographic parameters from past populations derived from archaeological contexts" (Hoppa 2002:9). Meindl and Russell (1998:376) further explained:

> Paleodemography is more than the study of mortality and fertility of archaeological populations. It also includes the estimation of the distribution, density, and age compositions of prehistoric peoples. It considers intrinsic rates of growth and decline, and it may include migration and the age and sex structure of migration as well.

Based on these definitions, the importance of paleodemography to the study of past human populations is apparent. Through paleodemographic studies, one gains an understanding of the dynamic changes affecting earlier populations, be they the effects of disease, conquest, or cultural practices. Yet, as important as this field may be, paleodemography is plagued by a number of assumptions and biases that, if not taken into account, can skew data and provide a rather tenuous foundation, resulting in inaccurate hypotheses.

Paleodemographers must assume that the forces acting upon current populations acted in a similar manner upon past populations. This is known as the Law of Uniformitarianism, the most fundamental assumption in paleodemography (Hoppa 2002:10). Uniformitarianism further implies that (1) humans have not changed in

their biological responses to the environment and (2) the biological development of age-related morphology is the same in all humans, regardless of time and space (Hoppa 2002:11). Without this assumption, paleodemographers simply could not employ the age-estimation criteria developed using modern human-skeletal comparative collections (Howell 1976).

Paleodemography must additionally assume that the population in question is stationary—in other words, that the composition of the population did not change through immigration or emigration and that the age-sex structure remained the same throughout time, while population growth/decline remained constant (Hoppa 2002:12). Though Acsádi and Nemeskéri (1970) found that population-structure fluctuations average over time to a growth rate approaching zero, analytical tools are available that allow paleodemographers to accurately capture these fluctuations. This assumption, however, contradicts Wood et al. (1992:344), who maintained that populations are not stationary but will change over time and that they are more susceptible to fluctuations in fertility rather than in mortality. Because of this, life tables more effectively measure fertility than mortality.

Wood et al. (1992:344) discussed two additional concerns that paleodemographers, as well as paleopathologists, must address during the course of an analysis: selective mortality and hidden heterogeneity in risks. Selective mortality is the notion that an osteological sample does not include individuals who were at risk from a disease at a specific age, only evidence that those individuals died at that age (Wood et al. 1992:344). For instance, of two individuals exhibiting skeletal responses from an epidemic, one individual may have died during the epidemic, whereas one may have survived the epidemic and died at a later date. Although each individual exhibits lesions associated with the epidemic, separation of the sample into two groups—victim and epidemic survivor—is impossible. Wood et al. (1992:344–345) also discussed hidden heterogeneity in risks. In other words, a skeletal sample is composed of different individuals with unknown degrees of susceptibility to a specific disease. This susceptibility may be related to genetic influence, social status, or temporal changes; each of these factors may not be readily apparent to the researcher, but they have a direct impact on the demographic structure of the skeletal sample.

Unlike in demography, the exact age of an individual is not known when working with skeletal material. Researchers must estimate the chronological age of an individual based on the skeletal age, using methods with underlying biological responses that are not fully understood. Because of various genetic and environmental influences, secular trends in skeletal development and growth cast further doubt on the eligibility of skeletal reference populations that do not match the sampled population temporally (Hoppa 2002:11; Kemkes-Grottenthaler 2002:48). To quote Kemkes-Grottenthaler (2002:48):

> In spite of the strong overall association between maturational and skeletal changes, the aging process is merely universal to the extent that it applies to both sexes and all populations. Beyond that, there is a remarkable interpersonal heterogeneity resulting from distinctive genetic differences, behavior variation, diverse predispositions, and the individual's lifetime interaction with the environment.

Misrepresentation of population structure also can occur from differential preservation of the skeletal sample and sex-based and age-related changes. Quite often, infants and older individuals, particularly females, are underrepresented in sampled populations. For instance, one study conducted by Walker et al. (1988) indicated that underrepresentation of infant and elderly individuals in the Mission La Purisima skeletal collection in California can "be attributed in large part to the susceptibility of the remains of individuals from these age classes to disintegration in the ground" (Walker et al. 1988:187). The highly transportable nature of infant remains by turbative agents, coupled with the fragility of undeveloped bone, result in rapid disintegration. A reduction in bone density from age-related osteoporosis, especially among postmenopausal women, likewise weakens the bone structure to a point at which bone destruction from diagenic processes occurs rapidly, moreso than in younger adults with stronger, denser bones.

Walker (1995) also found that sexual dimorphism continues to develop throughout the life of the individual. For example, postmenopausal hormonal shifts in women tend to result in increased robusticity on the crania of older women, and younger males tend to be less robust than older males (Walker 1995:37–40). Such morphological changes may bias a collection with poor preservation of pelvic elements, resulting in the misclassification of older women as males and younger males as females.

Finally, Bocquet-Appel and Masset (1982:Figure 1) found that paleodemographic profiles of a sample population can mirror the reference population used to develop the age or sexing technique. Current efforts to address these issues through advanced statistical methods, such as the use of parametric and semiparametric models (Konigsberg and Hermann 2002; Love and Müller 2002; Wood et al. 2002), have alleviated some of these problems, but the general caveat must be acknowledged.

Despite these inherent problems in paleodemography, much can still be gained from an understanding of the derived demographic structure of past populations. What follows is an exploration of the paleodemography of the Tucson population derived from the Joint Courts Complex project area burials.

Number of Individuals

Prior to addressing questions on the demographic makeup of the cemetery, it is crucial to first address the question of the number of individuals represented by the skeletal assemblage removed during the Joint Courts Complex project. A variety of disturbances throughout the cemetery hampered the estimation of the minimum number of individuals represented by the recovered assemblage. The excavated graves were in various stages of preservation and completeness. Some showed no evidence of disturbance, others were clearly used for repeated interments, and still others showed evidence of previously removed individuals. In all, over one-half of the grave pits (560 of 1,083) had some type of postcemetery disturbance, including building foundations, privies, cesspits, fuel-tank pits, tree pits, postholes, and utility trenches. Many of the postcemetery disturbances impacted the most complex portion of the cemetery, Cemetery Areas 3 and 4. Additionally, a portion of both the military and the civilian sections of the cemetery were impacted during the 1953 excavation of the basement for the Tucson Newspapers building (see Figure 1).

The extent and nature of these disturbances, coupled with the presence of fully articulated individuals, dictated a multifaceted approach to assessing the minimum number of individuals represented by the recovered skeletal assemblage. This was addressed using three methods: (1) the minimum number of individuals, (2) the most-likely number of individuals, and (3) a context-based number of individuals. Each of these methods is equally important, because no single method accurately represents the entire skeletal sample. All skeletal material recovered from within the project area was used in the following calculations, including the remains recovered by the Arizona State Museum in 1953 and by Tierra Right of Way Services in 2001.

Element-Based Minimum Number of Individuals

The most common technique for calculating the number of individuals present in cases of commingled remains is the minimum number of individuals method. Traditionally, the minimum number of individuals is a count of the most-unique individual element, or portion of an element, recovered from a skeletal assemblage.

Postcemetery disturbances, predominantly utility trenches, cut through the cemetery, including one of the most complex sections of the cemetery, and disturbed many grave pits. Of the over 201,565 total elements recovered, 194,029 were associated with individuals. Excluding those elements recovered from the Tucson Newspapers building, 4,833 of the total elements recovered were from nongrave or nonburial contexts. Of these, 4,344 could not be reassociated to any individuals. The large quantity of remains disturbed by trenches, coupled with the nature of disturbances and time constraints for analysis, allowed for remains to be reassociated with only 46 primary and enumerated individuals.

Because of the large number of unassociated remains, the minimum number of individuals was calculated using individual skeletal elements. All elements included in the calculation of the minimum number of individuals are anticipated to be present and identifiable at all age levels, including fetal remains.

For our purposes, the minimum number of individuals was calculated by determining the frequency of the most-prevalent element assigned a completeness score of partial (25–75 percent complete) to complete

(75–100 percent complete). In cases of bilateral elements (e.g., the left and right femur), the counts for the left and right were calculated, and the maximum was accepted as the minimum number of individuals for that element, or MNI = max (Left, Right). The size of the sample and the data-collection methods dictated this as the best method for arriving at a base minimum number of individuals, even though the potential of elements for a completeness of 25–49 percent were allowed in this count.

The minimum number of individuals method works under the assumption that each element included in the count is not duplicated (i.e., each element is counted only once for each individual). In instances where duplicate elements were present but located in different proveniences, one element was not considered when calculating the frequency for that element. Every effort was made during analysis to reunite disturbed, enumerated individuals with the correct primary individual(s). Additionally, during postlaboratory analysis, attempts were made to reassociate skeletal material disturbed by postcemetery features with the appropriate primary individual(s).

The calculation of the minimum number of individuals is presented in Table 92, with the frequency of partial, complete, and total elements. The five highest minimum number of individuals estimates are presented. The most-prevalent element is the right humerus, which suggests a minimum number of 1,025 individuals.

Most-Likely Number of Individuals

The most-likely number of individuals method is a statistical technique used to estimate the number of individuals needed to generate a commingled skeletal assemblage (Adams and Konigsberg 2004). Traditional minimum number of individuals estimates assume that, in the case of bilateral elements, every one of the elements present for the least-prevalent side can be matched to an element from the opposite, more-prevalent side. In areas suffering from high levels of taphonomic impact (i.e., disturbances), there is a high probability that this assumption will not hold true. In contrast, the most-likely number of individuals is a modification of the Lincoln index, a formula commonly used in the calculation of population size from zooarchaeological material. The most-likely number of individuals relies on pair matching, in which right and left bilateral elements in a skeletal assemblage are compared to determine whether they are consistent with a single individual. Those not paired indicate separate individuals.

The formula used to estimate the most-likely number of individuals was initially modified from the Lincoln index by Chapman (1951), to account for inherent biases introduced when calculating the Lincoln index. The equation was further modified by Adams and Konigsberg (2004:Equation 9), to generate a complete probability function for *N*:

$$\Pr(N \mid L, R, P) = \frac{L!R!(N-R)!(N-L)!}{(L-P)!(R-P)!(N-L-R+P)!(N+1)!(p-1)!} = \Pr(P \mid L, R, N) \times \frac{P}{(N+1)}$$

where *L* equals left, *R* equals right, *P* equals paired elements, and *N* is the number of individuals present in the population. This equation is based on a hypergeometric distribution and acts such that "Pr(P|L,R,N) is the probability from the hypergeometric distribution of getting *P* pairs, upon drawing *L* lefts and *R* rights from *N* individuals" (Adams and Konigsberg 2004:142). This equation is then applied to multiple bilateral elements using the probability distribution of *N* for each single element. These probabilities are then multiplied across the elements for each of the values for *N* and then normalized to equal 1.0 (Adams and Konigsberg 2004). Because the calculation of the most-likely number of individuals considers right and left elements as well as paired elements, this method works under the assumption of independence in the recovery of elements. Adams and Konigsberg (2004) applied this method to commingled human-skeletal assemblages and correctly estimated the population density with a high rate of success.

The large amount of skeletal material recovered during excavations for the Joint Courts Complex prevented pair matching of every element with every other element. Instead, field and laboratory procedures ensured that elements collected and associated with a named individual were from the same individual, and in the case of disturbed individuals, every effort was made to compare the remains associated with one individual to those in close proximity. Unassociated material, when possible, was reassociated with the correct individual(s). In order to match pairs, elements associated with an individual were considered present if any portion of the element was present. The presence of both a right and a left element for an individual was considered a positive pair. Elements with a completeness score of "partial" to "complete" and not associated with an individual were included, as unpaired elements.

For this analysis, a modified most-likely number of individuals calculation was used to estimate the most-likely number of individuals. Only the disturbed remains (enumerated individuals and unassociated remains) were used in the most-likely number of individuals analysis. The result of this analysis was then added to the number of primary individuals. Using this method to calculate the most-likely number of individuals (instead of using the entire cemetery population in the model), the primary individuals previously removed, such as those found in the military section, are accounted for in the analysis.

Important to note is that the assumption of independence in recovery of elements is violated. Many of the enumerated individuals were recovered from spatially related contexts (e.g., from within the same grave shaft). Total independence in recovery is only present in instances where significant disturbances result in wide dispersion of the remains, such as trenches or the basement of the Tucson Newspapers building. The highly significant likelihood-ratio test ($\Lambda = 0$, $df = 3$, $p = 1$) confirms this violation and indicates inconsistency in the estimator—a result of violating the assumption of independence. Despite this violation, the value estimated using the most-likely number of individuals model is likely a better indicator than the traditional minimum number of individuals method and supersedes any apparent shortcomings.

The five most-prevalent elements used in the analysis of the most-likely number of individuals are presented in Table 93. In order to develop as robust a model as possible, a multiple-element most-likely number of individuals was calculated using all five elements (i.e., femur, humerus, radius, tibia, and ulna) with the source code provided by Adams and Konigsberg (Konisgberg 2003). Both the single-element most-likely number of individuals and the five-element most-likely number of individuals are presented in Table 94. Although these elements were the most-commonly recovered elements, they were also used in this analysis because they were easily identified in all age groups.

The five-element model of the skeletal remains from disturbed contexts produces an estimate for the most-likely number of individuals of 219. This number is added to the 1,044 primary individuals to obtain a so-called "adjusted" most-likely number of individuals of 1,263 individuals.

Context-Based Number of Individuals

Although the examination of the minimum number of individuals based on elements is essential to incorporate remains and individuals from disturbed contexts, these numbers, by nature, will not accurately represent the entire cemetery population. In all, 1,044 primary individuals and 294 enumerated individuals were identified and excavated (see Chapter 2 for a full description of definitions of primary and enumerated individuals). All enumerated individuals were recovered from grave contexts, with the exception of 1 disarticulated individual recovered from Feature 746, a pit. Again, every attempt was made to reunite individuals recovered from disturbed contexts. Instances did exist in which remains may have been associated with several individuals in the immediate area and were therefore left as separate individuals or as unassociated remains.

Several instances of disturbances, exhumation, etc., biased the number of primary individuals recorded during the calculation of the minimum number of individuals and the most-likely number of individuals. Of the 64 grave shafts in the military section, complete to nearly complete individuals were recovered from only 4 graves; the other graves were previously exhumed, on orders from the U.S. Army (see Appendix K). Many of the individuals previously removed comprised a handful of scattered elements left behind in the grave shafts or coffins. These individuals, represented by very few bones, presumably did not have any skeletal material elsewhere on-site.

Additionally, incomplete remains of 47 individuals were salvaged by the Arizona State Museum in 1953, during the excavation of the basement for the Tucson Newspapers building, and 1 individual was excavated in 2001 by Tierra Right of Way Services. These individuals, with the 1,338 primary and enumerated individuals, bring the total number of context-based individuals recovered and analyzed within the project area to 1,386.

Discussion

The overall complexity and size of the Joint Courts Complex project does not permit a straightforward method for the calculation of a precise number of individuals represented by the skeletal remains. There are advantages and disadvantages to each of the three methods presented above for the calculation of the number of individuals represented within the scope of the project area. Each method has its benefits and flaws, and each approaches the dataset in slightly different ways.

The traditional minimum number of individuals method (n = 1,025) does not account for individuals previously removed but represented within the skeletal assemblage by the miscellaneous elements left behind in the grave pit. The context-based number of individuals (n = 1,386) is much higher than the other element-based estimations. There are several reasons for this discrepancy. First, this estimate considers both primary and enumerated individuals who are represented by only a few bones or bone fragments. This is crucial for including previously removed individuals and the remains recovered from disturbed contexts, such as the enumerated individuals in poor preservation. The second explanation is a consequence of including these individuals. Individuals based strictly on disturbed material may overinflate the actual estimate of the minimum number of individuals, because an enumerated individual may be represented by a single juvenile-bone fragment found within a grave that otherwise contains only adult material. If multiple graves containing juveniles of a similar age are present in the immediate vicinity, this single bone is considered a separate individual. Although the most-likely number of individuals violates the assumption of independence of recovery and pair-matching elements, the adjusted most-likely number of individuals of 1,263 is likely the best approximation of the number of individuals represented by the skeletal assemblage.

For the purposes of practicality, authors throughout the current volume analyzed skeletal remains based on their assigned designations as primary, enumerated, or basement individuals. Therefore, sample sizes will deviate from the adjusted most-likely number of individuals presented here as the best approximation for the number of individuals represented by the skeletal assemblage. Rather, samples are pulled from a total of 1,386 individuals, 1,044 of which are primary; 294 are enumerated, 47 are from the basement of the Tucson Newspapers building, and 1 was excavated in 2001 by Tierra Right of Way Services. Authors took the liberty of including individuals pertinent to their respective analyses and may have excluded individuals believed to not have relevance in a particular chapter. For example, the chapters dealing with juvenile and adult skeletal morphology (Chapters 9 and 10) only include the segments of the age range pertinent to their analyses. The chapter discussing trauma (Chapter 12) excludes enumerated and basement individuals because of concerns of completeness. So, the numbers of individuals included in the various samples will vary from chapter to chapter.

Skeletal Demography

Methods

Basic demographic information, such as age, sex, and biological affinity, was assessed during the laboratory-analysis phase. Although this information is covered in depth in Chapter 2, a brief summary of methods and techniques used is considered worthwhile and so will be provided here.

Age and sex were assessed using standard methods detailed in *Data Collection for Human Skeletal Remains* (Buikstra and Ubelaker 1994). Methods for age assessment include assessing changes in the pubic symphyseal face using the Todd (McKern and Stewart 1957; Todd 1921a, 1921b) and Suchey-Brooks (Brooks and Suchey 1990; Suchey and Katz 1986) methods, auricular-surface morphology (Lovejoy et al. 1985; Meindl and Lovejoy 1989), cranial-suture closure (Buikstra and Ubelaker 1994; Meindl and Lovejoy 1985), long-bone length and development (Scheuer and Black 2000), and dental development (Ubelaker 1989), among other attributes. Sex was assessed using standard cranial and pelvic ordinal morphological indicators (Acsádi and Nemeskéri 1970; Milner 1992; Phenice 1969). For the purpose of all sex-based analyses, only individuals with mean ages of 15 or higher were considered. At present, insufficient methods are available within the literature to accurately sex individuals in early adolescence. Additionally, variations in the adolescent growth spurt and the development of secondary sex characteristics between the sexes further complicate sex assessments for this age range (Scheuer and Black 2004). Sex information for individuals with mean ages of less than 15 years was disregarded. Biological affinity was only assessed for primary individuals. A complete description of the methods for the assessment of biological affinity can be found in Chapter 2.

Age categories were established based on the age ranges calculated during laboratory analysis, following Arizona State Museum procedures (Table 95) Age categories are used to divide the continuous age ranges assigned during laboratory data recovery into ordinal categories for analysis. Ages were placed within these age groups based on the calculated median age. Certain individuals within the sample could only be classified as "adult" or "18–99." This designation indicates that all elements present for the individual are skeletally mature but that insufficient aging data are present to narrow the age any further. The maximum age of 99 is arbitrary, and it is acknowledged that the actual ages of individuals may have fallen above this value.

For simplicity, individuals established during field and laboratory analysis were considered the units of analysis for the demographical study. Therefore, the numbers used for these analyses will not necessarily reflect the minimum number of individuals or the most-likely number of individuals established earlier but, rather, the context-based number of individuals (see section above).

Sample Description

The distributions of individuals by age, sex, and biological affinity are presented in Table 96. The adult to juvenile ratio is 1.12. In fact, nearly 32 percent of all individuals were less than 2 years of age. The male to female sex ratio for the overall cemetery sample is 1.39. Eleven percent more males than females were recovered throughout the project area. Important to note is that over 28 percent of the individuals are of unknown or indeterminate sex. The high percentage of indeterminate-sex individuals can be attributed to a number of factors, including previously removed individuals, burial preservation, and burial disturbances.

Nearly 63 percent of the 1,115 primary individuals were of indeterminate affinity. Overall, the cemetery was primarily composed of Hispanic individuals, with Euroamerican individuals the second-most-identified group. Forty nonspecific Native American and 3 Apache remains were recovered from throughout the civilian section of the cemetery. One male individual was assessed as African American. Almost three times as many Euroamerican males as Euroamerican females were present; approximately equal numbers of Hispanic and Native American males and females were present.

During the course of field excavation, the cemetery was divided into five cemetery areas (see Heilen and Hall, Chapter 4) (Figure 102). These divisions were primarily arbitrary, with the exception of the military section (Cemetery Area 1), where there is evidence that a wall surrounded and cordoned off this area when the cemetery was in use. The remaining cemetery areas were defined based on general spatial organization. For instance, the crowded organization and visually defined borders of Cemetery Area 4 suggest that there was an enclosure surrounding this area at some point in time, although no evidence of walls or enclosures was found during the excavation of any part of the cemetery (see Heilen and Hall, Chapter 4).

In order to elucidate temporal and population variation in the organization of the cemetery, the cemetery areas are utilized as independent analytical units to compare affinity-, sex-, and age-based similarities and differences.

Arizona State Museum/Basement

Human remains that had been disturbed by the excavation of a basement for the Tucson Newspapers building in 1953 were recovered by the Arizona State Museum. The human remains were selectively recovered from backdirt piles; so, no provenience information is available beyond general locale. Furthermore, the remains recovered from this area could have originated in both the military section (Cemetery Area 1) and the civilian section (Cemetery Areas 2–4). The lack of total recovery and the minimal provenience information for these remains permit only summary demographic information.

The majority of individuals recovered during the excavation of the basement were young to middle adult. Furthermore, males and females were equally distributed, with only one individual of unknown sex over 15 years of age. The females were primarily Hispanic, although Euroamerican and Native American (including two Apache) individuals were also present. Males in the Arizona State Museum collection were generally Hispanic or Euroamerican (Table 97).

Military Section (Cemetery Area 1)

The military section, located in the southwest corner of the project area (see Figure 102), was in use from 1862 to 1881. Many of the individuals in the military section were removed and relocated to Fort Lowell in 1884 (see Appendix K). Removal was not always complete, and in many instances, smaller bone elements were left behind in the grave pits or coffins.

The remains recovered from Cemetery Area 1 were primarily young-adult males, although 40 percent were identified only as "adult" (Table 98). Three young children (ages neonate to 6 years) were interred in the military section. Sex was assessed for only 27 percent of the individuals over the age of 15 years, and all of them were male. The majority of the individuals removed from the military section (15+ years) could not be assessed for sex (72 percent). The high number of indeterminate-sex individuals is the result of previous removal; in fact, only 4 of the 57 excavated graves contained complete or nearly complete individuals (see Appendix K). None of the recovered individuals were identified as female. Of the 13 individuals with an assessment of biological affinity, 8 were Euroamerican, and 5 were Hispanic. The majority of these were young adult or adult in age.

Although previous removal hampered the demographic analysis of the individuals recovered from the military section (Cemetery Area 1), the data are consistent with expectations of individuals enlisted in the military during that period of time.

Cemetery Area 2

Cemetery Area 2 is located in the southeast portion of the project area, adjacent to the military section. Nearly 7 percent of the individuals recovered from the Joint Courts Complex project area were located within Cemetery Area 2 (see Figure 102). Of those, nearly 76 percent were young to middle adult (Table 99). With only one exception, a 6–7-year-old child, all of the juveniles under the age of 12 years interred in this area were 3 years of age or younger.

The adults in Cemetery Area 2 were predominantly male (69 percent), and almost all of them were either Euroamerican or Hispanic. Very few females (7 percent) were documented in Cemetery Area 2. This distribution of individuals by group affiliation and sex is nearly equally distributed among Euroamerican and Hispanic. The only African American individual identified in the Joint Courts Complex project sample, a middle-adult male, was also located in this section of the cemetery. The overall male to female sex ratio for Cemetery Area 2 is 9.43. In other words, there were nine times more males than females. This highly disproportionate sex ratio may suggest that a recent migrant population composed of males was interred in this area.

Cemetery Area 3

Cemetery Area 3 spatially comprises the bulk of the civilian section, occupying most of the northern portion of the cemetery (see Figure 102) and containing over one-half of the total number of individuals recovered from the project area.

The age distribution based on age groups is presented in Table 100. This area contained a large number of fetal and infant remains, suggesting a high death rate for these age cohorts. Within Cemetery Area 3, over one-third of the individuals died before 2 years of age, and over one-half of the individuals died before age 12. The frequency of death during the young- and middle-adult years is also high (over 30 percent of total individuals in the area), decreasing in prevalence for old adults.

In Cemetery Area 3, the male to female sex ratio is even (0.99). Of the females with biological affinity identified, over two-thirds were Hispanic. Of the remaining females, 15 were Euroamerican, and 15 were Native American. The majority of males with biological affinity identified were Hispanic, followed by Euroamerican and Native American. Biological affinity was able to be assessed for 40 children between 2 and 12 years old. Of these children, there were near-equal numbers of Euroamerican and Hispanic individuals, and 2 individuals were Native American.

Overall, the population in Cemetery Area 3 was composed of an equal distribution of males and females, primarily young to middle adult in age. Hispanic appears to be the most-prevalent biological affinity, with Euroamerican and Native American individuals present in sizeable numbers. For individuals less than 15 years of age, near-equal numbers of Euroamerican and Hispanic individuals were present.

Cemetery Area 4

Cemetery Area 4 is directly north of the area disturbed by the construction of the basement for the Tucson Newspapers building (see Figure 102). This area is the densest section of the cemetery, representing 29 percent of the total number of individuals recovered but only 4.28 percent of the project area's acreage. Disturbances were noted throughout this area, including serial interments in grave shafts and postcemetery trenching for utility lines.

Like Cemetery Area 3, one-third of the individuals recovered in this area died by the age of 2, and nearly half died before age 12. The frequency of deaths markedly dropped during the 12–17-year age range (2.5 percent of the total population) and then increased among young adults (Table 101).

Males were more prevalent in Cemetery Area 4, by almost 9 percent, or a male to female sex ratio of 1.40. It should be noted that over half of the adult individuals were of indeterminate sex. This large number of indeterminately sexed remains precludes any solid statement on differences between the sexes.

Biological affinity was assessed for only 12 percent of the individuals in this area. The majority of individuals were Hispanic, with Hispanic individuals represented in all age classes for which biological affinity could be assessed (child to old adult). Native American and European individuals were present in similar numbers of females and males. Biological affinity was assessed for only nine of the individuals under the age of 15. Most of these individuals were Hispanic.

The degree of disturbance in Cemetery Area 4 is demonstrated by the high numbers of remains identifiable as adult (20 percent) only. These disturbances obviously also affect the analyst's ability to estimate sex. Sex could be estimated for only one-half of the individuals aged 15 or over. This should be kept in mind when examining age, sex, and biological-affinity distributions for this cemetery area.

Cemetery Area 5

Cemetery Area 5 represents the northernmost portion of the project area and is the smallest of the cemetery areas, comprising a little over 2 percent (32 individuals) of the Joint Courts Complex project sample.

Overall, 47 percent of the individuals in Cemetery Area 5 were between 18 and 34 years old (Table 102). Furthermore, 43 percent of the individuals were less than 12 years old, and only 17 percent of the individuals were 35 years of age or older. The small number of individuals in this area precludes any statement as to the significance of these differences.

Males and females were represented essentially evenly in this area (8 females and 9 males). The male to female ratio is 1.13. Fortunately, sex was able to be assessed for all of the individuals over the age of 15. Of the total of 15 individuals for whom biological affinity could be assessed, all were Hispanic, with the exception of 1 Euroamerican young-adult male. Hispanic females were young to middle adult, and Hispanic males were young to old adults.

Summary and Discussion

Examination of the basic demographic structure of the five cemetery areas reveals similarities and differences among them. The southern portion of the cemetery (Cemetery Areas 1 and 2) has a fairly consistent demographic profile. The northern portion of the cemetery (Cemetery Areas 3–5) is also fairly consistent. Combined relative-frequency graphs demonstrate differences between the southern and northern cemetery sections (Figures 103–105).

Clearly, the southern portion was primarily composed of young- to middle-adult males, with a very low number of young children and females. This portion of the cemetery is not reflective of the range of ages and proportion of sexes expected from a normally distributed population, where individuals of all age ranges (infant through old adult) and a near-equal sex ratio are expected. Additionally, the southern portion of the cemetery contained primarily Euroamerican and Hispanic individuals, with very few Native American individuals and the sole African American individual. This is consistent with expectations of a military population and a recent, nonlocal, immigrant population from the eastern United States and Mexico.

The northern portion of the cemetery (Cemetery Areas 3–5) is much more diverse in regard to age, sex, and biological affinity. This portion contained nearly equal numbers of all age categories and a nearly equal male to female ratio, indicating a relatively homogenous population. Individuals are represented in all age groups, from fetal to old adult. The individuals recovered from the northern portion of the cemetery were predominantly Hispanic, although Euroamerican and Native American individuals were also present. The northern portion of the cemetery is also characterized by a much larger number of juveniles. In fact, over half of the population recovered from the northern portion of the cemetery were under 18 years old.

Some of the differences noted among the individuals recovered from the northern portion of the cemetery are worthy of further discussion. A larger number of young juveniles were recovered from Cemetery Area 3 than from any other area. The male to female ratios are very close for Cemetery Areas 3 (0.99) and 5 (1.13), but within Cemetery Area 4, there were significantly more males than females (1.40). These differences may result from postdepositional disturbances and poor burial integrity contributing to difficulties in assessing the sex of individuals in Cemetery Area 4. Interestingly, Cemetery Areas 3–5 do not apparently suffer from infant underrepresentation, which is a common problem in many cemetery samples, in which very young individuals are often undernumerated because of postdepositional taphonomic destruction, a key point of consideration when modeling growth rates. The large number of infants recovered during the Joint Courts Complex project will prove invaluable for future studies.

Hazard Models

Hazard models are highly useful tools in demographic and paleodemographic analysis that express the risk of death as a continuous function over time (Chamberlain 2006; Wood et al. 1992). Hazard models have the potential for a much higher level of accuracy than the traditional life-table analysis (Frankenberg and Konigsberg

2006). In particular, they use the exact age of death (in contrast to the categories seen with life tables), and therefore, they use the maximum amount of information in an analysis. Hazard models were utilized to empirically compare the skeletal-age-at-death distributions of various demographic subsets within the cemetery.

A brief summary of the definitions of survivorship and mortality are presented here. Survivorship models predict the probability that an individual will survive to a specific age. Survivorship models function such that individuals have a 1.0 probability (100 percent chance) of being born and a 0.0 probability (0 percent chance) of exceeding the maximum age recorded for the population. The probability of survivorship for any age is expressed as a value between 1.0 and 0.0. Obviously, the probability of survivorship decreases with age. As such, each survivorship value is dependent on previous ages in the model (Chamberlain 2006).

The mortality (or hazard) rate of a population is the proportion of a population that dies within a specific interval of time (Chamberlain 2006). Among humans, the mortality rate is not consistent at all ages but varies throughout life. Typically, mortality is high in juveniles (particularly children and infants), decreases in late adolescence and early adulthood, and then increases again throughout middle and old adulthood (Caughley 1966).

Survivorship and mortality rates vary as a result of many factors, including, but not limited to, immigration and emigration, disease, sex, and socioeconomic status (Chamberlain 2006).

Methods

Siler models examine mortality across the entire lifespan, including juveniles, for whom the risk of death often starts high at birth and then declines rapidly. The Siler model consists of three components describing juveniles, age independents, and senescence. These three components can be thought of as clusters of distinct causes of death (Wood et al. 2002). A benefit of the Siler model is that, although it was not developed to account for infectious diseases, the method has empirical accuracy in so doing, because many infectious diseases target the juvenile and senescent portions of a population (Gage 1991). Furthermore, degenerative diseases predominantly affect the senescent portion, whereas accidents are associated with the age-independent category of the model (Gage 1991). The Siler model is able to document these hazards and gives the researcher a tool for empirically demonstrating differential exposure.

To examine total population mortality and survivorship, the following four-parameter Siler functions were utilized (Herrmann and Konigsberg 2002):

$$S(a) = \exp\left(-\frac{\alpha_1}{\beta_1}\left(1 - e^{-\beta_1 a}\right) - \alpha_2 a + \frac{\alpha_3}{\beta_3}\left(1 - e^{\beta_3 a}\right)\right)$$

$$h(a) = \alpha_1 \exp(-\beta_1 a) + \alpha_2 + \alpha_3 \exp(\beta_3 a)$$

Here, a is a variate representing the exact age at death, α_1 and β_1 are parameters that represent the juvenile component of mortality, and α_3 and β_3 represent the senescent component (Wood et al. 1992). The constant, age-independent hazard parameter (α_2) is excluded from this analysis, as it is rarely able to be estimated in paleodemographic analyses (Wood et al. 1992).

Gompertz models are parametric methods for gauging mortality in adult populations. They use two parameters: α, a scale parameter illustrating the level of adult mortality, and β, a shape parameter describing how the risk of death advances with age (Wood et al. 2002). To examine adult-only and sex-specific mortality and survivorship, the following two-parameter Gompertz models were used (Herrmann and Konigsberg 2002):

$$S(a) = \exp\left(\frac{\alpha}{\beta}\left(1 - e^{\beta a}\right)\right)$$

$$h(a) = \alpha \exp(\beta a)$$

Here, α is a variate representing the exact age at death, and α_1 and β_1 represent the scale and shape parameters, respectively (Holman 2001).

The individual parameters (α and β) for the hazard models were estimated in the MLE computer program (Holman 2001). Then, parameters were graphed using their respective models. Additional statistical tests relied on the log-likelihood statistic calculated by MLE. These consisted of a basic chi-square test of similarity for the sex, age, and biological-affinity ratios and a likelihood-ratio test of the modeled functions. When significant differences were found between modeled functions, the models were examined, in an effort to identify possible sources for the observed differences.

Materials

The skeletal sample used for the following demography analysis included all primary and enumerated individuals. To assess spatial variation and cemetery organization based on general demography, the cemetery areas described earlier were grouped into two sections: the southern section, composed of Cemetery Areas 1 (military section) and 2, and the northern section, composed of Cemetery Areas 3–5. The area from where the Arizona State Museum/basement remains originated appears to encompass both the military section (Cemetery Area 1) and the civilian section (Cemetery Areas 3–5). Therefore, these remains were not included in these analyses.

Individuals with no discernable age information (i.e., 0–99 and 2–99) were excluded from the sample. To prevent overfitting of the Siler model, fetal individuals deemed too young to survive birth (i.e., stillborn) were excluded from the analysis (Herrmann, personal communication 2009). Similarly, older fetal individuals with a maximum age over 0 years were considered perinatal and were modified to have a minimum age of 0 (Table 103).

For all hazard models, individuals with a median age of 15 or over were considered adults. The median age of 15 years was chosen as a minimum age for adults because it is at this age that individuals reach sexual maturation and that senescent causes of death come into play (Wood et al. 2002). For sex-based analyses, individuals with a designation of "possible male/female" were considered either male or female (Table 104).

Because of the small sample size of many of the biological affinities, only Hispanic and Euroamerican individuals were included in the biological-affinity-based hazard models (Table 105).

Models

Several independent comparisons were made to examine age, sex, and group differences within the overall cemetery population, but also within specific cemetery areas.

Age

Age differences within the cemetery population were examined using a Siler model, to examine differences between the presumably more-extraregional-based population (Cemetery Areas 1 and 2) and the regional population (Cemetery Areas 3–5) (Table 106). Significant differences among the modeled functions were found using chi-square and likelihood-ratio tests ($\Lambda = 82.1252$, $p < 0.001$).

The survivorship models are visibly distinct between the two cemetery areas (Figure 106). Survivorship for the southern section is relatively high from birth though adolescence. The chance of surviving to the age of 15 years is approximately 80 percent. This high rate of survivorship may reflect the near absence of an adolescent component in the southern portion of the cemetery. The survivorship curve begins to decline rapidly though the young- and middle-adult years, with only a 26 percent chance of surviving to 40.

Survivorship for the northern section demonstrates a sharp decrease during the earliest years of life. This reduction in survivorship is seen throughout the mid-childhood through young-adult years. The probability that individuals will survive gradually decreases during the middle- to old-adult years.

Throughout the majority of their life spans, the individuals in the northern cemetery section have a reduced level of survivorship. At approximately 45 years of age, both groups reach near-equal probabilities of survivorship (approximately 12 percent will survive to the age of 45). After this, the probability of survivorship for individuals in the southern section drops below that of the northern and remains lower throughout the remainder of the survivorship curve.

Mortality variation is also evident between the southern and northern portions of the cemetery. The southern section shows a decreased mortality probability in infants and young children, compared to that of the northern portion (Figure 107). The lower mortality probability in the southern section is likely influenced by undernumeration of infants and young children in that area.

Both models have close probabilities through the mid-20s, where the two curves sharply diverge. The mortality curve presented in Figure 107 indicates an increase in mortality in the southern section after young adulthood. Between 64 and 65 years of age, mortality reaches a probability of 1.0 (i.e., no individual survived to reach 70+ years of age). The curve for the northern section is less exaggerated and more normal, presenting a more gradual increase in mortality after the age of 25 and through the eighth decade of life. The higher mortality rate for the southern section is likely a reflection of the military section, which is largely composed of young to middle adults or individuals who could only be aged as "adult" (18–99 years).

Sex

Because of the large disparity in sex ratios observed in Cemetery Areas 1 and 2 compared to Cemetery Areas 3–5, hazard models examined sex-based comparisons from two different perspectives. First, because of the skewed sex ratio present in the southern section (11.0), male to female comparisons were only examined in the northern section, where the sex ratio was nearly equal (1.09). This should also have removed age biases introduced from a military or immigrant male population. Demographic differences in sex were examined using the Gompertz model (Table 107). The results of chi-square and likelihood-ratio tests for the comparison of males and females in the northern section show significant differences between males and females ($\Lambda = 10.3504$, $p = 0.0057$).

The survivorship model for males and females from Cemetery Areas 3–5 is presented in Figure 108. Interestingly, males and females have similar probabilities of survivorship at the extremes of the adult age range: 15–20 years old and over 75 years. Probability of survivorship for both groups decreases gradually as age advances. Females show consistently lower levels of survivorship than their male counterparts throughout the curve. The largest discrepancy in survivorship between males and females is in the sixth decade of life, where males have, on average, a higher probability of survivorship (0.13).

The mortality model (Figure 109) shows that the probability of death is relatively low for both sexes and is nearly equal up to middle adulthood (approximately 45 years of age). At that time, the mortality rate for females slowly increases, a trend that continues throughout senescence.

The second sex-based Gompertz model examines the survivorship and mortality of males in the southern and northern cemetery sections (Table 108). The results of the chi-square and likelihood-ratio tests show significant differences between males in the southern and northern sections ($\Lambda = 6141.1436$, $p > 0.0001$).

Males in the southern cemetery areas present a much lower survivorship throughout life (Figure 110), compared to their northern counterparts. The lower survivorship of the males in the southern section begins during the late 20s to mid-30s. This general pattern continues until around 60 years of age, when the greatest difference between the two cemetery sections begins. The males in the southern section have a 20 percent chance of surviving to the age of 60, whereas the males in the northern section have a 47 percent chance of surviving to the same age.

The mortality model for males (Figure 111) illustrates that individuals in the southern and northern cemetery areas have low but similar probabilities for mortality until approximately 45 years of age. After 45 years,

the probability for mortality for the males in the southern section significantly increases, compared to the northern areas. This elevated mortality continues throughout the remainder of life.

Biological Affinity

Differences in mortality and survivorship rates of the individuals identified as Euroamerican and Hispanic for the total cemetery sample were analyzed using a Gompertz model (Table 109). The small sample sizes of the other groups present in the cemetery prevented inclusion. Significant differences were noted between Hispanic and Euroamerican individuals ($\Lambda = 9.6664$, $p = 0.00796$).

The survivorship curve is presented in Figure 112. Euroamerican individuals have an overall reduced survivorship throughout life. This difference is most marked in the fourth decade of life, where Euroamerican individuals have a 36 percent chance of surviving to 35, compared to a 50 percent chance of surviving to the same age for Hispanic individuals.

Consistent with the reduced survivorship seen with Euroamerican individuals, the mortality hazard also shows significant differences between Hispanic and Euroamerican individuals (Figure 113). Throughout the mortality curve, Euroamerican individuals have a higher mortality rate than Hispanic individuals. This difference in mortality is most prominent throughout the fifth to sixth decade of life.

The differences in survivorship between Euroamerican and Hispanic individuals cannot be attributed to the military section alone. Nearly equal numbers of Euroamerican and Hispanic individuals were present in the military section and Cemetery Area 2. Furthermore, the age distribution is similar for both groups in the military section. This assertion is explored by looking for significant differences between the southern and northern cemetery areas for both Euroamerican and Hispanic individuals. To account for the lack of an adolescent component in the southern section, only individuals with a minimum age of 15 were included in this analysis.

A Gompertz function was used to model the hazard curve for Euroamerican individuals in the southern and northern cemetery areas (Table 110). Chi-square and log-likelihood-ratio tests produced nonsignificant differences between the northern and southern sections ($\Lambda = 1.1878$, $p = 0.5522$). The survivorship curves for the southern and northern sections (Figure 114) suggest that there is very little difference between the two until senescence. This indicates no significant differences in the survivorship and mortality profiles of Euroamerican individuals between the southern and northern cemetery areas.

Hispanic individuals in the southern and northern sections were likewise modeled with a Gompertz function (Table 111). Significant differences were noted between the two sections, using a chi-square and log-likelihood-ratio test ($\Lambda = 6.93088$, $p = 0.0313$).

The survivorship model for Hispanic individuals illustrates distinctions between those interred in the southern section of the cemetery and those interred in the northern section (Figure 115). Those in the southern section have a higher rate of survivorship than those in the northern section, until the age of 48. This difference is not substantial, at most no more than about a 5 percent difference between the two sections. Around 48 years of age, the probability of survivorship for the individuals in the southern section drops below that of the northern section. At 66 years, the probability of Hispanic individuals surviving drops below 1 percent.

The survivorship curve of individuals in the northern section is less dramatic than that of individuals in the southern section. Although the initial probability of survivorship is lower in the northern section, the curve for the southern section is gradual. The individuals in the northern section approach a 0.0 probability of survivorship during the mid- to late 80s.

The probability of mortality is relatively low and consistent for the Hispanic individuals interred in both the southern and northern cemetery sections throughout young and middle adulthood (Figure 116). At approximately 45 years of age, the mortality rate for individuals in the southern section increases quickly and hyperbolically, so that by 70 the mortality rate is 100 percent. This is attributed to the small sample of individuals with mean ages over 50 in this section (n = 3). The mortality rate for the individuals in the northern section also increases around 45 years, although at a much less exaggerated rate than in the northern section.

Summary and Discussion

Significant differences among the various age, sex, and biological-affinity groups were found within the cemetery. The age-based survivorship curve modeled for Cemetery Areas 1 and 2 (see Figure 108) reflects the hypothesized population in those areas: military personal, their immediate families, and individuals who migrated to Tucson from elsewhere. The composition of this population biased the sample by excluding the youngest and oldest members of society (the adolescent and senescent components). The survivorship curve for Cemetery Areas 3–5 (see Figure 108) is not unexpected for a civilian population; individuals are represented from the entire age range, including the fetal and neonate ages—portions of the population often difficult to model because of undernumeration of infant remains in cemetery samples (Walker et al. 1988).

In the northern cemetery section, females consistently have lower survivorship and higher levels of mortality throughout life than do their male counterparts (see Figures 101 and 102). Although this difference is statistically significant and consistent throughout the age curve, it is not an extreme or marked difference. Many factors may contribute to the higher hazard of mortality for women. The extensive complications that arise from pregnancy and childbirth are not the only hazards affecting females and not males. The large number of juveniles under the age of 2 (35 percent of the total sample of the northern section) may support this premise. Higher pregnancy rates result in a higher probability for a female to run into life-threatening complications in pregnancy. Additional factors that may play a role in higher female mortality include unequal access to resources and women's roles in daily work and activities.

Mortality and survivorship for males in the northern and southern sections are relatively similar for young adults. Differences become apparent beginning around the third decade, when the males in the southern section have a lower probability of survivorship than do their counterparts in the northern section. The males in the southern portion of the cemetery also have a higher probability of mortality, beginning around the age of 45. The composition of the two southern cemetery areas—Cemetery Area 1 (military men and their children) and Cemetery Area 2 (recent immigrants to the greater Tucson area)—is the likely causative agent for this increased death rate in middle adulthood. Although the life histories of the young-adult males in the southern and northern sections may differ, the hazards they faced were associated with day to day activities. European and Hispanic individuals also differed significantly in mortality and survivorship. A European individual was more likely to die at a given age than a Hispanic individual of the same age. Furthermore, significant differences were noted for Hispanic individuals over the age of 15 from the northern and southern sections of the cemetery. Up to approximately 45 years of age, Hispanic individuals in the southern section were much more likely to survive than individuals of the same age in the northern portion. After 45, however, a Hispanic individual in the southern portion of the cemetery was more likely to die than an individual of the same age in the northern portion. Interestingly, no significant differences were noted between European individuals in the northern section and those in the southern section.

The southern portion of the cemetery may represent a population of recent migrants to the area. An immigrant population could also explain the variation noted between Euroamerican and Hispanic individuals. If that is the case, the Euroamerican individuals may represent a group of continuous migrants to the area. The consistency noted among the Euroamerican sample and the lack of significant differences in the demographic profiles between Euroamerican individuals in the southern portion of the cemetery and those in the northern portion suggest consistent levels of age-independent and senescent health hazards for both samples of Euroamerican individuals. This indicates that, although the actual life histories of the European individuals in the southern cemetery may have been different from those in the northern cemetery, the hazards they were encountering caused similar probabilities of death after the age of 15.

The differences documented among Hispanic individuals suggest that the most important cause of these differences is variation in occupations and hazards between Hispanic individuals in the northern section and those in the southern section. Hispanic military individuals and recent immigrants from Mexico likely experienced very different life histories from those of the more-locally based, residential, civilian population in the northern section.

Conclusion

The focus of this chapter is the paleodemography of the Joint Courts Complex project area. The number of individuals recovered from within the project area was addressed through a multifaceted approach. The minimum number of individuals represented is 1,386, estimated using a context-based method. Other methods used to estimate the minimum number of individuals varied.

Through the analysis of the survivorship and mortality models, two separate subsets of populations are represented in the cemetery. The first is composed of the two southern cemetery areas (Cemetery Areas 1 and 2), representing an immigrant population. These individuals were primarily Hispanic and Euroamerican, young- to middle-adult males. Females, young children, and other biological affinities were represented in very small numbers but did not significantly contribute to the overall composition of the southern section of the cemetery. These numbers are represented in the Siler age models, showing a low mortality probability and high survivorship during the early years of life and a sharp decrease in survivorship and a higher probability of mortality beginning at young adulthood.

The three northern cemetery areas (Cemetery Areas 3–5) likely represent a local, imbedded population. This population included individuals representing the entire age spectrum and nearly even male to female ratios. The northern portion of the cemetery was primarily composed of Hispanic individuals, although Euroamerican and Native American individuals were also present. Females in the three northern cemetery areas could expect a reduced lifespan and a higher probability of mortality than males in the same area.

Differences in mortality and survivorship can be attributed to many causes. The high female mortality and decreased survivorship seen in the northern cemetery areas may be tied to the high number of fetal and infant remains also recovered in those areas. Frequently, diseases affecting a mother will also affect her fetus or infant.

In Volume 1, skeletal demography and the historical record were compared, and relationships between indices of fertility and mortality were discussed. Historical records describe Tucson as a very dynamic and diverse population during the time the cemetery was in use. This variation is reflected in the skeletal materials recovered from the Alameda-Stone cemetery. In part, the "demographic duality" described by Sheridan (1986:38) was documented within the cemetery sample: the southern areas were composed primarily of young- to middle-adult males, many of them Euroamerican, and the northern areas consisted of individuals of all ages and both sexes, many of them Hispanic. The more balanced and normal demographic structure of the northern areas is consistent with the historical demography of the local population of Tucson at the time, and the demographic structure of the southern areas is more consistent with an immigrating, frontier population.

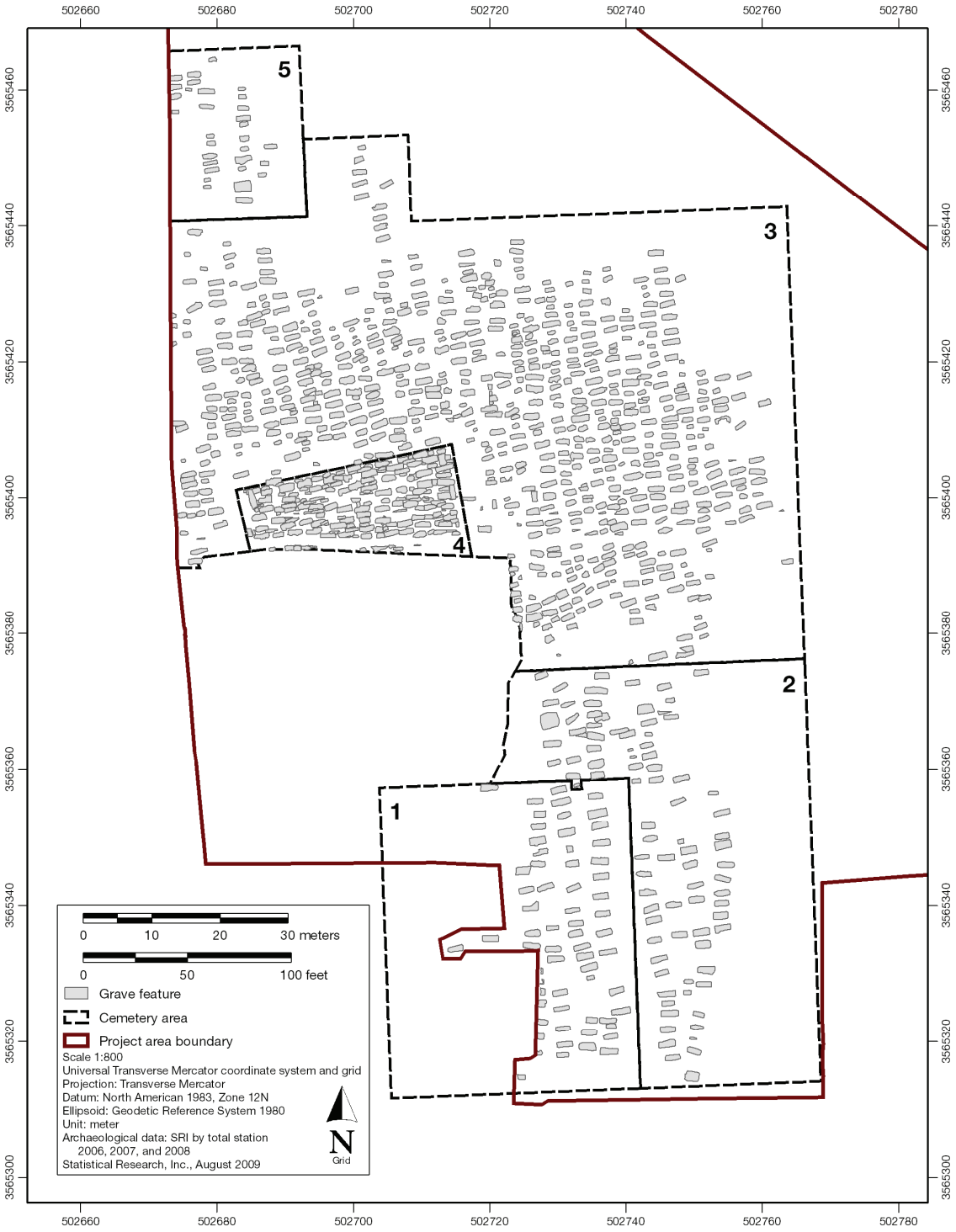


Figure 102. Map of Alameda-Stone cemetery with designated areas.

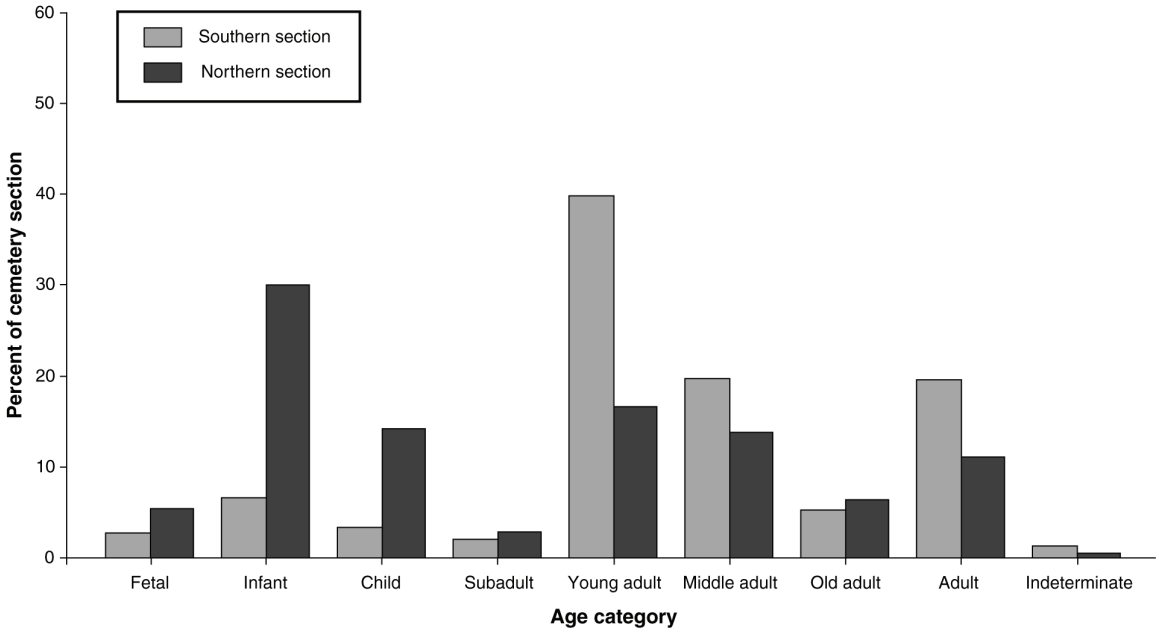


Figure 103. Relative frequency of individuals, by age category and cemetery section.

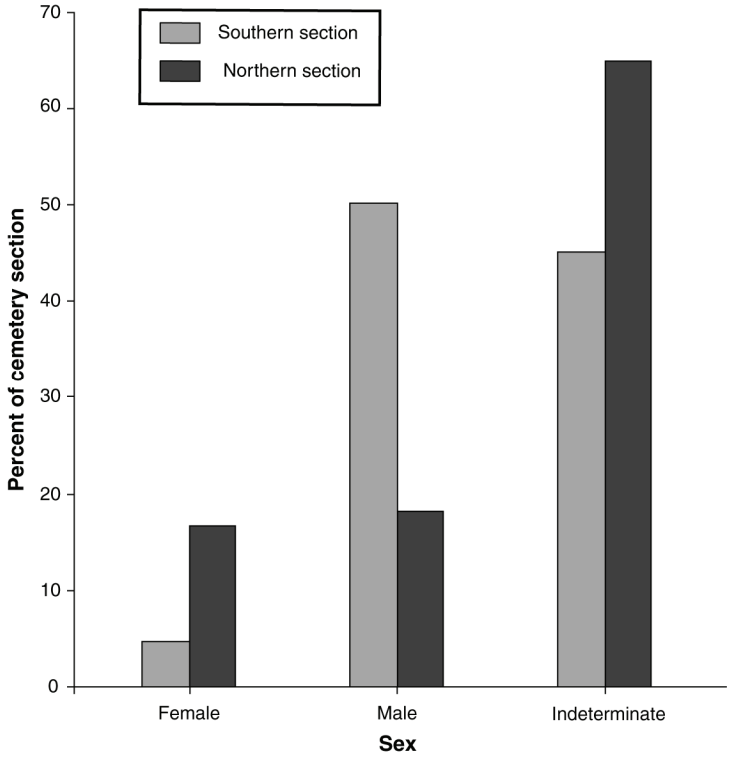


Figure 104. Relative frequency of individuals, by sex and cemetery section.

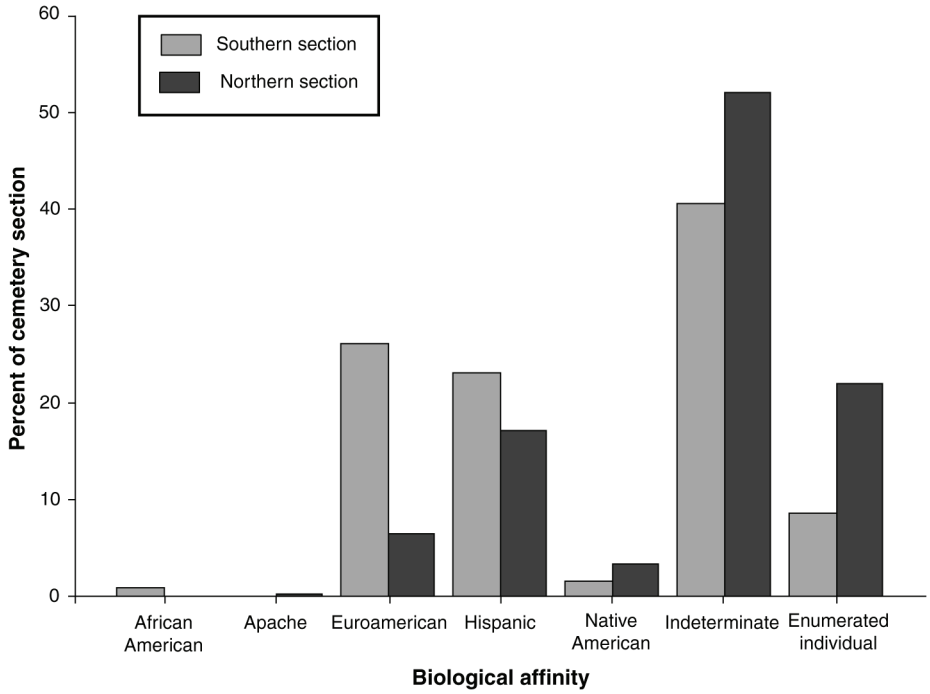


Figure 105. Relative frequency of individuals, by biological affinity and cemetery section.

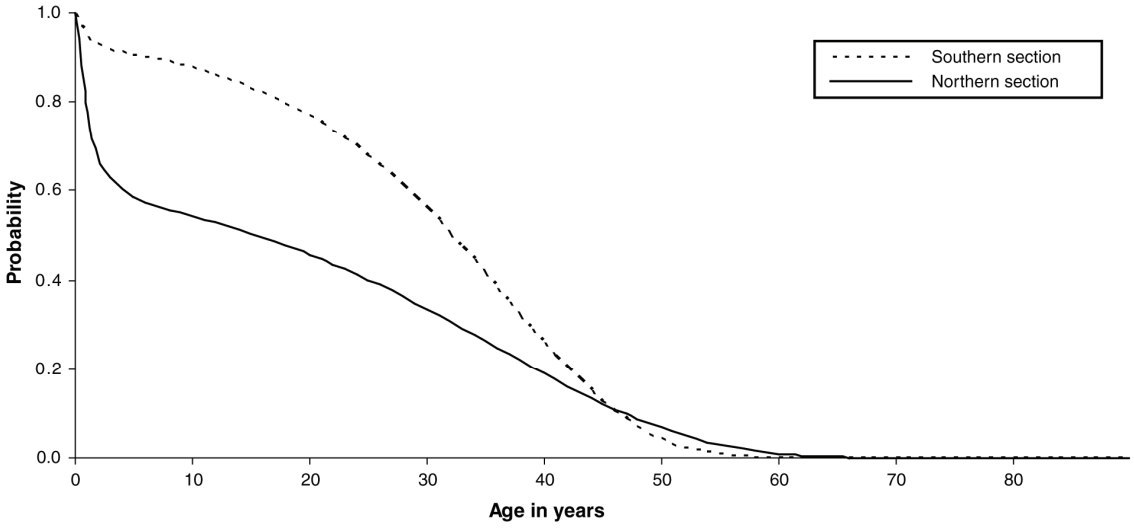


Figure 106. Probability density function for age, by cemetery section.

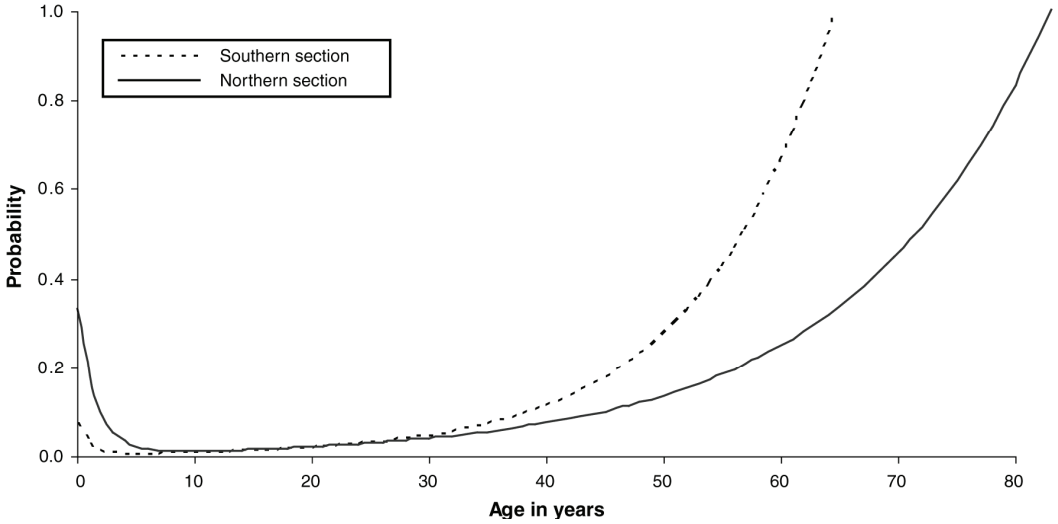


Figure 107. Mortality-hazard model for age, by cemetery section.

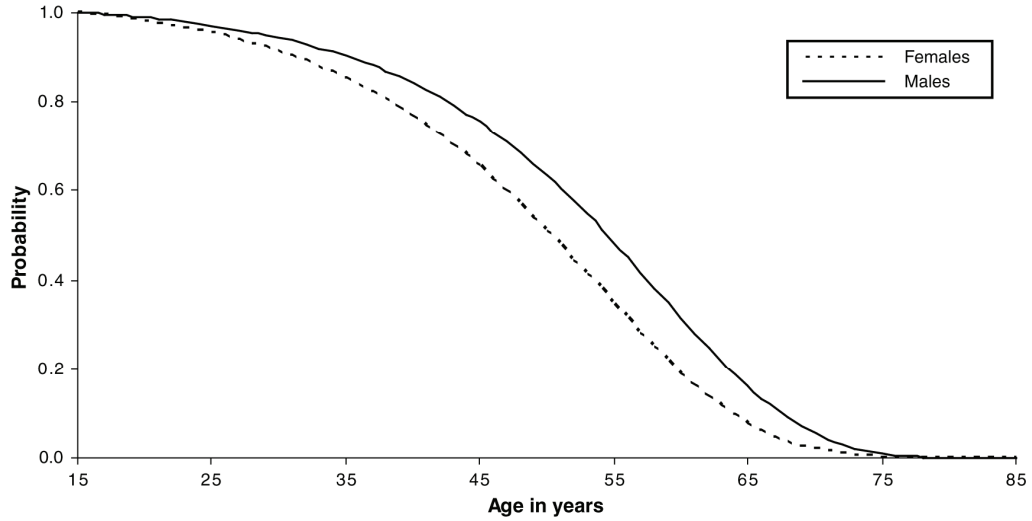


Figure 108. Male and female survivorship, Cemetery Areas 3–5.

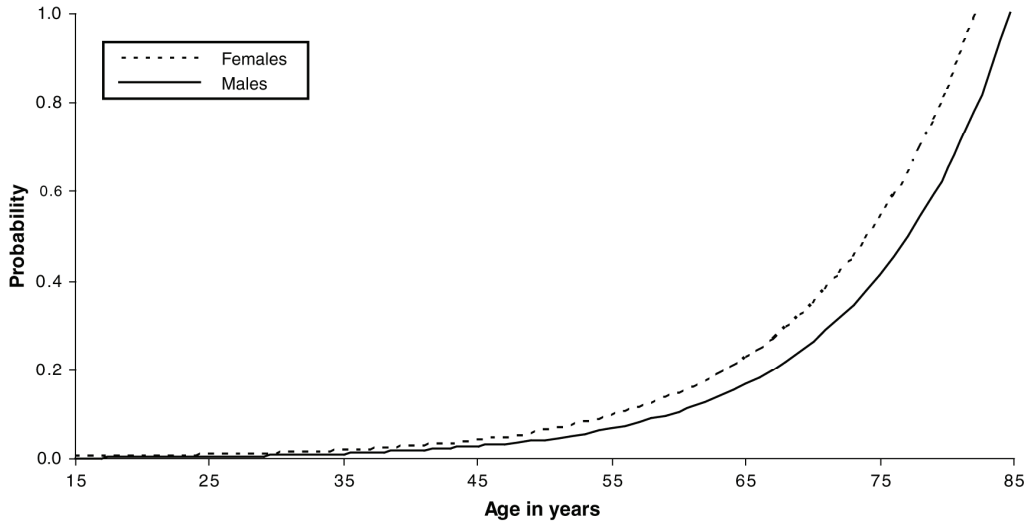


Figure 109. Male and female mortality model, Cemetery Areas 3–5.

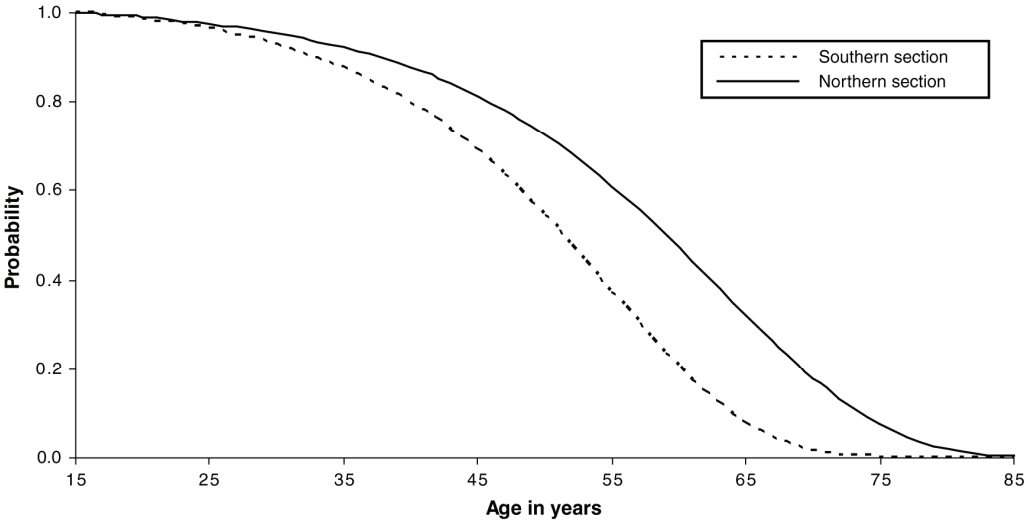


Figure 110. Male survivorship for southern and northern cemetery sections.

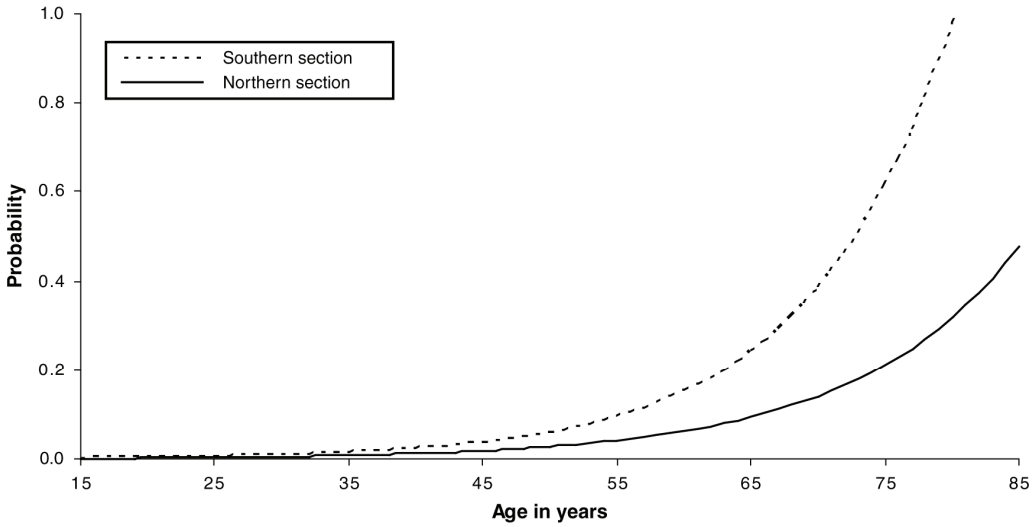


Figure 111. Male mortality for southern and northern cemetery sections.

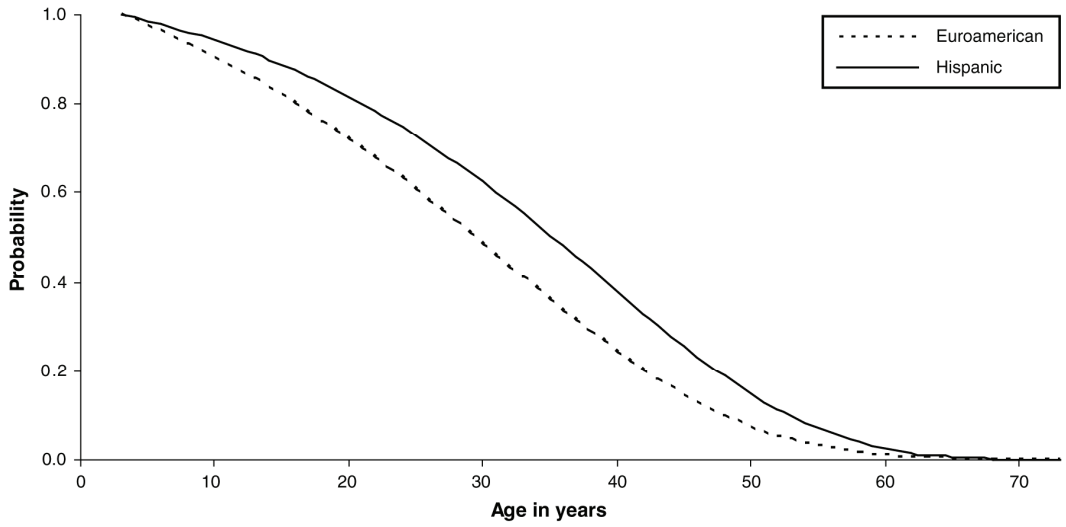


Figure 112. Survivorship model for Euroamerican and Hispanic individuals.

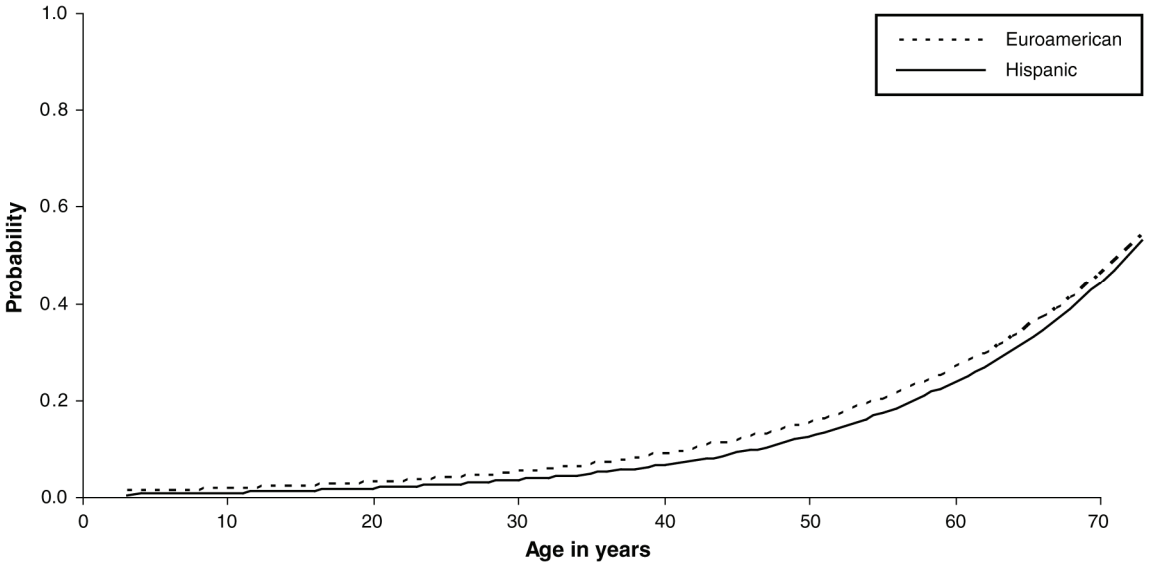


Figure 113. Mortality model for Euroamerican and Hispanic individuals.

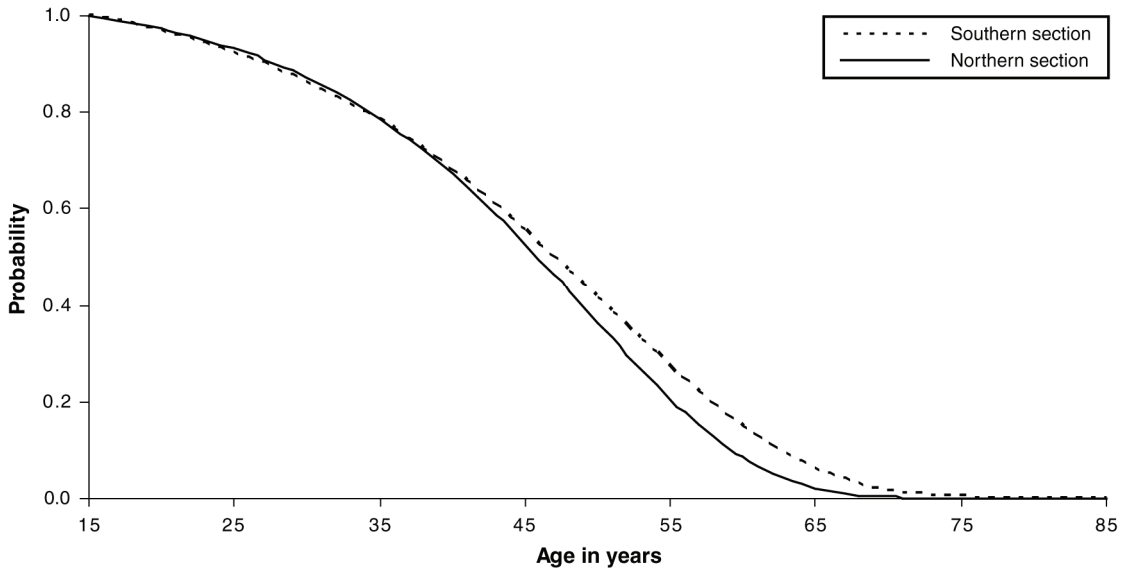


Figure 114. Survivorship model for Euroamerican individuals, by southern and northern cemetery sections.

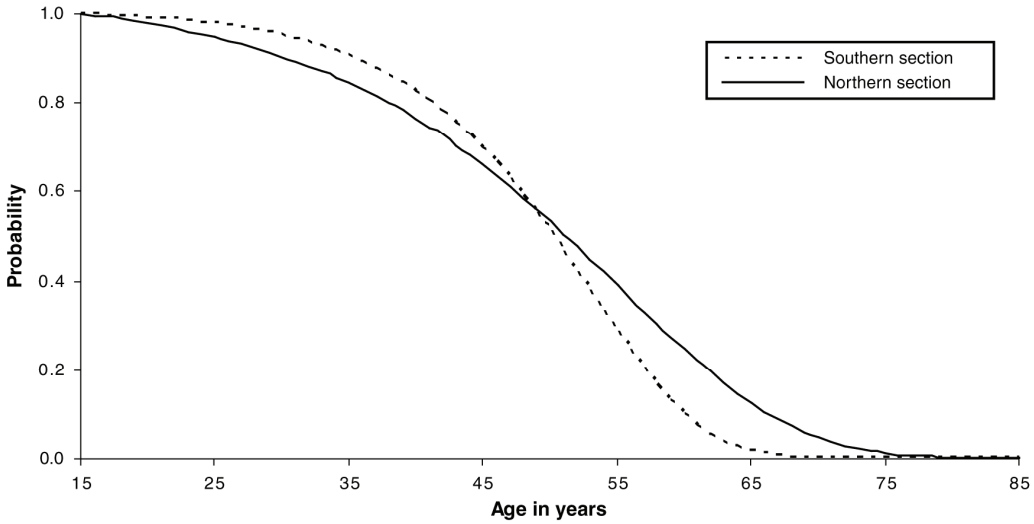


Figure 115. Survivorship model for Hispanic individuals, by southern and northern cemetery sections.

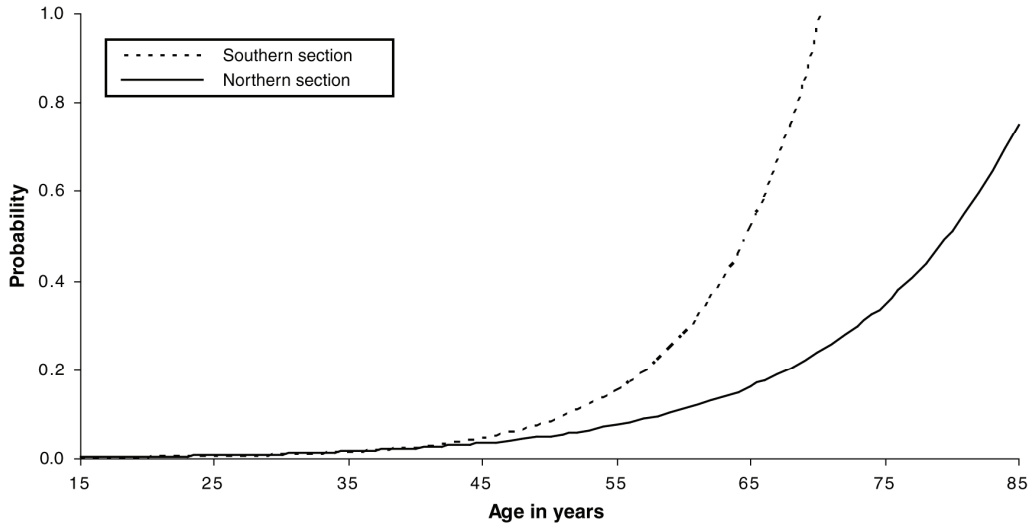


Figure 116. Mortality model for Hispanic individuals, by southern and northern cemetery sections.

Table 92. Most-Likely Number of Individuals (MLNI)

Element	Tibia	Radius	Humerus	Femur	Ulna	Overall
Left	97	99	107	109	100	512
Right	104	99	112	103	99	517
Paired	43	37	44	44	43	211
MLNI	212	219	219	219	219	219

Table 93. Five Most Prevalent Elements

Element	Right			Left		
	Complete	Partial	Total	Complete	Partial	Total
Femur	926	84	1,010	930	89	1,019
Humerus	928	97	1,025	926	88	1,014
Radius	904	101	1,005	905	90	995
Tibia	907	98	1,004	900	93	993
Ulna	907	94	1,001	893	93	986

Table 94. Frequencies of the Five Most Prevalent Elements

Element	Right			Left			Paired
	Nonassociated	Associated	Total	Nonassociated	Associated	Total	
Femur	42	982	1,024	46	996	1,042	951
Humerus	46	999	1,045	40	996	1,036	945
Radius	51	978	1,029	36	989	1,025	946
Tibia	42	986	1,028	40	981	1,021	951
Ulna	43	982	1,025	36	991	1,027	944

Table 95. Arizona State Museum Age Categories

Age Category	Minimum Age	Maximum Age
Fetal	–0.75	–0.01
Infant	0.0	1.99
Child	2.0	11.99
Subadult	12.0	17.99
Young adult	18.0	34.99
Middle adult	35.0	49.99
Old adult	50.0	99
Adult	18.0	99

Table 96. Total Cemetery Age, Sex, and Biological-Affinity Crosstabulation

Biological Affinity, by Sex	Arizona State Museum Age Category									Total	Total Percent (Sex)
	Fetal	Infant	Child	Subadult	Young Adult	Middle Adult	Old Adult	Adult	Indeterminate		
Female											
African American	—	—	—	—	0	0	0	0	0	—	
Apache	—	—	—	—	0	2	0	0	0	2	
Euroamerican	—	—	—	2	14	7	0	0	0	23	
Hispanic	—	—	—	5	49	28	12	0	0	94	
Native American	—	—	—	1	9	8	1	0	0	19	
Indeterminate	—	—	—	1	25	33	15	8	0	82	
Enumerated individuals[a]	—	—	—	—	3	1	0	2	0	6	
Subtotal	—	—	—	9	100	79	28	10	0	226	30.1
Male											
African American	—	—	—	—	0	1	0	0	0	1	
Apache	—	—	—	—	0	0	0	0	0	—	
Euroamerican	—	—	—	2	34	19	7	2	0	64	
Hispanic	—	—	—	2	41	48	20	3	0	114	
Native American	—	—	—	—	7	5	4	0	0	16	
Indeterminate	—	—	—	—	30	40	20	15	0	105	
Enumerated individuals[a]	—	—	—	—	2	1	1	10	0	14	
Subtotal	—	—	—	4	114	114	52	30	0	314	41.8
Indeterminate											
African American	0	0	0	0	0	0	0	0	0	—	
Apache	0	0	0	1	0	0	0	0	0	1	
Euroamerican	0	0	19	6	7	0	0	3	0	35	
Hispanic	0	0	28	4	7	1	1	1	0	42	
Native American	0	0	3	1	1	0	0	0	0	5	
Indeterminate	54	309	83	6	26	8	1	24	1	512	
Enumerated individuals[a]	13	61	42	7	21	7	2	93	5	251	

Biological Affinity, by Sex	Arizona State Museum Age Category									Total	Total Percent (Sex)
	Fetal	Infant	Child	Subadult	Young Adult	Middle Adult	Old Adult	Adult	Indeterminate		
Subtotal	67	370	175	25	62	16	4	121	6	846	28.2
Total	67	370	175	38	276	209	84	161	6	1,386	100.0
Total percent	4.83	26.7	12.63	2.74	19.91	15.08	6.06	11.62	0.43	100	

[a] Enumerated-individual frequencies do not include Arizona State Museum individuals, which are included in their respective affinity categories.

Table 97. Arizona State Museum/Basement Age and Biological-Affinity Crosstabulation, by Sex

Biological Affinity, by Sex	Age Category							Total
	Infant	Child	Subadult	Young Adult	Middle Adult	Old Adult	Adult	
Female								
Apache	—	—	—	0	1	0	0	2
Euroamerican	—	—	—	1	1	0	0	2
Hispanic	—	—	—	4	3	0	0	7
Native American	—	—	—	1	0	0	0	1
Indeterminate	—	—	—	2	5	2	0	9
Subtotal	—	—	—	8	10	2	0	20
Male								
Euroamerican	—	—	1	2	1	1	1	6
Hispanic	—	—	—	3	5	0	0	8
Indeterminate	—	—	—	5	1	0	0	6
Subtotal	—	—	1	10	7	1	1	20
Indeterminate								
Apache	0	0	1	0	0	0	0	1
Hispanic	0	0	0	1	0	0	0	1
Indeterminate	4	2	0	0	0	0	0	6
Subtotal	4	2	1	1	0	0	0	8
Total	4	2	2	19	17	3	1	48

Table 98. Military Section Age and Biological-Affinity Crosstabulation, by Sex

Biological Affinity, by Sex	Age Category							Total
	Infant	Child	Subadult	Young Adult	Middle Adult	Adult	Indeter-minate	
Male								
Euroamerican	—	—	—	1	0	0	0	1
Hispanic	—	—	—	1	1	0	0	2
Indeterminate	—	—	—	3	0	5	0	8
Subtotal	—	—	—	5	1	5	0	11
Indeterminate								
Euroamerican	0	0	0	4	0	3	0	7
Hispanic	0	0	0	2	0	1	0	3
Indeterminate	2	1	1	12	1	12	1	30
Enumerated individual	0	0	0	3	0	2	1	6
Subtotal	2	1	1	21	1	18	2	46
Total	2	1	1	26	2	23	2	57

Table 99. Cemetery Area 2 Age and Biological-Affinity Crosstabulation, by Sex

Biological Affinity, by Sex	Age Category								Total
	Fetal	Infant	Child	Subadult	Young Adult	Middle Adult	Old Adult	Adult	
Female									
Euroamerican	—	—	—	—	3	1	0	0	4
Hispanic	—	—	—	—	2	1	0	0	3
Subtotal	—	—	—	0	5	2	0	0	7
Male									
African	—	—	—	0	0	1	0	0	1
Native American	—	—	—	0	0	0	1	0	1
Euroamerican	—	—	—	1	16	8	2	1	28
Hispanic	—	—	—	1	10	13	3	0	27
Indeterminate	—	—	—	0	2	4	2	1	9
Subtotal	—	—	—	2	28	26	8	2	66
Indeterminate									
Enumerated individual	1	1	1	—	0	0	0	4	7
Native American	0	0	1	—	0	0	0	0	1
Indeterminate	3	7	2	—	2	0	0	1	15
Subtotal	4	8	4	0	2	0	0	5	23
Total	4	8	4	2	35	28	8	7	96

Table 100. Cemetery Area 3 Age and Biological-Affinity Crosstabulation, by Sex

Biological Affinity, by Sex	Age Category									Total
	Fetal	Infant	Child	Subadult	Young Adult	Middle Adult	Old Adult	Adult	Indeter-minate	
Female										
Enumerated individual	—	—	—	0	1	0	0	0	0	1
Native American	—	—	—	1	8	6	0	0	0	15
Apache	—	—	—	0	0	1	0	0	0	1
Euroamerican	—	—	—	2	8	5	0	0	0	15
Hispanic	—	—	—	3	33	21	11	0	0	68
Indeterminate	—	—	—	1	16	16	7	3	0	43
Subtotal	—	—	—	7	66	49	18	3	0	143
Male										
Enumerated individual	—	—	—	0	0	0	1	3	0	4
Native American	—	—	—	0	5	3	3	0	0	11
Euroamerican	—	—	—	0	12	8	4	0	0	24
Hispanic	—	—	—	1	18	25	12	1	0	57
Indeterminate	—	—	—	0	7	23	9	6	0	45
Subtotal	—	—	—	1	42	59	29	10	0	141
Indeterminate										
Enumerated individual	6	10	14	3	2	2	1	30	4	72
Native American	0	0	2	1	1	0	0	0	0	4
Euroamerican	0	0	18	5	2	0	0	0	0	25
Hispanic	0	0	20	3	2	1	1	0	0	27
Indeterminate	38	227	56	3	9	2	0	6	0	341
Subtotal	44	237	110	15	16	5	2	36	4	469
Total	44	237	110	23	124	113	49	49	4	753

Table 101. Cemetery Area 4 Age and Biological-Affinity Crosstabulation, by Sex

Biological Affinity, by Sex	Age Category								Total
	Fetal	Infant	Child	Subadult	Young Adult	Middle Adult	Old Adult	Adult	
Female									
Enumerated individual	—	—	—	—	2	1	0	2	5
Native American	—	—	—	—	0	2	1	0	3
Euroamerican	—	—	—	—	2	0	0	0	2
Hispanic	—	—	—	2	4	2	1	0	9
Indeterminate	—	—	—	0	6	12	6	5	29
Subtotal	—	—	—	2	14	17	8	7	48
Male									
Enumerated individual	—	—	—	—	2	1	0	7	10
Native American	—	—	—	—	2	2	0	0	4
Euroamerican	—	—	—	—	2	2	0	0	4
Hispanic	—	—	—	—	7	2	4	1	14
Indeterminate	—	—	—	—	12	12	8	3	35
Subtotal	—	—	—	0	25	19	12	11	67
Indeterminate									
Enumerated individual	6	50	27	4	16	5	1	57	166
Euroamerican	0	0	1	1	1	0	0	0	3
Hispanic	0	0	7	1	2	0	0	0	10
Indeterminate	10	63	19	2	3	5	1	5	108
Subtotal	16	113	54	8	22	10	2	62	287
Total	16	113	54	10	61	46	22	80	402

Table 102. Cemetery Area 5 Age and Biological-Affinity Crosstabulation, by Sex

Biological Affinity, by Sex	Age Category							Total
	Fetal	Infant	Child	Young Adult	Middle Adult	Old Adult	Adult	
Female								
Hispanic	—	—	—	6	1	0	0	7
Indeterminate	—	—	—	1	0	0	0	1
Subtotal	—	—	—	7	1	0	0	8
Male								
Euroamerican	—	—	—	1	0	0	0	1
Hispanic	—	—	—	2	2	1	1	6
Indeterminate	—	—	—	1	0	1	0	2
Subtotal	—	—	—	4	2	2	1	9
Indeterminate								
Hispanic	0	0	1	0	0	0	0	1
Indeterminate	3	6	3	0	0	0	0	12
Subtotal	3	6	4	0	0	0	0	13
Total	3	6	4	11	3	2	1	30

Table 103. Breakdown of Age Sample, by Age Category and Cemetery Area

Arizona State Museum Age Category	Cemetery Areas 1 and 2	Cemetery Areas 3, 4, and 5	Total
Infant	10	356	366
Child	5	168	173
Subadult	3	33	36
Young adult	61	196	257
Middle adult	30	162	192
Old adult	8	73	81
Adult	30	130	160
Total	147	1,118	1,265

Table 104. Breakdown of Sex Sample, by Age Category and Cemetery Area

Arizona State Museum Age Category	Cemetery Areas 1and 2		Cemetery Areas 3, 4, and 5		Total	
	Females	Males	Females	Males	Females	Males
Subadult	0	2	9	1	9	3
Young adult	5	33	87	71	92	104
Middle adult	2	27	67	80	69	107
Old adult	0	8	26	43	26	51
Adult	0	7	10	22	10	29
Total	7	77	199	217	206	294

Table 105. Breakdown of Hispanic and European Sample, by Age Category and Cemetery Area

Age Category	Cemetery Areas 1 and 2		Cemetery Areas 3, 4, and 5		Total	
	Hispanic	Euroamerican	Hispanic	Euroamerican	Hispanic	Euroamerican
Child	0	0	28	19	28	19
Subadult	1	1	10	8	11	9
Young adult	15	24	74	28	89	52
Middle adult	15	9	54	15	69	24
Old adult	3	2	30	4	33	6
Adult	1	4	3	0	4	4
Indeterminate	0	0	0	0	0	0
Total	35	40	199	74	234	114

Table 106. Siler Age Model Parameter Estimates, by Cemetery Area

Parameters	Cemetery Areas 1 and 2	Cemetery Areas 3, 4, and 5
α_1	0.076316278	0.327853125
β_1	0.986144957	0.634082397
α_3	0.003393305	0.006786348
β_3	0.088023516	0.060186103

Table 107. Gompertz Model Parameter Estimates, by Sex

Parameters	Females	Males
α	0.002959644	0.001808178
β	0.086783924	0.09061937
Log likelihood	–330.304	–321.622

Table 108. Gompertz Model Parameter Estimates for Males, by Cemetery Area

Parameters	Cemetery Areas 1 and 2	Cemetery Areas 3, 4, and 5
α	0.00224	0.00161
β	0.09362	0.08138
Log likelihood	–117.27	–3396.7

Table 109. Gompertz Model Parameter Estimates for Biological Affinity

Parameters	Euroamerican	Hispanic
α	0.011803068	0.006684086
β	0.054627499	0.062496952

Table 110. Gompertz Model Parameter Estimate for Euroamerican Individuals, by Cemetery Section

Parameters	Southern Section	Northern Section
α	0.005355001	0.004475847
β	0.073531156	0.086294957

Table 111. Gompertz Model Parameter Estimate for Hispanic Individuals, by Cemetery Section

Parameters	Southern Section	Northern Section
α	0.001157738	0.003560588
β	0.122170914	0.076473688

CHAPTER 8

Biological Distance and Geospatial Analysis

Joseph T. Hefner

Introduction

The use of measurements and observations on human skeletal remains—particularly on the cranium—to draw inferences concerning biological distance, biocultural continuity, and use of the cemetery space have been explored in-depth in bioarchaeological and biological anthropological settings, but never using a predominately Hispanic sample. These measures of biological distance within and between populations, as proxies and estimates of genetic distance, can be used to measure the similarity or divergence of populations via metric measurements of the skull and nonmetric manifestations expressed in the cranium. The importance of the Alameda-Stone cemetery population—a rich and diverse assortment of ethnicities found in Tucson during the nineteenth century—is demonstrated through the application of traditional and innovative approaches to the study of biological variation.

This chapter explores the biological and spatial variability within and between the samples recovered from the Alameda-Stone cemetery in Tucson during the nineteenth century. The primary goals of this chapter are twofold. Specifically, this chapter seeks to (1) identify subgroups within the cemetery using the above-mentioned data as a proxy for biological distance and (2) explore the observed variation in an attempt to understand overarching patterns of cemetery use by the peoples of Tucson through the skeletal remains recovered from the Alameda-Stone cemetery.

In this chapter, biological variability is examined using three sets of observations: the presence and magnitude of dental traits, measurements of the skull (craniometrics), and variations in the expression of cranial nonmetric attributes (morphoscopic traits). These observations are evaluated using statistical methods, such as discriminate function analysis, principal component analysis, cluster analysis, and neural networking. These methods identify and quantify patterns of difference and similarity within a framework allowing for statistical evaluation of their validity.

The results of each analysis are then explored as proxies for familial (or genetic) relationships to interpret patterns of spatial distribution throughout the cemetery. Although there is very little documentation regarding the distribution of individuals within the cemetery, the hypothesis that the grave pits were positioned and distributed in a nonrandom fashion is tested using the biological attributes as predicates for the observed cemetery layout. These observations are then explored using variogram analyses and kriging methods to evaluate the effect of these attributes on cemetery organization.

Biological Affinity

Before any discussion of biological distance, we must first understand the a priori labels attached to the individuals recovered from the cemetery. This section describes how Statistical Research, Inc., assessed biological affinity. An assessment of biological affinity was only one part of the final assessment of cultural affinity stipulated in the *Agreement on Treatment and Disposition of Burial Discoveries Dating After 1775* (A.R.S. §41-844, Case No. 06-14). Assessing the cultural affinity of human remains is often difficult because

no simple correspondence exists between one's biological affinity and one's culture. This is especially true in the context of nineteenth-century Tucson, where many people were of mixed biological ancestry but shared a generally Hispanic culture. At the same time, people with a similar biological ancestry might have quite different cultural affinities. For each set of human remains found in the Alameda-Stone cemetery, the assessment of cultural affinity relied on three lines of evidence: contextual indicators, osteological indicators, and historical evidence (see Appendix F). Detailed results of the assessments of cultural affinity for the civilian and military sections of the cemetery are discussed in Volume 1 and are included on the CD-ROM accompanying this volume as Appendixes F and K, respectively.

Biological Data

The estimation of biological affinity is meant to indicate the closest biological group, or ancestry, for each individual. The osteological analysis considered four classes of data to assess biological affinity as part of the assessment of cultural affinity: dental morphology, cranial and postcranial metrics, cranial nonmetric traits, and cranial deformation. These data were analyzed using statistical methods and reference samples appropriate for the type of data being considered.

Assessments of biological affinity were based primarily on cranial morphology and craniometric analysis. Some features of the cranium are better indicators of biological affinity; these include facial height, orbit shape, interorbital breadth, development and prominence of the nasal bones, the shape and width of the nasal aperture, and the morphology of the inferior nasal aperture. In addition, the palate and some of the traits of the dentition provide good indicators of biological affinity. When cranial traits were missing or fragmentary, the dentition and the postcranial elements were used.

Because of the poor condition of the human remains excavated from the Alameda-Stone cemetery, it was not possible to collect the entire set of osteological variables on every one of the individual skeletons. The variables that are present on fragmentary skeletal remains were evaluated to the greatest degree possible, but some missing data were encountered. Very little research has been conducted on the osteological indicators of biological affinity for subadult individuals, but every effort was made to produce a biological profile useful for predicting biological affinity for these individuals using the various lines of evidence described above.

Results of Biological-Affinity Assessment

Statistical Research, Inc., assessed the biological affinity of 1,115 individuals (Table 112; Figure 117). We were able to reach a final decision for 416 individuals. These included 1 African American, 3 Apache, 122 Euroamericans, 250 Hispanics, and 40 Native Americans. The distribution of the various groups follows an expected pattern (see Chapter 4): the majority of the recovered individuals were Hispanic, although other groups such as Euroamericans and Native Americans were well represented. These assessments are used throughout this chapter rather than the final assessments of cultural affinity because the latter includes nonbiological information (context, artifacts, etc.).

The majority of the individuals recovered and assessed were "indeterminate" for biological affinity, in large part because of taphonomic damage from animal and plant disturbances, ground compression from nearly 150 years of burial, coffin collapse, etc. Many of the remains were in an unfavorable state for the level of analysis necessary for even a rudimentary assessment of biological affinity. For example, the crania of many individuals were so poorly preserved that metric analysis was not possible. One of the advantages of dental and nonmetric assessments is that data can be collected from fragmentary remains, but even these types of data could not be collected for many individuals because the remains were in such poor condition. Taphonomic damage was not the only contributing factor for the large number of individuals assessed as indeterminate for biological affinity. There is a dearth of research for assessing biological affinity in juvenile remains, and given the large number of juveniles recovered from the cemetery, this results in a large number of individuals of indeterminate affinity. Only adults with observable attributes (dental, craniometric, or cranial nonmetric) could

be assessed to a particular affinity. Therefore, only adults with observable attributes (dental, craniometric, or cranial nonmetric) could be assessed to a particular affinity. Perhaps the data collected from the subadults will be used in the future to assist in the estimation of biological affinity from juvenile remains.

Again, the final assessments of cultural affinity appear in Appendixes F and K. Although the focus of this chapter is strictly the biological data, in Volume 1, Goldstein and others explore the implications of the cultural-affinity assessments and the distribution of those individuals throughout the cemetery.

The biological-distance studies outlined below corroborate the biological-affinity assessments, providing validity to the approaches adopted by Statistical Research, Inc., but they also reveal the potential relationships of the biological groups. The biological groups are identifiable within the cemetery, and the individuals making up each sample are similar to the ethnic groups (writ large) identified in Tucson during the nineteenth century. The levels of similarity identified below suggest close biological relationships within the population because of the shared genetic history of Hispanics, Euroamericans, and Native Americans in the southwestern United States.

Theoretical Foundations for Biological-Distance Studies

Craniometric and morphoscopic variability and dental morphology are all particularly well suited for analyses of biological distance, intracemetery relationships, and spatial patterning. The variables used in these analytical methods have been previously outlined, and each method has been shown to capture and highlight a great deal of intra- and interpopulation variability. There is a considerable body of literature outlining the use of dental (cf Greenburg et al. 1986; Scott 1973; Scott and Dahlberg 1982; Scott and Turner 1997; Turner 1979, 1986, 1998), craniometric (cf Devor 1987; Jantz 1970; Relethford 1994, 1996, 2001a, 2001b, 2004), and nonmetric, or morphoscopic (Hefner 2003; see Appendix F), traits to answer questions of biological relatedness.

The following sections explore the use of dental traits, craniometric analysis, and cranial nonmetric traits for identifying and analyzing biological relatedness using the statistical methods fully outlined below. Although each of these skeletal characteristics has been used by previous researchers to explore patterns of relationships in skeletal remains, the application of these methods to skeletal remains recovered from a nineteenth-century Tucson cemetery presents an interesting opportunity to understand the diverse ethnic history of a frontier community.

Dental Morphology

Dental morphological traits include features visible on the crown of the tooth, such as ridges, crenulations (crevices), pits, and cusps (elevations on the crown of a tooth making up part of the occlusal surface). The roots of teeth also present morphological characteristics that vary among individuals. Patterned variation in the phenotypic expression of dental morphologies has been used with great success in biological-affinity studies (Scott 1973; Scott and Turner 1997). Analyzing dental-trait frequencies is most often a comparison of trait frequencies within a group to frequencies in other groups in an attempt to show similarity or dissimilarity. This type of analysis has previously produced meaningful results at both regional and local levels (Greenburg et al. 1986; Scott 1973; Scott and Dahlberg 1982; Scott and Turner 1997; Turner 1986, 1998; Turner and Cadien 1969). Research on the identification and interpretation of intracemetery variability and familial relationships within relatively small sites also has been explored (Stojanowski 2003).

Detailed observational standards are necessary in order to categorize the various grades of expression for each morphological trait. In this study, the Arizona State University Dental Anthropology System was used following Turner et al. (1991). This system makes use of plaster reference plaques illustrating the minimum and maximum grades of expression for traits of the permanent dentition. Each plaque is used in conjunction with written descriptions of the characteristics. To date, this system is the only classification method for the

permanent teeth that systematically codes and analyzes the dentition as a complete unit. Brief descriptions of the traits observed and recorded in this study are presented in Appendix M (Scott and Turner 1997; Turner et al. 1991).

Crown characteristics were assessed visually using a handheld lens and a direct light source. Observations were recorded for both the left and right sides using a modified version of the Arizona State University dental form. However, the "individual count" method was employed to derive a single, individual-specific score for each tooth set. This method records the strongest expression of a dental trait, whether from the right or left side, thereby maximizing the final sample size and minimizing any potential problems with trait asymmetry or missing antimeres (opposite sides) (Scott 1980; Scott and Dahlberg 1982; Turner et al. 1991; Turner and Scott 1977). Thirty-three dental traits were scored and recorded for the Alameda-Stone cemetery individuals with permanent teeth. Moderate to severely worn teeth were not considered during trait assessment because obliteration of important or diagnostic features was likely. The dental traits recorded for the Alameda-Stone cemetery sample are presented in (Table 113).

Genetic factors influencing the expression of dental morphology have been outlined by multiple authors (Berry 1974; Dixon and Stewart 1976; Hillson 1996; Sperber 1990). Numerous authors have used dental morphologies to explore the potential site-specific and regional variation as estimators of biological distance (Bondioli et al. 1986; Brewer-Carias et al. 1976; Corruccini et al. 1982; Johnson and Lovell 1994; McClelland 2003). Many of these studies relied exclusively on dental traits to detect intrasite differences between groups and subpopulations within a larger sample. In any population, documenting the distribution and frequency of rare traits under strong genetic control can be compared within and between samples in order to identify clusters of individuals who demonstrate similar morphologies. For example, if a dental trait is relatively rare within a sample, a high frequency of that trait among a group of individuals may represent a homogenous genetic unit, such as a familial group (McClelland 2003:40). The suite of dental traits expressed within a sample has been used successfully to estimate biological distance. Previous work has demonstrated a significant relationship between actual genetic distances (which are usually unobtainable) and dental morphology (Dahlberg 1951; Griffin 1993; Turner 1985, 1986, 1990).

Again, biological distance is an estimate of genetic distance within or between populations, used as a measure of divergence based on trait manifestations expressed in the skeleton. The degree of relatedness assessed for a population rests on the aforementioned assumption that individuals or populations who share morphological expressions are more closely related than those who do not. Multivariate analysis of dental traits, which are polygenic heritable characters controlled by several genes at once, is useful for assessing patterns of dental variability within and between groups in the form of biological-distance estimates. To that end, dental morphological data were used to examine variation between and among the individuals recovered from the Alameda-Stone cemetery sample and to assess the meaning of that variation in the broader perspective of biological affinity and cemetery use.

Craniometric Variation

The adult skull, consisting of the cranium and mandible, comprises a complex set of 32 teeth and 24 bones that function as the skeletal framework for the head, serves as the housing and protective case for the brain and most sense organs, and is the location of the primary structures associated with mastication and breathing. Although morphological variation of the cranium between groups is important for biological-distance studies and ancestry estimation, such variation is limited. For instance, the distance between the eyes must fall within a certain range to maintain stereoscopic vision, and the position of the external ear is maintained to ensure that the brain can reliably and accurately process outside auditory cues. Nevertheless, the range of normal human variation is broad, and even within these functional confines, considerable variation does exist within and between groups.

Variation in cranial morphology is the result of the interaction between genes and the environment (Relethford 1994). As such, analyses using craniometric variables (i.e., measurements of the cranium and mandible) are useful for assessing biological relationships in broad, regional-based studies, as well as variability within a

small subset of a much larger population. Craniometric data are well suited to such studies because they represent a large amount of inter- and intrapopulation variability (Jantz 1970). Moreover, researchers have demonstrated that craniometric variability has a substantial heritability index, approximately 0.55 (Devor 1987); in other words, nearly 55 percent of craniometric variability is genetic (Devor 1987). This assumption permits researchers to use craniometric variables to explore cranial shape as an indicator of genetic relatedness without the expensive and destructive testing associated with molecular-level studies. Relethford (1994, 1996, 2001a, 2001b, 2004) and others have used this concept to explore worldwide diversity using craniometric analyses.

Studies on local levels of variation, including intracemetery variation, have also been conducted. Hooton's (1930) analysis of the Pecos Pueblo remains was one of the most influential early studies in regional variability. Although typological, Hooton's sound methodological approach using cranial and postcranial measurements to explore group variability set the stage for future bioarchaeological research. More recently, biological-distance studies using craniometric variables have been used successfully to identify closely related groups of individuals at the community level.

Craniometric data were collected from the individuals recovered from the Alameda-Stone cemetery following the methods outlined in Chapter 2. Figure 118 presents the cranial variables used for this analysis. All craniometric landmark data were collected using a Microscribe 3-D digitizer, although, for comparison with other reference groups, only traditional interlandmark distances were used. A total of 119 adult crania were digitized, but only 60 were complete enough for craniometric analysis. This small sample size imposes obvious limitations in assessing variability between cemetery areas and among individuals, as the sample size represents only approximately 5 percent or less of the individuals recovered. Moreover, because females were underrepresented in some of the reference groups used for comparative purposes, all samples had to be standardized using SAS, version 9.1.3, to remove sex-specific differences in means while preserving the original shape variation. These standardized data were used in all subsequent analyses (see below). Craniometric data were then used to examine variation between and among the individuals recovered from the Alameda-Stone cemetery and to assess the meaning of that variation in the broader perspective of biological affinity and cemetery use.

Morphoscopic and Epigenetic Traits

Morphoscopic and epigenetic traits (phenotypic differences that are not necessarily the results of changes to the genome) are distinguished from metric observations, because, unlike the latter, nonmetric traits are recorded visually, as categorical variables. These traits include minor variations in the form and structure of bone that cannot be metrically recorded. The usefulness of epigenetic and morphoscopic traits (herein referred to collectively as *cranial nonmetric traits*) for determining biological affinity is based on the assumption that these traits have an underlying genetic basis. Multiple genes likely play a role in the formation and development of nonmetric variables, but it is difficult to say with certainty which genes and which environmental factors are responsible for a given nonmetric trait. Nevertheless, there is evidence of a genetic, an epigenetic, and an environmental component to the expression of a nonmetric trait (Hauser and De Stefano 1989; Moss 1997a). Moss (1997a, 1997b, 1997c, 1997d) recommended a dynamic approach to cranial analysis that emphasizes functional cranial features rather than a sole reliance on genetic or epigenetic explanations for a feature. According to Moss (1997b), functional cranial features are independent of one another in size, shape, and position. Therefore, each of his so-called "functional cranial matrices" should not be treated as osteological units (e.g., mandible or maxilla) but, rather, treated independently.

The tissues of the skull associated with cranial nonmetric traits develop within this matrix and are subject to these guiding factors. For example, the formation and position of the malar tubercle on the maxilla may have a very specific genetic origin, but the extent to which the tubercle actually develops is likely an interaction of bony development, functional morphology, and adaptive processes. Establishing the relationship between the genetic basis for individual traits and the environmental effects on that trait is difficult, at best. There is currently very little information on the environmental factors affecting nonmetric-trait expression. These environmental and idiosyncratic life histories may have a dramatic effect on trait expression, leading to difficulty

in discerning whether trait expression reflects genetics, environment, or both. For example, Ossenberg (1970) examined the influence of artificial cranial deformation on the expression of extrasutural bone in a collection of Hopewell Indian crania. She found that localized stress (i.e., artificial deformation) produces an increase in the number of sutural bones and ossicles. While she could not ultimately rule out other environmental factors not explained by her model, the influence of outside (environmental) forces on the expression of traits thought to have a controlling genetic factor is problematic.

Therefore, the development of most nonmetric traits is assumed to be an interaction between genetic and epigenetic factors (Berry and Berry 1967; Grüneberg 1952). One solution to this problem was proposed by Moss (1997b) and Falconer (1965), who suggested a threshold model to explain the expression of a nonmetric trait. Moss's (1997d:339) functional-matrix hypothesis suggests more involvement of epigenetic factors for the development of shape variations, contrary to a strictly genetic basis, which posits that "all (phenotype) features are ultimately determined by the DNA sequence of the genome." According to Moss (1997a:411), assuming a strictly genetic origin for all anatomical structures is reductionist and molecular and is akin to suggesting that morphogenesis is as simple as passing directly from "DNA molecules to adult gross morphology." This approach ignores the role of epigenetic processes in human variation. Moss is not implying that the genome does not play a role in the development of form. Rather, he synthesizes the two paradigms and argues that "morphogenesis is regulated (controlled, caused) by the activity of both genomic and epigenetic processes and mechanisms . . . and only their integrated activities provide the necessary and sufficient causes of growth and development" (Moss 1997a:413). The threshold model accounts for both the genomic and the epigenetic mechanisms proposed by Moss.

To clarify, there are genetically determined threshold values for any nonmetric trait. These values correspond to the point at which one expression of a given character is expressed over another. When some stimulus (environmental or otherwise) exceeds a threshold-values limit, the tissue responds (i.e., bone deposition, bone resorption, or general maintenance) and results in the expression of another character state. The probability of an individual expressing one character state over another is dictated by an interaction between the individual's genes and the suite of epigenetic factors influencing the expression of that trait. The individual's position relative to each threshold value, therefore, dictates the expression of that trait. Threshold values do not shift in a new environment; only the stimuli affecting gene expression change; so, the frequency of expression for the various character states is different for each environment (e.g., different loadings). Genetic factors determine the threshold at which a trait is expressed, but the actual expression of the trait is dependent on whether environmental factors stimulate phenotypic expression of the trait.

Differences in the expression of traits also may be explained by factors such as sex, age, and trait collinearity. Research on the effects of each of these sources of variation is extensive in the physical anthropological literature. Differences between males and females in trait expression are ambiguous and show very little consistency among different studies (Hauser and De Stefano 1989). Berry (1975:529) believed the lack of consistency of sex dimorphism observed for many of the traits "confirms the idea that they are the outward manifestation of the activity of genetic, epigenetic, and even overtly environmental forces, and are a long way from the primary site of gene action." Hefner (2003) found similar results for sex differences in trait expression using cranial nonmetric traits. In that study, there were no significant differences in trait expression for males and females. The one possible exception is the expression of a postbregmatic depression on the parietal bones, which was moderately, but significantly, expressed more frequently in African American females than African American males.

The influence of age on nonmetric traits is a concern. Like examinations of sexual dimorphism, however, the literature is inconsistent regarding the actual effect of age on trait incidence. Some traits will be affected by age because of the formative processes associated with those traits. For example, the supranasal suture is a secondary center of ossification that tends to develop in individuals above the age of sexual maturity and would not be expected in juveniles (Hefner 2003). Buikstra (1972) documented several traits affected by age, but like many other investigators (Perizonius 1979), she concluded that age-related differences need only be considered in juveniles. As a result, the age-regressive nature of these traits can be safely ignored if only adult crania are used for analysis (Hauser and De Stefano 1989). This was the approach used in this study.

Statistical Methods

The large and diverse data set of biological data recovered from the Alameda-Stone cemetery presents a variety of methodological, biological, and archaeological questions to be addressed. Although finer levels of analysis are attempted for some research questions, the major goal of this chapter is the presentation of broad thematic questions and correspondingly broad answers to those questions. Multivariate statistical methods are particularly well suited for answering these questions. The set of variables that we are interested in examining are measured on multiple groups. Because we are interested in the patterns of differences between the groups for the set of variables, understanding which variable or group of variables is different for the groups is a necessary and important issue. In some instances, no one variable may distinguish the groups, but rather, it is the combination of variables in the set that differentiates between them. To that end, discriminant-function analyses (linear discriminant functions and canonical analyses) are used to identify the differences in dental, craniometric, and nonmetric traits between the samples. After the discriminating variables have been identified, other methods, including cluster analysis, neural networks, and specialized procedures (e.g., Defrise-Gussenhoven test for homogeneity) can be applied to the data set to explore the biological relationships (similarity/dissimilarity) of the individuals making up the samples.

Discriminant-Function Analysis

Discriminant-function analysis is a suite of statistical procedures (including linear discriminant-function analysis and canonical analysis) used to separate groups, classify unknown individuals into one of several reference populations, and measure the level of similarity between groups. All discriminant-function analyses use reference groups as the basis for the classification of unknown individuals. The selection of the reference sample composition has a substantial impact on the assignment of individuals of unknown group membership. A discriminant-function analysis will always classify an individual to one of the reference groups, even if the individual did not originate from one of these groups. Several statistics (discussed below) are available to test the goodness-of-fit for a discriminant-function analysis.

In short, a discriminant function works by transforming the original measurements from each reference group into a discriminant analysis score in a manner that maximizes differences within each sample. Discriminant-function scores of individuals of unknown group membership are then calculated and compared to the mean discriminant score of each reference group; the unknown is classified into the group containing the mean score closest to the unknown individual's score. As mentioned above, the discriminant function will always classify the unknown into one of the reference groups. Two statistics are calculated to support the classification: the posterior probability and the typicality probability. Posterior probabilities represent the calculated probability of group membership into each of the reference groups based on the relative distance of the unknown to each group. These values always sum to 1. For example, an unidentified individual may have posterior probabilities equaling 0.55 for Euroamerican, 0.25 for African American, and 0.20 for Hispanic. In this case, the unknown individual is closest to Euroamericans (posterior probability = 0.55) and would be classified to that group. However, the posterior probability alone does not provide adequate information for assessing a classification. Typicality probabilities are measures of the likelihood that the unknown belongs to *any* particular group and range in value from 0 to 1, based on how similar the individual measurements are to the reference means. It is interpretatively similar to the p value calculated from the normal distribution (Krzanowski 2000) and can be interpreted in a similar way, where any value higher than 0.05 suggests that the individual is not significantly different from others in the reference population. Generally, typicality probabilities greater than 0.05 do not require further evaluation. Values below 0.05 may represent outliers, measurement error, or pathological anomalies and therefore have questionable probability of membership in that group.

Certain assumptions about the data set must be met in order for the discriminant function to be optimal. These include large and representative sample sizes, multivariate normality, and equality of variance (*homoscedasticity*) among the groups. If any one of these assumptions is not met, the results of the discriminant-function analysis may not be reliable. Tests for each of these assumptions were made on the Alameda-Stone cemetery data set prior to any interpretation of the results.

The purpose of the discriminant-function analysis is to classify individuals in groups known or suspected to have inhabited Tucson during the period the cemetery was in use. In order to understand patterns of cemetery use within the Alameda-Stone cemetery, it was necessary to determine which groups are represented therein. A worldwide data set and a temporally and geographically representative data set were incorporated in all discriminant-function analyses, for comparative purposes. When available, the metric data collected on the individuals recovered from the cemetery were compared to these reference samples. Linear discriminant-function analysis was used to classify each of the individuals into one of the reference groups. Following this, a canonical analysis was used to measure the level of similarity of the assigned individuals to other reference groups, in an effort to see how the groups identified within the cemetery compared to other populations throughout the world.

Cluster Analysis

Cluster analysis (also known as segmentation or taxonomy analysis) is a technique for partitioning individuals into homogenous subsets using interobject similarities. Unlike discriminant-function analysis, in which group membership is known a priori (at least for the reference samples), cluster analysis requires no a priori group labels. The goal of a cluster analysis is to find subsets of the data such that the derived clusters of objects are more similar to each other than they are to objects in the other subsets (Krzanowski 2000). In this way, the clusters represent conceptually meaningful groups that share some suite of common characteristics.

There are a wide variety of clustering techniques. Of course, the many methods available, and the algorithms of each, inevitably lead to different solutions for the clustering of a data set. Therefore, selecting an appropriate clustering method relies on an understanding of the nature of the data set and the anticipated clustering of the individuals within the population.

Agglomerative hierarchical clustering analysis was used for the current research. This method is one of the most common clustering techniques, in part because of the ease of the calculations, but also because the algorithm used to define the clusters is intuitively simple to understand, and the resulting relationships may be interpreted without difficulty. In short, the cluster process begins with all data points as individual clusters, and at each step of the algorithm, the process merges the closest two data points (clusters) until only one cluster remains. The "closeness" of the individual clusters is determined using a distance measure (e.g., single linkage, complete linkage, group mean, or Ward's) and results in a proximity matrix used in all subsequent calculations. Generally, the results of a hierarchical clustering analysis are presented graphically as a dendrogram, which displays the cluster relationships (i.e., the order in which the clusters are merged and the relatedness between various clusters) in two dimensions.

Neural Networks

Neural networks grew out of research into artificial intelligence—specifically, attempts to mimic the biological neural system's capacity to learn by modeling the low-level structures of the brain (Patterson 1996). Such artificial neural networks can achieve remarkable results using a simple model. A neural network consists of controlled interconnections, learning rules, and model recall. The interconnections frame the network, the learning rules train the network by presenting examples of input-data patterns and the desired output, and the pattern-recognition knowledge learned in the training step is used to process (and in this case classify) a validation sample using a recall function. The most common neural network consists of three layers. The input layer is responsible for the initial processing of the data. The results are then further processed and stored in the output layer as a learning rule. The hidden layers are responsible for the translation of input data into output information. Because both learning and recall depend on the linear and nonlinear combinations of the data patterns rather than the statistical parameters of the input, neural networks do not require a priori assumptions about the distribution of the data set. In other words, a neural network can be trained using continuous or categorical variables without regard to the distribution of the data.

Results

The following section outlines the results of the dental, craniometric, and cranial nonmetric analyses. In order to explore both within- and between-group variation, and to explore patterns of cemetery use by the various populations in and around Tucson during the nineteenth century, each section focuses on inter- and intracemetery variability. The dental morphology section examines the variation in dental traits within the sample and then compares the identified groups within the Alameda-Stone cemetery sample to reference samples from various parts of the United States. Craniometric data recorded for a small sample from the Alameda-Stone cemetery provides further insight into the composition of the cemetery. Classification statistics and clustering methods build upon the foundation set by tests of homogeneity and provide important insight into the genetic history of Tucson. Finally, cranial nonmetric data are used to support the dental and craniometric analyses using traditional and novel classification statistics. All three classes of data—dental, craniometric, and cranial nonmetric—lead to remarkably similar clustering solutions, and each provides empirical support for the biological-affinity assessments produced by Statistical Research, Inc.

Dental Morphology

Thirty-three dental traits were scored from adult individuals recovered from the Alameda-Stone cemetery (see Table 113). Although all 33 traits were not used in the subsequent analysis, the percentages of all traits by sex, biological affinity, and cemetery area are presented in Table 114. Correlation coefficients were calculated using Spearman's rho to assess potential dependence issues between the dental traits (Table 115). Only cusp number and double shoveling were significantly correlated to other variables. These two dental traits were removed from subsequent analyses in order avoid problems associated with multicollinearity.

Intracemetery Population Variability

To assess variation in the dental morphology of the individuals interred within the cemetery and to assess general patterns of relatedness between the groups identified therein, a hierarchical cluster analysis was performed on the between-group distance matrix. All analyses were conducted in SYSTAT, version 12.0.

Of the 33 recorded traits, only 13 of the most significant traits were used (see Table 113). Only adult dentition was included, because the expression of many of these traits is dependent on age. Also, individuals with extreme dental attrition or pathology were not considered, because the effects of these conditions on the expression of dental traits is not fully understood. Table 116 presents the demographic profile for the selected sample. Because no significant differences were noted in the expression of traits between males and females, males and females were pooled to increase sample sizes. Sample sizes of both sexes were roughly equal. However, the sample size for African, Apache, and Yaqui were notably small (n = 1, 2, and 2, respectively), and therefore, any conclusions drawn about these groups are suspect and should be considered carefully.

According to the hierarchical cluster analysis, the Alameda-Stone cemetery sample follows an expected pattern. The dendrogram in Figure 119 illustrates the overall patterns of relatedness between African (n = 1), Apache (n = 2), European (n = 82), Hispanic (n = 199), Native American (n = 33), and Yaqui (n = 2) individuals. The groupings within these clusters are consistent with the geographic distribution and implied cultural relationships among the groups. The Apache are one cultural group within the broad Native American classification, with a suite of unique dental morphologies; however, the morphologies shared among all Native Americans (e.g., a high frequency of shovel-shaped incisors) are demonstrated by the closeness of the Apache to the rest of the Native American sample. Also of note, the Hispanic and Yaqui individuals are on the branch shared by the Native American and Apache, but the Hispanic and Yaqui are distinctly separate. The Yaqui originally lived in the valley of the Río Yaqui in the northern Mexican state of Sonora prior to migrating throughout the Sonoran Desert region into the U.S. Southwest, including Tucson. The shared geographic origin and the potential for gene flow between the Yaqui and Hispanic individuals likely explain the general degree of relatedness evident in the dendrogram.

Figure 120 presents the results of a cluster analysis performed using the same variables, but unlike in Figure 119, each group is partitioned by sex. The morphological distinction of the Apache and African American samples is clearly illustrated. Below that level, the stepped pattern suggests general male/female relatedness. The Yaqui and Native American females do not cluster with the remaining groups. Hispanic and Euroamerican males are most similar.

Intercemetery Variation

The affinity of the Alameda-Stone cemetery population to other contemporaneous populations was one of the central research issues guiding this analysis. Unfortunately, very little dental-trait data are available for Hispanic groups. This limits potential inferences on the relatedness of the Alameda-Stone cemetery population to other Hispanic populations using dental data. The lack of robust comparative samples speaks to the importance of the Alameda-Stone cemetery sample. On the other hand, a small data set is available for comparative purposes (see below). The Alameda-Stone cemetery sample was compared to nineteenth-century African American, Euroamerican, and Hispanic individuals excavated from the historical-period Alameda Hacienda Camposanto (Albuquerque, New Mexico) and a control sample of Native Americans from Playa Vista, California (Playa Vista Archaeological and Historical Project), who had a different population history from those of Native Americans in northern Mexico and southern Arizona.

Alameda Camposanto (LA 50420) is located in northwest Albuquerque, New Mexico, in the Rio Grande floodplain. The year that the Alameda cemetery was established is unknown; however, the burial ground dates to at least 1769, when the hacienda first appeared on a map. Excavation of a portion of the cemetery took place in 2003–2004, under the Office of Contract Archaeology, Maxwell Museum of Anthropology, University of New Mexico. Forty-one complete or mostly complete primary burials, 14 partial primary burials (about one-third of the individuals present), 2 secondary burials, and 17 disarticulated bone clusters were recovered. Dental data for nearly 70 individuals were provided by Heather Edgar for comparative purposes. Although incomplete, the data from Alameda proved invaluable for comparative purposes.

The dendrogram generated from the cluster analysis (Figure 121) shows a moderate level of similarity between the Euroamerican and Hispanic samples. The percentages of the dental morphologies shared in the Euroamerican sample were similar to the reported percentages in other European samples (excluding the Alameda sample), but the overall level of homogeneity within the Euroamericans was still moderate. The Hispanic samples were also remarkably similar, and their relative distance from the Euroamerican sample suggests a high degree of similarity to that group, as well. Again, the Apache and Yaqui sample sizes were small, and therefore, the cluster analysis and resulting dendrogram may not adequately capture the range of variation in those samples.

The associations of the populations employed in this analysis exhibit geographical and historical commonalities and are consistent with the results of previous studies (Scott 1973; Scott and Dahlberg 1982) that demonstrate the genetic component of dental morphology. The close biological distance between the Hispanic sample from Tucson and the Hispanic sample from Alameda was expected. However, this relationship has not been previously noted, and it could be related to geographical proximity and possible gene flow between these or ancestral groups. The overall similarity of the Euroamerican, Hispanic, and Native American samples from the Alameda-Stone cemetery suggests that proximity and resultant gene flow has led to a degree of similarity among them.

Discussion

The patterns observed support the analytical utility of cluster analysis and dental morphology. Results of the cluster analysis indicate that crown traits of the teeth from individuals recovered from the Alameda-Stone cemetery were similar to those of other groups sharing a similar biological affinity. These results do not suggest any aberrant problems and are relatively unsurprising.

Cranial Morphology

This section addresses the issue of variation among the cemetery population in several stages. First, we measure the overall homogeneity for the Alameda-Stone cemetery sample. If the individuals are heterogeneous, then pooling the sample without regard to affinity tells us very little about the diversity and/or continuity of the Alameda-Stone cemetery sample. On the other hand, we know that the population of nineteenth-century Tucson was genetically diverse, with a great amount of variation in phenotype. This then begs the question, *Can we view the Alameda-Stone cemetery sample as a single, homogeneous group with a shared history, or should we be more conservative and view these individuals as representing a culturally diverse and a biologically heterogeneous mixture of different populations?*

Measuring Intracemetery Homogeneity

This section examines the pattern and magnitude of cranial variation for the crania recovered from the Alameda-Stone cemetery using a procedure outlined by Jantz and Owsley (2001). For this section, the traditional linear craniometric data and the three-dimensional coordinate data collected on 61 individuals were used. Nineteen measurements that quantify the overall length, breadth, midfacial variation, and facial projection were included in this analysis. Some of the measurements included in the original Howells (1973) set of measurements were excluded when the measurements or landmarks were missing on any one specimen, or they were considered redundant or uninformative. All interlandmark distances and coordinate data were collected using a Microscribe 3DX digitizer (Immersion Corporation, San Jose, California) and the computer program 3Skull (v. 2.0.111P, developed by Stephen D. Ousley). Following data collection, the Alameda-Stone cemetery sample was compared to the craniometric database compiled by Howells (1989). The Howells samples represent historical-period populations from around the world; however, that data set does not include individuals of Hispanic ancestry. Therefore, the Howells database was supplemented with craniometric data from 100 modern individuals from the Pima County Medical Examiner's Office identified as Mexican (Birkby et al. 2008).

Quantifying and documenting the variation in the crania recovered from the Alameda-Stone cemetery presented a number of difficulties that make a traditional statistical approach burdensome. Although provenience information was known for each cranium, the identity of each was unknown. As such, each cranium initially was treated as a unique group with a sample size equal to one. Working under the assumption that these remains represented several populations buried together, the overall level of homogeneity within the sample was measured using the approach outlined below.

To measure the level of homogeneity, the squared Mahalanobis distance (D^2) between all pairs of crania was calculated using a vector of cranial measurements and a derived pooled within-group variance/covariance matrix (Krzanowski 2000). Recall that the sample size is initially one for each group; so, the variance/covariance matrix must be substituted with one derived from a sample with a genetic structure similar to the Alameda-Stone cemetery sample. Because the population that this material represents is not known, a conservative approach was followed. Jantz and Owsley (2001) suggested using a pooled within-group covariance matrix calculated from the Howells data set. This variance/covariance matrix seems appropriate because it incorporates a worldwide sample capturing most of human variation; however, for that same reason, the covariance may be slightly inflated between groups. Finally, the derived variance/covariance matrix was used to estimate the interindividual Mahalanobis distances for the Alameda-Stone cemetery sample.

Empirically demonstrating whether the individuals within the Alameda-Stone cemetery were homogenous relies on a series of statistical calculations first outlined by Defrise-Gussenhoven (1967). The Defrise-Gussenhoven test is based on the expectation that the distance between any two individuals drawn at random from the same population follows a predictable distribution (i.e., $\sqrt{(2p - 1)}$, with a variance of 1). This random expectation can be used to decide whether the distance between two crania is greater than would be expected if they were drawn from different populations. If a pair-wise distance is greater than the calculated threshold value (based on the sample size and the number of variables used in the analysis) of random expectation, then the two crania may have been drawn from different population groups.

As will be demonstrated below, in a traditional discriminant-function analysis, the posterior and typicality probabilities are used to measure the similarity of an unknown cranium to several reference groups. These probabilities are based on the Mahalanobis distance of the unknown to the centroid of the reference groups.

Intuitively, the closer the cranium in question is to the center of a reference group, the more likely it is to belong to that group. In the current application, the majority of the posterior probabilities calculated using the Howells data set are suspect, because Hispanic craniometrics are not included in the original reference groups. Adding craniometric data from the Hispanic individuals to the reference groups, the Mahalanobis distances for the crania are calculated more appropriately. In that way, one may determine whether the crania from the Alameda-Stone cemetery reasonably resemble a reference population of Hispanics. Such comparisons allow (1) the reconstruction of hypothetical relationships between the Alameda-Stone cemetery crania and Hispanic groups, (2) classification of the Alameda-Stone cemetery crania into population groups, and (3) quantification of any spatial distributions inherent in the Alameda-Stone cemetery sample.

Results

The squared Mahalanobis distances (D^2) between each pair of crania are presented in Table 117. In order to address missing variables, reduce redundancy in the data, and avoid overfitting, the number of craniometric variables was reduced to 11 for the full analysis. The expected distance for this analysis was 4.58 because there are 11 variables in the analysis (expected distance = $\sqrt{(2(11) - 1)}$). Again, this is the expected distance between crania drawn at random from a population with the same covariance matrix as the pooled-within matrix of reference samples. The mean distance within the Alameda-Stone cemetery samples was 5.04 (sd = 1.20). Based on the assumptions of the Defrise-Gussenhoven test, therefore, distances greater than 6.54 were considered significant. In any population, approximately 5 percent of the pair-wise comparisons are expected to fall above this value. In this analysis, there were 946 pair-wise combinations between the 44 crania.

Approximately 11 percent (n = 107) of the 946 combinations were significant at the 0.05 level (Table 118). Significant differences were by and large limited to two crania (Grave Pit 597, Burial 1464, and Grave Pit 10144, Burial 21881). These two crania accounted for almost one-half of the significant values (43.4 percent). This suggests several possibilities: measurement error was introduced during data collection (which was double-checked and found not to be the case); outliers occurred within the population; or these crania belonged to a distinct group(s). Both of these individuals were identified as Hispanic for both the biological-affinity and the final cultural-affinity assessment (see Appendix F). The current results do not negate that earlier assessment, but they do suggest an unexpected level of heterogeneity within the Hispanic sample. Finally, the possibility that these individuals were, in fact, potential outliers will be assessed more fully below.

Several points are worthy of mention. The Defrise-Gussenhoven test quantifies the level of homogeneity within a sample as a measure of random expectation. This test of overall homogeneity can, in turn, be used to identify potential outliers within the data set. Once any potential outliers are identified, a decision must be made regarding their treatment. Individuals identified as potential outliers were not removed from the final analysis, because dropping these individuals may provide less information on cranial variation. Conversely, keeping these potential outliers in the data set could lead to incorrect assumptions about the overall levels of homogeneity.

The Alameda-Stone cemetery sample was not homogeneous. The Defrise-Gussenhoven test suggests a level of heterogeneity likely related to the multiple groups known to have been interred within the cemetery. The two most distinct crania were not unique morphologically. However, the individual in Grave Pit 597, Burial 1464, had multiple, depressed cranial fractures, and the individual in Grave Pit 10144, Burial 21881, was completely edentulous (toothless). These factors do not appear to have contributed to the alleged distinctiveness of these two individuals, but these conditions are important to note. In general, the results of the Defrise-Gussenhoven test are consistent with the results from the analysis of dental morphology.

Canonical Discriminant Analysis and Discriminant-Function Analysis

The primary purposes of the canonical discriminant analysis and the discriminant-function analysis were to summarize the between-class variation and to explore the morphological differences between the Alameda-Stone cemetery sample and a selected series of reference groups. Variables were selected for the canonical discriminant analysis procedure to represent the overall craniofacial complex. To assess biological affinity, a

discriminant-function analysis was also conducted, in order to classify the Alameda-Stone cemetery sample into one of the reference groups. A forward, stepwise selection method was employed to determine the best discriminators among the variables. Because females in all samples were underrepresented, with the exception of the nineteenth-century Euroamericans, all groups were standardized using SYSTAT 12.0 to remove sex-specific differences in means while preserving the covariance structure. The standardized data were used in the analyses that follow.

The resulting distance matrix (Table 119) from the canonical discriminant analysis indicates that all groups were significantly different ($p < 0.001$). The distance matrix and the plot of the class means (Figure 122) indicate that the Alameda-Stone cemetery African American and the nineteenth-century African American sample were most similar to one another. Of course, because the Alameda-Stone cemetery sample of African Americans amounted to only one individual, any interpretation of that result is purely speculative. The plot of CAN 1 against CAN 2 demonstrates the close relationship of the Alameda-Stone cemetery samples to "parent" reference populations. For example, the Alameda-Stone cemetery Euroamericans were closest to the sample of nineteenth-century Euroamericans. The Alameda-Stone cemetery Hispanic and Native American samples were also very close. The position of the Alameda-Stone cemetery Hispanic sample among the Euroamerican, modern Mexican, and Native American samples suggests, as expected, the genetic contributions in the Hispanic sample from both Euroamerican and Native American ancestors. Interestingly, the Alameda-Stone cemetery Euroamericans were also very close to the sample of modern Mexicans. This also may have been the result of gene flow and admixture between the Alameda-Stone cemetery Euroamericans and Mexican and Mexican American individuals in Tucson. Overall, the Alameda-Stone cemetery Hispanic, modern Mexican, and Cuban samples all had higher vaults, taller faces, wider nasal apertures, taller zygomatics, more prognathism, and wider midfacial breadths than the Alameda-Stone cemetery Euroamerican, nineteenth-century Euroamerican, and African American samples.

For the discriminant-function analysis, Howells's worldwide database and supplemental Hispanic data were used as a reference sample to validate estimates of biological affinity assessed for the Alameda-Stone cemetery sample and to explore the morphological differences between the Alameda-Stone cemetery sample and those reference groups. The computer program DISPOP (Richard L. Jantz, Forensic Anthropology Center, University of Tennessee, Knoxville) requires all variables for analysis; so, 11 individuals with missing data were removed from the analysis. Likewise, only Euroamericans and Hispanics were included, because the samples for craniometric data of African Americans, Apaches, Native Americans, and Yaqui were prohibitively small. In the end, the discriminant-function analysis correctly classified (cross-validated) nearly 80 percent of the sample (Table 120), if we accept the original biological-affinity assessments as accurate. Eighty percent of the Euroamericans from the cemetery were reclassified into one of the European samples from the Howells data set (average posterior probability = 0.750). All of the misclassifications were into a Hispanic population; however, the average posterior probability was 0.46, only slightly better than random allocation (random allocation for three-way discriminant-function analysis = 0.333). The overall similarity of the Alameda-Stone cemetery Euroamerican sample to other Europeans from both the United States and Europe was expected, because these individuals arrived relatively later to Tucson from many parts of this and other countries. For the Hispanic individuals recovered from the Alameda-Stone cemetery, the discriminant-function analysis classified (cross-validated) 38 as Hispanic (average posterior probability = 0.650); 8 as European (average posterior probability = 0.510); and 5 as Native American (average posterior probability = 0.560). That some of the Hispanic individuals were classified as European and Native American is not surprising. Recall the position of the Alameda-Stone cemetery Hispanic sample in the canonical discriminant analysis.

The distance between the Alameda-Stone cemetery Hispanic sample and the Native American sample suggests a level of similarity among these individuals that would necessarily result in some misclassifications. Gene flow and admixture between Euroamerican settlers and Hispanic individuals in Tucson may account for the other misclassifications. Of course, the relatively low posterior probabilities (Table 121) for all groups may also provide a clue to the classification accuracy.

Cranial Nonmetric Traits

Forty-three cranial nonmetric traits were recorded for the individuals recovered from the Alameda-Stone cemetery (Table 122). Only adult individuals were incorporated in the assessment of cranial nonmetric traits. As in the analysis of dental morphology, sample sizes for males, females, and age groups were roughly equal, but the sample size for African and Apache (n = 1 and n = 1, respectively) were not. The visual assessment of cranial nonmetric traits—slight variations in cranial form—has been a standard but unreliable approach to estimating biological affinity. However, others have started to integrate statistical methods with cranial nonmetric traits in an effort to provide empirical support for their use. The following section uses these traits, in an effort to explore the patterns of variability within the Alameda-Stone cemetery sample.

Cluster Analysis

In order to assess variation in the cranial nonmetric traits expressed in the individuals interred within the cemetery and the general patterns of relatedness between the groups identified therein, a hierarchical cluster analysis was performed. All analyses were conducted in SYSTAT 12.0.

The hierarchical cluster analysis implies that the group composition of the cemetery follows the same patterns as indicated by both the dental morphology and the craniometric analyses. The dendrogram in Figure 123 illustrates the overall patterns of relatedness between African, Apache, European, Hispanic, and Native American individuals. These groupings are consistent with the earlier results. The African individual was clearly different from the others, as were the Apache individuals. Again, the sample sizes for these groups were small; so, the results of the cluster analysis may be misleading. Of the larger sampled groups, the relationship supports what is known regarding Native American, European, and Hispanic contact. The Hispanic and Euroamerican samples shared common morphologies. Possible gene flow between Euroamericans and Hispanics most likely explains the general degree of relatedness seen in the dendrogram.

Neural Networks

Methods constructed from existing expertise (i.e., how familiar the observer is with the population being documented) are generally heuristic, unempirical, and lacking a theoretical foundation. Cranial nonmetric data are far too complex, and the underlying processes are not nearly well enough understood, to make predictions based on observation alone. Models devised as simplified approximations of the true processes generating the data can be used to make predictions about some aspect of the population (e.g., sex, biological affinity, etc.).

For example, when estimating biological affinity, a sample of crania is documented, and then a decision is made regarding the suite of cranial nonmetric traits thought to characterize each group within the sample. This decision, and its particulars, depends on the interaction and distribution of the character states for each trait, not only within one population, but also within other populations. The large number of factors influencing cranial morphology—gene flow, environmental conditions, adolescent growth, secular change, and nutritional intake—do so to varying degrees, and in often convoluted and complex ways (Hauser and De Stefano 1989). Even in the unlikely scenario that the interaction of all of the factors is obvious, in order to fully understand the significance of these distributions, one must rely on a model of the processes and distributions that gave rise to the various morphologies in a sample. To that end, an artificial neural network model (Hassoun 1995) for analyzing these types of data and classifying unknown crania to biological groups was tested as a possible method for analyzing cranial nonmetric data.

Recent research on cranial nonmetric traits underscores the need for analytical processes designed to capture salient trends in the observed data with the purpose of making future predictions. A number of presentations and articles suggest Hispanic individuals are seemingly "intermediate" to Europeans, Africans, and Native Americans in the expression of some traits. That research, however, is based on old assumptions of cranial-nonmetric-trait distributions, without acknowledging any inherent shortcomings in those lists of trait distributions. Today, extreme-trait values and race-specific trait lists are not empirically supported, and furthermore, these lists do not account for most of the variation seen within and between groups. Although cranial-nonmetric-trait analysis is an important line of research, relying on a visual assessment alone to estimate biological affinity leads to unempirical typologies and incorrect classifications.

One answer to this dilemma is analyzing cranial nonmetric data within a statistical model suitable for large-scale computation, data mining, and analytical modeling. Unlike the traditional, visual approach to affinity estimation, statistical models use the distribution of the various character states of a trait within and between groups, rather than trait lists and extreme-trait values. Thus, the nature of biological variation is used to estimate geographic origins. Today, robust statistical methods are available for estimating affinity, including groups, like Hispanics, who were not traditionally included in affinity assessments.

To explore the applicability of artificial neural networks against the Alameda-Stone cemetery data set, a training set of 104 crania randomly drawn from a sample of 523 African American, Euroamerican, Native American, and Hispanic individuals was selected. The validation set represents the remaining 419 individuals. Eleven cranial nonmetric traits were used in the construction of the initial model (see Table 122). A feed-forward back-propogation neural network was used in the analysis. This method searches for classification patterns in the training sample that produce the lowest error rates in the validation set.

The initial univariate cluster analysis for each trait in the training set demonstrates exceptional classification—not unexpected, given the iterative nature of the process. Stopping at the training stage, however, would result in unpredictable and unrealistic classifications. The most desirable property of a network is its ability to generalize to new cases. In reality, the network is trained to minimize the error on the training set, but short of having a perfect and infinitely large sample, this is not the same as minimizing the error of the validation sample. The training set performs exceptionally well, reaching nearly perfect classification after only about 50 iterations. "Overfitting" of the data is a common problem in many multivariate models in which too many parameters are used in an analysis, fitting the test sample perfectly but failing to correctly classify individuals outside of the test sample. The same is true for neural networks. In order to avoid overfitting, it is necessary to use additional techniques, such as cross-validation, to indicate when further training is not resulting in an overfitting of the data set.

Although classification rates using the validation sample reach a more reasonable accuracy than the training set, rigorous cross-validation of the validation sample tests the performance of the neural network to obtain realistic estimates of reliability. The cross-validated classification of the validation sample was nearly 90 percent (Table 123). The error rates were relatively consistent among biological groups—a very promising feature of the neural network analyses. These results demonstrate that cranial nonmetric traits used in a neural network may improve classification accuracies over more-conventional methods, such as visual observation alone. Most promising is the neural network's ability to classify individuals belonging to Hispanic groups, which has not been attempted in the past and is now possible because of the large and diverse sample of Hispanic individuals from the Alameda-Stone cemetery.

Analyzing data within a statistical framework permits the construction of a flexible model specified by a set of parameters that best explain, or "fit," the data. Certainly, even when analyzing data within a statistical framework, problems can arise. One hopes that the particular setting of best-fit parameters provides some understanding of the underlying processes in trait formation and insight into the estimation of biological affinity, but this will not always be the case. Because models are simplifications of reality, there will inevitably be aspects of the data that are impossible to model. Unfortunately, outside of a statistical model, it is often difficult to know which aspects of the data are relevant and which are merely noise. Such scenarios are even more likely when the observer's experience alone is used to judge such a complex set of variables. Any subsequent predictions based on this approach are clouded by the inevitability of noise in the data set and an incomplete understanding of the underlying processes leading to these complex distributions. The benefit of an artificial neural network is clear: if observations and classifications can be explained, then one should be confident in future predictions, as well.

Spatial Patterning within the Alameda-Stone Cemetery

The spatial distribution of individuals within a cemetery is an important factor to consider when examining patterns of cemetery use. The analysis of spatial data within the cemetery is also of great interest, because most of the observed patterns are thought to be structured, reflecting culture-specific beliefs concerning death and burial. The attention given to the spatial variation of a cemetery underlies bioarchaeological investigations, and these considerations of that structure are important elements lending to an understanding of the cultural significance of that space. In the following section, the assumptions rest on the premise that there is an ordered, intentional distribution of individuals and that this relationship can be extrapolated in various ways.

General Observations

Table 124 presents the general demographic composition of each cemetery area. To test for statistical significance in this distribution, the African (n = 1) and Apache (n = 3) individuals were removed from the data set because of their small sample sizes, and a Pearson chi-square statistic was generated for the remaining sample. There were statistically significant differences in the distribution of biological groups within cemetery areas ($\chi = 34.357$, $df = 10$, $p < 0.001$). The manner in which the cemetery areas were designated is outlined in Heilen and Hall (see Chapter 4). Although these areas were designated without comprehensive prior knowledge of the distribution of individuals within the cemetery—but instead by intuitively integrating preliminary archaeological context, osteological, and historical information—some clear patterns emerge.

Cemetery Area 1 represents the military section of the Alameda-Stone cemetery and contained approximately 3 percent of the 1,386 recovered individuals. Euroamericans outnumbered Hispanics approximately 1.5 to 1 in this area. This number is somewhat misleading, however. Of the 57 individuals recovered from Cemetery Area 1, only 13 could be assigned a biological affinity: 8 Euroamericans and 5 Hispanics. One reason for such a low number of biological-affinity assessments is that the majority of the military personnel interred in this area were exhumed in 1884 by the U.S. Army and moved 7 miles away to the military cemetery at Fort Lowell (see Chapter 4). Left behind were skeletal elements not useful for determining biological affinity, such as vertebrae and bones of the hands and feet (see Appendix K). Nonetheless, a safe assumption places a larger number of Euroamericans in the section of the cemetery reserved for U.S. soldiers. There may also be evidence for postexhumation use of the military section by the civilian population (see Chapter 4), although these individuals were too young for identification of biological affinity.

Cemetery Area 2 comprised approximately 4 percent of the total number of recovered individuals. There, Euroamericans outnumbered Hispanics, but only slightly. Although Euroamericans constituted a little less than one-third of the total burial population, they composed nearly half of the individuals in Cemetery Area 2 (49.23 percent). Also of note in this area was the African American individual (Grave Pit 3315, Burial 6941). The exact number of individuals of African ancestry in Tucson during the period that the cemetery was in use is unknown. It is possible that other African Americans were buried within the Alameda-Stone cemetery, perhaps in Area 2, but because of poor preservation or ambiguous classifications, these individuals were not identified as such. Grave Pit 3315, Burial 6941, was dressed in military-style clothing, and the location of this burial just north of the military section of the cemetery (Cemetery Area 1) may indicate an association, however tenuous, with the U.S. Army post. This is merely conjecture, of course, and could not be supported without further historical documentation of the cemetery, in general, and the individual interred within Grave Pit 3315, Burial 6941, in particular.

Nearly 55 percent (n = 753) of the 1,386 individuals recovered from the Alameda-Stone cemetery were located within Cemetery Area 3. The majority of these individuals could not be assigned a biological affinity because of their ages; however, of those who could be identified to a biological group, roughly two-thirds were Hispanic. The remaining one-third consisted primarily of Euroamericans (25 percent of the total) and Native Americans (roughly 12 percent). The inherent difficulties associated with assessing biological affinity from the skeletal remains of children likely inflate the proportion of Euroamericans, and as a result, these proportions

pertain mostly to mature individuals. The majority of the children buried within the cemetery would have been Hispanic and, less often, Native American; so, these proportions should only be considered roughly representative of the proportion among adults. The unusually large number of children made assessments of biological affinity difficult, but they also present an interesting spatial question.

The concentration of so many children within a single area of Cemetery Area 3 is intriguing (Figure 124). Trask (see Chapter 7) and Keur (see Chapter 9) provide detailed aspects on the demography of Cemetery Area 3, but the number of children and young adults in this area deserves special attention, particularly as it relates to the spatial distribution of the population. Although Cemetery Area 4 (discussed below) had a slightly higher proportion of children and subadults, the children within Cemetery Area 3 presented several interesting features worthy of further investigation. In Cemetery Area 3, nearly one-quarter of the individuals were subadults or younger; indeed, the majority of children and subadults were concentrated in the most-eastern portion of that area, in relatively linear north/south rows (see Figure 124). It does not seem likely that the distribution was random. There are at least two possible explanations for the large number of children in this area: epidemics that predominantly affected children and child-specific cemetery areas. These will be discussed, in turn, below.

Epidemics, including small pox and influenza, were not uncommon occurrences in Tucson. Indeed, a small pox epidemic occurred in Tucson in 1870, killing at least 120 individuals (see Chapter 7, Volume 1 of this series). Medical officers stationed in Tucson at the time became concerned about small pox cases in California and New Mexico in 1868, and so, they inoculated the troops at Tucson, although with only limited success. In January 1870, small pox cases first appeared in Tucson, as a result of the spread of an epidemic in Altar, Mexico (Heilen et al. 2010). By the end of the epidemic in April 1870, small pox had claimed at least 120 lives, many of them Mexican American children (Heilen et al. 2010). The underdeveloped immune systems of children and the weakened immune systems of older adults make them particularly vulnerable to infection (Walker et al. 1988). Often these two demographic cohorts fall victim to epidemics in large numbers. Perhaps this explains the proportion of children in Cemetery Area 3, an issue explored further in Volume 1 of this series.

One other possible explanation deserves attention. A Catholic tradition practiced by Hispanics and some neighboring Native American tribes in and around Tucson during the nineteenth century treated children as *Los Angelitos* or "little angels," following their death (Toor 1947; Will de Chaparro 2007). The mortuary treatment of *Los Angelitos* is described fully in Chapter 8, Volume 1 of this series. Sewell and colleagues highlight the treatment of deceased children and present compelling evidence for differential handling of this demographic group. Unclear, however, is whether a certain section of the cemetery was designated for *Los Angelitos*. This does not appear to be the case, given the number of adults interspersed among the children, even in the areas of highest concentration. Unfortunately, the biological data do not provide much insight into this question, and a definitive answer may never be known. The number and distribution of children in Cemetery Area 3 was not an accident or random chance but likely represents a snapshot of a community providing special treatment to the young members of its community who died before their time, an inordinate number of deaths that affected a particular demographic within a short period of time, or perhaps both of these.

Cemetery Area 4 was the smallest of the five areas, but the density of burials within that small space was unmatched by any of the others. Although no evidence of a wall or enclosure was noted during excavations, clearly some form of demarcation existed in the past to separate this area from the larger portion of the cemetery. Although small, Cemetery Area 4 contained more individuals than Cemetery Areas 1, 2, and 5 combined (402 versus 183). Cemetery Area 4 comprised nearly 30 percent of the 1,386 individuals recovered. The density, however, also had a substantial effect on the assessment of biological affinity. Repeated use of such a small area of land led to multiple interments in the same space. Postcemetery disturbances (outlined in Chapter 4, this volume, and further discussed in Volume 3 of this series), such as utility trenches, also disturbed large sections of Cemetery Area 4, displacing remains and destroying skeletal elements useful for biological-affinity assessments. As discussed in Chapter 1, preservation was poorest for individuals buried in Cemetery Area 4, perhaps owing to frequent disturbances during and after the cemetery was in use. As a result, only 49 individuals (~12 percent) could be assigned a biological affinity. Of those, 7 were Native American, 9 were Euroamerican, and 33 were Hispanic. It is difficult to state with certainty how this area was used by the Tucson community. Theories range from consecrated grounds associated with the Catholic Church to a pauper

cemetery for the poor and destitute. The former would seem to be the more parsimonious of the two, because there was no evidence for lower social status recovered from this area, although currently no evidence exists to support either hypothesis.

The individuals recovered from Cemetery Area 5 constituted approximately 2 percent of the total burial population. This area contained 14 Hispanic individuals and 1 Euroamerican. Very little information can be drawn from this group. Although the possibility exists that this section of the cemetery represents the latest period of use, it is difficult to say with certainty whether that is indeed the case. Interestingly, two-thirds of these individuals were young adults or children. Cemetery Area 5 may simply have been an extension of Area 3, rather than a separate area of the cemetery reserved for distinct uses.

Geospatial Methods

There are a number of sophisticated methods used to analyze and measure spatial variation with biological-distance data. Many of these methods have been applied to prehistoric period and historical-period sites (Jobling et al. 2004). Methods such as cluster analysis (see above) infer the relationship of populations in terms of a biological and geographic distance, but they do not permit one to draw concrete conclusions (Cavalli-Sforza et al. 1994) about those relationships. These methods only allow one to say that a relationship exists. In a cemetery setting, however, the scale of the area of interest is such that cluster analysis alone does not permit the level of resolution necessary to interpret the relationships between individuals. Relethford (2008) recently outlined a geostatistical approach useful for biological-distance studies in a regional setting, but as of this writing, that method has not been applied to a cemetery. Nevertheless, it can be applied appropriately to a cemetery data set for the purpose of investigating spatial variation and the underlying patterns of cemetery use, because the underlying assumptions are not violated.

Geostatistical analyses were initially developed for applications in geology, but they have been modified for use in biological-distance studies. The method advocated by Relethford (2008) and used here begins with the assessment of an experimental variogram. Variograms plot the relationship between a biological-distance measure and the physical (spatial) distance between individuals, or data points. A variogram also provides empirical information regarding the magnitude, extent, and pattern of spatial correlation (Relethford 2008). For example, a straight, nonundulating variogram suggests a lack of spatial correlation, and a patterned (sloping or undulating) variogram indicates a correlation between physical distance and biological distance. Following variogram analysis, the calculated spatial correlation is used to interpolate values between individuals and the empty space surrounding them, to construct a smoothed plot from contour data. The z (height) value is the biological-distance measure for either an individual or an interpolated value. This process is known as kriging. Although the mathematical details of kriging are beyond the scope of this work, it is, simply put, a regression method used to estimate unsampled values using a weighted average of known values from nearby individuals (Legendre and Legendre 1998). These weighted averages are based on the results of fitting the variogram to the data set. The estimated and known values are then plotted. Unlike ad hoc methods of contouring, the kriging method is weighted using the specific underlying pattern of spatial correlation and variation derived from the experimental variogram analysis and, therefore, should represent a more accurate picture of spatial variation. It should be noted, however, that in the case of the cemetery, kriging can produce peaks and troughs in locations in which no graves were discovered, as the interpolated high and low values are based on values in surrounding grave locations. Such maps are used to show gradients and patterns that may be interpreted in light of cemetery use, population history, etc. The empty spaces (unsampled locations) between individuals are not meant to imply that an individual with those dimensions is represented in that space. Rather, the interpolated values are presented only to permit *interpretation* of the underlying patterns of spatial patterns through visualization of the data, in the form of a two-dimensional map.

There are many ways to examine the spatial distribution of biological data within the cemetery. The following section follows the same general outline used to explore patterns of variation within the cemetery—specifically, general demographics and dental, craniometric, and cranial nonmetric data sets derived from the Alameda-Stone cemetery sample.

General Demographic Trends

The focus of the following section is on the spatial distribution of the general demographic parameters (age, biological affinity, and sex) established for the individuals recovered from the cemetery. The graphic representation of these variables is achieved using variogram analysis and kriging methods. Trask (see Chapter 7, Table 96) provides abundant information on the available samples for the following analyses.

Age

The general distribution of the various age cohorts is illustrated in the contour map in Figure 125. The lag distances represent a variety of scales, or distances, used to test for a correlation between spatial and biological distance. The variogram is the plotted correlation against the lag distance at various scales. The variogram (see top of Figure 125) demonstrates a linear relationship and spatial correlation between age and geographic location within the cemetery. To examine the impact of this trend on the kriging analysis, a universal kriging method was applied in Surfer 8.09.2391, using the autofit function to fit a linear trend to the data and extract the residuals for subsequent variogram analyses. The derived parameters of the variogram analysis are presented in each figure. The results of the universal kriging method are similar to the initial variogram and kriging analysis (not shown), although less spatial correlation was apparent in the universal model. The general pattern observed is a linear clustering of younger individuals in Cemetery Area 3, with a trend to adults outside this area (although small "pockets" of children do exist in other regions within Cemetery Areas 3 and 4). This pattern fits quite cleanly with the interrow and intergrave analysis by Heilen (see Chapter 4), which suggested a division between the eastern and western portions of Cemetery Area 3. Such an underlying pattern may illustrate preferential or repeated use of this area of the cemetery for children. On the other hand, the large number of children in this area may also represent an epidemic or some other form of disaster that differentially affected children. Such patterns are difficult to interpret without introducing bias.

The kriging method for graphically representing these data permits only general inferences. Again, the general trend indicates a loose organization of children in the east-central quadrant of Cemetery Area 3. This is spatially the equivalent of the potential division between the eastern and western halves of Cemetery Area 3 discussed by Heilen and Hall in Chapter 4, and this may represent a separate cemetery area established in response to an epidemic, resulting in the eastern half of Cemetery Area 3. If these graves occurred later and perhaps more closely in time, the greater standardization of spacing in that half of Cemetery Area 3 would make sense. Figure 126 presents the geostatistical analysis of Cemetery Area 3, alone. This finer resolution clearly shows the inordinate clustering of children in this region of Cemetery Area 3 and the relatively linear nature of that spatial organization.

Biological Affinity

The geospatial analysis of the cemetery areas in regard to biological affinity is presented in Figure 127. The variogram shows a positive spatial correlation. Any assessment of spatial correlation must consider variance due to noise, or the nugget effect. A high nugget effect is "nonspatial variation at a local level, due to both random measurement error as well as variation that occurs on a spatial level at an interval less than the lag distance" (Relethford 2008:4). As this regards the distribution of biological groups in the cemetery, the high nugget effect ($C_o = 1.48$) noted would imply that the variation is noise and not spatial correlation (see Legendre and Legendre [1998] for the formula to calculate this value). One potential problem is that, in contrast to age, far-fewer and more-widely dispersed individuals were assessed for biological affinity. Several spatial patterns do emerge, however, even with the high nugget effect. The southern portion of the cemetery (Cemetery Areas 1 and 2) contained predominately Euroamericans, and the northern portion of the cemetery (Cemetery Areas 3, 4, and 5) contained a relatively heterogeneous mix of Hispanic, Euroamerican, and Native American individuals. At least as assessed according to this method, this area of the cemetery may account for the high nugget effect and would seem to suggest little patterning in the distribution of the various biological groups in the northern portion.

Sex

The geospatial analysis of the cemetery, using sex as the variable of interest, is presented in Figure 128. The ratio of males to females in the southern portion of the cemetery (Cemetery Areas 1 and 2) was nearly nine times higher (9.43) than the ratio of males to females (1.07) in the northern portion (Cemetery Areas 3, 4, and 5). The kriging map clearly illustrates this general trend. Cemetery Areas 1 and 2 were composed predominantly of males, and moreover, these individuals were predominately Euroamerican. This suggests that these areas, more so than Cemetery Areas 3, 4, and 5, may have been used by immigrant populations. As already stated, Cemetery Area 1 was associated with the military. Therefore, it is unsurprising that Cemetery Area 1 was composed entirely of males. Biological affinities of the seven females in Cemetery Area 2 were four Euroamericans and three Hispanics. The variogram is merely representing an interpolated distribution of males and females and is in no way meant to suggest that interpolated values between recovered individuals are representative of expectations. In other words, a variogram used in this manner is not meant to be predictive but, rather, to serve as a tool for exploring spatial patterning.

Dental Morphology and Patterns of Spatial Distribution

In order to explore dental morphology of individuals throughout the cemetery, a principal component analysis was performed on eight dental morphological traits using SYSTAT 12.0. The first four principal components were retained for further analyses. The component loadings for the first four principal components are presented in Table 125. Only those loadings with absolute values greater than 0.4 are presented, following Relethford (2008). The first principal component has high loadings on Carabelli's trait (a trait common among Euroamericans), congenital absence, and pegged molars, reflecting morphologies often associated with Euroamerican and Hispanic populations. The second principal component has high load values for shovel-shaped incisors, variant form, and winging, reflecting morphologies associated with Native Americans and, to a lesser extent, Hispanics. The third principal component has moderate loadings on Carabelli's trait, congenital absence, mesial cusp, pegged teeth, and variant form. The fourth principal component has moderate to high loadings on the metacone and winging, reflecting morphological consistencies with Native Americans and Hispanics.

A variogram using the first principal component is shown in Figure 129, using 12 spatial lags. Clearly the model is not linear, but instead, it is similar to the form that Legendre and Legendre (1998:723–724) suggested represents discrete units, or peaks, within the project area. These results lend further support to a division between Cemetery Areas 3 (west) and 4 and 3 (east). The distinctions between the eastern and western halves of Cemetery Area 3 may be the result of in-migration to Tucson during the nineteenth century by Euroamericans and subsequent genetic admixture, which would be reflected more in younger individuals. The high intercept reveals a high nugget effect, suggesting that some of the spatial correlation is the result of nonspatial sources of variation (e.g., random distribution of biological groups, gene flow, etc.).

The map produced using the kriging method supports this explanation. However, some patterns are worth further exploration. The lowest loadings of the first principal component were found along the eastern edge of Cemetery Area 3, whereas the higher loadings were in Cemetery Areas 1 and 2 and just north of Cemetery Area 4. These areas, more than the eastern edges of Cemetery Area 3, may have been associated with immigrant Euroamericans and Hispanic individuals and reflect genetic admixture between the two groups. The second, third, and fourth principal components generated patterns similar to the first principal component: nonlinear models with relatively high nugget effects.

The distribution, frequency, and genetic components of dental morphologies do not lend themselves to finer levels of understanding, but clearly the distribution of the general morphologies (compressed into single measures by the principal components analysis) does suggest some level of patterning within the cemetery. The use of these methods is neither predictive nor classificatory, but instead, these methods were employed to explore general patterns of spatial variation throughout the cemetery, which is clear from both the variogram and the associated contour map.

Cranial Morphology and Patterns of Spatial Distribution

To explore general spatial patterns of cranial variation throughout the cemetery, a principal components analysis was computed on 36 cranial variables previously standardized to remove the effects of sex. The component loadings for the first four principal components are presented in Table 126, along with the percent of variance explained by each. The first principal component reflects both craniofacial breadth (moderate to high loadings on jugal breadth, frontomolare breadth, minimum frontal breadth, and upper facial breadth) and midfacial morphology (moderate loadings on ectoconchion breadth, nasal height, and orbital breadth). The second principal component reflects facial projection (prognathism), with moderate loadings on basion-nasion length and basion-prosthion length. The remaining principal components are not discussed in the remainder of this chapter, because they are considered uninformative for the question at hand and redundant to the first two principal components.

The variogram for the first principal component is presented in Figure 130, using 25 spatial lags. Like the variogram constructed for dental morphology, the model is not linear. Several iterations and variogram components were assessed to obtain the best-fitting model, using the autofit function in Surfer 8.0. A logarithmic model appeared to be the best fitting and is presented (see Figure 130). A high nugget effect ($C_o = 3.73$) implies a high level of nonspatial variation. The nonlinear form of the variogram and the high nugget effect suggest that the underlying pattern of craniofacial morphology may not be spatially correlated, although the small sample size could play a role in the distribution of these morphologies. One of the consequences of a high nugget effect is smoothing of the generated contour map. However, the south-north cline in craniofacial morphology demonstrates a general trend of larger craniofacial structures in the southern portion of the cemetery, decreasing in size as one samples farther north. The Euroamericans located throughout the southern section of the cemetery exhibited a significantly larger craniofacial morphology compared to the Native Americans (buried in the southeast portion of Cemetery Area 3) and the gracile morphology of the Hispanics buried in the northern section of the cemetery. Finally, an examination of some of the sparsely sampled areas in the northern section of the cemetery did not suggest any problems with interpolation. The "pockets" of larger craniofacial complexes in the northern section may represent cranial variation similar to the southern section.

The variogram for the second principal component (facial projection) is presented in Figure 131. Again, the results support previous assumptions regarding the distribution of individuals of Euroamerican versus Hispanic biological affinity. Hispanics generally present slightly more prognathism (facial projection) than do Euroamericans. The general trend outlined in the contour map produced using the kriging method demonstrates a general north-south trend; individuals in the north had higher values for facial projection, with a smooth decrease into the southern section. Birkby et al. (2008) have suggested more facial prognathism for Hispanic individuals, compared to Euroamericans. These results suggest this was also the case for nineteenth-century Hispanics located in the northern portion of the cemetery.

Summary and Discussion

Dental, craniometric, and cranial nonmetric data were used to examine patterns of biological and spatial variability within the Alameda-Stone cemetery sample, representing inhabitants of nineteenth-century Tucson, Arizona. Several multivariate statistical approaches were used to identify subgroups within the cemetery and patterns of cemetery use by different subsets of the burial population. The significance of the results to these research goals are discussed below.

Identifying Subgroups within the Cemetery

The results of each multivariate analysis were consistent with one another in general terms. The analysis of the dental morphological variants was consistent with geographic distributions and implied cultural relationships. The various Native American groups known to be in Tucson during this period could not be reliably distinguished, with the exception of the Apache individuals, who, because of their distinctive Athabaskan origins, were morphologically distinct from other Native Americans. The Hispanic and the Yaqui (identified during the assessment of cultural affinity) individuals clustered closely together—an artifact of the genetic history and geographic origins of these closely related groups. When the sample is further separated by sex, a general male/female pattern of relatedness emerged (e.g., Hispanic males and females were most similar). Similar patterns of relatedness were also identified using craniometric data; however, the sample size of craniometric data was only around 6 percent of the primary individuals; so, the question of representativeness is paramount. The small sample sizes do not negate the value of this study but should serve as a caveat to the interpretation of the study in regard to our understanding of the cemetery. Nevertheless, the results of the craniometric study suggest a relatively heterogeneous population comprising the many ethnicities present in Tucson during the nineteenth century. Likewise, the cranial nonmetric data illustrate a similar pattern of relatedness (and heterogeneity). Again, the single identified African American and the Apache individuals were clearly distinct (dentally and morphologically) from all other groups. The Hispanic, Euroamerican, and other Native American groups were more similar to one another but were still morphologically distinct. The shared history of these three groups in Tucson (even at this early date) is evident from the data.

The cemetery population was not morphologically homogenous, although intergroup biological differences were not marked—a pattern consistent with the shared genetic history of a large proportion Tucson's population. This result is not unexpected for the Hispanic subpopulation, because many of these individuals immigrated from Sonora and Sinaloa. Despite known levels of high heterogeneity among Native Americans, the few Native Americans recovered from within the cemetery were relatively homogenous, suggesting a common ancestry. Among Euroamericans, however, the level of homogeneity noted is surprising. In all likelihood, many of the Euroamericans were individuals from northern Europe, particularly from the United Kingdom, Germany, and Scandinavia, but also from multiple parts of the United States (see Chapter 4). The level of homogeneity noted among the Euroamericans does not fit with what is known about these inhabitants and is more likely a reflection on the sensitivity of the Defrise-Gussenhoven test than an indication of the relationships among the Euroamericans.

Biological distances among the Alameda-Stone cemetery individuals were examined using dental, craniometric, and cranial nonmetric data with cluster analysis, canonical analysis, and discriminant-function analysis in relation to a model suggesting that the Euroamerican sample was composed primarily of late-arriving, immigrant populations from throughout the United States, Canada, and Europe. The Hispanic population was relatively stable, representing several generations of Tucsonans, but there was also migration to Tucson from Mexico during the period. In fact, migrants from Mexico, particularly northern Mexico, probably represented a large measure of the population increase during that time.

The biological distances among the various populations recovered from the cemetery demonstrate considerable overlap among the Hispanic groups but relatively little concordance between Euroamericans and Hispanics. However, both the Euroamerican and Hispanic samples were clearly distinct from the Native American sample, particularly the Apache sample. The Apache arrived late in the area and were relatively isolated from the other groups.

In general, the distribution of subgroups within the cemetery followed expectations regarding nineteenth-century Tucson: it was a mostly Hispanic community that also included African Americans, Euroamericans, and Native Americans among its members. Certainly, the large number of individuals who could not be identified to a particular biological affinity reflects not only the large number of children recovered but also the diverse history of Tucson, where many people from many backgrounds shared disparate cultural traditions, languages, and ancestry, thus masking some of the biological differences.

Finally, a comparison of the dental and craniometric data to other cemetery samples suggests that the Alameda-Stone cemetery sample of Hispanics was very similar to other nineteenth-century Hispanic samples,

such as those from Alameda in Albuquerque, New Mexico, but this sample of Hispanics was situated among the Euroamerican, modern Mexican, and Native American samples (see canonical discriminant analysis), suggesting genetic contributions from all three. The Alameda-Stone cemetery Euroamerican sample was also surprising, both in overall homogeneity and in patterns of relatedness to other samples. Quite surprisingly, the Euroamerican sample was relatively homogenous, despite historical evidence for immigrants to the area from not only parts of the United States but also various parts of Europe. This result may be related to the small number of intact crania available for analysis or the resolution of the methods and reference samples available. More research is needed to fully understand the relationships of these individuals to one another and to other populations, as well. In general, the Euroamericans recovered from the Alameda-Stone cemetery were most similar to other nineteenth-century Euroamericans.

Spatial Distribution and Cemetery-Use Patterns

In order to explore the spatial distribution of individuals and groups throughout the cemetery, geospatial methods (experimental variogram analysis and kriging) were used, following methods previously outlined by Relethford (2008). As with any study using biological variables, missing data and resulting small sample sizes hindered the analysis. However, several patterns did emerge that warrant further discussion. When one considers the general morphological differences between Hispanics and Euroamericans, the various contour maps produced with kriging suggest a broad spatial pattern: an overall north-south cline in dental and craniofacial morphology, with considerable variation that is not spatially related (i.e., a high nugget effect). However, given the distribution of the sample, and several other contributing factors, the differences may essentially relate to an east-west division of Cemetery Area 3, on the one hand, and a north-south division of the entire cemetery, on the other.

The noted spatial effects did not have high cross-validation results, so predicting an unknown individual or point is unwarranted and ill-advised. Fortunately, the purpose of this research was not predictive but, rather, exploratory, in an effort to understand the general patterns of spatial distribution throughout the cemetery.

The results presented are quite useful for detecting general patterns of spatial variability. It is important to point out that, although factors such as genetic relatedness and familial patterning could not be ascertained using these methods, these problems are not insurmountable. Indeed, the present study demonstrates that these methodological approaches can be applied to such questions if the data set is robust enough to support such models. A large body of research in geological sciences has been devoted to using these methods to formulate predictive models, but the use of these methods to study cemetery populations using biological variables is rare, at best.

Conclusions

This study is predicated on and illustrates the value of using various data sets and multiple methods from various subdisciplines within anthropology to explore patterns of biological variability. In particular, this research has joined dental, craniometric, and cranial nonmetric data sets with multivariate and geospatial statistical methods of analysis to illustrate the inter- and intrapopulation variability of nineteenth-century Tucson. The applications of multiple measures of biological variability have not been employed to their full potential. Although every aspect of the data set could not be explored, several directions for future research using the Alameda-Stone cemetery sample are quite promising.

These rather preliminary results suggest relatively high levels of heterogeneity for the population as a whole but relatively little variation within biological groups. The Alameda-Stone cemetery sample is, at present, the largest skeletal collection of nineteenth-century Hispanic individuals. The pattern of biological

relationships among southwestern Hispanics is an important future consideration, particularly if more Hispanic individuals from this period are recovered.

This large collection of nineteenth-century Hispanics also provides an opportunity to explore secular change among Hispanics. Forensic anthropological literature has seen a recent explosion in the number of articles dedicated to the identification of Hispanic individuals, particularly in the Southwest (Birkby et al. 2008; Spradley et al. 2008). Historical-period skeletal collections of Hispanic individuals have been lacking, at least until the recovery of the Alameda-Stone cemetery sample. The Alameda-Stone cemetery sample provides a unique chance to understand temporal and geographic trends among southwestern Hispanics.

Further exploration of the data set, using geospatial methods other than variogram analysis and kriging, may produce a clearer picture of the patterns of cemetery use, particularly familial patterning and kinship structures. Of course, limitations within the current data set, particularly the craniometric sample, will likely continue to hinder such analyses. The particular patterns indicated by the current research suggest that spatial patterning is likely, at least at the population level. However, a finer resolution may be possible, if traits or combinations of traits are identified that suggest familial inheritance.

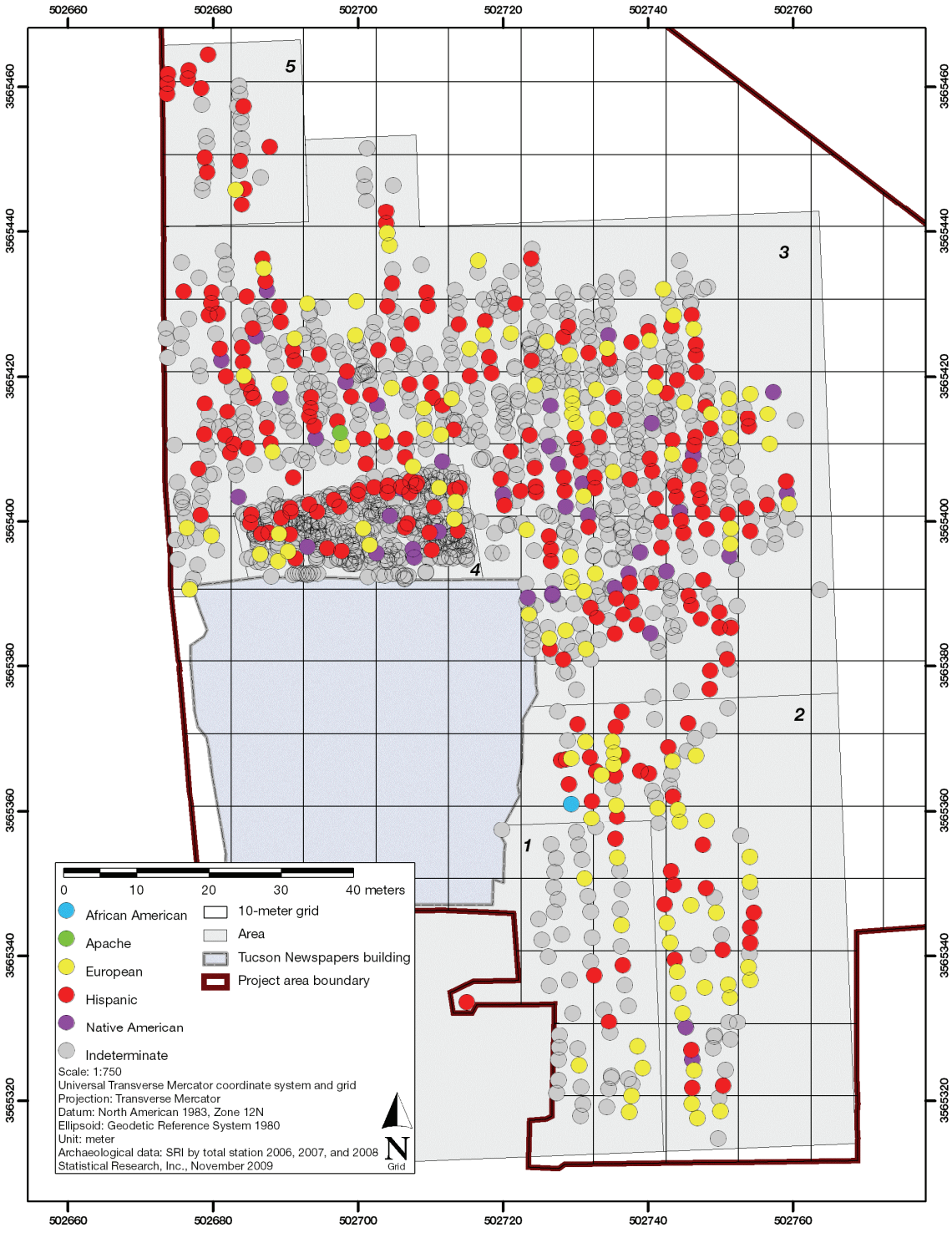


Figure 117. Distribution of individuals at the Alameda-Stone cemetery, by biological affinity.

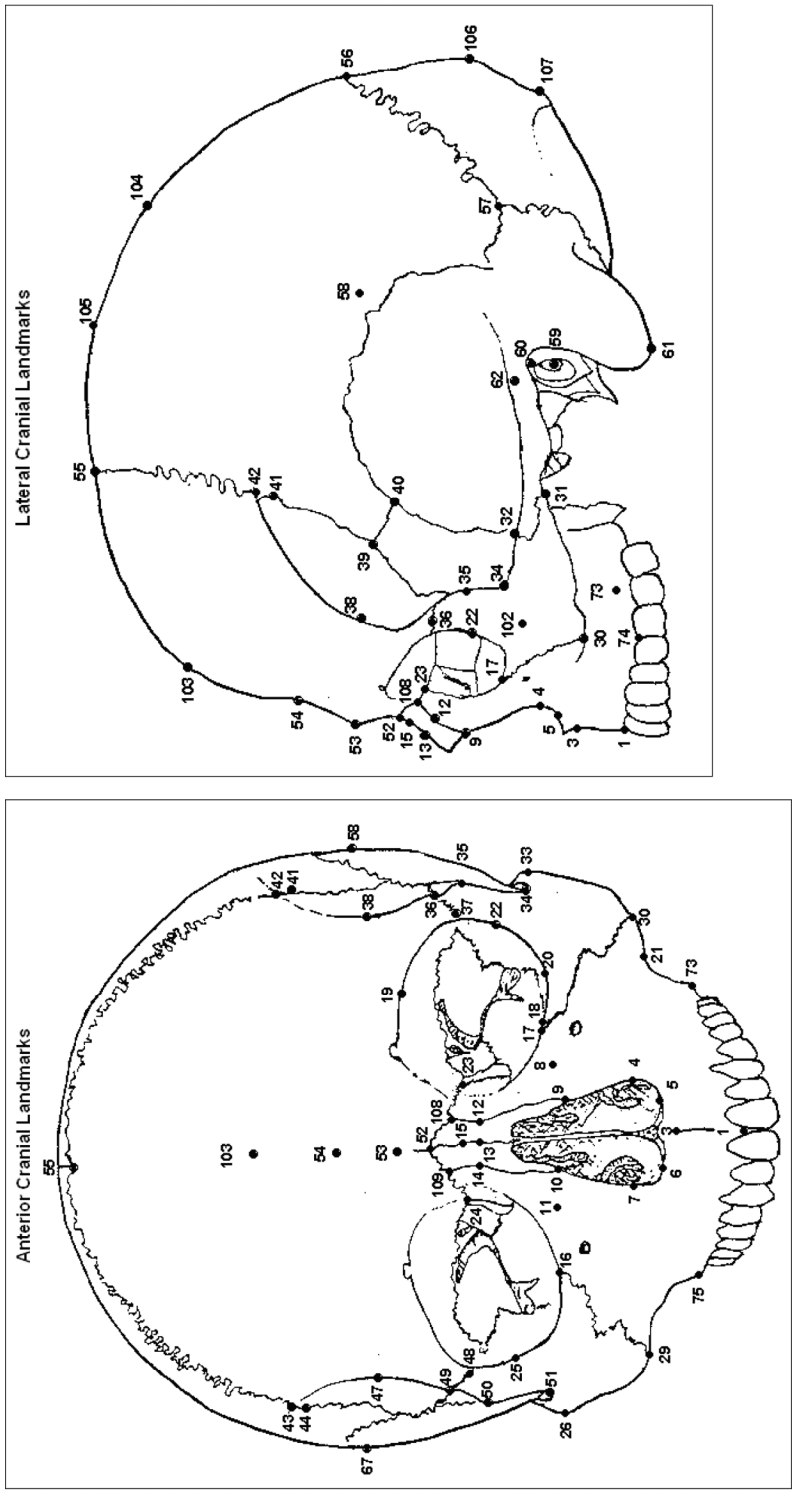


Figure 118. Cranial landmarks used in this analysis.

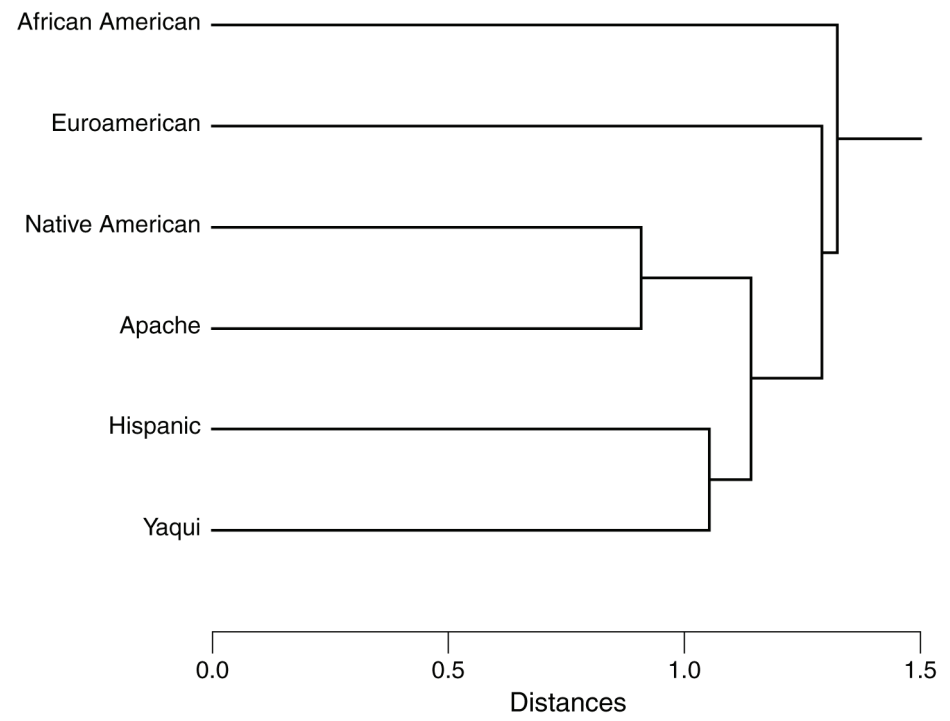


Figure 119. Dendrogram illustrating overall patterns of relatedness between biological-affinity groups within the Alameda-Stone cemetery sample, based on dental morphology.

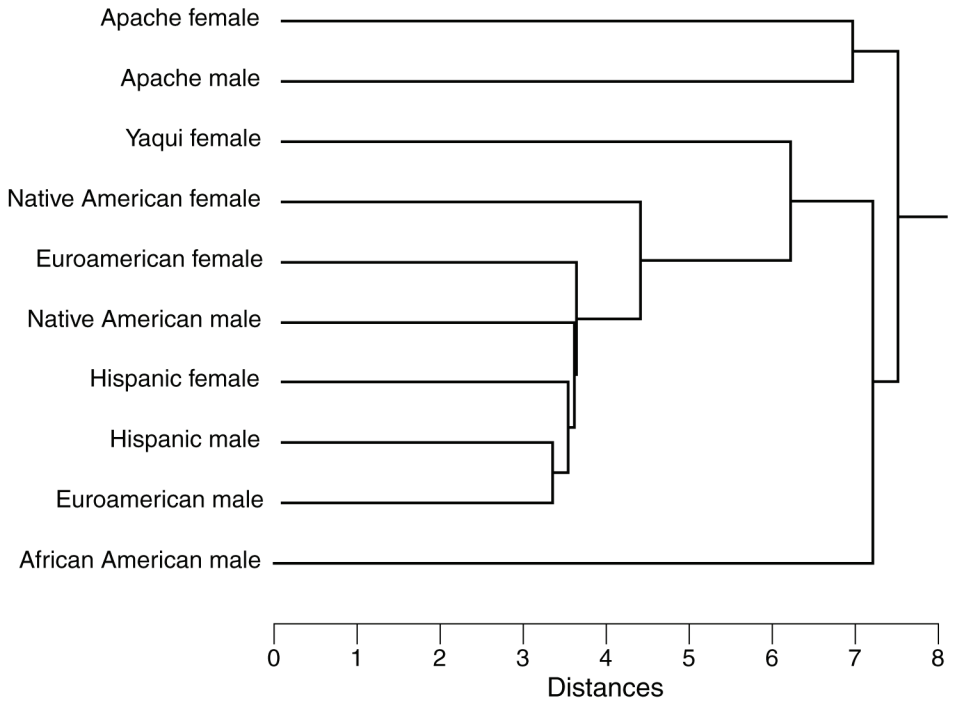
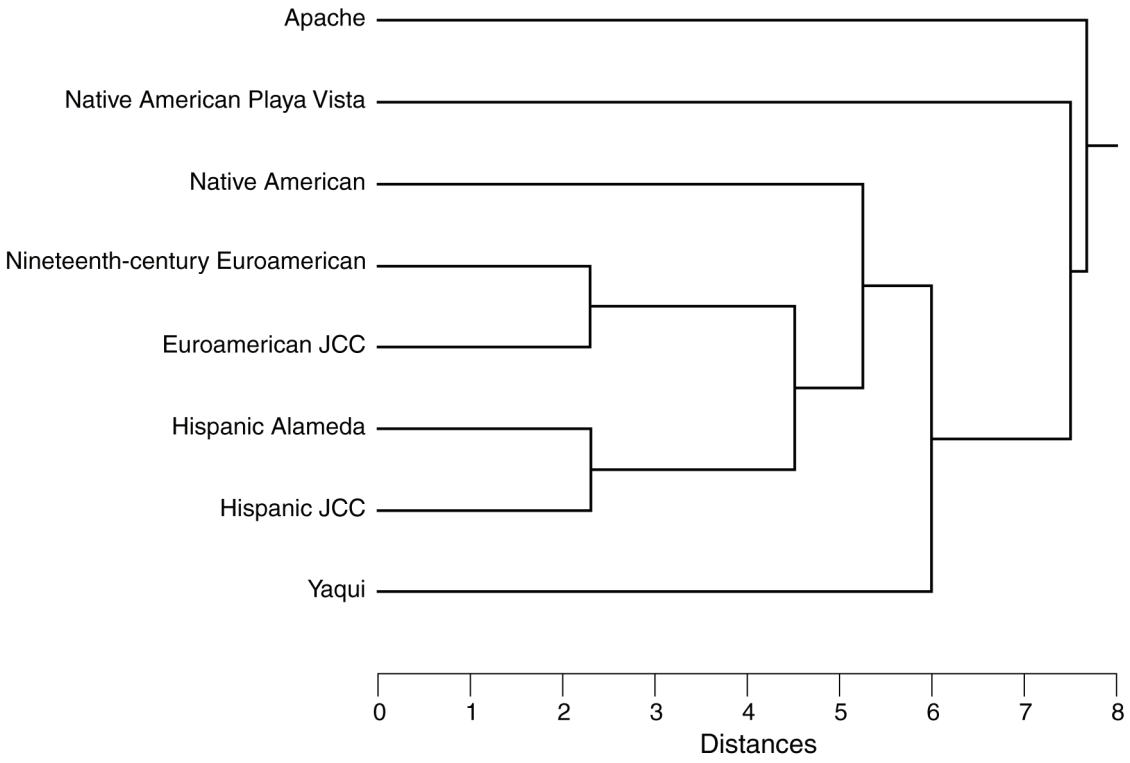
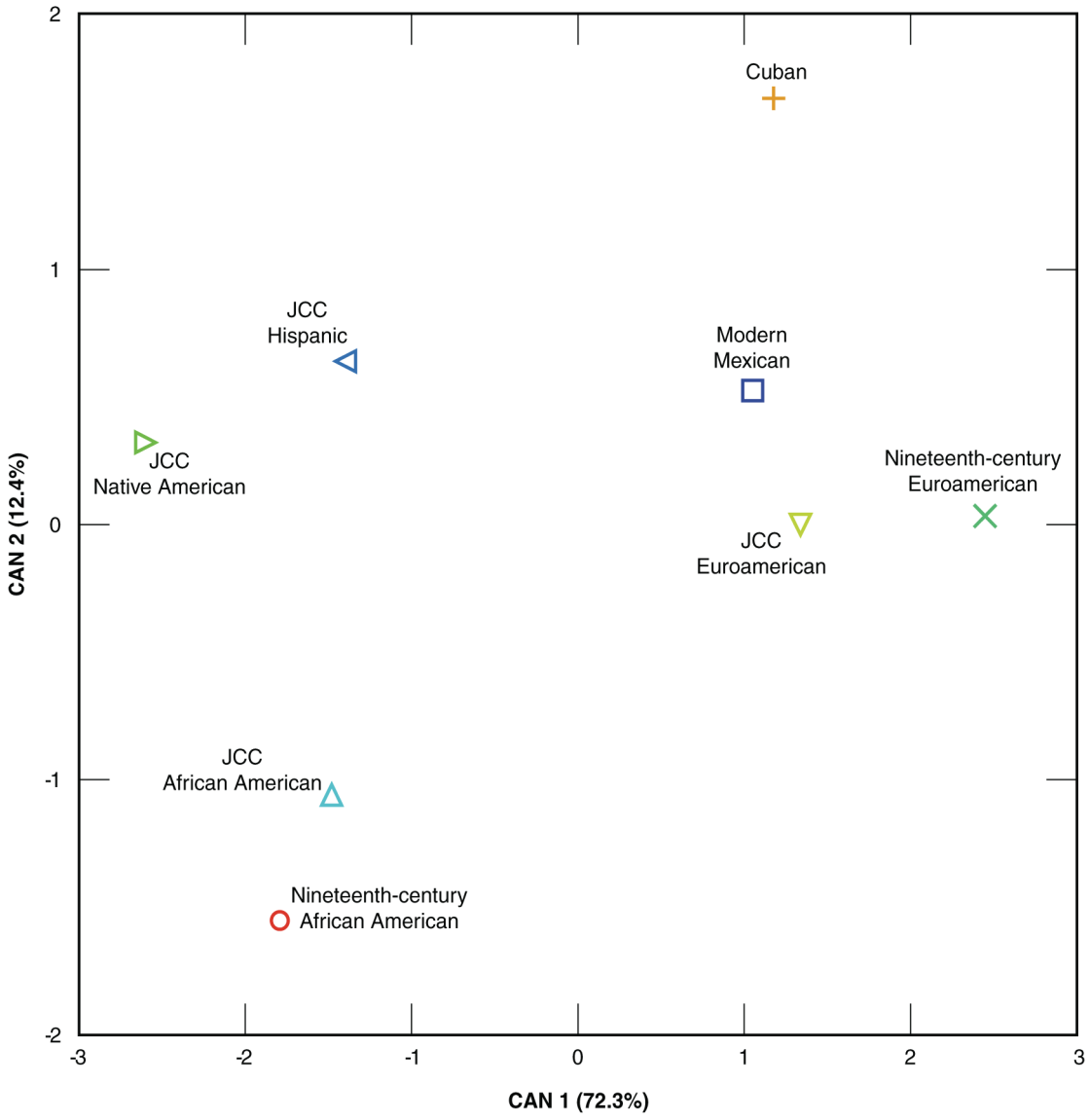


Figure 120. Dendrogram illustrating overall patterns of relatedness between biological-affinity groups, partitioned by sex, within the Alameda-Stone cemetery sample, based on dental morphology.



JCC = Joint Courts Complex

Figure 121. Dendrogram showing a moderate level of similarity between Euroamerican and Hispanic samples, based on dental morphology.



JCC = Joint Courts Complex

Figure 122. Distance matrix and plot of class means showing relationships between Alameda-Stone cemetery groups and comparative samples, based on craniometric data.

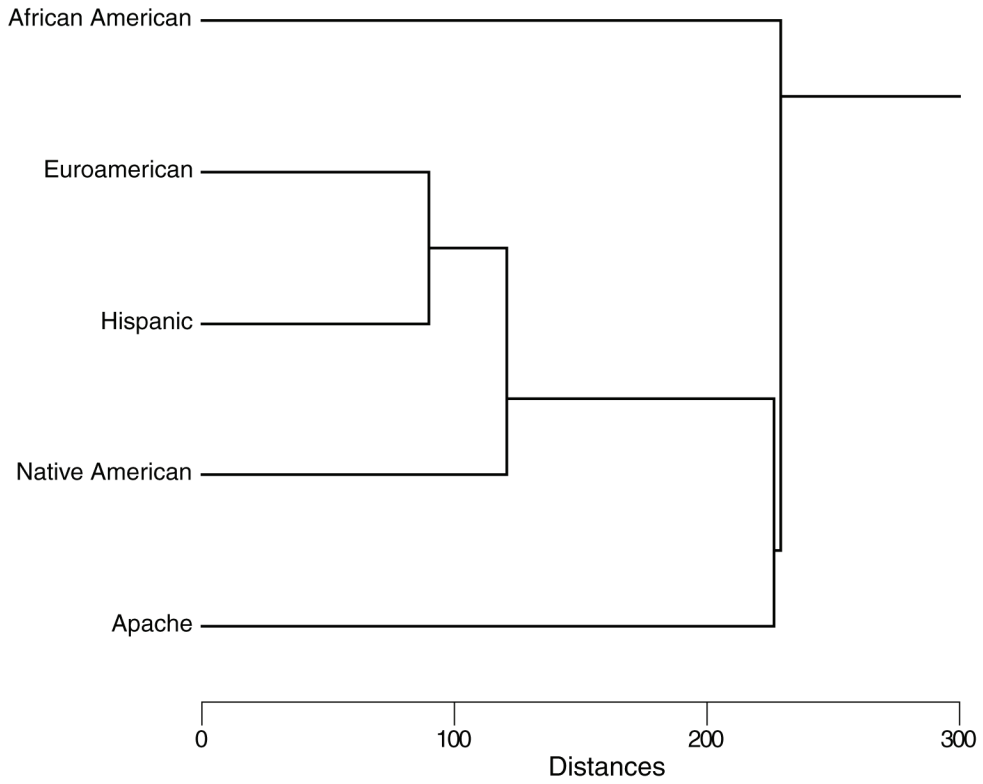


Figure 123. Dendrogram illustrating overall pattern of relatedness between biological-affinity groups within the Alameda-Stone cemetery sample, based on cranial nonmetric data.

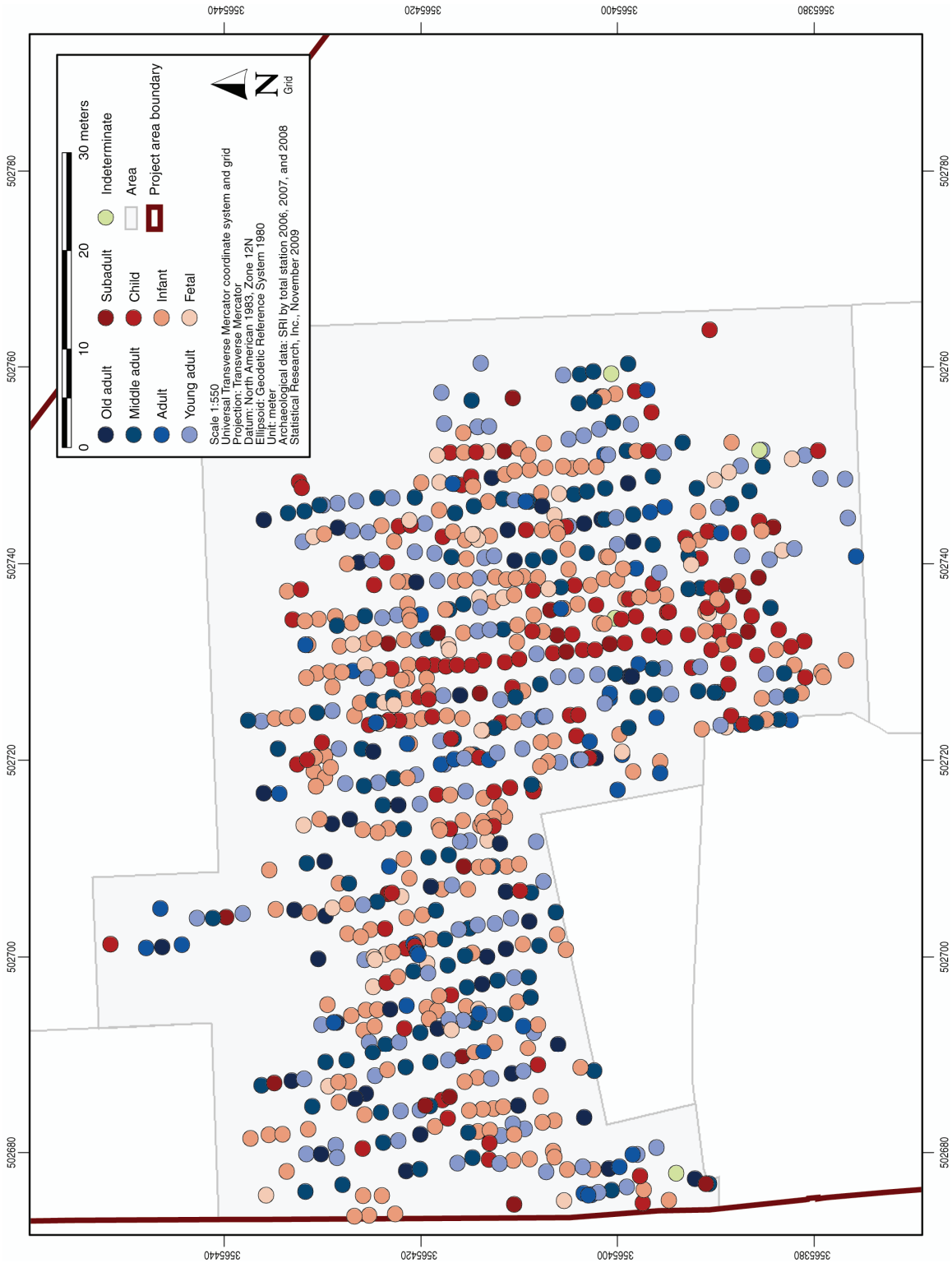


Figure 124. Distribution of subadults within Cemetery Area 3.

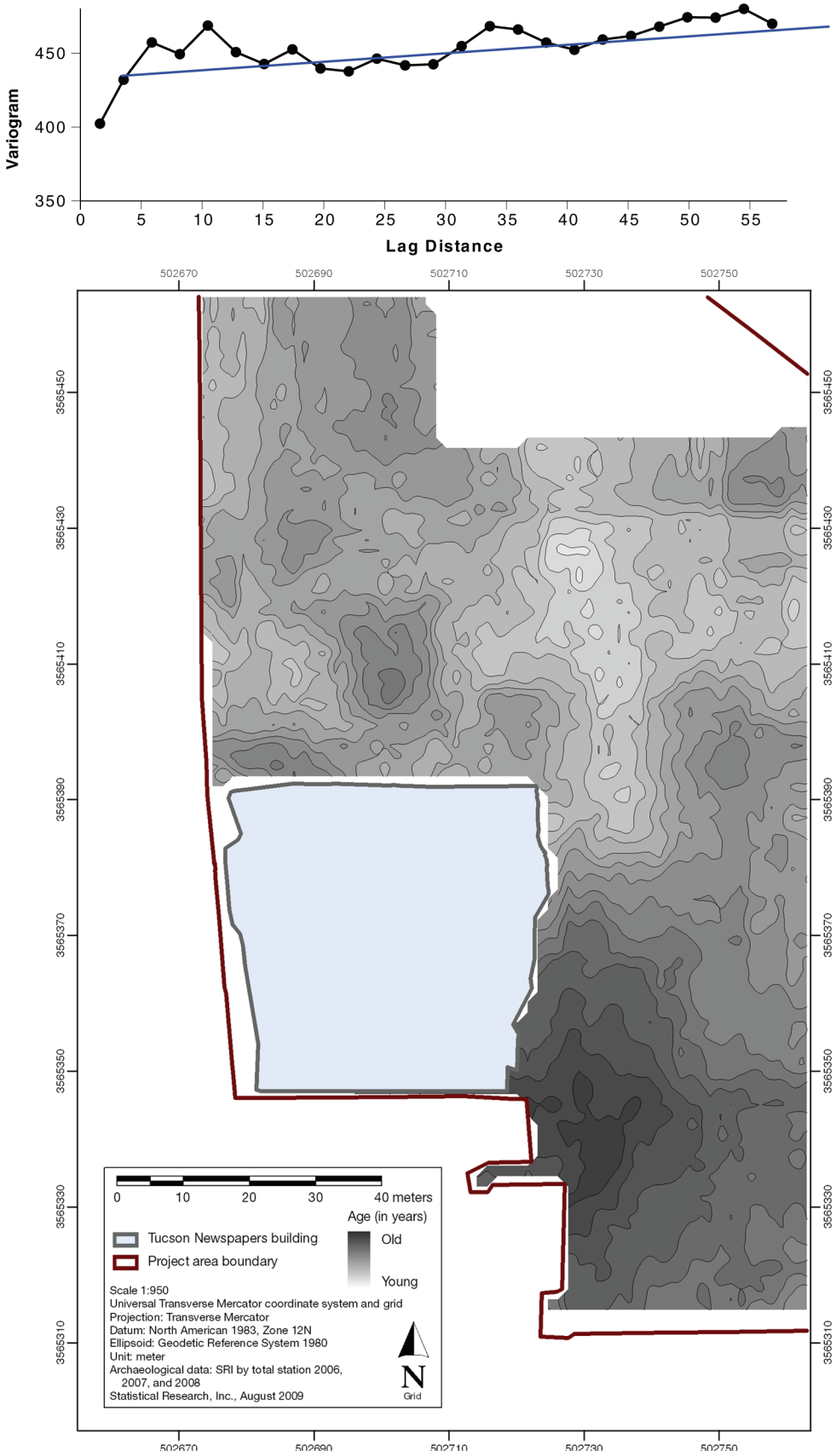
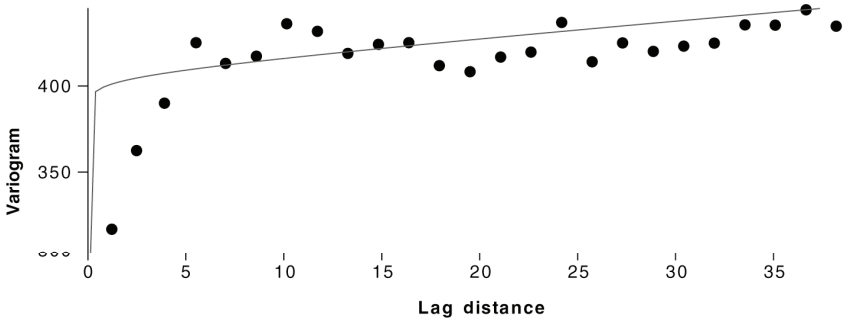


Figure 125. Variogram demonstrating linear relationship and spatial correlation between age and geographic location within the cemetery.



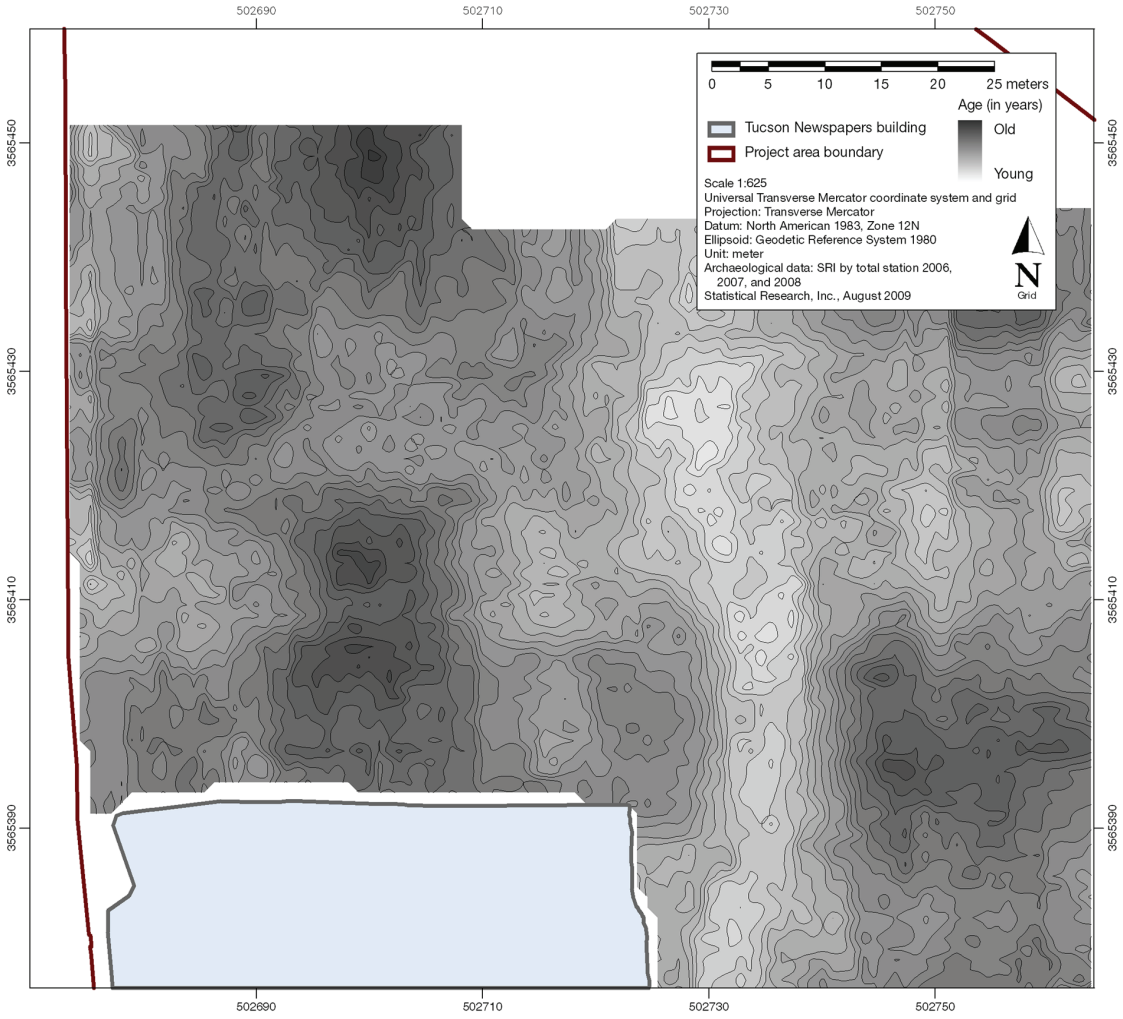


Figure 126. Variogram demonstrating linear relationship and spatial correlation between age and geographic location within Cemetery Area 3.

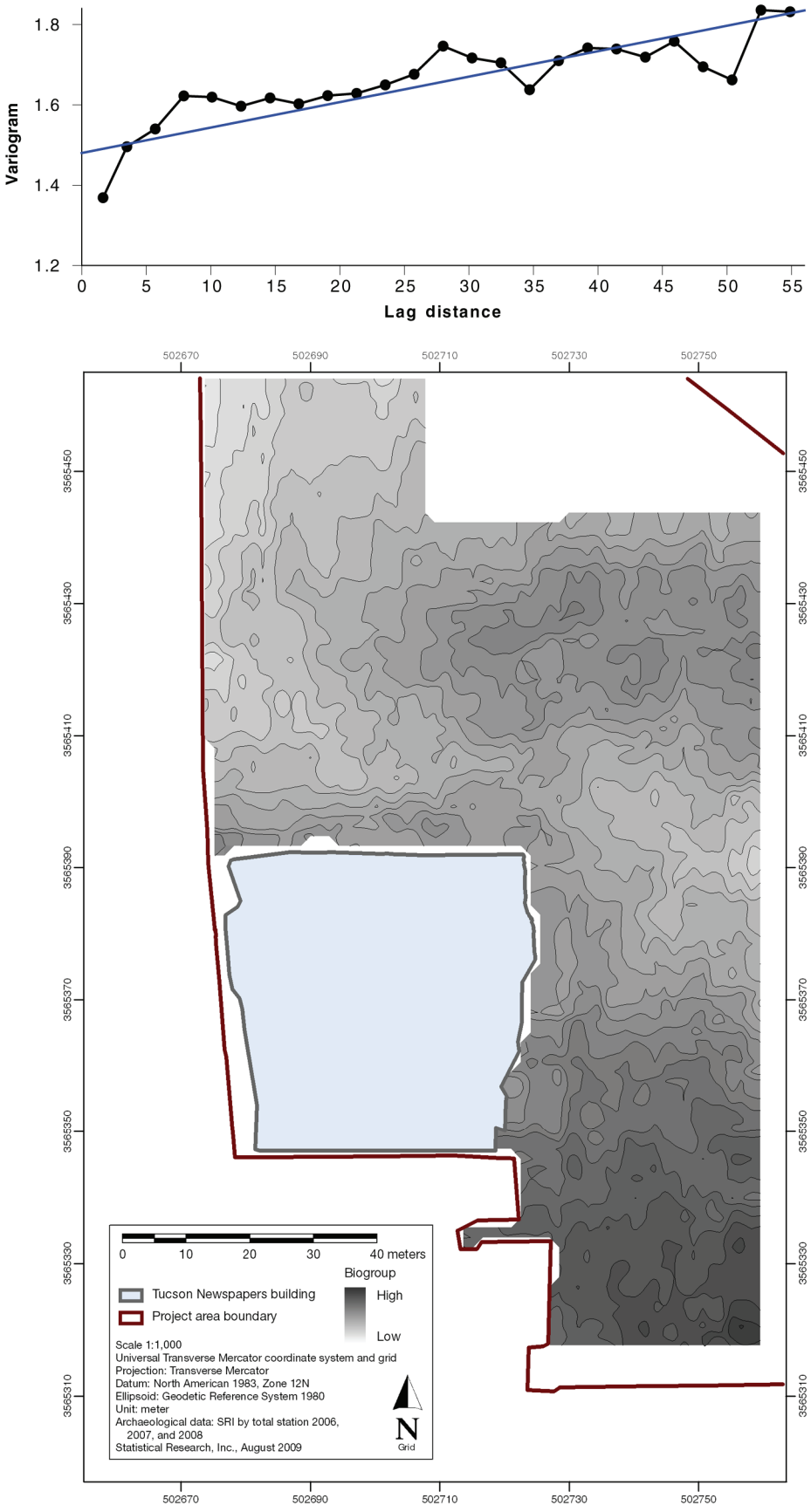


Figure 127. Variogram demonstrating linear relationship and spatial correlation between biological affinity and geographic location within the cemetery.

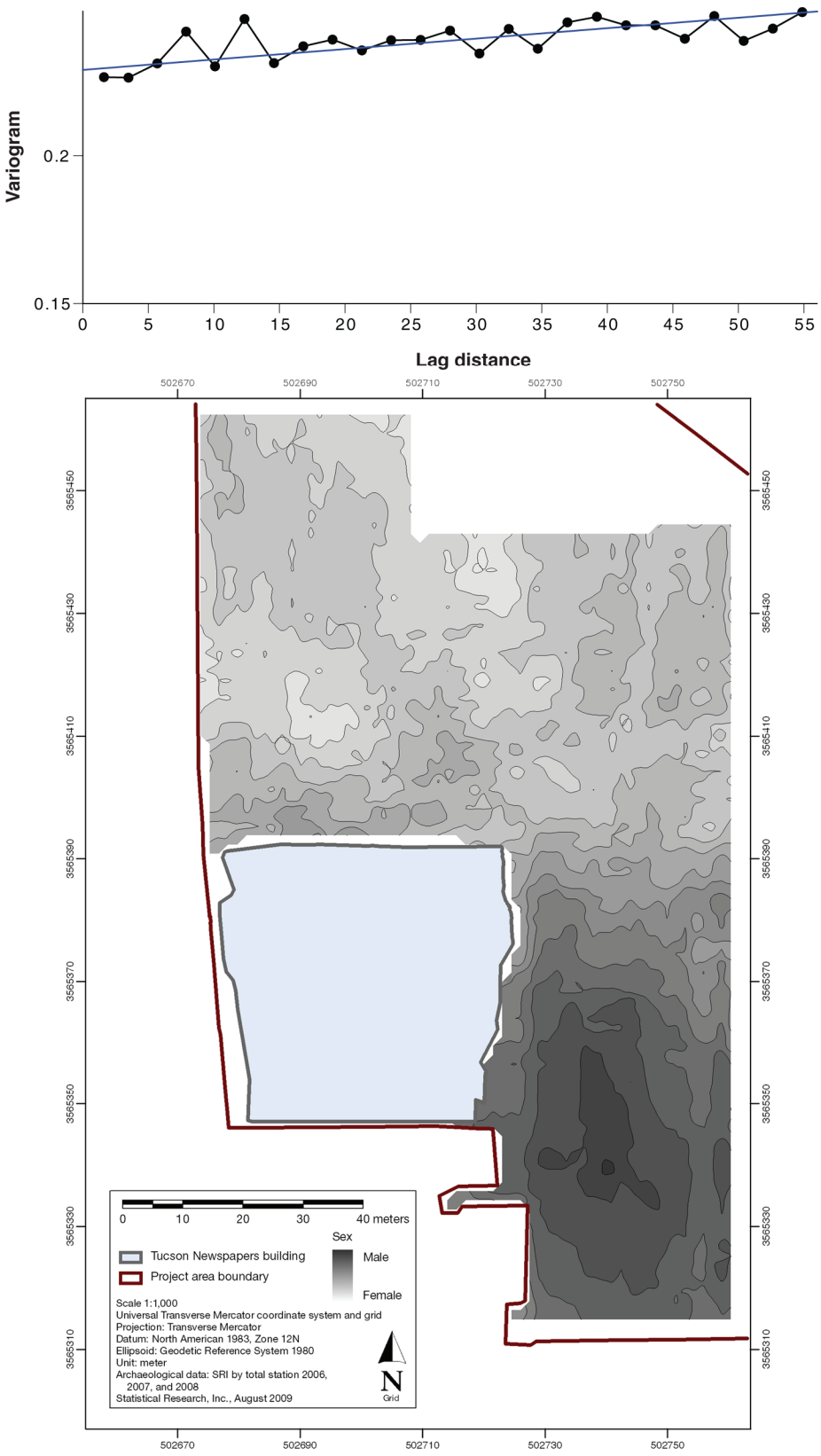


Figure 128. Variogram demonstrating linear relationship and spatial correlation between sex and geographic location within the cemetery.

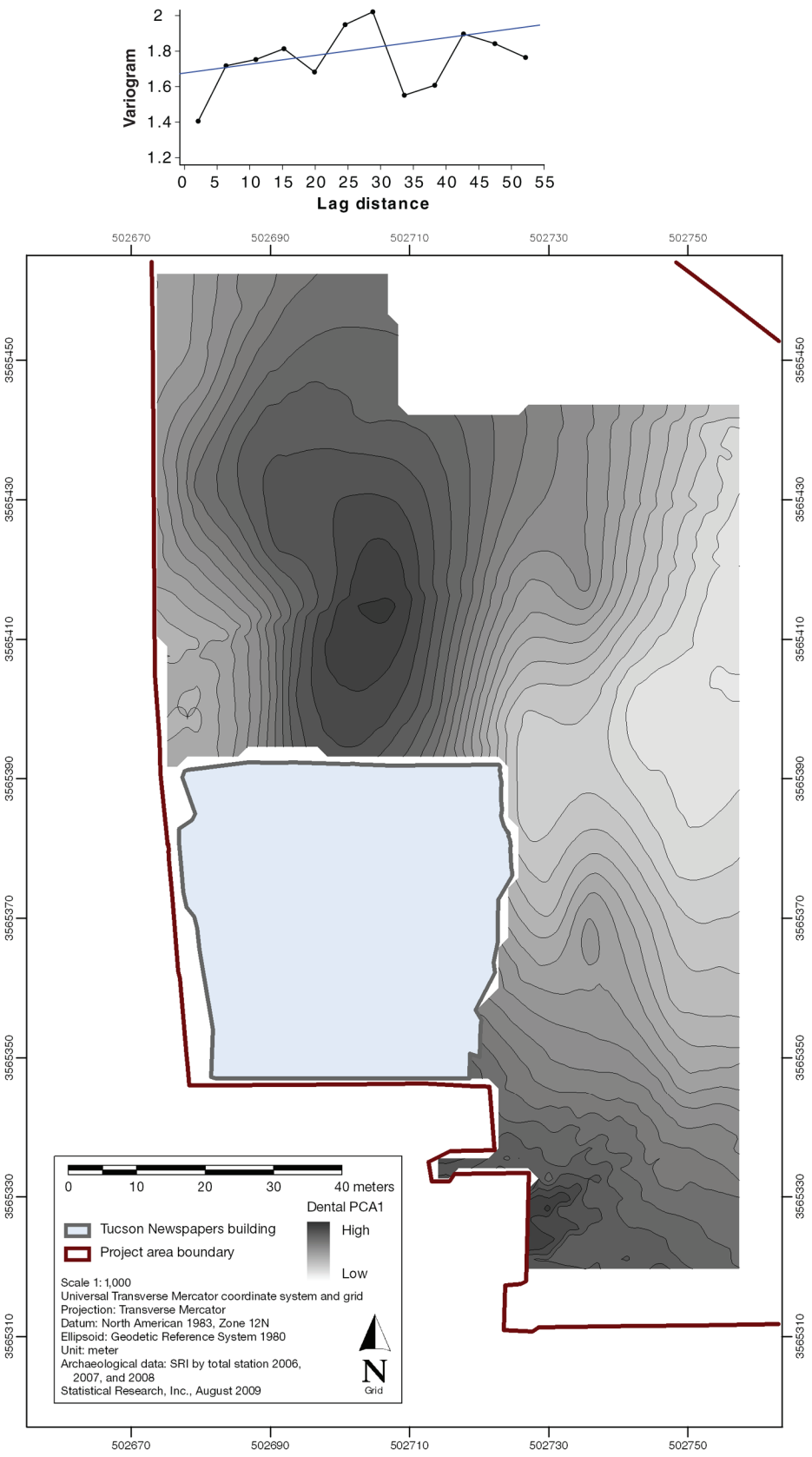


Figure 129. Variogram demonstrating linear relationship and spatial correlation between principal component analysis (PCA) of dental data and geographic location within the cemetery.

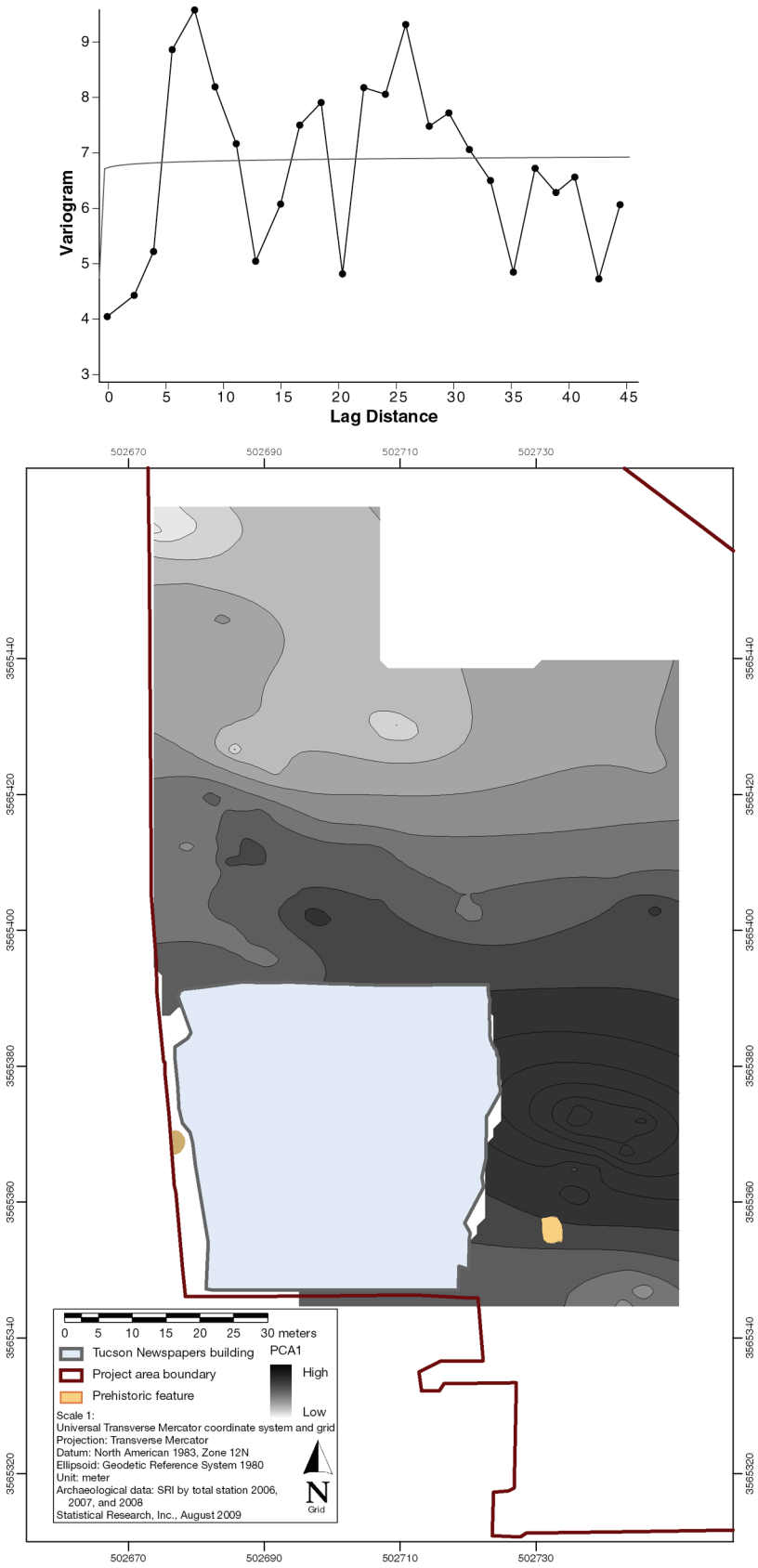
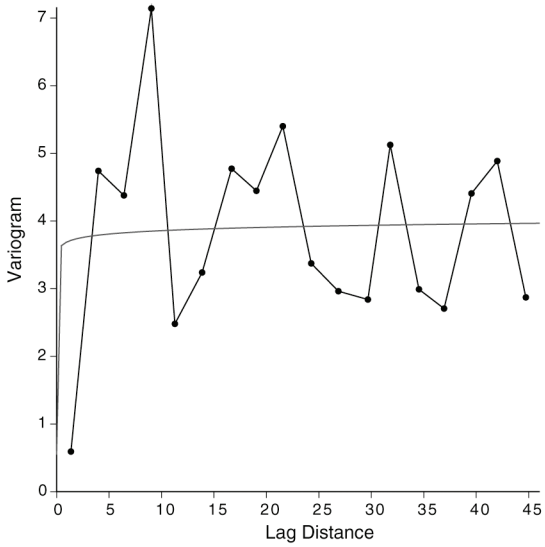


Figure 130. Variogram demonstrating linear relationship and spatial correlation between first principal component analysis (PCA) using cranial data and geographic location within the cemetery.



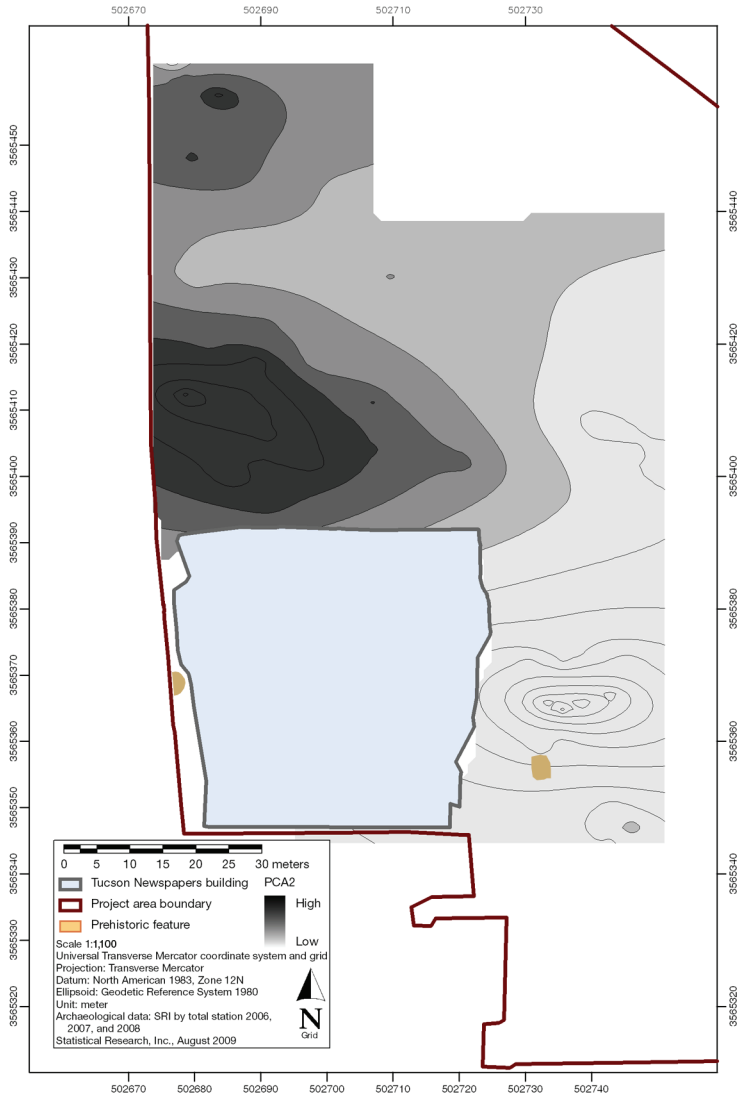


Figure 131. Variogram demonstrating linear relationship and spatial correlation between second principal component analysis (PCA) using cranial data and geographic location within the cemetery.

Table 112. Demographic Composition of Individuals Assessed for Biological Affinity in the Alameda-Stone Cemetery

Biological Group	Fetal	Infant	Child	Subadult	Young Adult	Middle Adult	Old Adult	Adult	Indeterminate	Total
African American						1				1
Apache				1		2				3
Euroamerican			19	10	55	26	7	5		122
Hispanic			28	11	97	77	33	4		250
Indeterminate[a]	54	309	83	7	81	81	36	47	1	699
Native American			3	2	17	13	5			40
Not determined[b]	13	61	42	7	26	9	3	105	5	271
Total	67	370	175	38	276	209	84	161	6	1,386

[a]Data were not conclusive.
[b]Little or no data.

Table 113. Dental Morphological Variants Collected During Data Analysis

Maxillary	Mandibular
Winging	Incisal shoveling
Incisal shoveling	Canine root number
Labial convexity of incisors	Premolar lingual cusp variation
Double-shoveling of incisors	Odontome
Interruption groove	Tome's root
Incisor variant	Deflecting wrinkle
Canine mesial ridge	Groove pattern
Distosagittal ridge	Cusp number
Odontome	Dental wear
Premolar root number	Protostylid
Carabelli's trait	Cusp 6
Hypocone	Cusp 7
Enamel extension	Distal trigonid crest
Cusp 5	Root number of molars
Root number–second molars	Congenital absence of central incisors
Peg-shaped third molar	
Congenital absence of lateral incisors	
Dental wear	

Table 114. Percentages of Dental Morphological Variants According to Biological Affinity in the Alameda-Stone Cemetery Sample

Variant	African American	Native American	Apache	Euroamerican	Hispanic	Yaqui
Carabelli's trait						
0	0	50.00	100.00	39.22	53.33	100.00
1	0	10.00	0.00	17.65	9.63	0.00
2	100	25.00	0.00	15.69	13.33	0.00
3	0	0.00	0.00	3.92	11.11	0.00
4	0	15.00	0.00	11.77	4.44	0.00
5	0	0.00	0.00	3.92	3.70	0.00
6	0	0.00	0.00	3.92	2.96	0.00
7	0	0.00	0.00	3.92	1.48	0.00
Congenital absence						
0	100	88.46	33.33	80.30	86.93	100.00
1	0	11.54	66.67	19.70	13.07	0.00
Cusp number						
3	0	6.67	0.00	0.00	0.00	0.00
4	100	20.00	100.00	22.45	23.73	0.00
5	0	53.33	0.00	49.00	54.24	0.00
6	0	20.00	0.00	26.53	19.49	100.00
7	0	0.00	0.00	2.04	1.70	0.00
8	0	0.00	0.00	0.00	0.85	0.00
Deflecting wrinkle						
0	0	50.00	0.00	62.50	56.67	0.00
1	0	50.00	0.00	6.25	6.67	0.00
2	0	0.00	0.00	12.50	20.00	0.00
3	0	0.00	0.00	18.80	16.67	0.00
Distal accessory ridge						
0	0	20.00	0.00	38.89	54.76	0.00
1	0	40.00	0.00	16.67	9.52	0.00
2	0	20.00	0.00	33.33	26.19	0.00
3	0	20.00	0.00	5.56	9.52	0.00
5	0	0.00	0.00	5.56	0.00	0.00
Distal trigonid crest						
0	100	93.75	100.00	96.49	97.87	100.00
1	0	6.25	0.00	3.51	2.13	0.00
Distosagittal ridge						
0	100	100.00	100.00	100.00	100.00	100.00
Double shoveling						
0	100	56.52	50.00	54.24	44.94	33.33
1	0	26.09	0.00	38.98	30.38	33.33
2	0	13.04	50.00	6.78	19.62	33.33

Variant	African American	Native American	Apache	Euroamerican	Hispanic	Yaqui
3	0	4.35	0.00	0.00	3.80	0.00
5	0	0.00	0.00	0.00	1.27	0.00
Enamel extension						
0	100	50.00	50.00	76.60	71.74	0.00
1	0	18.18	0.00	12.77	7.97	50.00
2	0	18.18	50.00	4.26	11.59	0.00
3	0	13.64	0.00	6.38	8.70	50.00
Entoconulid						
0	100	82.35	100.00	74.55	80.45	50.00
1	0	5.88	0.00	7.27	6.02	0.00
2	0	5.88	0.00	12.73	3.76	50.00
3	0	5.88	0.00	5.46	5.26	0.00
4	0	0.00	0.00	0.00	3.01	0.00
5	0	0.00	0.00	0.00	1.50	0.00
Groove pattern						
0	0	45.00	66.67	28.07	34.00	0.00
1	100	55.00	33.33	71.93	66.00	100.00
Hypocone						
0	0	10.00	0.00	2.00	4.20	0.00
1	0	0.00	0.00	0.00	0.70	0.00
2	0	10.00	0.00	2.00	2.10	0.00
3	0	10.00	0.00	8.00	6.99	0.00
3.5	0	0.00	0.00	6.00	0.70	0.00
4	100	40.00	100.00	52.00	48.25	100.00
5	0	30.00	0.00	30.00	37.06	0.00
Hypoconulid						
0	100	18.75	100.00	25.00	22.40	50.00
1	0	0.00	0.00	0.00	3.20	0.00
2	0	0.00	0.00	1.92	8.00	0.00
3	0	6.25	0.00	19.23	11.20	0.00
4	0	43.75	0.00	21.15	30.40	50.00
5	0	31.25	0.00	32.69	24.80	0.00
Interruption groove						
0	0	55.00	0.00	56.60	62.86	0.00
1	0	45.00	0.00	43.40	37.14	100.00
Labial curvature						
0	0	54.55	0.00	28.07	42.11	66.67
1	0	9.09	0.00	33.33	23.03	33.33
2	100	22.73	0.00	22.81	25.00	0.00
3	0	9.09	0.00	12.28	8.55	0.00

continued on next page

Variant	African American	Native American	Apache	Euroamerican	Hispanic	Yaqui
4	0	4.55	0.00	3.51	1.32	0.00
Lingual cusps						
-1	0	0.00	0.00	4.35	3.88	0.00
0	0	38.46	0.00	43.48	36.89	50.00
1	0	15.39	0.00	8.70	7.77	0.00
2	0	7.69	100.00	17.39	10.68	0.00
3	100	15.39	0.00	15.22	22.33	0.00
4	0	23.08	0.00	6.52	9.71	0.00
5	0	0.00	0.00	2.17	5.84	0.00
9	0	0.00	0.00	2.17	2.91	50.00
Mesial cusp						
0	100	68.75	100.00	64.44	73.33	66.67
1	0	31.25	0.00	35.56	26.67	33.33
Mesial ridge						
0	0	100.00	0.00	91.67	91.78	0.00
1	0	0.00	0.00	2.78	5.48	0.00
2	0	0.00	0.00	2.78	2.74	0.00
3	0	0.00	0.00	2.78	0.00	0.00
Metacone						
2	0	0.00	0.00	1.75	0.63	0.00
3	0	13.64	0.00	5.26	3.75	0.00
4	0	54.55	100.00	49.12	56.25	33.33
5	100	31.82	0.00	43.86	39.38	66.67
Metaconule						
0	100	80.00	100.00	70.59	77.70	66.67
1	0	10.00	0.00	9.80	4.32	0.00
2	0	0.00	0.00	7.84	10.07	33.33
3	0	5.00	0.00	5.88	4.32	0.00
4	0	5.00	0.00	0.00	0.72	0.00
5	0	0.00	0.00	5.88	2.88	0.00
Metaconulid						
0	100	94.12	100.00	92.45	89.66	100.00
1	0	0.00	0.00	0.00	4.83	0.00
2	0	0.00	0.00	3.77	2.07	0.00
3	0	0.00	0.00	3.77	2.76	0.00
4	0	5.88	0.00	0.00	0.69	0.00
Odontome						
0	100	100.00	100.00	100.00	99.38	100.00
1	0	0.00	0.00	0.00	0.62	0.00
Parastyle						
0	100	90.48	66.67	92.86	94.34	100.00

Variant	African American	Native American	Apache	Euroamerican	Hispanic	Yaqui
1	0	4.76	33.33	0.00	1.89	0.00
2	0	0.00	0.00	5.36	1.26	0.00
3	0	0.00	0.00	0.00	1.26	0.00
4	0	4.76	0.00	0.00	0.00	0.00
5	0	0.00	0.00	1.79	1.26	0.00
Peg tooth molar						
0	100	85.71	100.00	90.39	82.14	100.00
1	0	9.52	0.00	5.77	14.29	0.00
2	0	4.76	0.00	3.85	3.57	0.00
Protostylid						
0	0	56.25	50.00	68.52	55.22	0.00
1	100	37.50	50.00	16.67	35.08	100.00
2	0	6.25	0.00	1.85	2.99	0.00
3	0	0.00	0.00	7.41	2.24	0.00
4	0	0.00	0.00	0.00	1.49	0.00
5	0	0.00	0.00	3.70	1.49	0.00
6	0	0.00	0.00	1.85	0.75	0.00
7	0	0.00	0.00	0.00	0.75	0.00
Radical number						
1	0	3.85	0.00	6.35	7.19	33.33
2	0	30.77	0.00	23.81	23.95	0.00
3	100	30.77	50.00	46.03	43.11	33.33
4	0	30.77	50.00	22.22	24.55	33.33
5	0	3.85	0.00	1.59	1.20	0.00
Root number						
1	0	20.00	0.00	13.12	29.75	33.33
2	100	28.00	0.00	36.07	20.25	33.33
3	0	48.00	100.00	49.18	49.37	33.33
4	0	4.00	0.00	1.64	0.63	0.00
Shoveling						
0	0	20.00	0.00	42.22	36.61	0.00
1	0	13.33	100.00	20.00	16.96	50.00
2	0	20.00	0.00	28.89	19.64	0.00
3	0	0.00	0.00	0.00	14.29	0.00
4	0	20.00	0.00	6.67	9.82	0.00
5	0	0.00	0.00	2.22	2.68	50.00
6	0	20.00	0.00	0.00	0.00	0.00
7	0	6.67	0.00	0.00	0.00	0.00
Tricuspid (premolars)						
0	100	100.00	100.00	100.00	100.00	100.00

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Variant	African American	Native American	Apache	Euroamerican	Hispanic	Yaqui
Tuberculum dentale						
0	0	52.63	0.00	55.77	51.49	100.00
1	0	5.26	0.00	1.92	9.70	0.00
2	0	0.00	0.00	17.31	12.69	0.00
3	0	31.58	0.00	13.46	9.70	0.00
4	0	5.26	0.00	11.54	8.21	0.00
5	0	0.00	0.00	0.00	6.72	0.00
6	0	5.26	0.00	0.00	1.49	0.00
Variant form						
0	100	95.83	100.00	98.28	97.45	66.67
1	0	4.17	0.00	1.72	0.64	0.00
2	0	0.00	0.00	0.00	0.64	0.00
3	0	0.00	0.00	0.00	0.64	33.33
4	0	0.00	0.00	0.00	0.64	0.00
Winging						
1	0	0.00	0.00	2.17	1.48	0.00
2	0	7.14	0.00	4.35	2.96	0.00
3	100	92.86	0.00	91.30	92.59	100.00
4	0	0.00	0.00	2.17	2.96	0.00

Table 115. Spearman Correlation Matrix of Dental Morphological Variants in the Alameda-Stone Cemetery Sample

	Sex	Carabelli's Trait	Congenital Absence	Cusp Number	Distal Trigonid Crest	Double Shoveling	Enamel Extension	Entoconulid	Groove Pattern	Hypoconulid	Interruption Groove	Labial Curvature	Metacone	Peg Tooth	Root Number	Shoveling	Winging
Sex																	
Carabelli's trait	–0.068																
Congenital absence	0.290	0.043															
Cusp number	–0.084	0.221	–0.147														
Distal trigonid crest	–0.088	0.201	–0.051	–0.305													
Double shoveling	–0.192	0.123	–0.292	0.277	0.315												
Enamel extension	–0.249	0.130	0.123	0.183	0.104	0.152											
Entoconulid	–0.098	0.316	–0.160	0.846	–0.099	0.315	0.191										
Groove pattern	0.017	–0.093	–0.026	–0.186	0.079	0.048	–0.271	–0.364									
Hypoconulid	–0.179	0.144	–0.123	0.629	–0.273	0.196	0.152	0.449	–0.010								
Interruption groove	0.242	–0.193	–0.106	0.071	0.226	0.274	0.235	0.033	–0.154	–0.108							
Labial curvature	0.143	–0.059	–0.081	–0.042	–0.220	–0.404	–0.110	–0.035	–0.018	–0.074	–0.212						
Metacone	0.037	–0.223	–0.014	–0.082	–0.152	0.084	0.048	–0.165	0.055	0.061	–0.038	0.093					
Peg tooth	0.064	–0.098	0.340	–0.268	–0.107	–0.030	0.072	–0.224	–0.008	–0.184	–0.063	–0.042	–0.062				
Root number	0.120	0.199	0.060	–0.314	0.185	–0.125	–0.021	–0.164	–0.043	–0.031	–0.197	0.101	–0.129	0.285			
Shoveling	–0.261	0.071	–0.191	0.390	0.208	0.810	0.298	0.395	0.007	0.364	0.193	–0.250	–0.098	–0.005	–0.133		
Winging	0.016	0.060	0.067	0.179	0.041	–0.188	–0.107	0.083	–0.194	0.038	–0.040	–0.124	–0.168	–0.024	0.005	–0.252	

Table 116. Demographic Data for Individuals Used in the Dental Morphology Study of the Alameda-Stone Cemetery Sample, by Biological Group and Sex

Age Group	African American		Native American		Apache		Euroamerican		Hispanic		Indeterminate		Yaqui		Total	
	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female
Young adult	—	—	—	—	—	—	2	—	2	—	13	8	—	—	17	8
Middle adult	1	—	5	7	—	2	19	7	48	28	40	31	—	2	113	77
Old adult	—	—	4	1	—	—	7	—	19	12	19	14	—	—	49	27
Adult	—	—	7	9	—	—	34	13	41	49	27	22	—	—	109	93
Total	1	—	16	17	—	2	62	20	110	89	99	75	—	2	288	205

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Table 117. Mahalanobis Distances (D) between Each Pair of Crania

Joint Courts Complex	Joint Courts Complex																			
	7900	7509	10136	13520	689	727	697	5197	3280	688	7615	7573	7573	13514	13514	7981	10149	549	7924	10163	13562
7509	2.734	0																			
10136	4.788	4.386	0																		
13520	3.435	4.32	3.214	0																	
689	2.817	2.544	4.477	3.776	0																
727	3.561	3.974	5.281	4.072	2.475	0															
697	4.602	4.692	3.638	2.067	3.792	4.526	0														
5197	4.713	4.398	4.401	4.569	4.452	6.154	4.578	0													
3280	4.773	4.304	6.357	5.351	2.75	3.624	4.882	5.247	0												
688	5.271	4.516	**6.598**	6.494	3.943	5.455	6.253	5.748	3.787	0											
7615	3.646	3.839	4.703	4.364	3.13	3.46	5.058	4.09	3.969	4.548	0										
7573	3.744	3.416	3.298	3.657	3.195	4.064	3.905	4.27	5.141	4.967	3.325	0									
7573	4.573	3.468	4.366	5.095	3.701	5.028	4.871	4.383	5.305	4.605	4.107	1.927	0								
13514	4.659	3.969	4.279	4.643	3.394	4.536	4.715	5.001	4.302	4.087	4.079	3.851	4.582	0							
13514	4.492	3.633	4.276	4.508	2.999	3.626	4.649	5.143	3.849	4.399	3.513	3.831	4.557	1.512	0						
7981	5.398	4.095	5.397	5.697	3.796	5.117	5.33	6.132	5.163	4.529	5.382	4.393	4.405	3.398	3.349	0					
10149	4.521	3.21	4.168	4.51	3.655	4.703	4.325	4.442	5.295	5.553	4.289	2.159	2.166	4.311	4.082	3.965	0				
549	3.362	3.75	4.399	3.573	3.851	3.514	4.411	5.945	5.871	6.212	4.264	3.233	4.112	5.204	4.584	4.931	3.839	0			
7924	3.842	4.761	5.217	3.395	3.921	3.707	4.441	5.182	4.569	**6.759**	4.018	5.218	6.541	4.653	4.178	6.308	5.625	5.202	0		
10163	3.851	3.878	3.655	3.208	4.04	5.339	3.597	2.883	5.031	5.904	4.442	4.043	4.84	3.907	4.243	5.881	4.393	5.318	3.874	0	
13562	4.014	4.325	4.179	2.975	4.288	5.581	3.294	3.788	5.226	5.775	5.02	4.614	5.463	3.882	4.331	5.391	4.976	5.19	4.095	2.05	0
5197	4.997	4.976	5.115	5.037	4.853	6.54	5.111	1.021	5.513	5.914	4.27	4.832	4.914	5.573	5.713	**6.566**	5.113	6.359	5.509	3.646	4.269
695	5.071	4.859	3.913	3.397	4.108	4.167	2.773	5.581	4.836	6.235	5.169	4.298	5.055	4.434	4.055	5.621	4.824	4.373	4.988	4.161	4.246
3117	3.749	4.317	5.675	4.824	3.031	3.995	5.222	4.754	4.213	4.241	2.768	4.008	4.502	4.797	4.513	4.733	4.821	4.515	4.902	5.515	5.383
3287	**6.661**	6.356	4.405	5.044	6.073	**7.679**	4.745	4.547	**7.156**	**7.278**	**6.662**	5.672	6.447	5.028	5.841	6.238	5.944	**7.505**	6.15	4.129	4.027
7912	4.322	4.095	4.376	3.662	3.546	4.498	3.579	3.958	3.975	5.788	4.432	4.3	5.12	3.43	3.502	5.541	4.368	5.535	3.292	2.034	3.061
7945	3.414	3.691	4.806	4.602	3.074	3.745	5.284	3.837	4.185	4.772	1.588	3.355	3.973	3.814	3.367	5.182	4.07	4.365	4.06	4.092	4.808
3038	5.239	5.34	4.211	3.864	5.442	6.312	4.674	5.329	**6.843**	**6.82**	5.525	5.057	6.314	4.253	4.655	5.223	5.442	5.566	4.735	4.301	3.379
690	4.52	4.191	4.486	3.504	4.238	5.226	3.082	4.697	5.129	5.557	5.244	4.268	4.652	4.259	4.236	4.582	4.238	4.097	5.284	3.708	2.713
13566	5.301	5.056	4.391	4.655	4.746	5.412	5.093	3.21	5.324	**6.716**	3.447	4.551	5.387	4.624	4.293	6.455	4.722	6.036	3.88	3.551	4.728
592	6.478	5.762	5.193	5.584	5.128	5.828	4.474	**6.62**	6.059	6.1	**6.562**	4.246	4.158	5.247	5.414	5.481	4.589	5.512	**7.544**	5.797	6.016
7768	4.716	4.358	5.075	4.92	3.493	4.451	5.04	3.711	4.094	5.797	3.349	4.198	4.796	3.963	3.608	5.288	4.039	5.745	3.713	3.899	4.891
7589	4.379	4.65	4.781	3.419	3.269	2.542	3.613	5.668	3.955	5.877	3.833	3.948	5.213	3.617	2.92	4.907	4.367	4.073	3.104	4.419	4.477
7589	4.75	4.721	5.511	4.538	3.251	2.976	4.646	5.533	3.202	4.931	3.17	4.468	5.352	3.348	2.432	4.501	4.797	4.733	3.571	4.998	4.9
3248	4.612	3.988	5.775	5.094	4.053	5.253	5.296	3.944	4.086	4.39	3.536	4.641	4.959	3.716	3.608	4.608	4.391	5.529	4.486	4.136	3.97
10144	**6.854**	5.918	**6.924**	**6.847**	5.408	**6.957**	5.915	6.405	**6.559**	**6.703**	**7.142**	5.182	4.825	6.188	6.476	4.764	4.17	**6.89**	**7.746**	**6.668**	**6.801**
3286	**7.252**	6.278	4.955	5.622	6.264	**7.212**	5.234	5.643	**7.284**	**8.304**	**6.79**	5.562	6.334	5.411	5.573	6.038	4.77	**7.235**	5.999	5.048	5.557
3286	**7.002**	5.825	5.56	5.947	5.792	**7.023**	5.523	4.956	6.464	**7.268**	5.996	5.458	5.911	5.341	5.397	5.481	4.536	**7.218**	5.963	5.326	5.668
3288	**6.731**	5.539	5.35	6.165	5.309	5.893	5.956	5.646	5.728	**7.14**	5.551	5.405	5.901	4.069	3.717	5.562	4.732	**6.869**	5.34	4.916	5.85
7931	6.184	5.209	5.978	5.786	3.944	5.003	4.909	5.24	3.853	5.436	4.988	4.837	4.986	3.952	3.663	4.022	4.145	6.265	5.393	5.312	5.523
576	5.893	5.374	6.499	5.328	5.002	6.069	4.645	5.435	4.958	5.871	5.978	5.081	5.455	4.622	4.996	5.288	4.411	6.412	5.563	4.488	4.312
3241	**6.604**	6.189	**7.579**	**6.69**	5.159	6.397	6.211	5.562	4.351	4.747	5.267	6.189	6.321	4.961	5.053	5.091	5.961	**7.322**	6.063	6.175	5.665
3231	6.425	5.445	**7.612**	**7.031**	5.359	6.534	**6.791**	6.078	5.609	5.871	5.831	6.065	5.934	5.464	5.227	4.162	4.959	**6.609**	6.522	**6.63**	6.233
597	**7.838**	**8.03**	**7.21**	5.976	**7.427**	**7.7**	6.035	**7.744**	**8.29**	**9.071**	**7.627**	**6.943**	**8.171**	**6.809**	**6.923**	**6.755**	**6.734**	**7.346**	6.401	**7.132**	6.291

Table 117. Mahalanobis Distances (D) between Each Pair of Crania (*continued*)

Joint Courts Complex	Joint Courts Complex																					
	5197	695	3117	3287	7912	7945	3038	690	13566	592	7768	7589	7589	3248	10144	3286	3286	3288	7931	576	3241	3231
5197	0																					
695	6.265	0																				
3117	4.592	6.148	0																			
3287	4.99	6.31	**6.786**	0																		
7912	4.692	3.64	5.595	4.866	0																	
7945	4.071	5.229	3.167	**6.578**	4.044	0																
3038	5.698	5.934	5.676	3.821	5.017	5.656	0															
690	5.222	3.277	5.476	5.647	4.048	5.096	4.676	0														
13566	3.676	5.495	5.218	5.236	3.544	3.32	5.185	5.679	0													
592	**7.305**	3.628	**6.986**	**6.99**	5.405	6.441	**7.425**	4.665	**7.245**	0												
7768	4.125	5.458	4.376	5.645	3.116	2.711	5.648	5.553	2.395	**6.639**	0											
7589	6.166	3.289	4.72	6.451	3.266	3.858	5.183	4.236	4.495	5.261	3.805	0										
7589	5.844	4.396	3.908	**6.792**	3.968	3.328	5.421	4.658	4.386	6.137	3.541	2.024	0									
3248	4.143	5.891	4.028	5.885	4.148	3.503	4.628	4.327	4.076	**7.101**	3.683	4.557	3.581	0								
10144	**6.786**	**7.219**	6.271	6.489	6.306	**6.776**	**7.246**	6.38	**7.316**	5.777	5.811	**6.563**	**6.852**	6.441	0							
3286	6.349	6.36	**7.455**	4.021	4.78	**6.645**	4.873	6.202	4.782	**6.952**	4.887	5.739	6.369	5.981	5.674	0						
3286	5.424	**6.961**	6.296	4.371	5.16	6.071	4.897	6.245	4.456	**7.513**	4.366	5.931	5.87	4.749	5.218	2.481	0					
3288	6.401	5.512	**6.977**	6.019	3.761	5.023	6.176	6.092	3.868	6.493	3.359	4.558	4.693	5.201	**6.633**	3.988	4.544	0				
7931	5.673	5.258	5.104	6.012	4.086	4.672	6.25	5.171	4.773	5.563	3.188	3.93	3.475	4.235	4.507	4.932	4.302	3.683	0			
576	5.934	5.495	6.199	5.769	3.811	5.731	5.647	4.279	5.766	5.639	4.868	4.581	4.921	4.08	4.87	5.178	4.957	5.357	3.948	0		
3241	5.474	**7.132**	4.578	**6.624**	5.675	5.306	6.198	5.769	5.851	**7.717**	4.843	5.566	4.256	3.163	6.154	**6.942**	5.379	6.412	3.811	4.453	0	
3231	6.182	**7.658**	5.104	**7.34**	6.264	5.516	6.254	5.815	6.296	**8.023**	5.033	5.995	5.038	3.494	5.303	6.52	4.998	6.14	4.126	4.827	3.376	0
597	**7.968**	**7.751**	**7.255**	6.128	**6.98**	**7.798**	4.557	**6.667**	**7.071**	**8.681**	**6.994**	6.06	6.461	6.456	**7.097**	5.298	5.249	**7.425**	6.516	5.77	6.485	6.393

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Table 118. Number of Cases of a Significant Difference per Cranium in the Alameda-Stone Cemetery Sample

Rank	Grave Pit No.	Significant Differences	Percent Total
1	597	28	13.08
2	10144	20	9.35
3	592	15	7.01
4	3287	12	5.61
5	688	10	4.67
6	3286	10	4.67
7	549	8	3.74
8	3241	8	3.74
9	3231	8	3.74
10	7900	7	3.27
11	3286	6	2.80
12	3288	6	2.80
13	10136	5	2.34
14	727	5	2.34
15	3280	5	2.34
16	7615	5	2.34
17	695	5	2.34
18	3117	5	2.34
19	5197	4	1.87
20	7945	4	1.87
21	3038	4	1.87
22	13566	4	1.87
23	13520	3	1.40
24	7924	3	1.40
25	10163	3	1.40
26	5197	2	0.93
27	7981	2	0.93
28	7768	2	0.93
29	7589	2	0.93
30	7509	1	0.47
31	689	1	0.47
32	697	1	0.47
33	7573	1	0.47
34	7573	1	0.47
35	13514	1	0.47
36	13514	1	0.47
37	10149	1	0.47

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Rank	Grave Pit No.	Significant Differences	Percent Total
38	13562	1	0.47
39	7912	1	0.47
40	690	1	0.47
41	7589	1	0.47
42	3248	1	0.47
43	7931	0	0.00
44	576	0	0.00
Total		214	100.00

Table 119. Distance Matrix Calculated during the Canonical Discriminant Analysis of the Alameda-Stone Cemetery Sample

Biological Group	Euroamerican	Hispanic	Native American
Euroamerican	0		
Hispanic	6.555	0	
Native American	1.917	0.889	0

All distances are significant at the $p < 0.001$ level.
Wilks' $\lambda = 0.5731$, $df = 5, 2, 58$
Approx. $F = 3.4661$, $df = 10, 108$
Variables = bijugal breadth, nasal breadth, cheek height, bistephanic breadth, and parietal chord.

Table 120. Cross-Validated Classification Matrix from Discriminant-Function Analysis of the Alameda-Stone Cemetery Sample

Biological Group	Euroamerican	Hispanic	Percent Correct
Euroamerican	8	2	80
Hispanic	7	38	76
Total	15	40	78

Table 121. Predicted Biological Affinity, Mahalanobis Distances, and Posterior Probabilities from the Discriminant-Function Analysis of the Alameda-Stone Cemetery Sample

Grave Pit No.	Predicted	Native American (n = 3)	Nineteenth-Century African American (n = 1)	Nineteenth-Century Euroamerican (n = 8)	Hispanic (n = 32)
549	Hispanic	24.856	18.636	28.308	15.777 (0.79638)
576	Hispanic	22.726	18.875	16.735	11.283 (0.90953)
592	nineteenth-century Euroamerican	36.340	31.731	25.255 (0.88362)	44.452
597	Hispanic	38.017	43.031	40.639	28.187 (0.99018)
688	Native American	28.152 (0.79633)	36.815	45.065	32.574
689	Hispanic	11.091	14.236	18.460	5.267 (0.91541)
690	Hispanic	27.775	24.415	23.477	16.003 (0.94633)
695	Hispanic	30.337	20.728	20.462	14.727 (0.90305)
697	Hispanic	13.311	16.426	15.666	9.125 (0.83063)
727	Hispanic	20.621	18.945	25.235	13.011 (0.919)
3038	Hispanic	16.376	24.989	20.080	13.485 (0.78251)
3117	Hispanic	22.548	31.888	37.021	16.631 (0.87876)
3231	Hispanic	32.785	34.479	35.755	22.11 (0.98862)
3241	Hispanic	36.885	45.013	45.283	25.52 (0.99431)
3248	Hispanic	22.485	25.661	23.378	13.333 (0.96053)
3280	Hispanic	25.296	29.148	30.840	17.171 (0.93868)
3286	Hispanic	24.276	21.596	16.468	16.206 (0.50885)
3286	nineteenth-century Euroamerican	22.492	18.398	10.43 (0.96756)	19.195
3287	Native American	19.562 (0.69007)	32.933	23.047	22.180
3288	nineteenth-century African American	32.343	13.184 (0.77449)	15.940	19.732
5197	Hispanic	19.386	28.003	24.088	17.786 (0.56432)
5197	Hispanic	30.956	40.103	34.286	22.095 (0.93314)
7509	Hispanic	15.776	14.494	17.186	8.811 (0.89225)
7573	nineteenth-century Euroamerican	12.339	17.401	9.092 (0.75479)	16.340
7573	nineteenth-century Euroamerican	20.643	24.589	14.384 (0.80971)	25.352

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Grave Pit No.	Predicted	Native American (n = 3)	Nineteenth-Century African American (n = 1)	Nineteenth-Century Euroamerican (n = 8)	Hispanic (n = 32)
7589	Hispanic	23.644	19.537	22.327	14.505 (0.30716)
7589	Hispanic	13.355	9.896	10.194	9.315 (0.61624)
7615	Hispanic	26.807	26.183	32.704	21.339 (0.6163)
7768	Hispanic	18.895	16.618	14.054	9.703 (0.68227)
7900	Hispanic	20.524	24.606	28.177	10.49 (0.97309)
7912	Hispanic	18.636	14.239	8.439	7.782 (0.4595)
7924	Hispanic	31.669	29.639	25.050	15.377 (0.6234)
7931	Hispanic	18.318	15.507	15.336	13.34 (0.51113)
7945	Hispanic	24.887	21.361	24.917	13.58 (0.79726)
7981	Native American	14.19 (0.55997)	15.444	23.407	17.276
10136	nineteenth-century Euroamerican	16.250	16.346	15.093 (0.41457)	23.360
10144	nineteenth-century Euroamerican	28.101	30.340	25.661 (0.41523)	26.787
10149	nineteenth-century Euroamerican	15.283	12.113	4.75 (0.93144)	13.564
10163	Hispanic	16.354	18.844	11.110	10.308 (0.49558)
13514	Hispanic	15.443	15.002	19.309	12.234 (0.42047)
13514	nineteenth-century Euroamerican	13.313	15.535	11.866 (0.67049)	12.642
13520	Hispanic	15.435	18.142	18.218	10.015 (0.86231)
13562	Hispanic	18.094	24.224	17.403	12.747 (0.50145)
13566	Hispanic	33.986	26.369	22.717	20.341 (0.53501)

Note: Numbers in parentheses are the posterior probabilities; they are presented only if they were significant and represented the group affiliation for that cranium.

Table 122. Nonmetric and Epigenetic Traits Collected during Analysis of the Alameda-Stone Cemetery Sample

Cranial	Mandibular	Postcranial
Metopic suture[a]	Mental foramen[a]	Atlas bridging[a]
Supraorbital structures[a]	Mandibular torus[a]	7th cervical vertebra accessory foramina[a]
Infraorbital suture[a]	Mylohyoid bridge[a]	Septal aperture[a]
Infraorbital foramina[a]	Chin shape[b]	5th metatarsal apophysis[a]
Zygomaticofacial foramina[a]	Lower border[b]	Os tibiale externum[a]
Parietal foramen[a]	Ascending ramus[b]	Os calcaneus[a]
Sutural bones[a]	Gonion[b]	Os trigonum[a]
Inca bone[a]		Os acromiale[a]
Condylar canal[a]		Tarsal coalition[ab]
Hypoglossal canal[a]		
Sagittal sulcus flexion[a]		
Foramen ovale[a]		
Foramen spinosum[a]		
Pterygo-spinous bridging[a]		
Pterygo-alar bridging[a]		
Tympanic dehiscence[a]		
Auditory exostoses[a]		
Mastoid foramen[a]		
Keeling[a]		
Postbregmatic depression[b]		
Inion hook[b]		
Base chord[b]		
Base angle[b]		
Venal etching[b]		
Suture complexity[b]		
Vault height[b]		
Os Japonicum[b]		
Orbit shape[b]		
Orbit projection[b]		
Zygomatic projection[b]		
Posterior zygomatic tubercle[b]		
Canine fossa[b]		
Prognathism[b]		
Nasal aperture width[b]		
Nasal depression[b]		
Nasal form[b]		

[a] Epigenetic.
[b] Nonmetric.

Table 123. Cross-Validated Classification Matrix from the Neural Network for the Alameda-Stone Cemetery Sample

Biological Group	African American	Hispanic	Euroamerican	Native American
African American	88.83	3.72	5.85	1.6
Hispanic	1.32	89.47	6.58	2.63
Euroamerican	2.35	9.41	88.24	0.00
Native American	2.25	3.37	4.49	89.89

Table 124. Demographic Data of Individuals Used in the Spatial Analysis of the Alameda-Stone Cemetery

Biological Group	Age Category	ASM	Cemetery Area 1	Cemetery Area 2	Cemetery Area 3	Cemetery Area 4	Cemetery Area 5	Total	Percent
African American									
	middle adult			1				1	0.24
Native American									
	child			1	2			3	0.72
	subadult				2			2	0.48
	young adult	1			14	2		17	4.09
	middle adult				9	4		13	3.13
	old adult			1	3	1		5	1.20
Apache									
	subadult	1						1	0.24
	middle adult	1			1			2	0.48
Euroamerican									
	child				18	1		19	4.57
	subadult	1		1	7	1		10	2.40
	young adult	3	5	19	22	5	1	55	13.22
	middle adult	2		9	13	2		26	6.25
	old adult	1		2	4			7	1.68
	adult	1	3	1				5	1.20
Hispanic									
	child				20	7	1	28	6.73
	subadult			1	7	3		11	2.64
	young adult	8	3	12	53	13	8	97	23.32
	middle adult	8	1	14	47	4	3	77	18.51
	old adult			3	24	5	1	33	7.93
	adult		1		1	1	1	4	0.96
Total		27	13	65	247	49	15	416	100.00
Percent total		6.49	3.13	15.63	59.38	11.78	3.61		

Key: ASM = Arizona State Museum.

Table 125. Significant Component Loadings for the First Four Principal Components (PC) and the Percent of Variance Explained by Each for the Alameda-Stone Cemetery Sample

Dental Trait	Component Loadings			
	PC 1	PC 2	PC 3	PC 4
Carabelli's trait	-0.619		0.455	
Congential absence	0.668		0.467	
Metacone				0.734
Mesial cusp	-0.495		0.426	0.475
Peg tooth molar	0.744		0.431	
Shoveling		0.782		
Variant form		0.574	-0.433	
Winging		-0.601		0.483

Percent of Total Variance				
PC 1	PC 2	PC 3	PC 4	Total
21.377	18.217	15.033	13.326	67.953

Table 126. Significant Component Loadings for the First Four Principal Components (PC) and the Percent of Variance Explained by Each for the Alameda-Stone Cemetery Sample

Measurement	PC 1	PC 2	PC 3	PC 4
Bijugal breadth	0.737			
Bifrontal breadth	0.700			
Minimum frontal breadth	0.684	0.501		
Biauricalar breadth	0.626			
Upper facial breadth	0.621		0.532	
Nasion-prosthion height	0.617			
Biorbital breadth	0.586			
Nasal height	0.557			
Mastoid height	0.541		-0.441	
Orbit breadth	0.516			
Basion-nasion length	0.505	-0.564		
Maximum cranial breadth	0.467	0.627		
Basion-prosthion length		-0.540		0.495
Frontal chord			-0.812	
Minimum nasal breadth			0.525	
Nasal breadth				0.653
Bimaxillary breadth				0.637
Glabello-occipital length				
Parietal chord				
Nasio-occipital length		-0.442		
Orbit height				
Basion-bregma height				
Palate length		-0.413		
Interorbital breadth			0.462	

Percent of Total Variance Explained				
PC 1	PC 2	PC 3	PC 4	Total
32.178	24.356	11.691	7.278	75.503

CHAPTER 9

Juvenile Postcranial Morphology

Mitchell A. Keur

Introduction

Skeletal remains from juvenile individuals offer the investigator a number of useful lines of inquiry when attempting to reconstruct past lifeways. An examination of individuals who died during their growing years provides the physical evidence against which demographic models and mortality hypotheses may be compared. Attributes of juvenile growth, including rates of development and localized indicators of stress, illuminate the influence of environmental factors on genetic growth potentials. Finally, juvenile individuals are frequently more sensitive to disease and illness than mature individuals, and the distribution and pervasiveness of pathological conditions may be inferred by their lethality among the very young.

Unfortunately, the abundant potential of discoverable information is seldom reached because of the dearth of juvenile skeletal remains to examine. A tremendous amount of information about a population may be gleaned from examining juvenile remains, but juveniles are often poorly represented in skeletal collections. Just as younger individuals are more susceptible to environmental stressors and pathological conditions during life, they are also especially vulnerable to devastating taphonomic forces after death. Because of the lower fraction of durable inorganic material composing juvenile remains, even mild taphonomic conditions may obliterate substantial amounts of the juvenile contribution to the skeletal assemblage. The problem of juvenile underrepresentation in the skeletal sample frequently frustrates efforts by investigators to establish a complete picture of the population under study (see Guy et al. 1997; Hoppa 2002; Paine and Harpending 1998). In short, the segment of the population best situated to display the effects of environmental influence often do not adequately or completely appear in the skeletal record.

The skeletal assemblage from the Alameda-Stone cemetery comprised nearly 1,400 individuals interred in Tucson, Arizona, in the mid- to late nineteenth century. Of these, nearly one-half (n = 638) were estimated, by skeletal and dental analyses, to be juvenile, or under the age of 18 at death. Additionally, bone preservation for these juvenile individuals was generally good, providing for remarkable completeness in individual sets of remains (Figure 132). Good preservation and a large sample size from the Alameda-Stone cemetery afforded investigators a unique opportunity to explore demographic, environmental, developmental, and pathological characteristics of a past population with greater depth and resolution than are possible in most osteological investigations.

This chapter evaluates and interprets the rich set of data for juvenile individuals from the Alameda-Stone cemetery. The fundamental characteristics of juvenile growth and development are discussed, drawing from both skeletal and dental observations, followed by an examination of extrinsic factors affecting development, such as nutritional deficit and pathological conditions. Analytical methods are described, as well as the observed characteristics of divergent skeletal and dental development, both specific to the individual and in comparison to expected patterns.

Observations from the Alameda-Stone cemetery skeletal sample follow. These observations include the attributes of the applicable data set and the methods employed to analyze these data. The general composition of the juvenile sample was examined using maximum lengths of three long bones (humerus, femur, and tibia) to infer developmental rates, and frequencies of skeletal markers of childhood stress across the burial population. Finally, intra- and intercemetery comparisons are drawn to interpret spatial and demographic details of the

Alameda-Stone cemetery sample, as well as to illuminate meaningful similarities to, or differences from, other equivalent burial populations.

Basic Juvenile Growth and Development

Human growth from conception to maturity is among the most completely documented sequences in science (see Scheuer and Black 2000). An exhaustive description of human skeletal development from conception to maturation is not appropriate for the present discussion. Some details, however, warrant discussion, especially as they apply to observable differences in growth patterns between individuals and populations. Specifically, long-bone development and growth, and dental development and eruption, are of paramount concern to the present discussion.

Any discussion of development at a certain age dilutes the perspective of growth as a dynamic process. Indeed, even the event of birth itself is not reflected by indicators of skeletal development; growth progresses before, during, and after birth, and the event leaves no skeletal markers (Keur 2005:12). Therefore, skeletal and dental growth are described in terms of developmental attributes that occur during a prescribed period, and not in a discontinuous, stepwise fashion.

Bone development roughly falls into two categories: enchondral and intramembranous (Scheuer and Black 2000:18). The former refers to the ossification of cartilaginous tissues, and the latter is defined by ossification of mesenchymal connective tissues. The primary focus of the current discussion is enchondral growth, as it is the basis of long-bone diaphyseal lengthening and therefore the measure of juvenile growth. Intramembranous growth will be discussed later in this chapter with regard to its role in the formation of markers of childhood stress, such as cribra orbitalia, porotic hyperostosis, and periosteal bone infection (see Ortner 2003).

Enchondral bone growth is characterized by cartilaginous precursors to bone formation. Models of enchondral growth are referred to as cartilaginous models. Each cartilaginous model approximates the developing bone in shape and form. During the process of enchondral bone growth, specific cartilaginous loci begin to ossify, replacing cartilage with bone. This begins at the primary center of ossification, in the diaphysis, or shaft, in the case of long bones. Osteogenesis in primary centers of long bones begins during the embryonic and fetal periods of growth (Scheuer and Black 2000:18). Secondary centers of ossification later develop in two or more epiphyses. Regarding the elements under consideration in this discussion (humerus, femur, and tibia), secondary centers of ossification typically do not appear in the developmental sequence until around the time of birth (Scheuer and Black 2000). Between the diaphysis and the epiphyses is the metaphysis, which permits longitudinal growth without the biomechanical difficulties associated with large areas of cartilage in weight-bearing structures. The metaphysis is a small region of chondrogenic tissue that pushes the epiphyses from the diaphysis via new cartilage, while ossifying the previously produced cartilage. The result is growth in length while maintaining the structural strength of an almost completely ossified element. Growth from the ossifying cartilage produced by the metaphysis continues throughout childhood. Maturation of the element is complete when the metaphysis no longer produces new cartilage, and the remaining cartilage is ossified, joining the epiphyses to the diaphysis. The rate and sequence of epiphyseal development and fusion are well documented for each long bone and serve as one mechanism by which skeletal biologists estimate the age at death of immature individuals.

Intramembranous growth is responsible for appositional bone growth—the formation of new layers of bone over existing layers. In long bones, this generally translates to expansion in the diameter rather than length of a bone. Because this examination is limited to longitudinal measures of long bones in juvenile individuals, normal appositional growth is not of substantial concern. It is, however, important to the expression of pathological conditions discussed below. The mechanism of intramembranous growth, therefore, warrants some description.

The principal actor in intramembranous bone growth is the periosteum. Periosteum covers nearly every bone surface and is composed of an outer layer of dense connective tissue surrounding a network of more-elastic fibers (Gray 1966:283). Between the periosteum and the cortical bone surface are a number of osteoblastic cells responsible for appositional growth in juveniles and for bone remodeling in individuals of all ages. It is in the active remodeling process that certain pathological conditions may impart skeletal symptoms.

The periosteum is highly vascular, especially in juvenile individuals (Gray 1966:283). Because of this vascularity, the periosteum responds to systemic conditions more rapidly and substantially than does cortical bone. Indeed, bone maintenance in the form of remodeling is mediated by hormonal triggers for osteoclastic and osteoblastic activity within the periosteum. In a sense, the vascularity of the periosteum leads to a greater inclusion of conditions affecting the body than is seen in cortical bone. In other words, metabolic disorders and systemic infections, should they include any skeletal involvement, will appear on periosteal surfaces of the bone (see Chapter 11). It is important to note that these conditions do not substantively affect the mechanisms of enchondral bone formation. In other words, the rate and magnitude of long-bone-diaphysis growth may be affected by metabolic disorders or infections, but the particular reactions are periosteal.

Dental Development

In the developing skull, an arch of mesenchymal cells gives rise to the mandible and maxilla (Hillson 1996:118). Within this arch, a band of epithelium produces two lobes, one of which is the dental lamina. "Small swellings develop along the edge of the dental lamina so that, by the tenth week, there are ten of them for each jaw, and these are the enamel organs for the deciduous teeth, which will eventually form the enamel of their crowns" (Hillson 1996:118). The enamel organ then folds to create distinct internal and external areas. The internal area differentiates and forms two specialized cell types, odontoblasts and ameloblasts. Odontoblasts secrete a predentine matrix, upon which ameloblasts secrete enamel matrix.

The enamel matrix is approximately one-third organic material, which is eventually broken down and replaced by apatite crystallites (Hillson 1996:148). A fully realized crown is almost entirely mineral in composition. Tooth-crown enamel is laid down in layers, leading to appositional growth of the crown (Hillson 1996:119). Interruptions in this deposition are observed as linear horizontal grooves, or Type 1 hypoplasias (Buikstra and Ubelaker 1994:56). Although there are many metabolic and systemic causes for linear hypoplasias, their presence is a clear indication of interrupted growth, even if limited only to tooth formation (Hillson 1996:165–167).

Observations from the Alameda-Stone Cemetery

As noted above, the skeletal collection from the Alameda-Stone cemetery numbered nearly 1,400 individuals. Because any kind of individual-specific historical documentation was limited to those buried in the military section (Cemetery Area 1), the entire burial sample was treated as comprising analytical unknowns. In other words, basic osteological traits such as age at death, sex, biological affinity, and stature were estimated and calculated from observed physical characteristics, without deference to historical records or nonbiological contextual attributes (e.g., manner of burial clothing).

Age at death is among the individual attributes more germane to the present discussion. As noted in Chapter 2, age at death was estimated for every individual, regardless of recovery context. Numerical age ranges were established according to appropriate indicators of skeletal and dental growth, development, and maturation. As noted by Hillson (1996:146), estimating age in juvenile individuals from dental development and eruption exceeds the precision and accuracy of estimates based on skeletal growth and development (see Chapter 2 for details of dental-analysis methods). The reasons for this will be discussed below. Nevertheless, it should be noted that age at death for juvenile individuals was determined from dental attributes whenever available.

The individuals selected for the current discussions were chosen by two basic criteria. First, the distinction of "juvenile" was applied to individuals whose estimated age at death was less than 18 years. Although skeletal growth, development, and maturation occur continuously—not in discrete measures such as years—the analytical decision to set 18 as the age of maturity allowed the data to be operationalized, as this age is consistent with the cessation of growth in most attributes under consideration. Second, as noted above, estimations of juvenile age based on dental assessments offer higher reliability than their skeletal counterparts. Thus, only individuals for whom age was based on examination of dental development were included in the sample. These criteria define the universe of individuals from whom appropriate samples for subsequent analyses were drawn.

Methods

Age determinations based on dental development were recorded as ranges, standardized as years. Median ages were calculated for the age range for each individual, providing a point estimate to facilitate comparisons across the sample. Then, age cohorts at 1-year intervals were developed to aid in comparisons among individuals in the sample and to those from reference samples. Age cohorts were populated by those individuals whose median age fell within the ranges defined by the cohort. Table 127 summarizes the age categories and their respective ranges, the age cohorts and their respective ranges, and the number of individuals in each cohort. It should be noted that, although the subadult age category extends to age 18, the age cohorts under consideration were limited to individuals 16 years and younger. This was because of the criterion that only individuals aged by dental examination were included in the present discussion, and this age also corresponded to the upper bounds of samples to which the data set was compared. Therefore, 11 individuals with a median age between 16 and 18 were excluded. Additionally, these 11 individuals lacked the metric data contemplated in this study. Their absence from the sample was inconsequential.

Three skeletal elements stood out as appropriate for evaluation within the Alameda-Stone cemetery assemblage, as well as comparison to reference samples: the humerus, femur, and tibia. These elements were selected for study because of their high representation among juvenile individuals in the sample. The elements for each juvenile individual were measured according to Fazekas and Kósa (1978) and Buikstra and Ubelaker (1994). These measurements were recorded as attributes of the elements associated with each individual, allowing for comparisons at the elemental level. Additionally, each element from each individual was evaluated for anomalous or pathological presentation, also set as a data attribute of the elements themselves. The documentary protocol included measuring both left and right elements. This examination used a preference for the left element, deferring to the right side when the left was unobservable. Table 128 displays the number of elements with maximum diaphyseal length measurements per age cohort. Table 128 also shows the number of individuals in each cohort with at least one appropriate measure for the humerus, femur, or tibia (Valid Individuals). Of the 522 individuals described in Table 127, 79 did not possess at least one of these measures and were excluded from the sample. Therefore, the Alameda-Stone cemetery sample under consideration for the following investigations consisted of 443 individuals.

Results

Descriptive statistics were performed for each element type among the age cohorts. These appear in Appendix N. Figures 133–135 display mean element lengths for each cohort. Polynomial regression analyses for each element were consistent with the curvilinear growth of juvenile long bones described by Miles and Bulman (1994:124). To avoid overfitting, however, regression analyses were limited to second-degree (i.e., quadratic) polynomials. Polynomial regression equations for each element featured high r^2 values, ($p \geq 0.01$), indicating that, with some reasonable variation, long-bone lengths appeared uniform and predictable. This consistency indicates that the juvenile sample from the Alameda-Stone cemetery sample followed expected patterns, and the effects of individual outliers were minimal on the sample writ large.

A heuristic examination of these trends suggests that variability among the mean element lengths increased with the age cohorts. This was most apparent beginning at age 10.0 years. Cardoso (2007:227) has suggested that long-bone length in juveniles is determined by a basic genetic potential, modified by environmental factors. The dynamic proportions of these genetic and environmental proportions are not fully understood. Additionally, the first vestiges of sexual dimorphism begin to appear during preadolescence and early adolescence. How sex differences affect long-bone lengths in juveniles is beyond the reach of the present discussion.

Nevertheless, as is true with most biological attributes of humans, individuals accumulate variation over time. Environmental and behavioral factors continue to exert influence on the skeleton during growth and maturation. This accumulated variation, unique to each individual, is demonstrated in increasing levels of variability within the group as age increases. A good illustration of this is seen in age estimation from skeletal observations, and how precision of the estimate decreases as age increases. As humans engage in different activities in different environments throughout their lifetimes, the skeletal effects of these different behaviors and conditions continue to accumulate. The result is less consistency among individuals, and estimations of attributes based on skeletal markers must sacrifice precision to maintain accuracy. For example, the pubic symphyses of two adult individuals, both 50 years of age, may look quite different. Likewise, two qualitatively identical pubic symphyses may belong to individuals decades apart in age. Accumulated variation reduces the predictability of observations, analogous to the wider distribution and spread of point values after age 10 in Figures 133–135.

Pathology

As Saunders and Hoppa (1993) have described, juvenile growth is dramatically affected by illness and nutritional deficit. There is, however, what they termed a biological mortality bias, described as "the physiological and morphological difference between those who die and those who survive" (Saunders and Hoppa 1993:129). As is true in the osteological paradox (Wood et al. 1992), there is an unclear relationship between skeletal evidence of pathology and the ultimate contribution of such pathology to the death of the individual. The precise cause of death is typically elusive to the osteologist. In addition to the litany of fatal pathological conditions that feature no skeletal involvement, conditions that may affect the skeleton may prove lethal before any osteological evidence has manifested itself. In short, an individual must survive a pathological condition long enough for evidence of that condition to appear on the skeleton. If the condition is fatal before that time, no evidence of it would be observable on the remains. The paradox, then, is that victims of rapidly lethal conditions appear skeletally "healthy," in that no evidence of the pathology is observed. Conversely, individuals who do exhibit evidence of pathology necessarily must have survived the condition for some length of time, and, therefore, the observed condition may not be the ultimate cause of death.

The biological mortality bias (Saunders and Hoppa 1993) considers a different line of inquiry. Clearly, a juvenile skeletal collection comprises the individuals who died during growth, before maturation. This understanding leads to two questions regarding those individuals within the population. First, from membership in the juvenile skeletal collection, are these individuals inherently unrepresentative of the surviving populations, both healthy and unhealthy? Second, do skeletal lesions evident in the juvenile skeletal collection indicate a divergent pattern of growth and development, no longer reflective of that of the surviving individuals? Saunders and Hoppa (1993) examined these questions and concluded that although disease and malnutrition certainly affect long-bone length and overall stature, and although nonsurvivors are shorter, to a statistically significant degree, than survivors, the differences are probably negligible compared to other sources of methodological error, such as the inability to assign sex or imprecise aging methods. Therefore, the scientifically accepted limitations of current methods for juvenile assessments allow for the treatment of nonsurvivors as reasonably representative of the whole juvenile skeletal collection.

Three broad conditions were selected to identify juveniles from the Alameda-Stone cemetery with evidence of nutritional deficit or infections possibly leading to diminished growth. Cribra orbitalia and porotic hyperostosis are skeletal indicators of metabolic disorder (Walker et al. 2009). Enamel defects and linear hypoplasias indicate arrested growth, which could in turn be indicative of metabolic stress (Hillson 1996:165–176).

Finally, periosteal reactions such as proliferative growth or osteomyelitis provide evidence of infection (Mann and Murphy 1990:18). Cribra orbitalia and porotic hyperostosis, as well as enamel defects, were regarded in a simple presence/absence fashion for each individual. Instances of periosteal reaction were evaluated for each individual, with the involvement of three or more elements suggesting a systemic nature of the condition. Saunders and Hoppa (1993:131–132) concluded that there is a difference between the condition of being "stunted" and the process of "stunting":

> [T]he term "stunted" is used to mean a deficit in height-for-age as a growth measure. As such, stunted growth is represented by an absolute deficit below reference standards. However, being "stunted" has no bearing on the present state of an individual's growth but rather is a reflection of a past event. "Stunting" on the other hand is used specifically to refer to a current state of reduced growth velocity within an individual. Stunting may eventually result in stunted growth, although catch-up growth may prevent this from occurring.

In other words, "stunted" refers to a present condition, the state of being smaller than expected for one's age. "Stunting" refers to slowed growth, as it is occurring. Although these terms are obviously related, care must be taken to remain mindful of the distinction. Nutritional and pathological factors may certainly lead to stunting, the effects of which are not visible in a cross-sectional examination such as a skeletal sample. Likewise, stunting is a necessary condition for an individual to be stunted, but it is not a sufficient condition. An individual who is stunted must have experienced stunting in the past, but not all individuals experiencing stunting will become stunted. Catch-up growth may occur following periods of stunting, compensating for the slowed growth, and ultimately preventing the individual from being stunted. Furthermore, the property of being stunted is not a reflection of the circumstances affecting the individual at the time of observation (i.e., the time of death). Small long-bone lengths reflect past events, not those occurring when the individual died.

Frequencies of these conditions for juveniles from the Alameda-Stone cemetery are displayed in Table 129. Clearly, a low percentage of these juveniles exhibited evidence of childhood stress. On the basis of these low frequencies, one can reasonably conclude that these conditions would have little overall effect on the measures across the sample as a whole. Nevertheless, it is important to assess any meaningful differences between individuals exhibiting evidence of childhood stress and those appearing skeletally unaffected.

To accomplish this, mean long-bone lengths and standard deviations were calculated for individuals without evidence of childhood stress. These served as the baseline against which affected individuals were compared to discover differences in long-bone length at age, and whether these differences were significant. The humerus was selected for these comparisons because it offered the greatest number of data for both affected and unaffected individuals. Humerus-length data were available for 387 individuals.

To determine the impact of each condition, affected and unaffected individuals were assessed for each pathology separately. In other words, affected individuals were defined as those exhibiting one condition and no others. Similarly, unaffected individuals were defined as those exhibiting no conditions at all. The unaffected individuals numbered 320. A total of 21 individuals exhibited multiple conditions and were removed from consideration to avoid clouding the effects of each unique condition. These included 1 individual with all three conditions (cribra orbitalia/porotic hyperostosis, Type 1 hypoplasia, and systemic infection), 1 individual with cribra orbitalia/porotic hyperostosis and Type 1 hypoplasia, 2 individuals with Type 1 hypoplasia and systemic infection, and 17 individuals with cribra orbitalia/porotic hyperostosis and systemic infection. The number of individuals in the last group was high probably because individuals in nutritional deficit (as evidenced by cribra orbitalia and porotic hyperostosis) are more susceptible to infections (Saunders and Hoppa 1993:134).

The impact of these indicators of childhood stress can be seen in Table 130 and Figure 136. The mean humerus length and standard deviation were calculated for each age cohort, separated by the presence or absence of any one indicator of childhood stress. Independent-samples *t*-tests were then performed to examine whether differences in mean humerus length between affected and unaffected individuals were significant. Because of sample-size limitations, *t*-tests were generally feasible only for age cohorts 5.5 and younger.

Table 130 demonstrates that for each cohort mean humerus lengths for affected individuals were not statistically different from those of unaffected individuals. The only exception to this is at age 2.5, in which affected individuals' mean humerus lengths were significantly smaller than unaffected individuals' ($p = .045$). It should

be noted, however, that this significant difference was a result from just seven individuals in this age cohort who exhibited an instance of childhood stress.

To compare the individuals affected by childhood stress to the 320 unaffected individuals, mean humerus lengths and standard deviations were calculated for unaffected individuals in each age cohort. Next, *z*-scores were calculated for humerus measurements for each of the affected individuals to assess the magnitude and significance of differences from the unaffected, "normal" baseline.

Of the 18 individuals with cribra orbitalia or porotic hyperostosis, 16 comparisons could be made to unaffected individuals. Only 2 individuals featured *z*-scores with significance values at the $\alpha = 0.05$ level, 1 positive ($z = 2.097$) and 1 negative ($z = -3.962$). In other words, the only cribra orbitalia/porotic hyperostosis individual with a humerus significantly shorter than those of unaffected individuals in the same cohort was matched by an individual with a significantly *greater* humerus length.

For Type 1 hypoplasia, the results were similar. Eleven comparisons could be made from the 14 individuals with Type 1 enamel hypoplasia. Again, only 2 individuals were significantly different from cohort mean lengths ($\alpha = 0.05$). And again, 1 individual featured a negative *z*-score ($z = -2.586$), and the other featured a positive *z*-score ($z = 2.650$).

Finally, evidence of systemic infection was noted on 35 individuals, of whom 34 could be compared to unaffected individuals. Only 1 individual produced a significant *z*-score ($z = -1.997$; $\alpha = 0.05$), indicating that this individual had a significantly shorter humerus than those of its unaffected peers.

These results provide a compelling argument that the Alameda-Stone cemetery juveniles who exhibited evidence of childhood stress had a negligible effect on the mean long-bone lengths within their appropriate cohorts. Indeed, each individual significantly smaller than its peers was balanced by an individual significantly larger than its peers, nearly identical in magnitude. The one exception was a single individual exhibiting evidence of systemic infection with a significantly smaller humerus than unaffected individuals, without a correspondingly larger individual. Clearly, when placed in the entire sample of Alameda-Stone cemetery juveniles ($n = 443$), the impact of a single individual was inconsequential.

Comparative Examinations

Of considerable importance in any analysis of biological attributes for a skeletal collection is a comparison to those of other samples and populations. Ancestral, temporal, and geographic characteristics contribute to our broad understanding of human skeletal biology. These may provide the basic framework for more-ambitious investigations, such as the effects of behavior, disease, and social stratification on the sample of a particular people, in a particular time and place.

Methods

Comparisons were made between the Alameda-Stone cemetery sample and three other distinct samples. Although these samples are dissimilar to the Alameda-Stone cemetery skeletal collection in a number of meaningful ways, much can be learned from comparisons to disparate samples. Indeed, the limitations inherent in osteological observations of skeletal remains prevent investigators from drawing comparisons to very similar samples, even if they are widely available. Plainly, osteological analyses are not sensitive enough to distinguish between two very similar samples. Therefore, the comparative samples were selected because they were different from the Alameda-Stone cemetery sample in broad and easily recognizable ways, such as geographic location and placement in time.

The humerus, radius, ulna, femur, tibia, fibula, and ilium from protohistoric Arikara (hereafter called Arikara) in South Dakota were described by Merchant and Ubelaker (1977). Maximum long-bone lengths without epiphyses were recorded, with preference for the left side. A total of 193 individuals was examined, yielding a

variety of measures for each element type. The ages of the individuals were estimated on the basis of dental development, described by Moorrees et al. (1963a, 1963b), and individuals were assigned to 1-year cohorts.

Saunders et al. (1993) examined subadult individuals from St. Thomas' Anglican Church cemetery in Belleville, Ontario (hereafter called St. Thomas'). The cemetery was in use from 1821 until 1874 and probably contained burials of individuals of European ancestry. Remains from 216 subadult individuals were placed into 1-year cohorts based on dental development estimations after Moorrees et al. (1963a, 1963b). Diaphyseal long-bone lengths, as well as ilium and scapula observations, were recorded on the basis of element measurability.

Data collected by Maresh (1970) (hereafter called the Denver data set) served as the "modern" comparison for juvenile long-bone growth. Long-bone diaphyses were measured from 244 individuals in Denver, Colorado, born since 1940. These data differ from most comparative skeletal collections in several ways. First, subjects in the study were living individuals, measured in roughly 6-month intervals from birth until age 15 or older. Thus, a longitudinal perspective is gained, whereas most dry-specimen data sets are a cross section of age at death. Second, measurements were derived from radiographs. In addition to differences between living bone tissue and dry specimens, skeletal elements may be magnified in the radiograph because of X-ray focal length and distance from the element to the cassette. As Maresh (1970:162) noted, magnification or distortion errors were not corrected, but magnification between 1 and 3 percent has been suggested from dry-bone X-ray experiments. Finally, and most important, data collected by Maresh (1970) included specific age and sex information, details typically elusive during examinations of skeletal collections.

Sample size, mean element length, and standard deviations were available for each of the three comparative samples discussed above. The Denver data set is separated by sex, with longitudinal measures for 123 boys and 121 girls. Because the data from the Arikara, St. Thomas', and Alameda-Stone cemetery samples do not include reliable sex information, the Denver data set was combined for the purposes of the present discussion. The male and female sample sizes were summed for the number of cases at each age, mean element lengths at age were averaged, and standard deviations were calculated from pooled variances.

To maximize computational and comparative efficiency and parsimony, only the humeral, femoral, and tibial data from each sample were contemplated for evaluation. Additionally, the Arikara, St. Thomas', and Denver samples were limited to individuals of development (or, in the case of the Denver sample, known age) past the age of birth. The Alameda-Stone cemetery sample included several individuals still in fetal development ($n = 49$). The lack of comparative fetal data necessarily prevented an assessment of the prenatal environment as it relates to long-bone growth. There is little doubt that the conditions in utero have a significant impact on long-bone growth and development. Unfortunately, the comparative data did not permit examinations of ages before birth.

Results

Descriptive statistics for the three comparative samples and the Alameda-Stone cemetery sample are described in Appendix O. Figures 137–139 display mean long-bone lengths and 95 percent confidence intervals for the four samples under consideration. The most obvious characteristic of these comparisons is that juvenile individuals from the Alameda-Stone cemetery sample were smaller than individuals of similar age from other samples. This is true in varying degrees at all ages and includes all three elements evaluated.

Under closer scrutiny, several characteristics are immediately apparent in each of Figures 137–139. First, at the youngest postnatal ages (until about 2 years old), very little difference was visible among the point values of the four samples. Equally notable, however, was the absence of variability *within* each group at each age, evidenced by small or undetectable confidence intervals. Despite tight within-group measures, there was still significant variation among groups in long-bone lengths. In other words, although the point values at each age for the samples were similar, even slight differences among the groups are nonetheless real.

The significance of this finding should not be underestimated. From the time of birth, and because of prenatal development, differences among these samples were already manifest. Within-group variability, however, was slight, suggesting that each was an adequate representation of the overall population. This observation will be revisited later.

As age increased, within-group and among-group differences amplified. Within-group variability was hardly surprising: as the number of relevant factors affecting juvenile long-bone growth increase, rates and magnitudes necessarily become less stable. Genetics, behavior, illness, and diet all influence growth in undiscoverable proportions and intensities. The cumulative effects of these factors working in concert are seen in the increased ranges constituting the 95 percent confidence intervals.

At or around the second year of life, differences among the four samples were more apparent. The acceleration of long-bone growth decreased from a more quadratic curve to a more linear representation. This was best illustrated by the Denver sample because of its formidable sample sizes and longitudinal perspective. Nevertheless, each of the other samples followed a similar pattern of roughly linear growth velocities past the second year. The linearity of these growth velocities allows us to see scalar differences among the samples. Table 131 displays the quadratic regression formulas for long-bone lengths for each of the samples. Table 132 shows the linear regression formulas of the same data, selecting only individuals aged 2 years or older. The age coefficients appear relatively similar, indicating consistent growth velocities among the four samples. The additive constants, however, vary substantially. The meaning of these results is clear: the rate of growth was not dramatically different among the samples, but the amount of growth varied considerably.

To explore the significance of differences in growth rates, an independent-samples *t*-test was used to compare linear regression slopes and intercepts of the four samples. This is because "observed slopes and intercepts follow the *t* distribution" (Glantz 2005:278). The *t* distribution is expressed as

$$t = \frac{\text{difference of slopes (or intercepts)}}{\text{standard error of difference of slopes (or intercepts)}}$$

The two attributes displayed in linear regression are the slope (growth rate) and intercept (the bone length at the age when the relationship became linear—in this case, 2 years old). Independent-samples *t*-tests determine whether the Alameda-Stone cemetery sample was significantly different from each of the other samples in growth rate and bone length at 2 years old. The products of these examinations appear in Table 133. Regression formulas for humerus, femur, and tibia growth in Alameda-Stone cemetery individuals over 2 years old compared to those of other groups exhibited no significant difference in slope but highly significant differences ($\alpha = 0.001$) in intercept. These findings support the hypothesis that, after the age of 2 years, Alameda-Stone cemetery individuals grew at a rate consistent with that of similarly situated individuals in other populations. Differences in long-bone lengths at age are, therefore, the product of the length when linear growth began (i.e., *y*-intercept), around 2 years of age, rather than at lower growth velocities. In other words, diminished long-bone lengths in the Alameda-Stone cemetery individuals compared to those of the other samples were because of factors before the second year of life. Indeed, the insignificant differences in rates of growth demonstrate that the Alameda-Stone cemetery individuals did not experience stunting after the second year of life.

Even a cursory examination of the mean long-bone lengths at age reveals that juveniles from the Alameda-Stone cemetery were smaller than those from comparative samples. Considered together, the observations across the samples both before and after age 2 indicate that (1) the Alameda-Stone cemetery individuals were generally smaller at birth than individuals in comparative samples and (2) growth rates among all samples were relatively uniform after the second year. Indeed, juvenile individuals from the Alameda-Stone cemetery remained proportionately smaller through to skeletal maturation. Comparisons of adult measures of the Alameda-Stone cemetery individuals to those from other samples are explored in Chapter 10.

Several possible causes for the generally smaller size of the Alameda-Stone cemetery juveniles may be discussed, none of which is definitively discoverable with the analytical tools and biological materials available, and none of these causes is necessarily exclusive to all others. As noted above, three skeletal markers for childhood stress were contemplated for their possible influence on long-bone growth across the site. Cribra orbitalia and porotic hyperostosis served as proxy indicators of nutritional deficit. Periosteal reactions served as proxy for systemic infection, considered a sign of childhood morbidity, and probably slowed growth. Type 1 linear hypoplasias are definitive markers of interrupted growth, and their presence served as a proxy for possibly interrupted long-bone growth (Hillson 1996:165–176).

Comparisons of long-bone lengths across the site, set against the presence or absence of one or more of these markers of childhood stress, revealed no significant differences between affected and unaffected individuals. It warrants immediate emphasis that "affected" and "unaffected" were determined solely on the basis of *observable* markers of childhood stress. In other words, as Wood et al. (1992) reminded us, the skeleton is not necessarily an indicator of the conditions at the time of an individual's death, only the conditions before death. Indeed, several individuals who showed no skeletal evidence of systemic infection nevertheless may have been suffering systemic infection at the time of death. Mortality truncates the period required for skeletal evidence of morbidity.

The insignificant effects and low frequencies of markers of childhood stress among the Alameda-Stone cemetery juveniles suggest that environmental, pathological, and nutritional conditions associated with these markers were not the cause for their generally smaller size compared to similarly aged individuals from other samples. Indeed, were we to contemplate all four samples under consideration as parts of a single population, the individuals from the Alameda-Stone cemetery would appear stunted, without any evidence of stunting. In other words, the consistent trend of small-for-age long bones seen in the Alameda-Stone cemetery individuals does not appear to have been caused by nutritional deficiencies or pathological inhibitors to growth—these individuals were smaller than expected for their age (stunted) but did not demonstrate slowed growth velocity (stunting).

Another possible explanation relates to intrinsic factors of the Alameda-Stone cemetery individuals, namely, the population to which they belonged. Unfortunately, of the sample under consideration in the current discussion, evidence of biological affinity was available only for 52 individuals: 4 Native American, 22 Euroamerican, and 26 Hispanic. Examination of mean long-bone lengths at age for these groups revealed no meaningful differences among them. Indeed, the number of available data and the resolution of their analyses prevented the discovery of statistically reliable observations by ancestry.

Nevertheless, collateral information such as historical records indicates that the population in and around Tucson before and during the establishment of the cemetery was predominantly Hispanic (Sheridan 1986).This is corroborated by examinations of biological affinity among adult individuals at the site (see Chapter 8). This leads to a strong presumption that many, if not most, juvenile individuals for whom biological affinity could not be assessed were of Hispanic parentage. Equally strong, however, is the recognition that Tucson was exogamous with in-migration from other groups. Indeed, the variety of possible lineages precludes any reliable predictions of biological affinity in individuals for whom no affirmative evidence supports such a prediction.

Discussion

The observational reality is that juveniles from the Alameda-Stone cemetery were smaller than similarly situated individuals from other sites or contexts. Although the specific causes for these observations are many and closely related, two important conclusions can be drawn from the data. First, indicators of childhood stress were insufficient to explain within- and among-group differences. Individuals presenting evidence of metabolic disorders (e.g., cribra orbitalia or porotic hyperostosis), individuals presenting evidence of interrupted growth (e.g., Type 1 enamel hypoplasias), and individuals presenting evidence of systemic infection (e.g., generalized nonspecific periosteal new bone) featured long-bone lengths statistically indistinguishable from those of individuals with no evidence of these conditions. The few examples of significant differences between the affected and unaffected individuals were diluted by small numbers and inconsistent qualities of those differences (i.e., individuals with larger-than-mean measures and individuals with smaller-than-mean measures). Thus, the presence of indicators of childhood stress was not adequate to reveal substantive differences among the Alameda-Stone cemetery juveniles.

This is not to suggest, however, that childhood stress had no impact on growth characteristics in the sample. There is little doubt that growth rates were slowed and growth potentials were unrealized because of nutritional, environmental, or pathological factors. The ability to fully understand the effects of these factors is

diminished by the limitations of skeletal specimens in a cross-sectional perspective of a population. Several scenarios may lead to childhood stress indicators on individuals of a size similar to that of seemingly "healthy" (i.e., unremarkable) individuals. First, the childhood stress indicators may have been manifested relatively close to the time of death, and long-bone metrics are measures of growth rates before the time of death, not at the time of death. Second, the conditions leading to childhood stress indicators are not necessarily permanent, and improved conditions may return growth rates to normal values (i.e., catch-up growth). Finally, the delicate interplay among the timing of childhood stress, the timing of that stress manifesting itself on the skeleton, the growth before death, and the conditions at the time of death overwhelmingly frustrates the effort to create a concise and reliable sequence of events and description of conditions.

The second important conclusion is that the smaller size of the Alameda-Stone cemetery juveniles compared to that of other juveniles was not a product of lesser growth velocities, but rather of intrinsic factors like genetic composition. The Alameda-Stone cemetery juveniles were smaller than their peers in other contexts, consistently and regularly, across all age groups. Despite wide differences in time and place among the comparative samples, the growth velocities in the Alameda-Stone cemetery collection were not significantly different from those for the other samples. Linear and quadratic regression analyses of the assemblage confirm that the rate of change from one age cohort to the next was not meaningfully different from that of other samples. The significance surfaces when comparing the length-at-age intercepts, or the starting point for the effective growth rate. The Alameda-Stone cemetery juveniles were born smaller than comparable juveniles, and the data suggest they were smaller during fetal development as well; the relatively consistent growth rates maintained this size difference across age cohorts.

Several possible causes for these differences warrant examination. First, as noted above, dissimilar genetics play a key role. Indeed, growth and size potentials are entirely determined by genetics; environmental factors influence the extent to which those potentials are realized. Because the growth rates of the Alameda-Stone cemetery juveniles were not dissimilar to those of individuals from other samples, and because there were no meaningful differences between individuals exhibiting indicators of childhood stress and those who did not, there is insufficient evidence to support an argument for an environmental cause for the comparatively small Alameda-Stone cemetery juveniles. In other words, there were no observations to suggest that environmental factors affected the length-at-age measures in the Alameda-Stone cemetery sample differently from how they affected length-at-age measures for any of the comparative samples. Therefore, the differences appear to be closely related to intrinsic factors, such as population genetics. Unfortunately, the data did not permit discrimination of the Alameda-Stone cemetery juveniles into genetically derived groups such as biological affinity or sex. Any differences along those lines within the population are unknowable.

Another possible cause for disparity in growth magnitude but similarity in growth rate may be related to conditions in utero. The prenatal environment obviously affects growth until the time of birth. And although the Alameda-Stone cemetery collection included a substantial number of fetal individuals, the comparable data from other sites are inadequate. Indeed, as noted above, comparisons were available only from birth and beyond. It is possible that conditions in the fetal environment led to smaller sizes at birth, and subsequent postbirth conditions maintained the small magnitudes but similar rates of growth throughout childhood. Demographic examinations for the population would be required to determine whether poor conditions in utero led to an inordinately high fetal mortality.

The juvenile data set from the Alameda-Stone cemetery was unusually rich in number of individuals and observability of attributes. As has been shown, however, an abundance of data is often inadequate to address some of the more interesting questions when reconstructing past populations. Some of these questions, such as the distribution, pervasiveness, and influence of environmental and pathological conditions, are simply beyond the reach of the tools and methods currently available to skeletal biologists. Similarly, comparative analyses suffer from the limitations and inadequacies of other data sets. It is hoped that the Alameda-Stone cemetery data set will provide a robust comparative sample for future investigations.

Figure 132. Individual P, Grave Pit 7501, Burial 8651, an infant of indeterminate sex and biological affinity. Note good preservation of remains.

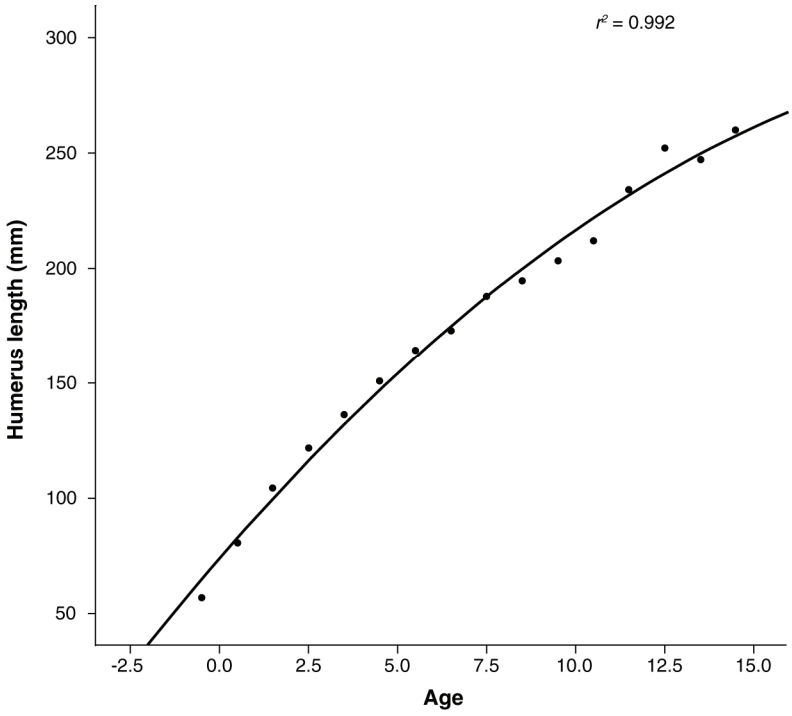


Figure 133. Mean humerus length for Alameda-Stone cemetery juveniles.

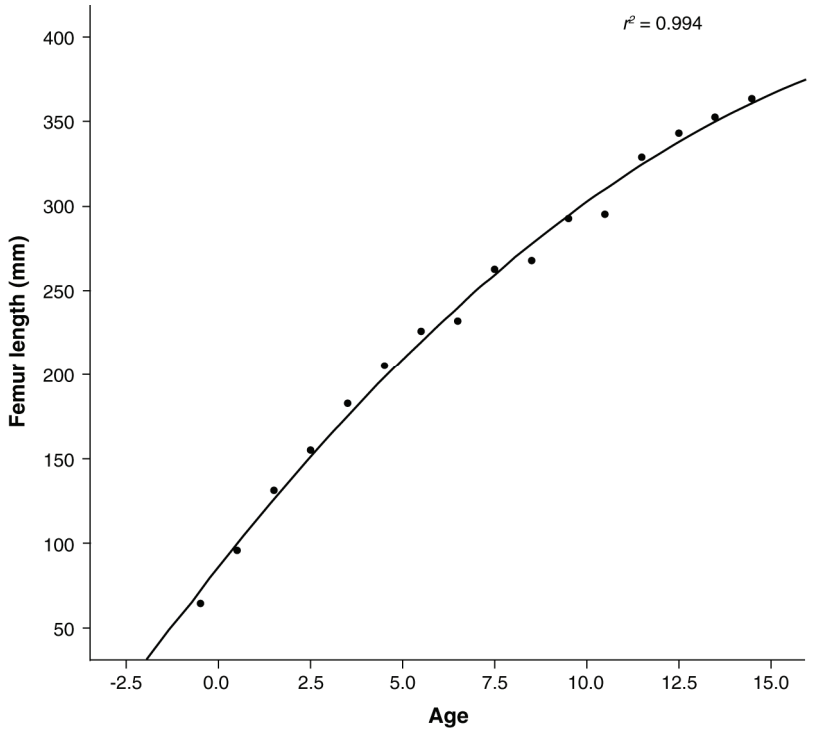


Figure 134. Mean femur lengths for Alameda-Stone cemetery juveniles.

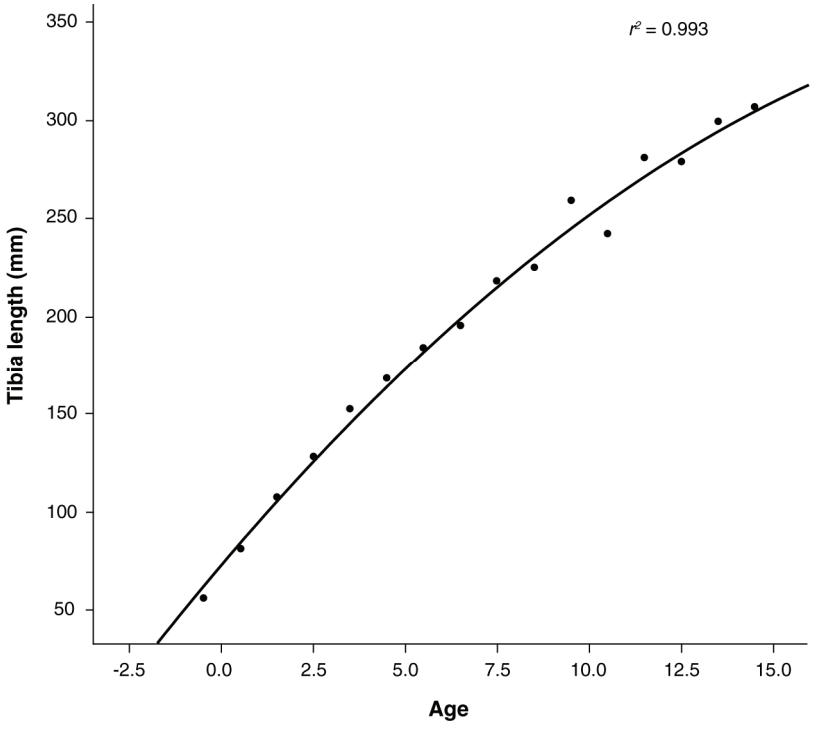


Figure 135. Mean tibia lengths for Alameda-Stone cemetery juveniles.

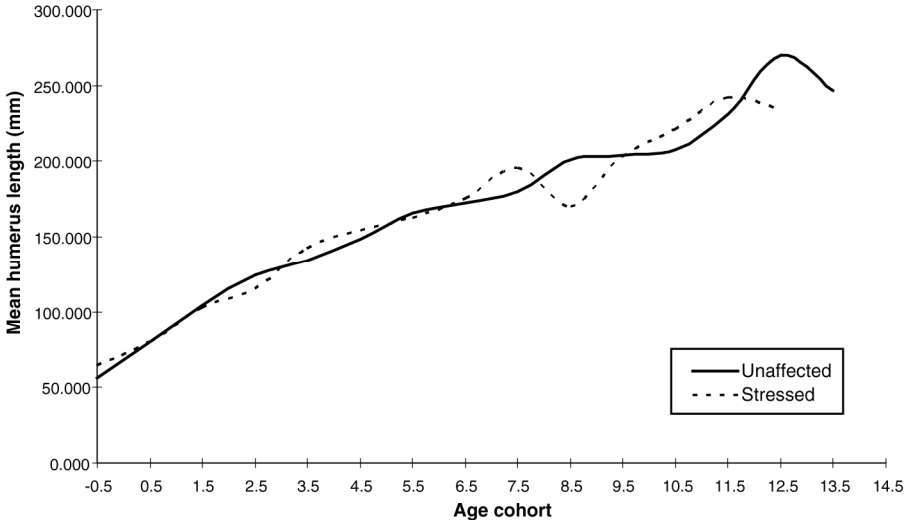


Figure 136. Mean humerus lengths for individuals with and without evidence of childhood stress.

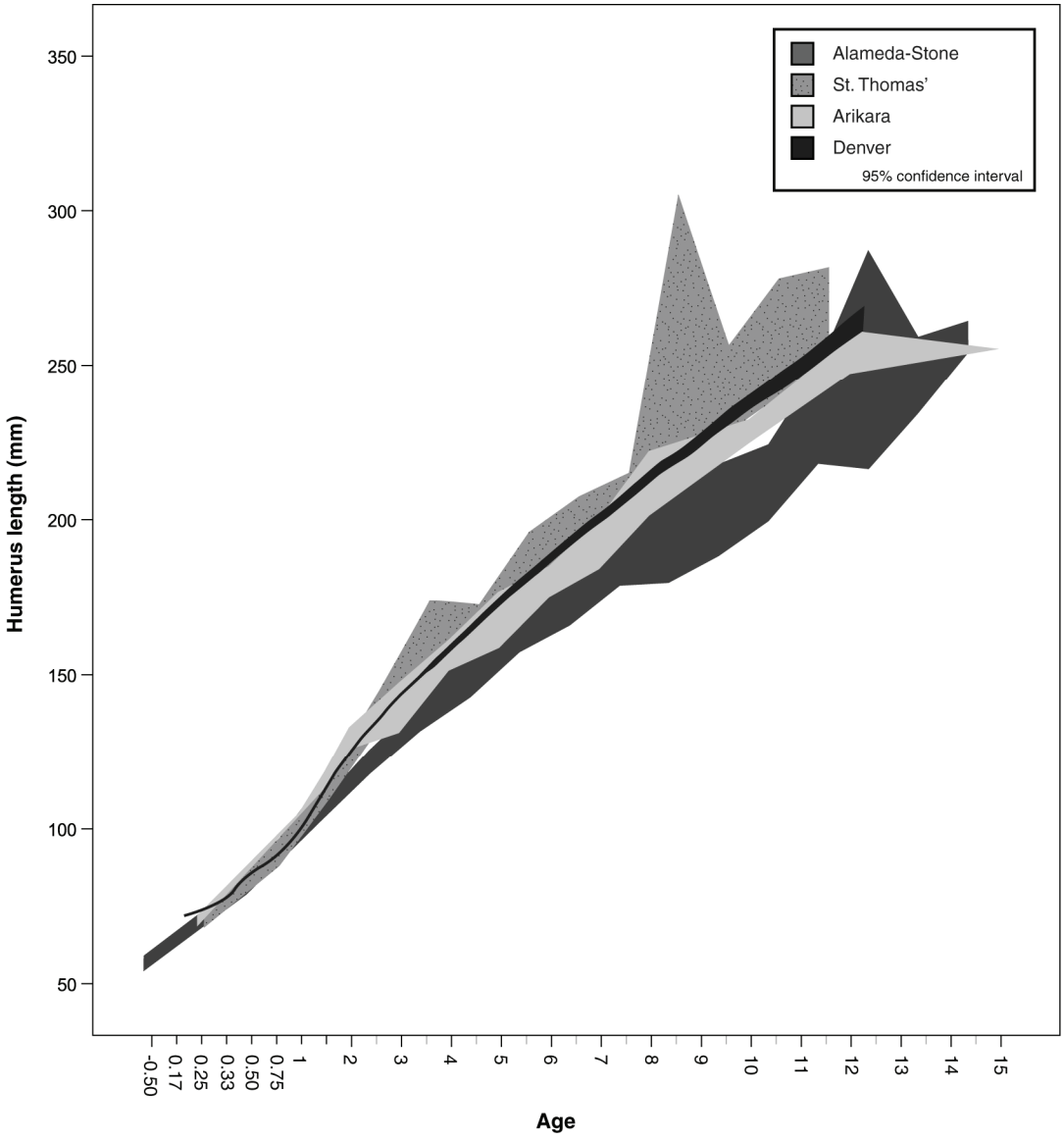


Figure 137. Mean humerus lengths and 95 percent confidence intervals for Alameda-Stone cemetery juveniles and comparative samples.

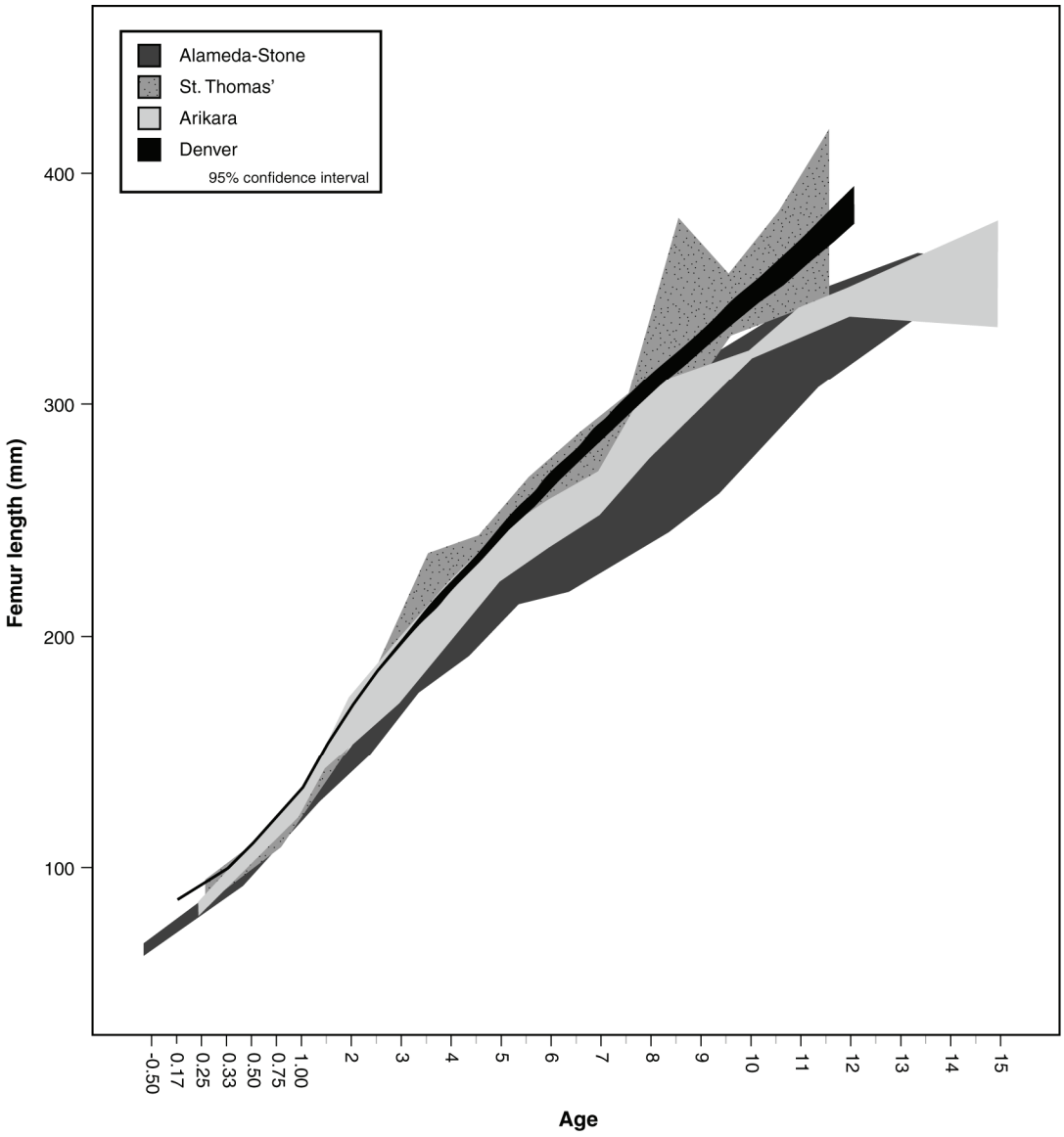


Figure 138. Mean femur lengths and 95 percent confidence intervals for Alameda-Stone cemetery juveniles and comparative samples.

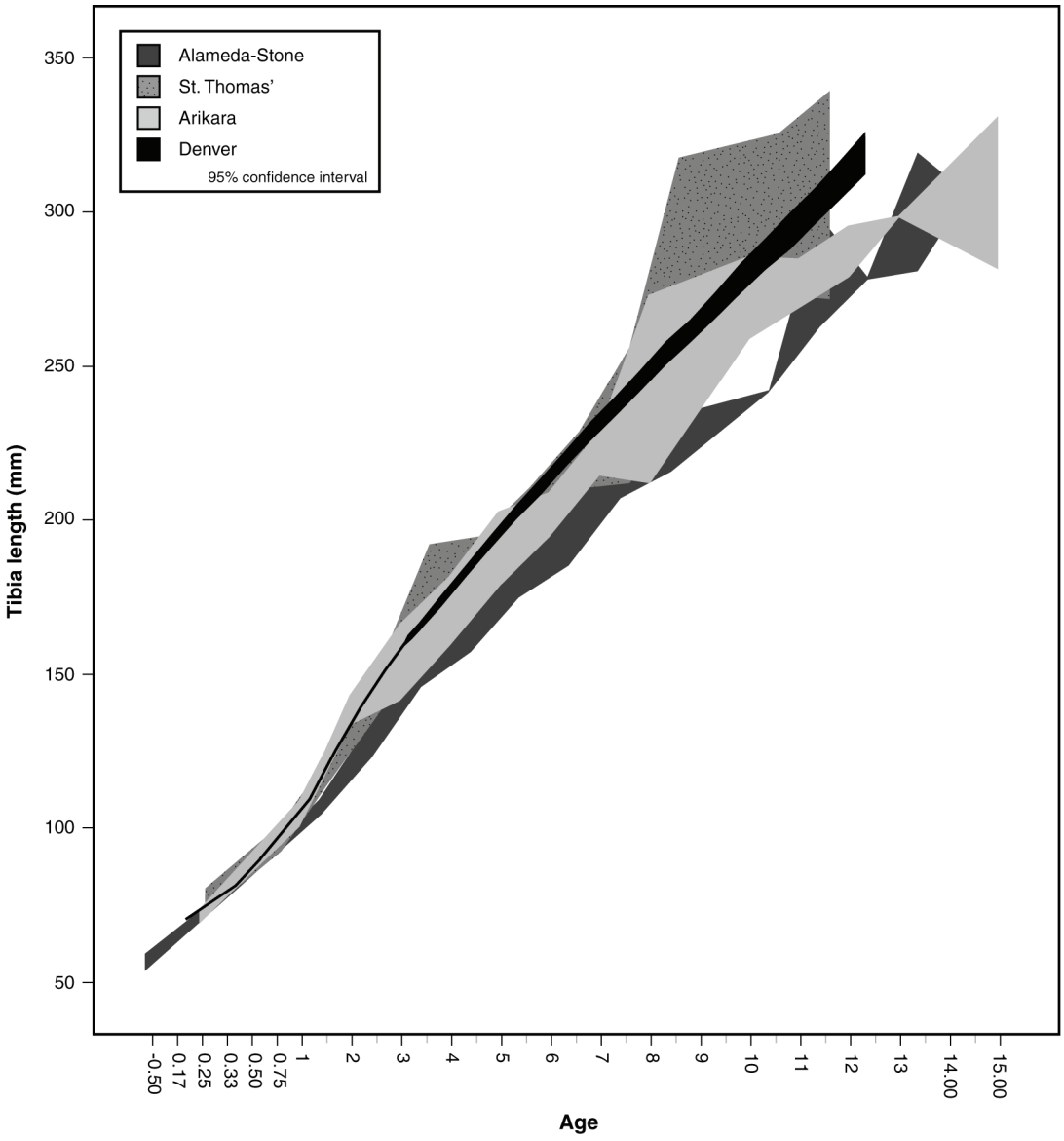


Figure 139. Mean tibia lengths and 95 percent confidence intervals for Alameda-Stone cemetery juveniles and comparative samples.

Table 127. Age Cohorts, Ranges, and Distributions, by Age Category

Age Cohort	Age-Cohort Range	No. of Individuals
	Fetal (-0.75–0 years)	
-0.5	-0.75–0	76
	Infant (0–2 years)	
0.5	0–1	193
1.5	1–2	104
	Child (2–12 years)	
2.5	2–3	38
3.5	3–4	28
4.5	4–5	15
5.5	5–6	12
6.5	6–7	13
7.5	7–8	4
8.5	8–9	7
9.5	9–10	5
10.5	10–11	5
11.5	11–12	7
	Subadult (12–18 years[a])	
12.5	12–13	3
13.5	13–14	5
14.5	14–15	4
15.5	15–16	3
Total		522

[a] No individuals between 16 and 18 years met the criteria for consideration in our analyses.

Table 128. Element Counts and Valid Individuals, by Age Cohort

Age Cohort	Humerus	Femur	Tibia	Valid Individuals[a]
-0.5	66	64	62	68
0.5	144	125	132	164
1.5	90	78	74	97
2.5	25	20	25	27
3.5	22	20	14	23
4.5	12	10	10	13
5.5	10	10	6	10
6.5	11	9	10	12
7.5	3	3	3	3
8.5	5	5	3	5
9.5	3	3	0	4
10.5	3	1	1	3
11.5	7	6	5	7
12.5	2	1	1	2
13.5	3	2	2	3
14.5	2	1	1	2
Total	408	358	349	443

[a] Individuals with at least one appropriate measure for humerus, femur, or tibia.

Table 129. Frequency of Pathological Conditions

Condition	Total Presence		Total Absence		Unique Presence		Unique Absence	
	n	%	n	%	n	%	n	%
Cribra orbitalia/ Porotic hyperostosis	38	8.58	405	91.42	18	5.33	320	94.67
Type I hypoplasia	18	4.06	425	95.94	14	4.9	320	95.81
Systemic periosteal reactions	57	12.87	386	87.13	35	9.89	320	90.11

Table 130. Comparison of Humerus Lengths for Individuals with and without Evidence of Childhood Stress

Age Cohort	Unaffected			Stressed			*t*	*p*
	Mean	sd	n	Mean	sd	n		
-0.5	56.280	9.025	60	64.600	9.060	3	1.558	0.124
0.5	80.431	11.720	111	80.521	11.704	22	0.033	0.974
1.5	104.562	8.881	76	103.075	9.659	12	0.533	0.596
2.5	124.129	7.377	17	115.571	12.216	7	2.127	0.045
3.5	134.548	9.851	18	142.433	14.351	3	1.214	0.240
4.5	148.850	15.247	8	154.800	11.439	4	0.684	0.510
5.5	165.600	12.985	5	163.100	10.716	4	0.309	0.766
6.5	172.834	12.537	10	175.500		1		
7.5	180.000		1	195.500		1		
8.5	200.800	11.680	4	170.600		1		
9.5	204.000		1	202.900	18.243	2		
10.5	207.500	10.607	2	221.000		1		
11.5	231.000	25.000	3	242.000	21.284	3	0.580	0.593
12.5	270.000		1	234.000		1		
13.5	247.000	10.817	3			0		
14.5			0	259.500	3.536	2		

Key: sd = standard deviation; n = number (count); *t* = *t*-statistic; *p* = probability.

Table 131. Quadratic Regressions for Humerus, Femur, and Tibia Lengths (All Ages[a])

Sample Population	Humerus Length		Femur Length		Tibia Length	
	Regression Equation	r^2	Regression Equation	r^2	Regression Equation	r^2
Alameda-Stone Cemetery	$y = 17.847x - 0.357x^2 + 73.820$	0.992	$y = 27.498x - 0.592x^2 + 86.502$	0.994	$y = 22.088x - 0.423x^2 + 73.079$	0.993
Arikara	$y = 21.928x - 0.655x^2 + 77.888$	0.988	$y = 33.759x - 1.064x^2 + 91.104$	0.992	$y = 26.662x - 0.749x^2 + 77.189$	0.994
St. Thomas'	$y = 24.593x - 0.631x^2 + 73.672$	0.976	$y = 36.327x - 0.950x^2 + 89.034$	0.988	$y = 27.642x - 0.648x^2 + 76.474$	0.986
Denver	$y = 22.640x - 0.640x^2 + 79.253$	0.995	$y = 34.556x - 0.922x^2 + 97.172$	0.996	$y = 27.780x - 0.706x^2 + 78.942$	0.996

[a] All samples are included.

Table 132. Linear Regressions for Humerus, Femur, and Tibia Lengths (Age 2 Years and Older[a])

Sample Population	Humerus Length		Femur Length		Tibia Length	
	Regression Equation	r^2	Regression Equation	r^2	Regression Equation	r^2
Alameda-Stone Cemetery	$y = 11.4677x + 97.632$	0.994	$y = 17.061x + 124.717$	0.994	$y = 14.588x + 100.372$	0.993
Arikara	$y = 10.947x + 113.824$	0.977	$y = 15.882x + 149.885$	0.976	$y = 13.972x + 119.018$	0.985
St. Thomas'	$y = 15.468x + 101.667$	0.971	$y = 22.421x + 132.667$	0.987	$y = 18.225x + 105.644$	0.984
Denver	$y = 13.262x + 108.202$	0.998	$y = 21.082x + 138.541$	0.998	$y = 17.381x + 111.270$	0.999

[a] All samples are included.

Table 133. Linear Regression *t*-Tests for Humerus, Femur, and Tibia Lengths: Alameda-Stone Cemetery Sample versus Other Samples (Age 2 Years and Older)

Comparison (Alameda-Stone Cemetery vs.), by Long Bone	Slope			Intercept		
	t	*df*	*p*	*t*	*df*	*p*
Humerus length						
Arikara	0.880	20	0.389	7.611	20	0.0001
St. Thomas'	1.390	19	0.181	10.717	19	0.0001
Denver	0.424	30	0.675	3.815	30	0.0006
Femur length						
Arikara	1.314	20	0.204	11.352	20	0.0001
St. Thomas'	1.394	19	0.179	10.965	19	0.0001
Denver	0.623	30	0.538	5.593	30	0.0001
Tibia length						
Arikara	0.934	20	0.362	8.461	20	0.0001
St. Thomas'	1.295	18	0.212	10.216	18	0.0001
Denver	0.569	29	0.574	5.187	29	0.0001

Key: *t* = t-statistic; *df* = degrees of freedom; *p* = probability.

CHAPTER 10

Adult Postcranial Morphology

Amber Harrison

Introduction

This chapter discusses the adult postcranial morphology of the Alameda-Stone cemetery population. The postcranial skeleton, which consists of all skeletal elements except the cranium and mandible, is very sensitive to environmental influences and provides insight into many aspects of the human condition. Traditional postcranial analyses to construct a biological profile generally include the determination of sex, the estimation of age, the estimation of stature, and, to a lesser degree, the estimation of ancestry. Osteological assessment of postcranial skeletal variation offers a means to evaluate the dynamics of a once-living population and inform our understanding of human ecological and cultural adaptation (Bass 1995; Buikstra and Beck 2006; Larsen 2002).

The following examination addresses broad questions regarding general health, biological affinity, and activity patterns among those who lived and worked in nineteenth-century Tucson. Specifically, this chapter addresses research questions by investigating variability within and between groups through analyses of adult stature, limb-bone biomechanics, and sexual dimorphism. To help further describe adult postcranial morphology in the Alameda-Stone cemetery sample, we present comparative data from historical-period burial samples, as well as prehistoric period and modern samples.

Alameda-Stone Cemetery Population

Starting as early as 1775, when it was founded, Tucson was a relatively quiet, isolated town surrounded by social and political changes occurring in the American Southwest (Sheridan 1986). At first on the frontier of northern New Spain, Tucson became part of Mexico in 1821. As a result of the Gadsden Purchase in 1854, Tucson was incorporated into the United States. Although Hispanic population numbers remained high, by the 1860s, Euroamericans dominated Tucson's economy. Most Mexican and Native American Tucsonans relied heavily upon a local subsistence-based economy, whereas Euroamericans had a stronger financial footing, with monetary ties outside the Arizona territory (Sheridan 1986). The 1880s brought the establishment of the railroad, and social reorganization continued, as class distinctions emerged out of population growth and the need for specialized labor. Despite what is known about the history of prerailroad Tucson, still little is known about the daily lives and activities of those living and working in nineteenth-century Tucson. The Alameda-Stone cemetery offers a unique glimpse into a population in transition, a population of mixed heritage, reflecting ancestral and cultural ties to regional groups adapted to the marginal desert environments of the Southwest, as well as Euroamerican tradition and enterprise (O'Mack 2005; Sheridan 1986).

Theoretical Background

Human bone tissue is highly sensitive to fluctuations in environmental circumstances. Nutritional, occupational, mechanical, and traumatic stressors, particularly in childhood, can leave indicators in adult postcranial remains (Larsen 1999). The effects of differential behavior among age groups, sexes, cultural groups, and social classes are known to affect the size and shape of individuals within a population (Grauer and Stuart-Macadam 1998). For example, delayed development due to illness or poor nutrition can lead to underdevelopment, malformed bones, and retarded growth. Extensive physical activity and load bearing may result in morphological changes to the joints and the diaphyses of long bones. Observations on adult height distributions and long-bone morphology are commonly used in bioarchaeological analyses to evaluate activity levels and general health. Generally, anthropologists are interested in identifying trends over time and space and between and within the sexes, age groups, and cultural groups, in order to generate inferences about behavior in light of the archaeological and historical records (Goldstein 2006; Katzenberg and Saunders 2000).

Multiple factors—including genetics, health, behavior, and environment—influence adult postcranial skeletal morphology (Larsen 2002; Liu et al. 2004.). Presently, the exact contribution of any single factor to the adult form of an individual's skeleton is not fully known. On the individual level, it is difficult to measure the effects of physiological and environmental stressors; however, on the aggregate level, patterns may emerge, and generalizations can be made regarding the interplay among environment, biology, and behavior as it is manifested in the skeleton. Research in the fields of anthropology, human growth and development, and economics has demonstrated that mean adult stature varies within and between populations faced with variable environmental, social, and cultural circumstances. Because growth and development in childhood is sensitive to environmental factors, such as nutrition, physical stress, sanitary conditions, and illness, trends in adult stature can offer an accurate reflection of living standards during the developmental period, at least at the population level. Following this, it is possible to track temporal and spatial trends in adult height as a means of evaluating general health and of reconstructing lifestyle and behavior patterns. Positive temporal trends (increasing stature) indicate that a population was generally healthier than the preceding generations. On the other hand, negative or static trends (decreasing or unchanged stature) suggest an adverse change in the environment affecting the growth potential of the members of the population (Bogin 1999; Eveleth and Tanner 1976; Steckel 1995; Steckel and Rose 2002).

Most useful in illustrating such changes are long-term historical studies on secular trends over periods of known socioeconomic change. These studies demonstrate the relationship between age at maturation and fluctuations in adult height with socioeconomic status, migration, and family size. Trends over time have been shown to correlate to major shifts in subsistence strategies, population migration, and industrialization. Such studies offer a growing base for worldwide comparative analyses for modern and archaeological samples (Bielicki and Welon 1982; Liu et al. 2004; Prazuck et al. 1988; Steckel and Rose 2002; Steegmann 1991; Young et al. 2008).

Although stature analyses may be useful for gauging the net general health status of a population, stature alone says very little about variability in body size, shape, and proportions. Examination of individual elements of the postcranial skeleton can further inform our understanding of human adaptation by looking at specific anatomical regions, such as the limb bones or the pelvic complex, where morphology is highly influenced by biology, behavior, and function (Ruff 1995). Variations in size and shape within and between populations reveal information about environmental sensitivity and functionality. The size and shape of an individual's long bones, for example, are in large part a reflection of total body size and physical activity. Cross-sectional and external metric observations—usually indexes of femora, tibiae, and humeri—are frequently used to quantify variability and reconstruct activity patterns (Bridges 2005; Buikstra and Beck 2006). Figures 140 and 141 illustrate variation in the femur in the anterior-posterior and medial-lateral planes as evaluated in cross-sectional analyses.

Numerous morphometric studies have illustrated the relationships between long-bone robusticity, symmetry, and shape and physical activity (Anderson and Trinkaus 1998; Ruff 1987; Ruff and Larsen 1990). Because long-bone-shaft robusticity and shape respond to mechanical forces, shaft shape and thickness can provide clues about activity levels. As strenuous activity increases, cortical bone thickness, and therefore midshaft size,

also increases. Habitual motion increases the deposition of bone and alters the shape of the midshaft in the direction of force. The inverse occurs when activity levels fall (Nystrom and Buikstra 2005). Thus, the geometric properties of long bones can provide useful information for the reconstruction of daily activity levels (Bridges et al. 2000; Wanner et al. 2007).

Biomechanical studies on professional tennis players demonstrate the effect of unilateral habitual activity, where cortical thickness at the midshaft is increased significantly from excessive, repetitive loading on the dominant playing arm (Ashizawa et al. 1999; Jones et al. 1977; Trinkaus et al. 1994). Using indexes to quantify anterior-posterior and medial-lateral diameters of long bones, researchers have demonstrated a relationship between diaphyseal midshaft shape and robusticity to subsistence strategy (Brock and Ruff 1988; Larsen and Ruff 1994; Marchi et al. 2006; Ruff et al. 1993). The diaphyses of hunter-gatherer femora were more expanded in the anterior-posterior plane than those of horticulturalists. This suggests that variability in long-bone shape may be attributable to greater stressors, such as running, walking long distances, or carrying substantial weight—workloads typical of a hunter-gatherer lifestyle. With the transition to a more sedentary lifestyle, a general trend over time to a more circular, rather than elongated, shape has been observed (Brock and Ruff 1988; Larsen and Ruff 1994; Marchi et al. 2006; Ruff et al. 1993).

Other morphological studies have looked at the variability in the structure of the subtrochanteric region (upper shaft) of the femur and have found notable differences between biological groups in a form classified as platymeria (Gill 2001). Platymeria is the "flattening of the upper end of the shaft of the femur in an anterior-posterior direction" (Townsley 1946:85). The platymeric index is calculated as the ratio of the medial-lateral and anterior-posterior aspects of the subtrochanteric region. This index has been shown to be a useful measure of ancestry, particularly for differentiating Native American populations from others (Gilbert and Gill 1990; Gill 2001; Stewart 1962; Wescott 2006). Previous studies have shown that Native American groups tend to have a relatively low platymeric index (elongated in the medial-lateral plane), whereas nonnative groups generally have a high platymeric index (circular in shape). The cause of platymeria is currently unknown, but temporal trends toward a higher platymeric index (less platymeric) have been observed (Brothwell 1981). The reason for such trends is unknown, but evidence suggests that the magnitude of platymeria exhibited in a population is both genetically and functionally controlled (Gilbert and Gill 1990; Townsley 1946). For example, growth studies indicate that the adult form of the subtrochanteric, or the upper femoral shaft, is complete by age 5, suggesting that it has a substantial genetic component (Wescott 2006, 2008). However, Ruff and Larsen (1990) have proposed that variability in the shape of the proximal shaft is influenced by mechanical loads resulting from hip-joint architecture. Furthermore, others have hypothesized that variability may be attributed to factors that include nutritional deficiencies or biomechanical stress from habitual activities, such as kneeling or squatting (Buxton 1938; Gilbert and Gill 1990; Larsen 2002; Townsley 1946). More carefully controlled research on femoral shape is needed to further understand the interplay between genetics and environment—and the influence of each—on the expression of platymeria in human populations.

Sexual dimorphism refers to body shape and size differences between males and females. On average, adult males are larger than females in most dimensions of the human body, including stature. Apart from the determination of sex, the evaluation of sexual dimorphism in postcranial remains can offer additional insight into the dynamics of a once-living population. Research has shown that sexual variability is the result of biological, ecological, and cultural circumstances; nevertheless, the exact driving forces behind variability in the magnitude of dimorphism within and between groups are not clear (Armelagos and Van Gerven 1980; Shine 1989; Wolfe and Gray 1982). Various theories have been suggested to explain the prevalence of sexual dimorphism and its fluctuations over the course of human evolution, including migration, marital and mating patterns, sexual selection, differences in sex roles in the division of labor, and subsistence strategies, among others (Hall 1982; Murdock and Provost 1973). If males and females are participating in disparate daily activities and responding to environmental pressures differently, differences in postcranial morphology will arise. Thus, sexual variability in robusticity (body size), stature, or limb-bone morphology may reflect differential behavior in daily life.

The evaluation of variability in the magnitude of sexual dimorphism in human populations, especially when viewed temporally and spatially, can reflect different environmental and cultural adaptations. For example, such assessments, especially at the level of the population, can provide clues about sexual selection,

mating patterns, ecological adaptation, and utilization of nutritional resources (Shine 1989; Wolfe and Gray 1982). Additionally, consideration of the magnitude of dimorphism within and between populations adds to a more accurate determination of sex in skeletal remains, as populations are known to vary considerably over time and space (Shine 1989). The magnitude in one population or sample may not be mirrored in another, thereby making sex determinations less accurate. Continued appraisal of trends in sexual dimorphism in large data sets, such as the Alameda-Stone cemetery sample, is necessary in order to broaden our understanding of human adaptation.

It should be emphasized that interpretation of postcranial skeletal data is not always straightforward. As mentioned above, confounding variables can affect the form of an individual's skeleton. Most notable are genetics, disease, daily activity, and nutrition. The sex, age, and biological affinity of an individual also greatly affect the size and shape of the skeleton. Bioarchaeological interpretation of skeletal remains must include a consideration of all aspects of the physical, cultural, and biological environments. Using comparative data can allow for control of certain measures when evaluating variability within and between populations. A true bioarchaeological approach must consider both biological and cultural contexts (Buikstra and Beck 2006).

Methods

Osteometric and nonmetric postcranial observations were recorded following standard osteological procedures presented in Chapter 2. Measurement descriptions and definitions can be found in Buikstra and Ubelaker (1994). In an effort to ensure full skeletal maturity, only primary adults with a median age of 18 years or older were evaluated. Individuals lacking spatial provenience were excluded. These included enumerated individuals, remains housed at the Arizona State Museum, and isolates. The decision to exclude the Arizona State Museum individuals was based upon the fact that they were collected during efforts unrelated to the Joint Courts Complex project. This reduced the number of individuals in the data set, unfortunately, but it also eliminated any potential error associated with data-collection procedures. Because a primary goal of this chapter is to identify patterns of adult variation within and between the sexes and biological groups, individuals of indeterminate sex and biological affinity were excluded in all analyses.

Adult stature estimates were calculated using FORDISC 3.0 (Ousley and Jantz 2005) (see Chapter 2). Point estimates were calculated as an average of the minimum and maximum stature ranges produced in FORDISC 3.0. Appendix P provides descriptive statistics for all postcranial elements by biological affinity and sex.

Unfortunately, cross-sectional long-bone analysis could not be conducted, because of the destructive and costly nature of the methods. As an alternative, standard external measurements were substituted, as a proxy for cross-sectional observations. Various researchers indicate that use of external measurements to describe structural morphology is a valid and useful approach (Herring and Swedlund 2003; Marchi et al. 2006; Wanner et al. 2007). Humeral and femoral indexes follow standard formulae and are presented in more detail below.

All statistical analyses were performed using SPSS 16.0 statistical software (Statistical Package for Social Sciences 2008). Descriptive statistics are provided for all analyses, and unless otherwise stated, unpaired *t*-tests at the 99 percent confidence interval were used to test for statistical significance between groups.

Comparative Samples

Despite interest in postcranial morphology among anthropologists, detailed bioarchaeological analyses involving large skeletal collections are limited. Analyses including stature are abundant, but in-depth studies concentrated on postcranial variability are not as plentiful, in part because of the often incomplete nature of archaeological specimens, as well as the general complexity associated with the interpretation of postcranial-morphology analyses. For these reasons, comparative data are limited in quantity and scope, and sample sizes

are often small and uneven. Despite these limitations, existing comparative data can serve as useful references and building blocks for measuring and understanding postcranial variability.

Comparative anthropometric and osteometric data used herein consisted of prehistoric period, historical-period, and modern samples from the United States. For stature analysis, comparative groups included nineteenth-century Mexican-born and American-born male inmates (from Carson 2008); nineteenth-century white males and females from Rochester, New York (from Steegmann 1991); four Native American groups (Caddo, Apache, Comanche, and Tonkawa) (from Jantz et al. 2001); and early-historical-period and modern Americans from the southern, eastern, and midwestern United States (see Steegmann 1991). For femoral morphology, comparative osteological samples were derived from Cole (1994), Jantz et al. (2001), and Wescott (2006) and included prehistoric period, Protohistoric period, historical-period, and modern (Forensic Data Bank) remains. Further details on each comparative sample are presented as the samples are used.

Comparative samples were chosen based upon availability and historical relevance. Additionally, these data were viewed as being most suited to addressing research questions applicable to the Alameda-Stone cemetery sample. For the Alameda-Stone cemetery, the biological affinity designations of Native American, Euroamerican, and Hispanic are used for individuals identified as such through osteological analysis. For the reference samples, the groups will be cited as they are presented in the literature (i.e., white, black, etc.).

The objective of using the data selected is not to identify secular trends and make definitive statements about nineteenth-century Tucsonans. Unfortunately, at present, the data needed for such analyses do not exist. Rather, the goal is to describe, in a general fashion, the Alameda-Stone cemetery sample in light of the archaeological and historical records. The information provided in this chapter will, in the near future, serve as a robust comparative sample as more regional data become available.

Unless otherwise noted, a series of assumptions should be acknowledged through the following analyses: (1) all of the comparative samples are considered to comprise healthy individuals; (2) anthropometric and osteological data are comparable; (3) despite population variation regarding geography, genetics, and cultural practices, biological processes of growth and development are analogous in all samples under evaluation; and (4) the determinations of sex and biological affinity are considered accurate.

Stature

Stature estimates were used to investigate variability within and between sexes and within and between biological groups (Native American, Hispanic, and Euroamerican) and to identify any spatial trends across the cemetery. As discussed in Chapter 4, for analytical purposes, the Alameda-Stone cemetery was divided into five areas. Cemetery Area 1 is identified as the military section, and Cemetery Areas 2–5 are considered civilian. These divisions are based on the known presence of military interments in the southwest corner of the project area, as well as distinct clustering and disturbances associated with Cemetery Areas 2–5.

Comparative stature data were drawn from anthropometric and osteometric sources derived from three main references: Carson (2008), Jantz et al. (2001), and Steegmann (1991). The anthropometric data consisted of a sample of nineteenth-century Mexican-born and American-born, male prison inmates (Carson 2008); eighteenth- through twentieth-century military and civilian records, mostly from the midwestern and eastern United States (Steegmann 1991); and Native Americans drawn from Boas's database and presented in Jantz et al. (2001) (see also Jantz 1995; Jantz et al. 1992). Osteometric data were from a collection of males and females recovered from a nineteenth-century cemetery in Rochester, New York, and nineteenth- and twentieth-century military and civilian collections housed at the Smithsonian Institution (Steegmann 1991).

The inmate sample consists of anthropometric data for adult males, 23–55 years of age, born in Mexico and the American West (Carson 2008). The Mexican individuals were born primarily in northern and central provinces and the Baja Peninsula after the 1848 border settlement and were incarcerated in the American West, as adults. Historical records on the inmate sample contain information on birthplace, age, and occupation. The total sample consists of 3,883 Mexican-born and 20,919 American-born adults. Unfortunately, the prison sample

only represents males; nevertheless, it is one of the few studies of Mexican data collected during a time of documented political and socioeconomic change. It offers an ideal backdrop for the evaluation of socioeconomic change regarding stature. Additionally, it presents some of the only regionally and temporally relevant comparative data.

Male and female data from a nineteenth-century poorhouse cemetery in Highland Park, Rochester, New York, consists of osteometric data for 129 institutionalized white males and females associated with an unmarked cemetery adjacent to a public poorhouse (Steegmann 1991). Additional material drawn from this source includes individuals from various historical sources, including military and civilian whites, blacks, and "multiple ethnicities" (Steegmann 1991:266) from the eighteenth through twentieth centuries. Sample sizes are variable and range from 33 to 29,736 males and from 22 to 3,581 females. Both osteological and anthropometric records were used.

Finally, Boas's anthropometric database sample was drawn from Jantz et al. (2001), and it contains anthropometric records on males and females from four Native American groups measured by Boas in 1892 (see Jantz 1995; Jantz et al. 1992). These include four tribal groups: the Apache of the Southwest and the Caddo, Comanche, and Tonkawa of the Plains. These samples are significant in that they represent largely homogenous nineteenth-century Native Americans who are considered to be distinct cultural units, living at a time "when acculturation had not progressed as far as today" (Jantz et al. 1992:456).

The comparative samples used here represent temporally, geographically, and culturally diverse populations suitable for comparison with the Alameda-Stone cemetery population. We first present an analysis of intrasite variability for the Alameda-Stone cemetery and then evaluate comparative data.

Stature in the Alameda-Stone Cemetery Sample

From the Alameda-Stone cemetery sample, adult stature was estimated for 252 males and 174 females (n = 426). We used *t*-tests to identify any significant differences in stature between the sexes, biological groups, and cemetery areas. The percent of sexual dimorphism was also calculated, to identify the magnitude of sex differences in stature. Combining biological affinities and cemetery areas, the mean stature for males (n = 252) was 167.33 ± 6.13 cm and 156.2 ± 4.73 cm for females (n = 174). As expected, males were significantly taller than females ($t = 20.1597$, $df = 424$, $p = 0.0001$).

When evaluated by cemetery area, males and females followed the expected pattern; males were taller, on average, across the cemetery. Table 134 provides descriptive statistics for males and females by cemetery area. When compared within sexes, males show more overall variability than females.

Males from Cemetery Areas 1 and 2 (south) were the tallest, followed by Cemetery Areas 3, 5, and 4 (north). It should be noted, however, that the total number of males in Cemetery Area 1 was low. When combined with Cemetery Area 2, stature for males remained the highest in the southern portion of the cemetery. The *t*-tests showed that the pooled sample of males in Cemetery Areas 1 and 2 was significantly taller than males in Cemetery Areas 3 ($t = 5.2022$, $df = 143$; $p = 0.0001$,) and 4 ($t = 4.0137$, $df = 73$; $p = 0.0001$). Cemetery Area 3 males were taller than males in Cemetery Areas 4 and 5, but the difference was not significant.

The pattern observed for females was slightly different. No females were recovered from Cemetery Area 1. Those from Cemetery Area 2 were the tallest, followed by Cemetery Areas 4, 5, and 3. Despite the marked height of the females in Cemetery Area 2, *t*-tests showed no statistically significant differences between cemetery areas for female stature.

In an effort to identify differences between groups, stature was assessed according to biological affinity. Table 135 provides descriptive statistics for the three biological groups identified in the cemetery. In the male sample, Euroamericans were the tallest, followed by Hispanics and Native Americans. In the female sample, all three biological groups were nearly identical in height. Males showed slightly more differences between biological groups than females; however, *t*-tests showed no statistically significant differences between means for males or females when compared across biological groups.

Overall, stature followed the expected trend: males were taller in all biological groups than their female counterparts. Euroamerican males were taller than all other males, but not by a statistically significant margin.

To describe the difference between male and female averages for adult height, percent dimorphism in stature was calculated. The percentage was calculated by subtracting the female mean from the male mean, then dividing by the male mean, and multiplying by 100 (see Frayer 1980). Table 136 shows female stature as a proportion of male stature. Data are presented first with all biological groups pooled, then separated by biological group.

For the pooled groups, males were approximately 11 cm (6 percent) taller than females. When divided by biological group, only a slight trend toward a lower magnitude of dimorphism for Native Americans was observed. Overall, the magnitude of sexual dimorphism was roughly equal across groups: males were 6–7 percent taller than females, on average. The Alameda-Stone cemetery sample fell just short of the 12–13-cm difference reported for modern populations (Bogin 1999; Eveleth and Tanner 1990). This indicates that, at least on the population level, there were no marked deviations from the expected normal height range for modern humans.

Comparison of Stature to Other Groups

Because stature varies over time and space and according to environmental circumstances, comparisons were made with other samples to identify how nineteenth-century Tucsonans compared to other geographically and temporally diverse groups.

Table 137 shows descriptive statistics for the Alameda-Stone cemetery and all comparative data (compiled from Carson [2008], Jantz et al. [2001], and Steegmann [1991]) used in the following analysis. In some cases, statistical comparisons could not be made, as data were only available for one sex or the other, but for descriptive purposes, these groups are included in the table. We first present summary statistics and then make comparisons between the Alameda-Stone cemetery sample and the selected comparative samples.

The Alameda-Stone cemetery biological groups were pooled, as only minimal between-group differences were found. Furthermore, groups were pooled in an effort to boost sample sizes, as well as to evaluate stature of the Alameda-Stone cemetery individuals as a population. For both sexes, the 1975 U.S. sample (all ethnicities) were the tallest. Mexican-born nineteenth-century prisoners were the shortest males, and the Caddo were the shortest females. For males, the Alameda-Stone cemetery sample was the second-shortest group, after the Mexican-born prisoners, and for females, the Alameda-Stone cemetery sample was the third-shortest group, after the Caddo and Apache.

We used *t*-tests to test for significant differences in means between the Alameda-Stone cemetery sample and the nineteenth-century prisoners (males); the Rochester, New York, poorhouse (1826–1863); and the 1975 U.S. samples. These were chosen based upon availability of data.

Results showed that the Alameda-Stone cemetery males and females were significantly shorter than those from the Rochester, New York, poorhouse. Males were shorter by approximately 5.97 cm ($t = 7.799$, $df = 326$, $p = 0.0001$), and females were shorter by approximately 3.7 cm ($t = 4.784$, $df = 225$, $p = 0.0001$).

Compared to the nineteenth-century Mexican-born and American-born prisoners, Alameda-Stone cemetery males were approximately 0.6 cm shorter than the American-born prisoners ($t = 3.424$, $df = 21169$, $p = 0.0006$) and approximately 1.5 cm taller than the Mexican-born prisoners ($t = 8.0926$, $df = 4133$, $p = 0.0001$). Both comparisons showed statistically significant differences.

Finally, the Alameda-Stone cemetery sample was compared to the 1892 Native American groups from Boas's anthropometric database. For males, the Apache were taller than those at Alameda-Stone cemetery by approximately 2 cm, and the Tonkawa were nearly identical in stature to the Apache; however, there were no statistically significant differences between any of the groups. The males from Alameda-Stone cemetery and the Comanche and Caddo samples were nearly identical in height (approximately 167 cm). For females, only the Caddo and Alameda-Stone cemetery showed statistically significant mean differences ($t = 2.0645$, $df = 182$, $p = 0.0404$). The Caddo were approximately 3.2 cm shorter than the Alameda-Stone cemetery females. The Alameda-Stone cemetery, Comanche, and Tonkawa females were roughly equal in stature.

Percent sexual dimorphism in stature was also evaluated for all groups (with both male and female data), to identify the magnitude of sexual dimorphism in the Alameda-Stone cemetery sample compared

to other groups. Table 138 shows the range of sexual dimorphism for each group. The Alameda-Stone cemetery sample showed the least dimorphism, and the Pennsylvania free blacks exhibited the highest degree.

Summary of Stature Data

The Alameda-Stone cemetery sample was analyzed for intrasite variability in stature, and then comparisons were made between the Alameda-Stone cemetery sample and other historical-period anthropometric and osteological data. As mentioned at the outset, the purpose of this section (and the chapter at large) is not to provide extensive interpretation; rather, it is to broadly evaluate postcranial variability in light of existing data.

In terms of sex, variability in the Alameda-Stone cemetery sample followed the expected trend: males (for all groups) showed a greater overall mean stature than females. In general, males also showed greater variability than females in adult stature. For the Alameda-Stone cemetery sample, this may be, at least in part, a reflection of differential gene flow (Stefan 1999). That is, there was a greater influx of males into Tucson from different geographical, biological, and cultural backgrounds. For example, stature for the males from the southern cemetery section was significantly greater than that of those buried in the northern section. This is most likely the result of greater numbers of taller Euroamericans interred in the southern section of the cemetery. Additionally, this is supported by the lack of variation in female height between cemetery areas and between biological affinities, indicating that females were more homogenous across the site. Another explanation may be a greater male sensitivity to environmental stressors during the growth period. Previous research suggests that males are more sensitive to nutritional environments than females, the result of more-canalized growth patterns in females, thought to be an adaptive mechanism related to the requirements of childbirth. As a result, males have a tendency to exhibit a wider range of variability in various measures of adult morphology (Hamilton 1982; Holden and Mace 1999).

The magnitude of sexual dimorphism in stature for the Alameda-Stone cemetery as a population, as well as when separated by biological group, fell within the normal range for modern human populations, indicating no unusual patterning in dimorphism. Euroamericans showed the greatest magnitude, at 12 percent, followed by Hispanics, at 11 percent, and Native Americans, at 10 percent. None of these groups differed significantly, however. Although not statistically significant, the level of variation observed between groups may indicate differential behavior patterns or, as stated above, differential growth environments leading to greater or lesser degrees of dimorphism.

The comparison of stature data from other temporally and geographically diverse samples suggests that the Alameda-Stone cemetery males were the second-shortest group, after the Mexican-born inmate sample. The Alameda-Stone cemetery females were also found to be among the shortest, next to the Caddo and Apache samples. For both sexes, the 1975 U.S. sample (all ethnicities) was the tallest, by a significant margin. That the 1975 group had the tallest stature by a large margin may be the result of improved living conditions over time; however, as illustrated in Figures 142 (males) and 143 (females), when all groups are evaluated temporally, a secular increase is not observed.

Long-Bone Morphology

The estimation of adult stature provides a general picture of variation within the population, and an evaluation of individual bones or anatomical complexes of the postcranial skeleton may shed additional light on activity levels seen within and between groups. This section presents a biomechanical analysis of external humeral-shaft diameters and an analysis of femoral morphology. Indexes of the humerus and femur are used to evaluate directional asymmetry, robusticity, and overall shape, to identify trends that may lead to a more complete understanding of the daily lives of those recovered from the cemetery.

Humeral Robusticity and Shape

The biomechanical responses of bone to physical stress can provide information useful for the reconstruction of activity levels in past populations (Bridges 1989). Cross-sectional analysis of bone morphology is considered the most effective and accurate way to evaluate the strength of a bone, but such analysis is costly, highly intrusive, and destructive. As an alternative, external dimensions were used as a proxy to measure cross-sectional shape and symmetry of the upper arm. The humerus-midshaft shape, considered a measure of strength, was calculated following Wanner (2007). Humerus-midshaft shape is calculated by multiplying the minimum diameter of the humeral shaft by 100 and dividing the result by the maximum diameter of the humeral shaft. A value of less than 76.5 indicates a shaft that is flattened in the anterior-posterior plane, and a value greater than 76.5 represents a more circular shaft and, therefore, one that is less stressed in the anterior-posterior plane. Those with a value greater than 76.5 are classified as eurybrachic, or as having a rounded humeral shaft, and those that fall below 76.5 are considered platybrachic (Larsen 1999; Pietrusewsky and Douglas 2002).

Humerus-midshaft shape was first evaluated for males and females of pooled biological groups, then by cemetery area (by sex only) and by biological group. We used *t*-tests to test for any significant differences between mean values. Percent dimorphism was also explored. Sexual dimorphism was calculated by subtracting the female mean from the male mean, dividing by the male mean, and multiplying by 100. Sample sizes were greatly reduced when divided by cemetery area; therefore, Cemetery Areas 1 and 2 (south) and Cemetery Areas 3, 4, and 5 (north) were combined for both sexes. Unfortunately, when split further, by biological group and cemetery area, the samples became too small to produce meaningful results. Table 139 presents descriptive statistics and percent dimorphism for humerus-midshaft shape for the pooled biological groups from Alameda-Stone cemetery.

Males and females were found to be largely symmetrical in humerus-midshaft shape, and overall, males displayed a more rounded morphology (eurybrachic by definition), compared to the more flattened (platybrachic) shaft of their female counterparts. Both sexes showed a more rounded left shaft, but neither sex showed statistically significant differences between sides. Humerus-midshaft shape was found to be highly sexually dimorphic, with statistically significant differences for both sides (left: $t = 7.2196$, $df = 229$, $p = 0.0001$; right: $t = 9.0494$, $df = 219$, $p = 0.0001$). There was a 9 percent difference between the sexes on the left and a 10 percent difference on the right side.

Table 140 presents descriptive statistics for humerus-midshaft shape by cemetery area. When divided by cemetery area (north and south), males were found to be nearly symmetrical between sides. Males from the south showed a more circular shaft than those from the north, and both were considered to be eurybrachic. A statistically significant difference ($t = 3.4361$; $df = 120$; $p = 0.0008$) was found between the right humeri of those in the north and south; those from the south displayed a tendency toward a more circular morphology.

For females, no statistically significant differences were found between right and left humeri within either cemetery area. Opposite of that for males, there was a significant difference ($t = 2.0037$; $df = 92$; $p = 0.0480$) between left humeri of the females buried in the northern and southern areas. Those from the southern cemetery area were found to be eurybrachic, and those from the northern were not.

When separated by sex and biological group, all male humeri exhibited eurybrachic shaft morphology. Table 141 shows humerus-midshaft shape by sex and biological group. For males, the left sides for all groups were nearly identical, but the right sides showed a higher range of variation. No statistically significant differences were observed between sides for any group. Euroamerican humeri showed the most circular morphology, followed by those of Hispanics and Native Americans. Despite differences seen in the Native American group, none was found to differ significantly.

For females, all groups fell under a value of 76.5, indicating an overall flatter humerus morphology. No significant differences were found between right and left sides for any group. Euroamericans were nearly identical between sides and showed the highest value approaching eurybrachia. For both sides, Native American humeri were found to be significantly flatter than Euroamerican humeri (left: $t = 2.0872$; $df = 26$; $p = 0.048$; right: $t = 2.8857$; $df = 19$; $p = 0.0095$). No significant differences were found between Euroamericans and Hispanics for either right or left humeri.

Sexual dimorphism in humerus-midshaft shape was evaluated for variation between biological groups. Table 142 shows the percent dimorphism for all Alameda-Stone cemetery groups. Native Americans showed the greatest amount of dimorphism for both sides, with the left side showing the highest, at circa 12 percent, and the right showing 11 percent. For both Euroamerican and Hispanic humeri, the left side displayed a circa 8 percent difference, and the right side displayed a circa 9 percent difference.

Summary of Humeral Morphology Data

Overall, asymmetry in humeral shape in the Alameda-Stone cemetery sample was minimal, with a slight right directionality, as indicated by a more flattened humeral shaft. On the whole, these values indicate a higher anterior-posterior loading on the right side for both sexes.

Humerus-midshaft shape was also more strongly sexually dimorphic on the right side. Males from the southern cemetery area showed significantly more rounded morphology on the right humeral shaft than those males buried in the northern portion of the cemetery. Comparison of the females in the northern and southern cemetery areas showed no asymmetry, but the left humeri of those buried in the south were found to be flatter overall than those in the north.

When divided by biological group, all males exhibited largely symmetrical upper arms, with rounded shaft morphology. No significant differences were found between sides, but the right showed a greater range of variation. Native American males showed the flattest humeral morphology, but no groups showed significant differences. Females for all groups showed a flatter humeral morphology, with minimal asymmetry. Native American females were found to have significantly flatter humeri for both right and left sides than did Euroamericans. Only modest differences between Hispanics and Euroamericans were observed.

Interestingly, and unlike the results for stature, Native Americans displayed the greatest amount of sexual dimorphism in humeral morphology for both right and left sides. Euroamericans and Hispanics displayed a lower level of dimorphism and asymmetry. For the right sides, Euroamericans and Hispanics were nearly identical.

These results showed a slight overall right directionality for the sample, indicating greater use of the right arm. Variation between males and females was significant and is a good indicator in support of differential behavior patterns between males and females, in general. However, it should be noted that this also suggests that there is a strong sex-linked component in humeral-shaft morphology. Because of this, humeral-shaft morphology cannot be explained by behavior alone. Additionally, when evaluated by biological group, it becomes apparent that there are striking differences in morphology, particularly for Native Americans. Overall, this pattern of variation in upper-arm morphology indicates that biological affinity and sex were important factors in guiding humeral morphology in this sample.

Femoral Shape and Robusticity

External femoral dimensions were used as a proxy for femoral shape and robusticity. Because the articular surface is a reflection of body mass, femoral-head diameter was used as a measure of overall robusticity (Wescott 2006). Femoral-midshaft shape and femoral robusticity were calculated using indexes frequently employed in bioarchaeological analyses to approximate cross-sectional properties (Cole 1994; Wescott 2006). Percent dimorphism was also explored, using the same formula presented above.

Femoral-midshaft shape was calculated by dividing the anterior-posterior diameter by the medial-lateral diameter. Femoral robusticity was calculated by adding the anterior-posterior and medial-lateral midshaft diameters, multiplying by 100, and dividing by the maximum diameter of the femoral head. Following Ruff (1987) and as presented in Wescott (2006), a value of 1.0 (1:1 ratio) indicates that the shaft is circular in shape. A value greater than 1.0 represents a shaft that shows elongation in the anterior-posterior plane. A value less than 1.0 indicates a shaft that is elongated in the medial-lateral plane. Elongation of the femoral shaft in the anterior-posterior plane is associated with increased loading forces and suggests strenuous lower-body activity

(Ruff 1987; Wescott 2006). The femoral robusticity value provides an approximation of femoral torsional strength, where higher values indicate greater robusticity.

Femoral-midshaft shape and femoral robusticity are first explored for the Alameda-Stone cemetery sample by sex, with biological groups pooled, then by cemetery area (sex only) and biological group. We then explore comparative data. As with observations of the humerus, sample sizes were greatly reduced when divided by cemetery area; so, Cemetery Areas 1 and 2 (north), and Cemetery Areas 3, 4, and 5 (south) were combined for both sexes. When split further by biological group and cemetery area, the samples became too small to produce meaningful results.

Femoral Shape and Robusticity in the Alameda-Stone Cemetery Sample

Variation within and between groups may offer insight into differential activity levels of those from the cemetery. Additionally, variation between the sexes may indicate differential behavior patterns as a result of the sexual division of labor. Femoral-midshaft shape and femoral robusticity were calculated for the Alameda-Stone cemetery individuals, first with biological groups pooled and then separated by cemetery area and then biological group, in order to identify sex- and group-specific differences. We then compared the Alameda-Stone cemetery sample to other groups, drawn from Wescott (2006), representing differing subsistence strategies and activity levels.

The comparative samples included broad-spectrum, marine, and equestrian hunter-gatherers; three groups of semisedentary horticulturalists; and early and late industrial groups. Table 143 shows descriptive statistics for femoral-midshaft shape and femoral robusticity for male and female pooled biological groups. Table 144 shows summary statistics separated by sex and group.

Males and females each exhibited a slight anterior-posterior elongation of the femoral midshaft, with ratios of 1.04 and 1.01, respectively. Males showed a significantly more elongated femoral-midshaft shape than females ($t = 2.2577$, $df = 163$, $p = 0.0253$), whereas females showed only minimal elongation. For femoral robusticity, males and females showed no significant difference.

As with the previous analyses, the cemetery was divided into northern and southern areas and compared by sex. Table 145 provides descriptive statistics for femoral-midshaft shape and femoral robusticity by cemetery area and sex. No statistically significant differences were found for femoral-midshaft shape or femoral robusticity in either sex. For males, femoral-midshaft shape was found to be nearly identical between northern and southern, with only slightly more variation in femoral robusticity. Conversely, femoral robusticity was found to be nearly identical for females between northern and southern areas, with only somewhat more variability in femoral-midshaft shape. Overall, there was virtually no difference between these variables between cemetery areas.

When split by biological group, all male femora showed significant anterior-posterior elongation, and males were generally more robust than females. Native American male femora showed the most-pronounced anterior-posterior elongation and were most robust. However, no significant differences were found between male means of femoral-midshaft shape and femoral robusticity when separated by biological group. It should be noted that the sample sizes for Native American males and females and Euroamerican females were low. For females, femoral-midshaft shape was similar between Hispanics and Euroamericans, showing slight anterior-posterior elongation. Native American female femora had more medial-lateral elongation, but the mean difference was not enough to be statistically significant. For female femoral robusticity, Hispanic femora were the most robust, but they were not significantly larger than Euroamerican and Native American femora.

Sex differences in femoral-midshaft shape and femoral robusticity within groups were also explored. For Native Americans, females showed a more pronounced medial-lateral elongation in the femora, rather than the anterior-posterior elongation of the midshaft seen in Native American males ($t = 2.3829$, $df = 9$, $p = 0.0410$) Interestingly, only Native American males and females showed significant differences in femoral robusticity, with an approximately 6 percent difference; in that group, males were significantly larger ($t = 2.4978$, $df = 7$, $p = 0.0411$). Euroamerican and Hispanic males and females, on the other hand, showed no significant differences in either femoral-midshaft shape or femoral robusticity. Table 146 presents the percent dimorphism for femoral-midshaft shape and femoral robusticity for the Alameda-Stone cemetery biological groups.

Comparisons of Femoral Shape and Robusticity to Other Groups

In an effort to further understand variability in the Alameda-Stone cemetery sample, comparisons were made to other groups categorized by subsistence strategy (mobility levels), as presented in Wescott (2006). The subsistence strategies described therein include broad-spectrum, woodland, equestrian, and marine hunter-gatherers; village horticulturalist-hunters; incipient and maize-dependent horticulturalists; and early- and late-modern industrialists (in order of greatest to lowest mobility level). Each of these groups was given an intensity score between 0 and 5, with 0 being "extremely low" and 5 being "very high" mobility (Wescott 2006:203).

Although Wescott found little correlation between mobility level and femoral-midshaft shape and femoral robusticity, some interesting patterns emerged from that data set. Marked variability between subsistence intensities and the sexes did exist and could not be explained by mobility alone. These findings warrant further exploration. As stated above, the goal herein is not to make pointed statements about activity patterns for the Alameda-Stone cemetery individuals but, rather, to descriptively place the sample in light of expectations based upon previous bioarchaeological research, such as Wescott (2006). The value of the Alameda-Stone cemetery data set resides in establishing a reference set for nineteenth-century Tucsonans, as well as building upon existing comparative data. Table 147 provides descriptive statistics for each subsistence group and the Alameda-Stone cemetery sample, separated by sex and group (see Wescott [2006] for coding and further discussion on provenience).

We used *t*-tests to compare all groups except the Alameda-Stone cemetery Native Americans (both sexes) and Euroamerican females. Because of the small sample sizes of these groups, Z scores were used to test for any significance in difference between mobility groups for both variables. This approach tests for significant differences between individual measurements and the population parameters (mean and standard deviation) of the other group.

For the Alameda-Stone cemetery Euroamerican males, a significant difference was found for femoral-midshaft shape between late-modern industrialists ($t = 3.3598$, $df = 440$, $p = 0.0008$), equestrian hunter-gatherers and maize horticulturists ($t = 3.9605$, $df = 127$, $p = 0.0001$), incipient and village horticulturalists ($t = 4.1151$, $df = 613$, $p = 0.0001$), and broad-spectrum hunter-gatherers ($t = 4.0784$, $df = 77$, $p = 0.0001$). In all cases, the Euroamerican male femora showed significantly less anterior-posterior elongation. For femoral robusticity, Euroamericans showed no significant differences between any of the mobility groups.

The same pattern was found for the Alameda-Stone cemetery Hispanic males; significant differences were found in femoral-midshaft shape between late-modern industrialists ($t = 4.4257$, $df = 468$, $p = 0.0001$), equestrian hunter-gatherers and maize horticulturists ($t = 4.7501$, $df = 155$, $p = 0.0001$), incipient and village horticulturalists ($t = 5.4896$, $df = 641$, $p = 0.0001$), and broad-spectrum hunter-gatherers ($t = 4.5520$, $df = 105$, $p = 0.0001$). In all cases, the Hispanic male femora showed significantly less anterior-posterior elongation. For femoral robusticity, Hispanic femora showed no significant differences between any of the mobility groups.

Using Z scores, no significant differences were found between Alameda-Stone cemetery Native American males and any of the mobility groups, for either femoral-midshaft shape or femoral robusticity. Femoral-midshaft shape for Native American males was identical to that of the late-modern industrialists, and for femoral robusticity, Native American males showed the greatest femoral robusticity for all groups.

For Alameda-Stone cemetery Hispanic females, significant differences in femoral-midshaft shape were found between late-modern industrialists ($t = 6.6246$, $df = 283$, $p = 0.0001$), equestrian hunter-gatherers and maize horticulturists ($t = 2.3768$, $df = 160$, $p = 0.0186$), and incipient and village horticulturalists ($t = 3.4286$, $df = 541$, $p = 0.0007$). Alameda-Stone cemetery Hispanic female femora exhibited significantly less anterior-posterior elongation. For femoral robusticity, Hispanic female femora showed no significant differences between any mobility groups. Hispanic female femora were among the most robust of the groups.

Using Z scores, no significant differences were found between Alameda-Stone cemetery Euroamerican and Native American females and the mobility groups, for either femoral-midshaft shape or femoral robusticity. As in other analyses, Native Americans stood out, in that they were the only group that had a femoral-midshaft-shape value below 1.0. As with the humeral shaft, the femoral shaft also showed more of a pronounced medial-lateral elongation. Although not significant, Native American female femora were found to be the least robust of all of the groups. Euroamerican female femora showed the next-lowest femoral-midshaft shape value, at 1.0, and exhibited the least robusticity, after the Native Americans.

Summary of Femoral Morphology Data

In general, Alameda-Stone cemetery male femora exhibited an elongated (in the anterior-posterior plane) femoral-midshaft shape, compared to those of females. This could be interpreted as a reflection of overall higher stress loads for males. Female femora showed a greater range of variability in femoral-midshaft shape, likely resulting from a greater range of activities among Alameda-Stone cemetery women. The lack of differences between those buried in the northern and southern areas of the cemetery indicates no differences in (lower-body) activity levels between the northern- and southern-area groups.

For all groups except Hispanics, femoral robusticity was greater for males than females, but sex differences were not striking. Again, Native Americans stand out in regard to femoral morphology, in that males were the most robust and females the least robust of the groups. Only Native Americans showed a significant difference between the sexes in femoral robusticity.

Overall, the Alameda-Stone cemetery sample showed limited variability in sexual dimorphism for femoral-midshaft shape and femoral robusticity between groups. Among the groups, Native Americans stood out in both femoral-midshaft shape and femoral robusticity. Native American males showed a greater general robusticity than their female counterparts. For femoral-midshaft shape, only Native Americans showed a substantial difference between males and females, displaying a nearly 13 percent difference. That Native Americans showed greater sexual dimorphism than Euroamericans or Hispanics suggests differential behavior and or environments. It should be cautioned, however, that these results may be affected by the relatively small sample sizes for Native Americans and that other factors, including genetics, need to be considered.

As compared to Wescott's mobility groups, significant differences were found for male femoral-midshaft shape between Alameda-Stone cemetery Euroamericans and Hispanics and the late-modern industrialists; equestrian, maize, incipient, and village horticulturalists; and broad-spectrum hunter-gatherers. No significant differences were found between Wescott's groups and the Alameda-Stone cemetery groups for femoral robusticity, but Alameda-Stone cemetery Native American males were found to have the most-robust femora. For females, Hispanics were found to differ significantly from the same groups as the males for femoral-midshaft shape, but no significant differences were found for Euroamerican or Native American females for femoral-midshaft shape. No significant differences were found between any of the female groups for femoral robusticity. In all cases, femora from the Alameda-Stone cemetery groups were found to exhibit less anterior-posterior bending, indicating lower levels of lower-body stress.

Platymeria in the Alameda-Stone Cemetery Sample

The platymeric index was calculated in an effort to characterize the morphology of the subtrochanteric region of the femur because this area is believed to be a distinguishing Native American feature. Platymeric values were calculated for 127 males and 91 females. The platymeric index is established using the anterior-posterior and medial-lateral subtrochanteric dimensions. Individuals falling below 84.9 are considered to be platymeric, or flattened in the anterior-posterior plane, and those falling between 85 and 99.9 are classified as eurymeric (Brothwell 1981). Like the morphology of the midshafts of humeri and femora, flattening of the subtrochanteric shaft is thought to be an indicator of increased stress or load bearing. Aside from being an indicator of activity, the platymeric index has been correlated to biological affinity, specifically as a notable feature within Native American groups (Gill 2001).

For the purposes of this chapter, the platymeric index was evaluated both between and within groups and sex differences, in an effort to identify variability and to evaluate its potential utility in identifying biological affinity for the Alameda-Stone cemetery sample. For this analysis, only biological affinity was explored; no comparisons were made according to cemetery area.

Differences in the mean values between sexes and samples were tested for significance. First, the Alameda-Stone cemetery sample was evaluated by sex, with biological groups pooled. Then the Alameda-Stone cemetery sample was evaluated for differences between biological groups by sex. Because sample sizes became too small when divided by cemetery area and biological group, such comparisons were not made.

Alameda-Stone cemetery individuals were then compared to other Hispanic, Native American, mixed, and modern populations.

The Alameda-Stone cemetery males (n = 127), with a mean of 86.7 ± 9.51, exhibited a more rounded subtrochanteric shape and did not evince platymeria. The females (n = 91), however, had a mean of 81.6 ± 8.9, falling below the 84.9 percent threshold for platymeria (Brothwell 1981). The difference between males and females was statistically significant ($t = 3.9896$, $df = 216$, $p = 0.0001$).

Table 148 shows summary statistics for platymeria by sex and biological group. Female femora in all groups fell below 84.9 percent and were considered platymeric. Native American female femora showed the highest level of platymeria. Hispanic femora were more circular. Euroamerican femora were intermediate to Native Americans and Hispanics. Male femora within the sample were not considered platymeric for any group.

Comparison of Platymeria with Other Groups

The platymeric values for the Alameda-Stone cemetery biological groups were compared to other osteological samples. Comparative data were drawn from Cole (1994) and Jantz et al. (2001). Those drawn from Cole (1994) included two samples of Northern Plains Indians (Plains Woodland and Plains Coalescent). From Jantz et al. (2001) came three Spanish Mission samples from the Texas coast (Refugio, Mission San Juan Capistrano, and Pecos Church), consisting of a combination of Native American and European individuals and individuals of mixed ancestry, and from Pecos Pueblo (New Mexico), associated with the Glaze 6 historic component. Derived from both sources were additional data from modern Hispanics, whites, and blacks from the Forensic Data Bank. These samples were chosen based upon availability of data and because they represent geographically, culturally, and temporally diverse groups (Table 149).

In general, with the exception of the Forensic Data Bank samples, female femora in all groups exhibited platymeria. Males, on the other hand, showed a greater tendency toward a more rounded upper femoral shaft and a higher level of variability. Following the contention that platymeria is more pronounced in Native American groups, Alameda-Stone cemetery Native Americans should most closely resemble the Plains and Pecos samples for both sexes. For males, this was not found to be the case: Alameda-Stone cemetery individuals were nearly identical to the Forensic Data Bank samples. For females, the platymeric index was found to be closest to the more mixed groups of Refugio and San Juan Capistrano.

Summary of Platymeria Data

Based upon previous research (Gilbert and Gill 1990; Gill 2001; Wescott 2008), Native American femora generally present the highest expression of platymeria, followed by those of Hispanics and Euroamericans. So, the platymeric index should reflect biological affinity, at least to some degree, for the Alameda-Stone cemetery Native Americans. Additionally, based upon previous findings (Gill 2001), females across all groups should display lower indexes (higher expression) than males.

These expectations were not met for the male sample. Females, however, did fall in line with the results presented in previous research. Interestingly, Alameda-Stone cemetery Native American male femora showed the most circular (less platymeric) subtrochanteric region, followed by Euroamericans and Hispanics. As predicted, all female femora exhibited pronounced platymeria. Native American female femora had the highest expression of platymeria. The negligible between-group variation suggests that platymeric index alone would not serve as a useful indicator of biological affinity. Unfortunately, the small sample sizes of the Native Americans may hamper the identification of any true patterns associated with biological affinity.

These results indicate that the expression of platymeria may be more dependent upon sex than biological affinity. Factors other than biological affinity, such as genetics, environment, and behavior, are also likely to affect the expression of platymeria in a population and need to be considered. That there is a tendency for platymeria in females, regardless of group, suggests a sex-based origin for a flat upper-femoral shape. As suggested

by some, upper-femoral morphology may be influenced more by pelvic morphology and/or differential physical activity than biological affinity. Larger samples would be needed to solidify any real relationship between biological affinity and platymeria.

Discussion

The goal of this chapter was to broadly describe adult postcranial morphology of the Alameda-Stone cemetery population. Stature, limb-bone morphology, and sexual dimorphism were evaluated in an effort to address research questions regarding health, biological affinity, and activity patterns.

Despite being among the shortest when compared to other eighteenth- through twentieth-century samples, stature data from the individuals recovered from the Alameda-Stone cemetery suggest a population that was generally healthy. In general, males showed slightly more variability in all observations. This is a common finding and is thought to be related to greater male sensitivity to environmental pressures during the growth period, versus a more-canalized response in females (see Stinson 2005). Additionally, greater male variability may be attributed to higher levels of male mobility, with a greater influx of males from varying geographical, biological, and cultural backgrounds (see Stefan 1999). With the exception of Euroamerican males recovered from the southern portion of the cemetery, adult height for both sexes was comparable across cemetery areas and biological groups. Historically, Euroamericans have defined the upper boundaries for stature, a trend upheld in the Alameda-Stone cemetery sample. Overall for males, Euroamericans were the tallest, followed by Hispanics and Native Americans, and for females, all groups were nearly identical in height. Males were, on average, 11 cm taller than females, a difference that is considered to be within the normal range for modern humans (Bogin 1999). When evaluated by biological affinity, sexual dimorphism in stature was roughly equal among the groups, although Native Americans did show a slight tendency for a lower magnitude of dimorphism. Variation in sexual dimorphism in stature may be interpreted as the result of a combination of genetics and, possibly, differential growth environments.

When viewed in a comparative framework, mean stature values for the Alameda-Stone cemetery sample fall at the lower end of the spectrum. Males in all groups were taller than females. It is difficult to make any conclusive statements regarding temporal trends, because sample sizes were skewed. The Alameda-Stone cemetery males were most similar in stature to the sample of nineteenth-century Mexican-born inmates and Boas's Native American groups and most dissimilar to the poorhouse cemetery group from Rochester, New York. For females, the same pattern was observed. The overall findings may be attributed to (1) the genetic composition of the Alameda-Stone cemetery sample, wherein most southern Native groups and Hispanics generally show shorter stature than Euroamericans (Bertroni et al. 2005; Prince and Steckel 2000; Spradley et al. 2008); (2) the location of Tucson, with the preindustrial Southwest presenting a harsher environment with fewer nutritional resources, resulting in lower stature values; and (3) the economic pressures that may have limited access to nutritional resources and health care and thereby contributed to an overall shorter stature at the population level.

Limb-bone morphology was evaluated in an effort to identify trends that may aid in the interpretation of behavior patterns. Directional asymmetry of humerus-midshaft shape, femoral-midshaft shape, and femoral robusticity were evaluated for differences within and between sexes and groups. Variation in upper-arm shape and asymmetry are thought to reflect differential activity patterns, where asymmetry indicates side use and shaft shape indicates intensity. A more rounded shaft suggests decreased anterior-posterior bending strength (less stress), and a flatter morphology indicates greater anterior-posterior bending strength (more stress). Directional asymmetry and shaft morphology may indicate habitual motion related to occupation or other repetitive behavior. As indicated by research on athletes (Weiss 2009), such an analysis provides additional evidence for the interpretation of occupation or associated behaviors in past populations.

Overall, the Alameda-Stone cemetery sample was remarkably symmetrical in the upper arm, showing only minimal differences between the right and left sides for any group. Males were found to exhibit a generally

rounded (eurybrachic) humeral shape, and females, a more flattened (platybrachic) morphology. Differences between the sexes in humerus-midshaft shape were significant for both right and left sides, showing a more pronounced variation on the right side that suggests a relationship between sex and shaft morphology. Morphological differences between those buried in the northern and southern cemetery areas were also noted. Males from the southern cemetery area showed a significantly more rounded shaft on the right humerus than those in the northern, which indicates greater use of the right arm in those buried in the northern area. For females, the opposite was found; there were significant differences in humeral morphology of the left side. Female left humeri from the southern cemetery area were found to be more rounded than humeri from the northern area, which exhibited flatter shaft morphology. This suggests differential activity levels between individuals buried in the northern and southern cemetery areas for both sexes. Although asymmetry was not marked for any group or sex except Euroamerican males, a slight right directionality was observed, and this indicates greater anterior-posterior bending strength, possibly related to handedness (Wanner et al. 2007). The difference between the sexes also indicates differential behavior, possibly associated with occupation.

When separated by biological affinity, some differences in humerus-midshaft shape were observed. Euroamerican humeri were found to exhibit the most circular morphology, followed by Hispanics and Native Americans. For females, all groups showed a flatter humeral morphology than males, with Native Americans exhibiting pronounced flattening, especially as compared to Euroamericans. All groups displayed marked sexual differences in humeral morphology, and Native Americans were found to exhibit the highest magnitude of dimorphism. Hispanic and Euroamerican humeri were comparable. That Native American humeri were found to differ markedly by group and sex from Euroamerican and Hispanic humeri indicates differential behavior patterns for this group. The lower mean values for Native Americans indicate that they were engaged in activities resulting in greater anterior-posterior bending strength for both sides. Furthermore, the higher magnitude of sexual dimorphism suggests greater levels of differential treatment within the group.

For the femur, shape and robusticity were evaluated as measures of size and strength. Like the upper arm, the morphology of the femoral midshaft responds to external loading forces, and indexes can provide a general indication of lower-body activity. The platymeric index of the upper femoral shaft was also evaluated, as previous research has found it to be an accurate measure of ancestry, particularly in Native Americans. Platymeria was examined to determine whether or not it is an applicable measure for ancestry for the Alameda-Stone cemetery sample.

Overall, for the Alameda-Stone cemetery sample, male femora showed a greater level of anterior-posterior elongation than their female counterparts, indicating greater stress levels for males as a whole. No sex differences were detected for femoral robusticity. The cause for this is not clear. Additionally, no differences were found between cemetery areas for either observation, indicating equal lower-body activity between those buried in the northern and southern cemetery areas. Comparison of femoral morphology between groups showed only a limited amount of variation, with Native American males showing the greatest anterior-posterior elongation and robusticity. Native American females also stood out in femoral-shaft shape, in that they showed a more medial-lateral elongation. Hispanic female femora were found to be the most robust. In looking at differences within biological groups, only Native Americans showed significant differences in shaft morphology and robusticity. This may be the result of Native American males' engaging in more strenuous lower-body activity than did their female counterparts.

With regard to Wescott's (2006) results and the findings from the Alameda-Stone cemetery sample, a few broad statements on femoral morphology can be made. First, the Alameda-Stone cemetery sample falls in line with secular trends toward a more circular midshaft shape that characterizes a more sedentary population (Ruff 1987). Second, the low magnitude of sexual dimorphism in femoral robusticity, which is also a reflection of body size, meets expectations based on long-term trends toward an overall reduction in the magnitude of dimorphism as sedentism steadily increases (Rockhold 1998; Ruff 1987). Finally, based on the previous statements, inconsistencies in finer comparative analyses, such as Wescott's, may be attributable to methodological issues, such as sample size and behavioral interpretation. Overall, the results for this comparison are difficult to interpret in regard to activity levels of the Alameda-Stone cemetery population. Despite shortcomings of using external measurements compared to cross-sectional analysis (see Bertram and Swartz 1991; Frost 1997), this approach offers a practical, standardized, and nonintrusive method of measuring and comparing femoral variability.

Using the platymeric index, sex- and group-specific variability was explored in the morphology of the upper femoral shaft. Although the causes of platymeria are currently unknown, previous research has indicated that platymeria is a useful measure of determining ancestry, particularly in Native Americans. According to Brothwell (1981), an index of 84.9 or less is considered to be platymeric. Using 84.9 as the cutoff point, all female femora from the Alameda-Stone cemetery were considered platymeric. Native American female femora exhibited the highest expression of platymeria; Native American male femora, on the other hand, were the least platymeric. Overall, the differences between biological groups were not significant.

When compared to other Native American, mixed (historical-period Euroamerican and Native American), and recent groups, Alameda-Stone cemetery male femora were found to be nearly identical in platymeria to the modern Forensic Data Bank sample. Female femora were found to resemble the more mixed Mission groups of Refugio and San Juan Capistrano Texas samples.

Results indicate that the platymeric index is highly variable. Although no relationship was found between platymeria and biological affinity, there appears to be a sex-linked component to platymeria. The level of sexual dimorphism in the upper femur was high; therefore, further investigations of femoral morphology for the determination of sex, rather than biological affinity, may be useful. That platymeria was more consistent in females may be the result of factors other than ancestry, such as pelvic morphology. High levels of variability in upper-femoral shape between groups and sexes may also reflect differential biomechanical stressors.

The Alameda-Stone cemetery sample was found to show some variability between biological groups and the northern and southern cemetery areas. Varying magnitudes of sexual dimorphism between the groups suggest differential development and behavior. Overall, for the Alameda-Stone cemetery, Native American long bones were found to exhibit the most-distinct morphology in all analyses. Variation in adult postcranial morphology suggests differential behavior patterns that reflect differences in activity between the biological groups and sexes for the Alameda-Stone cemetery sample.

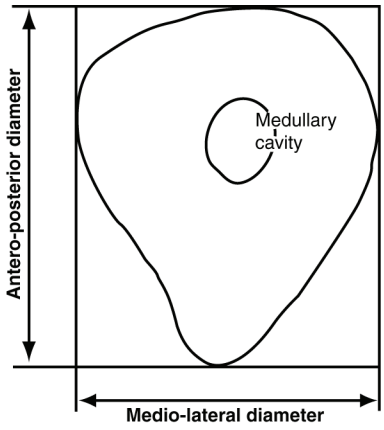


Figure 140. Elongated femur as shown in cross-sectional analysis.

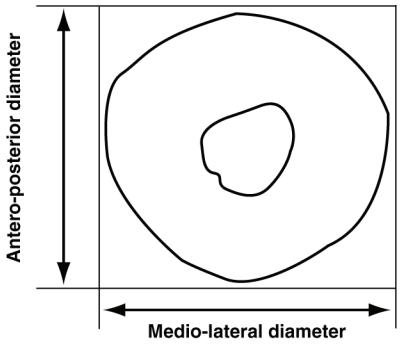
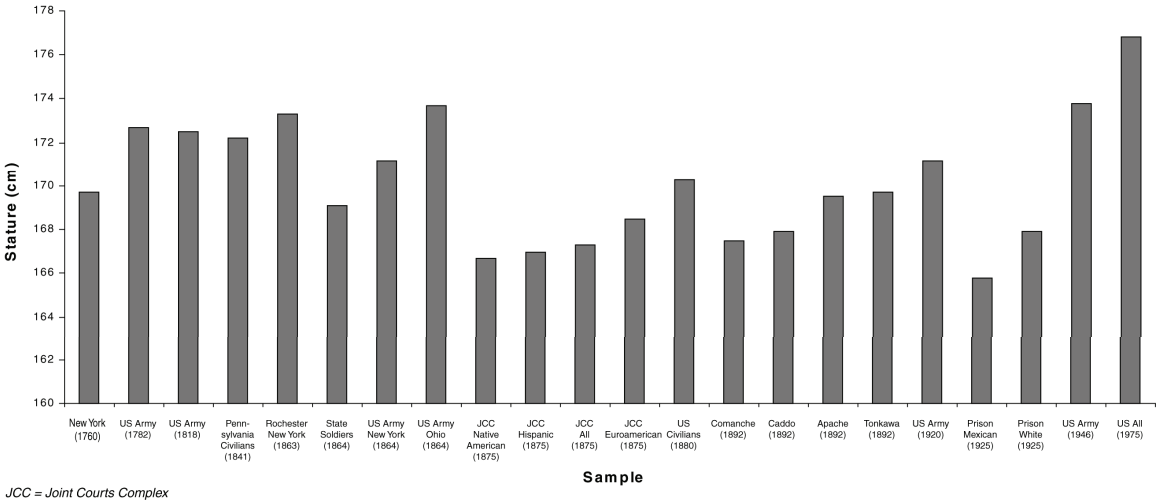
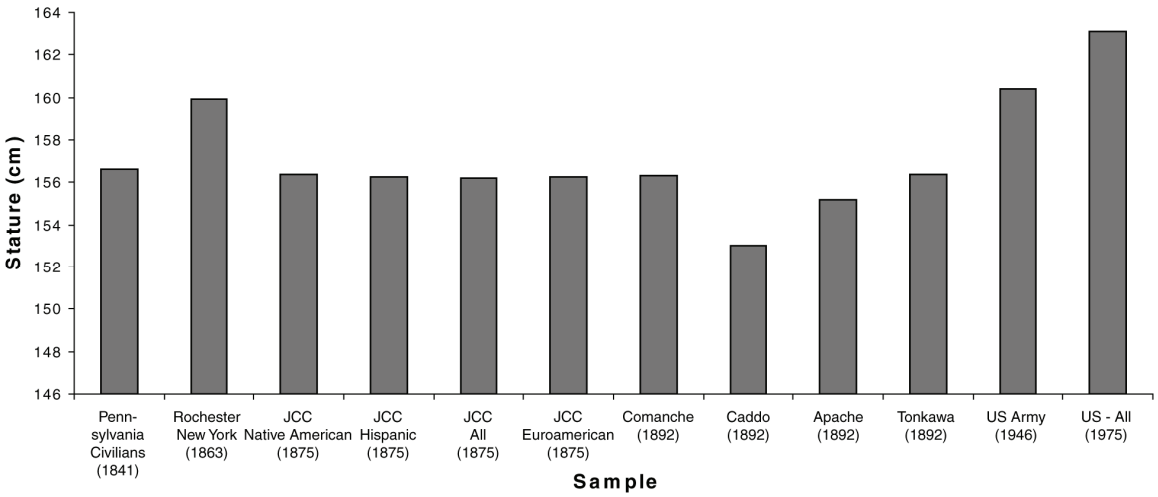


Figure 141. Rounded femur as shown in cross-sectional analysis.



JCC = Joint Courts Complex

Figure 142. Mean stature estimates for Alameda-Stone cemetery males and comparative samples.



JCC = Joint Courts Complex

Figure 143. Mean stature estimates for Alameda-Stone cemetery females and comparative samples.

Table 134. Stature Means by Cemetery Area in the Alameda-Stone Cemetery Sample

Cemetery Area	Sex	n	Mean (cm)	sd
1	Male	3	171.41	3.62
	Female	0	0.00	0.00
2	Male	53	171.19	6.87
	Female	6	159.66	3.58
3	Male	89	168.84	5.67
	Female	90	155.47	4.34
4	Male	19	163.96	7.26
	Female	10	156.11	2.37
5	Male	6	167.232	5.3
	Female	7	156.05	4.45

Table 135. Stature Means by Biological Affinity in the Alameda-Stone Cemetery Sample

Biological Group	Sex	n	Mean (cm)	sd
Euroamerican	Male	57	168.49	6.94
	Female	16	156.25	4.68
Hispanic	Male	98	166.95	6.63
	Female	80	155.56	4.18
Native American	Male	15	166.7	6.44
	Female	17	156.38	4.22

Table 136. Percent of Sexual Dimorphism in Stature in the Alameda-Stone Cemetery Sample

Biological Group	Male Mean (n)	Female Mean (n)	Difference (cm)	%
All Alameda-Stone cemetery	167.32 (252)	156.2 (174)	11.12	6.6
Native American	166.71 (15)	156.38 (17)	10.33	6.2
Hispanic	166.95 (98)	155.56 (80)	11.39	6.8
Euroamerican	168.51 (57)	156.25 (16)	12.26	7.2

Table 137. Stature Means for All Comparative Samples and the Alameda-Stone Cemetery Sample

Samples	Method	Date	Male Mean (cm)	n	sd	Female Mean (cm)	n	sd	Source
Alameda-Stone cemetery—All	osteometric	1862–1875	167.3	252	6.1	156.2	174	4.7	current study
Alameda-Stone cemetery—Native American	osteometric	1862–1875	166.7	15	6.44	156.38	17	4.22	current study
Alameda-Stone cemetery — Euroamerican	osteometric	1862–1875	168.49	57	6.94	156.25	16	4.68	current study
Alameda-Stone cemetery — Hispanic	osteometric	1862–1875	166.95	98	6.63	156.25	80	4.18	current study
Nineteenth-century Southwest prison (Mexican)	anthropometric	1851–1925	165.8	3,883	2.5	—	—	—	Carson 2008
Nineteenth-century Southwest prison (White)	anthropometric	1851–1925	167.9	20,919	2.7	—	—	—	Carson 2008
Comanche	anthropometric	1892	167.5	76	6.2	156.3	33	4.5	Jantz et al. 2001
Caddo	anthropometric	1892	167.9	18	6.6	153	10	5.9	Jantz et al. 2001
Apache	anthropometric	1892	169.5	116	5.9	155.2	37	5.1	Jantz et al. 2001
Tonkawa	anthropometric	1892	169.7	13	5.8	156.4	18	5.4	Jantz et al. 2001
Northern states soldiers, blacks	anthropometric	1864	169.1	8,078	—	—	—	—	Steegman 1991
New York provincial soldiers	anthropometric	1760	169.7	2,232	6.7	—	—	—	Steegman 1991
Midwest U.S. civilians, whites	osteometric	1880s	170.3	79	—	—	—	—	Steegman 1991
New York soldiers, U.S. Army	anthropometric	1864	171.2	29,736	—	—	—	—	Steegman 1991
U.S. miliary, whites	osteometric	1920s	171.2	33	—	—	—	—	Steegman 1991
Pennsylvania civilians, free blacks	osteometric	1823–1841	172.2	34	—	156.6	34	—	Steegman 1991
Mid-Atlantic soldiers, U.S. Army	anthropometric	1818	172.5	1,018	—	—	—	—	Steegman 1991
Mid-Atlantic soldiers, U.S. Army	anthropometric	1776–1782	172.7	275	—	—	—	—	Steegman 1991
Nineteenth-century poorhouse, Rochester, New York	osteometric	1826–1863	173.3	76	4.9	159.9	53	5.54	Steegman 1991
Ohio soldiers, U.S. Army	anthropometric	1864	173.7	15,661	—	—	—	—	Steegman 1991
U.S. Army/general	anthropometric	1946	173.8	25,000	6.3	160.4	—	6.3	Steegman 1991
U.S. all ethnicities	anthropometric	1975	176.8	908	7	163.1	1,453	6.2	Steegman 1991

Samples	Method	Date	Male Mean (cm)	n	sd	Female Mean (cm)	n	sd	Source
Southern U.S. slaves, blacks	anthropometric	1828–1860	—	—	—	158.6	299	—	Steegman 1991
General U.S. civilians	anthropometric	1962	—	—	—	160.3	3,581	6.5	Steegman 1991
Midwest U.S. civilians, whites	osteometric	1880s	—	—	—	162.3	22	—	Steegman 1991

Table 138. Percent Sexual Dimorphism in Stature in the Alameda-Stone Cemetery, Biological Groups Combined and Comparative Samples

Samples	Male Mean (cm)	Female Mean (cm)	Difference	Percent Dimorphism
Alameda-Stone cemetery—All	167.3	156.2	11.1	6.63
Alameda-Stone cemetery—Native American	166.7	156.38	10.32	6.19
Alameda-Stone cemetery—Euroamerican	168.49	156.25	12.24	7.26
Alameda-Stone cemetery—Hispanic	166.95	156.25	10.7	6.41
Comanche	167.5	156.3	11.2	6.69
U.S. army/general	173.8	160.4	13.4	7.71
Nineteenth century poorhouse, Rochester	173.3	159.9	13.4	7.73
U.S. all ethnicities	176.8	163.1	13.7	7.75
Tonkawa	169.7	156.4	13.3	7.84
Apache	169.5	155.2	14.3	8.44
Caddo	167.9	153.1	14.8	8.81
Pennsylvania civilians, free blacks	172.2	156.6	15.6	9.06

Table 139. Humeral-Midshaft Shape for Alameda-Stone Cemetery Males and Females

Measurement	Males (n)	Mean (mm)	sd	Females (n)	Mean (mm)	sd	Percent Dimorphism
Humeral midshaft shape—left	137	82.20	7.83	94	74.9	7.12	8.88
Humeral midshaft shape—right	132	81.83	7.03	89	73.41	6.40	10.29

Table 140. Humeral-Midshaft Shape for Alameda-Stone Cemetery Males and Females, by Cemetery Area

Sex and Location	Left Mean (mm)	n	sd	Right Mean (mm)	n	sd	Side Difference (cm)
North males	81.38	93	7.37	80.38	87	6.68	1
South males	83.93	44	8.56	84.64	45	6.89	0.71
Difference	2.55			4.26[a]			
North females	74.52	88	7.09	73.05	83	6.43	1.47
South females	80.44	6	5.25	78.32	6	3.22	2.12
Difference	5.92[a]			5.27			

[a]Indicates a statistically significant difference between cemetery areas.

Table 141. Alameda-Stone Cemetery Humeral-Midshaft Shape, by Sex and Biological Group

Sex	Group	Left Mean (mm)	n	sd	Right Mean (mm)	n	sd
Male	Native American	82.35	13	6.85	78.81	11	6.61
	Euroamerican	82.19	39	7.67	83.43	40	6.98
	Hispanic	82.18	85	8.12	81.45	81	7.01
Female	Native American	72.02	14	3.29	70.04	11	4.29
	Euroamerican	75.95	14	6.23	75.75	10	4.78
	Hispanic	75.28	66	7.77	73.61	68	6.72

Table 142. Percent Dimorphism in Humeral-Midshaft Shape in the Alameda-Stone Cemetery, by Biological Group

Group	Left Mean, Male (mm)	Left Mean, Female (mm)	Percent Diameter	Right Mean, Male (mm)	Right Mean, Female (mm)	Percent Diameter
Native American	82.35	72.02	12.54402	78.81	70.04	11.12803
Euroamerican	82.19	75.95	7.592164	83.43	75.75	9.205322
Hispanic	82.18	75.28	8.396203	81.45	73.61	9.625537

Table 143. Femoral-Midshaft Shape (FMS) and Femoral Robusticity (FMR) for Alameda-Stone Cemetery Males and Females

Femoral Measurements	n	Mean	sd
		Male	
FMS	98	1.04	0.09
FMR	90	121.83	5.94
		Female	
FMS	67	1.01	0.10
FMR	61	121.12	7.48

Table 144. Femoral-Midshaft Shape (FMS) and Femoral Robusticity (FMR) in the Alameda-Stone Cemetery, by Sex and Biological Group

Biological Group	n	FMS	sd	n	FMR	sd
			Male			
Native American	4	1.1	0.09059	4	123.3	4.16
Euroamerican	33	1.04	0.08528	31	121.12	6
Hispanic	61	1.04	0.0923	55	122.11	6.06
			Female			
Native American	7	0.9704	0.08484	5	115.62	4.877
Euroamerican	8	1.007	0.07072	8	117.5	6.936
Hispanic	52	1.02	0.10284	48	122.29	7.44

Table 145. Femoral-Midshaft Shape (FMS) and Femoral Robusticity (FMR) for the Alameda-Stone Cemetery, by Sex and Cemetery Area

Sex and Area	FMS	n	sd	FMR	n	sd
North males	1.04	61	0.09	119.94	57	12.24
South males	1.04	37	0.08	121.61	35	6.08
North females	1.01	61	0.1	121.12	55	7.54
South females	1.02	6	0.07	121.12	6	7.57

Table 146. Percent Dimorphism in Femoral-Midshaft Shape (FMS) and Femoral Robusticity (FMR) for Alameda-Stone Cemetery Biological Groups

Biological Group	Male FMS	Female FMS	Percent Dimorphism	Male FMR	Female FMR	Percent Dimorphism
Native American	1.1	0.9704	11.78182	123.3	115.62	6.22871
Euroamerican	1.04	1.007	3.173077	121.12	117.5	2.988771
Hispanic	1.04	1.02	1.923077	122.11	122.29	-0.14741

Table 147. Femoral-Midshaft Shape (FMS) and Femoral Robusticity (FMR) for the Alameda-Stone Cemetery and Comparative Samples

Group	Intensity	Male						Female					
		FMS	n	sd	FMR	n	sd	FMS	n	sd	FMR	n	sd
Late-modern Americans, post-1900 (Forenisc Data Bank)	0	1.1	409	0.1	122.2	428	7.6	1.13	233	0.11	122.7	249	8.1
Early-modern American (Terry collection)	1	1.06	101	0.1	120.1	109	7.5	1.05	48	0.11	123.6	58	7
Equestrian hunter-gatherer and maize horticulture	2	1.11	96	0.09	120.8	101	7.5	1.06	110	0.1	123.6	118	7.1
Incipient and village horticulture	3	1.12	582	0.11	121.4	648	6.9	1.07	491	0.1	120.5	581	7.3
Woodland and marine hunter-gatherers	4	1.08	44	0.12	122.8	52	9.1	1.04	27	0.09	122.2	33	7.6
Broad-spectrum hunter-gatherers	5	1.12	46	0.09	122.5	56	5.2	1.02	28	0.09	121.8	33	8.5
Alameda-Stone cemetery—All	predicted 1/2/3	1.04	98	0.09	121.8	90	5.9	1.01	67	0.1	121.12	61	7.485
Alameda-Stone cemetery—Euroamerican	predicted 1	1.04	33	0.08	121.1	31	6	1	8	0.07	117.5	8	6.936
Alameda-Stone cemetery—Native American	predicted 2/3	1.1	4	3.11	123.3	4	4.1	0.97	7	0.08	115.62	5	4.877
Alameda-Stone cemetery—Hispanic	predicted 2/3	1.04	61	0.09	122.1	55	6	1.02	52	0.1	122.29	48	7.44

Table 148. Platymeric Index for the Alameda-Stone Cemetery, by Biological Group and Sex

Biological Group	Males			Females		
	n	Mean	sd	n	Mean	sd
Native American	13	90.24	14.37	9	78.11	9.92
Euroamerican	41	87.89	10.43	14	80.71	8.52
Hispanic	73	85.42	7.69	68	82.23	8.82

Table 149. Platymeric Index for the Alameda-Stone Cemetery and Comparative Samples

Group	Male			Female			Source
	n	Mean	sd	n	Mean	sd	
Alameda-Stone cemetery—Native American	13	90	14.37	9	78	9.92	present study
Alameda-Stone cemetery—Euroamerican	41	88	10.43	14	81	8.52	present study
Alameda-Stone cemetery—Hispanic	73	85	7.69	68	82	8.82	present study
Alameda-Stone cemetery—All	127	87	9.51	91	81	8.88	present study
Refugio	23	81	6.2	26	79	7.3	Jantz et al. 2001
Capistrano	15	86	11.2	12	81	8.9	Jantz et al. 2001
Pecos Church	14	81	8.6	17	73	7.1	Jantz et al. 2001
Pecos Glaze 6	15	71	4.8	10	72	5.9	Jantz et al. 2001
Plains Woodland	28	76	7	25	74	6	Cole 1994
Plains Coalescent	239	73	6	193	72	6	Cole 1994
Recent Hispanic	29	86	7.8	5	88	6.9	Forensic Data Bank
Recent whites	168	90	8.9	116	89	7.3	Forensic Data Bank
Recent blacks	77	90	9.05	45	89	12.01	Forensic Data Bank

CHAPTER 11

Pathological Conditions

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This chapter details the pathological conditions observed in the human skeletal remains recovered from the Joint Courts Complex project. The first section discusses the theoretical foundations guiding paleopathological research. This is followed by a discussion of the particular pathological conditions affecting the recovered sample, with a focus on infectious and degenerative joint diseases. The chapter concludes with a review of the findings and an interpretation of how those findings translate to life in nineteenth-century Tucson.

Introduction

Paleopathology is a reconstructive scientific discipline (Ortner 2003:110) establishing the presence of diseases and the impact of those diseases on the individual, as well as the population. The methods are largely macroscopic observation and descriptions of abnormal bony changes. The distribution of these lesions within and between groups provides empirical evidence on the incidence of a particular pathology in a sample.

The pathology of bones and joints may be evaluated in many ways. Some authors prefer to categorize pathologies through subcategories. For the purposes of this report, however, conditions are evaluated according to six primary categories of disease. These categories include infectious, neoplastic, circulatory, metabolic, congenital, and systemic disease. Table 150 includes a review of these categories and examples of the pathologies that fall within each group.

Before beginning an in-depth analysis of the pathological conditions affecting the Alameda-Stone cemetery population, several caveats regarding the interpretation of the data set should be addressed. A number of factors hinder the study of disease in the skeleton, and foremost among these is the limited number of ways bone can respond to any stress. The paleopathologist must (1) consider the nature of the response to a condition (i.e., is it bone forming or bone destroying?) and (2) consider the pattern and distribution of that response in the skeleton. Simultaneously, the paleopathologist must keep in mind that different diseases and skeletal conditions generate similar skeletal changes. Certainly, postdepositional taphonomic factors can complicate a skeletal analysis. Beyond general taphonomic factors (e.g., animal and insect activity, erosion, and the effects of soil composition on bone), the fragile nature of most pathological bone puts it at higher risk of fragmentation. These factors should all be considered during an analysis, because ignorance of any one can potentially result in the misidentification of a pathological condition.

There are a variety of responses to disease, ranging from a quick death to a long-term survival. The effects of disease on bone are rarely manifested in individuals who succumb to acute or rapidly progressing infections. In order for skeletal involvement to occur, an extended period of survival is often required (Ortner 2003:113–114). Survival, however, requires a reasonably sufficient immune response. If no observable skeletal changes are noted, then (1) the individual had a sufficient immune response to eliminate or control a pathogen; (2) the individual died from an ailment not affecting the skeleton; or (3) the individual died from an ailment that can affect the skeleton but fell victim to the illness prior to the occurrence of bony changes (Ortner 2003:110).

Wood et al. (1992:344–345) presented three theoretical issues that may arise when attempting to measure the health of a population from skeletal data. These include (1) demographic nonstationarity, (2) selective mortality, and (3) hidden heterogeneity in risks. Each of these is of concern. First, as noted in Chapter 7, the

Alameda-Stone cemetery population was not demographically stationary; migration and exogamy were substantial characteristics of this population. Second, the crux of the argument for selective mortality is that the skeletal sample is not representative of the entire population under study. For example, the individuals within the Alameda-Stone cemetery sample identified to be between 30 and 40 years of age represented only a portion of the 30–40-year-old individuals from the population. The other individuals who also fell within this age range at the same moment in time (during life) did not die. In other words, the skeletal data do not represent the entire population at risk for a particular hazard; so, estimates of a particular ailment or condition based on skeletal data alone may overestimate the occurrence of an ailment or condition for the whole population (Wood et al. 1992:344).

Hidden heterogeneity in risks also questions the representative nature of a skeletal sample. A population, by its very nature, is heterogeneous; each member has a different level of susceptibility to health risks ("frailty") (Wood et al. 1992:345). Varying levels of risk result from such factors as socioeconomic status, microenvironmental variation, temporal trends, or genetics.

These constraints notwithstanding, accurate paleopathological research is achievable, and meaningful statements can be made regarding the health of past populations. This chapter details the pathological conditions observed in the skeletal remains recovered from the Alameda-Stone cemetery and provides some insight into the life of early Tucsonans.

Infectious Disease

Infections result from the infiltration of the body by disease-causing microbes, such as bacteria, viruses, fungi, and parasites (Barnes 2005:24; Larsen 1997:64). Although infection is not always synonymous with disease—in fact, most infections do not result in disease—the progression from infection to disease depends on the virulence of the pathogen, the route of transmission, and the strength of the infected individual's immune system (Larsen 1997:64). An individual's health depends on the balance between the strength of their immune system and the potency of the invading microorganisms; so, the potential for disease increases dramatically when the immune system is compromised. Factors affecting the strength of the immune system include genetic defects, poor nutrition, and environmental influences (Barnes 2005:25).

One contributing factor to the body's response to infection is age, because the strength of the human immune system fluctuates over the course of a lifetime. In neonates, the immune system is not fully formed. Developing fetuses and newborns rely on antibodies passed from the mother in utero or during lactation to attach to foreign substances and assist in destroying potential health threats. However, women in poor health cannot provide adequate protection for a child. Humans are most vulnerable to disease and infection during the first 36 months of life. By 3 years of age, most individuals have developed an immune system sufficiently robust to fight off infections on their own. The adolescent growth spurt introduces new physiological stresses on the immune system as "roving microbes can trigger overzealous immune responses . . ." or "[n]ormally quiescent commensal microbes can . . . become aggressive during this physiological upset and can provoke the immune system into action" (Barnes 2005:24). By the time adulthood is reached, the immune system is at the peak level of protection, but as an individual becomes an older adult, the factors associated with aging adversely affect the immune system, resulting in a vulnerability akin to a newborn's (Barnes 2005:24).

The following sections detail the evidence of infectious disease observed among the skeletal remains recovered during the Joint Courts Complex project, including inflammation and nonspecific infection, such as periosteal new bone formation and osteomyelitis; respiratory infections, such as sinusitis and tuberculosis; and syphilis. Each will be examined independently below.

Inflammation and Nonspecific Infections

Inflammation and infection in skeletal remains can be identified in the periosteum (see below), the cortex, and the medullary cavity of bone. Although the specific etiology is often undiscoverable, the cause of infection can be isolated to either a direct, localized condition, such as a traumatic episode, or a systemic condition disseminated through the bloodstream (Ortner 2003). The following sections detail infectious conditions affecting the skeletal remains of the Alameda-Stone cemetery sample.

Periosteal New Bone

The periosteum is a fibrous membrane covering all nonarticular surfaces of bones that acts as an anchor for muscles and tendons, houses the cells responsible for bone production (osteoblasts), and provides bone with its blood supply and innervation (White 2000:25). The periosteum responds to any insult (e.g., infection, disease, or trauma) by forming new bone (periosteal new bone). This subsequent new bone formation has been referred to as periostosis, periostitis, and periosteal new bone. The last term will be used herein to avoid confusion and to conform to newly advised standards (Ortner 2003).

Traumatic episodes, neoplastic diseases, and infectious agents all produce periosteal new bone (Ortner 2003). Other conditions generating periosteal new bone formation include circulatory disorders, joint disease, skeletal dysplasias, metabolic disease, and blood (hematological) disorders (Waldron 2009:116; Weston 2008:49–50). In other words, any action that breaks, tears, or stretches the periosteum may stimulate new bone formation in the affected area. The most common cause of periosteal new bone formation is a reaction to infectious agents as the body attempts to neutralize the pathogen and promote healing (Weston 2008:49).

The following criteria were employed to determine the frequency of periosteal new bone in the Alameda-Stone cemetery sample. First, individuals were excluded from analysis if preservation of the skeletal elements was so poor that a visual assessment for any pathological condition was not possible. Second, overinflation of the frequency of periosteal new bone was circumscribed by dividing the total number of affected elements by the frequency of that element in the skeleton. To simplify and summarize the incidence of periosteal new bone, skeletal elements were categorized by functional regions. These categories included the skull (the entire bony structure of the head, including the mandible), the arm (humerus, radius, and ulna), the hand (carpals, metacarpals, and carpal phalanges), the vertebrae (cervical, thoracic, and lumbar), the pelvis (sacrum, ilium, ischium, and pubis), the leg (femur, tibia, fibula, and patella), the foot (tarsals, metatarsals, and tarsal phalanges), the ribs, and the shoulder (scapula, clavicle, and sternum). Differences in periosteal new bone formation within and between age cohorts were assessed by dividing the sample into the following age categories: fetal, infant, child, subadult, young adult, middle adult, old adult, and adult (see Chapter 2).

When periosteal new bone was noted, each lesion was characterized as active or healed/healing and as localized or systemic. Periosteal new bone was considered healed/healing if macroscopic evidence of remodeling (i.e., lamellar bone with incorporated margins into the surrounding cortex) was observed. To determine whether the condition was localized or systemic, each individual burial was assessed for multiple lesions. A systemic infection was defined as periosteal new bone lesions appearing on three or more skeletal elements in a single individual.

Results

Periosteal new bone was observed on 1,348 skeletal elements representing 210 individuals. This translates to nearly 20 percent of the 1,089 observable individuals from the Alameda-Stone cemetery sample. The distribution of the affected elements appears in Figure 144. Elements of the skull composed approximately 30 percent of the affected bones. Over 26 percent of elements with periosteal new bone were those composing the leg. Elements of the arm were the next-most-common site of periosteal new bone, with approximately 22 percent

of the total. The distribution of infection dropped dramatically for the remaining regions of the skeleton. Indeed, nearly 80 percent of all skeletal elements presenting evidence of infection were from the skull or limbs. Factors influencing the distribution of periosteal new bone, such as demographic attributes, pervasiveness of the infection, and the degree of healing, are examined below.

The percentage of periosteal new bone by age appears in Table 151. Some interesting observations are revealed in comparing the proportion of individuals exhibiting periosteal new bone in each age group and how the affected individuals were distributed among the age groups. The fetal age group had the fewest number of individuals with evidence of infection. Only 5 (8.06 percent) of the 62 fetal individuals exhibited periosteal new bone. Likewise, of the 210 individuals with periosteal new bone, the 5 fetal individuals represented only 2.38 percent. This is unsurprising, given the better protection from infectious disease in the in utero environment.

The incidence of periosteal new bone among observable individuals increased roughly linearly from fetal ages through middle adulthood, with a notable spike during infancy. Figure 145 demonstrates this linear relationship. With the exception of infants, the trend is remarkably linear. Using the median ages for the age categories and eliminating the infants and old adults, a steady increase of about 0.5 percent per year was noted (see Figure 145), but when examining the age distribution of periosteal new bone among affected individuals, this linear increase with age breaks down. The frequency of periosteal new bone among all individuals in each age group did not directly mirror the distribution of individuals with periosteal new bone among the age groups. Nearly 19 percent of observable infants showed evidence of infection. Among individuals with periosteal new bone, however, 30 percent were infants. Infants were very likely disproportionately afflicted with periosteal new bone. When sample size between age categories was considered, there was a dramatic increase among the infants (Figure 146).

Sex could be determined for 111 of the 210 individuals with periosteal new bone. Approximately 60 percent (n = 67) were male, whereas about 40 percent (n = 44) were female. The disparity between males and females in the presentation of periosteal new bone was statistically significant ($\chi^2 = 4.766$, $df = 1$, $p = 0.05$). Explanations for the difference in infection between the sexes will be explored further below, with consideration of the pervasiveness and level of healing associated with observed infections.

A biological-affinity assessment was available for 412 of the 1,089 observable individuals and 86 of the 210 affected individuals. Table 152 shows the distribution of individuals by biological affinity and the within-group frequency of periosteal new bone. Approximately 20 percent of Hispanics and Euroamericans and 27.5 percent of Native Americans exhibited periosteal new bone. This was likely a product of the low number of observable Native Americans. Indeed, of the 86 individuals with periosteal new bone for whom biological affinity could be determined, only 12.8 percent (n = 11) were Native American.

The spatial distribution of individuals with periosteal new bone excavated during the Joint Courts Complex project appears in Table 153. Spatial distribution of individuals with periosteal new bone did not differ significantly throughout the cemetery, with the exception of Cemetery Area 4 (Table 154). In that area, far fewer individuals were affected by periosteal new bone than expected. Burial preservation was a concern in this area, but every effort was made to control for preservation bias using only observable individuals (and elements) when calculating frequencies. Indeed, Cemetery Area 1, which was also highly disturbed and poorly preserved, fell within the expected range of individuals with periosteal new bone. Therefore, preservation bias is not a likely explanation for this disparity. The age distribution of individuals interred in Cemetery Area 4 also did not affect these results. There was no statistically significant difference in the incidence of periosteal new bone for the children buried in Cemetery Area 4 evaluated against any of the other areas ($\chi^2 = 3.113$, $df = 3$, $p = 0.736$). Explanations for the relatively low number of individuals in Cemetery Area 4 with periosteal new bone are many and are discussed in Chapter 7, Volume 1 of this series.

Active versus Healing/Healed Periosteal New Bone

Skeletal response to infection is slower than that of soft tissue, both in onset and healing. Evidence of infection, in the form of periosteal new bone, does not appear on bone until the condition has become sufficiently

established, long after soft tissues such as skin and fascia would have presented symptoms of the infection. Likewise, the durability of bone leads to longer-lasting evidence of infection; the individual may have recovered from the disease, but the evidence of healing or healed infection persists on the bone long after soft tissues have fully recovered.

The distinction between active and healing or healed periosteal new bone is a critical aspect in determining the survivability of infection, both on the individual and population scale. Although the cause of death of an individual is rarely conclusive from skeletal remains, the difference between activity levels in periosteal new bone is a powerful inferential tool in determining whether an individual died during the course of the infection (either from the infection itself or other opportunistic factors capitalizing on a stressed immune system) or survived the infection with adequate time for evidence of healing to appear on the skeleton.

This section examines the differences between active and healing/healed periosteal new bone, as expressed in various demographic groups and spatial components. It should be noted that the unit of analysis in this examination is the element, not the individual. This is because different events and processes interact with affected skeletal elements differently, even in a single individual. One individual may feature both active and healed lesions from varied causes, thereby clouding the analysis of skeletal healing. Demographic information for these elements was drawn from the individual from whom the elements came. Additionally, as noted above, the distinction is not intended to confirm a cause of death. Evidence of active periosteal new bone does not indicate lethality of infection; rather, evidence of healing indicates the health of the individual and ability to overcome the infection.

Nearly 99 percent (163 of 166) of the affected neonate skeletal elements showed active lesions (Table 155). This high proportion of active periosteal new bone is unsurprising for two reasons. First, a newborn's immune system is weak compared to those of older children and adults, and as a result, they are more susceptible to infection. Second, individuals in the neonatal sample had less time to heal such lesions, regardless of whether or not the infection was the cause of death. Nevertheless, the high frequency of active lesions suggests a high mortality rate from infection among neonatal individuals.

The activity level of periosteal lesions was markedly different between the juvenile and adult series (Figure 147; see Table 155). The bimodal nature of the distribution suggests that juveniles (particularly the very young) were more likely to have active lesions, whereas healed or healing lesions were more likely in older children and adults. However, it should be noted that similar percentages were observed for juveniles and young adults but that healed lesions were more common among middle and old adults. These differences were statistically significant ($\chi^2 = 222.754$, $df = 1$, $p < 0.01$). Activity level also differed significantly among juveniles ($\chi^2 = 71.229$, $df = 3$, $p < 0.01$). Walker et al. (2009:111) and others (Stuart-Macadam 1985; Walker 1985; Walker and Lambert 1989) have shown that active lesions are generally limited to children and adolescents and that healed or healing lesions are characteristic of older adults; although the analysis reported in this chapter shows that active lesions extended into young adulthood for the Alameda-Stone cemetery sample (Figure 148).

As noted above, males generally suffered from more periosteal new bone than did females. Table 156 demonstrates that the principal difference in periosteal new bone between men and women was the activity of the lesion, a difference that was statistically significant ($\chi^2 = 42.773$, $df = 1$, $p < 0.01$). Males featured a nearly equal distribution of healed (n = 177) and active (n = 173) lesions. Females, on the other hand, exhibited a far greater number of healed (n = 197) than active (n = 50) lesions. This difference in active versus healed lesions observed on females was statistically significant ($\chi^2 = 87.486$, $df = 1$, $p < 0.01$).

The reasons for the differences between the sexes in activity of periosteal new bone are not straightforward. Ortner (2003:114, 117) provided some insight into sex differences, suggesting that "the immune response of women to infectious disease is greater and more effective than the response of men." The two primary reasons for these differences include "selective pressures" associated with pregnancy and childbirth and "gender-related differences in physiology, particularly sex hormones" (Ortner 2003:114). The greater immune response in women (and thus a higher resistance to infection) not only affects healing rates but may also affect overall morbidity. One other explanation for the differences in lesions found between men and women is differential hazards. Men, more often than women, participate in physically demanding activities, which result in a higher-risk lifestyle and more-frequent injury. Therefore, the lesions associated with males would more likely

be in a "constant" active state. On the other hand, women actually had more lesions per individual (6.2 per woman) than men (5.2 per individual), although, compared to women, men had twice as many *active* lesions per individual, and women had twice as many *healed* lesions per individual. In other words, women had more periosteal new bone lesions on average, but those lesions were much more likely to have been healed, suggesting women may have more often survived.

Biological groups also differed significantly in the activity of periosteal new bone ($\chi^2 = 46.871$, $df = 2$, $p < 0.01$). The majority of the periosteal new bone lesions identified on Euroamericans and Native Americans were well healed or healing, whereas Hispanics featured slightly more active lesions than healed lesions (Figure 149). This seems to contradict the sex-mediated differences noted above, as males more often had active lesions, and Euroamericans were mostly males. Sample sizes are likely skewing these observations. As noted above, juveniles generally exhibited far more active than healed lesions. Second, based on criteria for determining biological affinity in juvenile individuals and historical information presented in Volume 1, a large number of juvenile individuals were likely to have been Hispanic, compared to relatively few individuals from other groups (see Chapter 7). So, the larger number of identified Hispanic children, compared to relatively few Euroamerican and Native American children, may be affecting these results. Nevertheless, the differences among biological groups remain significant when juveniles are removed from the sample.

A spatial examination of the differences in activity levels of periosteal new bone revealed no discernable pattern (Table 157). Because of small sample sizes in some parts of the cemetery, only Cemetery Areas 2, 3, and 4 were examined for differences in periosteal new bone activity. Overall, there was a significant difference in the distribution of active and healed/healing lesions among these three areas ($\chi^2 = 9.89$, $df = 2$, $p = 0.007$). This collective difference was from the influence of Cemetery Area 2. No significant difference was found between Cemetery Areas 3 and 4 ($\chi^2 = 0.793$, $df = 1$, $p = 0.373$). Cemetery Area 2, however, featured a far greater proportion of healed lesions and was significantly different from both Cemetery Areas 3 ($\chi^2 = 9.449$, $df = 1$, $p = 0.002$) and 4 ($\chi^2 = 8.529$, $df = 1$, $p = 0.003$). The likely cause of this difference in Cemetery Area 2 was the age composition of the individuals in that area: Cemetery Area 2 was composed primarily of adult individuals, and, as noted above, adult individuals are more likely to exhibit healing or healed periosteal new bone.

Localized versus Systemic Periosteal New Bone

As noted above, the most common cause for the formation of periosteal new bone is infection. The nature and origin of this infection is rarely discernable from an examination of the periosteal new bone itself. An assessment of the amount and distribution of the lesions is necessary to examine possible causes for the infection. A single, localized infection is typically the product of a discrete event affecting that element or region, such as an injury. Multiple lesions spread across the skeleton, on the other hand, are predicated upon communication of the pathogens throughout the body by the bloodstream. Therefore, differentiation between localized and systemic infections is an important factor in establishing the cause of the periosteal new bone, as well as the health of the individual on which it appears.

Systemic infections were identified based on two criteria. First, three or more skeletal elements were required to show periosteal new bone, for the reasonable assumption that the infectious pathogens were circulated throughout the body. Two or fewer affected elements, therefore, were regarded as localized, even though the elements need not be contiguous. Second, all of the elements affected by systemic infection had to exhibit similar levels of healing to avoid misidentifying multiple discrete instances of localized infection as systemic. A reasonable assumption with systemic infections is that affected elements present similar characteristics of that infection. It should be noted that localized and systemic infections do not necessarily result from completely separate origins. A localized infection may become systemic. Conversely, systemic infections will not mimic localized infections. Nevertheless, as with active or healed periosteal new bone, the scope and magnitude of infection provides information related to individual and general health.

Of the 210 individuals exhibiting periosteal new bone, over one half (n = 120) showed some level of systemic infection. The age of the affected individual was an important contributing factor to systemic infection (Table 158). For fetal, infant, and child age categories, systemic infections outnumbered localized infections.

Again, this illustrates the vulnerability of younger individuals to infection as a result of the underdeveloped immune system for those age groups (Barnes 2005:24). The prevalence of periosteal new bone was higher overall among adults, but juveniles were disproportionately experiencing diffuse periosteal new bone reactions symptomatic of systemic infection. Although the difference in the number of juveniles and adults with systemic infections was not dramatic (Figure 150), such a pattern is consistent with other skeletal series (Walker et al. 2009). Past the age of a child (12 years old), the proportion of systemic infection to localized infection dropped considerably, increasing through the middle-adult age category. The reasons for this are unclear.

Comparing localized versus systemic infections according to sex did not reveal any meaningful difference between males and females. As noted above, males showed a significantly higher incidence of periosteal new bone than did females, but the pervasiveness of these infections was equivalent between the sexes. Of the 67 males with periosteal new bone, 52.2 percent (n = 35) were systemic; of the 44 females with periosteal new bone, 54.5 percent (n = 24) were systemic. This is an important finding, as it relates to the above discussion of active versus healed lesions between males and females. Recalling that females featured a significantly higher proportion of healed lesions to active lesions, it appears that, on balance, males and females were equally affected by the virulence of infectious pathogens—the ability of those pathogens to travel through the body, but the ability to combat these pathogens was stronger in females.

Differences in pervasiveness of infection were apparent among the biological groups. Among Euroamericans, 60 percent (n = 15) of affected individuals showed evidence of systemic infection. Hispanics were more evenly split, with only 52 percent (n = 26) of individuals exhibiting systemic periosteal new bone. Native Americans were much more strongly represented by localized infections; just 27 percent (n = 3) of individuals presented systemic infection. Although sample size is of obvious concern, the disparity among systemic infection in Euroamericans, Hispanics, and Native Americans was substantial but not statistically significant ($\chi^2 = 3.308$, $df = 2$, $p = 0.191$). Nevertheless, the high proportion of localized infections in Native Americans suggests that the formation of periosteal new bone in these individuals was more likely related to injurious, opportunistic infection. Unfortunately, the data are not robust enough to explore this with statistical reliability.

A spatial evaluation of localized versus systemic infection for Cemetery Areas 2, 3, and 4 revealed some surprising results. In each area, systemic infections composed a larger proportion than localized infections (Table 159). Cemetery Area 2 featured the highest proportion of systemic infection, with 68.8 percent (n = 11) of affected individuals displaying periosteal new bone on three or more elements. In Cemetery Area 4, 61.3 percent (n = 19) of individuals exhibited evidence of systemic infection. Most surprising was Cemetery Area 3. This area was composed of a large number of juveniles, and as noted above, individuals under the age of 12 years were disproportionately affected by systemic infections. Yet Cemetery Area 3 presented the smallest proportion of individuals with systemic infection, just 54.1 percent (n = 73). Of course, individuals in Cemetery Area 3 composed the largest block of individuals with multiple lesions; nearly 71 percent of individuals with systemic infection were found in this area. Within that area, though, the incidence of periosteal new bone was more evenly divided between localized and systemic infection.

One possible explanation for this unexpected result also applies to the distribution of systemic infection between juveniles and adults. The susceptibility of juvenile individuals to infection in general does, indeed, lead to a higher incidence of systemic infection in younger individuals. Similarly, infection is more likely to be lethal in younger individuals. The disparity, then, may be a product of the delay between infection and evidence of that infection appearing on the skeletal remains. As noted above, periosteal new bone is a skeletal response to infection, and a period of survival is required for that response to manifest. Simply put, individuals with infection may die before an observable localized infection shows evidence of becoming systemic, or even before any skeletal evidence of infection appears at all. Clearly, the entire juvenile skeletal sample was composed of individuals who died prematurely, regardless of whether any contributory factors to death were evident on the skeletal remains. In other words, the relatively small proportion of juvenile individuals that exhibited evidence of systemic infection may belie the actual number of juvenile individuals with systemic infection, including those who died before the infection became skeletally observable.

Comparative Samples

Comparison of the results from the Alameda-Stone cemetery sample with other sites is challenging, because most studies report the results for periosteal new bone differently. General comparisons are made here with the understanding that sample size, temporal differences, sample composition, and the type of data reported result in serious limitations.

Freedman's Cemetery, a historical-period (1869–1907) African American cemetery located north of downtown Dallas, Texas, provides interesting parallels and contrasting data for periosteal new bone lesions compared to the Alameda-Stone cemetery sample. In the Alameda-Stone cemetery sample, periosteal new bone lesions were more numerous among adults than juveniles, but the latter were much more likely to present active, systemic lesions. At Freedman's Cemetery, juveniles, rather than adults, were more likely to have periosteal new bone lesions (74 percent and 60 percent, respectively). Similar to the Alameda-Stone cemetery sample, the Freedman's Cemetery juveniles also had a higher prevalence of active periosteal new bone lesions (Tiné 2000). The higher frequency of active lesions at time of death among the Alameda-Stone cemetery sample suggests that infection may have contributed to overall mortality. Of the adults with periosteal new bone lesions, most demonstrated a degree of remodeling consistent with healing. Males and females were affected similarly between the two cemeteries.

A relatively predictable pattern of periosteal new bone formation was observed at the Refugio Mission Cemetery, a historical-period Catholic cemetery in Texas dating to the early 1800s; the tibia and femur were the most commonly affected elements. Although statistical results were not provided, frequencies for periosteal new bone lesions appear in a table of all recovered major long bones. Based on the frequency data presented by Jantz et al. (2001), males, more often than females, exhibited periosteal new bone lesions, similar to observations made for the Alameda-Stone cemetery sample. The same was true for older (35+ years) individuals over younger individuals (15–35 years). The long bones of the lower limbs, especially the tibia, showed a significantly higher frequency of lesions than the long bones of the arms at the Refugio Mission (Jantz et al. 2001).

Roughly 3 percent (15 of 544) of the individuals recovered from Voegtly Cemetery, a historical-period cemetery (1833–1861) associated with the Voegtly Evangelical Lutheran Church in Pittsburg, Pennsylvania, exhibited periosteal new bone lesions (Ubelaker and Jones 2003). Four of these could be directly linked to trauma. Three juveniles and 8 adults (7 males and 1 female) were identified from the remaining 11 cases of periosteal new bone (Ubelaker and Jones 2003). In 60 percent of the individuals with periosteal new bone, there was no evidence of healing; the remaining individuals displayed evidence of significant remodeling or healing (Ubelaker and Jones 2003). Like other cemetery samples, including the Alameda-Stone cemetery sample, the most-affected elements were the tibia and the femur. The relatively low incidence of infection at the Voegtly Cemetery (3 percent) compared to the Alameda-Stone cemetery sample (around 20 percent) is likely attributable to the demographic composition of the two cemeteries: Voegtly Cemetery was populated by middle-/upper-class individuals, whereas the Alameda-Stone cemetery was a municipal cemetery as diverse as the population in Tucson at the time.

Osteomyelitis

Osteomyelitis is an infection in the bone most often caused by a blood-borne (hematogenous), pus-producing (pyogenic) bacterium. Pyogenic osteomyelitis is the most common form, and in 90 percent of all cases, a staph (e.g., *Staphylococcus aureus*) infection is to blame. Osteomyelitic infection can be acute, subacute, or chronic. The latter two stages normally result from failed medical treatment or a failed immune response (Aufderheide and Rodríguez-Martín 1998:172). Acute osteomyelitis, on the other hand, can be hematogenous, or blood-borne, resulting from an infection somewhere else in the body or from a direct insult to the bone (Aufderheide and Rodríguez-Martín 1998:172). In osteomyelitis, the infection reaches the skeleton from three possible causes: (1) a focal infection elsewhere in the body via the circulatory system, (2) direct injection of the pathogen through a bone-penetrating injury, or (3) via direct extension from an adjacent soft-tissue infection (Ortner 2003:181; Roberts and Manchester 2005:169–172).

Osteomyelitis presents as both lytic and proliferative change to the affected element, with involvement of the medullary cavity. A necessary presentation also includes an involucrum ("swelling" of the cortical bone) and at least one cloaca (opening in the involucrum for pus drainage). Osteomyelitis was fairly rare in the Alameda-Stone cemetery sample. Twenty-nine elements representing 13 individuals exhibited osteomyelitis. The majority of affected individuals were adults (Table 160). The most-affected elements were the tibia (n = 10) and femur (n = 6) (Figure 151). Among the adults, 3 individuals had two or more elements affected. All of the affected individuals were interred within the civilian portion of the cemetery in Cemetery Area 2 (n = 3), 3 (n = 7), or 4 (n = 3).

Unlike the adults, all of the subadults with osteomyelitis had multiple affected elements, characteristic of a systemic infection. The femora, tibiae, and left ulna of an infant (Grave Pit 13654, Burial 27544-P) between birth and 6 months of age displayed active and multilayered, proliferative periosteal new bone, as well as osteomyelitis (Figure 152). A second infant (Grave Pit 7957, Burial 19539-P), aged between 3 and 5 months, had a progressive osteomyelitis on multiple elements of the cranial and postcranial skeleton (Figure 153). An older infant (Grave Pit 13573, Burial 25106-P), aged between 9 months and 1 year, presented proliferative periosteal new bone growth with evidence of healing throughout the skeleton. Based on the distribution and appearance of these lesions, congenital syphilis (see Treponemal Infection below) is likely.

Two adults had osteomyelitis in a single element, suggesting a localized infection. For example, the right tibia of an adult (indeterminate biological affinity and indeterminate sex) recovered from Grave Pit 7809 exhibited healing osteomyelitis associated with a well-healed fracture. The tibia presented evidence of expansion at the distal diaphysis and metaphysis, proliferative periosteal new bone that was well incorporated into the surrounding region, and a cloaca with smooth, rounded edges located on the lateral aspect of this area.

Five adults presented evidence of osteomyelitis from a systemic infection of unknown etiology. An adult Hispanic male (Grave Pit 7553, Burial 9721-P) displayed widening of the diaphyses and metaphyses of several lower-limb elements with associated remodeling and macroporosity. Grave Pit 13614, Burial 21829-P, was an adult Euroamerican male with evidence of osteomyelitis on the distal end of the right femur, which displayed a large cloaca on the anterior articular surface. The excessive marginal lipping along the medial aspect of the articular surface, as well as the nature and extent of this lesion, preliminarily suggests tuberculosis (Figure 154).

Osteomyelitis was fairly rare within the Alameda-Stone cemetery sample. This is comparable to the findings at antecedent cemeteries. Seven individuals from the Mission of San Agustín cemetery (see Chapter 1) had evidence of inflammatory or infectious disease, but only 1 individual exhibited osteomyelitis. This individual was an adult female who suffered from a systemic infection (Dayhuff 2002). Of the individuals interred within the Tucson Presidio (see Chapter 1), 12 exhibited pathology consistent with a disease process, but none that could be confidently identified as osteomyelitis. One individual, a child between 5 and 6 years, exhibited proliferative periosteal new bone of the right humerus along with sequestrum, but no cloaca (Dayhuff 2002). Dayhuff (2002:138) indicated that this individual may have had "possible osteomyelitis" at the time of death.

Meningeal/Endocranial Reactions

Meningitis is an acute inflammation of the meninges, a fibrous membrane complex that separates the brain from the cranial bones. Several meningeal diseases produce characteristic lesions on the endocranial lamina of the skull (Ortner 2003:93). These changes appear as either diffuse regions of new bone or isolated layers of bone on the original cortex with expansion around the blood vessels. This new bone can appear as either "hair-on-end" extensions or as impressions of the capillaries extending into the inner table. These changes can also be porous in nature. A number of etiologies have been suggested for endocranial lesions, including chronic meningitis, trauma (Ortner 2003), anemia, neoplasia (Roberts and Manchester 2005), scurvy, rickets, and tuberculosis (Lewis 2004:82; Ortner 2003), as well as changes related to growth and development (Lewis 2004; Scheuer and Black 2000). Nonspecific meningitis usually results from bacterial, viral, or fungal infection or a secondary condition related to severe cases of otitis media, syphilis, typhoid fever, measles, whooping cough, or pneumonia (Lewis 2004:85).

Following Lewis (2004:89–90), endocranial lesions were divided into four types: (1) pitted lesions, (2) deposits of white or gray fiber or immature new bone, (3) capillary formations (new bone organized with or around vascular structures), and (4) "hair-on-end" formation (i.e., a frosted appearance and an expansion of diploe). To accurately investigate the prevalence of endocranial lesions, juvenile skeletons were divided into seven age categories, following Lewis (2004). The age groups were neonate (less than 40 weeks gestation), birth to 1.0 year, 1.1–2.5 years, 2.6–6.5 years, 6.6–10.5 years, 10.6–14.5 years, and 14.6–18.0 years.

The presence and positional distribution (frontal, parietals, and occipital) of endocranial lesions within each age group were recorded. Individuals were not included if these elements were unobservable or absent. Thirty-one juveniles and 2 adults were identified with endocranial lesions. These are discussed separately below.

Table 161 displays the prevalence of endocranial reactions in each age group. Over 80 percent (n = 25) of the affected individuals were between birth and 2.5 years of age. Lesions on the occipital were most frequent (48 percent) (Table 162). Endocranial lesions were associated with capillary formations or vascular impressions within all age groups, suggesting that some level of healing occurred prior to death (Lewis 2004). Three infants presented new bone formation. One infant exhibited an area of increased porosity. In all of these cases, the meningeal reactions were active at the time of death.

The etiology of these lesions was difficult to determine. When evidence of other pathologies was considered, the majority of the lesions appeared to have resulted from systemic infections and metabolic disorders. However, 16 juveniles presented no other skeletal pathology. Over half of these (n = 10) were between birth and 2.5 years old, suggesting a developmental, rather than a pathological, origin for these "lesions." Grave Pit 7860, Burial 18542-P, a child between 11 and 13 years of age, exhibited meningeal reactions only on the frontal bone (Figure 155), symptomatic of a nonspecific hemorrhage or infection. Of the remaining individuals, pathological conditions in addition to the meningeal reactions included evidence of systemic infection, metabolic disorders, and developmental disorders (see Table 162).

Nearly all juveniles (n = 26) with endocranial reactions were located in Cemetery Area 3. This is not unexpected, considering the large percentage of identified infants and subadults located in that area. Cemetery Areas 4 and 5 each contained two juveniles with endocranial reactions. None of the affected individuals were located in Cemetery Areas 1 and 2.

A meningeal reaction on the frontal bone of an adult Hispanic male (Grave Pit 3356, Burial 6801-P), indicative of a nonspecific infection or hemorrhage, was noted in Cemetery Area 2. A second individual, an older adult Hispanic individual of indeterminate sex (Grave Pit 13916, Burial 28759) in Cemetery Area 3, presented meningeal reactions affecting both parietals and the frontal bone. Because this individual also suffered from bilateral sinusitis, general thickening of the cranial vault, several osteomas, periapical abscessing, antemortem tooth loss, and periodontal disease, a secondary infection is the likely cause for these endocranial lesions.

A qualitative comparison of the incidence of endocranial lesions documented in the Alameda-Stone cemetery sample and other cemeteries is inconclusive. The Refugio Mission Cemetery contained one individual, an adult male aged between 30 and 35 years of age, with endocranial porosity of the temporal bone (Jantz et al. 2001). The Voegtly Cemetery also offered only a single case of endocranial lesions: an infant (aged 1.4 years) showing new bone formation with minimal remodeling on the endocranial surface of the occipital. The infant remains were incomplete; so, a thorough assessment of the individual was not possible (Ubelaker and Jones 2003). The Tucson Presidio contained two individuals with meningeal reactions, both children (1 year and 2 years of age). Both displayed evidence of endocranial lesions along the sagittal sulcus, as well as evidence of porotic hyperostosis (in the 1 year old) and cribra orbitalia (in the 2 year old) (Dayhuff 2002).

Respiratory Infections

Diseases and infections of the respiratory system affect the lungs, pleural cavity, bronchial tubes, trachea, and upper respiratory tract. Generally, these conditions leave no lasting impressions on the skeletal remains. However, there are some conditions that do leave tell-tale signs on the skeleton.

Sinusitis

The sinuses of the frontal, ethmoid, sphenoid, and maxilla act as physical and chemical barriers against airborne particulates and pathogens. Any disruption of these barriers can result in the buildup of fluid in the sinus, creating an idyllic culture medium for bacterial growth and subsequent tissue damage represented by the inflammation of the mucosal lining, or sinusitis (Merrett and Pfeiffer 2000:304; Roberts 2007:794). Symptoms of sinusitis include nasal congestion, purulent nasal and pharyngeal discharges, facial and dental pain, cough, periorbital edema, earache, sore throat, wheezing, and fever (Evans 1994; Merrett and Pfeiffer 2000:304; Roberts 2007:795). Although sinusitis can affect all of the sinuses, the condition most commonly seen in a bioarchaeological setting affects the maxillary sinuses (Roberts 2007:792). The effects of acute sinusitis manifest between 7 days and less than 1 month after exposure. If symptoms persist for more than 3 months, the condition is considered a chronic infection (Merrett and Pfeiffer 2000:304). When left untreated, chronic sinusitis may affect surrounding bony tissue (Merrett and Pfeiffer 2000:304); the result is periosteal new bone formation, plaque-like bone growth, bony spicules, and pitting (Aufderheide and Rodríguez-Martín 1998:257; Raphaël et al. 1997:610; Roberts and Manchester 2005:174).

Maxillary sinusitis results from several factors, including dental disease, poor ventilation, air pollution, overcrowding, smoke from burning fuel, tobacco smoke, a dry atmosphere, poor levels of hygiene, allergies, and other respiratory tract infections (Aufderheide and Rodríguez-Martín 1998:257; Roberts 2007:795). Various types of bacteria may contribute to the development of sinusitis and include *Streptococcus pneumoniae, Haemophilus influenzae, Moraxella catarrhalis, Staphylococcus aureus,* and *Pseudomonas aeruginosa*. Roberts (2007) suggests that fungi found in the southwestern United States may be a culprit for the development of sinusitis in that region of the United States.

To assess the frequency of sinusitis in the Alameda-Stone cemetery sample, osseous changes were examined macroscopically. Sinusitis was recorded as present when periosteal or proliferative reactive bone, spicule(s), bony nodules, or plaque-like new bone growth was noted in the maxillary sinus (observations were limited to those maxillae that allowed observations of the sinuses). Only adults, 18 years or older, were assessed for sinusitis. Dental disease associated with the maxillary sinus was noted.

The maxillary sinuses of 245 individuals could be assessed for sinusitis. Only 4 percent (n = 10) presented evidence of chronic maxillary sinusitis (Table 163). This number likely underestimates the incidence of sinusitis for the Alameda-Stone cemetery sample because complete and intact sinuses could not be examined. Of the affected individuals, 3 were young adults, 3 were middle adults, and 4 were old adults. Six of these individuals were female, 3 were male, and 1 was of indeterminate sex. Interestingly, 7 of the 10 individuals observed with sinusitis also displayed evidence of a dental pathology, suggesting a correspondence between sinusitis and dental pathology. In their study of chronic maxillary sinusitis, Raphaël et al. (1997) suggested that odontogenic sinusitis was the dominant etiological factor.

Roberts (2007) has suggested tobacco smoke inhalation may be related to respiratory disease and sinusitis. One individual (Grave Pit 7553, Burial 9721-P) exhibited a pipe facet, suggesting habitual tobacco consumption, a factor that may have precipitated or exacerbated sinusitis (Figure 156).

Evidence for sinusitis from the Alameda-Stone cemetery sample was compared to skeletal populations from the Refugio Mission Cemetery and the Voegtly Cemetery. A direct comparison of the frequency of sinusitis may be misleading, but evidence of the condition was documented at these cemeteries. Sinusitis was identified on four individuals, or roughly 2 percent of the sample, at the Refugio Mission Cemetery (Jantz et al. 2001). This frequency is close to the frequency observed in the Alameda-Stone cemetery sample. Only one

case of sinusitis was identified at the Voegtly Cemetery, with bony reactions of both the left and right maxillary sinuses, indicating long-term infection (Ubelaker and Jones 2003). Ubelaker and Jones (2003) suggested dental disease was a causative factor.

Tuberculosis

Tuberculosis is an infectious disease caused by a species of Mycobacterium known as *M. tuberculosis*. *M. tuberculosis* is a form of bacteria that is transmitted from human-to-human, primarily through the respiratory tract. The main target of tuberculosis is the lungs, followed by single or multiple foci in the regional hilar lymph nodes (Ortner 2003:227). Symptoms of tuberculosis include coughing (often blood-stained), difficulty breathing, weakness, lethargy, loss of appetite, weight loss, hoarseness and loss of voice-pitch control, chills, night sweats, irritability, pallor, fever, and chest pain (Roberts and Buikstra 2003:5, 20).

After infection, bacteria enter the circulatory system, spreading to organs in the body, including the skeleton (Braun et al. 1998:271). In adults, this usually involves the metaphyses and epiphyses of the long bones, but in infants and children, more of the skeleton is involved. In juveniles, the tuberculosis foci often occur in the tubular bones of the hands and feet and the ossification centers of the carpal and tarsal bones. At all ages, the ribs, vertebrae, and sternum are affected (Ortner 2003:228). Additionally, inflammation in the synovial joints often occurs, particularly in the hip and knee (El-Najjar 1981:86–87).

Bone deposition and resorption may occur, and resorption is generally the dominant characteristic. Focal, resorptive lesions dominate the vertebral bones and joints (Aufderheide and Rodríguez-Martín 1998), and proliferation has been observed on the internal aspects of the ribs (Roberts 1999). Primary destructive lesions, usually in the spinal column, appendicular skeleton, and occasionally the skull, are characteristics of tuberculosis (Roberts and Buikstra 2003:189).

Example One

None of the individuals recovered from the Alameda-Stone cemetery sample display the characteristic destructive lesions of the vertebral bodies. Nevertheless, several individuals display other evidence of tuberculosis. A young-adult female of indeterminate biological affinity (Grave Pit 10133, Burial 19965-P) between 25 and 35 years of age exhibited a number of pathologies consistent with tuberculosis (Figure 157). Although there was taphonomic damage on the inferior aspect of the nasal region, the nasal bridge was flattened, and remodeling was evident. The facial surfaces of the maxillae were severely concave posterior to the canine jugum and would have presented a hollowed or sunken appearance below the cheeks. On the right maxilla there was slight periosteal new bone development, with associated microporosity and a large lytic lesion with sharp, irregular margins and slight porosity. The lesion penetrated the palatine processes of the maxillae. Elements of both legs exhibited periosteal new bone, including active periosteal new bone at the anterior distal aspect of the left femur and healing periosteal new bone at the medial midshaft and lateral distal aspects of the right tibia, as well as the anterior aspect of the left tibia. The right patella had a large lytic lesion anteriorly at the superior-medial aspect. This lesion was about 2 cm deep, with smooth but irregular edges and no evident periosteal new bone.

Rhinomaxillary changes are associated with leprosy, tuberculosis, and syphilis; however, the alterations observed on Grave Pit 10133, Burial 19965-P, were not consistent with leprosy. Moderate alveolar porosity and absorption of the maxillae was evident, the nasal spine was present, and the nasal conchae and palatine processes of the maxillae lacked pitting. None of the carpal or tarsal phalanges exhibited concentric bone loss, a condition that would be consistent with leprosy. The facial bones most affected by tertiary syphilis include the nasal bones, the vomer, the palate (maxillae), and the nasal conchae. From destruction of these elements, the nasal cavity may appear enlarged and empty (Ortner 2003:283). The vomer in this individual was unremarkable for pathology, and the lytic lesion in the palate did not exhibit signs of sclerosis. *Lupus vulgaris*, one form of tuberculosis, can often lead to destruction of the nasal area and maxillae. Thus, considering the suite of

pathological conditions noted on Grave Pit 10133, Burial 19965-P, this form of tuberculosis, which can affect the skin and soft tissues of the face, is the most likely explanation.

Example Two

The most common skeletal manifestation of tuberculosis in infants through adolescents is spina ventosa or tuberculosis dactylitis (Aufderheide and Rodríguez-Martín 1998:138; Ortner 2003:242). Spina ventosa is a form of dactylitis. Dactylitis results in lesions of the tubular bones of the hands and feet. These lesions typically begin with necrosis of the cortex, which can result in the formation of a sequestrum, giving a thickening or "ballooned" appearance to the periosteum (Ortner 2003:242). Eventually, as healing continues, subperiosteal new bone may form underneath this "shell" (Rothschild and Martin 1993:72). It is of note that in spina ventosa, the interphalangeal joints are generally not affected, although the growth plates can be, resulting in a shortening of the digits (Aufderheide and Rodríguez-Martín 1998:166; Ortner 2003:242). Attributing lesions of dactylitis to spina ventosa can be assisted by manifestations of tuberculosis elsewhere in the body (Ortner 2003:242), but one must be cautious, as bone changes in spina ventosa are similar to those observed in osteomyelitis or congenital syphilis (Ortner 2003:242).

Dactylitis was observed in the left hand of a Hispanic child (Grave Pit 13600, Burial 28511-P) between the ages of 6 and 10 years. Expansion was noted in the first tarsal phalanx, and a similar type of expansion was noted in a partially intact proximal carpal phalanx. The proximal end of the carpal phalanx did not display taphonomic damage, but the distal end may have consisted of just a shell. The medial aspect (of the carpal phalanx) was still intact, and the internal aspect was smooth and microporotic. Destruction such as this is most likely osteomyelitis. A middle carpal phalanx displayed expansion of the entire element, especially the proximal end, and there was minimal reactive bone on the palmar surface. The left foot displayed periosteal new bone in a number of tarsals and metatarsals. The fourth and fifth metatarsals displayed cortical hyperostosis and periosteal new bone on the dorsal aspect. The left calcaneus and cuboid displayed sheath-like periosteal new bone on all nonarticular surfaces.

In addition to the pathology seen in the foot and hand, periosteal bone was evident on the cranium and other postcranial elements, including (1) periosteal new bone on the occipital, covering most of the squamous with plaque-like bone formation and pitting; (2) active periosteal new bone on the ectocranial surface of the frontal bone, including both orbits; (3) proliferative, active periosteal new bone growth on the anterior aspect of the left and right clavicles (the medial aspects were damaged postmortem, preventing observation and analysis); (4) active, sheath-like periosteal new bone growth covering the posterior surface of the right scapula; and (5) periosteal new bone growth on the pleural or visceral surface, near the sternal ends of the right sixth and seventh ribs, suggestive of tuberculosis.

Pulmonary Tuberculosis

In pulmonary tuberculosis, new bone formation on either the visceral or pleural aspect of the ribs is common. The vertebral ends of the third through seventh ribs, usually bilaterally, are involved because the infection occurs in the middle and lower lungs (Matos and Santos 2006; Santos and Roberts 2006). Rib lesions alone, however, are not definitive for tuberculosis. An adult (Grave Pit 20511, Burial 19953-P) of indeterminate sex and indeterminate ancestry, between 25 and 30 years of age, displayed evidence of active periosteal new bone formation on the visceral aspect of four left middle ribs at the vertebral ends and one at the sternal end. The right eleventh and twelfth ribs also had lesions on the vertebral ends. Additionally, the right fibula exhibited periosteal new bone growth covering most of the diaphysis. Several other individuals also presented periosteal new bone growth on the visceral surfaces of the ribs, but these lesions were located either on the shaft or sternal aspects of the ribs. Visceral reactions have also been documented in nontubercular pulmonary diseases, such as pneumonia, bronchitis, emphysema, or pleurisy (Mays et al. 2003). Several studies using skeletal material dating to the preantibiotic age suggest an association between visceral surface lesions and pulmonary infectious disease (Matos and Santos 2006; Santos and Roberts 2001, 2006).

A Euroamerican male (Grave Pit 1479, Burial 2506) between 20 and 25 years of age presented thick periosteal new bone growth covering the vertebral ends and most of the shafts of several right ribs, including the first. Unfortunately, the ribs were fragmentary; so, the exact number and position of the ribs could not be determined with confidence. Also, one of the right ribs exhibited an antemortem fracture likely associated with a small-caliber lead projectile found in situ between the sixth and ninth ribs. Although infection stemming from the fracture may explain the periosteal new bone seen in the right ribs, this individual also displayed evidence of sinusitis, which suggests a pulmonary or respiratory infection as the most likely causative factor.

In pulmonary, nontubercular infection, there is no pattern to the distribution of rib lesions; generally very few ribs are affected, although when affected, the sternal ends of the inferior ribs are involved more frequently (Matos and Santos 2006; Santos and Roberts 2006). Three adults had periosteal new bone at different locations on the visceral aspect of the ribs (not the vertebral ends). A Hispanic male (Grave Pit 3366, Burial 3920-P) between 35 and 50 years of age had plaque-like periosteal new bone on the visceral surface of the body and intercostal grooves of two middle ribs (the sixth through eighth). Additionally, there were lesions at the attachment of the medial heads of both femora and on the left humeral head, although these lesions may be related to behavior rather than to a pathogen. A Hispanic female (Grave Pit 7919, Burial 18924-P) between 18 and 30 years of age with Klippel-Feil syndrome, exhibited plaque-like periosteal new bone growth on the visceral surface of several right and left rib fragments, as well as on the radii, ulnae, tibiae, and fibulae.

Of the cemeteries used as comparative groups, Voegtly Cemetery was the only cemetery to identify individuals with tuberculosis. Four individuals presented skeletal evidence of tuberculosis, and only two of these individuals had involvement of the ribs. Molecular evidence for *M. tuberculosis* for two of these individuals further supports the presence of tuberculosis among the population interred at Voegtly.

Treponemal Infection

Treponemal infection, or treponematosis, is a chronic or subacute infection caused by spirochetes of the genus *Treponema*. Treponemes enter the host through damaged skin or mucous membrane, giving the bacteria access to broken blood vessels. These bacteria prefer areas of the body with the lowest temperature and where oxygen is readily available (such as the region of the tibia) (Barnes 2005:203). There are four forms of the disease (yaws, bejel, pinta, and venereal syphilis), and all are more or less morphologically indistinguishable (Waldron 2009:102). The routes of infection and clinical manifestation of each differ and may be the result of the bacteria adapting to a diversity of environments (Aufderheide and Rodríguez-Martín 1998:154; Waldron 2009:102). Yaws is found in tropical and subtropical humid areas; bejel, also called endemic syphilis, is found in rural areas in temperate and subtropical nonhumid regions; pinta is found in tropical regions of America from Mexico to Ecuador; and venereal syphilis, also referred to as acquired syphilis, is the most ubiquitous and is found in urbanized populations in most geographic regions (Aufderheide and Rodríguez-Martín 1998:154). The organism associated with venereal syphilis is spread via sexual contact when the bacteria are transferred from an infected, open lesion (Waldron 2009:102). Congenital syphilis is considered a subcategory of venereal syphilis, as it can only be passed on to a child by a mother infected with venereal syphilis. It is important to note that the different types of treponemal diseases do share some characteristic features, and thus, with only isolated bone, a definitive diagnosis is likely not possible on the macroscopic level (Rothschild and Rothschild 1997:39). Rothschild and Rothschild (1997:39) do point out that if there is significant remodeling so extensive as to severely reduce or eliminate evidence of periosteal new bone (with the exception of saber shins), the diagnosis of syphilis should be considered the most likely pathology.

All forms of treponemal infection are characterized by primary, secondary, latent, and tertiary phases. In the primary phase, an ulcerative lesion, or chancre, appears at the site of inoculation and usually heals in 2–8 weeks (Ortner 2003:278; Waldron 2009:103). The treponeme binds to the lining of the walls of the blood vessel, causing irritation and an inflammatory response by the host (Barnes 2005:207). Soon after, the secondary phase follows, marked by flu-like symptoms, a rash on the soles of the feet and the palms of the hands,

and joint pain, as the treponemes are spread throughout the body via the bloodstream (Ortner 2003:278; Waldron 2009:103,105). The rash may appear as a series of small bumps that transform into ulcerating lesions, wart-like growths, or erosive patches of discolored skin. Most individuals recover from the secondary phase in several weeks (Barnes 2005:209). The infected host is contagious during the primary and secondary phases. According to Barnes (2005:210), approximately one-third of all infected individuals develop a tolerance to the remaining treponemes after secondary symptoms disappear. After a long latent period (up to 30 years), however, more-severe symptoms may appear (Barnes 2005; Waldron 2009:103). In some cases, incapacitating lesions in the cardiovascular and central nervous symptoms appear suddenly, between 5 and 20 years after initial infection (Aufderheide and Rodríguez-Martín 1998:158). The tertiary stage is characterized by the formation of gummas (Ortner 2003; Waldron 2009:103). Inflammatory cells surround and gradually incase the bacteria within thick, fibrous capsules, which can rupture and create a severe ulcer. These gummas can invade the skin, mucous membranes, and bones near the skin's surface (Barnes 2005:210).

Two adults were identified with treponemal infection. A male between 45 and 65 years of age (Grave Pit 10078, Burial 14566-P) exhibited caries sicca on the frontal bone; the gummatous lesions were healed and remodeled (Figure 158). No other elements were affected. A second individual, a female (Grave Pit 10103, Burial 11970-P) of indeterminate ancestry between 25 and 35 years of age, exhibited evidence of caries sicca on the right parietal. There was some weathering on the parietal, but remodeled gummatous lesions were apparent. The left parietal had a depressed area near the temporal line. This area was not the result of trauma and exhibited porosity and the beginning of two smaller foci within the lesion. The right radius, the right ulna, the left femur, both tibiae, and the right fibula exhibited areas of periosteal new bone growth. The distal aspect of the femur, the shaft of both tibiae, and the proximal fibula presented a slight expansion.

Saber shin is the result of apposition of periosteal new bone on the anterior aspect of the tibia and has been linked to treponemal infection (Ortner 2003). A Hispanic male (Grave Pit 7720, Burial 16836-P) between 35 and 45 years of age displayed anterior bowing of the tibiae (Figure 159). Additionally, there was periosteal new bone on both tibiae, the right fibula, and the left fifth metatarsal. The absence of dental abnormalities distinguished these lesions from those of congenital syphilis.

Congenital Syphilis

Women who contract venereal syphilis during pregnancy can transmit the infection to the unborn fetus through the placenta, especially during the secondary stage of the treponemal infection (Roberts and Manchester 2005:211). The result is usually fetal death, stillbirth, or the premature or full-term birth of an infant infected with syphilis (Mansilla and Pijoan 1995:188; Ortner 2003:289). Infants with early development of congenital syphilis frequently do not show signs of the disease until 3 weeks postpartum. Almost half of all infants die (Barnes 2005:212). If, however, the disease is mild, it is possible for the child to survive, and over time, the symptoms may disappear. Indeed, the disease may remain latent for several years (Mansilla and Pijoan 1995: 188; Ortner 2003:290), but it can reappear between 4 and 15 years of age. This is known as late congenital syphilis (Mansilla and Pijoan 1995:188). The manifestation of congenital syphilis varies depending on the period of childhood (early or late) in which it appears.

Skeletal characteristics of early congenital syphilis include osteochondritis (Ortner 2003:290). Osteochondritis is poor bone formation in the areas of endochondral growth (Mansilla and Pijoan 1995:189). This is most marked in the distal aspect of the femur and proximal aspect of the tibia, the location of the fastest growing metaphyses (Ortner 2003:291). As the calcification of cartilage increases, an uneven or jagged metaphysis forms, usually displacing the epiphysis (Mansilla and Pijoan 1995:189). The presence of osteochondritis alone is not diagnostic of congenital syphilis. Other characteristics of early congenital syphilis include saber shin, diaphyseal osteomyelitis, osteitis, periosteal new bone (Jaffe 1975; Ortner 2003; Resnick and Niwayama 1988; Steinbock 1976), diaphyseal osteomyelitis (Steinbock 1976), and multilaminated deposition of subperiosteal bone.

In late congenital syphilis, gummatous periostitis and osteomyelitis occasionally may occur. The tibia, ulna, and radius are the most commonly affected elements (Ortner 2003:293). Dental alterations may also be

present, particularly on the maxillary incisors and the first molars, as these teeth calcify during the first year of life (Mansilla and Pijoan 1995:189–190). The maxillary incisors, particularly the central incisors, may develop a deep, vertical notch. This dental alteration is known as "Hutchinson incisors." The first molars may also be affected, resulting in significantly smaller than normal size and exhibiting an irregular and rough occlusal surface with small bumps that represent atrophied cusps. Affected molars are generally referred to as "Mulberry molars" (Mansilla and Pijoan 1995:190).

Four infants were identified with evidence of congenital syphilis. Three of these individuals had osteomyelitis and multilaminated circumferential periosteal new bone on several long bones (see Osteomyelitis). The fourth infant (Grave Pit 29282, Burial 28755-P) had possible osteochondrosis of the distal metaphysis of the right femur (Figure 160). Although nearly all long bones displayed evidence of taphonomic damage, thereby preventing a full analysis of the extent of disease processes for this individual, some observations were still possible. Multiple long bones had multilayered periosteal new bone, and the humeri and femora both exhibited expansion of the distal metaphyses. Expansion of the proximal aspect of the right ulna with possible osteomyelitis was noted, as well as expansion of the entire diaphysis of the right radius. Laboratory analysis notes indicate that the ribs had a swollen and expanded appearance; however, no photos were available for confirmation.

A child between 10.5 and 12 years of age (Grave Pit 13926, Burial 28294) displayed evidence of congenital syphilis. Hutchinson's incisors were observed on the mandibular lateral incisors and the maxillary central incisors. The mandibular central incisors were peg-shaped, and Mulberry molars were evident for all first molars (Figure 161). This individual also displayed periosteal new bone on the visceral surface of several sternal rib ends.

Indirect Evidence

In the late-nineteenth and early-twentieth centuries, syphilis was treated with heavy metals, including mercury, arsenic, and bismuth. Mercury was often applied as a topical salve or an oral administration referred to as *calomel*. Arsenic and bismuth were injected intravenously or intramuscularly (Steele 2005). The purpose of these treatments was to eliminate the external symptoms and to minimize transmission (Steele 2005:92).

X-ray fluorescence spectroscopy provides a rapid, nondestructive method for the analysis of metallic elements in a sample, including artifacts and human skeletal elements, providing qualitative and quantitative data. The X-ray fluorescence spectroscopy analysis showed evidence of mercury in a number of specimens, including the individual in Grave Pit 7695, Burial 14872-P, possibly indicating oral and topical forms of mercury that were commonly used to treat syphilis (Appendix E; Steele 2005). The individual, a young adult Euroamerican female aged between 25 and 30 years, showed very high levels of mercury and exhibited osteomyelitis of the distal end of the left fibula and the left scapula, as well as healed periosteal new bone of the diaphysis of the left tibia. The pathological conditions noted on the skeleton are not entirely consistent with treponemal infection for two reasons: (1) there was no bilateral involvement of the tibiae and (2) the sequestrum and cloaca noted on this individual are rarely seen in treponemal infections (Aufderheide and Rodríguez-Martín 1998:158–159). That said, however, well-preserved hair recovered from the area on and around the pubic bones produced high levels of mercury (59.63 $\mu g/cm^2$), as did soil and bone fragments from the same burial (306.1 $\mu g/cm^2$). Such high levels of mercury, especially in the pubic hair, suggest the medicinal use of mercury in this area. Gonorrhea was also treated with mercury in the form of urethral injections and irrigations, which could be an alternative explanation for the presence of this metal (Steele 2005:117).

Evidence of pre-Columbian treponemal disease has been documented in the southwestern United States, including Arizona (Quebbeman 1966). Rothschild and Rothschild (1996) have suggested that evidence for pre-Columbian treponemal disease could date anywhere between 1600 and 800 B.P. Assistant Surgeon Bernard Irwin (1860:213) reported in 1859 (regarding research and observations made over the previous year, 1858) that venereal diseases in every form were constantly encountered among Mexicans in Sonora. Immigration to Tucson from Sonora, as well as from other parts of the United States, occurred during the latter half of the nineteenth century, especially after the arrival of the railroad (Lockwood and Page 2005; Quebbeman 1966).

Some of these individuals brought various diseases with them, including tuberculosis, gonorrhea, smallpox, and syphilis. Dayhuff (2002:69) identified one individual from Mission San Agustín with treponemal disease. This individual, a female aged 15 to 20 years, displayed stellate lesions on the right parietal, and the right femur exhibited thickening of the cortical bone distally and an expansion of cancellous bone in the medullary cavity. The right fibula had active periosteal new bone, with accompanying thickening of the diaphysis. These pathological features suggest the presence of treponemal disease in Tucson by the mid-nineteenth century. The presence of the congenital syphilis also confirms the existence of venereal syphilis in the Tucson population. It is not surprising that only a small number of adults display skeletal changes consistent with syphilis, because skeletal involvement is rare.

Neoplasms

A neoplasm is an uncontrolled growth or mass of tissue cells in which growth exceeds or is uncoordinated with the surrounding tissue, ranging from the simplest of warts to the most deadly of tumors or cancers. These growths may be benign or malignant, and they can occur in any tissue or organ in the body, including the skeleton. Neoplasms can affect every segment of society, regardless of age, sex, ethnicity, health, or socioeconomic status (Roberts and Manchester 2005:252).

Two benign neoplasms commonly encountered in archaeological contexts include cysts and osteomas. Cysts are fluid-filled cavities surrounded by a lining of connective tissues (Ortner 2003:504). Osteomas are bone-forming, slow-growing lesions, usually located on the outer surface of the cranium, particularly the frontal and parietal bones (Aufderheide and Rodríguez-Martín 1998:375). Button osteomas are rather common and usually appear as small, rounded, smooth projections of lamellar bone, ranging in size from pinheads to tennis balls (Roberts and Manchester 2005:255). Occasionally, the clavicle, humerus, femur, and tibia can develop osteomas (Aufderheide and Rodríguez-Martín 1998:375). It is important to note that some publications have argued that osteomas, specifically button osteomas, may not be neoplastic. More research is needed to determine the etiology and pathophysiology of these conditions (Capasso 1997; Eshed et al. 2002; McCarthy and Frassica 1998:200).

Button osteomas were identified on the crania of eight individuals from the Alameda-Stone cemetery. Both males and females were affected. Two of the affected individuals had multiple osteomas (Table 164).

Evidence of a possible enchondroma was noted on the left middle finger (left third proximal carpal phalanx) of the individual recovered from Grave Pit 68, Burial 137-P (Figure 162). An enchondroma is a benign, cartilaginous tumor that commonly occurs in late childhood through middle age. These benign tumors most often appear in the metaphyseal area of the tubular bones, especially those of the hands and feet.

Several individuals had cysts on the palatine processes of the maxillae. A young-adult female between 25 and 35 years of age and of indeterminate biological affinity (Grave Pit 10133, Burial 19965-P) had a perforated palate, most likely resulting from a cyst in the nasomaxillary region. The lesion was large, and the margins were irregular and sharp, with porosity evident on the anterior aspect of the lesion. The vomer was displaced to the right, suggesting pressure in this region. An adult Hispanic female between 30 and 50 years of age (Grave Pit 7521, Burial 8966-P), displayed a large, oval-shaped midline cyst penetrating the palatine processes of the maxillae (Figure 163). The palatines were minimally involved anteriorly, and the vomer was missing postmortem. The anterior alveolar bone and dentition were both unaltered. An adult Hispanic male between 20 and 30 years of age (Grave Pit 17766, Burial 19781-P) presented a possible globulomaxillary cyst, a developmental defect. There was a cyst, or void, approximately 9 mm in diameter, posterior to the right maxillary canine, with no porosity or reactive bone in the surrounding area. Globulomaxillary cysts are found at the lateral junction of the premaxilla and maxilla, between the lateral incisor and canine (Barnes 1994:178).

Degenerative Conditions

Degenerative conditions are characterized by deterioration of the body and manifest in numerous ways, including lipping, pitting, and eburnation. Degenerative conditions can be either pathological in origin or simply the product of predictable changes in aged individuals. Although there are some observations that can lead to a differential diagnosis, age-related degenerative change and pathological degeneration of bone often present similarly. Thus, the age of the individual and the manifestation of the degenerative change are important factors in identifying the origin of the condition. A number of pathological presentations fall under the category of degenerative conditions. Each will be discussed below.

Osteoarthritis or Degenerative Joint Disease

Rogers and Waldron (1995:32) characterized osteoarthritis as "a focal loss of articular cartilage and subsequent bony reaction of the subchondral and marginal bone." According to Hollinshead (1982:629–630, referenced by Steele and Bramblett 1988:215), changes of a microscopic pathological nature happen in the articular cartilage of all individuals over 30 years of age. The most common of all articular diseases, osteoarthritis is degenerative in nature, with changes due to overuse activity and increased age. Secondary degenerative arthritis can result from other causes, including trauma, inflammation, metabolic disorder, and congenital disease (Ortner and Putschar 1981:419). Osteoarthritis is also referred to as degenerative joint disease, osteoarthrosis, or hypertrophic arthritis (McCarthy and Frassica 1998:324). Often, the terms osteoarthritis and degenerative joint disease are used interchangeably. For the purposes of this discussion, degenerative joint disease will be used to refer to these conditions.

There are two categories of degenerative joint disease: primary and secondary. Primary degenerative joint disease involves bony joint changes with no preexisting joint disease. Secondary degenerative joint disease occurs when there is a "well-defined, pre-existing joint disorder," such as rheumatoid arthritis, trauma, or osteonecrosis (McCarthy and Frassica 1998:324). The affected joints and the nature of the changes to the joint allow for a more thorough differential diagnosis between the two.

Degenerative joint disease is identified by the presence of eburnation (a change that occurs from bone-on-bone friction that creates a dense, smooth surface resembling ivory) (Figure 164) or the presence of two or more other characteristic features, such as osteophytes/lipping, pitting, and changes at the surface of the joint (Figure 165). Ortner and Putschar (1981:420) state that eburnation is pathognomonic for the advanced stage of degenerative joint disease, although others have argued against the symptomatic nature of eburnation as a diagnostic feature of degenerative joint disease.

To assess the frequency and distribution of degenerative joint disease in the Alameda-Stone cemetery sample, each joint surface was scored by a Statistical Research, Inc., analyst (Table 165). Joint surfaces were then combined into left and right joint complexes, as well as spinal segments. The joint complexes are described in Table 166. By combining joint surfaces, a composite score was generated for each individual. No scores were duplicated; therefore, each joint complex could be assigned no more than one of any particular score. Those joint surfaces that could not be scored because of absence or fragmentation were indicated with a null value for all statistical analyses. For any joint complex that received a joint score other than "1" (normal), the numerical assignment for the normal score was dropped, to avoid false positives. Only adult individuals were assessed for degenerative joint disease. In subsequent analyses, only individuals with degenerative joint disease were used to test for differences between groups (e.g., males versus females or Hispanics versus Euroamericans).

After removing subadults and unobservable cases, 603 individuals remained. This subgroup of the Alameda-Stone cemetery population consisted of males (49 percent), females (36 percent), and individuals of indeterminate sex (15 percent). Table 167 presents the demographic data for the degenerative joint disease sample, and Table 168 summarizes the frequency of observed degenerative joint disease by sex and age category. No significant differences were noted between left and right sides for any of the joint complexes. Spearman's

correlation coefficients demonstrated high positive correlations between all left and right paired joints (average $r = 0.794$, significant at the 0.05 level), suggesting overall bilateral symmetry.

The expression of degenerative joint disease differed significantly between males and females (Table 169), with the exception of the right ankle ($U = 21934.50$, $p = 0.063$), which was not significantly different. The upper limbs (shoulder, elbow, and wrist) and lower backs of males were affected much more than those of females. Conversely, the lower limbs (particularly the knee) of females were much more likely to be affected by degenerative joint disease. The differential expression of degenerative joint disease throughout the body suggests that men and women were participating in different activities (occupational and lifestyle), and thus, the mechanical stressors acting on individual joints were expressed differently.

Significant differences in the expression of degenerative joint disease were also noted after further refining the male and female samples to include age information. The young, middle, and old age groups were all significantly different in the expression of degenerative joint disease throughout the skeleton (Table 170; see also Appendixes Q.1–Q.3). It is not surprising that the incidence of degenerative joint disease increased from young to old age (see Table 168). Within the Alameda-Stone cemetery sample, males and females presented a very similar pattern. All old adult females (27 out of 27) and nearly all old adult males (50 out of 51) had at least one joint affected by degenerative joint disease. Percentages of young- and middle-adult individuals affected by degenerative joint disease ranged from a low of roughly 39 percent (young-adult females) to a high of nearly 90 percent (middle-adult males). Individuals of indeterminate sex may represent a slightly degraded signal. These individuals were likely lower in percent affected because they were generally in a poorer or more fragmented condition, making degenerative joint disease harder to recognize.

Differences in the expression of degenerative joint disease between biological affinities (Tables 171–173; see Appendixes R.1–R.3) were assessed after removing individuals identified as Apache and African American, because the sample sizes for these groups were low. Indeterminate individuals were also removed, because they would not provide any useful information for such comparisons. Native Americans had the highest percentage of individuals affected by degenerative joint disease (74 percent), followed by Hispanics (69 percent) and Euroamericans (55 percent). Hispanics showed significantly more degenerative joint disease in both shoulders and both elbows than did Native Americans or Euroamericans. Although the exact mechanisms behind this significant increase are unclear, mechanical loading and strain from habitual, repetitive motions is a possible source. For example, the use of a mano and metate (a grinding stone used to grind corn and make mole pastes) or a *molcajete* (mortar and pestle used to make salsas) impart a great deal of force on the shoulders and elbows during use.

Differences in the expression of degenerative joint disease were also tested between cemetery areas. First, the relative frequency of affected joints in each cemetery area (age-class pooled: adult, young adult, middle adult, and older adult) was assessed, and this was found to be statistically different ($\chi^2 = 18.034$, $df = 5$, $p = 0.003$). Only 30 percent of the observable sample in Cemetery Area 1 were affected by degenerative joint disease. In all other cemetery areas, the affected individuals outnumbered the unaffected. The discrepancy between Cemetery Area 1 and the other areas is most likely a reflection of the sample composition. As Heilen and Hall (see Chapter 4) and Trask (see Chapter 7) both explain, Cemetery Area 1 was composed predominately of young-adult Euroamerican males in the military. This factor, combined with preservation problems in Cemetery Area 1, would undercount individuals affected by degenerative joint disease. The effects of degenerative joint disease on the individual skeletal regions did not differ significantly by area, with the exception of the forearms and hands, the right hip, the left knee, and the lower back. The pattern of these differences is not very clear.

Several general patterns were also established. For all individuals with some form of degenerative joint disease, the temporomandibular joint showed the lowest frequency, and the elbows showed the highest frequency (Figure 166). When joint-complex sides were combined, the trend remained unchanged, with the temporomandibular joint complex displaying the lowest frequency and the elbow joint complex displaying the highest frequency, followed by the shoulders and the knees (Figure 167).

In order to understand how life in Tucson affected early Tucsonans and whether their experience was shared or unique to other populations, comparisons were made to contemporaneous cemetery samples in the

United States and Canada. Because each recovery project collects and analyzes data in similar but not identical ways, most comparisons cannot be made on a one-to-one basis in a quantitative fashion.

Mild arthritic conditions were noted in the individuals recovered from the Freedman's Cemetery. The incidence of degenerative joint disease from the Freedman's Cemetery may be inflated, because some negative data were discarded by the Freedman's Cemetery researchers as "unobservable data," as a result of the researchers' failure to distinguish between the absence of the degenerative condition or an unobservable joint surface (Tiné 2000:497). The knee joint appears to have been the most affected, as well as other lower-body joints, and males displayed evidence of arthritic changes more than females. The Freedman's Cemetery closely matches the frequencies of male/female affected joints in the Alameda-Stone cemetery sample, although the latter did not show high frequencies of degenerative joint disease in the knee joint. Also, unlike the Alameda-Stone cemetery sample, the Freedman's Cemetery demonstrated low frequencies of degenerative joint disease in the hands and wrists, whereas the Alameda-Stone cemetery sample showed relatively high frequencies of degenerative joint disease for these two joint complexes.

Researchers of the Refugio Mission cemetery observed a high frequency of degenerative joint disease for older adults, specifically in the knees. Unlike the Alameda-Stone cemetery sample, the young adults from the Refugio Mission sample showed very little evidence of degenerative joint disease (Jantz et al. 2001:87). The general trend at the Refugio Mission suggests a higher frequency of degenerative joint disease for older adults compared to young adults, and males more often affected than females. In general, the rate of degenerative joint disease within the Refugio Cemetery population was low, especially when compared to other populations. This low frequency indicates a relatively low level of physical stress (Jantz et al. 2001). The individuals in the Alameda-Stone cemetery sample, in comparison, lived a more strenuous life, if the overall higher frequencies and more widely dispersed presence of degenerative joint disease between males and females, age groups, and biological-affinity groups is taken as such an indicator. The joint complexes affected also indicate different lifestyles or activities. Elbows and shoulders in the Alameda-Stone cemetery sample evidenced a higher frequency of degenerative joint disease; at the Refugio Mission Cemetery, the lower limb, particularly the knee, was the most affected joint.

At the Voegtly Cemetery, many of the individuals presented evidence of arthritic change. Thirteen individuals presented severe arthritic development in the spine, 11 individuals presented severe arthritic changes of the shoulder, and 10 displayed arthritic changes in the elbow. In all three of these comparative samples, Freedman's Cemetery, Refugio Mission, and Voegtly Cemetery, more males than females presented extreme arthritic changes, similar to the patterns in the Alameda-Stone cemetery sample. Osteoarthritis in the hip and ankles was also noted at the Voegtly Cemetery. Unlike in the Alameda-Stone cemetery sample, which demonstrated relatively high frequencies of degenerative joint disease in the wrist, only 1 male had extreme arthritic changes in the wrist (Ubelaker and Jones 2003:33–34). Age ranges for individuals displaying extreme arthritic conditions (anywhere in the skeleton) spanned from young adult to old adult, as was also the case in the Alameda-Stone cemetery sample. The data from the Voegtly Cemetery report only included specific frequencies for severe arthritic change, and it is not clear from the report how many individuals were observable or observed for a given condition (Ubelaker and Jones 2003). Although more-specific comparisons between the Voegtly Cemetery sample and the Alameda-Stone cemetery sample are not possible, it is noteworthy that extreme arthritic change was not confined to individuals of older age and, like in the Alameda-Stone cemetery sample, the shoulder and elbow were frequently affected in the Voegtly sample, perhaps indicating shared lifestyles, such as in occupations or day-to-day activities.

Examining the individuals from the Presidio and San Agustín Mission, both located in "Spanish Colonial Tucson" circa 1700–1821, Dayhuff (2002:10, 13, 93) found that females from both populations exhibited a higher likelihood of bilateral degenerative joint disease, specifically at the shoulder; however, males from the Mission tended to exhibit a unilateral expression in the same joint. The unilateral expression of degenerative joint disease for males in the right shoulder is interesting. Within the Alameda-Stone cemetery sample, there was no difference in the expressions of degenerative joint disease between right and left sides.

Rheumatoid Arthritis

Rheumatoid arthritis is a form of inflammatory arthritis with indications of a genetic predisposition for the disease, most often affecting the tissue of the synovial joints of the hands, wrists, feet, and ankles (Kilgore 1989:177; McCarthy and Frassica 1998:337). Infiltration of inflammatory cells causes the synovial membrane to become thick and vascularized, and if it continues in this chronic state, a pannus (or thickened growth of synovial tissue covering the joint margin and destroying the cartilage) may develop (Rogers and Waldron 1995:56). The erosions associated with rheumatoid arthritis are typically located along the edges of the articular surface and are characteristically rounded and smooth, often excavating into the trabecular bone (Rothschild et al. 1999:264). Rothschild et al. (1999) noted that it is not a particular number of lesions that leads to diagnosis of rheumatoid arthritis; rather, it is the pattern, distribution, and nature of the lesions that aid in differential diagnosis.

Osteoporotic bone is also characteristic of rheumatoid arthritis (Rothschild et al. 1999:264). The relatively porous nature of bone affected by rheumatoid arthritis could contribute to poor preservation and may explain, in part, the paucity of evidence of rheumatoid arthritis in antiquity (Inoue et al. 1999). "As the disease progresses, alteration of articular surfaces and weakening or destruction of supporting ligaments and tendons produce subluxation, restricted joint mobility, and deformity, particularly in the smaller peripheral joints and cervical spine" (Kilgore 1989:177).

Several individuals in the Alameda-Stone cemetery sample exhibited possible evidence of rheumatoid arthritis. A middle-adult Hispanic female (Grave Pit 7920, Burial 18909-P) displayed evidence of lytic erosive lesions at both proximal humeri. The lesions were rounded and symmetrical and were located at the margins of the articular surfaces. A second example was an adult of indeterminate biological affinity and indeterminate sex (Grave Pit 10188, Burial 16817-P) who presented symmetrical lesions at the first proximal phalanx, as well as degenerative activity, including lipping at the hands and feet. A young-adult male of indeterminate biological affinity (Grave Pit 7862, Burial 18599-P) presented symmetrical lesions and porosity at both the left and right feet.

Of the various historical-period cemeteries used to compare experiences between historical-period populations, none mentions rheumatoid arthritis; indeed, other than osteoarthritis, there are no discussions of any of the subcategories of degenerative joint disease or other degenerative conditions.

Diffuse Idiopathic Skeletal Hyperostosis

Diffuse idiopathic skeletal hyperostosis, previously known as Forestier's disease, can involve the spine as well as the insertion sites of ligaments and tendons, forming bony spurs known as enthesophytes (McCarthy and Frassica 1998:334; Rogers and Waldron 1995:47). Rogers and Waldron (1995:47) described diffuse idiopathic skeletal hyperostosis as a disorder "characterized by exuberant hyperostosis and ankylosis of the spinal column, and calcification or ossification of extra-spinal entheses and ligaments" and "almost invariably on the right-hand side."

Very few individuals were diagnosed with diffuse idiopathic skeletal hyperostosis in the Alameda-Stone cemetery sample. One individual with strong evidence for the condition was a middle-adult Hispanic male (Grave Pit 695, Burial 8752-P). Fusion along the right side of multiple thoracic vertebrae (Figure 168), incipient ankylosis at the first thoracic and seventh cervical vertebra, and fusion at the sixth and seventh cervical vertebrae, was consistent with diffuse idiopathic skeletal hyperostosis. The inferior aspect of the sacroiliac joint appeared to have been in the early stages of ankylosing. In addition to the ankylosing joints, there was hypertrophy at the left and right humeri, well-developed tubercles at the left and right femur at the attachment for the iliofemoral ligament, exostoses at the superior linea aspera of the right femur, and exostoses at the left and right tibia at the soleal line.

A second Hispanic middle-adult male (Grave Pit 3070, Burial 3893) may also have suffered from diffuse idiopathic skeletal hyperostosis. The seventh thoracic vertebra through the first lumbar vertebra were fused along the lateral borders. There was ankylosis at the right side and beginning ankylosis at the left side of the

sacroiliac joint. There is a possibility that this individual suffered from ankylosing spondylitis, but the other lumbar vertebrae were not involved, and the ankylosis at the sacroiliac joint appears to be a bridging of the joint and not the direct fusion one would expect in ankylosing spondylitis.

Seronegative Spondyloarthropathies

Seronegative spondyloarthropathies are a group of diseases involving inflammation and erosions, primarily of the entheses or ligamentous insertions, as well as the internal structure of joints (Rogers and Waldron 1995:69; Rothschild et al. 1999:259). This group of spondyloarthropathies includes Reiter's syndrome (reactive arthritis), psoriatic arthritis, and ankylosing spondylitis (McEwen et al. 1971). These conditions are called "seronegative," because the blood is negative for the rheumatoid factor autoantibody, and are therefore distinct from rheumatoid arthritis.

Characteristic features of seronegative spondyloarthropathies include (1) asymmetrical lesions; (2) proliferation of new bone, with erosions located both centrally and marginally; (3) involvement of the sacroiliac joint; (4) skip lesions in the spine; (5) entheses ossification; (6) spinal involvement; and (7) periosteal new bone formation on the short bones of the hands and feet (Inoue et al. 1999:2; McEwen et al. 1971; Rogers and Waldron 1995:77; Rothschild 1982).

A single individual was identified with reactive arthritis. A middle-adult Euroamerican male (Grave Pit 13614, Burial 21829-P) presented severe lipping at the distal femur and proximal tibia, along with a distinct cloaca on the anterior distal surface of the right femur (Figure 169). This individual likely suffered from a systemic infection related to osteomyelitis or, more likely, tuberculosis (see Tuberculosis section, above, for a detailed discussion of the noted pathologies).

Two individuals suffered from unknown seronegative spondyloarthropathy. The cervical vertebrae and upper lumbar of a middle-adult male of indeterminate biological affinity (Grave Pit 7765, Burial 13394-P) were fused. No ankylosing at the sacroiliac joint was noted, and no fusion of lower lumbar vertebrae was identified. In addition to the ankylosis, there was a well-formed enthesopathy at the calcaneum. Periosteal new bone was noted on several elements, including the bones of the left wrist, the right arm, and the left and right legs. A precise differential diagnosis was not possible; so, a general categorization of seronegative spondyloarthropathy is suggested. One Hispanic male (Grave Pit 7553, Burial 9721-P) had complete fusion of the fourth and fifth thoracic vertebrae and several bony nodules in the early stages of syndesmophyte formation. There was a large syndesmophyte between the fifth and sixth thoracic vertebrae in the early stages of fusion. The fifth lumbar was fully ankylosed to the first sacral vertebra, and there was complete ankylosis of the right and left sacroiliac joint. The skip lesions and ankylosis along the spinal column did not support a diagnosis of ankylosing spondylitis or diffuse idiopathic skeletal hyperostosis; however, the presence of a cloaca and periosteal reactions on other elements suggests a spondyloarthropathy, such as reactive arthritis.

Gout/Hyperuricemia

Gout, or gouty arthritis, is a metabolic arthritis caused by environmental or genetic factors. Gout is characterized by the deposition of monosodium urate crystals in the joints, eliciting an inflammatory response (Rogers and Waldron 1995:78). Gout is associated with hyperuricemia, a high serum urate concentration (Ortner and Putschar 1981:415). Elements most often affected include the feet (toes and ankles), but gout can also develop in the hands, wrists, elbows, and knees (Rogers and Waldron 1995:80–81). Approximately 75 percent of all cases of gout will involve the first metatarsophalangeal joint (Rogers and Waldron 1995:83–84). Gouty arthritis tends to manifest in individuals over the age of 40, typically in males more than females, and rarely affects those of African descent (Ortner and Putschar 1981:415, referencing Shepherd-Wilson and Gelfand 1962).

Erosions resulting from gout are often rounded in appearance and asymmetrical, may involve new bone formation at the margins, and are often located in the long axis of the bone. It is also of note that the erosions

have a punched-out appearance, with a sclerotic margin and edges that appear to overhang, referred to as "Martel hooks" (Rogers and Waldron 1995:79–80).

Two cases of gout were identified in the Alameda-Stone cemetery sample. Although there may have been additional cases, taphonomic factors and other pathologies hindered further identifications. An adult of indeterminate sex and biological affinity (Grave Pit 10316) presented gout-like lesions on three carpal phalanges (Figure 170). The second individual (Grave Pit 7720, Burial 16836), a middle-adult Hispanic male, presented gouty lesions on the feet and upper arms.

Osteophytosis

Osteophytes are bony projections varying in size and location along the margins of joints affected by osteoarthritis. These bony projections arise from "abnormalities of bone-cartilage interaction . . . that begin early in the development of osteoarthritis" (McCarthy and Frassica 1998:329). Osteophyte development is associated with osteoarthritis, diffuse idiopathic skeletal hyperostosis, pseudogout, neuropathic joints, rheumatoid arthritis, psoriatic arthritis, reactive arthritis, trauma, ankylosing spondylitis, acromegaly, fluorosis, ochronosis, and spondylosis deformans (McCarthy and Frassica 1998:329; Rogers and Waldron 1995:26). Osteophyte formation increases with age, and osteophytes can occur independent of signs of degenerative joint disease, although they are a common feature of degenerative joint disease (Rogers and Waldron 1995:25–26). Rogers and Waldron (1995:23, 26) made a point to argue that the presence of osteophytes alone should not be used as a sole diagnostic factor for the identification of degenerative joint disease and that the bony outgrowths noted in some literature are likely exostoses, not osteophytes. Enthesophytes are osteophytic outgrowths at the site of tendon insertions, or entheses (Rogers and Waldron 1995:24).

Osteophytes are very common. Most individuals over 50 years of age will likely have at least one joint with osteophyte development (Rogers and Waldron 1995:20). The development of vertebral osteophytes, however, may occur as early as the third decade of life and may affect any vertebra (Ortner and Putschar 1981: 420). The joints most commonly affected by osteophytes include the margins of the vertebrae, knees, and hips. At the vertebrae, it is more common to find osteophytes at the superior and inferior margins of the cervical or lumbar vertebrae and less common in the thoracic vertebrae, likely because of a number of factors, including different activities and weight issues. "In the spine, osteophytes on the vertebral bodies are somewhat different from those in other sites . . . in that they take their origin from the point of attachment of the fibres of the annulus fibrosa. Osteophytes [at the vertebrae] tend to develop horizontally, but may turn vertically if they become sufficiently large" (Rogers and Waldron 1995:21). Rogers and Waldron (1995:20) also mention that osteophytes are common at the vertebral facets, as well as on the odontoid process of the second cervical vertebrae.

Some authors have suggested that vertebral osteophytosis is a manifestation or reflection of intense physical labor (Bridges 1992; Chapman 1972; Jurmain 1977, 1990; Lovell 1994; Walker and Holliman 1989). Others have suggested that advanced age, strenuous activity, and metabolic/genetic factors (Bridges 1992; Chapman 1972; Jurmain 1977, 1990; Kahl and Smith 2000; Lovell 1994; Walker and Holliman 1989) facilitate osteophyte formation. Distinguishing between age-related changes and changes resulting from such factors as mechanical overload or injury is difficult.

To assess osteophytic development within the Alameda-Stone cemetery sample, each joint surface was scored by a Statistical Research, Inc., analyst. These scores were each assigned a numerical value of zero to 4, based on the severity of osteophytic development (see Chapter 2). Those joint surfaces that could not be scored because of absence or fragmentation were left blank for statistical analyses. Any adult cases to which there were no scores assigned were removed. After removal of subadults (given the absence of osteophytic development) and cases where all joint complexes were null, there were 485 individuals remaining for analysis.

Spearman's correlation coefficient was used to assess the relationship between superior and inferior vertebral surfaces. As expected, all values were significantly and positively correlated ($p < 0.05$). In other words, as osteophytosis increases on the inferior surface, so, too, does it increase on the superior surface.

Differences in osteophyte development between each sex, biological affinity, cemetery area, and age group were assessed using the nonparametric Kruskal-Wallis test. The expression of osteophyte development

was not statistically significant between biological groups or cemetery areas. The significant differences observed among age groups and males and females are discussed below.

As expected, there were significant differences among all of the age cohorts ($p < 0.001$), supporting the age-progressive nature of osteophyte formation. Osteophyte formation followed a predictable pattern, forming first in the lumbar and thoracic vertebrae, then moving into the cervical region. The knees and hips also presented a fairly consistent pattern.

There was a significant difference between males and females, but only in the development of osteophytes on the thoracic and lumbar vertebrae. More males than females presented osteophyte development ($p > 0.001$) in these areas. Following a biomechanical model, these results could support sexual divisions of labor and differences in workloads between the sexes.

Comparing the Alameda-Stone cemetery sample to the Freedman's cemetery sample reveals differences in types of activity practiced by the two groups. Females at the Freedman's Cemetery presented severe osteophytosis in the cervical vertebrae, which the authors suggested supports the historical data concerning female occupations, such as seamstresses, launderers, and domestic workers, involving activities that result in more stress to the neck. The thoracic and lumbar vertebrae showed high rates of mild osteophytosis. All of the males at Freedman's presented high rates of osteophytosis, but no specific details were provided regarding the actual patterns. On average, 30 percent of the females assessed for osteophytosis presented some level of development, whereas, for males, the average was much closer to 50 percent. The Refugio Cemetery shared some general patterns with the individuals in the Alameda-Stone cemetery sample, such as an increase in osteophyte development from the cervical to the lumbar vertebrae. No other patterns were observed, and no other statistics were provided in the Refugio report. Minor joint changes and osteophytosis were fairly common at the Voegtly cemetery, with 3 females and 10 males showing severe arthritic changes at the vertebrae, including osteophyte development. No other information was provided by the authors.

Osteochondritis Dissecans

Osteochondritis dissecans is precipitated by severe trauma to articular cartilage and bone, which results in the shearing off of bone and cartilage, known as an osteochondral fragment. According to Rogers and Waldron (1995:28), osteochondritis dissecans is likely overdiagnosed in the literature. Osteochondritis dissecans primarily affects adolescents (McCarthy and Frassica 1998:135), and the lesions vary in size, with peak onset between the ages of 15 and 20. The lesions associated with osteochondritis dissecans are the result of "probable disruption" and fragmentation of articular cartilage resulting from trauma (Rogers and Waldron 1995:28) and are typically unilateral. Osteochondritis dissecans most often affects males, and the most frequent site affected is the distal femoral condyle, followed by the "humeral compartment of the humeroradial joint" (Rogers and Waldron 1995:28–29).

A number of cases of osteochondritis dissecans were identified within the Alameda-Stone cemetery sample. A young-adult Hispanic male (Grave Pit 3036, Burial 7023-P) presented osteochondritis dissecans on the distal left humerus (Figure 171). An osteochondritis dissecans lesion was also noted on the distal left humerus of an old-adult Hispanic female (Grave Pit 7952, Burial 19541-P), and osteochondritis dissecans lesions on both knees were recorded on a middle-adult Hispanic female (Grave Pit 7920, Burial 18909-P). It is interesting to note that, although osteochondritis dissecans is often considered rare and is more often associated with males, the Alameda-Stone cemetery sample exhibited three cases, two of which were female.

Metabolic Disorders: Cribra Orbitalia and Porotic Hyperostosis

Two indicators of poor nutrition include porotic hyperostosis and cribra orbitalia. Each of these conditions is common in the bioarchaeological record, and both have been linked to nutritional deficiencies. The skeletal

manifestations of each condition are similar and are both observed macroscopically (Figures 172 and 173). Porotic hyperostosis is characterized by pitting and porosity on the external surface of the frontal, parietals, and/or occipital. The same pitting and porosity in the roof of the orbits characterizes cribra orbitalia (El-Najjar and Robertson 1976; El-Najjar et al. 1976; Mittler and Gerven 1994; Walker 1985; Zaino and Zaino 1975).

Lesions of the skull associated with porotic hyperostosis result from an enlargement of the diploe (spongy bone) of the skull due to marrow hypertrophy. A number of etiologies have been proposed for porotic hyperostosis. Throughout the twentieth century, iron-deficiency anemia was the most frequently cited cause of these conditions, a model that fits well with the transition from a foraging to predominately agriculture lifestyle. However, Walker et al. (2009) recently demonstrated that the clinical manifestation of iron-deficiency anemia decreases rather than increases the production of marrow and could not be responsible for either porotic hyperostosis or cribra orbitalia. Rather, they argue that the formation of porotic hyperostosis results from an acquired anemia associated with a megaloblastic marrow response in nursing infants because of depleted maternal Vitamin B_{12} reserves and the unsanitary living conditions associated with dense populations. Vitamin C deficiencies and subsequent subperiosteal hematomas within the eye orbit are suspected to be the contributing factors for cribra orbitalia. Nevertheless, both porotic hyperostosis and cribra orbitalia indicate metabolic deficiencies, although the nature of deficiency remains unclear.

All individuals with cranial elements were evaluated for cribra orbitalia and porotic hyperostosis. The presence of the pathology and the affected element were each recorded. In order to avoid under- or overinflation of frequencies, an adjusted number of observable individuals were used for each analysis. To find the frequency of porotic hyperostosis and cribra orbitalia in the Alameda-Stone cemetery sample, completeness scores for the bones of the cranial vault were used to weight the total number of adult cranial vaults, including the eye orbits. The number of complete elements was multiplied by a factor of 1, partial elements by a factor of 0.5, and fragmentary elements by a factor of 0.25. In this way, a closer approximation of the actual quantity of observable material was used to calculate the frequency of each condition. Walker et al. (1996:Table 14) used a similar method to examine human remains recovered from CA-LAN-264, an archaeological site near Malibu, California, for pathological conditions.

Nearly 900 individuals recovered from the Alameda-Stone cemetery were complete enough for analysis, although far fewer individuals presented these pathological conditions (Table 174). Approximately 7 percent of the Alameda-Stone cemetery sample were affected by cribra orbitalia, and 3 percent were affected by porotic hyperostosis. A single individual (Grave Pit 13926, Burial 28294) had both cribra orbitalia and porotic hyperostosis. There was not a significant correlation of cribra orbitalia and porotic hyperostosis (tetrachoric correlation coefficient; $r = 0.001$). There was also no correlation of cribra orbitalia or porotic hyperostosis to any other pathology, including periosteal and proliferative reactions, lytic lesions, or developmental defects (average tetrachoric correlation coefficient; PHr = 0.051 and COr = -0.021). Only a single individual (Grave Pit 13926, Burial 28294) showed evidence of both cribra orbitalia and porotic hyperostosis. No significant differences were observed in the distribution of either porotic hyperostosis or cribra orbitalia between demographic categories (Table 175). Surprisingly, there was also no significant difference between pooled age categories (juvenile [under 18] or adult [18 or over]; $p = 0.361$). Over one-half of the sample were of indeterminate sex and indeterminate biological affinity, because half of the sample were juveniles. Determining sex and biological affinity is difficult with juveniles because of incomplete maturation and development of secondary sexual characteristics, and there has been very little up-to-date research on assessing the biological affinity of the skeletal remains of young individuals (see Chapter 7).

Although significant differences were not detected in the frequency of either cribra orbitalia or porotic hyperostosis, several interesting patterns emerged from the analysis that are worthy of closer scrutiny. Males were slightly more likely to be affected by these conditions than were females. Infants and children were affected more often than any other age group. This is not surprising given, the etiology of both conditions and the weak immune systems of children. Euroamericans were more affected than any other group; they were nearly two times as likely to be affected by cribra orbitalia. The frequency of cribra orbitalia and porotic hyperostosis did not significantly differ between cemetery areas. The unusually high frequency of both conditions in Cemetery Area 1 was clearly the result of diminished sample size. Cemetery Area 5 had the highest incidence of cribra orbitalia and porotic hyperostosis among the four remaining areas. Although sample size and poor preservation could be to blame, the relatively high frequency of both conditions in this area is intriguing.

Comparative Samples

Very little evidence for either porotic hyperostosis or cribra orbitalia was noted in the Freedman's cemetery population. Only 5.7 percent of the sample showed the possibility of porotic hyperostosis, and only 7.6 percent presented evidence of cribra orbitalia. No significant differences were noted between males and females at the Freedman's Cemetery. Overall, the incidence of porotic hyperostosis and cribra orbitalia was higher in the Freedman's Cemetery than in the Alameda-Stone cemetery sample. Observing nutritional deficiencies among recently emancipated African Americans is unsurprising. Rose (1985) noted that hardships and difficulties did not end for African Americans after the end of the Civil War. The low incidence of porotic hyperostosis in the Alameda-Stone cemetery sample—in comparison to the Freedman's Cemetery—most likely reflects the availability of meat in Tucson during the time the Alameda-Stone cemetery was in use (see Chapter 7, Volume 1 of this series).

At the Voegtly Cemetery, nine individuals were affected by cribra orbitalia. Interestingly, there was no evidence of porotic hyperostosis in the Voegtly Cemetery. This population showed lower stress levels than the populations of other cemeteries, including Freedman's and the Alameda-Stone cemetery.

Metabolic Disorders: Osteoporosis

Osteoporosis is broadly defined as a metabolic disorder resulting in bone loss. More specifically, there are changes within the mineral density and structure of bone that eventually lead to highly porotic bone. Numerous studies have attempted to explore osteoporosis using different methodologies and different criteria, resulting in varied and often conflicting results (Agarwal and Grynpas 2009:244).

Stini (1990) discussed the etiology of osteoporosis and suggested the following causative factors: inhibited calcium absorption, calcium turnover, changes in absorptive ability of the intestinal tract, and hormone changes. Osteoporosis has been classified into two categories. Primary osteoporosis includes age-related (or senile) osteoporosis and postmenopausal osteoporosis (Brickley 2002:365). Secondary osteoporosis results from disease or malnutrition (Brickley 2002:365, referencing Woolf and St. John Dixon 1998). If a population demonstrates a higher than expected rate of osteoporosis in young individuals, malnutrition is the likely cause (Zaki et al. 2008).

The reduced mechanical strength of osteoporotic bone often leads to injury and fracture. The hip is a common location for fracture, generally occurring at the neck of the femur. Other common locations include the wrist and the spinal processes of the vertebrae (Brickley 2002:365; Mays 2006; Stini 1990). Women tend to suffer the effects of osteoporosis more often than men.

Seventeen individuals from the Alameda-Stone cemetery sample demonstrated lightweight, porotic bone consistent with osteoporosis. One was of indeterminate sex, 7 (41.2 percent) were female, and 9 (52.9 percent) were male. No significant differences were noted between males and females. This is unexpected, considering the trends discussed from other sites.

Of the 17 individuals with osteoporosis, 4 were Hispanic (23.5 percent), 3 (17.6 percent) were Euroamerican, and 1 was Native American (5.9 percent). The majority (52.9 percent) of individuals with osteoporosis, however, were of indeterminate biological affinity. When the cemetery areas were examined, it was noted that Cemetery Areas 1 and 2 featured no individuals with osteoporosis. Cemetery Area 3 had the largest number of individuals with osteoporosis, with 11 individuals (64.7 percent). Cemetery Area 4 had 5 individuals (29.4 percent), and Area 5 had just 1 individual (5.9 percent).

Approximately 40 percent of the individuals with osteoporosis were young adults. The percentage of individuals from the young-adult category was not expected, because this condition most often affects older individuals. The high number of young adults with osteoporotic bone in the Alameda-Stone cemetery sample may indicate systemic malnutrition or disease.

Although reports on historical-period cemeteries, such as Freedman's, Voegtly, and the Presidio/Mission, briefly mentioned osteoporosis, none of these provided specific data on the frequency of the disorder within their samples. To some extent, this may be attributable to the seeming absence of this pathology, either as a result of taphonomy or because the individuals did not, indeed, show evidence for the disease. The authors of the

Refugio Cemetery reported four cases of osteoporosis and discussed in detail the most severe case of the four, an older-adult female of Native American biological affinity. This individual suffered severe osteoporosis that resulted in multiple fractures and likely rendered the individual immobile. In the Alameda-Stone cemetery sample, there were no severe cases of trauma that could be directly associated with osteoporosis as the prime causative factor.

Other Pathologies: Nasal Turbinate Hypertrophy

Warming, filtering, and humidifying air, as well as regulating the flow of air, are the primary tasks of the nasal turbinates (Kiroglu et al. 2007:67). Nasal turbinate hypertrophy occurs when the nasal conchae become enlarged. When this condition occurs bilaterally, the hypertrophy results in nasal obstruction and discomfort (Fradis et al. 2002:332). There are different causative factors for turbinate hypertrophy, including allergies, "pseudoallergies," and nonallergic rhinitis (Ottaviani et al. 2003:306). Allergies are the most common cause for nasal turbinate hypertrophy.

Analysts identified two individuals with nasal turbinate hypertrophy: an old-adult Hispanic female (Grave Pit 7970, Burial 19501-P) with nasal turbinate hypertrophy on the left side (Figure 174) and a middle-adult Hispanic female with bilateral nasal turbinate hypertrophy (Grave Pit 7981, Burial 19628-P).

Nasal turbinate hypertrophy has not been discussed at other comparable historical-period sites, such as Freedman's Cemetery, Refugio, or Voegtly, but that does not necessarily translate to an absence of the pathology. The fragility of the human skull, particularly the nasal cavity, could have lead to obliteration of evidence of these nasal issues.

Conclusions

The examination of pathological conditions in the human skeleton aids investigators in the reconstruction of individual histories, as well as a survey of health and disease affecting an entire population. Because pathology is any deviation from normal physiological processes, the interaction of the disease with the skeleton is often difficult to assess. The number of ways bone can respond to illness is infinite, and several conditions present similarly. The relatively slow response of bone to both disease and healing further frustrates diagnostic efforts. Nevertheless, skeletal analysis can provide meaningful and reliable inferences of individual and population susceptibility to and recovery from illness. The frequency and distribution of pathological conditions, as well as their magnitude and presentation, offer insight into the lives and deaths of the individuals under consideration.

The Alameda-Stone cemetery sample included 1,089 individuals evaluated for a suite of pathological conditions, including infectious disease, degenerative changes, and metabolic disorders. Demographic information (age at death, sex, and biological affinity) and spatial distribution of grave pits were used as individual attributes to discover patterns in the incidence and pervasiveness of these conditions. Owing to the diagnostic limitations of osteopathology noted above, the conclusions drawn from these examinations are carefully developed to avoid speculation.

Infectious diseases most commonly manifest as periosteal new bone. Because this nonspecific condition appears from a variety of causes, the distribution of periosteal new bone across the sample is more important than individual presentations. Broadly, adult individuals were more affected than were juveniles. When examining different attributes of the condition, however, the balance changed. Juveniles suffered more systemic infections than localized infections, whereas adult individuals were more evenly split between systemic and localized infections. Similarly, far fewer juvenile elements with periosteal new bone showed evidence of healing than did those from adults. Therefore, although juveniles composed a lesser fraction of individuals with periosteal new bone, the presentation of the condition was largely active and systemic.

Differences between the sexes were generally limited to the numbers of individuals affected and specifically limited to disparities in the occurrence of healing. Significantly more males exhibited periosteal new bone than did females. Male individuals were more or less evenly divided between active lesions and those showing healing. Females, however, were far more likely to exhibit healing or healed periosteal new bone. The magnitude of affected bone, however, was similar between the sexes: the distribution of localized and systemic infections was approximately half for both males and females.

Although differences in number, activity, and pervasiveness of periosteal new bone were noted among biological groups and cemetery areas, definitive assessments are elusive. Analyses by biological groups and cemetery areas suffered from widely varied sample sizes, as well as influence from other attributes, such as age and sex.

Other infectious diseases recorded in limited numbers among individuals from the Alameda-Stone cemetery sample included osteomyelitis, endocranial reactions, sinusitis, tuberculosis, and treponemal infections, such as syphilis.

Degenerative change was most fully explored by an analysis of generalized degenerative joint disease. This condition differs from other disease processes in that it can occur as a natural consequence of advanced age or as a result of behavioral overuse. In other words, degenerative joint disease is not necessarily predicated upon pathogens, nutritional stresses, or genetic anomalies. As such, it provides insight into the lives of the individuals under consideration without requiring the presumption of illness.

Unsurprisingly, the more-aged individuals were more affected by degenerative joint disease. Males and females demonstrated statistically significant differences in the distribution of joints affected by degenerative joint disease. Frequencies demonstrated that males expressed degenerative joint disease more commonly in the arms and lower back, whereas females showed greater expression in the legs. Among biological affinities, Native Americans had the highest incidence of degenerative joint disease (74 percent), followed by Hispanics (69 percent), and Euroamericans (55 percent). The affected joints were generally equivalent among the biological groups, with one exception: Hispanics displayed significantly more degenerative joint disease in the joints of the arm. The occupational demands and behaviors contributing to the distribution of degenerative joint disease between the sexes and among the biological groups were further discussed in Chapter 7, Volume 1 of this series.

Other pathological degenerative diseases encountered in the Alameda-Stone cemetery sample included rheumatoid arthritis, diffuse idiopathic skeletal hyperostosis, reactive arthritis, and gout.

Metabolic disorders and nutritional deficiencies affect the skeleton with a pathological presentation. Cribra orbitalia and porotic hyperostosis, suggestive of Vitamin C and Vitamin B_{12} deficiencies, were observed in limited frequencies: less than 7 percent of observable individuals exhibited cribra orbitalia, and less than 3 percent exhibited porotic hyperostosis. Slightly more of these individuals were juvenile, consistent with the collateral effects of underdeveloped immune systems. Although generally regarded as disproportionately affecting children, adults were also affected by cribra orbitalia and porotic hyperostosis, in sufficient numbers to eliminate any significance in age differences. Conversely, osteoporosis, a metabolic disorder commonly regarded as affecting older individuals, featured a composition of approximately 40 percent of young adults. In short, cribra orbitalia and porotic hyperostosis skewed unexpectedly old, whereas osteoporosis skewed unexpectedly young.

The individuals in the Alameda-Stone cemetery sample displayed a variety of pathological conditions. Illness was common, but not to an extent beyond what is predictable of a mid-nineteenth-century municipality. Disease was most frequent among juveniles, the more vulnerable segments of the population. Differing patterns of activity and occupational demands likely contributed to disparate impacts of disease among adult individuals. The observations detailed above, although clearly unique to the population under consideration—influenced by their demographic composition, environment, behavior, hazards, and resources—were not dramatically dissimilar to theoretical expectations or comparable data sets. Skeletal observations from the Alameda-Stone cemetery sample help to reveal the health of these individuals and the manner in, and extent to which, it was compromised.

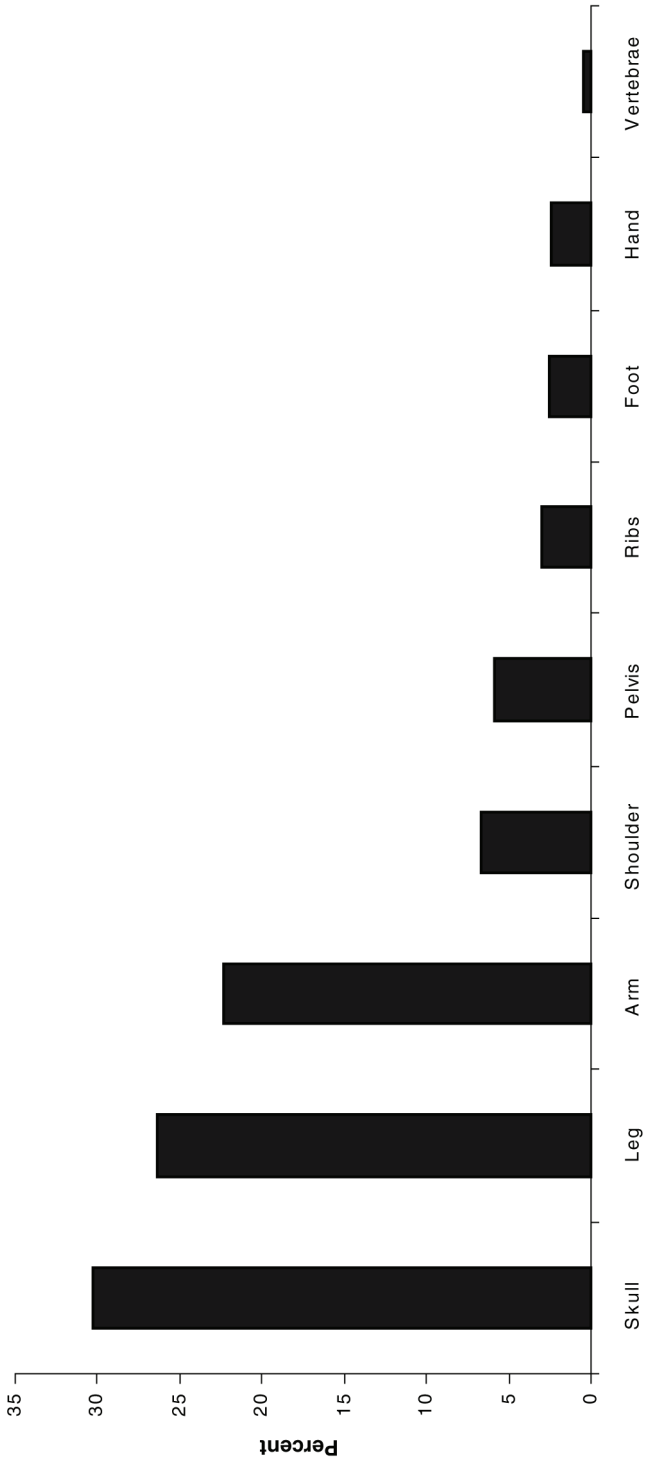

Figure 144. Frequency of periosteal new bone, by skeletal region.

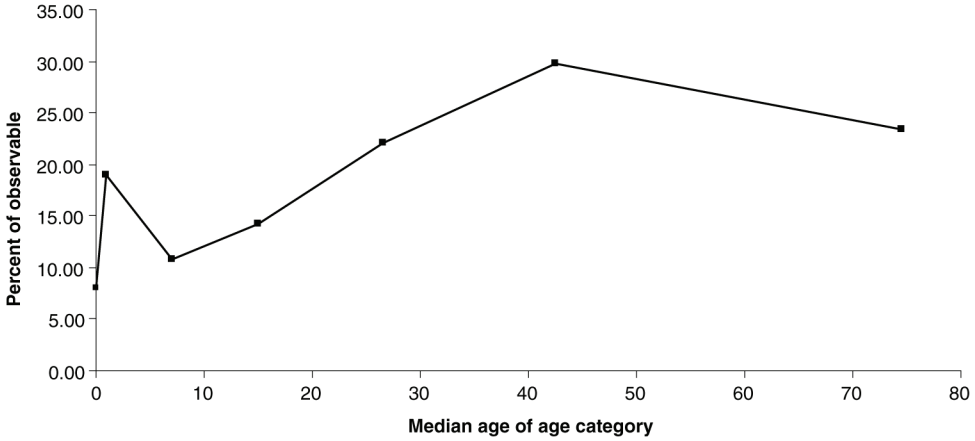

Figure 145. Frequency of periosteal new bone among observable individuals.

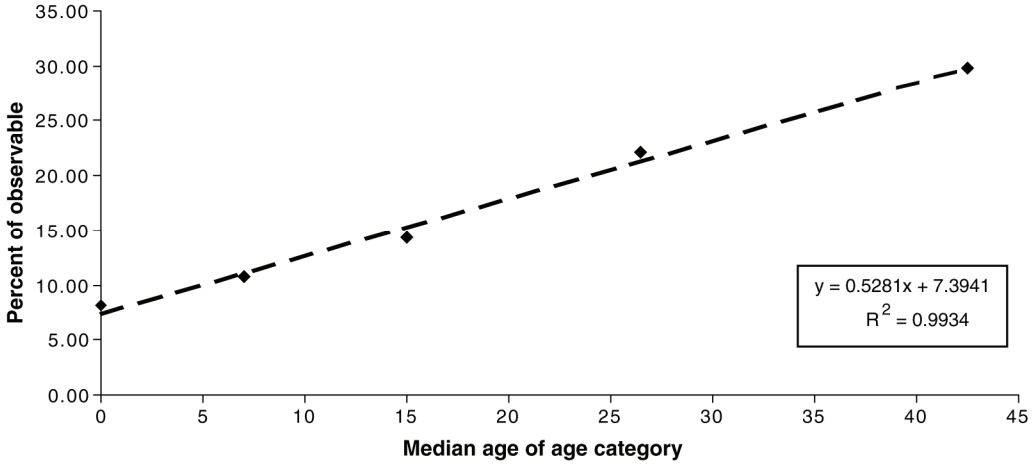

Figure 146. Frequency of periosteal new bone in observable individuals, by median age.

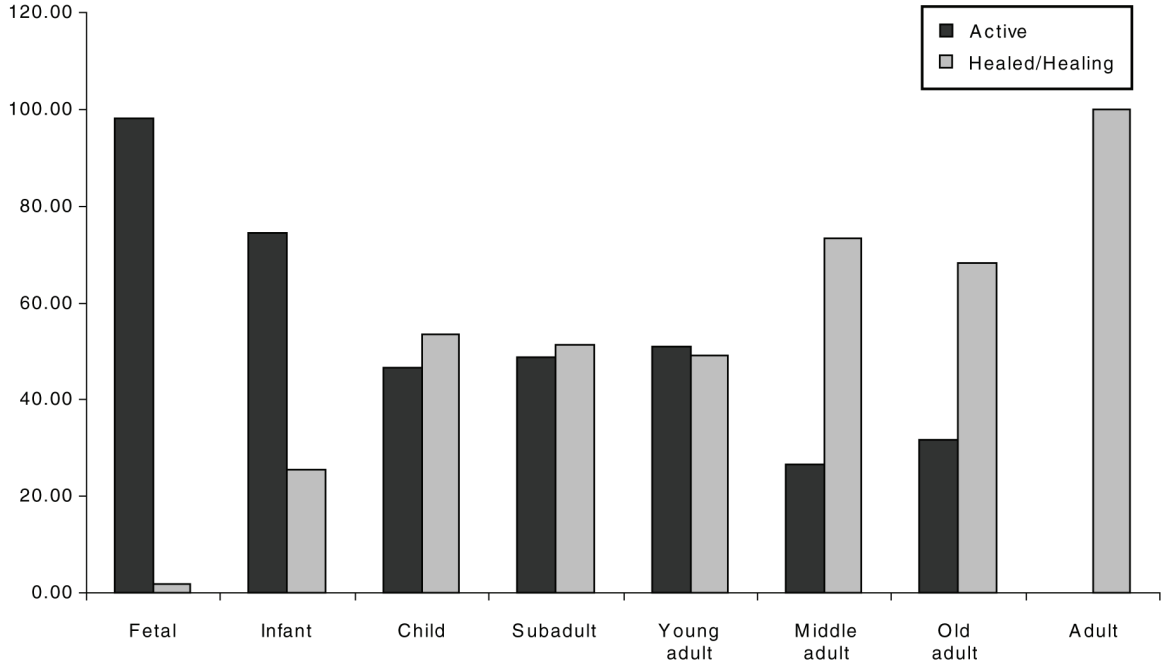

Figure 147. Distribution of active and healing/healed periosteal new bone, by age category.

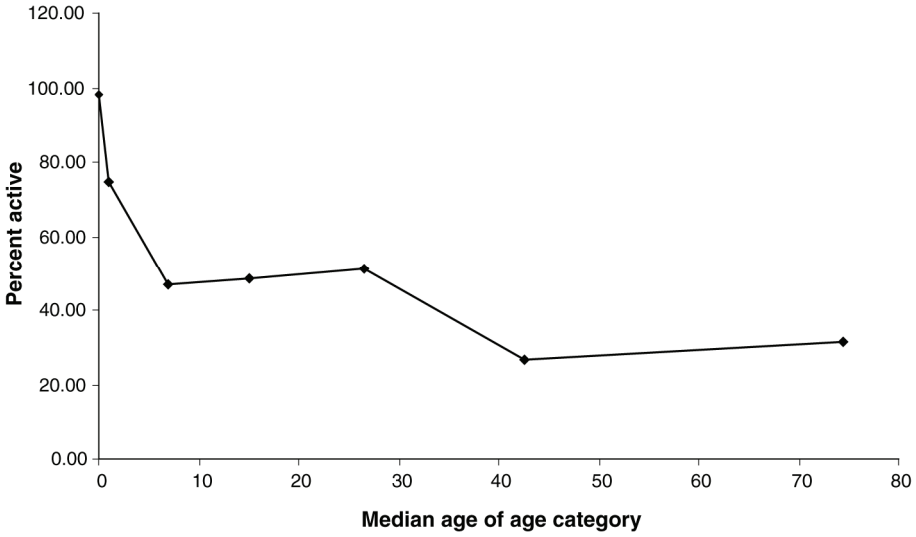

Figure 148. Distribution of active periosteal new bone, by median age.

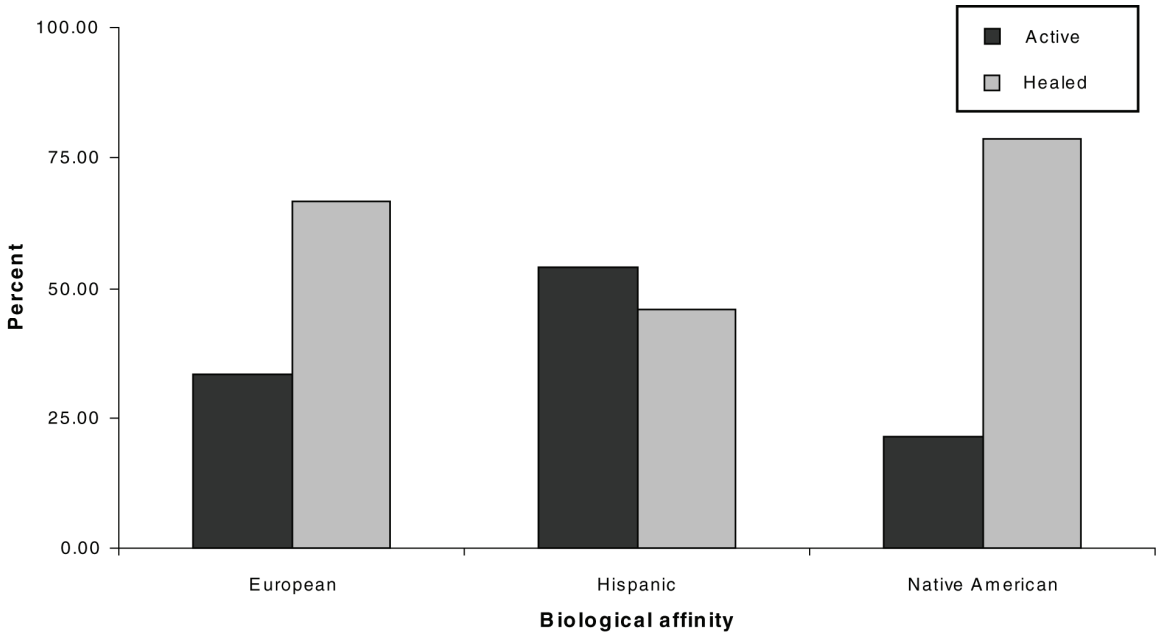

Figure 149. Distribution of active versus healing/healed periosteal new bone, by biological affinity.

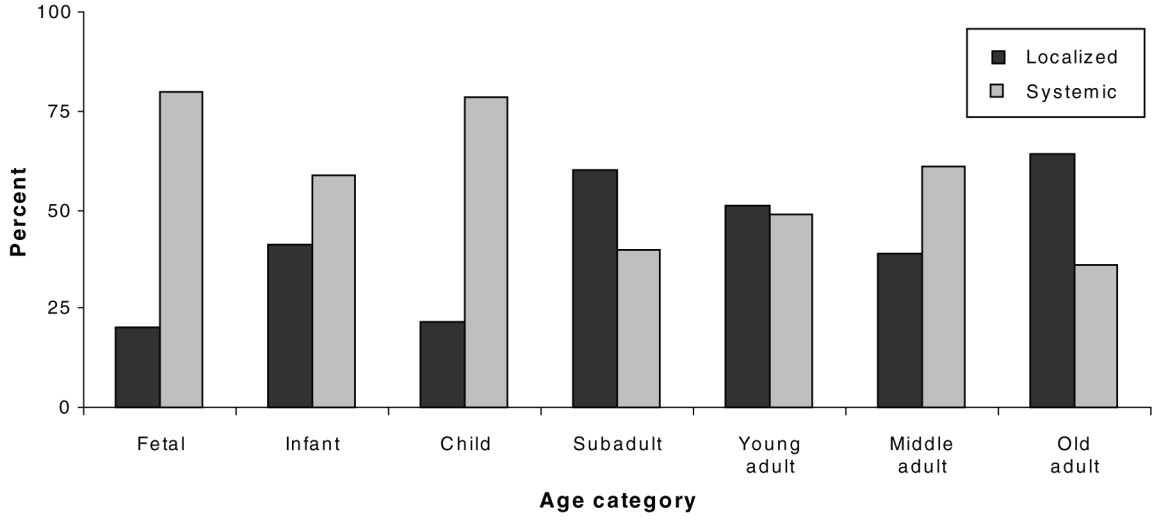

Figure 150. Distribution of localized versus systemic periosteal new bone, by age category.

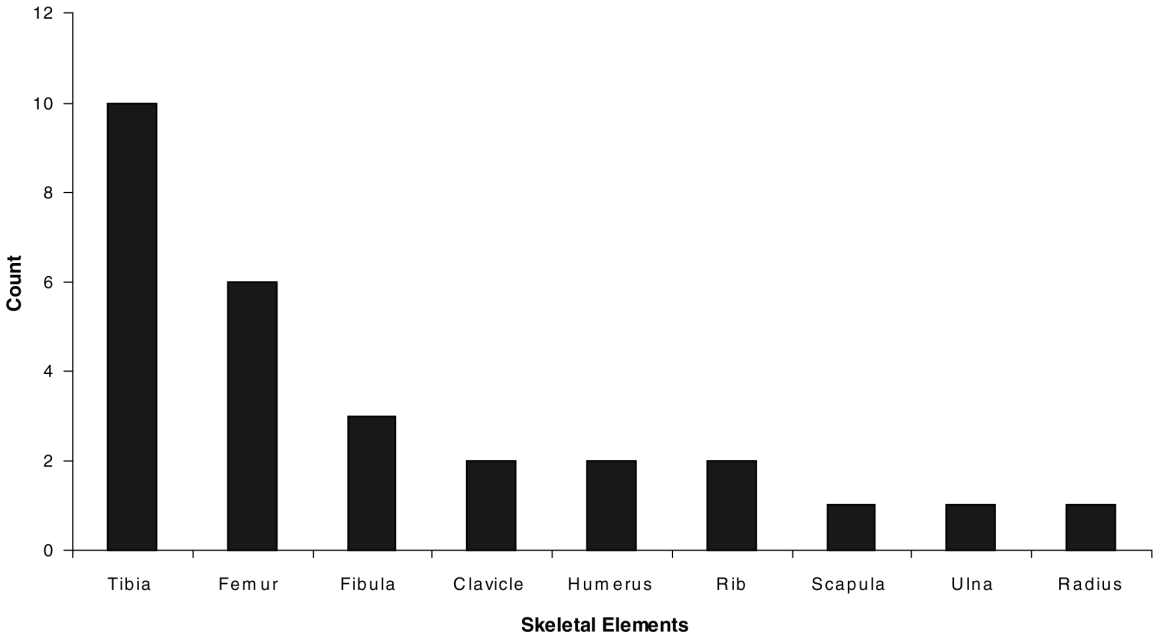

Figure 151. Frequency of skeletal regions affected with osteomyelitis.

Figure 152. Left ulna from Individual P, Grave Pit 13654, Burial 27544, an infant of indeterminate sex and biological affinity. Medial aspect, showing proliferative periostitis with development of involucrum and cloaca.

Figure 153. Right tibia and fibula, showing proliferative periostitis, from Individual P, Grave Pit 7957, Burial 19539, an infant of indeterminate sex and biological affinity. Note cloacae and development of involucrum at the distal aspect of the tibia.

Figure 154. Right femur with large cloaca at the distal aspect, anteriorly, from Individual P, Grave Pit 13614, Burial 21829, a middle-adult Euroamerican male.

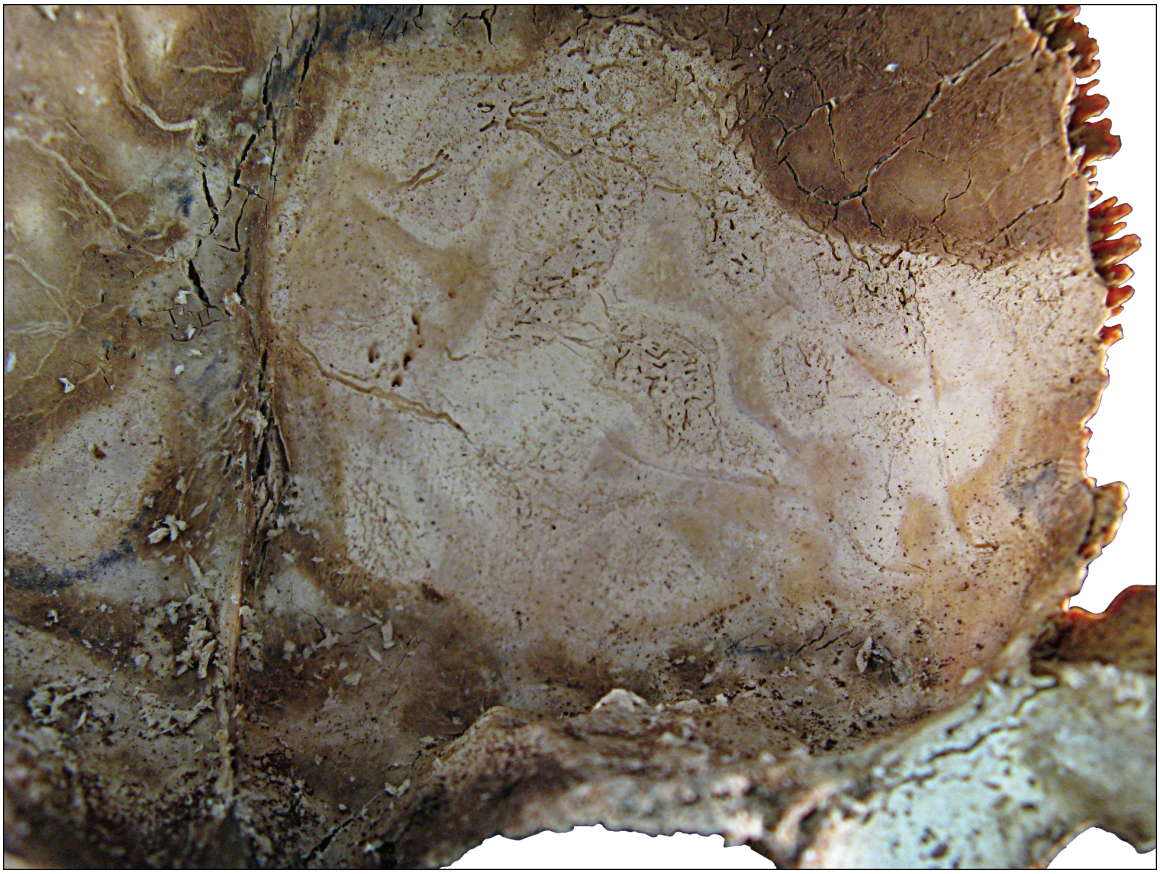

Figure 155. Endocranial view of the left side of the frontal of Individual P, Grave Pit 7860, Burial 18542, a subadult of indeterminate sex and biological affinity. Note areas of plaquelike bone formation with vascular impressions.

Figure 156. Inferior view of right maxillary sinus of Individual P, Grave Pit 7553, Burial 9721, an old-adult Hispanic male.

Figure 157. Anterior view of cranium of Individual P, Grave Pit 10133, Burial 19965, a young-adult female of indeterminate biological affinity.

Figure 158. Frontal of Individual P, Grave Pit 10078, Burial 14566, an old-adult male of indeterminate biological affinity, with caries sicca.

Figure 159. Tibiae, medial view, showing anterior bowing, of Individual P, Grave Pit 7720, Burial 16836.

Figure 160. Osteochondrosis of the distal end of the right femur of Individual P, Grave Pit 29282, Burial 28755, an infant of indeterminate sex and biological affinity.

Figure 161. Mulberry molars—first molars of Individual P, Grave Pit 13926, Burial 28294, a Euroamerican child of indeterminate sex.

Figure 162. Possible enchondroma on left third proximal carpal phalanx of Individual P, Grave Pit 68, Burial 137, an adult of indeterminate sex and biological affinity.

Figure 163. Midline cyst of the palatine processes of the maxillae of Individual P, Grave Pit 7521, Burial 8966, a middle-adult Hispanic female.

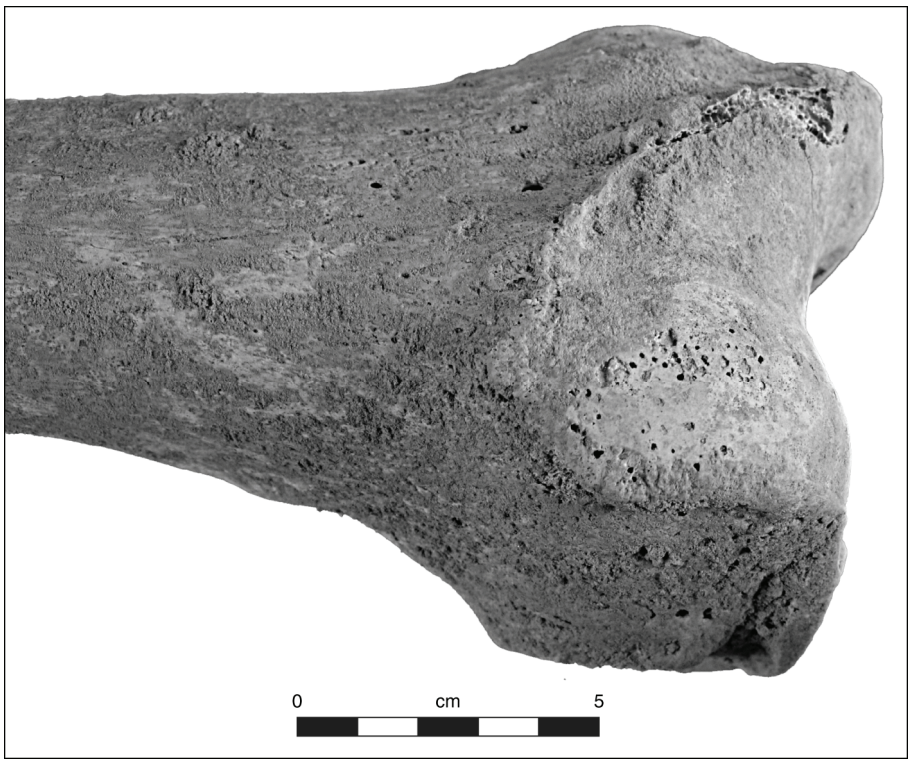

Figure 164. Eburnation at the joint surface, Individual P, Grave Pit 13845, Burial 17449, a middle-adult male of indeterminate biological affinity.

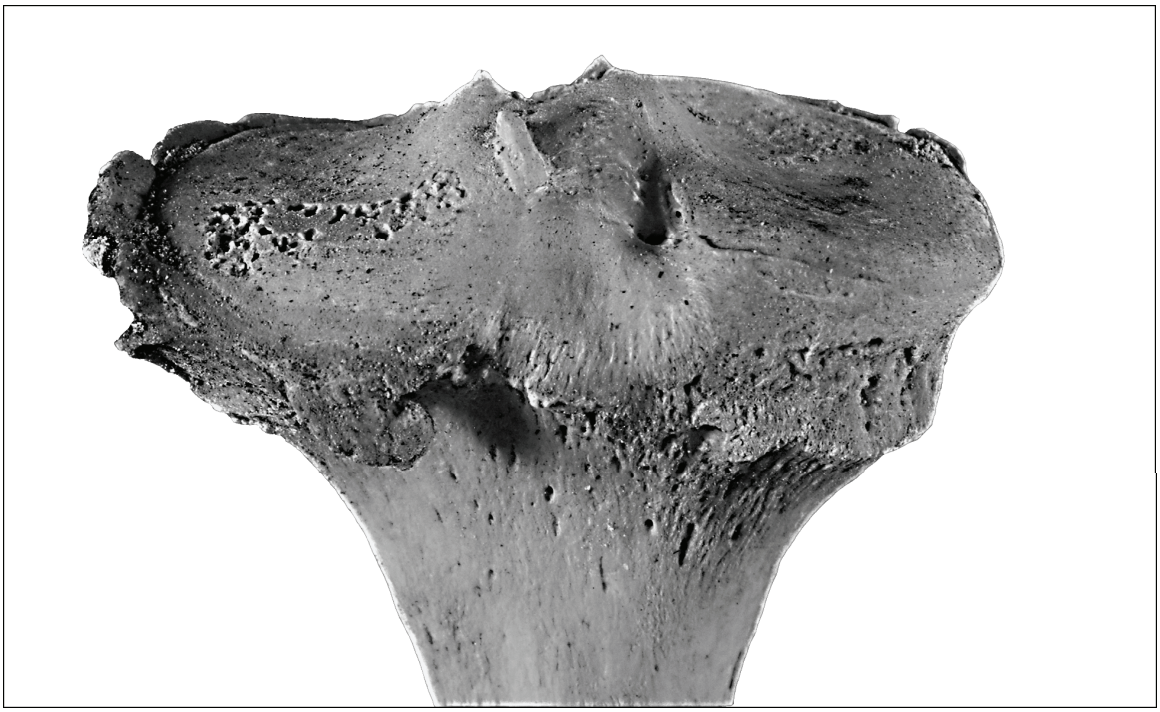

Figure 165. Pitting and lipping at the joint surface, Individual P, Grave Pit 7515, Burial 9820, an old-adult Hispanic female.

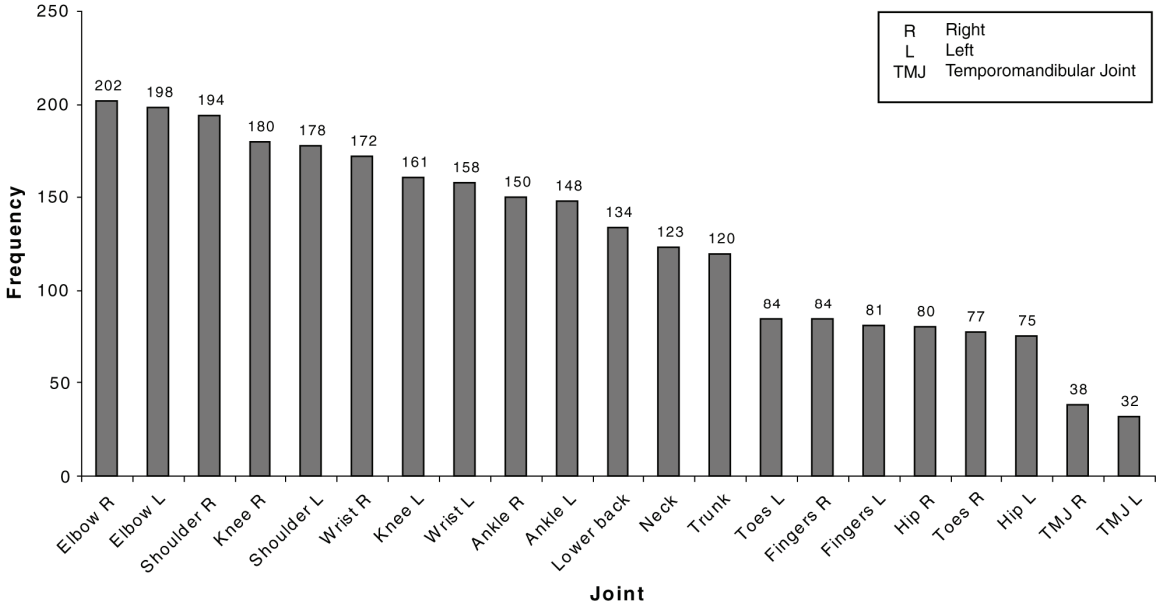

Figure 166. Distribution of degenerative joint disease at each joint complex (normal scores removed).

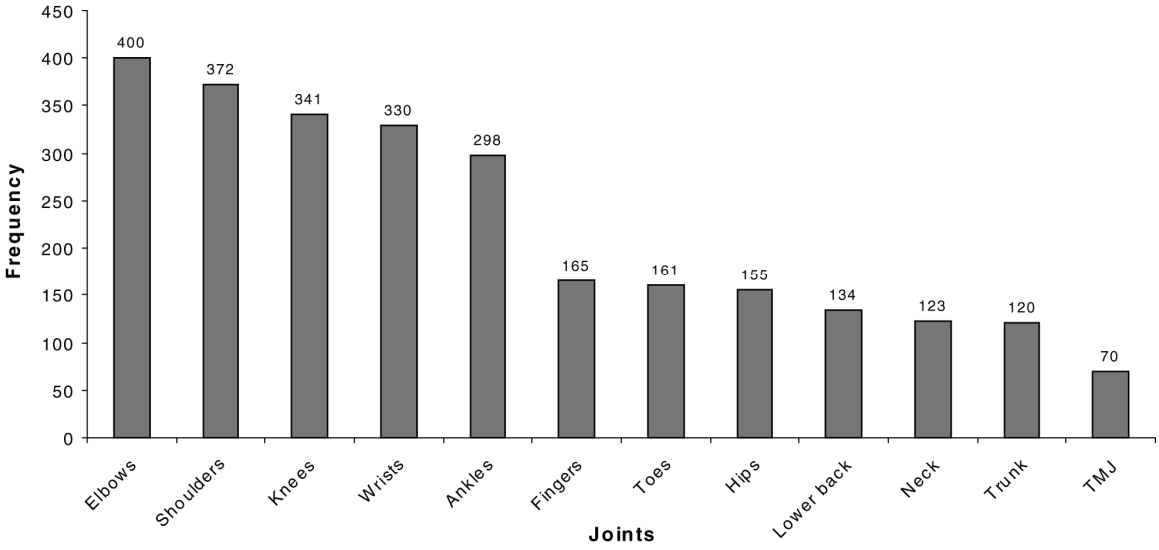

Figure 167. Distribution of degenerative joint disease at combined joint complexes (normal scores removed).

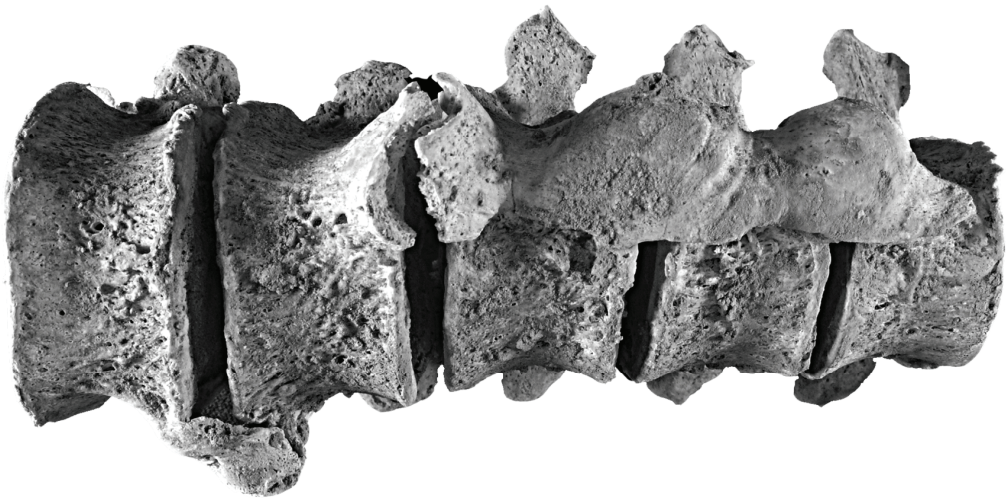

Figure 168. Ankylosed thoracic vertebrae from Individual P, Grave Pit 695, Burial 8752, a middle-adult Hispanic male.

Figure 169. Reactive arthritis at the right knee of Individual P, Grave Pit 13614, Burial 21829, a middle-adult Euroamerican male.

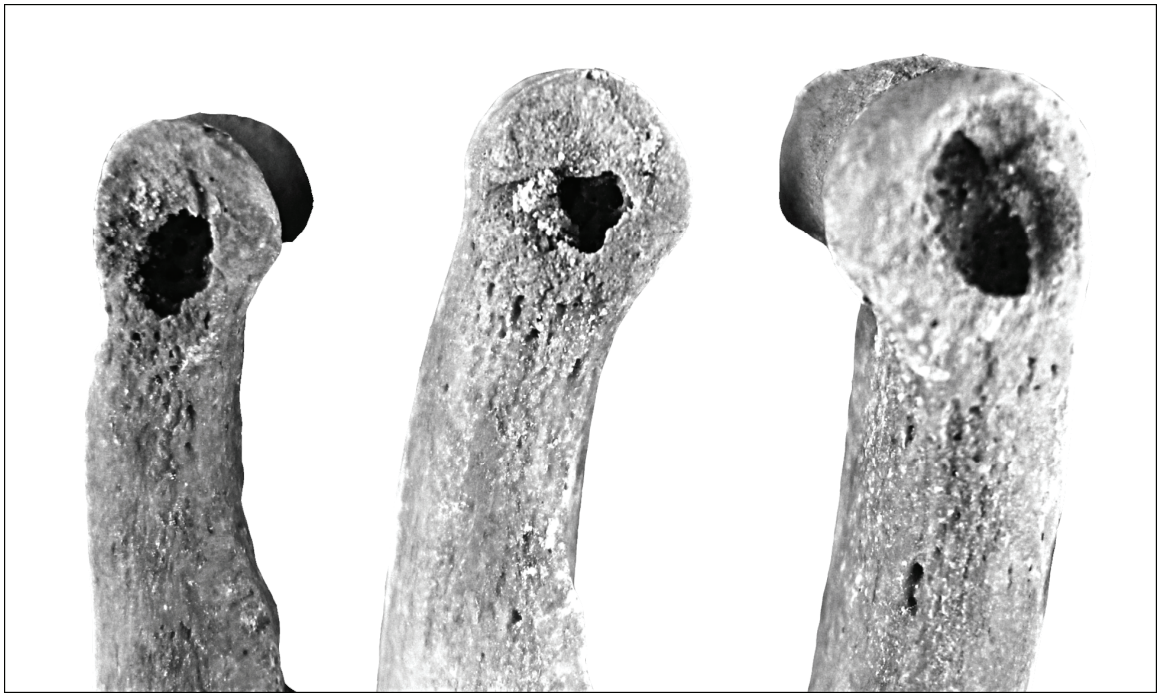

Figure 170. Gout at two middle carpal phalanges and one proximal carpal phalanx, Individual 1, Grave Pit 10316, an adult of indeterminate sex and biological affinity.

Figure 171. Osteochondritis dissecans at the distal left humerus, Individual P, Grave Pit 3036, Burial 7023, a young-adult Hispanic male.

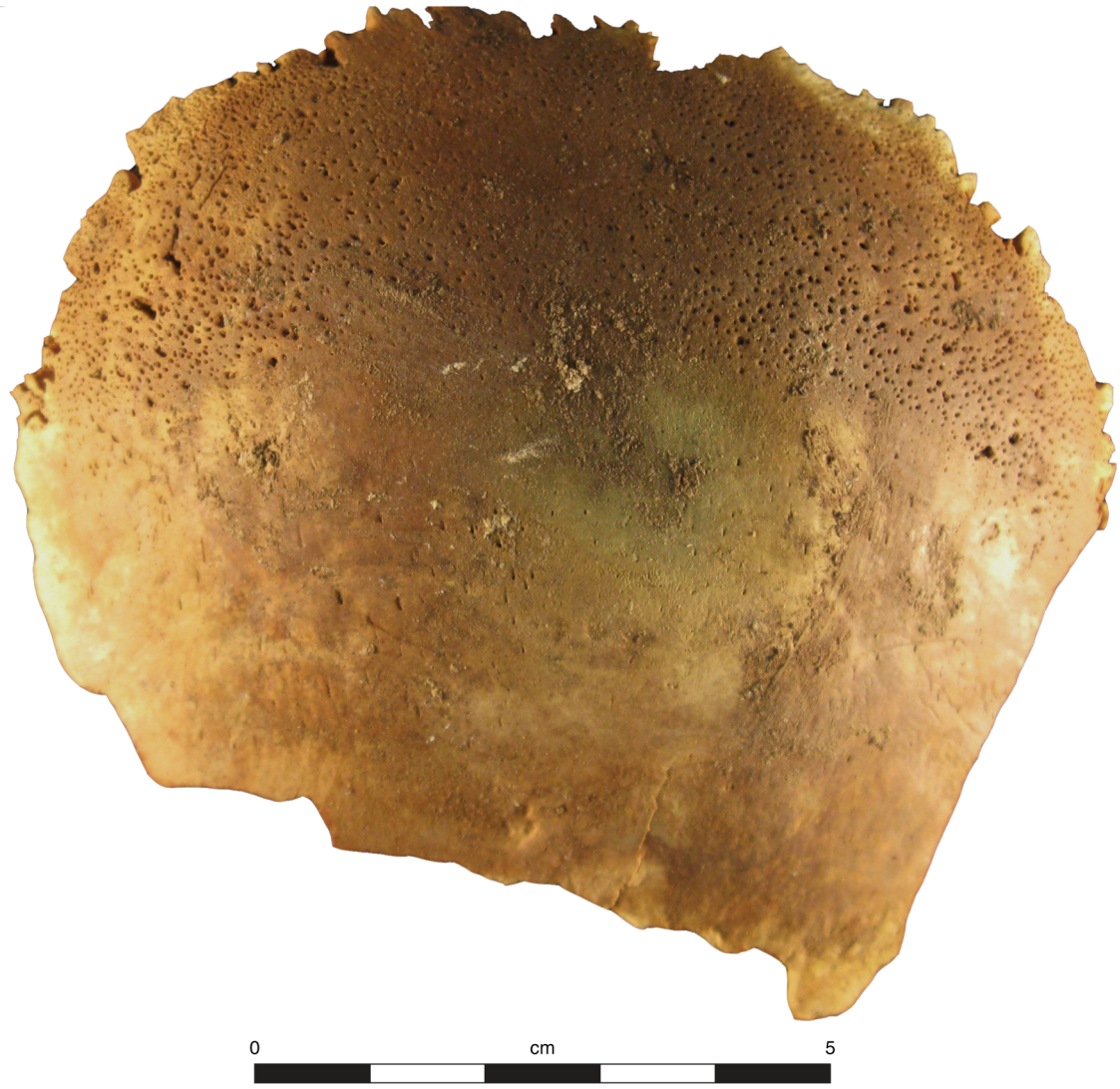

Figure 172. Porotic hyperostosis on the occipital of Individual P, Grave Pit 13706, Burial 26489, a child of indeterminate age and biological affinity.

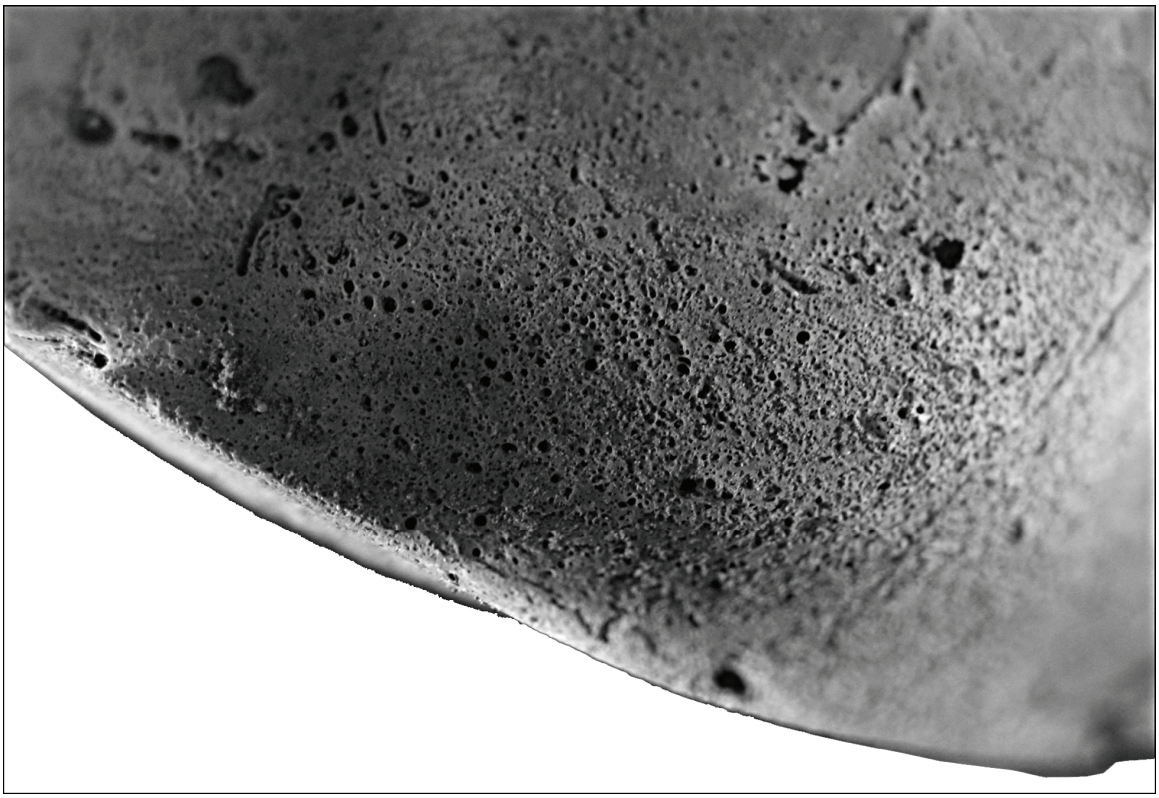

Figure 173. Cribra Orbitalia at the right orbit of Individual P, Grave Pit 13509, Burial 21998, an infant of indeterminate age and biological affinity.

Figure 174. Nasal turbinate hypertrophy, Individual P, Grave Pit 7970, Burial 19501, an old-adult Hispanic female.

Table 150. Bone and Joint Diseases

Disease Category	Example
Congenital	osteogenesis imperfecta, achondroplasia
Metabolic	cribra orbitalia, porotic hyperostosis, osteomalacia
Circulatory	osteonecrosis
Infectious	osteomyelitis
Neoplastic	osteomas, cysts, osteosarcoma
Systemic disease	renal osteodystrophy

Note: Adapted from McCarthy and Frassica (1998:1).

Table 151. Frequency of Individuals with Periosteal New Bone in the Alameda-Stone Cemetery Sample, by Age Category

Age Category	Observable Individuals (n)	Affected Individuals (n)	Percent of Observable Individuals	Percent of Affected Individuals
Fetal	62	5	8.06	2.38
Infant	333	63	18.92	30.00
Child	130	14	10.77	6.67
Subadult	35	5	14.29	2.38
Young adult	240	53	22.08	25.24
Middle adult	171	51	29.82	24.29
Old adult	60	14	23.33	6.67
Adult	58	5	8.62	2.38
Total	1,089	210	19.28	100.00

Table 152. Frequency of Periosteal New Bone within Biological Affinity Groups in the Alameda-Stone Cemetery Sample

Biological Affinity	Observable Individuals (n)	Affected Individuals (n)	Percent of Observable Individuals	Percent of Affected Individuals
European	122	25	20.49	29.07
Hispanic	250	50	20.00	58.14
Native American	40	11	27.50	12.79
Total	412	86	20.87	100.00

Table 153. Frequency of Periosteal New Bone in the Alameda-Stone Cemetery Sample, by Cemetery Area

Cemetery Area	Observable Individuals (n)	Affected Individuals (n)	Percent (of observable)	Percent (of affected individuals)
1	18	2	11.11	1.07
2	88	16	18.18	8.56
3	670	135	20.15	72.19
4	254	31	12.20	16.58
5	30	3	10.00	1.60
Total	1,060	187	17.64	100.00

Table 154. Pearson's Chi-Square for Spatial Distribution of Periosteal New Bone in the Alameda-Stone Cemetery Sample

Cemetery Area	n	Observed		Expected		χ^2
		Unaffected	Affected	Unaffected	Affected	
1	18	16	2	14.526	3.474	0.775
2	88	72	16	71.015	16.985	0.071
3	670	535	135	540.680	129.320	0.309
4	254	223	31	204.974	49.026	8.213[a]
5	30	27	3	24.210	5.790	1.666
Total	1,060	873	187			

[a]Significant at the 0.05 level.

Table 155. Frequency of Active versus Healing/Healed Periosteal New Bone in the Alameda-Stone Cemetery Sample, by Age Category

Age Category	Affected Elements (n)	Active Lesions (n)	Healed/Healing Lesions (n)	Percent Active	Percent Healed/ Healing
Fetal	166	163	3	98.19	1.81
Infant	459	342	117	74.51	25.49
Child	15	7	8	46.67	53.33
Subadult	39	19	20	48.72	51.28
Young adult	316	161	155	50.95	49.05
Middle adult	307	82	225	26.71	73.29
Old adult	38	12	26	31.58	68.42
Adult	8	0	8	0.00	100.00
Total	1,348	786	562	58.31	41.69

Table 156. Pearson's Chi Square for Differences in Periosteal New Bone Activity between Males and Females in the Alameda-Stone Cemetery Sample

Sex	Lesion Type		χ^2	*df*	*p*
	Active Lesions (n)	Healed Lesions (n)			
Male	173	177	0.046	1	0.831
Female	50	197	87.490	1	< 0.010
Total	223	374			

Table 157. Distribution of Active versus Healing/Healed Periosteal New Bone in the Alameda-Stone Cemetery Sample, by Cemetery Area

Cemetery Area	n	Observed (n)		Percent	
		Active	Healed	Active	Healed
2	54	23	31	42.59	57.41
3	1,025	640	385	62.44	37.56
4	179	118	61	65.92	34.08
Total	1,258	781	477	62.08	37.92

Table 158. Frequency and Distribution of Localized versus Systemic Periosteal New Bone in the Alameda-Stone Cemetery Sample, by Age Category

Age Category	Affected Individuals (n)	Localized (n)	Systemic (n)	Percent Localized	Percent Systemic
Fetal	5	1	4	20.00	80.00
Infant	63	26	37	41.27	58.73
Child	14	3	11	21.43	78.57
Subadult	5	3	2	60.00	40.00
Young adult	53	27	26	50.94	49.06
Middle adult	51	20	31	39.21	60.79
Old adult	14	9	5	64.29	35.71
Total	205	89	116	43.41	56.59

Table 159. Frequency and Distribution of Localized versus Systemic Periosteal New Bone in the Alameda-Stone Cemetery Sample, by Cemetery Area

Cemetery Area	Affected Individuals (n)	Localized (n)	Systemic (n)	Percent Localized	Percent Systemic
2	16	5	11	31.25	68.75
3	135	62	73	45.93	54.07
4	31	12	19	38.71	61.29
Total	182	79	103	43.41	56.59

Table 160. Summary of Individuals with Osteomyelitis in the Alameda-Stone Cemetery Sample

Grave Pit No.	Burial	Cemetery Area	Age (years)	Sex	Biological Affinity
826	6825	2	25–30	male	European
829	6904	2	35–45	male	European
3244	3417-P3	2	40–60	male	Hispanic
7553	9721	3	50+	male	Hispanic
7578	9871	3	18–35	female	Native American
7695	14872	3	25–30	female	European
7809	—	4	18–99	indeterminate	indeterminate
7957	19539	3	0.25–0.42	indeterminate	indeterminate
13573	25106	3	0.67–1.33	indeterminate	indeterminate
13600	28511	4	6–10	indeterminate	Hispanic
13611	21790	3	25–30	female	Native American
13614	21829	3	30–40	male	European
13654	27544	4	0.00–0.50	indeterminate	indeterminate

Table 161. Frequency of Endocranial Lesions in the Alameda-Stone Cemetery Sample, by Age Category

Age Category (years)	Number of Aged Individuals	Number with Skull	Number with Endocranial Lesions	Percent with Endocranial Lesions
<40 weeks	69	49	0	0.00
0.0–1.0	254	184	14	7.60
1.1–2.5	141	113	11	9.70
2.6–6.5	77	56	5	8.90
6.6–10.5	34	31	0	0.00
10.6–14.5	23	16	1	6.25
14.6–18.0	27	19	0	0.00
Total	625	468	31	6.60

Table 162. Summary of Individuals with Endocranial Lesions in the Alameda-Stone Cemetery Sample

Grave Pit No.	Burial No.	Cemetery Area	Age (years)	Sex	Biological Affinity	Elements Affected	Other Pathologies	Type of Pathology
546	3623	3	1.1–2.5	indeterminate	indeterminate	occipital	yes	cribra orbitalia, developmental
580	2739	3	1.1–2.5	indeterminate	indeterminate	parietal and frontal	no	none
694	8781	5	2.6–6.5	indeterminate	indeterminate	all	yes	cribra, infection of palate
5166	7061	3	0.0–1.0	indeterminate	indeterminate	occipital	yes	porotic hyperstosis
5195	8702	5	0.0–1.0	indeterminate	indeterminate	all	yes	right radius with healed fracture, infection
7555	9991	3	0.0–1.0	indeterminate	indeterminate	all	no	none
7591	9688	3	1.1–2.5	indeterminate	indeterminate	all	no	none
7601	12656	3	0.0–1.0	indeterminate	indeterminate	all	yes	metabolic
7605	11714	3	2.6–6.5	indeterminate	indeterminate	occipital and parietal	no	none
7616	14860	3	1.1–2.5	indeterminate	indeterminate	parietal	no	none
7619	11907	3	1.1–2.5	indeterminate	indeterminate	occipital and parietal	yes	systemic infection
7654	11956	3	1.1–2.5	indeterminate	indeterminate	frontal	no	none
7655	13133	3	1.1–2.5	indeterminate	indeterminate	occipital	no	none
7671	16769	3	0.0–1.0	indeterminate	indeterminate	occipital	no	none
7674	14654	3	0.0–1.0	indeterminate	indeterminate	parietal	no	none
7683	14609	3	0.0–1.0	indeterminate	indeterminate	occipital	no	none
7686	14705	3	2.6–6.5	indeterminate	European	occipital and parietal	yes	metabolic
7703	16502	3	1.1–2.5	indeterminate	indeterminate	occipital	no	none
7708	16588	3	0.0–1.0	indeterminate	indeterminate	occipital and parietal	yes	cribra
7768	13013	4	1.1–2.5	indeterminate	indeterminate	parietal	yes	infection right radius
7836	10441	3	0.0–1.0	indeterminate	indeterminate	occipital	yes	cribra, systemic infection
7850	18523	3	0.0–1.0	indeterminate	indeterminate	occipital	no	none
7860	18542	3	10.6–14.5	indeterminate	indeterminate	frontal	no	none
7925	18753	3	0.0–1.0	indeterminate	indeterminate	occipital	yes	metabolic

Grave Pit No.	Burial No.	Cemetery Area	Age (years)	Sex	Biological Affinity	Elements Affected	Other Pathologies	Type of Pathology
7965	19563	3	0.0–1.0	indeterminate	indeterminate	occipital and parietal	yes	systemic infection
10081	10206	3	1.1–2.5	indeterminate	indeterminate	all	yes	infection left femur
10141	21883	3	2.6–6.5	indeterminate	indeterminate	occipital and parietal	no	none
10235	10235-37	ASM	0.0–1.0	indeterminate	indeterminate	frontal	yes	systemic infection
10317	28688	3	1.1–2.5	indeterminate	indeterminate	occipital	no	none
13606	25191	4	0.0–1.0	indeterminate	indeterminate	parietal	no	none
13855	28617	3	2.6–6.5	indeterminate	indeterminate	all	no	none

Key: ASM = from the Arizona State Museum collection.

Table 163. Individuals with Sinusitis in the Alameda-Stone Cemetery Sample

Grave Pit No.	Individual	Age (years)	Sex	Biological Affinity	Cemetery Area	Affected Side(s)	Dental Abscess	Periodontal Disease
1479	F-2506-P	18–34	male	European	2	left	no	no
3122	F-3707-P	18–34	female	Hispanic	3	both	no	yes
3238	F-6823-P	35–49	male	Hispanic	2	left	no	no
7524	F-5500-P	18–34	female	indeterminate	3	left	yes	yes
7553	F-9721-P	50+	male	Hispanic	3	both	no	yes
10235	F-10235-26	35–49	female	Hispanic	ASM	right	no	yes
10235	F-10235-27	50+	female	indeterminate	ASM	both	no	yes
13916	F-28759-P	50+	indeterminate	Hispanic	3	both	yes	yes
24868	F-25397-P	50+	female	indeterminate	4	right	yes	yes
28339	F-28339-1	35–49	female	indeterminate	3	both	yes	unknown

Key: ASM = from the Arizona State Museum collection.

Table 164. Individuals with Button Osteomas in the Alameda-Stone Cemetery Sample

Grave Pit No.	Burial	Age (years)	Sex	Biological Affinity	Location of Osteoma(s)	Number of Osteomas
7587	9602	35–45	female	Hispanic	parietal	1
7896	19543	45–99	female	Hispanic	frontal	1
13657	26836	50–99	female	Native American	parietal	1
13916	28759	50–60	indeterminate	Hispanic	frontal, parietals	5
17605	18963	30–40	male	indeterminate	occipital	1
10235-14	NA	35–60	*cf.* male	Hispanic	frontal	1
10235-17	NA	30–50	*cf.* male	Hispanic	parietal	1
10235-46	NA	25–45	female	indeterminate	frontal	2

Table 165. Degenerative Joint Disease Scoring Assignments

Stage of Degenerative Joint Disease	Letter Score	Numerical Score
No data	—	—
Normal	a	1
Lipping	b	2
Pitting	c	3
Eburnation	d	4
Lipping and pitting	bc	5
Lipping and eburnation	bd	6
Pitting and eburnation	cd	7
Lipping, pitting, and eburnation	bcd	9
Normal, lipping and pitting	(a)bc	5
Normal, lipping and eburnation	(a)bd	6
Normal, pitting and eburnation	(a)cd	7
Normal, lipping, pitting, and eburnation	(a)bcd	9

Table 166. Joint Complexes and Corresponding Joint Surfaces

Joint Complex	Elements
Temporomandibular joint	Left and right temporomandibular (mandibular fossa), left and right mandibular condyles.
Shoulder	Left and right glenoid fossa of the scapula, left and right acromion process of the scapula, left and right medial clavicle, left and right lateral clavicle, left and right proximal humerus.
Elbow	Left and right distal humerus, left and right proximal radius, left and right proximal ulna.
Wrist	Left and right distal radius, left and right distal ulna, left and right carpals, left and right metacarpals.
Fingers	Left and right proximal carpal phalanges, left and right middle carpal phalanges, left and right distal carpal phalanges.
Hip	Left and right acetabulum, left and right proximal femur.
Knee	Left and right distal femur, left and right patella, left and right proximal tibia, left and right proximal fibula.
Ankle	Left and right distal tibia, left and right distal fibula, left and right calcaneus, left and right tarsals, left and right metatarsals.
Toes	Left and right proximal tarsal phalanges, left and right middle tarsal phalanges, left and right distal tarsal phalanges.
Neck	Occipital condyles, left and right superior and inferior facets of cervical vertebrae.
Trunk	Left and right superior and inferior facets of thoracic vertebrae.
Lower back	Left and right superior and inferior facets of lumbar vertebrae, superior sacral facets of the sacrum.

Table 167. Demographic Profile of Individuals with Degenerative Joint Disease in the Alameda-Stone Cemetery Sample

Biological Affinity/Sex	Age	Cemetery Area					Arizona State Museum	Total
		1	2	3	4	5		
African American								
Male								
	adult	0	0	0	0	0	0	0
	young adult	0	0	0	0	0	0	0
	middle adult	0	1	0	0	0	0	1
	old adult	0	0	0	0	0	0	0
Apache								
Female								
	adult	0	0	0	0	0	0	0
	young adult	0	0	0	0	0	0	0
	middle adult	0	0	1	0	0	1	2
	old adult	0	0	0	0	0	0	0
Euroamerican								
Male								
	adult	0	1	0	0	0	1	2
	young adult	1	16	11	2	1	2	33
	middle adult	0	8	8	2	0	1	19
	old adult	0	2	4	0	0	1	7
Female								
	adult	0	0	0	0	0	0	0
	young adult	0	3	8	1	0	1	13
	middle adult	0	1	5	0	0	1	7
	old adult	0	0	0	0	0	0	0
Indeterminate								
	adult	3	0	0	0	0	0	3
	young adult	4	0	2	1	0	0	7
	middle adult	0	0	0	0	0	0	0
	old adult	0	0	0	0	0	0	0
Hispanic								
Male								
	adult	0	0	1	0	0	0	1
	young adult	1	10	18	7	2	3	41
	middle adult	1	13	25	2	2	5	48
	old adult	0	3	12	4	1	0	20
Female								
	adult	0	0	0	0	0	0	0
	young adult	0	2	33	4	6	4	49
	middle adult	0	1	21	2	1	2	27

continued on next page

Biological Affinity/Sex	Age	Cemetery Area					Arizona State Museum	Total
		1	2	3	4	5		
	old adult	0	0	11	1	0	0	12
Indeterminate								
	adult	1	0	0	0	0	0	1
	young adult	2	0	2	2	0	1	7
	middle adult	0	0	1	0	0	0	1
	old adult	0	0	1	0	0	0	1
Native American								
Male								
	adult	0	0	0	0	0	0	0
	young adult	0	0	5	2	0	0	7
	middle adult	0	0	3	2	0	0	5
	old adult	0	1	3	0	0	0	4
Female								
	adult	0	0	0	0	0	0	0
	young adult	0	0	8	0	0	1	9
	middle adult	0	0	6	2	0	0	8
	old adult	0	0	0	1	0	0	1
Indeterminate								
	adult	0	0	0	0	0	0	0
	young adult	0	0	1	0	0	0	1
	middle adult	0	0	0	0	0	0	0
	old adult	0	0	0	0	0	0	0
Indeterminate								
Male								
	adult	5	1	5	4	0	0	15
	young adult	1	2	7	14	1	4	29
	middle adult	0	4	22	12	0	1	39
	old adult	0	2	9	8	1	0	20
Female								
	adult	0	0	3	6	0	0	9
	young adult	0	0	16	6	1	2	25
	middle adult	0	0	16	13	0	4	33
	old adult	0	0	6	6	0	2	14
Indeterminate								
	adult	12	3	7	25	0	0	47
	young adult	11	2	6	5	0	0	24
	middle adult	1	0	2	6	0	0	9
	old adult	0	0	0	2	0	0	2
Total		43	76	289	142	16	37	603

Table 168. Frequency of Degenerative Joint Disease among Males and Females in the Alameda-Stone Cemetery Sample, by Age Group

Sex	Age	Observable	Affected	Percent Affected
Female				
	young adult	96	37	38.54
	middle adult	77	63	81.82
	old adult	27	27	100.00
	subtotal	200	127	63.50
Male				
	young adult	110	45	40.91
	middle adult	112	100	89.29
	old adult	51	50	98.04
	subtotal	273	195	71.43
Indeterminate				
	young adult	39	13	33.33
	middle adult	10	5	50.00
	old adult	3	3	100.00
	subtotal	52	21	40.38
Subtotals				
	young adult	245	95	38.78
	middle adult	199	168	84.42
	old adult	81	80	98.77
Total		525	343	65.33

Table 169. Mann-Whitney U Statistic for Degenerative Joint Disease between Males and Females in the Alameda-Stone Cemetery Sample

Joint Complex	U Statistic	*df*	*p*-value
Left shoulder	19863.00	1	0.007
Right shoulder	20229.00	1	0.009
Left elbow	18660.00	1	0.001
Right elbow	18407.00	1	0.001
Left wrist	22381.00	1	0.029
Right wrist	20440.00	1	0.004
Left ankle	21692.50	1	0.029
Right ankle	21934.50	1	0.063
Trunk	16970.50	1	0.002
Lower back	17802.00	1	0.041

Table 170. Kruskal-Wallis Test Statistic for Degenerative Joint Disease in the Alameda-Stone Cemetery Sample, by Age Group

Joint Complex	H Statistic	*df*	*p*-value
Left temporomandibular joint	12.835	2	0.002
Right temporomandibular joint	38.754	2	< 0.01
Left shoulder	139.294	2	< 0.01
Right shoulder	144.639	2	< 0.01
Left fingers	56.307	2	< 0.01
Right fingers	42.293	2	< 0.01
Left toes	24.936	2	< 0.01
Right toes	25.921	2	< 0.01
Left knee	95.911	2	< 0.01
Right knee	97.900	2	< 0.01
Left elbow	112.111	2	< 0.01
Right elbow	107.279	2	< 0.01
Left wrist	81.200	2	< 0.01
Right wrist	82.682	2	< 0.01
Left hip	36.616	2	< 0.01
Right hip	54.259	2	< 0.01
Left ankle	72.377	2	< 0.01
Right ankle	73.754	2	< 0.01
Neck	100.539	2	< 0.01
Trunk	74.783	2	< 0.01
Lower back	121.382	2	< 0.01

Table 171. Frequency of Degenerative Joint Disease among Biological Groups in the Alameda-Stone Cemetery Sample, by Sex

Affinity	Sex	Observable	Affected	Percent Affected
Euroamerican				
	male	59	35	59.32
	female	20	9	45.00
	indeterminate	7	3	42.86
Subtotal		86	47	54.65
Hispanic				
	male	109	83	76.15
	female	88	54	61.36
	indeterminate	9	6	66.67
Subtotal		206	143	69.42
Native American				
	male	16	13	81.25
	female	18	12	66.67
	indeterminate	1	1	100.00
Subtotal		35	26	74.29
Subtotal, by sex				
	male	184	131	71.20
	female	126	75	59.52
	indeterminate	17	10	58.82
Total		327	216	66.06

Table 172. Frequency of Degenerative Joint Disease among Biological Groups in the Alameda-Stone Cemetery Sample, by Age Group

Affinity	Age	Observable	Affected	Percent Affected
Euroamerican				
	young adult	53	16	30.19
	middle adult	26	24	92.31
	old adult	7	7	100.00
Subtotal		86	47	54.65
Hispanic				
	young adult	97	43	44.33
	middle adult	76	67	88.16
	old adult	33	33	100.00
Subtotal		206	143	69.42
Native American				
	young adult	17	9	52.94
	middle adult	13	12	92.31
	old adult	5	5	100.00
Subtotal		35	26	74.29
Subtotal by age				
	young adult	167	68	40.72
	middle adult	115	103	89.57
	old adult	45	45	100.00
Total		327	216	66.06

Table 173. Kruskal-Wallis Test Statistic for Degenerative Joint Disease in the Alameda-Stone Cemetery Sample, by Biological Affinity

Joint Complex	H Statistic	*df*	*p*-value
Left shoulder	6.014	2	0.049
Right shoulder	5.120	2	0.077
Right elbow	6.955	2	0.031
Right wrist	6.355	2	0.042

Table 174. Demographic Profile and Frequencies for the Individuals in the Cribra Orbitalia and Porotic Hyperostosis Subsample for the Alameda-Stone Cemetery Sample

Demographic Categories and Cemetery Areas	Cribra Orbitalia			Porotic Hyperostosis		
	Observable (Adjusted n)	Affected	Percent Affected	Observable (Adjusted n)	Affected	Percent Affected
Sex						
Female	145.8	5	3.43	174.83	3	1.72
Indeterminate	353.4	32	9.05	478.00	13	2.72
Male	194.0	8	4.12	237.50	8	3.37
Subtotal	693.2	45	6.49	890.33	24	2.70
Arizona State Museum Age Category						
Fetal	35.0	1	2.86	50.00	0	0.00
Infant	205.0	21	10.24	282.00	9	3.19
Child	92.4	7	7.58	117.17	5	4.27
Subadult	19.2	2	10.42	24.50	0	0.00
Adult	6.2	2	32.26	84.33	2	2.37
Young adult	144.0	9	6.25	176.50	6	3.40
Middle adult	135.0	3	2.22	160.17	2	1.25
Old adult	58.0	0	0.00	70.67	0	0.00
Subtotal	694.8	45	6.48	965.34	24	2.49
Biological Group						
African	1.0	0	0.00	1.00	0	0.00
Native American (including Apache)	28.4	0	0.00	37.00	1	2.70
European	80.0	9	11.25	100.30	4	3.99
Hispanic	198.0	8	4.04	224.50	3	1.34
Indeterminate	385.8	28	7.26	527.50	16	3.03
Subtotal	693.2	45	6.49	890.30	24	2.70
Cemetery Area						
1	3.8	1	26.32	4.16	1	24.04
2	65.4	3	4.59	81.00	2	2.47
3	484.0	29	5.99	614.50	14	2.28
4	112.0	6	5.36	158.00	5	3.16
5	25.0	3	12.00	29.70	2	6.73
Subtotal	690.2	42[a]	6.09	887.36	24	2.70
Total	689.2	45	6.82	890.33	24	2.70

[a]Three individuals from the Tucson Newspapers building were not included in the cemetery area assessment.

Table 175. Statistical Significance between Demographic Categories for Cribra Orbitalia and Porotic Hyperostosis in the Alameda-Stone Cemetery Sample

Condition	Demographic Categories	χ^2	*df*	*p*-value
Porotic hyperostosis				
	sex	0.61	2	0.74
	age	3.98	6	0.68
	biological affinity	3.46	3	0.33
	cemetery area	4.56	5	0.47
Cribra orbitalia				
	sex	0.61	2	0.74
	age	3.98	6	0.68
	biological affinity	3.46	3	0.33
	cemetery area	4.56	5	0.47

CHAPTER 12

Trauma Analysis

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Introduction

Trauma is the second-most-common pathological condition observed on the human skeleton, following degenerative changes related to age progression (Ortner and Putschar 1981:55). By definition, trauma is a bodily injury, or wound, inflicted though either accident or violence (Roberts 1991:226). Injuries occurring as a result of physical force or some other biomechanical induction result in a wide variety of lesions and include fractures, dislocations, new bone formations near joint surfaces (exostoses), the loss of a blood supply, or the separation of vertebral segments (spondylolysis) (Aufderheide and Rodríguez-Martin 1998; Merbs 1989; Ortner and Putschar 1981; Steinbock 1976).

Because the individuals recovered from the cemetery lack soft tissue, the skeleton holds the only available evidence of traumatic events. For anthropologists, the frequency and distribution of trauma are viewed as indicators of the quality and style of life within a community but also as gauges of the level of human-to-human (interpersonal) violence within that community. Because most trauma inflicted upon individuals involves only soft-tissue injuries, the evidence of traumatic events observed by osteologists represents only a small fraction of the total number of injuries actually affecting an individual or group. Generally speaking, only severe traumatic events that leave a signature on the skeleton are observable and, therefore, documented.

This chapter will describe the frequency and distribution of trauma observed on individuals from the cemetery. First, we will present a brief discussion of fractures—the most-common trauma type—and some characteristics of the timing of injuries and skeletal responses to trauma in the living individual. Following this will be a description of trauma observed on the site and comparisons of trauma frequencies by age, sex, biological affinity, and cemetery area. This will be followed by general observations of injuries across the site, as well as a brief discussion of evidence of surgery, autopsy, and weapons trauma. Next, injuries specific to the vertebral column and shoulder and hip joints will be described and examined for patterns in demographic and spatial characteristics. Finally, trauma from the cemetery will be compared to trauma reported for other, similar archaeological sites. These intrasite and intersite investigations will help to further our understanding of individuals living in Tucson in the mid- to late-nineteenth century, as well as the hazards they faced.

Fractures: Causes, Timing, and Responses

Fractures are by far the most-common traumatic conditions affecting the skeleton (Shipman et al. 1985:285). Because fractures, by definition, affect a skeletal structure, they are frequently documented in archaeological skeletal samples (Judd and Roberts 1999:229). As Schwartz (2007) noted, "undue or unusual stress can cause a bone to fracture, because the force of the assault outpaces the rate at which the bone can respond to the stress" (2007:339). Such stress may result from a wide range of causes, from ordinary falls to invasive surgeries. In every case, however, bone will fracture if it experiences force exceeding its biomechanical limits.

A variety of fracture types can affect the human skeleton. The type and magnitude of a fracture depend on a number of factors, including the age of the individual, the location of the injury, the individual's health, the manner in which the injury was sustained, and the biomechanical forces involved in the creation of the fracture (see Galloway et al. 1999). In the human skeleton, bone fractures tend to follow predictable patterns based on the specific biomechanical forces affecting the element.

Timing of Injuries

When examining skeletal remains for trauma, it is important to (1) determine whether the injury occurred before, around the time of, or after death and (2) distinguish a traumatic event from the naturally occurring skeletal anomalies or pathologies (Galloway et al. 1999:6). The timing of a traumatic event includes traumas that occurred before death (antemortem), at or near the time of death (perimortem), or after death (postmortem). To distinguish among these, the margins of the injury are assessed to determine the degree of healing. If there is healing, or if the lesion is completely healed, the episode is considered antemortem. Postmortem damage to the remains is recognized by a fresh, clean separation of the bone that is of a color inconsistent with the surrounding surfaces. Such coloration indicates that the event occurred long after death and was only recently exposed to the taphonomic factors responsible for staining. Perimortem damage, however, is determined by a *lack* of evidence: if no evidence of healing is present but the damage to the bone does not feature postmortem taphonomic characteristics, the injury is considered perimortem. Bone responds to injury much more slowly than do soft tissues, and several days or weeks may pass before evidence of healing is observable on skeletal remains. Likewise, several days or weeks may pass after death before bone responds to forces in a way that indicates postmortem damage. Therefore, the determination that an injury is perimortem must include a time frame starting several weeks prior to death and extending several weeks following death.

Bone Responses to Trauma

There are two basic types of bone cells within living bone: osteoblasts, which build new bone, and osteoclasts, which dissolve (resorb) old or damaged bone. In the event of a fracture, osteoclasts rush to the site of the injury to destroy and remove damaged bone cells. At the same time, osteoblasts begin to produce new bone cells by laying down a loose matrix of bone (woven bone) to unite the ends of the fractured bone by means of a callus of new bone (Ortner 2003:126). In time, through a process called resorption, the callus is gradually dissolved, completing the remodeling process. In young children, resorption of the callus surrounding a fracture may be complete within a few months, but in the adult, especially the older adult, the process of callus resorption takes years (Ortner and Putschar 1981:63).

Conversely, bone may have negative responses to trauma. These include localized infections at the injury site and misalignment of fractured elements during healing. The cause and nature of trauma are clearly of importance when reconstructing lifeways of individuals in the past. Equally important, however, is an evaluation of these negative responses to nonlethal trauma. Poorly or improperly healed fractures, as well as the presence of opportunistic infection, such as pyogenic bacteria leading to osteomyelitis, aid in discernment of the success and availability of medical care for the population. Indeed, a critical aspect of trauma analysis includes an examination of what happened *after* the injury was sustained. Observations of these negative responses are discussed below.

Methods of Trauma Analysis

To examine the frequency and distribution of skeletal trauma among individuals recovered from the cemetery, it was necessary first to define the sample under consideration. The 1,386 discrete individuals excavated from the site includes both primary and enumerated individuals. To avoid underestimating the frequency of trauma across the site, it was important to limit the sample to those individuals with relatively complete sets of remains. To accomplish this, only primary individuals were assessed for the present discussion, resulting in an initial sample size of 1,044 individuals.

Trauma was assessed according to simplified regions of the skeleton, to identify areas of the body more or less affected by injury. These regions were Cranial (skull and hyoid), Thoracic (vertebrae, ribs and sternum,

pelvis, clavicles, and scapulae), Arms (humeri, radii, and ulnae), Hands (carpals, metacarpals, and finger phalanges), Legs (femora, patellae, tibiae, and fibulae), and Feet (tarsals, metatarsals, and toe phalanges). The presence or absence of the elements composing each of these regions allowed for corrections for observability. For instance, six elements compose the arms of an individual. If an individual is missing the left radius and ulna, then that individual is considered 66.7 percent complete for the Arms region (four of six elements present). This correction permits a more accurate analysis of injury by calculating observed trauma from observable regions. Additionally, the regions corrected for observability were combined into a mean observability for the individual, allowing for comparisons based on individual attributes. This permitted a standardized assessment of trauma on the individual level, corrected for how much of the individual was available for observation. Of the 1,044 primary individuals, the corrected observable total number of individuals was 764.

In order to identify patterns and distinctions among demographic and spatial attributes, the presence and absence of skeletal trauma were examined according to age, sex, biological affinity, and cemetery area. With the exception of cemetery area, which was determined as a function of excavation efforts, each of these categories of attributes contains various numbers of individuals for whom a definitive conclusion could not be made. In other words, several primary individuals were of indeterminate sex, indeterminate biological affinity, or prohibitively broad age categories (e.g., adult, 18–99 years old). Because each analysis of trauma distribution relies on specific placement within groups, those individuals who were indeterminate for the characteristic under consideration were excluded from the calculations. It should be noted that the exclusions were on an attribute-by-attribute basis; an individual of determinate sex but indeterminate biological affinity would only be excluded from examinations for the latter. Cemetery area, on the other hand, was assigned based on the location of the grave in the project area and cannot suffer from an "indeterminate" designation; every individual has a determined cemetery-area attribute.

Because of the fragility of individual remains, numerous postmortem fractures were observed (see Chapter 2). Most of these were easily identified from the unstained (whitish) appearance of the recently fractured bone. Hutchinson (1996) noted that fractures occurring in fresh bone are usually uniform in their cortical and noncortical coloration and that the edges of the break tend to have acute or obtuse angles. On the other hand, postmortem breaks are usually perpendicular to the long axis of the bone and have irregular surfaces (Kaufman et al. 1997). See Chapter 2 for a discussion of the taphonomic influences affecting the recovered skeletal material.

Trauma Observed at the Cemetery

This section addresses the occurrence of general trauma in the cemetery population. Instances of trauma were assessed according to age, sex, biological affinity, and cemetery area, in an effort to identify patterns across the project area. Each of the attributes listed above was evaluated separately. Because of the complex nature of the vertebral elements and their associated trauma types, the vertebral column is also presented separately.

Of the 764 observable primary individuals exhumed at the cemetery, 197 exhibited evidence of trauma (Table 176). The following section provides trauma frequencies by each demographic and spatial attribute: age, sex, biological affinity, and cemetery area.

Age

Comparing instances of trauma by the ages of the individuals reveals predictable patterns of injury across the population. Because trauma is evaluated cumulatively, it is unsurprising that trauma frequencies increase with age. Simply put, the longer an individual has lived, the more likely it is that he or she has sustained skeletal injury sometime in life. This presupposes, of course, that the trauma recorded was not lethal. Table 177 displays the instances of trauma by age category, the frequency of trauma among all individuals within each age category, and the distribution of trauma by age.

Adult individuals exhibited dramatically more trauma than did juvenile individuals. Indeed, adult individuals composed slightly more than half of the observable sample but represented over 91 percent of the total number of individuals exhibiting trauma. The difference in incidence of trauma between juvenile individuals and adult individuals is significant ($\chi^2 = 160.987$; $df = 1$; $p < .01$). In addition to the disproportionately small contribution of juvenile individuals to overall occurrence of trauma, the frequency of trauma among juvenile individuals was low. Of the 405 observable adult individuals, 181 showed evidence of trauma, resulting in a frequency of 44.7 percent. Conversely, of the 359 observable juvenile individuals, less than 5 percent (n = 16) showed evidence of injury. Clearly, the hazards facing adult individuals were more pervasive and substantial than those facing juveniles. Although every juvenile age category (fetal, infant, child, and subadult) featured at least 1 individual with trauma, the overall incidence of trauma among juveniles was too small to warrant further scrutiny among those categories; any patterns could be the result of happenstance, rather than meaningful correspondence between juvenile age group and injury.

Adult individuals showed trauma in sufficient frequency and distribution among the age categories to explore further. Of the 405 observable adult individuals, 12 could not be assigned to a particular age category (young adult, middle adult, or old adult). Of the 393 adult individuals for whom age categories were assigned, 173 showed evidence of injury (see Table 177). Middle- and old-adult individuals showed nearly identical frequencies of trauma, approximately 49 percent of observable individuals. Young adults, however, showed a much lower frequency of slightly more than 37 percent. A Pearson's chi-square test indicates that there is no significant difference for the presence or absence of trauma among the adult age groups ($\chi^2 = 5.758$; $df = 2$; $p = .056$). Nevertheless, a comparison of trauma among adult age groups is justified. Table 178 shows observed and expected instances of injury among the adult age groups. Young adults exhibited less trauma than expected, whereas both middle and old adults exhibited more trauma than expected. The relatively low frequency of trauma among young-adult individuals, as compared to middle- and old-adult individuals, is likely the result of the cumulative nature of evidence for injury. As noted above, evidence of nonlethal skeletal trauma is persistent, often observable for years after the injury is sustained. So, the trauma observed on adults of advancing ages may be, in part, the result of injuries from earlier in life.

Sex

Differences in trauma frequencies between males and females provide a powerful view into the life experiences of men and women in Tucson during the mid-nineteenth century. A casual observer may reasonably expect males to show more evidence of trauma than females show, a trend that is substantially consistent among most human populations across time and space (Walker 1997). The cemetery population follows this trend.

As seen in Table 179, of the 392 observable primary individuals for whom sex could be determined, 44.6 percent (n = 175) exhibited evidence of trauma. This is consistent with the 44.7 percent trauma frequency in observable adult primary individuals (see Table 177). This similarity clearly occurs because the overwhelming majority of individuals with identifiable sex are also adult. For examinations by sex, the analytical decision was made to exclude from comparison individuals for whom sex could not be estimated (including juvenile individuals and adult individuals of indeterminate sex). Table 179 shows the frequency of trauma among the 392 observable individuals with identified sex, as well as the distribution of trauma between the sexes.

Males were far more affected by trauma than were females. Of the 175 observable individuals whose sex was identified, trauma distribution was approximately 71 percent (n = 125) in males and 29 percent (n = 50) in females. Over half of all observable male individuals exhibited evidence of injury, whereas just 30 percent of all observable females showed skeletal trauma. This difference is substantial and statistically significant ($\chi^2 = 22.028$; $df = 1$; $p < .01$), but the disparity is unsurprising; as noted above, males in general show more skeletal trauma than do females (Walker 1997). The differences in trauma between males and females may be further explored by examining the regions of the skeleton affected by injuries for each.

Table 180 shows the observable skeletal regions for each sex, as well the number and frequency of individuals with trauma in each region. The incidence of trauma was substantially larger for males than for females

in every skeletal region. The magnitude and significance of these differences are explored through a Pearson's chi-square test for each region. The results of these tests appear in Table 181.

As presented in Table 181, the differences in trauma between males and females were significant ($\alpha = 0.01$) for the Cranial, Thoracic, and Hands regions. For all regions, the general trend is that male individuals displayed more trauma than was statistically expected, whereas females displayed less trauma than was statistically expected. These disparities are, of course, consistent with the general observations of trauma for males and females. Of the six regions, however, these three showed differences so dramatic as to warrant statistical significance. The calculated expected values are based on a fundamental principle: the conditions leading to trauma (behavior, risk, etc.) are assumed to be equal for both males and females. For the Cranial, Thoracic, and Hands regions, the observations are so contrary as to indicate the conditions were *not* equal. Therefore, males and females were engaged in activities that led to significantly more hazard in these skeletal regions for males and significantly less hazard for females.

One could contemplate any numbr of activities or behaviors in which females participated more than males, and vice versa. Clearly, the far greater proportion of males with trauma versus the proportion of females with trauma suggests that greater hazards existed in mid-nineteenth-century Tucson for men than for women. It must be emphasized, however, that only a particular type of trauma is under consideration here: injuries that leave skeletal evidence. Strictly soft-tissue injuries, sustained by individuals of both sexes, are beyond the scope of the skeletal data set. It is important to recall that these observations may be biased toward trauma that may disproportionately affect males and may underrepresent trauma that may disproportionately affect females.

Biological Affinity

The cemetery population featured diversity in biological ancestry among its individuals, as did the population living in Tucson in the mid-nineteenth century. Indeed, the cemetery population reasonably reflects the distribution of biological affinity expected from census data of the time (see Appendix F). Table 182 shows the frequency and distribution of trauma by biological affinity. It should be noted that one primary individual was identified as African American. This individual did not exhibit any skeletal trauma and is therefore not included further in the present discussion. Additionally, biological affinity is more successfully determined for juvenile Hispanic individuals than for Euroamerican individuals. As noted above, age is a significant factor in predicting the incidence of trauma. To avoid the reducing factors of including juvenile individuals, the present examination is limited to adults.

The total number of observable primary individuals with identifiable biological affinity is 335, approximately 42 percent ($n = 142$) of those who showed evidence of trauma. This frequency is consistent with the frequency of trauma observed among the individual biological groups. Euroamerican individuals showed the lowest frequency, with 37.5 percent, and Hispanic individuals showed the highest frequency, with 45.2 percent. Unsurprisingly, the distribution of trauma among the groups is roughly equivalent to the distribution of all individuals in the sample among the groups. For example, among the sample of 335 individuals, 61.6 percent ($n = 206$) were Hispanic. Of the 142 individuals with trauma, 65.5 percent ($n = 93$) were Hispanic. In other words, the contribution of each group to the entire sample is consistent with the contribution of each group with trauma to the sample with trauma. On its face, it appears that no group is substantially more or less affected by trauma than would be reasonably assumed from the numbers of individuals in the entire sample.

This assessment is confirmed by a Pearson's chi-square test of trauma by biological affinity. Table 183 shows the observed and expected trauma by biological affinity. Although Euroamerican individuals showed slightly less trauma than was expected and Hispanic individuals showed slightly more trauma than was expected, the differences in observed trauma among the biological groups was not significant ($p = .427$). In short, the hazards facing Euroamerican, Hispanic, and Native American individuals at the site were generally equivalent.

This is a somewhat curious result. As with presumed divisions of labor and activity between males and females, one could equally reasonably presume different behaviors among the different biological-affinity groups. As noted above, however, skeletally observable trauma does not necessarily constitute the sum of

injury sustained by an individual or a group; injury to only soft tissues generally leaves no skeletal markers. Nevertheless, trauma evaluated in the present discussion was observed according to equal parameters for each group. If there were, indeed, differences in trauma among the groups from different activities and risk factors, those differences are not discernible from these data. In other words, the data cannot refute the statistical hypothesis that adult Euroamerican, Hispanic, and Native American individuals from the site overall faced equal hazard for skeletal injury.

Cemetery Area

The cemetery was separated into five areas during excavation. The military section (Cemetery Area 1) was the only area with historical documentation defining its location and size (see Chapter 4). The civilian portion of the cemetery was separated into the four remaining areas, based on spatial patterns of the grave pits and initial assessments of the individuals populating those areas. Table 184 shows the frequency and distribution of trauma among observable primary individuals in each of the five areas. Because the division of individuals is based on location and not on any biological attributes, the observability of individuals is based on all 1,044 primary individuals. In other words, because no primary individual is "indeterminate" for cemetery area, only the completeness of the skeleton affects the observable number of individuals.

As noted above, the spatial attribute of cemetery area is different from the biological attributes used to examine meaningful differences in trauma at the site. Certain assumptions were employed when defining cemetery areas, many of which are related to biological characteristics described above. Therefore, it is imprudent to evaluate observed trauma without consideration of the other factors contributing to the delineation of each of the areas.

Cemetery Area 1 is different from the other areas for three important reasons. First, as noted above, Cemetery Area 1 was defined based on historical documentation of the military section of the cemetery. It is the only area with boundaries known to have existed when the cemetery was in use. Second, because Cemetery Area 1 corresponds to the military section, it features a set of demographic and behavioral assumptions. Although not all individuals in Cemetery Area 1 were (or could have been) military service members, involvement with the military likely led to a nonrandom distribution of adult male individuals, with a nonrandom set of behaviors that may have led to a disproportionate risk of skeletal injury. Finally, Cemetery Area 1 composes the only part of the cemetery known to have been systematically (although not entirely) excavated prior to the current efforts. The result was not only a lower degree of completeness of the skeletons encountered but also a disproportionate distribution of the skeletal regions recovered for analysis. In Chapter 4, Heilen and Hall indicate that several individuals recovered from Cemetery Area 1 were represented mostly by elements of the extremities (the areas of the hands and feet) and few elements of the axial skeleton (the Cranial and Thoracic regions). Because of these three factors, Cemetery Area 1 is not reasonably comparable to the rest of the cemetery. Indeed, the historical documentation for this area included a level of injury documentation unavailable for the rest of the cemetery (see Chapter 7, Volume 1 of this series).

Cemetery Areas 2, 3, 4, and 5 compose the civilian section of the site and feature fewer inherent assumptions frustrating comparative trauma analysis. Some modification, however, is still necessary. As noted above, juvenility is a significant factor in observed skeletal trauma. In Chapter 7 of this volume, Trask indicates that juvenile individuals composed over 50 percent of Cemetery Area 3. The disproportionately high number of juvenile individuals leads to artificially low frequencies of trauma. To sensibly compare instances of skeletal injury by spatial factors, only adult individuals in the four civilian areas (Cemetery Areas 2, 3, 4, and 5) will be considered. These conditions result in an observable sample of 395 individuals, 44.1 percent ($n = 174$) of whom exhibited trauma. Table 185 shows the frequency and distribution of trauma for adults in these four areas. Table 186 displays the observed and expected incidences of trauma for these subsamples, as well as the Pearson's chi-square-test values for these areas.

Based on the criteria above, the incidence of trauma is significantly different among the cemetery areas ($\alpha = 0.01$). A careful examination of Table 186 reveals that Cemetery Areas 3, 4, and 5 showed less observed trauma than was statistically expected. Cemetery Area 2, however, showed far greater trauma than expected.

By eliminating Cemetery Area 2 from the comparison, the differences in Cemetery Areas 3, 4, and 5 are no longer significant ($\chi^2 = 1.298$; $df = 2$; $p = .523$). Indeed, the greater-than-expected trauma observed in Cemetery Area 2 is of sufficient magnitude to skew the collective results. In other words, only Cemetery Area 2 was significantly different from the other areas.

Cemetery Area 2 was distinct from the other civilian cemetery areas in two ways. Table 187 shows the proportion of observable adult males in each of the civilian areas, as well as the frequency of trauma among those males. As seen in the table, Cemetery Area 2 featured a higher proportion of males than any other cemetery area (as noted above, males generally show significantly more trauma than do females). Additionally, the frequency of males with trauma in Cemetery Area 2 was substantially higher than what was seen in the other civilian parts of the cemetery. Indeed, the frequency of observable males with trauma across the entire project area was 54.6 percent. In Cemetery Area 2, however, the frequency of observable males with trauma was 66.1 percent. So, Cemetery Area 2 was different from the other civilian parts of the cemetery, both in demographic composition and the behavior and activities of its members, as evidenced by the relatively high frequency of trauma. The possible reasons for these differences have been discussed in Volume 1 of this report.

General Fracture Observations

The following sections provide discussion of the timing of fractures and skeletal responses for all individuals recovered from the site. Because of the multitude of factors influencing the timing of injuries and physiological responses to trauma, no effort was made to further separate these observations by demographic or spatial characteristics as above. Indeed, seemingly identifiable patterns among the numerous individual-specific variables affecting each case would be misleading. Instead, the population was examined as a whole, to explore general distributions for the entire site (Walker 1997:175). Additionally, the following discussion is limited only to skeletal fractures, to the exclusion of other types of trauma (e.g., gunshot wounds, sharp force trauma, etc.), including specific vertebral trauma discussed below. This is for two reasons. First, fractures were the most-commonly encountered trauma type seen in the cemetery; therefore, a focus on fractures maximizes the available sample. Second, injuries and the consequences of their healing or lethality are best evaluated by excluding classes of trauma that may be disproportionately fatal, such as weapons trauma. In other words, the broad category of "fractures" does not presuppose a bias toward survivable injuries or life-threatening injuries.

Antemortem Versus Perimortem Fractures

A total of 143 general nonvertebral fractures were recorded. Of these, 94.4 percent (n = 135) were antemortem, as evidenced by some degree of healing (Table 188). The Cranial skeletal region showed the highest number of antemortem fractures (n = 35), followed by the Thoracic region (n = 32). The 135 antemortem fractures were distributed among 86 individuals. Table 189 shows the distribution of antemortem trauma by region, biological affinity, and sex. It should be noted that Table 189 presents the data on an individual basis, per skeletal region; some individuals displayed fractures on multiple regions and multiple fractures within a single region.

All biological groups showed more antemortem fractures for males than for females, in every skeletal region. Unfortunately, the group with the most-similar numbers of males and females with antemortem fractures was that for which biological affinity was indeterminate. Few patterns are discernable from the data. Euroamerican males showed nearly equal numbers of antemortem fractures for the Cranial and Thoracic regions. Hispanic males, however, showed twice as many antemortem cranial fractures as Thoracic fractures. Moreover, Hispanic males showed equal numbers for the Thoracic, Arms, and Feet regions, a distribution not seen in other groups. Indeed, apart from the most general assessments, no conclusions can be drawn from the distribution of antemortem fractures by individual attributes.

The remaining 5.6 percent (n = 8) of general, nonvertebral fractures showed no evidence of healing and no clear indication of a taphonomic origin and were therefore considered perimortem (see Table 188). Of these eight perimortem fractures, five were associated with head structures (including the cranium, mandible, and hyoid) and may have contributed to the deaths of the individuals. The remaining perimortem fractures included two fractures to arm elements and one to a leg element. The role these fractures had in the deaths of the individuals cannot be assessed from the evidence. The low number of perimortem fractures precludes comparative evaluation according to attributes such as sex or biological affinity.

The proportion of antemortem general fractures (94.4 percent) to perimortem general fractures (5.6 percent) is largely unsurprising. A careful consideration of this disparity reveals fundamental truths of trauma analysis on a populational scale. First, antemortem fractures will naturally outnumber perimortem fractures, simply by virtue of the time elapsed between sustaining the injury and the death of the individual. In other words, antemortem injuries are cumulative, and their evidence may persist for years before the individual dies. Conversely, there is a relatively narrow window during which an individual may suffer a perimortem fracture, regardless of whether or not that injury contributed to his or her death. Simply put, antemortem fractures represent a much greater period of time during which an injury may occur. Second, on the other hand, perimortem injuries may be incidental to the death of the individual, and several nonnatural causes of death may leave no skeletal markers. Therefore, the observer is cautioned from inferring more about the role of violence and injury in the deaths of individuals in the population than the skeletal evidence is able to support. Rather, the frequency and distribution of fractures before the time of death and around the time of death help to illuminate the *magnitude* of injurious hazards but not necessarily their severity.

Negative Responses to Trauma

As noted above, the physiological and biomechanical consequences of nonlethal fractures provide insight into medical practices and opportunities for care following an injury. Two ways in which these manifest on skeletal remains are localized infections associated with fractures and misalignment of healed elements. Although every skeletal element is theoretically susceptible to localized infection, misalignment is generally limited to major long bones. To provide a consistent sample for the following discussion, the 34 arm and leg elements showing evidence of antemortem fracture (Table 190) were assessed for infection or misalignment. Chapter 7, Volume 1 of this series provides a discussion of medical practices in the mid-nineteenth century and their availability to Tucsonans at that time.

Infection

The skin, as an organ, is generally successful in providing protection against foreign bacteria. When the skin is compromised, however, opportunistic, localized infections may set in. Compound, or open, fractures are of considerable concern for infection; portions of the fractured element are exposed to air and vulnerable to infection. Although the examination of dry bone cannot unequivocally indicate whether a fracture was compound, evidence of localized infection may serve as a reasonable proxy. Medical care with antibiotics is often required to prevent or treat infections associated with fractures. Although antibiotics were available in Tucson during the time the cemetery was in use, the accessibility to treatments may have been limited.

Of the 34 appendicular elements with antemortem fractures, 26.5 percent (n = 9) showed evidence of active or healing bone infection (Figure 175). A sample of 9 cases is generally too small to reliably examine with statistical analysis, and the occurrence of opportunistic infection followed few discernable patterns (see Table 190). Reactive bone was noted on all types of appendicular elements, with the exception of the femur. The infected elements came from individuals ranging in age from infant to old adult, although most elements (n = 7) came from adult individuals. Of these 7 elements, only 2 belonged to a female—indeed, a single individual with infections noted on the right tibia and fibula. Biological affinity was determined for five individuals with infected elements. Of these, four were Hispanic and one was Native American. Finally, 7 of the 9 elements were recovered from Cemetery Area 3; the remaining 2 were recovered from Cemetery Area 2 and Cemetery Area 5.

Misaligned Fractures

Prior to medical advances like radiography (x-rays), doctors had a difficult time properly aligning fractured bones. Comminuted fractures (those fractures resulting in numerous bone fragments) were nearly impossible to refit without performing dangerous, and often deadly, surgery. The result was misalignment and was often accompanied by physical dysfunction of the bone or adjacent joint or complete immobilization of that region of the body (Eiff et al. 2002:7–26). In remote regions of the Arizona territory, especially those without a doctor or effective anesthetist, the undoubtedly painful process of alignment was often abandoned, leaving the individual with a healed but misaligned fracture (Dudar and Solano 2007).

The proper realignment of a fractured bone is necessary for the affected element and adjacent joints to remain functional. The presence and distribution of misaligned fractures in a skeletal samples can potentially provide a great deal of information regarding occupational stressors and life hazards, as these are often serious injuries, as well as information on access and quality of medical treatments during a specific time period. The presence of such fractures, especially in high frequencies in archaeological samples, could be interpreted as an indicator of hazardous lifestyles coupled with nonexistent or inadequate medical treatment (Neri and Lancellotti 2004).

Of the 34 antemortem long-bone fractures, 29.4 percent (n = 10) healed with some degree of misalignment (Figure 176). Again, the small number of cases precludes any meaningful statistical evaluation. Each type of long bone, except the humerus and femur, showed examples of misalignment. Interestingly, only left elements showed misaligned healing. Unlike the distribution of elements showing infection, in which only 1 individual featured multiple infected elements, 6 of the 10 misaligned fractures came from just 2 individuals (see Table 190). Because such a large proportion of misaligned elements came from just 2 individuals, the sample was further reduced for examining demographic or spatial patterns. No juvenile individuals showed misaligned long-bone fractures, but the range of adult ages is represented. Of the 6 individuals under consideration, 5 were male. Four individuals were Hispanic, 1 was Euroamerican, and 1 was of indeterminate biological affinity. Only Cemetery Areas 2 and 3 contained individuals with misaligned long-bone fractures.

The small number of appendicular elements (from a smaller number of individuals) exhibiting negative responses to trauma is perhaps more instructive than the characteristics and distribution of those negative responses. As noted above, the presence and pervasiveness of negative responses to nonlethal trauma can shed light on medicine and healthcare available to the population. Strictly speaking, the eight individuals showing opportunistic infection from fracture represent only 0.77 percent of the primary individuals in the cemetery. Likewise, the six individuals with misaligned long-bone fractures compose just 0.57 percent of the primary individuals. It would seem, therefore, by either treatment or happenstance, the cemetery population was not devastated by negative responses to trauma. A deeper discussion of health and medical practices appears in Chapter 7, Volume 1 of this series.

Trauma from Surgery, Amputation, or Autopsy

As noted above, trauma can also be the result of surgical procedures, including amputations and autopsies. These represent a distinct class of trauma that is neither accidental nor violent, and they warrant special attention. Although clearly a postmortem procedure, evidence of autopsy gives unique insight into medical practices of the day. Additionally, skeletal evidence of autopsy fits squarely within the range considered perimortem for trauma analysis. The prevalence and practice of surgeries and autopsies is discussed in Chapter 7, Volume 1 of this series.

In the Joint Courts Complex burial sample, three individuals exhibited evidence of amputation. Two individuals showed amputation of the lower leg (Figure 177), and one showed amputation of the forearm. Demographic and spatial characteristics of these three individuals are listed in Table 191. Two of the three individuals (Grave Pit 3231, Burial Feature 6901, and Grave Pit 13706, Burial Feature 26489) presented evidence of

infection associated with the amputated elements, and amputation may have been the course of treatment. Both of these individuals also exhibited evidence of infection and reactive bone elsewhere on the skeleton. None of the individuals showed evidence of healing or new bone growth around the margins of the cuts, suggesting that the individuals did not survive long after the procedures.

Evidence of autopsy was noted on three individuals. None of these individuals showed evidence of amputation. Two individuals featured saw marks encircling the top of the cranium (Figure 178), indicating removal of the brain. The other individual exhibited cut marks, on a recovered rib, consistent with the "Y-incision" used to eviscerate internal organs. It should be noted that none of the individuals exhibited both brain and thoracic autopsy marks. Table 191 shows the demographic characteristics of the individuals with evidence of autopsy, as well as their locations in the cemetery. Military and civilian medical treatments are discussed in Chapter 7, Volume 1 of this series.

Weapons Trauma

Trauma due to weapons represents an important category of injury on a populational basis. At its most basic level, weapons trauma is the result of behavior outside the range of most occupational hazards. The specific situations leading to trauma from weapons are often not identifiable; malicious or destructive intent cannot necessarily be inferred from the presence of injury from weapons. That said, however, certain cases afford investigators the opportunity to reconstruct the events and make strong suggestions regarding the circumstances surrounding the trauma.

Evidence of weapon injuries was noted for 18 individuals at the cemetery and includes weapons trauma resulting from projectiles, such as firearms or stone points, and incisive, perforating, or chopping injuries from sharp-force trauma. Blunt-force trauma is more difficult to assess and requires considerably more evidence before concluding that a skeletal fracture is from a weapon. Therefore, to avoid potentially inflating the number of cases of blunt-force trauma from weapons, only those instances with compelling supporting evidence are considered. This does, of course, increase the risk of underrepresenting the number of individuals with weapons-based blunt-force trauma. Nevertheless, the evaluation of reliable cases is more illuminating than the enumeration of unreliable cases.

Table 192 displays the demographic and spatial information for the 18 individuals exhibiting trauma from weapons and whether their injuries showed evidence of healing. The absence of healing associated with weapons trauma does not necessarily indicate that the injury was fatal or even contributory in the death of the individual. As noted above, skeletal trauma may precede death by several weeks without evidence of healing. Furthermore, death is the cessation of physiological processes of strictly soft tissues (e.g., brain function, heart function, etc.), and skeletal remains are not sensitive to these processes in a currently observable way. In other words, apart from extreme cases of catastrophic trauma completely inconsistent with prolonged life, any statement of the cause of death is unverifiable speculation. Nevertheless, 3 individuals did present perimortem injuries of sufficient severity to reasonably suggest lethality (Grave Pit 534, Burial Feature 1278, and Grave Pit 22157, Burial Feature 21848). These are described in full in Chapter 14.

Table 192 indicates that the most-common form of weapons trauma observed from the cemetery is that resulting from firearms. Of the 18 individuals with weapons injuries, 11 had gunshot wounds. Blunt-force or sharp-force trauma was observed on 5 individuals, 2 of whom featured both types (Grave Pit 22157, Burial Feature 21848). Finally, clear evidence of trauma from stone projectile points was observed on 2 individuals.

Skeletal interpretation of this kind of trauma is incomplete without significant discussion of the artifacts associated with these individuals, such as firearm ammunition and projectile-point typologies. Additionally, a description of the weaponry available and in use during the time the cemetery was active is critical to a comprehensive discussion of injuries from weapons. Indeed, weapons trauma is unique in its reliance on material culture. An osteological, artifactual, and historical discussion of this sociologically important type of trauma is explored comprehensively in Chapter 7, Volume 1 of this series.

Vertebral Trauma and Dislocation

Skeletal fractures can appear on nearly any element and result from a countless number of situations and circumstances. The cranium and appendicular skeleton are especially vulnerable to forces from any direction and origin. The vertebral skeleton, however, is unique in its interconnectedness and specific force loading. Although a fall from a height or a strike from a blunt object may certainly affect vertebral elements as it would any other element, the structure and articulation of the spine provides for a particular suite of injuries, many of which are related to occupational hazards or repeated behaviors. Similarly, dislocations represent a specialized variety of trauma that relies on the interaction of multiple elements, rather than simply the application of sufficient force. Thus, spinal trauma and dislocations warrant special attention.

This section details the various traumatic conditions unique to the vertebral column affecting the spine and vertebral elements associated with the individuals recovered. Specifically, spondylolysis, vertebral-compression fractures, clay-shoveler's fractures, and Schmorl's nodes will be discussed for their presentation and distribution among individuals. It should be noted, however, that both osteoarthritis and osteophytosis may be traumatic in origin, and these conditions can be rather nonspecific in nature. Further information regarding the prevalence of these conditions in this skeletal sample is found in Chapter 11.

Spondylolysis

Spondylolysis (Figure 179) is a vertebral stress fracture that separates the neural arch from the remainder of the vertebra. This condition is caused by the sudden and often traumatic forward movement of the affected vertebral body beyond the normal range of motion (Capasso et al. 1999:24; Merbs 1996:357). Spondylolysis is characterized as partial, bilateral, or unilateral and may occur in any vertebra, although the condition most frequently occurs in the lower lumbar region (Merbs 1983:120). Finally, spondylolysis may occur at the interarticular area, the pedicle, or the lamina on the affected vertebra, although failure in the interarticular area is most common. The etiology of this condition is debated. Merbs (1983:172–174) suggested that spondylolysis is precipitated by a variety of factors, including genetic predisposition and behavioral patterns facilitating the development of the spondylolytic condition.

To find the frequency of spondylolysis among the skeletal sample, completeness scores for each lumbar vertebra were used to weight the total number of adult lumbar vertebrae recovered from the project area. Following the definitions for skeletal completeness described in Chapter 2, the number of complete elements was multiplied by a factor of 1, partial elements by a factor of 0.5, and fragmentary elements by a factor of 0.25. By incorporating completeness, a closer approximation of the actual quantity of observable material can be used to calculate the frequency of this condition. A similar method was used by Walker et al. (1996) to examine human remains recovered from CA-LAN-264, an archaeological site near Malibu, California, for such pathological conditions as periostitis (Walker et al. 1996:Table 14).

Within the Joint Courts Complex sample, 16 lumbar vertebrae associated with 14 individuals were affected by spondylolysis. This translated to a weighted frequency of approximately 1 percent for all adult lumbar vertebrae in the skeletal population (Table 193). At the individual level, approximately 3 percent of all adults recovered from the cemetery exhibited spondylolysis (Table 194). This discrepancy in frequencies is best explained by the incomplete recovery of elements assigned to specific individuals.

Although this condition was observed on the third and fourth lumbar vertebrae, the majority of the spondylolytic vertebrae were fifth lumbar vertebrae (see Table 193). Spondylolysis was limited to one instance per individual, with one dramatic exception, Grave Pit 7576, Burial Feature 9542. This individual, a female of 45+ years of age, exhibited spondylolysis of the third, fourth, and fifth lumbar vertebrae.

When the distribution and frequency of spondylolytic lumbar vertebrae by sex was explored, the male and female distributions were nearly identical (see Table 194). Spondylolysis was more expressed in the middle-adult females and rather equally distributed across young- and middle-adult males.

Hispanic, Euroamerican, and Native American individuals all expressed spondylolysis (Table 195). Nearly 65 percent of the individuals exhibiting spondylolysis were Hispanic, although the small number of cases of spondylolysis (n = 14) does not permit testing for statistical significance. Nearly 4 percent of all Hispanic individuals recovered from the cemetery exhibited spondylolysis; only 2.5 percent of all Euroamerican individuals recovered were similarly affected (see Table 195). Because so few individuals were identified as Native American, the frequency of spondylolysis associated with this group is unusually large but could likely be the result of chance (Beningfield and Heselson 1989).

Individuals exhibiting spondylolytic vertebrae were recovered from three areas in the cemetery: Cemetery Areas 3, 4, and 5 (Table 196). Interestingly, this is similar to other biological variables primarily observed in either the northern section (Cemetery Areas 3, 4, and 5) or the southern section (Cemetery Areas 1 and 2) of the cemetery (see Chapter 8). Most (approximately 70 percent) of these individuals were found in Cemetery Area 3. Furthermore, these individuals were clustered in the northwest, central, or northeast sections of Cemetery Area 3. This close spatial relationship may suggest a behavioral or genetic association among these individuals.

Clay-Shoveler's Fracture

Another type of vertebral fracture observed within this skeletal sample is the clay-shoveler's fracture (Figure 180). Gaining its name from a specific fracture first observed among laborers in nonindustrialized areas in the early-twentieth century, a clay-shoveler's fracture is an avulsion fracture (i.e., a fracture in which a fragment of bone tears away from the main mass of bone) associated with the sixth or seventh cervical or first thoracic vertebra, usually resulting when the trapezius and rhomboid muscles suddenly contract, breaking the bone (Solaroğlu et al. 2007:162; Unay et al. 2008:187). Although the contraction of the muscle is the causative factor of a clay-shoveler's fracture, direct trauma has also been suggested (Solaroğlu et al. 2007:163; Unay et al. 2008:187).

Clay-shoveler's fractures were only observed on the seventh cervical vertebrae in the Joint Courts Complex burial sample, although the condition is associated with multiple vertebrae in the literature. The frequency of this condition was determined using the same weighting method used to calculate the frequency of spondylolysis. Only three instances of clay-shoveler's fractures were observed, resulting in a 0.7 percent frequency at the element level, or approximately 1 percent at the individual level (see Tables 193 and 194).

All three clay-shoveler's fractures were associated with males: two middle adults and one young adult.

Schmorl's Nodes

Schmorl's nodes are small depressions occurring on the superior and/or inferior surfaces of the vertebral body (Figure 181). Research has shown that Schmorl's nodes are more frequent in the lower (seventh through twelfth) thoracic vertebrae and all five lumbar vertebrae (Capasso et al. 1999:38; Jurmain 1999:163).

Establishing the etiology of Schmorl's nodes is confounded by its seemingly ubiquitous nature. Some researchers assert that these fractures result from the herniation of the intervertebral disc, creating a nodule that, through repetitive mechanical activity and loading, forms lesions on the vertebral plate (Capasso et al. 1999:38).

As previously mentioned, Schmorl's nodes are generally more frequent in the lower (seventh through twelfth) thoracic and lumbar vertebrae (Capasso et al. 1999:38; Jurmain 1999:163). Overall, such a pattern was also observed in this skeletal sample. Generally speaking, the frequency of Schmorl's nodes increased from less than 1 percent in the upper (first through sixth) thoracic vertebrae to nearly 10 percent on the inferior surface of the eleventh thoracic vertebrae and began to diminish in frequency across the lumbar vertebrae and first sacral vertebra. In fact, the mean frequency of Schmorl's nodes in the upper thoracic vertebrae was only 0.7 percent, whereas the mean frequency in lower thoracic vertebrae was approximately 5 percent.

Schmorl's nodes were observed on the vertebrae of at least 106 adult individuals in the cemetery. This translates to a frequency of approximately 14.5 percent for all adult individuals recovered from the cemetery.

Several patterns emerge when examining the frequency of Schmorl's nodes in the sample according to sex, biological affinity, and age (Table 197). First, four times as many males (n = 77) were observed with Schmorl's nodes than females (n = 21). Among all individuals for whom sex was determined, 24.3 percent of males exhibited Schmorl's nodes, whereas only 9.2 percent of females showed the lesions. This predilection toward male individuals supports previous research (Hilton et al. 1976). Additionally, of the individuals with Schmorl's nodes for whom biological affinity could be estimated (n = 73), the majority of the individuals were Hispanic or Euroamerican, with approximately twice as many Hispanic individuals (n = 45) as Euroamerican (n = 21). Finally, approximately 80 percent of the individuals were either young or middle adults, with nearly equal numbers of individuals represented by each (see Table 197).

Vertebral-Compression Fractures

Compression fractures of the spine generally occur from a fall and, in most cases, are the result of an accident (Ortner 2003:144). However, a large number of compression fractures also occur from synergism involving trauma and a degenerative condition, like senile osteoporosis, or a disease process, like tuberculosis of the spine. Once the structural integrity of the underlying bone is weakened, accident or stress more easily causes vertebral body failure. The most-common vertebral-compression fracture is the collapse of the anterior aspect of the body, creating a wedge-shaped appearance to the vertebra (Figure 182).

Thirty-seven vertebral-compression fractures were observed on a minimum of 22 adult individuals. This translates to an approximate frequency of 3 percent for all adult individuals recovered from the cemetery. Several demographic-based patterns emerge (Table 198). First, approximately four times as many males (n = 17) as females (n = 4) were observed with vertebral-compression fractures, a finding significant at the 0.05 level ($\chi^2 = 8.048$, $df = 1$, $p = .005$). Additionally, of the individuals for whom biological affinity could be estimated (n = 17), the majority were Hispanic. There were nearly three times as many Hispanic individuals (n = 11) with vertebral-compression factures observed as Euroamerican (n = 4) and nearly six times as many Hispanic individuals as Native American (n = 2). Of course, the frequency for Native American individuals is actually relatively high, because their numbers were so few. However, the limited sample size did not permit further testing. Finally, this traumatic condition was observed in all adult categories (i.e., young, middle, and old), but nearly twice as many middle adults as young or old adults were affected (see Table 198).

The overall pattern of vertebral-compression fractures is similar to the observations on Schmorl's nodes in this skeletal sample, with an increased distribution in the lower thoracic and lumbar vertebrae, particularly the eighth and twelfth thoracic and fifth lumbar vertebrae. The distribution of vertebral-compression fractures in this skeletal sample, however, is rather bimodal, as fractures also occur in the mid- to lower-cervical vertebrae. Compression fractures were rare from the seventh cervical to the fourth thoracic vertebrae.

One interesting observation regarding Schmorl's nodes and vertebral-compression fractures is that, of the 22 adult individuals exhibiting vertebral-compression fractures in this skeletal sample, half also exhibited Schmorl's nodes. As reported by Pfirrmann and Resnick (2001:368), Schmorl's nodes have been found to be associated with moderate degenerative disc disease. Likewise, vertebral-compression fractures can also be related to degeneration of the spine. The prior condition of degenerative changes to the spine can lead to incidences of both Schmorl's nodes and compression fractures. It is unclear for these 22 individuals, however, whether the presence of one trauma type precipitated or exacerbated the presence of the other.

Dislocation

A dislocation, or luxation, is a traumatic condition in which two bones forming a joint are forced out of anatomical position, significantly disrupting the joint capsule (Aufderheide and Rodríguez-Martin 1998:25; Ortner and Putschar 1981:85). In order to detect a dislocation in dry bone, the condition must have been chronic, causing considerable damage to the joint capsule. Dislocations treated soon after occurrence or mild forms of dislocation generally go undetected in dry bone. Although any joint may be affected, the shoulder and hip are the most commonly observed sites of dislocation.

To calculate the frequency of dislocations, it was necessary to correct for the number of elements present. Similar to the method used for spinal trauma described above, the total numbers of adult shoulder and hip joints were determined, to establish the number of individuals who could exhibit evidence of dislocation. Therefore, regarding the shoulder joint, an individual was counted as whole if both the left and right shoulders were available for examination and as half if only one shoulder was available and was excluded if neither shoulder was available. For shoulder dislocation, the corrected number of individuals in the sample was 639. Of these, 3 showed evidence of dislocation, resulting in a frequency of 0.47 percent. Likewise, the frequency of hip dislocations was determined by a corrected number of individuals of 666. Of these, 6 showed evidence of hip dislocation, resulting in a frequency of 0.9 percent.

Because of the low numbers of individuals with dislocations, meaningful patterns were difficult to assess. Both males and females suffered dislocations, and the entire range of adult ages was represented. The infrequency of the condition also suggests that the injury was not associated with any regular activity or occupation. Indeed, if dislocations were a regular consequence of specific behaviors in Tucson in the mid-nineteenth century, one would expect a higher proportion of individuals to show evidence of this trauma. Additionally, not every incidence of dislocation results in skeletally observable evidence. If the joint is "relocated" soon after the injury, the skeletal elements may show no evidence of the injury having occurred.

Comparison with Other Populations

The extent and distribution of skeletal trauma from a cemetery population provides useful information for reconstructing the individual and group characteristics of those who populated the cemetery. Equally important is a comparison of injuries sustained in one population to injuries sustained in other populations. Such comparisons are critical in identifying biological and behavioral anomalies possibly unique to a particular group of individuals in a particular spatial and temporal environment.

Unfortunately, direct comparisons are often impossible. The incompatibilities among data sets are many, and the qualitative nature of skeletal-trauma evaluation leads to problems in both data collection and data reporting. Because of these limitations, only the most broad and general comparisons may be drawn among different data sets. Trauma analysis relies on observations supporting sensible hypotheses, but unknowable factors are too numerous to permit definitive statements. Consequently, a responsible comparison of skeletal trauma from various data sources is done without undue reliance on interpretation.

That said, three data sets were selected for examination against observations of trauma from the Alameda-Stone cemetery. These included Freedman's Cemetery in Texas, Elmbank Church and Cemetery in Toronto, and the African Burial Ground in New York. These comparative data sets are introduced in full in Chapter 1. Their selection for comparison to the Joint Courts Complex sample is based on two considerations. First, the available information on trauma reported for each is generally adaptable for comparison to this sample. Second, each site represents a range of characteristics in location, time period, and composition, allowing for various attributes similar and dissimilar to the Alameda-Stone cemetery to be evaluated for trauma frequency and distribution. Comparisons among these cemetery populations can help illuminate consistencies or disparities in the manifestations of skeletal trauma across several varied samples.

As noted above, however, skeletal-trauma analysis does not yet benefit from standardized observation and recordation in the same way element measurements or epigenetic traits do. Comparisons among many samples, therefore, must be made using the data with the greatest reliability and consistency across data sets. To that end, skeletal trauma observed on the Alameda-Stone cemetery population is compared to that of other sites using trauma frequencies in each of five skeletal regions (Cranial, Arms, Hands, Legs, and Feet), as well as a single element type, the clavicle. This design provides for the richest collection of comparable data. Direct comparisons are available for all skeletal regions only between the Alameda-Stone and Freedman's cemeteries. The Elmbank Cemetery sample is missing frequency data for the Hands and Feet regions, but information for the Cranium, Arms, and Legs regions and the clavicle are available. Table 199 shows the available

frequencies for skeletal trauma observed on each region for the Alameda-Stone, Freedman's, and Elmbank cemeteries. It is important to note, as well, that frequencies examined in this section are based on total numbers of individuals from each site, without the correction for observability made in the preceding sections.

Trauma distribution in the Joint Courts Complex sample is generally similar to that of Freedman's and Elmbank Cemeteries, with some variation in magnitude. The skeletal region with the highest frequency of trauma for both the Alameda-Stone (4.31 percent) and Elmbank Cemetery (8.25 percent) samples was the Cranial region. Freedman's Cemetery featured only 4.2 percent cranial trauma, roughly half the frequency reported from Elmbank Cemetery. Trauma recorded on the Arms region is equivalent for all three samples.

Clavicle trauma among the three samples showed a curious distribution. The Joint Courts Complex sample featured clavicle trauma at just 1.63 percent. A clavicle-trauma frequency of 2.9 percent was reported for Freedman's Cemetery. Elmbank Cemetery, however, showed a notably higher clavicle-trauma frequency of 5.56 percent. The reasons for this higher incidence of clavicle trauma at Elmbank Cemetery is not addressed in the primary literature. Indeed, it is unclear whether the 1.63 percent from the Alameda-Stone and the 2.9 percent from Freedman's Cemetery represent an unusually low frequency of clavicle trauma or Elmbank Cemetery's 5.56 percent represents an unusually high frequency. Furthermore, because the most common cause for clavicular fractures is a ubiquitous fall onto outstretched arms (Galloway 1999:115), few conclusions can be drawn from these frequencies.

The only remaining skeletal region allowing for three-way examination was the Legs region, and another interesting comparison emerged. Leg-trauma frequencies were roughly similar between the Alameda-Stone (3.35 percent) and Elmbank Cemetery (2.82 percent) samples. Freedman's Cemetery, however, reported a leg-trauma frequency of 8.6 percent. This is between two and three times the frequency seen at the Alameda-Stone and Elmbank Cemetery. Clearly, the sample from Freedman's Cemetery suffered from a larger-than-expected incidence of leg trauma. Tiné (2000:509) suggested some reasons for the high frequency of leg trauma in the Freedman's Cemetery sample. Although these may provide an explanation for the high *within-sample* frequency of leg trauma, they do not suggest an explanation for the high frequency of leg trauma at Freedman's Cemetery, compared to other sites.

Trauma frequencies for the extremities are missing from the Elmbank Cemetery data set, and comparisons could be drawn between the Alameda-Stone and Freedman's Cemetery samples only for trauma occurring on the Hands and Feet regions. The Joint Courts Complex sample featured slightly less trauma of the hands (3.16 percent) than was seen at Freedman's Cemetery (4.8 percent). A wider disparity was seen in foot-trauma frequencies: the Joint Courts Complex sample showed a foot-trauma frequency of 2.20 percent, whereas the Freedman's Cemetery sample featured a foot-trauma frequency of 4.2 percent. Although these are not equal in magnitude, it is unsurprising that the Freedman's Cemetery sample reported more foot trauma, given the high incidence of lower-limb trauma in general and of leg trauma in particular. Interestingly, the Freedman's Cemetery sample showed equal frequencies (4.2 percent) for both cranial trauma and foot trauma. The Joint Courts Complex sample, however, showed a cranial-trauma frequency (4.31 percent) nearly double that of foot trauma (2.20 percent). Unfortunately, it is unclear whether the frequency for foot trauma was unusually high at the Joint Courts Complex or unusually low at Freedman's Cemetery.

It was not possible to obtain raw data or corrected frequencies on trauma from the authors of the African Burial Ground report. Despite that, a sense of the level of traumatic injuries suffered by enslaved populations (although impossible to compare quantitatively to the Joint Courts Complex sample) can be surmised from the reported frequencies, although the percentages are likely inflated to a degree, representing the method of calculation rather than solely a higher incidence of traumatic injuries. Nevertheless, a rank-order assessment of trauma by region allows for comparison of the African Burial Ground sample to those described above. Table 200 shows the rank order of trauma by skeletal region for the Joint Courts Complex, Freedman's Cemetery, Elmbank Cemetery, and African Burial Ground samples. In each, skeletal regions exhibiting the most trauma are noted as "1st," and subsequent regions are listed in descending order of frequency. Although this method does not permit the assessment of differences in magnitude of observed trauma, it does allow for a reliable comparison of the distribution of trauma across the skeleton for each sample.

The Joint Courts Complex sample showed the highest incidence of trauma on the cranium, as did the sample from Elmbank Cemetery. Interestingly, both the Freedman's Cemetery and African Burial Ground samples

featured the highest incidence of trauma on the legs, and cranial trauma was third most common for both samples. The second-most-frequent region for trauma in the Elmbank Cemetery sample was the clavicle, which was the *least* frequent region for the other samples with clavicle data (Joint Courts Complex and Freedman's Cemetery). Indeed, several discrepancies are apparent among the rank orders of the various samples.

No two samples featured the same rank order for trauma by skeletal region. These differences serve to underscore the uniqueness of each sample in any number of attributes, including the composition, location, and intended purpose of each cemetery. Indeed, each sample represents a particular, generally composed group. The Alameda-Stone cemetery was a municipal cemetery, Freedman's Cemetery was composed primarily of individuals of the lowest socioeconomic statuses, Elmbank Cemetery was associated specifically with the rural Catholic community northwest of Toronto, and the African Burial Ground consisted almost entirely of enslaved Africans. Each of these cemeteries comprised individuals with greatly different activities, behaviors, obligations, and hazards. These differences are reflected in the patterns of trauma observed in each. Although detailed comparisons of injuries from these cemetery populations is beyond the scope of the present discussion and the capacities of the available data, a general evaluation of incidence of trauma from these samples indicates that the Joint Courts Complex is neither unique nor common in trauma magnitude and distribution.

Conclusions

The patterns and distribution of skeletal trauma from the Alameda-Stone cemetery provide for a unique perspective on occupational demands, behavioral hazards, and, to a lesser degree, consequences of personal interactions. The success of and access to medical treatments are revealed by observations of nonlethal injuries. Differences among individuals' attributes, such as age, sex, and biological affinity, are important foundations for trauma comparison, to examine what dangers were faced by whom. Indeed, skeletal trauma—as innocuous and common as Schmorl's nodes or as devastating as a life-threatening gunshot wound—is among the most immediate and behavioral of observations available to biological anthropologists. Far more than demographic, biometric, or even pathologic data, the response of the skeleton to force and activity provides the greatest view into what was being done by whom.

Unfortunately, the interpretation of skeletal trauma is often frustrated by the numerous ways in which similar injuries may be sustained, as well as the fundamental impossibility of exact reconstruction of the events leading to trauma and their timing relative to death. Of the 197 primary individuals from the cemetery who exhibited evidence of trauma, very few showed enough information for a reasonable and responsible interpretation of the circumstances surrounding the injuries, whether they were intentional or accidental, survivable or fatal. The rest were evaluated, not based on consideration of the universe of possible scenarios, but according to the reliability of the evidence and the soundness of the conclusions. Skeletal-trauma interpretation is an enterprise that frequently tempts speculation.

Some general patterns were observed among the instances of trauma from the cemetery sample. Evidence of injury increased with age. Fetal and infant individuals showed few incidences of trauma, whereas nearly one in every two adult individuals showed evidence of trauma. Males exhibited significantly more trauma than did females, especially in the Cranial, Thoracic, and Hands regions. Very few meaningful differences in observable trauma were noted among the different biological groups, but any such differences may be diluted by other attributes, such as age and sex. Spatially, Cemetery Area 2 showed the highest proportion of individuals with trauma (see also Chapter 7, Volume 1 of this series).

A total of 143 general, nonvertebral fractures were recorded, of which 94.4 percent occurred long enough before death for evidence of skeletal response to appear. Ten fractured long bones healed misaligned, and 9 presented evidence of active infections associated with the broken elements. The proportion of antemortem fractures is unsurprising, as broken long bones are generally survivable. It is unclear whether those 9 fractures with infections active at the time of death contributed to death. Vertebral trauma in the form of spondylolysis and Clay-shoveler's fractures was observed on 1 percent or fewer of the adult elements. At the individual level,

2 percent of adults exhibited vertebral-compression fractures, and slightly over 10 percent of adult individuals presented Schmorl's nodes on one or more vertebrae.

Overall, the frequency and distribution of trauma observed in the cemetery sample was not dramatically dissimilar to those expected of a nineteenth-century municipal cemetery in the U.S. Southwest. Special cases of weapons injury and trauma resulting from surgery or autopsy were observed in limited numbers. These findings, of course, establish that both violence and medical procedures were present in the time and place associated with the cemetery. The low *observed* frequency, however, is insufficient to suggest the *total* frequency of these behaviors; it is impossible to know how often weapons or medical techniques that left no skeletal evidence were employed.

This chapter has served to describe the details and generalities of skeletal trauma observed from the cemetery. Discussion of the factors leading to and resulting from injuries in the population appears in Chapter 7, Volume 1 of this series. This chapter has demonstrated that the skeletal trauma observed from the cemetery followed general patterns and also featured unique and unusual cases. Demographic and spatial attributes were considered, to identify trends or patterns in individuals showing trauma, and comparisons were made with other varied samples, to determine this sample's place among them. The above discussion, when joined with other observations of the cemetery, such as artifact analysis and historical documentation, will help in understanding the lives of the people in and around Tucson in the mid-nineteenth century, the activities in which they engaged, and the dangers they faced, from the prosaic to the deadly.

Figure 175. Left radius with antemortem fracture and periosteal reaction, Individual P, Grave Pit 13848, Burial 28554, a middle-adult Hispanic male.

Figure 176. Misaligned antemortem fracture of the left tibia, Individual P, Grave Pit 3288, Burial 7199, a young-adult Euroamerican male.

Figure 177. Amputated proximal left tibia and fibula, Individual P, Grave Pit 3231, Burial 6901, a middle-adult Hispanic male.

Figure 178. Sawed cranium, indicative of autopsy, Individual P, Grave Pit 10126, Burial 19954, an old-adult Hispanic male.

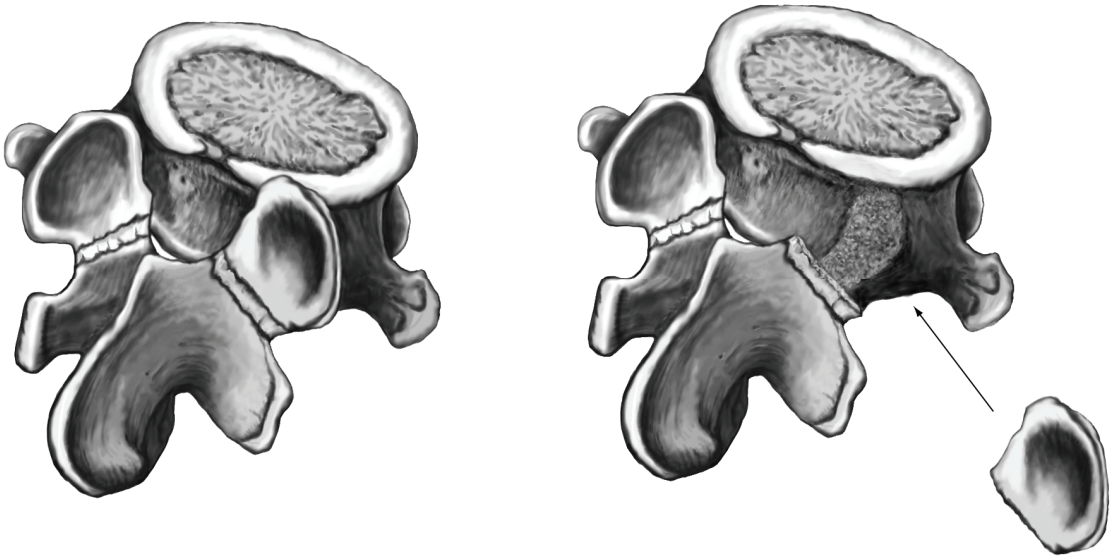

Figure 179. Spondylolysis.

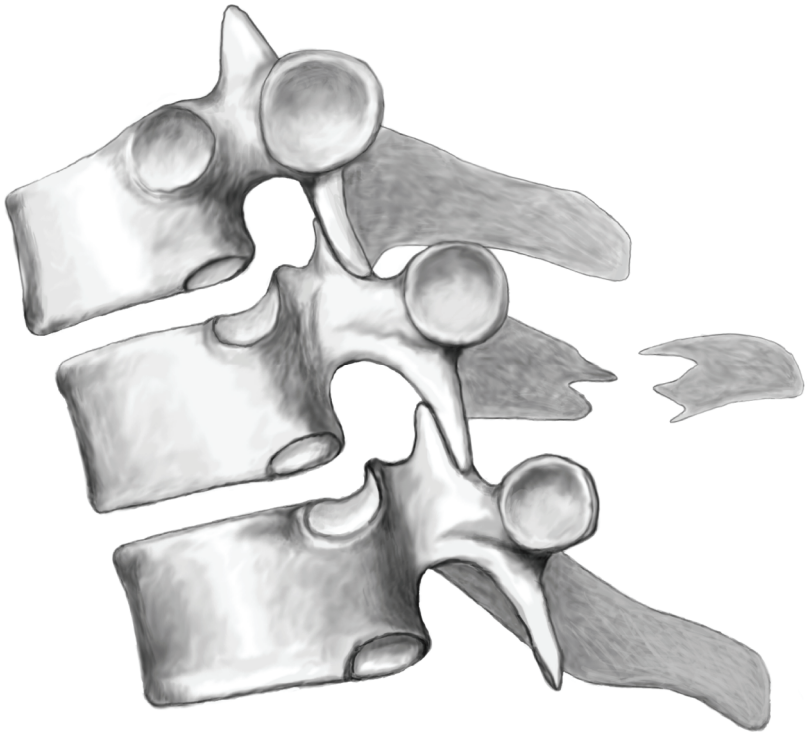

Figure 180. Clay-shoveler's fracture.

Figure 181. Schmorl's nodes on seventh through tenth thoracic vertebrae, Individual P, Grave Pit 3241, Burial 6835, a middle-adult Hispanic male.

Figure 182. Seventh through twelfth thoracic vertebrae, showing compression fractures, Individual P, Grave Pit 952, Burial 7022, a middle-adult Euroamerican male.

Table 176. Trauma Frequencies, by Cemetery Area, Biological Affinity, and Sex

Sex, by Biological Affinity	Cemetery Area					Total
	1	2	3	4	5	
Euroamerican						
Male	0	16	8	2	1	27
Female	0	2	4	0	0	6
Indeterminate	1	0	1	1	0	3
Hispanic						
Male	1	19	33	4	3	60
Female	0	1	21	3	2	27
Indeterminate	0	0	4	1	1	6
Native American						
Male	0	1	5	0	0	6
Female	0	0	6	0	0	6
Indeterminate	0	0	1	0	0	1
Indeterminate						
Male	2	4	15	11	0	32
Female	0	0	8	3	0	11
Indeterminate	4	1	5	1	1	12
Total	8	44	111	26	8	197

Table 177. Trauma Frequency and Distribution, by Age

Age	Observable Individuals	Individuals with Trauma	Frequency of Trauma (%)	Distribution of Trauma (%)
Juvenile				
Fetal	34	1	2.94	0.51
Infant	204	4	1.96	2.03
Child	99	5	5.08	2.54
Subadult	22	6	26.68	3.05
Subtotal	359	16	4.45	8.12
Adult				
Young adult	172	64	37.30	32.49
Middle adult	154	76	49.33	38.58
Old adult	67	33	49.01	16.75
Adult	12	8	68.68	4.06
Subtotal	405	181	44.73	91.88
Total	764	197	25.79	100.00

Table 178. Observed and Expected Trauma for Adult Age Groups

Age	Observed		Expected	
	No Evidence of Trauma	Evidence of Trauma	No Evidence of Trauma	Evidence of Trauma
Young adult	108	64	96.285	75.715
Middle adult	78	76	86.209	67.791
Old adult	34	33	37.506	29.494
Total	220	173		

Pearson's chi-square test: $\chi^2 = 5.758$; df = 2; $p = 0.056$.

Table 179. Trauma Frequency and Distribution, by Sex

Sex	Observable Individuals	Individuals with Trauma	Frequency of Trauma (%)	Distribution of Trauma (%)
Female	163	50	30.67	28.57
Male	229	125	54.59	71.43
Total	392	175	44.64	100.00

Table 180. Trauma, by Sex and Skeletal Region

Trauma, by Sex	Skeletal Region					
	Cranial	Thoracic	Arms	Hands	Legs	Feet
Female	164	167	179	152	181	138
Trauma	8	22	7	3	11	5
Percent with trauma	4.89	13.21	3.91	1.98	6.06	3.61
Male	220	235	253	220	247	198
Trauma	35	65	21	21	20	15
Percent with trauma	15.90	27.68	8.31	9.52	8.11	7.57

Table 181. Pearson's Chi-Square-Test Values for Trauma, by Skeletal Region and Sex

Skeletal Region	Male	Female
Arms[a]		
Total	253	179
Observed trauma	21	7
Expected trauma	16.398	11.602
Cranial[b,c]		
Total	220	164
Observed trauma	35	8
Expected trauma	24.635	18.365
Feet[d]		
Total	198	138
Observed trauma	15	5
Expected trauma	11.786	8.214
Hands[e,c]		
Total	220	152
Observed trauma	21	3
Expected trauma	14.194	9.806
Legs[f]		
Total	247	181
Observed trauma	20	11
Expected trauma	17.89	13.11
Thoracic[g,c]		
Total	235	167
Observed trauma	65	22
Expected trauma	50.858	36.142

[a]Chi-square-test values: $\chi^2 = 3.333$; $df = 1$; $p = .068$.
[b]Chi-square-test values: $\chi^2 = 11.498$; $df = 1$; $p < .01$.
[c]Significant at the $\alpha = 0.05$ level.
[d]Chi-square-test values: $\chi^2 = 2.269$; $df = 1$; $p = .132$.
[e]Chi-square-test values: $\chi^2 = 8.539$; $df = 1$; $p < .01$.
[f]Chi-square-test values: $\chi^2 = 0.634$; $df = 1$; $p = .426$.
[g]Chi-square-test values: $\chi^2 = 12.08$; $df = 1$; $p < .01$.

Table 182. Trauma Frequency and Distribution, by Biological Affinity

Biological Affinity	Individuals with Trauma	Frequency of Trauma (%)	Distribution of Trauma (%)	Total
Euroamerican	36	37.50	25.35	96
Hispanic	93	45.15	65.49	206
Native American	13	39.39	9.15	33
Total	142	42.39	100.00	335

Table 183. Pearson's Chi-Square-Test Values for Trauma, by Biological Affinity

Biological Affinity	Total	Observed Trauma	Expected Trauma
Euroamerican	96	36	40.693
Hispanic	206	93	87.319
Native American	33	13	13.988
Total	335	142	

Note: Pearson's chi-square test: $\chi^2 = 1.702$; $df = 2$; $p = 0.427$.

Table 184. Trauma Frequency and Distribution, by Cemetery Area

Cemetery Area	Individuals with Trauma	Frequency of Trauma (%)	Distribution of Trauma (%)	Total
1	8	61.54	4.06	13
2	44	58.67	22.34	75
3	111	21.35	56.35	520
4	26	19.85	13.20	131
5	8	32.00	4.06	25
Total	197	25.79	100.00	764

Table 185. Trauma Frequency and Distribution for Adults, by Civilian Cemetery Area

Cemetery Area	Individuals with Trauma	Frequency of Trauma (%)	Distribution of Trauma (%)	Total
2	43	64.18	24.71	67
3	101	41.74	58.05	242
4	24	34.29	13.79	70
5	6	37.50	3.45	16
Total	174	44.10	100.00	395

Table 186. Pearson's Chi-Square-Test Values for Trauma, by Cemetery Area

Cemetery Area	Total	Observed Trauma	Expected Trauma
2	67	43	29.514
3	242	101	106.603
4	70	24	30.835
5	16	6	7.048

Note: Pearson's chi-square test: $\chi^2 = 14.527$; $df = 3$; $p < 0.01$.

Table 187. Proportion of Observable Adult Males, by Cemetery Area and Frequency of Trauma

Cemetery Area	Total (n)	Males (n)	Males with Trauma (n)	Proportion of Males per Area (%)	Frequency of Males with Trauma per Area (%)
2	67	59	39	88.1	66.1
3	242	114	61	47.1	53.5
4	70	40	17	57.1	42.5
5	16	8	4	50.0	50.0

Table 188. Distribution of General Skeletal Fractures, by Region and Timing

Region	Antemortem Fractures (n)	Perimortem Fractures (n)	Total
Arms	22	2	24
Cranial	35	5	40
Feet	23	0	23
Hands	11	0	11
Legs	12	1	13
Thoracic	32	0	32
Total	135	8	143

Table 189. Antemortem Fractures, by Skeletal Region and Individual

Sex, by Biological Affinity	Skeletal Region						Total
	Cranial	Thoracic	Arms	Hands	Legs	Feet	
Euroamerican							
Male	5	6	2	0	1	4	18
Female	1	0	0	0	0	0	1
Indeterminate	0	0	0	1	0	0	1
Hispanic							
Male	15	7	7	4	3	7	43
Female	0	1	2	0	1	1	5
Indeterminate	1	0	0	0	0	1	2
Native American							
Male	0	0	2	0	0	0	2
Female	0	0	0	0	1	0	1
Indeterminate	0	0	1	0	0	0	1
Indeterminate							
Male	2	1	3	3	0	3	12
Female	1	1	1	0	4	1	8
Indeterminate	1	1	1	2	0	2	7
Total	26	17	19	10	10	19	101

Table 190. Individuals with Arm or Leg Elements with Antemortem Fractures

Grave Pit	Burial Feature	Individual	Age	Sex	Biological Affinity	Cemetery Area	Element	Side	Infection?	Misaligned?
726	13500	primary	middle adult	male	Hispanic	3	radius	left	no	yes
726	13500	primary	middle adult	male	Hispanic	3	ulna	left	no	yes
875	2769	primary	middle adult	male	Hispanic	3	ulna	right	no	no
3115	3628	primary	middle adult	male	Hispanic	3	ulna	left	yes	no
3248	3777	primary	old adult	male	Hispanic	2	fibula	left	yes	no
3288	7199	primary	young adult	male	Euroamerican	2	fibula	left	no	yes
3288	7199	primary	young adult	male	Euroamerican	2	radius	left	no	yes
3288	7199	primary	young adult	male	Euroamerican	2	tibia	left	no	yes
3288	7199	primary	young adult	male	Euroamerican	2	ulna	left	no	yes
3357	6837	primary	middle adult	male	Euroamerican	2	radius	right	no	no
5196	8659	primary	adult	male	Hispanic	5	ulna	left	no	no
5195	8702	primary	infant	indeterminate	indeterminate	5	radius	right	yes	no
7503	9625	primary	middle adult	male	Native American	3	ulna	left	no	no
7574	8995	primary	middle adult	female	Hispanic	3	ulna	left	no	no
7745	12776	primary	old adult	female	indeterminate	4	fibula	left	no	no
7838	16822	primary	young adult	female	indeterminate	3	fibula	right	yes	no
7838	16822	primary	young adult	female	indeterminate	3	tibia	right	yes	no
7862	18599	primary	young adult	male	indeterminate	3	humerus	left	no	no
7912	18723	primary	old adult	male	Hispanic	3	ulna	left	no	no
7917	18925	primary	old adult	female	indeterminate	3	humerus	right	no	no
7920	18909	primary	middle adult	female	Hispanic	3	fibula	left	no	yes
7923	18901	primary	old adult	male	Native American	3	ulna	left	no	no
7923	18901	primary	old adult	male	Native American	3	radius	left	no	no
7941	18929	primary	middle adult	female	indeterminate	3	fibula	right	no	no
10131	21541	primary	old adult	female	indeterminate	3	femur	right	no	no
10132	21555	primary	middle adult	male	Hispanic	3	tibia	left	no	no

Grave Pit	Burial Feature	Individual	Age	Sex	Biological Affinity	Cemetery Area	Element	Side	Infection?	Misaligned?
10309	28677	primary	subadult	indeterminate	Native American	3	humerus	left	yes	no
12955	28615	primary	middle adult	male	Hispanic	3	ulna	left	no	no
13566	25073	primary	old adult	male	Hispanic	3	fibula	left	yes	yes
13848	28554	primary	middle adult	male	Hispanic	3	radius	left	yes	yes
13925	28767	primary	young adult	female	Native American	3	tibia	left	no	no
17548	25345	primary	middle adult	male	indeterminate	3	humerus	right	yes	no
17621	19785	primary	old adult	female	Hispanic	3	radius	left	no	no
17874	19999	primary	old adult	male	indeterminate	3	ulna	left	no	yes

Table 191. Individuals with Evidence of Amputation or Autopsy

Grave Pit	Burial Feature	Age	Sex	Biological Affinity	Cemetery Area	Condition	Pathology
785	3810	adult	male	indeterminate	1	amputation: left fibula	None observed.
813	6747	adult	indeterminate	indeterminate	1	autopsy: thorax	None observed.
3231	6901	middle adult	male	Hispanic	2	amputation: left lower leg	Infection near site of amputation.
3239	3799	young adult	male	Euroamerican	2	autopsy: cranium	Healed depression fracture; infection on left humerus.
10126	19954	old adult	male	Hispanic	3	autopsy: cranium	Fractures and infection on left lower ribs.
13706	26489	child	indeterminate	indeterminate	4	amputation: left lower arm	Infection near site of amputation.

Table 192. Individuals with Weapons Trauma

Grave Pit	Burial Feature	Individual Name	Sex	Age	Cemetery Area	Biological Affinity	Condition	Healing?
534	1278	P	male	middle adult	2	Euroamerican	gunshot wound	no
592	2595	P	male	middle adult	2	Hispanic	gunshot wound	no
3244	3417	P1	male	middle adult	2	Hispanic	arrow	no
3288	7199	P	male	old adult	2	Euroamerican	gunshot wound	yes
5196	8659	P	male	young adult	5	Hispanic	gunshot wound	no
5392	8899	P	male	old adult	5	indeterminate	gunshot wound	yes
7529	8941	P	indeterminate	child	3	Euroamerican	gunshot wound	yes
7797	13206	P	male	middle adult	4	Hispanic	gunshot wound	no
7810	13131	P	female	middle adult	4	indeterminate	gunshot wound	no
10138	23296	P	male	middle adult	3	indeterminate	sharp-force trauma	no
13539	21747	P	male	young adult	3	Hispanic	gunshot wound	yes
13614	21829	P	male	middle adult	3	Euroamerican	gunshot wound	yes
13699	28544	P	male	middle adult	4	Hispanic	arrow	yes
13848	28554	P	male	middle adult	3	Hispanic	blunt-force trauma	yes
17765	19780	P	indeterminate	middle adult	3	Hispanic	gunshot wound	yes
22157	21848	P1	female	young adult	3	Euroamerican	blunt-force and sharp-force trauma	no
22157	21848	P2	male	middle adult	3	indeterminate	blunt-force and sharp-force trauma	no
24758		2	male	old adult	4	indeterminate	sharp-force trauma	no

Table 193. Frequency of Lumbar Spondylolysis and Clay-Shoveler's Fractures for All Adult Individuals, by Element

Element Name, by Trauma	Completeness			Number of Elements		Number of Affected Elements	Frequency	
	Complete	Partial	Fragment	Total	Weighted		Total Frequency	Weighted Frequency
Clay-shoveler's fracture								
Seventh cervical	403	7	35	445	415.3	3	0.7	0.7
Lumbar spondylolysis								
Third lumbar	378	39	12	429	400.5	1	0.2	0.2
Fourth lumbar	381	42	11	434	404.8	2	0.5	0.5
Fifth lumbar	386	42	10	438	409.5	12	2.7	2.9
Unknown lumbar	81	85	87	253	145.3	1	0.4	0.7
Total lumbar	1,226	208	120	1,554	1,360.0	16	1.0	1.2

Table 194. Frequency of Spondylolysis and Clay-Shoveler's Fractures, by Age and Sex

Age	Spondylolysis			Clay-Shoveler's Fracture	
	Female	Male	Both	Female	Male
Young adult					
Total	91	103	194	91	103
Individuals with lesions	2	4	6	0	1
Frequency	2.20	3.88	3.09	0	0.97
Middle adult					
Total	75	99	174	75	99
Individuals with lesions	4	3	7	0	2
Frequency	5.33	3.03	4.02	0	2.02
Old adult					
Total	12	33	45	12	33
Individuals with lesions	0	1	1	0	0
Frequency	0	3.03	2.22	0	0
Indeterminate adult					
Total	18	34	52	18	34
Individuals with lesions	0	0	0	0	0
Frequency	0	0	0	0	0
All adults					
Total	196	269	465	196	269
Individuals with lesions	6	8	14	0	3
Frequency	3.06	2.97	3.01	0	1.12

Table 195. Distribution of Lumbar Spondylolysis, by Biological Affinity

Biological Group	Total Number of Individuals	Individuals with Lesions	Frequency
African American	1	0	0.00
Euroamerican	121	3	2.48
Hispanic	248	9	3.63
Native American	42	1	2.38
Indeterminate	679	1	0.15
Total	1,091	14	1.28

Table 196. Distribution of Spondylolysis and Associated Demographic Information across the Cemetery

Cemetery Area	Number of Burials	Sex		Age			Biological Affinity			
		Male	Female	Young Adult	Middle Adult	Old Adult	Hispanic	Euroamerican	Native American	Indeterminate
3	10	5	5	4	5	1	6	3	1	
4	3	3		1	2		2			1
5	1		1	1			1			

Table 197. Demographic Profile of Individuals with Observable Schmorl's Nodes

Attribute	Number	Frequency
Age		
Young adult	40	37.74
Middle adult	45	42.45
Old adult	16	15.09
Indeterminate adult	5	4.72
Age total	106	100.00
Biological affinity		
Native American	7	6.60
Euroamerican	21	19.81
Hispanic	45	42.45
Indeterminate	33	31.13
Biological-affinity total	106	100.00
Sex		
Female	21	19.81
Male	77	72.64
Indeterminate	8	7.55
Sex total	106	100.00

Table 198. Demographic Profile of Individuals with Observable Compression Fractures

Attribute	Number	Frequency
Age		
Young adult	6	27.27
Middle adult	10	45.45
Old adult	6	27.27
Indeterminate adult		0.00
Age total	22	100.00
Biological affinity		
Native American	2	9.09
Euroamerican	4	18.18
Hispanic	11	50.00
Indeterminate	5	22.73
Biological-affinity total	22	100.00
Sex		
Female	4	18.18
Male	17	77.27
Indeterminate	1	4.55
Sex total	22	100.00

Table 199. Trauma Frequencies for the Alameda-Stone Cemetery, Freedman's Cemetery, and Elmbank Cemetery Samples, by Skeletal Region

Skeletal Region	Alameda-Stone Cemetery	Freedman's Cemetery	Elmbank Cemetery
Arms	3.07	3.5	3.32
Clavicle	1.63	2.9	5.56
Cranial	4.31	4.2	8.25
Feet	2.20	4.2	—
Hands	3.16	4.8	—
Legs	3.35	8.6	2.82

Table 200. Rank-Order Trauma Frequencies for the Joint Courts Complex and Comparative Samples, by Skeletal Region

Skeletal Region	Joint Courts Complex	Freedman's Cemetery	Elmbank Cemetery	African Burial Ground
Arms	4th	5th	3rd	2nd
Clavicle	6th	6th	2nd	
Cranial	1st	3rd	1st	3rd
Feet	5th	3rd		5th
Hands	3rd	2nd		4th
Legs	2nd	1st	4th	1st

CHAPTER 13

Dental Health in Late-Nineteenth-Century Tucson

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Late-nineteenth-century Tucson was an Arizona frontier settlement with a multiethnic community largely composed of Hispanic and Native American people and Euroamerican migrants. The recovery of over a thousand of the inhabitants of this resilient western town has opened a window to the past and presents an opportunity to better understand life in Tucson during the 1800s. This chapter presents the results of a detailed analysis of a large sample of the dentitions of the adult burial population from that frontier community.

Research objectives for the dental analysis of the cemetery sample included determining the general dental health for the entire population and possible variation in health between cemetery groups, based on biological affinity and sex. Many factors influence the dental health of a population, including the types of foods consumed, the manner in which the foods are processed and prepared, and the extent of physiological stress related to the environment (Adams 1999; Bhat and Nelson 1989; Buikstra and Ubelaker 1985; El-Najjar et al. 1978; Goodman, Martin, et al. 1984; Goodman and Rose 1991; Harmon and Rose 1988; Larsen et al. 1991; Lingström et al. 2000; Rose et al. 1985; Turner 1979). Additionally, social and economic identity may be reflected in the state of an individual's dental health, the presence of dental restorations or other evidence of professional dentistry, or unusual forms of dental wear indicating a daily activity involving the teeth (Glenner and Willey 1998; Kirk 1896; Larsen 1985; Little et al. 1992; Milner and Larsen 1991; Molnar 2008; Molnar 1972; Schulz 1977; Walker and Hewlett 1990; Wheat 1967; Wynbrandt 2000). These variables were considered during the dental analysis of the Alameda-Stone cemetery sample and are discussed in this report.

Dental Anthropology and Archaeology

For well over a century, dental anthropology has contributed to comprehending the lifeways of living people and the interpretation of human remains from archaeological contexts (Brothwell 1963; Hooton 1918; Hrdlička 1908; Koritzer 1977; Moodie 1929; Nelson 1938). The basic areas of study integral to dental anthropology are drawn from the concepts of odontology, which emerged as a scientific study in the eighteenth century. This discipline focuses upon understanding and explaining the structural and developmental aspects of human teeth and the etiology of and remedies for oral diseases (Hillson 1996). Certainly in the past century, dental anthropology has gained recognition from the scientific community with the identification of the crown and root morphology shared between ancestral primates and modern human beings (Butler 1963; Gregory 1922; Gregory and Hellman 1926; Kraus 1951, 1957; Weidenreich 1937). In so doing, this area of research has provided and substantiated evidence for human evolution to human population movements around the world (Brace and Montagu 1977; Dahlberg 1945, 1951, 1971; Greenburg et al. 1986; Haeussler and Turner 1992; Hanihara 1968, 1977; Hanihara 1991, 1992, 2008; Hrdlička 1911, 1920, 1921, 1924). For in-depth information on this subject, the reader is referred to *The Anthropology of Modern Human Teeth* (Scott and Turner 1997) for a comprehensive review of the literature related to dental morphology and global human variation. The microevolution of regional groups has also been determined through the identification of dental morphological traits. Such research is a popular topic for dental anthropologists from the greater U.S. Southwest (McClelland 2003; Morris et al. 1978; Scott 1973; Scott and Dahlberg 1982; Turner 1986, 1993, 1998). Morphological and affinity data for the Alameda-Stone cemetery sample are presented in Chapter 7.

Other lines of investigation in dental anthropology also contribute to the understanding of humans, both past and present. The subsistence strategy, overall health, and habitual, or regular, activities of a population can be interpreted from particular observations of the teeth. These include but are not limited to pathological conditions and the rates and forms of dental wear. The prevalence of dental diseases, such as cavities (caries), gum disease (periodontitis), and calculus, may indicate a group's dietary intake and food-processing methods (Fink and Merbs 1991; Hartles 1967; Hawkey 1988; Kerr 1990; Larsen 1995; Larsen et al. 1991; Leigh 1925; Littlejohn and Frohlich 1993; Nelson et al. 1999; Nelson et al. 1990; Powell 1985).

The degree of dental wear observed in a population may also provide insight into the diet of that population. Individuals with minimal dental wear likely consumed a relatively soft diet of highly processed foods on a regular basis. Conversely, individuals with teeth exhibiting extensive loss of enamel and crown height likely relied upon a harsher, more abrasive diet (Leigh 1925; Lincoln-Babb 1995; Molnar 1971a, 1971b; Schmucker 1985; Smith 1984; Teaford and Lytle 1996; Walker 1978; Watson 2008). Abscessing and antemortem tooth losses are most often associated with a cariogenic diet, or the regular consumption of foods conducive to the formation of caries. Abscesses and antemortem loss, however, can also occur from extreme wear of the dental crown and exposure of the pulp chamber, allowing bacteria and infection to compromise the tooth and the surrounding bone.

Dental wear, in the form of angles or notches on the occlusal surface of a tooth may indicate unintentional modification of the teeth from habitual behaviors, including occupational tasks and consumption of particular foods (Indriati and Buikstra 2001; Larsen 1985; Milner and Larsen 1991; Molnar 1971a, 1972; Turner and Machado 1983). Examples of behavioral or activity-caused alterations include crescent-shaped edges of occluding anterior teeth, which are commonly identified in historical-period populations as pipe facets, and transverse grooves on the occlusal surfaces of teeth associated with basket making in prehistoric period and extant Native American groups. Other forms of dental modification involve intentional or cosmetic alteration by filing, chipping, or drilling. Although the practice is not relevant to the Alameda-Stone cemetery sample, intentional dental modification is a very interesting and unique area of study within dental anthropology that holds particular societal implications for individuals and populations (Gill 1985; Holder and Stewart 1958; Milner and Larsen 1991; Romero 1958; Stewart 1941).

Developmental defects of enamel are linked to a variety of metabolic conditions and environmental stresses that occur during the formation of the deciduous and permanent tooth crowns (Duray 1996). Frequencies of enamel defects or enamel hypoplasias in a study population suggest compromised nutrition and/or poor health for a percentage of the people within that sample (Duray 1996; El-Najjar et al. 1978; Goodman et al. 1980; Goodman and Rose 1991; May et al. 1993). The overall health status of the population can in part be proposed based on the prevalence of enamel defects.

A period of disturbance in the enamel-laying process for a tooth has long been determined by measuring from the crown-root junction to the center of the disturbance, which typically manifests for a permanent tooth as a horizontal groove or series of pits. The individual's age at the time of this disruption in growth development may be estimated from determined chronologies for enamel-matrix formation and the mineralization of the permanent and deciduous teeth (Blakey and Armelagos 1985; Goodman et al. 1980).

Over recent years, it has been questioned whether the methods for recording macroscopic observations for enamel hypoplasias accurately reflect the onset of the metabolic disturbance that caused the defect. The discovery of microscopic disturbances in the enamel-laying process on either side of the macroscopically observable defect has suggested longer periods of metabolic disturbance for individuals than defined by the commonly used standards (Blakey and Armelagos 1997; Hillson and Bond 1997). Regardless of the exact time for the onset of the metabolic disturbance, it has not been disputed that a developmental enamel defect that can be easily identified and observed without magnification is a real indication of a disruption in the enamel-laying process due to compromised health for a certain period of time.

Environmentally related metabolic disturbances that potentially cause enamel defects on developing teeth are childhood illnesses, trauma, food shortage, and aggregation (El-Najjar et al. 1978; Hillson 1996; Jackson 1985; Lambert and Walker 1991). With the last condition, numerous people living in close proximity facilitates the transmission of diseases, the young being particularly susceptible. Unsanitary environments occur from poor sewage disposal; increasing parasite loads, which promote gastro–intestinal disorders; and compromised

nutritional intake. A high amount of fluoride in the local water supply can soften developing enamel and also contribute to enamel defects (Hillson 1996; Pindborg 1970).

In a number of archaeological burial populations, the majority of the observed enamel defects on the developing permanent teeth of affected individuals has been recorded as occurring between the ages of 2 and 4 years, an age range believed consistent with weaning. It has been hypothesized that weaning from breast milk and the resulting nutritional imbalance likely induced periods of growth disruption and caused enamel hypoplasias (Corruccini et al. 1985; Goodman et al. 1987; Ogilvie et al. 1989). The weaning hypothesis, however, has been contested in some fairly recent studies of historical-period cemetery populations, as the historical records pertaining to those burial groups indicate that the initiation of the weaning process was as young as 6–9 months of age (Blakey et al. 1994; Šlaus 2008; Wood 1996). The peak ages determined for the observed enamel defects within those specific historical-period samples were older, as well, by 1 to nearly 4 years.

Weaning, the complete replacement of breast milk by other foods, does not, however, happen within all populations over a short period of time. Documentation of weaning as a gradual process taking a year or more to complete has been cited in historical and ethnographic research (Blakey et al. 1994; Herring et al. 1998; Hrdlička 1908; Lipsky et al. 1994; Šlaus 2008). Post-weaning stress has been proposed as an explanation for enamel defects that occur later in burial populations (Blakey et al. 1994). The period of childhood that encompasses the weaning process may well incorporate many of the detrimental conditions related to health and environment (Herring et al. 1998). From the beginning of the process, the constant source of nutrition for the child is altered, and the child is exposed to more people, which also increases the potential for exposure to unhygienic conditions. Ultimately, there is no single cause for enamel hypoplasias, as a diverse range of environmental and uniquely personal disturbances can contribute to their formation (Blakey and Armelagos 1997; Hillson 1996; Hillson and Bond 1997).

Specific forms of severe illness, such as congenital syphilis or a systemic disorder, can also cause developmental manifestations to the teeth (Bhat and Nelson 1989; Hillson et al. 1998; Pindborg 1970). For syphilis, these include notched incisal edges of the upper central incisors and multiple rounded cuspules on the occlusal surfaces of the molars.

As with the recording of dental morphological traits, pathology, wear, and other dental observations have been extensively recorded for prehistoric period and living Native American populations from the greater Southwest (Fink and Merbs 1991; Guthrie and Lincoln-Babb 1998; Hrdlička 1908; Lincoln-Babb 2001; McClelland 2005; Minturn and Lincoln-Babb 1995; Regan et al. 1996; Turner 1985, 1998). Thus far, the vast majority of burial populations from archaeological contexts from the greater Southwest have been prehistoric period in age. The dental remains of only two historical-period southern Arizona archaeological populations have been analyzed and reported up to this point (Dayhuff 2002). The recovery of the Alameda-Stone cemetery sample necessitated a comprehensive collection of dental data that would accurately represent southern Arizona residents during the nineteenth century.

Dental Analysis and the Alameda-Stone Cemetery Sample

The dental anthropologists for this study reviewed initial observations made by osteologists in the field for the teeth of each recovered individual. The field observations generally consisted of noting the presence or lack of teeth or sometimes juvenile age based on the degree of dental development. Sometimes unique attributes, such as supernumerary or an above-normal number of teeth, were observed, and the location of the tooth was recorded. Most features of the teeth, however, were not observed in the field for various reasons, including time allowance, uncertainty with the identification of pathological conditions, or because dirt covered the teeth. The presence of dental restorations was consistently missed during the field inspection, even by one of the current authors. Many of these cavity fillings, located on the interproximal surfaces of teeth, were very small and obscured by dirt. Once the teeth were cleaned, the restorations were readily apparent.

The documentation process was guided by criteria in *Dental Anthropology* (Hillson 1996) and *Standards for Data Collection from Human Skeletal Remains* (Buikstra and Ubelaker 1994). Crown and root traits were largely recorded following the Arizona State University Dental Anthropology System (Turner et al. 1991). Dental documentation in the lab included tooth presence and eruption status, loss of a tooth before or after death, degree of dental development, crown measurements, and wear. Unique attributes of wear related to behavioral activity were also described, as was crowding and occlusion form, if observable. Each tooth and section of alveolar bone was closely inspected for the presence and location of caries, enamel defects, calculus, chipping, periodontal disease, and abscessing.

All dentitions were examined at the on-site lab for the Joint Courts Complex project, using appropriate lighting and magnification (a 10× or greater hand lens). To minimize interobserver error, only a few analysts conducted the in-depth dental analysis.

Identification of individual remains was difficult at times because multiple individuals were occasionally interred in the same grave pit, either intact or disturbed. When loose teeth and alveolar bone were encountered that could not be clearly associated with a certain individual, every effort was made to reunite those elements and assign them to the appropriate set of skeletal remains. This was painstakingly done by looking at every attribute of the teeth and bone for similarities. Many times, dental wear or degree of development was consistent with skeletal age identifiers, permitting reunification of all of the remains.

In accordance with the protocol for burial treatment, no destructive analyses were conducted. Photography was permitted for the dental remains of all identified Hispanic, Euroamerican, and African American people. We fully exercised the privilege of photo documentation during dental analysis. Digital photographs were taken of both pathological and healthy teeth.

Dental remains were associated with a total of 1,049 individuals recovered during the Joint Courts Complex project. The dental data from the Alameda-Stone cemetery sample are presented in various ways, to compare this sample with previous burial samples recovered from archaeological contexts. One of the primary objectives was to determine the dental health of the Alameda-Stone cemetery population. The dental analysis and the manner used to synthesize the pathology data were directed by this endeavor. In reviewing reports from other historical-period cemeteries, pathology data were generally presented by tooth position or by population frequencies. The former method was generally employed when preservation was poor or uncertainty existed regarding the actual number of individuals recovered. The latter method allows the frequencies of pathological conditions to be generated for the sample based on data derived from each individual dentition. This approach is favored for population reports.

The permanent and deciduous teeth for all 1,049 individuals were evaluated for dental caries, tooth status, antemortem loss, and enamel hypoplasia and were categorized by age group. Appendix O presents these data. Although information of this nature is valuable for determining trends in populations, discussion of dental pathology by tooth position in the sample from the Alameda-Stone cemetery is limited.

The pathological conditions recorded for each tooth position were also documented for each primary adult burial of the Alameda-Stone cemetery sample. A primary burial was defined during the project as the principal inhumation associated with a specific grave pit. These individuals were selected for the dental analysis sample because they were generally more complete and better preserved and their archaeological context was defined. For the purposes of this study, primary adult burials were individuals with a median age estimate of 15 years or more. Incidences for pathology by cemetery areas, group affinity, and sex were the primary concern of this analysis. The raw data for these observations from the sample are presented in Appendix P. Of the 521 adults identified as primary burials that were at least 15 years of age, 465 had dental remains, including the alveolar bone of 6 edentulous adults. The adult population sample consisted of 235 males, 170 females, and 54 individuals of indeterminate sex.

A total of 151 of the 465 primary burials with dental remains were of indeterminate sex and/or biological affinity. These individuals were excluded from specific analyses, but they were incorporated when calculating overall population frequencies. As discussed in by Heilen and Hall in Chapter 4, the Alameda-Stone cemetery was partitioned into five areas by Statistical Research, Inc., as excavations drew to a close. Table 201 shows the sample counts by cemetery area, sex, and biological affinity. Figure 183 illustrates sample counts by biological affinity and cemetery area, and Figure 184 illustrates sample counts by biological affinity and sex.

The overall distribution of the sample of primary adult burials used in this dental analysis varied within cemetery areas by sex and biological affinity. Most notable was the absence of identified females and a nearly exclusive Euroamerican population in Cemetery Area 1. Although females were present in Cemetery Area 2, the percentage of Hispanic and Euroamerican females there was negligible. There were, however, nearly twice as many Hispanic and Euroamerican males as females in the sample from Cemetery Area 2, with both affinities equally represented. Each of the remaining samples from the three cemetery areas were largely composed of similar numbers of Hispanic males and females. Native American adults were represented in the overall sample by 16 females and 16 males. The majority of these individuals were from Cemetery Area 3. There were no Native Americans in the samples from Cemetery Areas 1 and 5, and there was only 1 Native American male in the sample from Cemetery Area 2. Cemetery Area 2 was also the location for the single African American male in the sample used for this dental analysis.

Data are also presented for the presence of dental caries and dental enamel hypoplasia in juveniles aged 6 months to 14 years, who, in this study, were defined as individuals with an estimated median age of less than 15 years. Because of issues of observability, the number of individuals included in the sample for dental analysis varied, with 267 observable for caries and 310 observable for developmental defects of enamel. Biological affinity could not be estimated for most juvenile individuals. The subsample for juvenile hypoplasia included 4 Native American, 1 Apache, 21 Euroamerican, and 29 Hispanic individuals and 255 individuals of indeterminate biological affinity. The same subsample included no observable individuals from Cemetery Area 1, 7 from Cemetery Area 2, 226 from Cemetery Area 3, 69 from Cemetery Area 4, and 7 from Cemetery Area 5.

Overview of Comparative Cemetery Samples

Information about dental pathology from nine largely contemporaneous historical-period samples was selected for comparison to the sample recovered during excavations of the Alameda-Stone cemetery. Table 202 provides information on comparative samples used in the present analysis. The number of individuals for each comparative sample was reported as either represented or fully recovered, based on specific or approximate counts as presented by the original researchers. Well-preserved and distinct burial events for individuals led to a certainty in the number of individuals recovered, whereas poor preservation and comingling created uncertainty in the minimum number of individuals. The number of individuals presented in the dental sample column for each population in Table 202 was derived from the maximum sample size discussed for either caries or hypoplasia frequency calculations. The various samples were chosen because, together, they represent a range of economic conditions, lifestyles, and biological affinities reflective of the 1800s in the western and eastern United States and Canada. The rates for caries and enamel hypoplasia are of main interest for all these populations because they are the basic indexes of a population's dental health.

Arizona

The San Agustín Mission and Presidio samples were primarily distinguished by ancestry, with the Mission sample primarily representing local Native Americans and the Presidio representing a mixture of Native Americans and Hispanic colonists. These two early-historical-period communities and cemeteries of Tucson, Arizona, overlapped in time (Dayhuff 2002). Both of these samples predated the sample recovered from the Alameda-Stone cemetery by possibly as many as 100 years and as few as 20 years. The Mission sample exhibited nearly twice as many carious teeth (57 carious teeth/594 observed teeth = 9.6 percent) as the Presidio sample (11 carious teeth/274 observed teeth = 4 percent); however, the observed caries frequency for each was low. An indigenous diet, primarily consisting of corn, cacti fruits, game, and domestic meats, was surmised for the Mission people. It was proposed that the Presidio population consumed a similar amount of meat, but sugar-rich fruits from cacti were absent from their diet. Population hypoplasia rates were similar; the Mission group had an affected population rate of 71.9 percent, and the Presidio had an affected population rate of 76.5 percent.

Texas

The Refugio and Freedman's Cemeteries are quite distinct from each other in population composition and lifeways. Seventy-one of the 177 individuals recovered from the Nuestra Señora del Refugio Mission cemetery in Refugio County, Texas, were identified as Native Americans and probable members of the Karankawa tribe (Jantz et al. 2001). The remaining 106 individuals recovered were of Hispanic, Euroamerican, or indeterminate biological affinity. The dental-pathology data for the Refugio Mission sample supported a traditional indigenous diet consistent with a hunting and gathering subsistence, rather than a dependence on mission food items (Jantz et al. 2001). The observed caries rate in adults was 8.7 percent. Hypoplasia rates were determined by tooth position and sex. When considering only affected maxillary central incisors and canines from both sexes, 68–88 percent of the males and females presented enamel defects.

The Freedman's Cemetery is located north of the downtown district of Dallas, Texas. This cemetery was the primary burial area for all the postslavery African-American communities of Dallas from 1869 to 1907. Approximately 25 percent of the cemetery was recovered during a highway expansion project, permitting analysis of over 1,150 individuals. A major research directive for this burial sample was to determine whether pathology frequencies varied over time in a growing urban setting. Three distinct time periods were selected, and based upon context, each burial was assigned to one period—early, middle, or late. Based on the skeletal and dental analyses, the researchers proposed that individuals from the middle period suffered poorer health than those from the early and late periods. The public-health infrastructure apparently improved during the later period, after a serious decline during the middle period. The diet of sharecroppers, and presumably the individuals interred in the Freedman's Cemetery, consisted of salt meat, corn bread, sorghum syrup or molasses, and few vegetables (Davidson et al. 2002). Early access to sugars and other foods was probably limited during the early period because of differential access to these food types. The increase in caries, especially for women, during the middle period is perhaps related to greater access to town with jobs as domestics for wealthy Euroamerican families. Regardless, overall diet did not likely change much with time. Caries rates from Freedman's Cemetery, for males and females with at least one carious tooth, ranged from approximately 77 to 91 percent.

Utah

The Mormon Pioneer sample was recovered from an early Salt Lake City burial ground established shortly after the first wave of Mormon migration into the area in the mid-1800s. The adult population of two males and seven females was foreign born, with ancestral ties to Great Britain and Scandinavia. The small community was familiar with travel and establishing their lives anew; so, the typical hardships experienced by most frontier people were presumably not as physiologically disruptive. The extensive number of carious teeth and antemortem tooth loss suggest that the population was dependent upon a high-carbohydrate diet of breads and cereals and that they consumed considerably less meat than other western populations. Other reasons, however, such as genetic factors or fluorine content in water, may have also contributed to the very high observed rate of caries (Tigner-Wise 1989). Caries were observed on 54.8 percent of the sample; however, the small sample size should be acknowledged. Nonetheless, all of the adults had at least one carious tooth. Females had less caries than males, 24 percent compared to 78 percent, respectively, but this could also be related to the relatively small sample size for males. Data on enamel hypoplasias were not collected for the Mormon Pioneer sample.

California

The Palace of the Legion of Honor burial sample was recovered from a section of the Golden Gate Cemetery in San Francisco during renovations of the Palace. Although diverse ethnicities and standards of living characterized the burials recovered during the 1994 excavation, the 90 adults selected for skeletal and dental analyses were chosen from burial contexts that suggested lower-economic, working-class Euroamerican individuals

(Buzon et al. 2005). These individuals were considered representative of the majority of the people in late-nineteenth-century San Francisco, an immigrant population nutritionally compromised, struggling to live and work in a rapidly expanding, unsanitary urban environment.

Again, the Palace of the Legion of Honor sample is considered to represent a population with poor dental health. In fact, they had an observed caries rate of approximately 8 percent. Slightly less than 43 percent of the individuals had at least one carious tooth. The enamel hypoplasia rate of 29 percent was calculated only from observations of affected incisors and canines and the total observed teeth.

Pennsylvania

The Voegtly Church Cemetery was discovered in 1987 during highway construction through Old Alleghany Town, now subsumed as part of Pittsburgh, Pennsylvania. The church and cemetery serviced the Swiss-German population of the area for nearly 30 years in the early- to mid-nineteenth century. The population was reputed to have led a humble and economically and socially cohesive lifestyle, yet surrounded by the makings of early industrialization and commercialization. Unsanitary urban conditions and the easy transmission of disease follow in such environments. The observed caries rate for all permanent teeth at Voegtly was 28.5 percent. Forty percent of the female teeth and 23.1 percent of male teeth were carious (Ubelaker and Jones 2003). The overall percentage of permanent teeth with enamel hypoplasia among the Voegtly sample was 18.2 percent (17 percent for males, 12 percent females, and 24.2 percent for subadult individuals of unknown sex).

Canada

The St. Thomas' Anglican Church in Belleville, Ontario, erected a parish hall on land previously used during the early- to late-nineteenth century as a church burial ground. A large sample from this cemetery was recovered and thoroughly analyzed by bioarchaeologists (Saunders et al. 1997; Saunders et al. 2002). It was determined through these studies that there were no significant differences in disease and pathology loads among all the socioeconomic classes. Diet was "heavy with fat and starches" (Saunders et al. 2002:135); meat; grain crops, especially wheat for bread and alcohol; and fresh and preserved fruit and vegetables (Saunders et al. 1997; Saunders et al. 2002). Refined flours (for cakes and breads) and sugar were important and widely available in Belleville. Many different types of foods were available because Belleville was an urban import/export distribution center (Saunders et al. 2002). The observed caries rate for maxillary and mandibular teeth was approximately 31 percent (Saunders et al. 1997).

Caries and Antemortem Loss

Caries is a disease of the dental hard tissue that progressively causes damage to a tooth and may spread to adjacent teeth. Caries, or cavity, formation is an age-dependent and multifactorial pathology. Features strongly associated with the formation of carious lesions include the host's genetic proclivity for caries, the oral environment encompassing the biochemical composition of the saliva, and the diet of the individual. *Streptococcus mutans* is a naturally occurring microorganism within the mouth that is highly cariogenic and attaches as plaque deposits on the teeth. Starchy, pasty foods contribute to the build-up of calculus and plaque, which, with bacteria, convert into fermentable sugars that cause demineralization of the enamel (Hamada 2002; Harris 1966; Hartles 1967). Left untreated, a carious lesion ultimately leads to the exposure of the pulp chamber of the tooth and further spreading of the bacteria. This may result in an abscess of the alveolar bone at the site of the infected tooth and eventual loss of the tooth. Antemortem tooth loss is most frequently caused by caries. Table 203 presents a summary of antemortem loss for all individuals in the Alameda-Stone cemetery sample.

The table shows a relatively low amount of overall antemortem loss (~12 percent). The lowest rate (2.9 percent) was recorded for Cemetery Area 1, but this may be affected by preservation. As a result of previous removal of burials from that area, many of the teeth were found loose, with no associated maxillary or mandibular bone. Because antemortem tooth loss can only be identified by the presence of remodeled tooth sockets, the prevalence of antemortem loss may appear artificially low. A very low frequency of antemortem tooth loss (3.9 percent) was also found in Cemetery Area 5, but this result does not appear to have been influenced by preservation. The highest recorded rate (15.6 percent) was found in Cemetery Area 4. Even when Cemetery Area 1 was excluded from the comparison, the differences in antemortem tooth loss frequencies were significant among the remaining four areas ($\chi^2 = 52.44$, $df = 3$, $p < 0.001$). Males had higher antemortem tooth loss rates than females in three of four cemetery areas, but overall male (12.7 percent) and female (11.9 percent) rates were quite similar and were not significantly different ($\chi^2 = 1.32$, $df = 1$, $p = 0.251$).

Rates of antemortem tooth loss also differed among biological-affinity groups. The Native American group experienced the lowest rate (7.67 percent), followed by Euroamericans (9.14 percent), the one African American individual (10.71 percent), and the Hispanic individuals (11.00 percent). The differences among Native Americans, Euroamericans, and Hispanics were highly significant ($\chi^2 = 12.03$, $df = 2$, $p = 0.002$) and probably reflect variation in the relative cariogenicity of the diets.

Detailed data for caries and antemortem loss by tooth position in the Alameda-Stone cemetery sample are presented in Appendix O. A quick summary of those data follows. Interproximal carious lesions were the most frequently observed. It should be kept in mind, however, that one interproximal lesion affects two adjacent teeth and that some teeth had interproximal lesions on both the mesial and distal sides. Carious lesions were observed most frequently on molars, and more mandibular than maxillary molars were lost before death, for both sexes. Conversely, there were more carious maxillary molars, as fewer mandibular molars were retained with the progression of age. Mature- and old-adult females had the overall highest percentages for molar loss and caries of all adult age cohorts and between the sexes.

Three different methods for reporting caries are presented for the Alameda-Stone cemetery sample, to enhance comparability of this sample to other burial samples.

The individual caries frequency (number of individuals with one or more carious teeth of the total number of individuals observed) provides the percentage of individuals within a sample with at least one carious tooth. This is one method of recording caries that suggests the prevalence of caries within a population sample. Only the erupted permanent teeth of individuals with a median age of 15 years or older were considered in calculating adult caries rates. The individual caries frequency for the Alameda-Stone cemetery sample was 66.4 percent (306 of 461 individuals had at least one carious tooth). Although the figure may appear high, it should be kept in mind that 21 percent of the sample had only one carious lesion and nearly 30 percent of the total population had only two to four carious teeth. The individual caries frequencies for the cemetery areas exhibited some variation; those from Cemetery Area 2 had the greatest number of individuals with caries, at 81.9 percent. Cemetery Areas 3 and 4 were quite similar, with respective frequencies at 66.9 percent and 63.2 percent. Cemetery Area 5 had a slightly lower frequency, at 57.1 percent. Cemetery Area 1 had the lowest frequency, at 41.2 percent. The low frequency for this area, using this method of recording, is not surprising, as many individuals were represented by only a few teeth. We see the percentages nearly double between major age cohorts. Mature and old adults aged 35 years and greater had an individual caries frequency of 42.1 percent. Young adults, 15–34 years of age, had a frequency of 24.2 percent. The individual caries frequency for the juvenile subsample was 13.5 percent (36 individuals with at least one carious permanent or deciduous tooth among 267 observable individuals). As caries is an age-related phenomenon, the substantially lower rate among juveniles is not unexpected.

The observed caries frequency (number of observed carious teeth of the total number of observed teeth in a population) is a basic rate for the prevalence of caries within a study group. The observed caries rate provides an index of carbohydrate/protein consumption for a population. Numerous studies in dentistry and dental anthropology have found a correlation between a reliance on highly processed, carbohydrate-rich foods to a high frequency of caries (Leigh 1925; Lukacs 1996; Powell 1985; Turner 1979; Walker and Erlandson 1986). This recording method for caries is most comparable to other samples, as it is frequently provided in population reports for dental pathology. For purposes of comparison, we discuss observed caries frequencies in greater

detail for the Alameda-Stone cemetery sample. Table 204 presents the observed caries frequencies for the Alameda-Stone cemetery sample.

The observed caries frequency for the overall adult sample was 9.2 percent (1,001 carious teeth of the 10,885 teeth observed). If shared interproximal lesions on adjacent teeth were counted as one lesion rather than counting each carious lesion as a single episode, the observed rate was 8.1 percent (881 carious lesions of the 10,885 observed teeth). The highest apparent observed caries frequencies were for Euroamerican males in Cemetery Area 1 and Native American (Apache) females in Cemetery Area 3. However, each group was represented by a single individual; therefore, these differences were inconclusive. Overall, caries frequencies were highest in Cemetery Areas 1 and 2 and lowest in Cemetery Area 5. These differences were highly significant ($\chi^2 = 51.99$, $df = 4$, $p < 0.000$). It is quite interesting that so many of the remaining teeth from the previously removed military burials of Cemetery Area 1 were pathological, especially as most of these teeth were from the anterior dentition. Extensive research has proven that the anterior teeth, incisors to canines, are less likely to develop caries than molars and premolars. Because these males were mostly servicemen, they most likely had not lived in Tucson for an extended period of time and quite possibly developed caries from consuming foods elsewhere. Military diet may have also included more starch-laden, pasty food items than those consumed by the majority of the Hispanic population. Overall, Cemetery Area 2 had higher rates for caries than Cemetery Areas 3, 4 and 5, but the rates were comparable for males and females and for Hispanics and Euroamericans.

Males throughout the cemetery exhibited higher caries rates than females (9.57 percent versus 8.59 percent), which is not usually the case in population studies (Larsen et al. 1991). The difference does not quite reach statistical significance ($\chi^2 = 2.88$, $df = 1$, $p = 0.089$). As women typically have greater access to food, as preparers of meals, it is presumed that snacking throughout the day heightens their susceptibility to caries (Kelley et al. 1991; Larsen et al. 1991; Lukacs 1996). Recently, studies have suggested that the biochemical composition and flow of saliva in females is related to an increase in caries susceptibility (Lukacs and Largaespada 2006).

The corrected caries rate (or frequency) incorporates a measure for antemortem tooth loss caused by caries. This frequency provides a more realistic number for the pervasiveness of caries within a population and is always higher than the observed caries frequency; in fact, it often is twofold. The Lukacs (1992, 1995) method is preferred by the authors, although several other calibration techniques have become available in recent years (Erdal and Duyar 1999; Hillson 2001). The preference for the Lukacs formula is, in part, to stay consistent with our previously reported studies. In addition to counting the number of teeth lost antemortem, the Lukacs correction formula also determines the nature of pulp-chamber exposure for teeth, be it from caries or extreme wear. There were only 20 out of 428 teeth with pulp-chamber exposure caused by noncarious or wear-related exposure in the Alameda-Stone cemetery sample. This indicates that caries probably caused the vast majority of antemortem loss. The presence of teeth and alveolar bone is necessary to evaluate corrected caries rates; in this analysis, only primary adult burials with a minimum of 8 teeth and sockets were included in the calculation. The following calculations were used to determine the corrected caries rate:

1. Estimated number of teeth lost due to caries. (Number of teeth lost antemortem [883] × proportion of teeth with pulp exposure due to caries [408/428; 95.3 percent] = 841.5 or 842 estimated number of teeth lost due to caries.)
2. Total estimated number of teeth with caries. (The estimated number of teeth lost from caries [842] + number of carious teeth observed [947] = 1,789 total estimated number of teeth with caries.)
3. Total number of original teeth. (The number of teeth observed [10,417] + number of antemortem loss teeth [883] = 11,300 total number of original teeth.)
4. Corrected caries rate = total estimated number of teeth with caries (1,789) ÷ total number of original teeth (11,300) = 15.8 percent.

The corrected caries rates rendered the expected near-twofold increase for each observed caries frequency for the cemetery areas, except for Cemetery Area 5. A very low number of antemortem lost teeth (two) for the sample influenced this outcome of only 5.2 percent. Cemetery Areas 1 and 2 continued to demonstrate somewhat higher caries rates than the other areas, yet the corrected rates did not increase as

much as those of Cemetery Areas 3 and 4. The limited increase in the corrected rates for the former two cemetery areas is likely because of fewer mature and old adults in those areas; older individuals have a greater tendency for caries, pulp-chamber exposure, and antemortem loss. Additionally, the majority of the caries observed for Cemetery Area 2 were in teeth with dental restorations. The treatment and filling of carious lesions obviously curtails the progression of the disease and the observation for pulp-chamber exposure. Cemetery Areas 3 and 4 once again had frequencies resembling each other, at 15.8 and 14.2 percent, respectively. Similar percentages of antemortem losses and teeth with pulp-chamber exposure caused by caries were certainly related to similar diets, which contributed to their similar frequencies.

Males overall had higher corrected rates, looking at each affinity group (Table 205); this is consistent with their higher observed caries frequencies. Hispanics, Native Americans, and individuals of indeterminate affinity had very similar rates, suggesting similar diets or at least the consumption of similar amounts of processed carbohydrates. Euroamericans had slightly lower rates, which may be in part owing to the exclusion of some individuals because of lack of teeth and alveolar bone required for this recording method, or may be because the Euroamericans consumed a somewhat different diet for a period of their lives outside of Tucson. The African American male had the highest rate, but this has no comparative significance, as this was the only individual in the sample representing that affinity.

Observed caries frequencies for the different biological-affinity groups from the cemetery (excluding the Apache and African American, each represented by one individual) varied from a high of 9.45 percent for Hispanics to a low of 7.52 percent for Native Americans. The differences among observed caries rates for Native Americans, Euroamericans, and Hispanics were not significant ($\chi^2 = 3.69$, $df = 2$, $p = 0.158$). These frequencies were very similar to San Agustín (9.6 percent) and the Presidio of Tucson (4.0 percent), and they were not much higher than the rate for the sample from Refugio Mission (8.7 percent). The Palace of the Legion of Honor burial sample was also within this range, at 8 percent. The similar rates for the Alameda-Stone cemetery sample and two earlier-historical-period Tucson burial populations (San Agustín and Presidio) suggest that diet, and more specifically the amounts of carbohydrates and proteins consumed, did not change much through time in the region. Additionally, it is unlikely that there was any great variation in the cariogenicity of foods consumed based on biological affinity. Indigenous foods, such as corn, squash, and beans, remained food staples, and meat was generally available from domestic and game animals (Dobyns 1976; Griffitts, personal communication 2009; Lockwood and Page 2005; Sheridan 1986). Processed sugars were not consumed in any great quantity, except perhaps by the migrant Euroamerican males who had access to these foods in other locations. Dissimilarity, however, existed between the sample from Alameda-Stone cemetery and two earlier populations of Tucson in the distribution of caries among the sexes. The females of the earlier groups were reported as having higher rates of caries than the males (Dayhuff 2002).

The great differences in observed caries rates between the Alameda-Stone cemetery sample and the Freedman's, Mormon, Voegtly, and St. Thomas' samples are most easily explained as greater access and consumption of sugar for the latter groups. Sugarcane and beets were grown elsewhere in the United States but not in the Southwest until well after the closure of the Alameda-Stone cemetery (Hamnett 1999; Harveson et al. 2009). Although sugarcane production began in Mexico over 450 years ago, that sugar was primarily exported to Europe and was not widely available to most people living in the U.S. Southwest during and prior to the period when the cemetery was in use (Hamnett 1999; Palmer 2005). *Piloncillo*, a hardened brown cone of boiled and evaporated sugarcane juice, widely used in Mexico, was probably the most common form of sweetener used by the Hispanic people and possibly other residents of Tucson during the nineteenth century.

Populations and individuals with higher numbers of caries may have also had greater access to highly processed flours. The regular consumption of breads and cakes has been recorded for the Freedman's, Mormon, Voegtly, and St. Thomas' populations. Although wheat was a major crop for the Tucson area during the 1800s, it appears that only one flour mill was in operation during the 1850s to early 1870s (Sheridan 1986). As with sugarcane, most wheat harvested likely went to other or more-affluent groups, rather than the Hispanic or Native American people of Tucson. Tortillas, rather than loaves, were probably the bread items most frequently consumed by the majority of the residents. These would have been made with hand-ground corn, a process still common in Mexico until the early-twentieth century, when women began frequenting *tortillerias* (Pilcher 2005). Hand-ground corn, or wheat, for that matter, would not have been as easy to process into a flour as fine as milled products.

Unfortunately, comparable data on observed caries rates for juveniles are not available from the reference samples mentioned above. The overall deciduous-tooth caries rate for juveniles in the Alameda-Stone cemetery sample was 2.61 percent. The rate was lowest in Cemetery Area 2 (1.69 percent) and highest in Cemetery Area 3 (2.75 percent), but the differences were slight, and the samples from Cemetery Areas 2 and 5 were very small. The difference between deciduous caries rates in Cemetery Areas 3 and 4 was not statistically significant ($\chi^2 = 0.53$, $df = 1$, $p = 0.467$). The Native American juvenile rate (12.77 percent) was highest, but the sample was quite small. The difference in the deciduous caries rates for Hispanics (6.1 percent) and Euroamericans (4.44 percent) did not reach significance ($\chi^2 = 0.77$, $df = 1$, $p = 0.381$). The lowest rate, by far, was for the juveniles of indeterminate affinity (1.75 percent), who had the largest number of individuals overall. The reasons for this disparity are unknown.

Calculus and Periodontal Disease

In addition to caries, the consumption of pasty, processed foods can be inferred from the presence of calculus or calcified plaque. Periodontal disease, porosity, and resorption of the bony sockets holding the teeth in place are typically associated with the presence of calculus. Mineralized plaque, or calculus, can accumulate on a tooth's surface, usually around the cemento-enamel junction. The crystals of the hardened plaque irritate the gums and cause the gingival tissue to pull away from the tooth, allowing bacteria in and resulting in a localized loss of alveolar bone. These deposits occur if soft, processed foods are consumed frequently and cleansing agents or dental hygiene (e.g., tooth brushing) are lacking.

Table 206 presents the degree of calculus deposition for the Alameda-Stone cemetery sample. Nearly every adult (91 percent) within the Alameda-Stone cemetery sample had some degree of calculus buildup on their teeth. Most of these deposits were light, but a few individuals suffered from excessive amounts of calculus buildup that completely covered the surface of the teeth. An example of excessive calculus is described in Chapter 14. In that example, the calculus deposition was so extreme on one side of the mouth that it seemed likely the individual was in some way impaired and used only one side of the mouth for chewing.

As with calculus, the majority of the adults in the Alameda-Stone cemetery sample had some measure of periodontal disease. Approximately 61 percent of the population evinced porosity and bone loss around the alveoli, or tooth sockets. The frequency of this dental pathology is presented in Table 207. Alveolar porosity and bone loss was consistent among males, females, and biological groups. Several individuals presented severe periodontitis—the entire alveolar bone exhibited inflammation and infection. These cases, however, were rare and may have been related to systemic disorders of an unknown etiology.

Abscesses of the Alveolar Bone

Inflammation of the dental pulp is produced when the pulp chamber is exposed through carious destruction, extreme wear, or a fractured crown. Exposure of the pulp chamber leads to an increased susceptibility to bacterial infection that will, if left untreated, eventually travel down the root and form an abscess in the periapical region. Pressure caused by the accumulation of fluid eventually leads to resorption of the alveolar bone. Frequently, a drainage path is created by a fistula, a canal communicating with the buccal or lingual surface of the mandible or maxilla, or with the maxillary or nasal sinus (Hillson 1996:284–287). Prior to the development of antibiotics, a dental abscess frequently resulted in a life-threatening spread of infection to other body tissues (Alt et al. 1998:257–262).

Abscesses were common in the Alameda-Stone cemetery sample (Table 208). Forty-six percent of the adult individuals exhibited one or more alveolar lesion. Overall, males suffered a somewhat higher rate of abscessing (50.5 percent; n = 100) than females (41.7 percent; n = 63). The difference between sexes, however, was not statistically significant ($\chi^2 = 2.66$, $df = 1$, $p = 0.103$). Abscess frequencies varied from a low of 39 percent among Euroamericans to a high of 48 percent among Native Americans. The differences among the three affinity groups were not statistically significant ($\chi^2 = 1.20$, $df = 2$, $p = 0.548$). However, when the

frequencies of individuals with two or more abscesses were compared, there was evidence of differences between the groups; Euroamericans presented lower frequencies of abscesses (10.9 percent; n = 7), and Hispanics (27.8 percent; n = 50) and Native Americans (28.0 percent; n = 7) presented somewhat higher-than-expected frequencies ($\chi^2 = 7.65$, $df = 2$, $p = 0.022$).

Developmental Enamel Defects

Enamel hypoplasia is a dental pathology reflecting stress in a population. These lesions appear as pits, grooves, or discolorations on the surface of a tooth's crown. Hypoplastic defects are conservatively identified as lesions exhibiting a clear difference in enamel thickness and breadth discernible without magnification (following Goodman and Rose [1991]). This is easily accomplished using a fingernail to palpate a horizontal groove—the most typical form of enamel defect found in permanent teeth—on the tooth's surface.

Enamel hypoplasias are caused by a disruption in the enamel-formation process during a crown's development, which is generally complete for all teeth by the age of 18 years. A defect can occur during a single episode of metabolic disturbance. These episodic scars result from nutritional deficiency alone or in synergism with childhood illness. Compromised nutrition for some children occurs during the weaning process, others experience compromised nutrition because of illness and/or an increased parasite load brought on from unsanitary conditions in their environment. Severe (i.e., numerous or heavily expressed) enamel defects can be caused by chronic health problems.

The frequency distribution of enamel hypoplasia may be calculated as a percentage of all affected teeth or as a percentage of affected individuals. The latter method is preferred as a measure of population prevalence, because a single episode of interrupted enamel growth can affect more than one developing tooth. In this study, only linear defects, pits, and other variations in enamel thickness or morphology were considered when determining whether an individual was affected by enamel hypoplasia. Opacities and other types of hypocalcification were not included. Although a population count is the preferred measure of hypoplasia frequency, tooth-count hypoplasia frequencies are also reported herein to facilitate comparisons with reference samples and to provide information on the most-affected teeth. In the following discussion, we report enamel hypoplasia prevalence in adults and juveniles separately (Table 209).

The level of variation for the rates of enamel hypoplasia within and between cemetery areas suggests some difference in expression. The highest tooth-count frequency of enamel hypoplasia was found in Cemetery Area 1 (9.05 percent), more than two-and-a-half times the overall rate for the Alameda-Stone cemetery sample (3.30 percent). This difference was highly significant ($\chi^2 = 30.44$, $df = 4$, $p < 0.001$). A majority of the teeth recovered within Cemetery Area 1 represented previously excavated burials. The relative dearth of skeletal material made estimations of sex difficult, at best. However, because Cemetery Area 1 was associated with the U.S. Military, it is safe to assume that a majority of the teeth recovered in this area belonged to males. Considering the cemetery as whole, however, males and females presented a similar tooth-count frequency of enamel hypoplasia (~ 3.2 percent) and were not statistically significantly different from each other ($\chi^2 = 0.00$, $df = 1$, $p = 0.976$). Differences in the expression of enamel hypoplasia according to biological affinity (comparing the three largest groups) were also significant ($\chi^2 = 30.83$, $df = 2$, $p < 0.001$). Euroamericans had the highest rate of affected teeth, at nearly 6 percent. Hispanics (2.93 percent) and Native Americans (2.42 percent) had much lower rates of enamel defects. Tooth-count frequencies for the African American and Apache affinity groups were both nil, but each of these groups was only represented by one individual; so, these results do not provide definitive information regarding the overall dental health of these two groups. The frequencies of enamel hypoplasia among adults varied significantly, depending on tooth class. The majority of defects were linear horizontal grooves on the canines; this is the most typical form of enamel hypoplasia for the permanent teeth on the most commonly affected teeth of the dentition. The maxillary and mandibular canines exhibited the highest frequency of defects: 12.82 percent (n = 50) for the right mandibular canine, 12.75 percent (n = 52) for the left mandibular canine, 9.75 percent (n = 39) for the right maxillary canine, and 8.96 percent (n = 36) for the left maxillary canine. None of the other individual tooth-count frequencies exceeded 5 percent.

Using the individual count method (Table 210), 25.1 percent of adults in the Alameda-Stone cemetery sample exhibited enamel hypoplasia on at least one tooth in the dental arcade. As illustrated in Figure 185, rates for Hispanics (27.13 percent) and Euroamericans (26.92 percent) were nearly identical; individuals of indeterminate biological affinity and Native American individuals had slightly lower incidences. Lower rates were also identified for the two African American and Apache individuals. The differences among the three largest affinity groups were not statistically significant ($\chi^2 = 0.85$, $df = 2$, $p = 0.625$), nor was there a significant difference between males and females, overall ($\chi^2 = 1.01$, $df = 1$, $p = 0.315$).

Enamel Hypoplasia in Permanent Teeth of Juveniles

Tooth-count enamel hypoplasia frequencies for the sample of permanent teeth from juvenile individuals were substantially higher than for the adult sample, with a mean value of 11.53 percent for the juveniles from the Alameda-Stone cemetery sample as a whole (see Table 209). The highest rate was observed in Cemetery Area 5 (15.38 percent), followed by Cemetery Area 4 (14.29 percent), Cemetery Area 2 (11.11 percent), and Cemetery Area 3 (10.53 percent). The subsamples from Cemetery Areas 2 and 5 were too small for statistical testing, but the differences between Cemetery Areas 3 and 4 did not quite reach statistical significance at the 95 percent confidence level ($\chi^2 = 3.04$, $df = 1$, $p = 0.081$). The Native American subsample had the highest rate (32.35 percent) among affinity groups, and the Euroamerican subsample had the lowest rate (7.94 percent). The Hispanic group had an intermediate hypoplasia rate (10.28 percent). The differences among these three affinity subsamples were highly significant ($\chi^2 = 33.41$, $df = 2$, $p < 0.001$). A majority of hypoplastic defects in juvenile permanent teeth were linear horizontal grooves. The highest frequencies of this type of defect were 32.5 percent (n = 13) for the right mandibular canine, followed by 29.0 percent (n = 9) for the left maxillary canine, 20.51 percent (n = 8) for the left mandibular canine, and 17.14 percent (n = 6) for the right maxillary canine.

Enamel Hypoplasia in Deciduous Teeth of Juveniles

The tooth-count enamel hypoplasia frequency for the sample of deciduous teeth for the Alameda-Stone cemetery sample as a whole was 4.70 percent (see Table 209). The incidence of this pathology was somewhat higher in Cemetery Areas 4 and 5, but the differences in rates between cemetery areas (excluding Cemetery Area 2, which was a substantially smaller sample) were not significant ($\chi^2 = 3.98$, $df = 2$, $p = 0.137$). In this subsample, biological affinity could only be determined for a small number of individuals. The highest percentage of deciduous tooth hypoplasia was for the indeterminate affinity group (5.22 percent), followed by Native Americans (4.26 percent). Hispanic and Euroamerican juveniles had substantially lower frequencies, at 2.74 percent and 0.83 percent, respectively. The difference between the Hispanic and indeterminate affinity subsamples was significant ($\chi^2 = 3.83$, $df = 1$, $p = 0.050$). The difference between the Euroamerican and Hispanic groups did not reach significance at the 95 percent confidence level (Fisher's exact, 2-tailed, $p = 0.1308$).

The type of enamel defect most frequently found in deciduous teeth differed from that found in the juvenile permanent teeth. Most of the deciduous-tooth hypoplastic defects were irregularly shaped and shallow-plane form defects, generally affecting the deciduous canines. The highest frequency was 13.86 percent (n = 23) for the right mandibular canine, followed by 11.1 percent (n = 18) for the left mandibular canine, 10.99 percent (n = 20) for the right maxillary canine, and 10.0 percent (n = 19) for the left maxillary canine. Defect frequencies for all other tooth classes and defect types did not exceed 4 percent.

To determine frequencies of enamel hypoplasia in the juvenile sample, we used data from both permanent and deciduous teeth. One-third (n = 101) of the juveniles each had a hypoplastic defect on at least one permanent or deciduous tooth. As with tooth-count hypoplasia frequencies, the juvenile rate exceeded the adult rate. The fact that the juvenile subsample experienced greater levels of developmental stress is not surprising, because the sample is composed entirely of individuals who did not survive into adulthood. In this case, higher hypoplasia frequency seems to be related with increased morbidity, but see Wood et al. (1992: 354–356) for a hypothetical case in which higher rates of hypoplasia could indicate a relatively healthier population. On an individual-count basis, Hispanic juveniles presented a much higher rate of enamel hypoplasia

(51.72 percent; n = 15) than either Euroamerican juveniles (28.57 percent; n = 6) or juveniles of indeterminate affinity (29.80 percent; n = 76). However, the differences between Hispanic and Euroamerican subsamples did not reach statistical significance at the 95 percent confidence level ($\chi^2 = 2.68$, $df = 1$, $p = 0.102$).

Qualifying the timing and extent of enamel defects is possible. The age of an individual at the time an enamel defect becomes macroscopically observable can be determined by measuring the distance from the cemento-enamel junction to the middle of the defect. The severity and duration of the stress event is inferred by the number of scars, or defects, noted and the teeth involved (Rose et al. 1985).

The majority of males and females experienced a stressful event that interrupted amelogenesis, or enamel deposition, between 2 and 4 years of age (Figure 186). As discussed earlier in this chapter, a frequently cited potential cause of enamel hypoplasias for many populations around this age is weaning (Almedom 1991; Fink 1989; Goodman, Armelagos, et al. 1984; Goodman et al. 1987; Herring et al. 1998; May et al. 1993). Children transitioning from breast milk to adult foods experience a general decrease in nutritional uptake, and a subsequent interruption in amelogenesis can be expressed as enamel hypoplasia in the developing dentition (Herring et al. 1998). A study on the relationship between hypoplasia development and weaning was conducted using the dental data from 27 enslaved African Americans from early-nineteenth-century plantation sites in Maryland and Virginia and 75 subadults and adults from the contemporaneous (1823–1841) African American First African Baptist Church cemetery in Pennsylvania (Blakey et al. 1994). It was found that the hypoplasia frequencies for these samples peaked between 0.05 and 3.75 years—later than the expected weaning age (approximately 1 year). A period of postweaning stress was proposed, and as the term suggests, there is subsequent compromised nutrition during the weaning process that continues for an extended period of time. Although weaning was acknowledged as a likely cause of early stress, the authors support a "syncretic interaction" between childhood diseases and malnutrition during the formative years as the most likely factor affecting the formation of hypoplastic insults (Blakey et al. 1994).

Roughly 25 percent of the adult population recovered during excavations of the Alameda-Stone cemetery had at least one enamel hypoplasia (see Table 210). Very few individuals in the dental sample exhibited multiple episodes of stress (i.e., multiple teeth with defects). These frequencies were comparable to contemporaneous historical-period populations—such as Freedman's, Voegtly, and St. Thomas'—but less than those reported for the earlier Tucson populations from San Agustín (71.9 percent) and the Presidio (76.5 percent). Childhood environmental stress may be reflected in the permanent dentitions, particularly among the Euroamerican male settlers of Tucson, but also among some of the Hispanic men and women. For some, these stressful events occurred during childhood in locations other than Tucson, at least for the Euroamericans. Two environmental stress factors that have bearing on the prevalence of enamel hypoplasia are aggregation and poor sewage control. The former allows easy transmittal of disease; the latter promotes unhealthy living and gastrointestinal disorders. Despite the fact that the Santa Cruz River provided water for crop irrigation, wells were the primary source for drinking water in the pueblo. The cleanliness of the water in town during the period of cemetery use is unknown, but the observed frequencies of enamel hypoplasia, in all likelihood, would be higher for the Tucsonan population if the water supply had been detrimental to the overall health of the people. A consideration specific to Tucson was the stress introduced by Apache attacks and consequential disruptions in food supplies during the early 1800s. These factors may have contributed to the development of some of the observed defects for the early San Agustín and Presidio samples of Tucson but do not seem to have affected the Tucson population documented in the sample recovered during excavations of the Alameda-Stone cemetery.

Unfortunately, comparative data on enamel hypoplasia frequencies in juveniles are not available. As previously mentioned, the majority of the defects in deciduous teeth were different from the type seen in the permanent dentition. In deciduous teeth, the defects noted in the Alameda-Stone cemetery sample have been referred to as "Localized Hypoplasia of the Primary Canine" (Lukacs and Walimbe 1998; Skinner and Hung 1989; Skinner and Newell 2003). Multiple authors agree that this type of defect is related to a deficiency of alveolar bone formation on the labial, or cheek, side of the crypt of the developing tooth. This often results in a small area of missing alveolar bone, referred to as a fenestration. As a result of this defect, the surface of the developing tooth crown is vulnerable to damage from the pressure of objects manipulated in the mouth. The etiology of the deficient bone development is a matter of debate, but in one epidemiological study (Skinner and

Hung 1989), low socioeconomic status, ethnicity, and low rates of breastfeeding were associated with this defect. It was hypothesized that a calcium-deficient diet resulting from relatively low rates of milk consumption was the likely cause. Therefore, there is some basis for concluding that the type of enamel hypoplasia most affecting the deciduous teeth of juveniles in the Alameda-Stone cemetery sample may reflect a nutritional deficiency. This is in contrast with the types of enamel hypoplasia more common in permanent teeth—the result of generalized developmental stress, which may also indicate deficient nutrition or disease episodes.

Enamel Chipping

Researchers have correlated the relationship between meat consumption and the degree of chipping of dental enamel within a population (Turner and Cadien 1969), a finding supported by data for the prehistoric Southwest, where chipping has been more frequently encountered in hunter-gatherer and mixed-economy populations than in agricultural groups (Lincoln-Babb 1995, 2001; Schmucker 1985). Blocky breakage of enamel on the occlusal edges of posterior or buccal teeth occurs when these teeth are used to crush small bones or the hulls of nuts or from biting inclusions in processed foods. The anterior teeth can exhibit removal of enamel flakes for the same reason, but fractures on the anterior teeth more frequently occur during task-related use of teeth (Hawkey 1988). Each tooth in the Alameda-Stone cemetery sample that exhibited a single chip was counted. The location and size of the defect was noted for each.

Table 211 shows the frequency of enamel chipping in the Alameda-Stone cemetery sample. Males in the Alameda-Stone cemetery sample had more chipped teeth than females. Figure 187 shows the frequency of chipping by biological affinity and sex. Native American males presented the highest percentage of chipped teeth for both sexes and all biological groups. Hispanic and Euroamerican males presented similar frequencies for chipped teeth, both around 8.5 percent. Native American females had a higher rate (6.1 percent) of chipped teeth than Hispanic (4.8 percent) and Euroamerican females (5.1 percent). The population frequency for one or more chipped teeth was 70.6 percent (324 of 459). A little over one-half (247 of 459) of those individuals had one to four chipped teeth.

The Refugio Mission Cemetery sample presented a high rate of enamel chipping, at 47 percent (Jantz et al. 2001). A hunting-gathering subsistence was suggested for the population. The vast majority of the chipped teeth in the Alameda-Stone cemetery sample were from the anterior dentition, particularly the incisors. Although diet certainly plays a role in the prevalence of chipped teeth in a population, the numerous small defects indicate that the teeth were used in ways beyond simply mastication. Daily activities for many individuals must have relied on the so-called "third hand," meaning the use of the teeth for clenching and gripping objects while performing other activities with the hands.

Dental Wear

The utility of tooth wear in age determination, dietary reconstruction, and examination of nondietary cultural dental modification has been recognized for some time (Hillson 1996; Larsen 1985; Molnar 1971a, 1971b; Powell 1985; Rose and Ungar 1998). Dental anthropologists distinguish between dental attrition caused by contact between occluding or neighboring teeth and dental abrasion, which results from contact of teeth with foreign items (Hillson 1996:231). Except in the case of localized abrasion resulting from manipulation of a foreign object, such as a pipe stem, the relative contribution of attrition and abrasion to the wearing down of the occlusal surface cannot be distinguished through macroscopic examination. Nevertheless, the overall pattern of dental wear can be used for age assessment or for detecting differences in diet in age-matched samples. The latter objective is the focus of this section. Late-nineteenth-century Tucson was a multiethnic community, and ethnicity is often related to differences in cuisine. To the extent that individuals of differing ancestry were buried in different sections of the cemetery, we expect that patterns of dental wear will show significant variation matching this spatial distribution.

Dental wear was recorded, as described in Chapter 2, using scoring systems recommended in Buikstra and Ubelaker (1994). Although these methods are the currently accepted protocols, many different scoring systems were used in the past (Rose and Ungar 1998:353–356). This, unfortunately, makes it difficult to compare studies by different authors. The wear stages used in this study are ordinal stages, which represent approximately equal intervals. However, nonparametric statistical measures of significance are more appropriate, both because of the use of ordinal variables and because they do not assume that the variables are normally distributed. A Kruskal-Wallis analysis of variance using ranked data is recommended in this case (Sokal and Rohlf 1969:388).

Comparison of Mean Wear Scores

In qualitative terms, the overall pattern of dental wear in the Alameda-Stone cemetery sample may be characterized as light to moderate. Mean wear values for the cemetery as a whole are shown in Table 212. Unless noted otherwise, the mean wear scores shown in the following tables are taken from the right side of the mouth, and the sample was limited to individuals who were at least 15 years old. A typical adult individual in the cemetery had anterior teeth worn to the extent that a line or point of dentin was visible on the occlusal surface. First molars were worn more or less flat, with small points of exposed dentin. Second molars had developed rounded cusps, and third molars had small facets but still retained most of the original cusp morphology.

Examination of mean wear values for subsets of the burial sample indicated that there were significant differences among the groups. Severity of dental wear differed for males and females, overall, as shown in Table 213 and Figures 188 and 189. Males had consistently higher wear for every tooth. The magnitude of the differences in mean wear scores was generally not large, but nearly every difference was significant at an alpha level of 0.05.

There were also significant differences in wear rates among individuals buried in different cemetery areas. Mean anterior and premolar wear scores for males and females in the five cemetery areas are shown in Table 214, and mean molar wear scores are listed in Table 215. Comparisons were significant among males for all teeth, except the third molars. It is not surprising that third-molar wear is not as consistent as wear patterns on other teeth, because these teeth are much more variable in the timing of their eruptions. They are also much more likely to not be in perfect occlusal alignment. Wear is consistently heavier in Cemetery Areas 3 and 4 than in Cemetery Area 2. Cemetery Area 5 males had heavier wear than Cemetery Area 2 males in 13 of 16 teeth. Females in Cemetery Areas 3 and 4 also had heavier wear than females in Cemetery Area 2 for all teeth, except the maxillary third molar. The differences were significant for 8 of 16 teeth. Cemetery Area 5 females had lighter wear than Cemetery Area 2 females in 10 of 16 teeth, but the differences were slight.

Wear patterns also differed with respect to adult age categories and cemetery areas. Mean anterior and premolar wear scores are tabulated by age group and cemetery area in Table 216, and mean molar wear scores are shown in Table 217. Once again, wear tended to be heavier in Cemetery Areas 3 and 4 than in Cemetery Area 2. This was true of all age groups, but the pattern was most evident among the young-adult age group. In this subset, 13 of 16 teeth exhibited significant differences in wear. In the middle-adult age group, wear was significant in only 2 teeth; and 5 of 16 teeth in the 50-year-and-older group showed significant wear differences. The fact that wear patterns were less consistent in older-adult age groups is not unexpected. Because dental pathologies, such as caries and antemortem tooth loss, are age-related, individuals in the older-adult age groups are more likely than young adults to have missing teeth or teeth that are no longer in functional occlusion. Consequently, adjacent teeth or teeth on the other side of the mouth may begin to wear at a faster rate. Other teeth will cease to wear when the occluding tooth is absent. The result is a lack of uniformity in wear throughout the dental arcade.

Finally, there were consistent differences in mean wear scores when we compared individuals with different assessments of biological affinity. Mean wear scores for individuals of Native American, Euroamerican, and Hispanic ancestry are listed in Table 218 and illustrated in Figures 190 and 191. The differences among these groups in tooth wear were striking. Wear was highest for every tooth class in Native Americans and lowest for Euroamericans. Differences in mean wear were significant for 15 of 16 teeth at an alpha level of 0.05, with most meeting the stricter criteria at the 0.01 level of significance.

Principal Axis Analysis of Wear Rates

Another approach for assessing dental wear in archaeological samples that avoids the problem of controlling for age differences uses relative rates of wear. Wear rates can be calibrated based on the fact that the second molar typically enters into occlusion 6 years after the first molar. Therefore, the wear expressed on the first molar at the moment when the second molar first begins to wear is the result of 6 years of use. This could be directly determined by examining a subset of individuals in the 12-year-old age group. Unfortunately, there were no individuals in the sample from Cemetery Area 2 in this age group; so, direct comparisons of wear rates between the population subsets that showed the most consistent differences in mean wear scores was not possible. There is also a theoretical problem concerning the use of wear data from juveniles to characterize patterns of tooth wear more generally. As Wood et al. (1992) have explained, juveniles in a skeletal sample may not be representative of the burial population as a whole, because those individuals who did not survive to adulthood may well have experienced a higher level of stress or morbidity in their short lives. It is quite possible that a higher level of morbidity may have affected the diet, and therefore, juvenile tooth wear may not be representative of the population as a whole.

There is another method that allows us to use adult wear scores to estimate the rate of tooth wear in an indirect manner. In the principal axis method, first proposed by Scott (1979), wear scores for paired first and second molars are plotted, and a line is fitted to the cloud of points. The line represents the principal axis of the ellipse formed by the plotted points. Principal-axis analysis is recommended in lieu of regression because neither variable can be assumed to be measured without error and neither variable can be said to predict the other (Sokal and Rohlf 1969). The slope and *y*-intercept of the line each give information about wear patterns (Benfer and Edwards 1991). First-molar wear is typically plotted on the *y*-axis, and second-molar wear is plotted on the *x*-axis. Therefore the *y*-intercept (where second-molar wear is 0) represents the amount of wear experienced during the 6-year interval between eruption of the first and second molars. A low value for the *y*-intercept indicates a low rate of dental wear for the sample, and conversely, a high value represents a high rate of dental wear.

The slope of the principal axis reflects the relative rates of wear on the second and first molars and therefore reflects experience during later childhood and adulthood. Interpreting wear rates from the slope of the principal axis is more complex than interpretation of the *y*-intercept. If the first and second molars wear at the same rate throughout adulthood, the slope will be 1.0. Benfer and Edwards (1991) observed that the relative rates of wear may change during later adulthood because the first molar reaches maximal wear, with no enamel remaining on the occlusal surface. In this case, the Scott scoring system would register no further wear increase for the first molar, whereas the wear score for the second molar could continue to increase. The result is a slope of less than 1.0 (Benfer and Edwards 1991). Such a situation is interpreted as reflecting a very rapid rate of wear wherein older individuals begin to favor the use of the second molar, which is more effective because of the remaining occlusal topography. Slopes greater than 1.0 would indicate a continuing preference for use of the first molar, even after the posterior molars had erupted. Benfer and Edwards (1991) also pointed out that slopes that deviate from 1.0 affect the value of the *y*-intercept; this should be kept in mind when comparing populations.

Because antemortem tooth loss or severe tooth decay would affect the relative rates of wear on occluding or adjacent molars, the sample used in this study was limited to individuals having wear scores for all four molar quadrants of the maxillary and mandibular first and second molars from the same side. Table 219 shows the intercepts and slopes of the principal axis, based on scores for paired first and second permanent-molar wears, and the results are plotted separately for females and males in Figures 192 and 193, respectively. Intercepts range between –2.57 and 2.64, indicating a very low rate of wear in childhood. This indicates that, for the population as a whole, the first molar had accumulated only minimal wear during the 6 years between eruption of the first and second molars. Unlike the mean wear values of the previous comparisons, the *y*-intercept values did not vary consistently between cemetery areas.

The slope of the principal axis varied between 1.128 and 1.503, with a mean value of 1.378 for maxillary molar pairs and 1.274 for mandibular molar pairs. This indicates that, in every group, the first molar tended to wear at a somewhat greater rate than the second molar in later childhood and adulthood. Males and females did

not differ significantly in the slope of the principal axis for maxillary and mandibular molar pairs, as indicated by overlapping 95 percent confidence intervals. Principal-axis slopes also had overlapping confidence intervals for both maxillary and mandibular molar pairs from the five cemetery areas. As demonstrated previously, mean wear scores indicated significant differences in overall wear between males and females and among the five cemetery areas. In this sample, principal-axis analysis failed to distinguish among the groups, perhaps because the rate of wear was so low. Nevertheless, the evidence for continued preference for use of the first molar is intriguing. Comparisons with other studies may be illuminating. Watson (2008) applied principal-axis analysis in his examination of tooth wear at the Early Agricultural period (1600 B.C.–A.D. 200) site of La Playa in northwest Mexico. This population had a subsistence pattern of mixed foraging and agriculture, and tooth wear was heavy, with *y*-intercepts ranging from 5.912 to 17.052. Principal-axis slopes ranged from 0.402 to 0.886, indicating that the rates of second-molar wear in adulthood exceeded that of first-molar wear. Benfer and Edwards (1991) analyzed tooth-wear rates in several human skeletal collections from the central coast of Peru, dating from 9000 to 1500 B.P. Subsistence patterns ranged from hunter-gatherer adaptations in the earlier samples to an agriculturally dependent economy in the more recent samples. Principal-axis slopes increased through time from about 0.4 for the hunter-gatherer sample to a maximum of 1.2 for the most recent sample. Conversely, *y*-intercepts decreased over the time period from about 4.5 for the hunter-gatherer group to a minimum of about 0.8 for the agriculturally dependent sample. The authors interpreted these data as consistent with a pattern of decreased molar wear over time. The principal-axis slopes for the Alameda-Stone cemetery sample were higher, and the *y*-intercepts were lower than the values reported for the Peruvian agricultural population. This pattern is fully consistent with a pattern of decreasing tooth-wear rates through time and probably reflects dietary changes involving the use of more highly processed foods.

In populations with a heavy tooth-wear regime, the first molar may become less useful for food processing at an early age, resulting in a shift to the posterior molars. Use of the first molars and premolars in traditional manufacturing activities would tend to accelerate this trend. With a much less abrasive diet and other tools available for manufacturing use, the modern population of late-nineteenth-century Tucson followed a much different pattern of dental wear.

It would be interesting to compare results of principal-axis analysis with those of other historical-period cemeteries, but unfortunately, these data are not available. However, limited comparisons of mean wear scores with other historical-period cemetery samples were possible. Two comparative samples that were useful for placing the Alameda-Stone cemetery population in context were those from Freedman's Cemetery in Texas and San Agustín Mission in Tucson. The junior author of this chapter conducted the dental-wear assessment of the San Agustín Mission sample, using the same recording protocols used for the Alameda-Stone cemetery sample. The published dental-wear data from Freedman's Cemetery was presented in a somewhat different format, and this limited the number of teeth that could be compared. Mean wear scores for these three collections are compared in Table 220.

As demonstrated in Figures 194 and 195, wear was heaviest in the San Agustín sample. Wear in the Alameda-Stone cemetery sample was consistently heavier than that reported for Freedman's Cemetery. The average wear value for anterior teeth at Freedman's was slightly lower than that of any of the anterior or premolar teeth of the Alameda-Stone cemetery sample. It is interesting to note that the pattern of heavier tooth wear in males documented in the present study was also reflected in the Freedman's Cemetery sample.

Examination of dental-wear patterns in the Alameda-Stone cemetery sample reveals a regime of light to moderate wear. Wear was somewhat lighter than in the earlier San Agustín Mission sample, probably indicating a diet with slightly less-abrasive foods. However, overall wear was consistently heavier in the nineteenth-century Tucson burial population than in the late-nineteenth-century and early-twentieth-century Freedman's Cemetery sample from Dallas, Texas. It is likely that the diet in Tucson was heavily influenced by indigenous, as well as Hispanic, culinary traditions and regionally available foodstuffs. This apparently resulted in a relatively more abrasive dental environment than that of the post–Civil War African American population of Dallas.

Within the Alameda-Stone cemetery sample, there were consistent differences in wear between males and females, between cemetery areas, and between individuals of differing biological affinity (Table 221). These were most apparent in the young-adult age group and likely reflect differences in culinary traditions associated

with differing ethnicities. Dental-wear patterns suggest that Native American culinary traditions included foods that were more abrasive than those in Hispanic culinary practices, and individuals assessed as non-Hispanic Euroamerican had the least-abrasive dietary items overall.

Dental wear attributed to habitual or task-related nondietary activities was also recorded for the Alameda-Stone cemetery sample. A total of 409 adult individuals were determined to be observable for these modifications.

Crescent-shaped wear facets on the occlusal surfaces of opposed anterior teeth were found in 10 adult individuals. This wear pattern was possibly the result of abrasion from a pipe stem. Tobacco use, overall, does not appear to have been common. Brown stains, possibly the result of long-term use of tobacco products, were recorded for only one individual: a Hispanic male from Cemetery Area 3. This individual did not have pipe facets, and the staining could have resulted from either chewing tobacco or cigarettes.

Notches on the occlusal surfaces of incisors and canines were also recorded for 10 adults. These modifications likely resulted from manipulation of small, hard objects, possibly including toothpicks or sewing needles. Other types of modifications included grooves on the interproximal surfaces of molars or premolars (n = 4), steeply angled occlusal wear facets (n = 7), drilling (n = 1), and undefined grooving, scratching, or unusual wear angles (n = 15). The interproximal grooves and drilling modifications were likely therapeutic or palliative treatments related to dental pathologies. Nearly all of the people with indications of task or habitual nondietary wear also had chipped teeth.

Overall, habitual or task-related wear was present in 11.49 percent (n = 47) of the observable adult dental sample. Individually, the distribution of these dental modifications among cemetery areas, sexes, and biological-affinity groups did not differ significantly from expectations, although the frequency of Euroamericans with pipe facets (5.6 percent; n = 4) was somewhat higher than expected, based on overall frequency in the burial population. Because habitual or task-related dental modifications were rare in the Alameda-Stone cemetery sample, the numbers of individuals in each comparative subset were very small, and the results of chi-square tests would be suspect. Alternatively, the significance of the occurrence of these modifications can be assessed by probabilities calculated from the binomial expansion (Sokal and Rohlf 1969). For example, in the case referred to above, 4 of 71 observable Euroamerican individuals exhibited pipe facets. Based on the overall frequency of this modification in the Alameda-Stone cemetery sample (10 of 409, or 2.44 percent), the 2–tailed probability that 4 or more of 71 randomly selected individuals would present this trait has a value of $p = 0.0962$. Calculations were performed using the binomial function of a statistical package designed by Keith Kintigh (Tools for Quantitative Archaeology software).

If we consider all types of habitual or task-related dental modification cumulatively (with an overall frequency of 11.49 percent) and apply the same statistical method as in the case above, there is evidence that the frequency of these characteristics was significantly higher than expected in Euroamericans (19.72 percent; $p = 0.0389$). The frequency among Hispanic individuals was lower than expected (7.14 percent), but this difference did not reach significance at the 95 percent confidence level ($p = 0.0798$). Dental modifications in males (14.42 percent) and females (7.79 percent) also failed to reach statistical significance ($p = 0.1980$ and 0.1653, respectively). The percentage of dental modification in the Cemetery Area 2 (18.57 percent) appears to have been somewhat higher than expected, but did not reach statistical significance at the 95 percent confidence level ($p = 0.0875$).

Dental Restorations

Dental disease, including caries, antemortem tooth loss, calculus, and periodontal disease, was among the most common disorders that affected the individuals buried in the Alameda-Stone cemetery and must have been cause for much suffering. In all likelihood, the most common treatment was extraction of decayed teeth, an assumption supported by the frequency of antemortem tooth loss. Historical accounts (Arizona Hall of Fame Museum 1996:73–74) reported that dentists in early Arizona traveled from town to town, setting up temporary offices in hotels or other public accommodations. There was no osteological evidence to indicate the extraction

techniques used, but it is likely that any medical professional in early Tucson would have had suitable equipment to permit extraction of erupted teeth.

The availability of professional dental care, whether provided by doctors or itinerant dentists, would have been limited and, therefore, likely reflective of the patient's economic status. Furthermore, some individuals in the cemetery may have had access to professional treatment as a result of travel to larger cities where dentists were more numerous.

A small subsample of the individuals buried at the cemetery apparently had access to professional dental care. This was indicated by the presence of intact dental fillings from 11 sets of remains. The actual number of individuals who received this treatment was likely greater than this. Some people may have had filled teeth that were later extracted. Some of the filled teeth found at the cemetery showed evidence of continued decay and would eventually have been either refilled or extracted. It is also possible that fillings may have fallen out, either during life or as a result of decomposition of the remains. This possibility is supported by the finding of at least 2 cases of possible drilled teeth in individuals with no extant fillings.

Individuals with intact dental fillings are listed in Table 222. A total of 39 dental fillings were found with the remains of 11 individuals. This represents approximately 1 percent of the 1,049 individuals with observable dentitions. As shown in Figure 196, the individuals who had received this form of professional dental care were not uniformly distributed throughout the cemetery. All of the individuals with fillings were found in Cemetery Area 2, with the sole exception of the individual in Grave Pit 22157, who was recovered from Cemetery Area 3. Within Cemetery Area 2, there was one cluster of three adjacent individuals (Grave Pits 533, 534, and 825). Five others (Grave Pits 3230, 3244, 3287, 3311, and 3315) were also in close proximity.

Access to dental care in early Tucson was also apparently conditioned by sex. Ten of the 11 individuals with fillings were male. On the other hand, the sample of individuals who received professional dental care appears to have been ethnically diverse. In terms of biological affinity, 4 individuals were Euroamerican, 5 were Hispanic, and 1 was likely to have had African ancestry. Furthermore, all were adults, with the middle-adult group having the greatest number of cases.

Two individuals were exceptional in terms of the number of fillings. The adult males in Grave Pits 533 and 534 had a total of 24 gold fillings, or 62 percent of the total number of fillings recovered in the project area. These individuals were buried in adjacent graves, indicating a strong likelihood of some kind of relationship. The exceptional quality of dental care that these individuals received may indicate that they resided somewhere other than Tucson when the treatment was received.

Six other individuals also had gold fillings. Gold fillings were identified by inspection. Other materials were identified with the use of X-ray fluorescence spectroscopy (see Appendix B). One individual had a filling that was composed almost entirely of tin, and three individuals had fillings that were probably amalgam (typically a mixture of tin, silver, and mercury). These alternate materials were presumably less costly and more available than gold.

The distribution of fillings throughout the dental arcade is shown in Table 223. A majority of fillings were found in the upper jaw. The most commonly filled tooth in both the maxilla and mandible was the second molar. The cheek teeth (premolars and molars) had the majority of fillings (30 of 39), whereas fillings in anterior teeth (9 of 30) were found almost exclusively in the two individuals from Grave Pits 533 and 534.

Most fillings were located on occlusal (n = 17) or interproximal surfaces (n = 16). There were also a few instances of fillings on buccal or lingual surfaces. The individual in Grave Pit 533 had small fillings in the lingual fossae of both lateral maxillary incisors (Figure 197). A deep fossa is sometimes present in this tooth and is susceptible to the development of caries, but there was no evidence of carious destruction in these locations in this individual. It is possible that there was minimal demineralization that was covered up by the filling, but it is also possible that this was a case of prophylactic dental treatment.

Other types of dental treatment were extremely rare in the burial sample. The adult male individual in Grave Pit 22157 had two fillings but also had a dental appliance, consisting of a plate with an artificial maxillary tooth crown (Figure 198). The crown was porcelain, and the plate was either gold plated or a gold/copper alloy. The porcelain crown replaced the left central maxillary incisor and was anchored in the mouth by a bracket that attached to the neck of the left first premolar. This was the only instance of a dental prosthesis found with an individual buried at the cemetery.

Another type of rare dental treatment consisted of separation of the teeth through removal of interproximal portions of the enamel. This treatment could have been a preliminary preparation that was done to facilitate placement of a filling, but it could also have been used to remove shallow carious lesions without the need of restorative material (Harris 1885:406–428). Harris (1885) was the essential dental text in the mid- to late-nineteenth century and would have been familiar to most practitioners (Harris 1885:xv). The individual found in Grave Pit 2117 received this treatment on the right mandibular second premolar and first molar (Figure 199). Although the teeth were successfully separated, there was a carious lesion on the mesial interproximal surface of the first molar. Whether this lesion developed after the procedure or the treatment failed to eliminate the defect is not known. Nevertheless, the uniformity of the separation indicates that the practitioner had access to appropriate dental instruments.

The large sample of late-nineteenth- to early-twentieth-century burials from Freedman's Cemetery in Dallas (Tiné 2000:514–517) offers an interesting comparison. Professional dental treatment was not common during this time period, and the African American population represented at Freedman's Cemetery was economically disadvantaged, in relation to other populations in large American cities. At Freedman's Cemetery, fillings were found in 3.8 percent of observable individuals, with all but one individual from the post-1900 sample. Unlike the Alameda-Stone cemetery sample, at Freedman's Cemetery, dental work was nearly as common in females as males (3.4 percent and 4 percent, respectively).

At Freedman's Cemetery, as at the Alameda-Stone cemetery, almost all fillings were gold. However, at Freedman's, there were more fillings in anterior than posterior teeth. Tiné (2000) suggested that this may have been related to status, because gold fillings on anterior teeth may have been more visible than posterior fillings. It was also noted that nongold fillings, which were rare at Freedman's Cemetery, were limited to posterior teeth. Most individuals in the Freedman's sample who had fillings also had unfilled cavities elsewhere in the mouth, and the author suggested that there was more concern with treating cavities in anterior teeth because the fillings would be more visible. All of the individuals in the Alameda-Stone cemetery sample who had fillings also had unfilled cavities in other teeth. However, this may simply have been a matter of continued susceptibility to caries as a result of diet and inadequate dental prophylaxis. The two individuals from the Alameda-Stone cemetery sample who each had 10 or more fillings had additional untreated cavities. It is likely that these unfilled defects were not the result of an inability to pay for the work. Furthermore, the fillings on their anterior teeth were either on lingual surfaces or were small, interproximal fillings that would not have been very visible.

Although there does not appear to be evidence of dental treatment as a conspicuous indicator of economic status, the few examples of professional dental work in the burial sample and the unequal spatial distribution indicates that availability was likely limited to individuals of higher status. These findings may also indicate travel to other regions or migration from a place of greater economic resources.

Limited evidence of late-historical-period dentistry was recovered from two features that came from occupations postdating the operation of the cemetery. Two teeth with amalgam fillings were recovered from Feature 10214, which was a privy likely associated with the residence of a dentist (see Volume 3 of this series). A partial denture from the right side of the lower jaw was recovered from Privy Pit 650, which was associated with one or more residences. This dental appliance probably dates to the turn of the twentieth century. A dentist was permanently located in Tucson as early as 1879 (*The Arizona Daily Citizen*, 14 June 1879:1), and this undoubtedly increased the availability of dental treatment.

General Observations

Unusual dental conditions observed during analysis of the Alameda-Stone cemetery sample were thoroughly documented and photographed as permitted by the Burial Agreement. The discoloration of at least a few teeth within the majority of children and adults was not uncommon, an apparent taphonomic signature for the entire burial population. Dental anomalies, including ectopic eruption and supernumerary teeth, were observed for a few adult primary burials in the sample. Severe illness was evident for two juveniles, based on their dental morphology, and also suggested for some adults, based on their pathological dentitions. Violence-related

trauma was surmised for one adult male, from the perimortem breakage of alveolar bone and the mandible. Overall, more-intimate details about the lives of a number of individuals were made apparent through their dentitions.

The permanent maxillary canines and first premolars are the teeth that most frequently erupt in a location other than their normal placement within the dental arcade. This occurrence is termed ectopic eruption and has been associated with developmental problems, such as a cleft palate or the displacement of the tooth germ (Chen et al. 2002; Pindborg 1970). A retained deciduous tooth that blocks the eruption of a permanent tooth can also cause ectopic eruption. In addition to these environmentally related conditions, inheritance is also a causal agent of maleruption and the development of supernumerary teeth (Alt and Vach 1995; Chen et al. 2002; Ely et al. 2006). A duplicated or additional tooth in the standard permanent dentition of 32 teeth is referred to as a supernumerary.

Five primary adult burials from an approximate sample of 465 adults had unusual eruption or placement of supernumerary teeth within the alveolar bone. Two Native American females (Grave Pits 7886 and 7916) and 1 Hispanic male (Grave Pit 10148) had ectopically erupted supernumerary maxillary canines. Two additional males (Grave Pits 7720 and 7918), one Hispanic and one of indeterminate biological affinity, had maxillary supernumerary teeth embedded or partially erupted in the anterior palate. None of the individuals with ectopic or malerupted teeth had cleft palates or any other unusual attributes of their dentitions.

Another seven adults in the Alameda-Stone cemetery sample had erupted supernumerary teeth in the proper area of the dental arcades, including two individuals that each had two supernumerary teeth. A female of indeterminate biological affinity (Grave Pit 10383) had an extra lower central incisor and maxillary fourth molar. A Native American male (Grave Pit 13502) had bilateral supernumerary mandibular premolars.

Of the 12 cases of supernumerary teeth, 5 were Hispanic individuals (3 males and 2 females). Three Native American individuals, 2 individuals of indeterminate affinity, and 2 individuals of Euroamerican descent also had supernumerary teeth. It is interesting that the 2 Euroamerican individuals, a female (Grave Pit 1779) and one individual of indeterminate sex (Grave Pit 7685), each had a supernumerary maxillary lateral incisor. They were the only cases of identified Euroamericans with supernumerary teeth and with the duplication of that particular tooth. As inheritance is a factor contributing to the presence of ectopic and supernumerary teeth, the possibility of kinship between some of these cases of ectopic and supernumerary teeth seems likely.

Another heritable anomaly is microdontia. This dental variant consists of teeth that are considerably smaller in size but with fairly normal morphology. Microdontia has been associated with hypodontia, the absence or lack of development of teeth in a standard dentition, and with mental retardation, dwarfism, congenital deafness, and other developmental ailments (Pindborg 1970). Two females, one Hispanic (Grave Pit 7790) and one of indeterminate affinity (Grave Pit 10133), had quite small teeth but complete dentitions. No indications of compromised health were observed.

On the other hand, definite instances of poor health were observed through the dentitions of two juveniles. A Euroamerican child (Grave Pit 13296) aged 10–12 years at time of death exhibited textbook examples of teeth with characteristics associated with congenital syphilis (Pindborg 1970). Hutchinson's incisors and mulberry molars were observed for permanent teeth within the maxillary and mandibular dentitions of this individual. Another child (Grave Pit 7792), aged 6–9 months at time of death, had deciduous teeth with severe enamel defects that affected the entire surfaces and interiors of the teeth, resulting in a "melted" appearance. Pathological aspects of the infant's skeletal remains supported a chronic systemic disorder for this child (Bhat and Nelson 1989). Both of these children and detailed descriptions of the teeth are discussed in Chapter 14. Also discussed at length in Chapter 14 is the one obvious case of violence observed during dental analysis. An adult male in Grave Pit 22157 had a broken mandible, caused by blows to the jaw at or near the time of death. This individual was also discussed in the section on dental restorations, being the one individual in the entire Alameda-Stone cemetery sample with a dental appliance.

Conclusion

It has long been recognized that oral health has a significant impact on the overall physical, social, and psychological health of individuals and populations. Dental health is also strongly reflective of variation in diet, personal dental hygiene, and access to professional dental care. The analysis of the dental remains from the Alameda-Stone cemetery sample has provided an exceptional opportunity to document dental health from a frontier settlement of the Old West. The time period represented by this burial population was one of significant changes in southern Arizona, conditioned by the acquisition of the territory by the United States and the subsequent influx of Euroamerican settlers. Yet Tucson remained very much a frontier community on the margin of a developing nation. Long-distance commerce and travel were quite limited in Tucson in the days preceding the arrival of the railroad. This undoubtedly had an impact on dietary breadth, and it is reasonable to expect a continuation of patterns established in Tucson as a Spanish colonial settlement.

In order to better comprehend the picture of dental health in late-nineteenth-century Tucson, we would like to compare this sample with other samples from the same time period. We were very fortunate in having two small comparative samples from Tucson dating to the decades immediately preceding the establishment of the Alameda-Stone cemetery. Additional comparisons were possible with several historical-period cemeteries from other regions in the United States.

Two of the most revealing dental pathologies, in terms of diet and generalized stress, are caries and enamel hypoplasia. Examination of the comparative frequencies of caries reveals a bimodal distribution, with several burial samples having observed caries frequencies of less than 10 percent and another group having frequencies in excess of 25 percent. It is notable that the two samples from eastern North America (Voegtly Cemetery, Pennsylvania, and St. Thomas' Anglican Church Cemetery, Ontario), which represent predominately middle-class communities, both had high rates of caries (Table 224). In contrast with frontier settlements, these communities were located in regions with well-established transportation networks, and as discussed previously, a wide range of foodstuffs would have been available, including sugar and refined flour. Freedman's Cemetery in Dallas also represents a community that would have had relatively easy access to transportation networks, especially by the late-nineteenth and early-twentieth centuries, when the cemetery was in use. The highest individual caries frequency of any group in this comparison was recorded for the Freedman's Cemetery sample.

By contrast, all of the frontier settlements in the comparative samples had substantially lower observed caries frequencies. The Palace of the Legion of Honor section of Golden Gate Cemetery in San Francisco also had a very low rate, which is surprising, given the likelihood that the city was a major commercial center. The fact that the population represented by this cemetery was believed to represent an economically disadvantaged subpopulation may be relevant. It suggests that access to the more cariogenic dietary items may have been conditioned by economic status.

Observed and individual caries frequencies for the Alameda-Stone cemetery sample and the San Agustín Mission were remarkably similar, suggesting a continuation of dietary staples from the late-eighteenth century to the late-nineteenth century. The Presidio de Tucson cemetery, however, had the lowest observed caries frequency of any of the comparative groups.

There was also an apparent bimodal distribution in the frequencies of enamel hypoplasia in the comparative samples, but it did not separate the samples into the same groups as did the caries frequencies. Roughly a quarter of the individuals at the Alameda-Stone cemetery and the Voegtly Cemetery exhibited enamel hypoplasia on at least one tooth, whereas about three-quarters of the individuals in the two earlier Tucson samples and the Refugio Mission sample had these defects. The San Francisco and Pennsylvania samples also had higher rates, in terms of the frequency of teeth affected, than the Alameda-Stone cemetery sample as a whole. As a generalized indicator of episodic growth disruption, enamel hypoplasia may reflect periods of nutritional deprivation and/or exposure to disease. We may expect both of these factors to have been accentuated in populations with lower socioeconomic status and especially in dense urban populations, which facilitate the spread of infectious disease. It seems likely that the earlier Tucson population, represented by the San Agustín Mission and Presidio samples, was subjected to higher levels of stress. It is possible that the history of periodic

Apache raids may have played a part in disrupting food supplies or leading to other hardships that left their mark on developing teeth.

Overall, dental health in late-nineteenth-century Tucson seems consistent with that expected for a frontier settlement in this era. Caries and hypoplasia were fairly common conditions, but they were not as prevalent as in some other comparable communities. The very limited evidence of professional dental care in the Alameda-Stone cemetery sample is also consistent with a prerailroad frontier community. It is undoubtedly the case that the most common remedy for dental disease during this era was extraction, as it had been for most of human history. As for prevention, we lack direct evidence of personal dental hygiene in the community represented by this sample. But we do know that people through time have used various implements for cleaning their teeth, including small picks and softened twigs. Toothbrushes were not commonly available or used in the United States until mass production of the appliance began in 1885 (U.S. Library of Congress 2009), which postdates the period of cemetery use. The use of a toothbrush in American society did not really become a standard hygiene practice until after World War II, when it became a daily duty brought home by returning soldiers.

Although the overall picture of dental health in the Alameda-Stone cemetery population conforms to expectations for a frontier settlement, there were intriguing differences within the cemetery between men and women, between spatially defined cemetery subdivisions, and between individuals with different biological affinity. Considering the cemetery as a whole, males and females experienced similar levels of dental pathologies. There were no significant differences between the sexes in the frequencies of dental abscesses, enamel hypoplasia, or antemortem tooth loss. Caries frequencies were somewhat higher for males than for females, but this did not quite reach statistical significance. Males, however, did accumulate significantly more tooth wear than did females, suggesting that there were some underlying differences in diet. Perhaps the most compelling evidence of a difference between the sexes in dental health was the fact that dental fillings were almost exclusively found in men, although they were confined to a small subset of the male population. These men must either have enjoyed an economic advantage or had greater access to professional dental care as a result of their travels.

Significant differences were also apparent in the spatial distribution of dental pathologies within the cemetery. Antemortem tooth loss was higher than expected in Cemetery Area 4 and very low in Cemetery Area 5. Cemetery Area 5 also had the lowest observed caries frequency; this pathology was significantly more common in Cemetery Areas 1 and 2. Tooth wear was higher in Cemetery Areas 3 and 4 than in Areas 1 or 2 for almost every tooth. The pattern of relatively low wear and high incidence of caries in Cemetery Areas 1 and 2 strongly suggests that the individuals buried in this cemetery subdivision had diets with softer or more highly processed foods, probably with a higher carbohydrate component. It is also notable that nearly all of the cases of dental restorations were concentrated in Cemetery Area 2.

There was also a disparity in the spatial distribution of enamel hypoplasia. The incidence of this pathology in the permanent teeth of adults was significantly more common in Cemetery Area 1, the military section of the cemetery. This indicates that the individuals who ended up in military service differed from the burial population as a whole in having experienced greater levels of nutritional or disease stress in childhood. Furthermore, although they may have enjoyed access to softer or more finely processed foods in adulthood, there was a price to pay in terms of more dental decay. Enamel hypoplasia frequencies in juveniles were somewhat elevated in Cemetery Areas 4 and 5, but none reached statistical significance.

The differences in dental pathologies and wear were, perhaps, more compelling when comparing individuals of differing biological affinity. Antemortem tooth loss was less common than expected in Native Americans and more common than expected in Hispanics. Differences in caries frequencies among the same three groups did not reach statistical significance, but it is interesting that it followed the same pattern with lower-than-expected frequencies in Native Americans and higher-than-expected rates in Hispanics. When considering individuals with two or more dental abscesses, however, Native American and Hispanic individuals suffered from significantly higher frequencies. The higher percentage of abscesses in Native Americans, combined with the lower rate of antemortem loss, may seem inconsistent. One possibility is that Native Americans had less access to medical treatment than Hispanics, and consequently, abscessed teeth were more likely to be retained in the mouth. It may also be relevant that evidence of professional dentistry was apparently limited to Euroamerican and Hispanic individuals.

When we compare the incidence of enamel hypoplasia as a count of affected teeth in adults, we find that the occurrence of this pathology was significantly greater among Euroamerican individuals than among Native Americans or Hispanics. Because many of the Euroamericans may have migrated to Tucson after the Gadsden Purchase, this pathology actually reflects childhood stress that they experienced somewhere outside the region. The incidence of enamel hypoplasia among juveniles in the Alameda-Stone cemetery sample, however, follows a different pattern. In examination of the permanent teeth of juveniles, we find that Native Americans had higher rates of enamel hypoplasia and Euroamericans had lower rates than expected. Hispanic juveniles experienced about the expected prevalence of this type of defect. These differences were highly significant and suggest that Euroamerican juveniles had an advantage in being buffered against nutritional deprivation or exposure to infectious disease. Differences in the occurrence of enamel hypoplasia in deciduous teeth followed a similar pattern, with higher rates among Native Americans, moderate rates in Hispanics, and lower rates in Euroamericans, although the differences among these affinity groups did not reach statistical significance. The comparison in this case was made difficult by the fact that the majority of young juveniles could not be assigned to a biological-affinity group. The highest rate of enamel hypoplasia in deciduous teeth was actually found in the indeterminate affinity group and is difficult to interpret.

The most consistent differences among affinity groups were found in terms of mean wear scores of the permanent teeth. Native American individuals experienced heavier wear than Hispanic individuals, and Euroamerican individuals experienced lower wear rates on teeth than either of these groups. The differences were consistent for every tooth category and were statistically significant in nearly every case. This may be the most compelling evidence of differences in dietary staples and food preparation related to ethnicity.

The dental health of the Alameda-Stone cemetery sample was not perfect, by any means, but the low caries rates, generally mild cases of periodontal disease, and low to moderate rates for enamel hypoplasia are suggestive of a generally healthy population.

Perhaps increased safety from the constant presence of the military in the 1860s, generally healthy diets with nominal amounts of processed flours and sugars, and the lack of rapid urbanization when compared with other historical-period populations meant that life in frontier Tucson was relatively good.

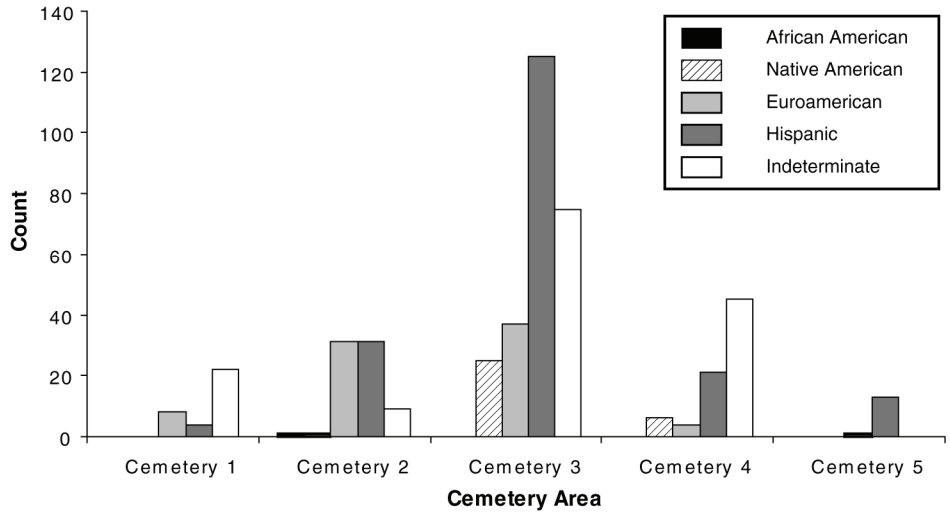

Figure 183. Adult dental sample by biological affinity and cemetery area, Alameda-Stone cemetery.

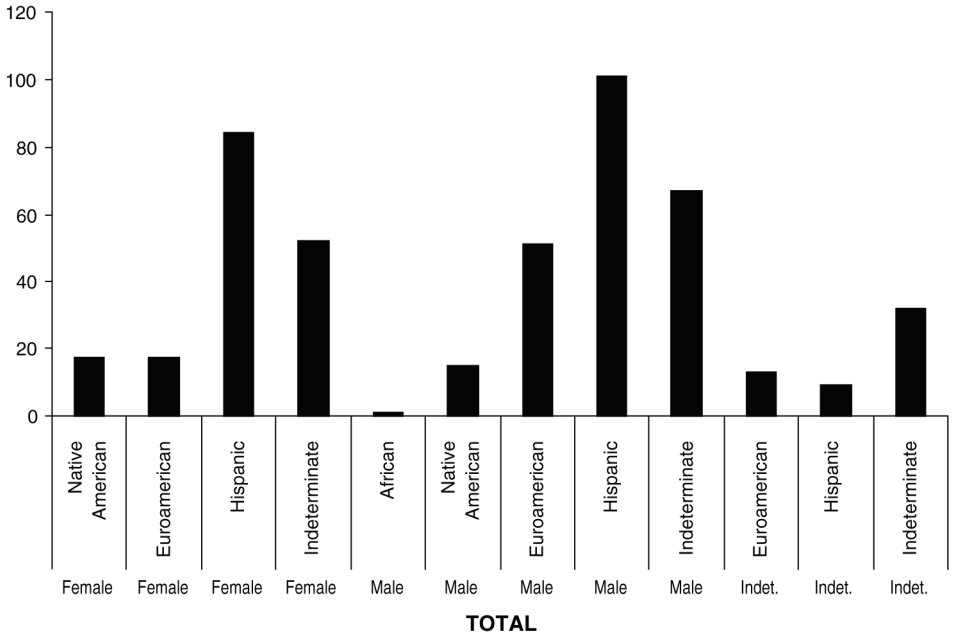

Figure 184. Adult dental sample by biological affinity and sex, Alameda-Stone cemetery.

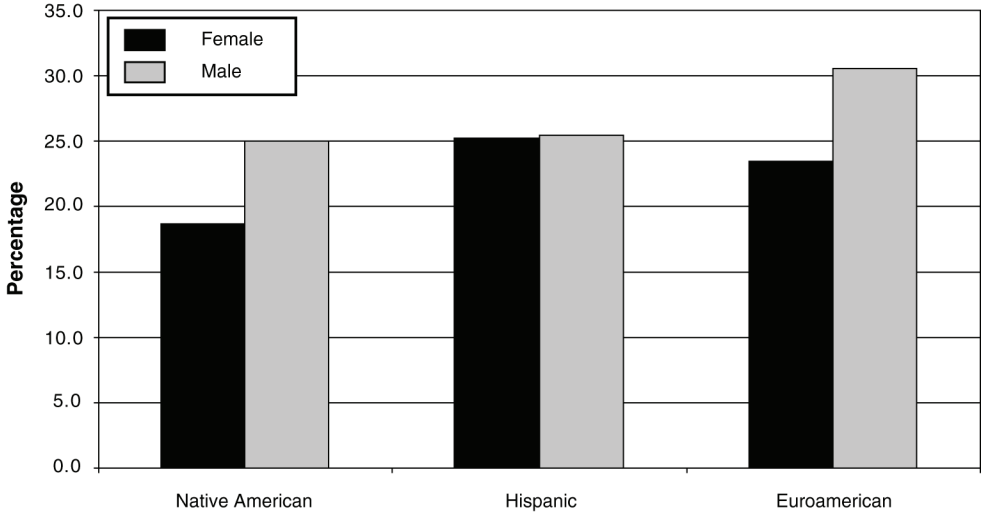

Figure 185. Distribution of enamel hypoplasias by biological affinity and sex for the adults of the Alameda-Stone cemetery.

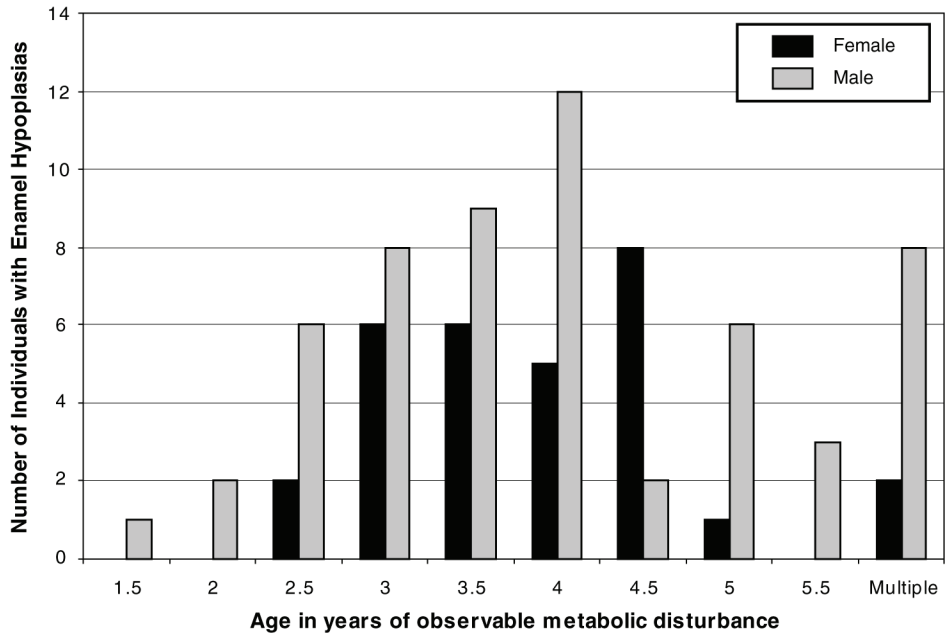

Figure 186. Age when metabolic disturbance began for adults recovered from the Alameda-Stone cemetery sample.

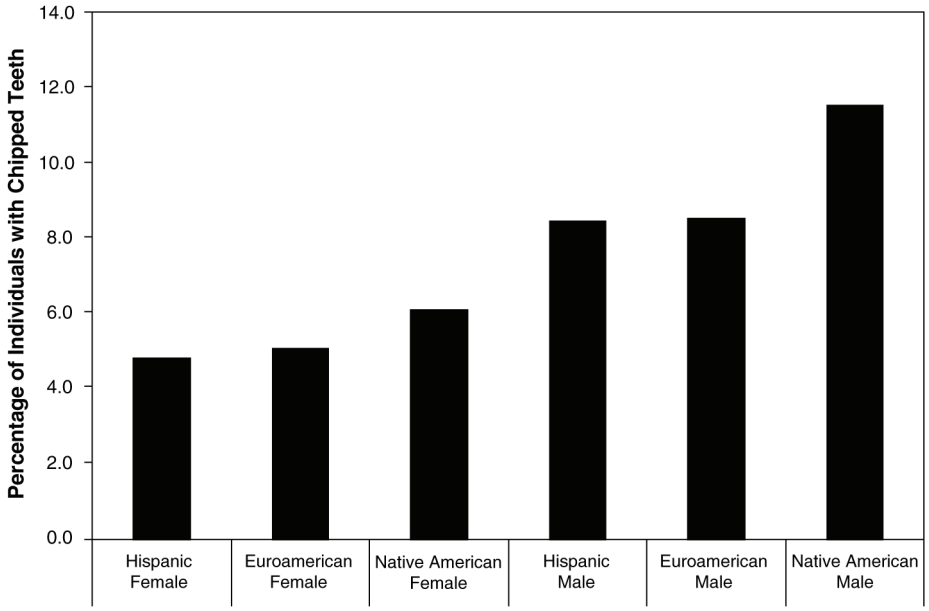

Figure 187. Distribution of enamel chipping among the adults of the Alameda-Stone cemetery sample.

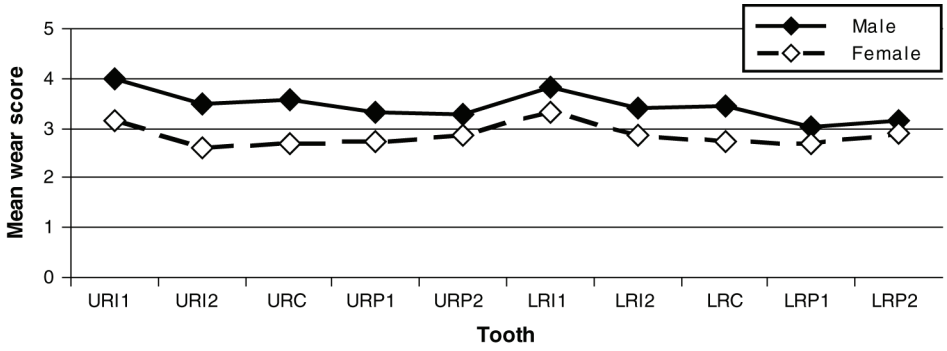

Figure 188. Male and female anterior and premolar tooth wear for the Alameda-Stone cemetery sample.

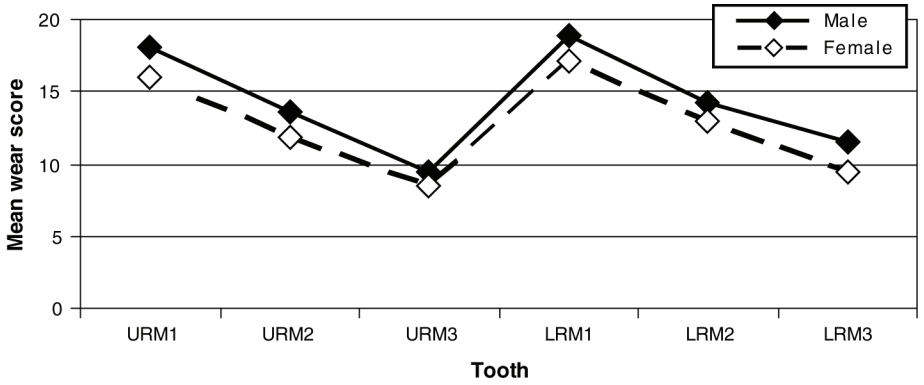

Figure 189. Male and female molar tooth wear for Alameda-Stone cemetery sample.

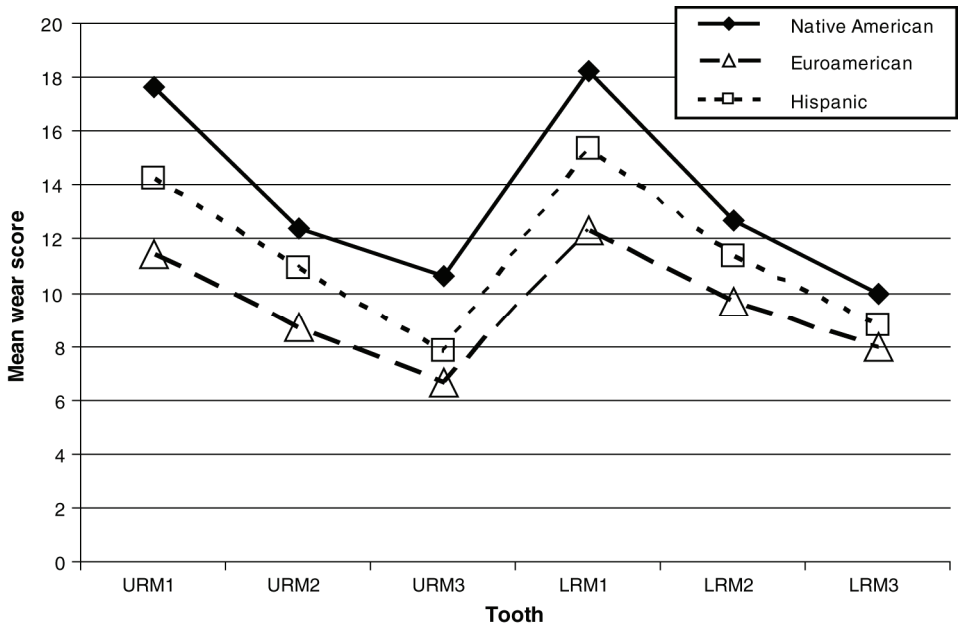

Figure 190. Comparison of molar wear values for the Alameda-Stone cemetery sample, by biological affinity.

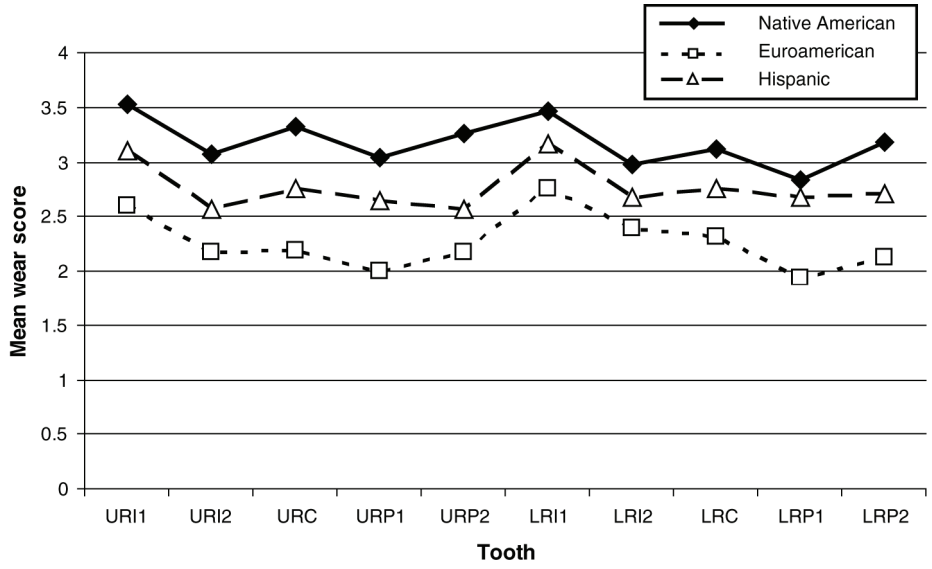

Figure 191. Comparison of anterior and premolar tooth wear values for the Alameda-Stone cemetery sample, by biological affinity.

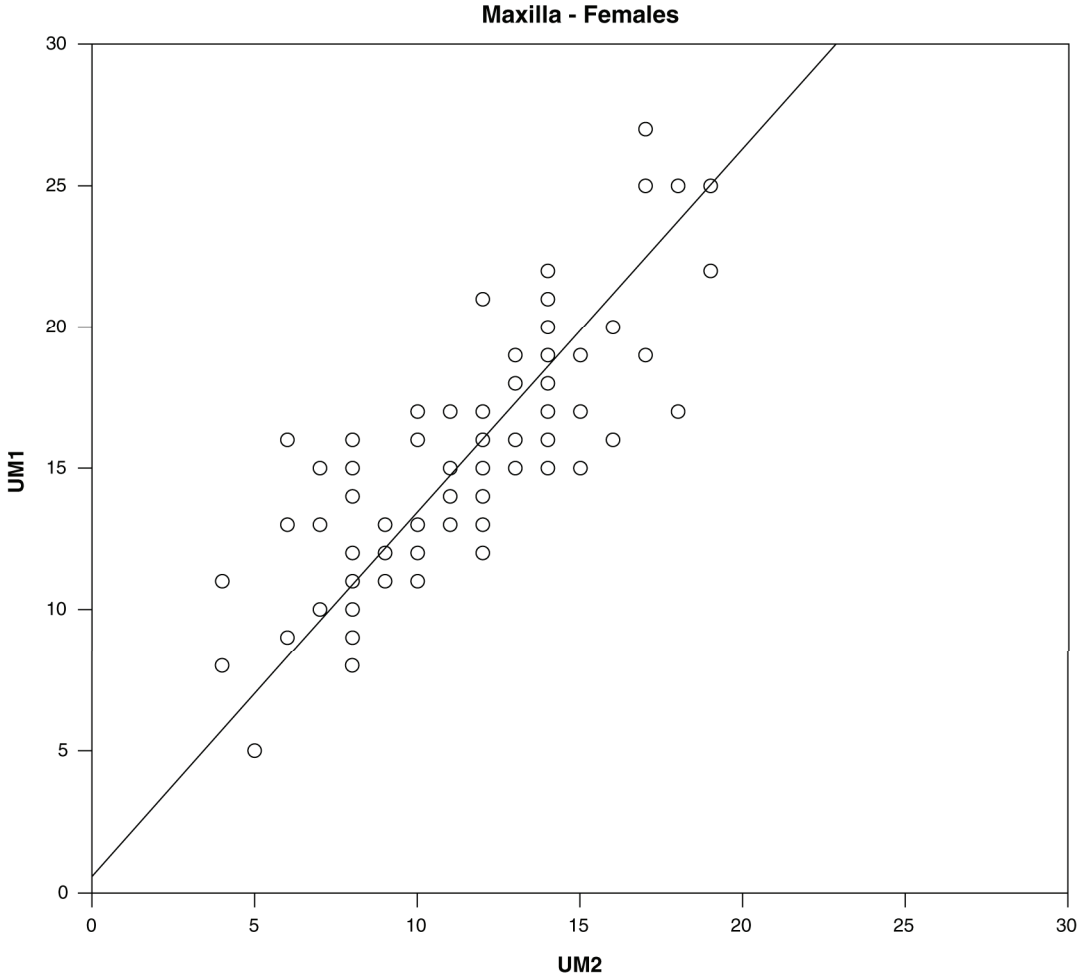

Figure 192. Principal axis plot of wear values for paired first and second permanent maxillary molars for female adults of the Alameda-Stone cemetery sample.

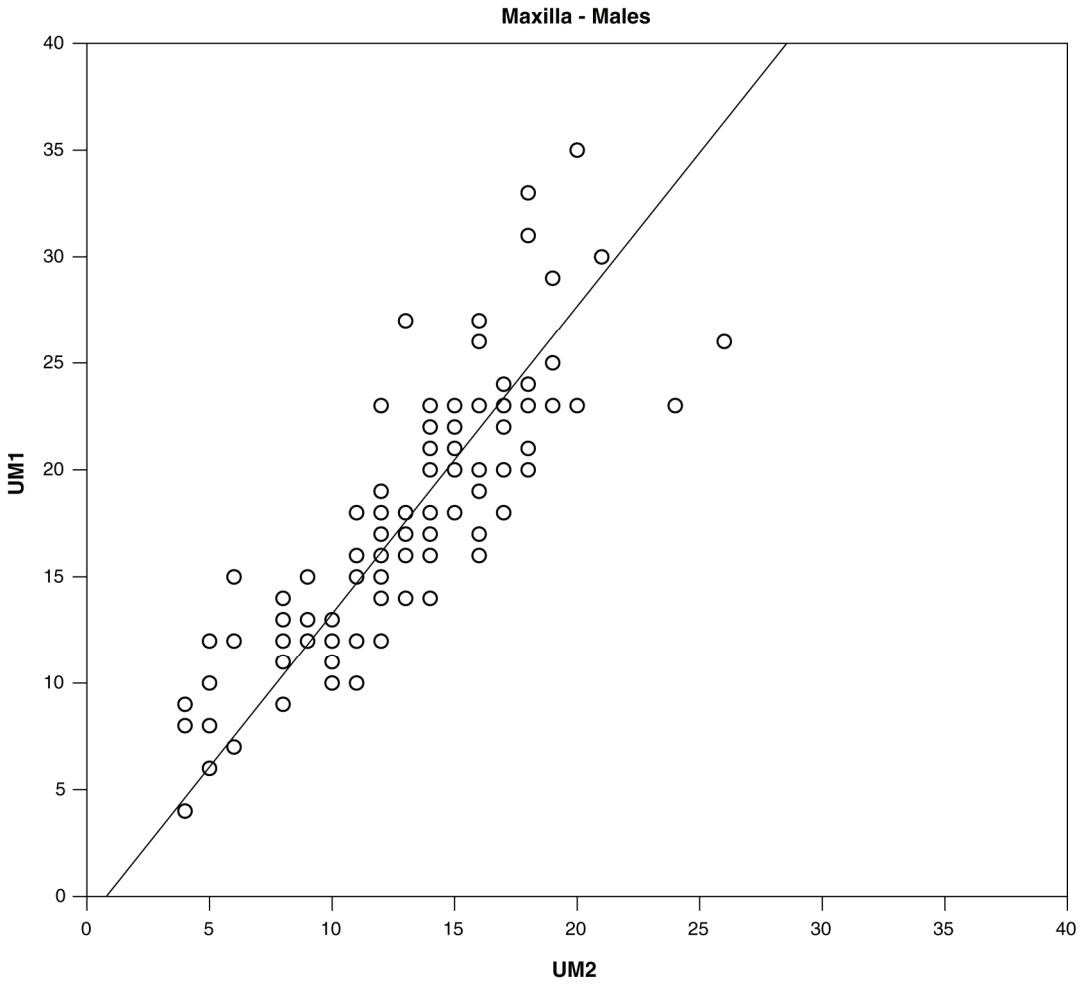

Figure 193. Principal axis plot of wear values for paired first and second permanent maxillary molars for male adults of the Alameda-Stone cemetery sample.

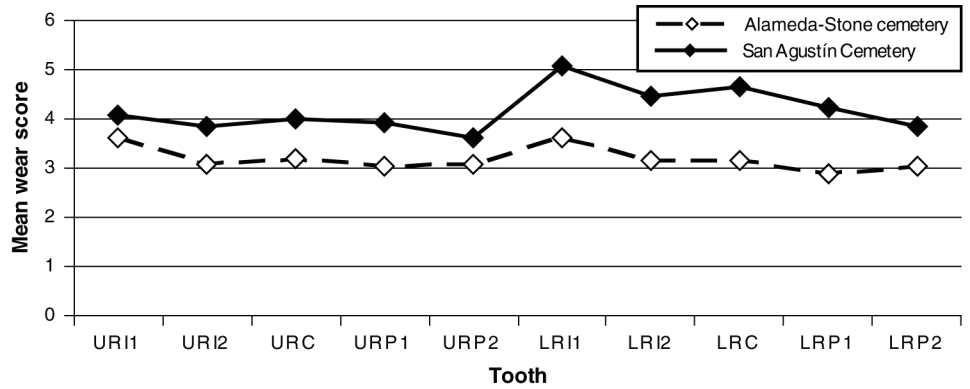

Figure 194. Comparison of anterior and premolar tooth wear values between the Alameda-Stone cemetery sample and the San Agustín Cemetery.

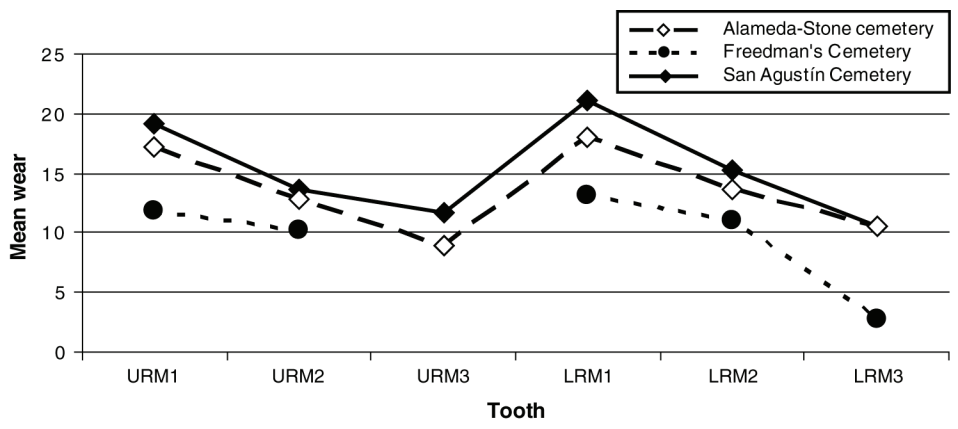

Figure 195. Comparison of molar wear values between the Alameda-Stone cemetery sample with other cemetery samples.

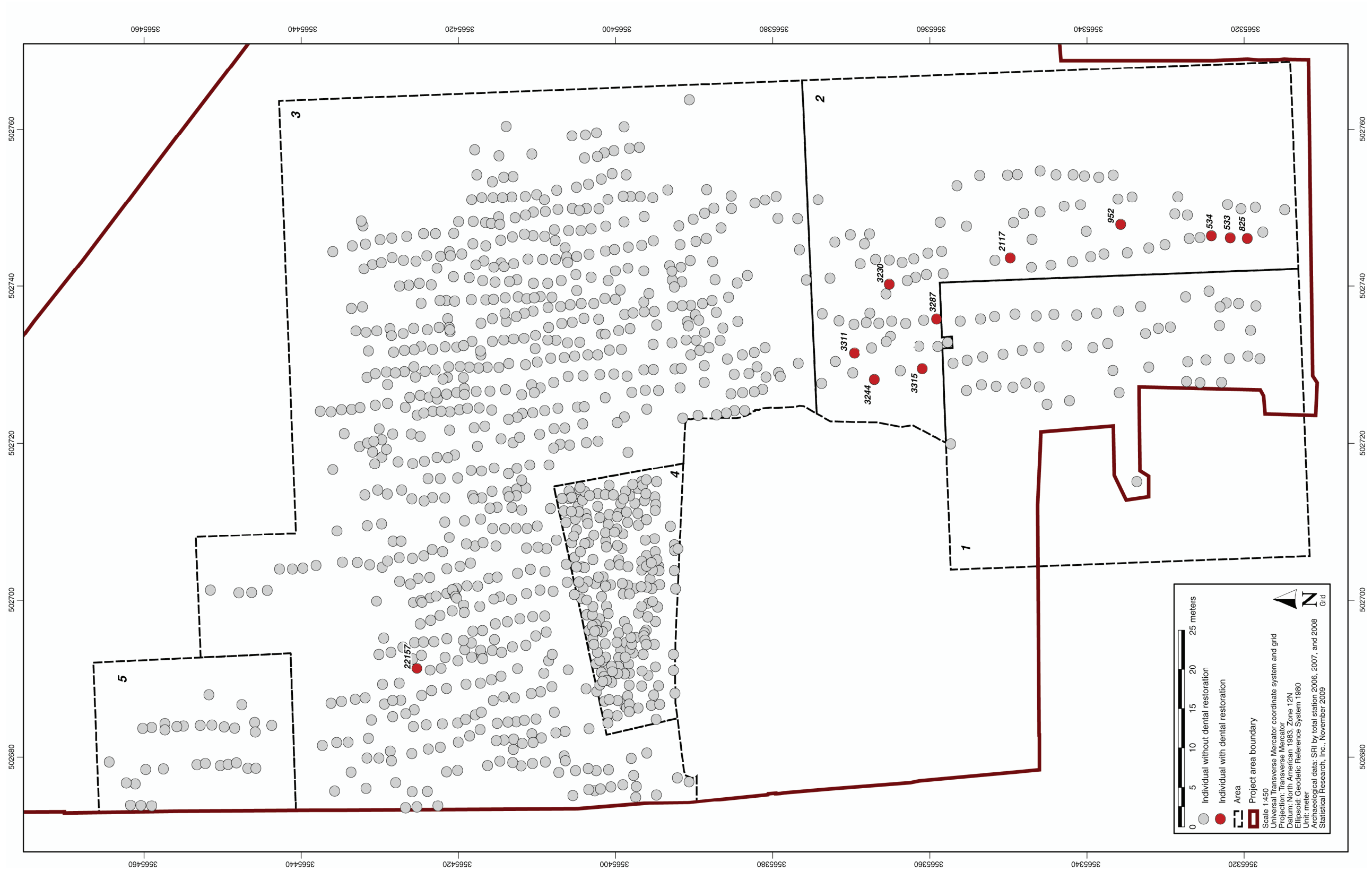

Figure 196. Map of Alameda-Stone cemetery with locations of individuals with dental restorations, Alameda-Stone cemetery sample.

Figure 197. Gold fillings in lingual fossa of lateral incisor and between premolars of Individual P, Grave Pit 533, Burial 1113, a middle-adult Hispanic male.

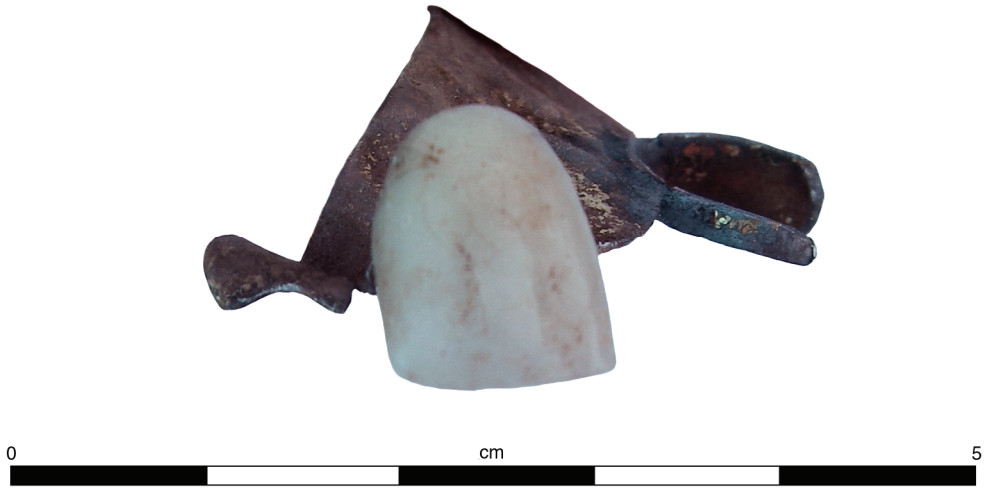

Figure 198. Dental plate with artificial tooth, Individual P2, Grave Pit 22157, Burial 21848, a middle-adult male of indeterminate biological affinity.

Figure 199. Dental treatment by removal of interproximal surfaces, Individual P, Grave Pit 2117, Burial 6794, a young-adult Hispanic male.

Table 201. Alameda-Stone Cemetery Sample of Primary Burials Used in Dental Analysis, by Cemetery Area, Sex, and Biological Affinity

Biological Affinity	Area 1		Area 2		Area 3		Area 4		Area 5		Total	
	n	%	n	%	n	%	n	%	n	%	n	%
						Female						
Native American	—		—		13	4.53	3	3.13	—		16	3.07
Apache	—		—		1	0.35	—		—		1	0.19
Euroamerican	—		3	3.95	14	4.88	—		—		17	3.26
Hispanic	—		4	5.26	66	23.00	7	7.29	7	43.75	84	16.12
Indeterminate affinity	—		—		41	14.29	24	25.00	—		65	12.48
Subtotal	—		7	9.21	135	47.05	34	35.42	7	43.75	183	35.12
						Indeterminate Sex						
Euroamerican	7	15.22	1	1.32	4	1.39	1	1.04	—		13	2.50
Hispanic	2	4.35	—		4	1.39	3	3.13	—		9	1.73
Indeterminate affinity	26	56.52	3	3.95	14	4.88	11	11.46	—		54	10.36
Subtotal	35	76.09	4	5.27	22	7.66	15	15.63	—		76	14.59
						Male						
African American	—		1	1.32	—		—		—		1	0.19
Native American	—		1	1.32	11	3.83	4	4.17	—		16	3.07
Euroamerican	1	2.17	27	35.53	20	6.97	3	3.13	1	6.25	52	9.98
Hispanic	2	4.35	27	35.53	56	19.51	11	11.46	6	37.50	102	19.58
Indeterminate affinity	8	17.39	9	11.84	43	14.98	29	30.21	2	12.50	91	17.47
Subtotal	11	23.91	65	85.54	130	45.29	47	48.96	9	56.25	262	50.29
Total	46	8.83	76	14.59	287	55.09	96	18.43	16	3.07	521	100.00

Table 202. Comparative Historical-Period Cemetery Samples Used in Dental Analysis

Cemetery	Location and Period of Cemetery Use	Project Count of Individuals or MNI	Approximate Number of Adults in Dental Sample	Investigator(s)	Population Profile
Alameda-Stone cemetery	Tucson, Arizona (1861–1875)	1,339 (represented)	467	this chapter	Hispanic, Native American and Euroamerican groups represented; Frontier Arizona territory communities.
Tucson Presidio Cemetery	Tucson, Arizona (1776–1830s)	104 (recovered)	17	Dayhuff 2002	Euroamerican, Hispanic groups represented; community reliant upon military protection.
San Agustín del Tucson Mission	Tucson, Arizona (1750s–1840s)	53 (recovered)	32	Dayhuff 2002	Primarily Native American mission population.
Nuestra Señora del Refugio Mission	Refugio, Texas (1807–1825)	177 (represented)	70	Jantz et al. 2001	Primarily Native American mission population; ~ 30 percent of burials Euroamerican and admixed individuals.
Freedman's Cemetery	Dallas, Texas (1869–1907)	1,157 (recovered)	611	Davidson et al. 2002	African American cemetery population from post-slavery communities of Dallas, Texas.
Palace of the Legion of Honor	San Francisco, California (1868–1906)	900 (recovered)	80	Buzon et al. 2005	Primarily Euroamerican, lower economic class sample from burial population.
Mormon Pioneer Population	Salt Lake City, Utah (1847–1860)	34 (recovered)	9	Tigner-Wise 1989	Primarily northern European biological affiliation for migrant population.
Voegtly Church Cemetery	Pittsburgh, Pennsylvania (1833–1861)	687 (represented)	69	Ubelaker and Jones 2003	Primarily Swiss-German ethnicity; evidence of urbanization.
St. Thomas' Anglican Church Cemetery	Belleville, Ontario, Canada (1821–1874)	577 (recovered)	229	Saunders et al. 1997; Saunders et al. 2002	Primarily middle- to upper-class Euroamerican population; evidence of urbanization.

Table 203. Antemortem Loss for Alameda-Stone Cemetery Sample, by Cemetery Area and Biological Affinity

Biological Affinity	Area 1		Area 2		Area 3		Area 4		Area 5		Total	
	n	%	n	%	n	%	n	%	n	%	n	%
	Female											
Native American												
Number of permanent teeth (erupted)	—		—		394		81		—		475	
Antemortem loss (number of teeth)	—		—		24	6.1	4	4.9	—		28	5.9
Euroamerican												
Number of permanent teeth (erupted)	—		89		386		—		—		475	
Antemortem loss (number of teeth)	—		2	2.2	26	6.7	—		—		28	5.9
Hispanic												
Number of permanent teeth (erupted)	—		120		1,778		204		224		2,326	
Antemortem loss (number of teeth)	—		4	3.3	211	11.9	12	5.9	—		227	9.8
Indeterminate affinity												
Number of permanent teeth (erupted)	—		—		850		284		—		1,134	
Antemortem loss (number of teeth)	—		—		131	15.4	112	39.4	—		243	21.4
Subtotal permanent teeth (erupted)	—		209		3,408		569		224		4,410	
Subtotal of antemortem loss (number of teeth)	—		6	2.9	392	11.5	128	22.5	—		526	11.9
	Indeterminate Sex											
Euroamerican												
Number of permanent teeth (erupted)	39		28		116		12		—		195	
Antemortem loss (number of teeth)	—		—		—		—		—		—	
Hispanic												
Number of permanent teeth (erupted)	33		—		86		70		—		189	
Antemortem loss (number of teeth)	—		—		34	39.5	1	1.4	—		35	18.5
Indeterminate affinity												
Number of permanent teeth (erupted)	90		31		57		64		—		242	
Antemortem loss (number of teeth)	—		—		—		18	28.1	—		18	7.4
Subtotal permanent teeth (erupted)	162		59		259		146		—		626	
Subtotal antemortem loss (number of teeth)	—		—		34	13.1	19	13.0	—		53	8.5
	Male											
African American												
Number of permanent teeth (erupted)	—		28		—		—		—		28	
Antemortem loss (number of teeth)	—		3	10.7	—		—		—		3	10.7
Native American									—			
Number of permanent teeth (erupted)	—		22		276		74		—		372	
Antemortem loss (number of teeth)	—		6	27.3	26	9.4	5	6.8	—		37	9.9

continued on next page

Biological Affinity	Area 1		Area 2		Area 3		Area 4		Area 5		Total	
	n	%	n	%	n	%	n	%	n	%	n	%
Euroamerican									—			
Number of permanent teeth (erupted)	8		692		540		71		32		1,343	
Antemortem loss (number of teeth)	—		95	13.7	48	8.9	13	18.3	—		156	11.6
Hispanic												
Number of permanent teeth (erupted)	53		744		1,443		289		183		2712	
Antemortem loss (number of teeth)	7	13.2	65	8.7	214	14.8	25	8.7	2	1.1	313	11.5
Indeterminate affinity												
Number of permanent teeth (erupted)	20		168		712		544		—		1,444	
Antemortem loss (number of teeth)	—		26	15.5	124	17.4	74	13.6	15	100.0	239	16.6
Subtotal permanent teeth (erupted)	81		1,654		2,971		978		215		5,899	
Subtotal antemortem loss (number of teeth)	7	8.6	1,95	11.8	412	13.9	117	12.0	17	7.9	748	12.7
Total permanent teeth (erupted)	243		1,922		6,638		1,693		439		10,935	
Total antemortem loss (number of teeth)	7	2.9	201	10.5	838	12.6	264	15.6	17	3.9	1,327	12.1

Table 204. Observed Caries Frequencies for the Alameda-Stone Cemetery Sample, by Cemetery Area and Biological Affinity

Biological Affinity	Area 1		Area 2		Area 3		Area 4		Area 5		Total	
	n	%	n	%	n	%	n	%	n	%	n	%
	Adult Female											
Native American												
Number of permanent teeth (erupted)	—		—		372		81		—		453	
Caries (number of teeth)	—		—		21	5.65	4	4.94	—		25	5.52
Apache												
Number of permanent teeth (erupted)	—		—		22		—		—		22	
Caries (number of teeth)	—		—		16	72.73	—		—		16	72.73
Euroamerican												
Number of permanent teeth (erupted)	—		89		386		—		—		475	
Caries (number of teeth)	—		12	13.48	15	3.89	—		—		27	5.68
Hispanic												
Number of permanent teeth (erupted)	—		120		1,778		204		224		2,326	
Caries (number of teeth)	—		16	13.33	156	8.77	20	9.80	9	4.02	201	8.64
Indeterminate affinity												
Number of permanent teeth (erupted)	—		—		827		284		—		1,111	
Caries (number of teeth)	—		—		82	9.92	26	9.15	—		108	9.72
Subtotal of permanent teeth (erupted)	—		209		3,385		569		224		4,387	
Subtotal of caries (number of teeth)	—		28	13.40	290	8.57	50	8.79	9	4.02	377	8.59
	Adult Indeterminate Sex											
Euroamerican												
Number of permanent teeth (erupted)	39		28		116		12		—		195	
Caries (number of teeth)	4	10.26	—		4	3.45	2	16.67	—		10	5.13
Hispanic												
Number of permanent teeth (erupted)	33		—		86		70		—		189	
Caries (number of teeth)	1	3.03	—		21	24.42	—		—		22	11.64
Indeterminate affinity												

Biological Affinity	Area 1		Area 2		Area 3		Area 4		Area 5		Total	
	n	%	n	%	n	%	n	%	n	%	n	%
Number of permanent teeth (erupted)	90		31		57		64		—		242	
Caries (number of teeth)	9	10.00	1	3.23	5	8.77	15	23.44	—		30	12.40
Subtotal of permanent teeth (erupted)	162		59		259		146		—		626	
Subtotal of caries (number of teeth)	14	8.64	1	1.69	30	11.58	17	11.64	—		62	9.90
	Adult Male											
African American												
Number of permanent teeth (erupted)	—		28		—		—		—		28	
Caries (number of teeth)	—		3	10.71	—		—		—		3	10.71
Native American												
Number of permanent teeth (erupted)	—		22		276		74		—		372	
Caries (number of teeth)	—		1	4.55	33	11.96	3	4.05	—		37	9.95
Euroamerican												
Number of permanent teeth (erupted)	8		692		540		71		32		1,343	
Caries (number of teeth)	5	62.50	91	13.15	36	6.67	6	8.45	—		138	10.28
Hispanic												
Number of permanent teeth (erupted)	53		744		1,443		289		183		2,712	
Caries (number of teeth)	7	13.21	96	12.90	133	9.22	23	7.96	12	6.56	271	9.99
Indeterminate affinity												
Number of permanent teeth (erupted)	20		168		685		544		—		1,417	
Caries (number of teeth)	2	10.00	30	17.86	50	7.30	31	5.70	—		113	7.97
Male number of permanent teeth (erupted)	81		1,654		2,944		978		215		5,872	
Male caries (number of teeth)	14	17.28	221	13.36	252	8.56	63	6.44	12	5.58	562	9.57
Subtotal of permanent teeth (erupted)	243		1,922		6,588		1,693		439		10,885	
Subtotal of teeth	28	11.52	250	13.01	572	8.68	130	7.68	21	4.78	1,001	9.20
	Juveniles, Deciduous Teeth											
Native American												
Number of deciduous teeth (erupted)	—		15		32		—		—		47	

Biological Affinity	Area 1		Area 2		Area 3		Area 4		Area 5		Total	
	n	%	n	%	n	%	n	%	n	%	n	%
Caries (number of teeth)	—		1	6.6	5	15.63	—		—		6	12.77
Apache												
Number of deciduous teeth (erupted)	—		—		—		—		—		—	
Caries (number of teeth)	—		—		—		—		—		—	
Euroamerican											—	
Number of deciduous teeth (erupted)	—		—		228		20		—		248	
Caries (number of teeth)	—		—		11	4.82	—	0.00	—		11	4.44
Hispanic												
Number of deciduous teeth (erupted)	—		—		231		87		10		328	
Caries (number of teeth)	—		—		13	5.63	7	8.05	—		20	6.10
Indeterminate affinity												
Subtotal of deciduous teeth (erupted)	—		44		1,800		481		78		2,403	
Subtotal of teeth	—		—		34	1.89	6	1.25	2	2.56	42	1.75
Total of deciduous teeth (erupted)	—		59		2,291		588		88		3,026	
Total of teeth	—		1	1.69	63	2.75	13	2.21	2	2.27	79	2.61

Table 205. Corrected Caries Rates, by Sex and Biological Affinity for the Alameda-Stone Cemetery Sample

Biological Affinity	Female %	Male %	Indeterminate Sex	Total %
African American	NA	19.4	NA	19.4
Native American	13.9	19.5	NA	16.3
Euroamerican	11.2	15.9	3.4	14.2
Hispanic	13.9	17.7	27.2	16.3
Indeterminate affinity	16.8	16.4	13.4	16.4
Total corrected caries rate	14.4	17.1	16.8	15.8

Table 206. Degree of Calculus Deposition for the Alameda-Stone Cemetery Sample, by Biological Affinity and Sex

Sex	0		1		2		3		4		5		6		NA		NO		Total
	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	
African American																			
Male	—		—		—		1	100	—		—		—		—		—		1
Native American																			
Female	3	18	7	41	5	29	1	6	1	6	—		—		—		—		17
Male	1	7	4	27	9	60	1	7	—	—	—		—		—		—		15
Subtotal	4	13	11	34	14	44	2	6	1	3	—		—		—		—		32
Euroamerican																			
Female	1	6	5	29	7	41	2	12	2	12	—		—		—		—		17
Indeterminate Sex	2	15	7	54	3	23	1	8	—		—		—		—		—		13
Male	6	12	13	25	14	27	10	20	4	8	1	2	1	2	2	4	—		51
Subtotal	9	11	25	31	24	30	13	16	6	7	1	1	1	1	2	2	—		81
Hispanic																			
Female	3	4	39	46	21	25	13	15	4	5	2	2	1	1	—		1	1	84
Indeterminate Sex	—		4	44	2	22	2	22	—				—		—		1	11	9
Male	10	10	21	21	35	35	19	19	8	8	4	4	3	3	—		1	1	101
Subtotal	13	7	64	33	58	30	34	18	12	6	6	3	4	2	—		3	2	194
Indeterminate Affinity																			
Female	11	20	18	33	11	20	6	11	2	4	1	2	2	4	2	4	2	4	55
Indeterminate Sex	2	6	16	50	9	28	2	6	—		1	3	—		1	3	1	3	32
Male	2	3	26	37	16	23	15	21	6	9	1	1	—		3	4	1	1	70
Subtotal	15	10	60	38	36	23	23	15	8	5	3	2	2	1	6	4	4	3	157
Total	41	9	160	34	132	28	73	16	27	6	10	2	7	2	8	2	7	2	465

Key: 0 = Absent; 1 = thin line on few teeth; 2 = thin line to moderate deposits observed; 3 = moderate deposits on majority teeth; 4 = moderate to heavy deposits observed; 5 = only heavy deposits observed; 6 = heavy deposits on majority teeth; NA = not applicable, teeth missing; NO = not observable, poor preservation.

Table 207. Alveolar Bone Status for Alameda-Stone Cemetery Sample, by Biological Affinity and Sex

Biological Affinity	0		1		2		3		4		5		3; 4		3; 4; 5		3; 5		NA		NO		Total
	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	
Female																							
Native American	2	12	5	29	3	18	2	12	—		—		—		—		—		1	6	4	24	17
Euroamerican	5	29	5	29	4	24	1	6	—		—		1	6	—		—		1	6	—		17
Hispanic	17	20	26	31	21	25	14	17	1	1	—		1	1	—		—		1	1	3	4	84
Indeterminate affinity	5	9	12	22	9	16	5	9	4	7	—		—		—		—		6	11	14	25	55
Subtotal	29	17	48	28	37	21	22	13	5	3	—		2	1	—		—		9	5	21	12	173
Indeterminate sex																							
Euroamerican	2	15	1	8	—		—		—		—		—		—		—		8	62	2	15	13
Hispanic	—		—		3	33	—		—		—		—		—		2	22	2	22	2	22	9
Indeterminate affinity	1	3	3	9	—		1	3	1	3	—		—		—		—		23	72	3	9	32
Subtotal	3	6	4	7	3	6	1	2	1	2	—		—		—		2	4	33	61	7	13	54
Male																							
African American	—		—		1	100	—		—		—		—		—		—		—		—		1
Native American	—		7	47	5	33	1	7	—		—		—		—		—		1	7	1	7	15
Euroamerican	8	15	19	37	12	23	6	12	2	4	—		—		—		—		4	8	1	2	52
Hispanic	13	13	31	31	27	27	17	17	—		1	1	4	4	1	1	1	1	1	1	5	5	101
Indeterminate affinity	—		13	18	17	24	13	18	3	4	1	1	—		—		—		10	14	14	20	71
Subtotal	21	9	70	29	62	26	37	15	5	2	2	1	4	2	1		1		16	7	21	9	240
Total	53	11	122	26	102	22	60	13	11	2	2	0	6	1	1		3	1	58	12	49	10	467

Key: 0 = healthy, no periodontal disease; 1 = slight periodontal disease; 2 = moderate periodontal disease; 3 = severe periodontal disease; 4 = resorbed from antemortem loss; 5 = infection; NA = not applicable, no bone; NO = not observable, poor preservation.

Table 208. Abscess Totals for the Alameda-Stone Cemetery Sample, by Biological Affinity and Sex

No. of Abscesses	0		1		2		3		4		5		6		7		10		11		No Bone		Not Observable		Total
	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	
African American																									
Male	—		—		1	100	—		—		—		—		—		—		—		—		—		1
Native American																									
Female	8	47	3	18	1	6	—		1	6	—		—		1	6	—		—		1	6	2	12	17
Male	5	33	2	13	3	20	1	7	—		—		—		—		—		—		1	7	3	20	15
Subtotal	13	41	5	16	4	13	1	3	1	3	—		—		1	3	—		—		2	6	5	16	32
Euroamerican																									
Female	12	71	2	12	2	12	—		—		—		—		—		—		—		1	6	—		17
Indeterminate sex	4	31	1	8			—		—		—		—		—		—		—		7	54	1	8	13
Male	23	45	15	29	4	8	1	2	—		—		—		—		—		—		5	10	3	6	51
Subtotal	39	48	18	22	6	7	1	1	—		—		—		—		—		—		13	16	4	5	81
Hispanic																									
Female	49	58	12	14	11	13	3	4	1	1	2	2	2	2	—		1	1	—		1	1	2	2	84
Indeterminate sex	2	22	—		—		1	11	—		—		—		—		—		2	22	2	22	2	22	9
Male	45	45	22	22	10	10	3	3	4	4	2	2	3	3	3	3	2	2	—		1	1	4	4	99
Hispanic total	96	50	34	18	21	11	7	4	5	3	4	2	5	3	3	2	3	2	2		4	2	8	4	192
Indeterminate Affinity																									
Female	19	35	10	18	3	5	2	4	3	5	2	4	1	2			—		—		7	13	8	15	55
Indeterminate sex	5	16	—		—		—		—		—		—		—		—		—		23	72	4	13	32
Male	25	35	11	15	5	7	3	4	1	1	4	6	—		—		1	1	—		13	18	8	11	71
Subtotal	49	31	21	13	8	5	5	3	4	3	6	4	1	1	—		1	1	—		43	27	20	13	158
Total	197	42	78	17	40	9	14	3	10	2	10	2	6	1	4	1	4	1	2		62	13	37	8	464

Table 209. Hypoplasia Rates for Teeth from the Alameda-Stone Cemetery Sample, by Cemetery Area, Sex, and Biological Affinity

Biological Affinity	Area 1		Area 2		Area 3		Area 4		Area 5		Total	
	n	%	n	%	n	%	n	%	n	%	n	%
	Adult Female											
Native American					—		—		—		—	
Number of permanent teeth (erupted)	—		—		372		81		—		453	
Hypoplasia (number of teeth)	—		—		6	1.61	2	2.47	—		8	1.77
Apache	—		—		—		—		—		—	
Number of permanent teeth (erupted)	—		—		22		—		—		22	
Hypoplasia (number of teeth)	—		—		—	0.00	—		—		—	0.00
Euroamerican	—						—		—		—	
Number of permanent teeth (erupted)	—		89		386		—		—		475	
Hypoplasia (number of teeth)	—		13	14.61	15	3.89	—		—		28	5.89
Hispanic	—		—		—						—	
Number of permanent teeth (erupted)	—		120		1,778		204		224		2,326	
Hypoplasia (number of teeth)	—		18	15	53	2.98	—		4	1.79	75	3.22
Indeterminate affinity	—		—		—		—		—		—	
Number of permanent teeth (erupted)	—		—		827		284		—		1,111	
Hypoplasia (number of teeth)	—		—		25	3.02	4	1.41	—		29	2.61
Subtotal of permanent teeth (erupted)	—		209		3,385		569		224		4,387	
Subtotal of hypoplasia (number of affected teeth)	—		31	14.83	99	2.92	6	1.05	4	1.79	140	3.19
	Adult Indeterminate Sex											
Euroamerican												
Number of permanent teeth (erupted)	39		28		116		12		—		195	
Hypoplasia (number of teeth)	4	10.26	—		2	1.72	—		—		6	3.08
Hispanic												
Number of permanent teeth (erupted)	33		—		86		70		—		189	
Hypoplasia (number of teeth)	9	27.27	—		7	8.14	2	2.86	—		18	9.52
Indeterminate affinity												
Number of permanent teeth (erupted)	90		31		57		64		—		242	
Hypoplasia (number of teeth)	5	5.56	—		2	3.51	—	0.00	—		7	2.89
Subtotal of permanent teeth (erupted)	162		59		259		146		—		626	
Subtotal of hypoplasia (number of affected teeth)	18	11.11	—		11	4.25	2	1.37	—		31	4.95

Biological Affinity	Area 1		Area 2		Area 3		Area 4		Area 5		Total	
	n	%	n	%	n	%	n	%	n	%	n	%
	Adult Male											
African American												
Number of permanent teeth (erupted)	—		28		—		—		—		28	
Hypoplasia (number of teeth)	—		—		—		—		—		—	
Native American	—											
Number of permanent teeth (erupted)	—		22		276		74		—		372	
Hypoplasia (number of teeth)	—		—		6	2.17	6	8.11	—		12	3.23
Euroamerican												
Number of permanent teeth (erupted)	8		692		540		71		32		1,343	
Hypoplasia (number of teeth)	—		40	5.78	23	4.26	13	18.31	—		76	5.66
Hispanic												
Number of permanent teeth (erupted)	53		744		1,443		289		183		2,712	
Hypoplasia (number of teeth)	—		3	0.4	38	2.63	9	3.11	10	5.46	60	2.21
Indeterminate affinity												
Number of permanent teeth (erupted)	20		168		685		544		—		1,417	
Hypoplasia (number of teeth)	4	20	2	1.19	19	2.77	15	2.76	—		40	2.82
Subtotal of permanent teeth (erupted)	81		1,654		2,944		978		215		5,872	
Subtotal of hypoplasia (number of affected teeth)	4	4.94	45	2.72	86	2.92	43	4.4	10	4.65	188	3.2
Total number of permanent teeth (erupted)	243		1,922		6,588		1,693		439		10,885	
Total hypoplasia (number of teeth)	22	9.05	76	3.95	196	2.98	51	3.01	14	3.19	359	3.3
	Juveniles, Permanent Teeth											
Native American												
Number of permanent teeth (observable)	—		15		53		—		—		68	
Hypoplasia (number of teeth)	—		—		22	41.51	—		—		22	32.35
Apache												
Number of permanent teeth (observable)	—		—		—		—		—		—	
Hypoplasia (number of teeth)	—		—		—		—		—		—	
Euroamerican												
Number of permanent teeth (observable)	—		—		235		42		—		277	
Hypoplasia (number of teeth)	—		—		18	7.66	4	9.52	—		22	7.94

continued on next page

Biological Affinity	Area 1		Area 2		Area 3		Area 4		Area 5		Total	
	n	%	n	%	n	%	n	%	n	%	n	%
Hispanic												
Number of permanent teeth (observable)	—		—		327		91		10		428	
Hypoplasia (number of teeth)	—		—		37	11.31	5	5.49	2	20	44	10.28
Indeterminate affinity												
Number of permanent teeth (observable)	—		3		240		161		3		407	
Hypoplasia (number of teeth)	—		2	66.67	13	5.42	33	20.5	—		48	11.79
Total number of permanent teeth (observable)	—		18		855		294		13		1,180	
Total hypoplasia (number of teeth)	—		2	11.11	90	10.53	42	14.29	2	15.38	136	11.53
	Juveniles, Deciduous Teeth											
Native American												
Number of deciduous teeth (observable)	—		15		32		—		—		47	
Hypoplasia (number of teeth)	—		—	0.00	2	6.25	—		—		2	4.26
Apache												
Number of deciduous teeth (observable)	—		—		—		—		—		—	
Hypoplasia (number of teeth)	—		—		—		—		—		—	
Euroamerican												
Number of deciduous teeth (observable)	—		—		222		20		—		242	
Hypoplasia (number of teeth)	—		—		2	0.9	—	0.00	—		2	0.83
Hispanic												
Number of deciduous teeth (observable)	—		—		221		87		20		328	
Hypoplasia (number of teeth)	—		—		5	2.26	2	2.3	2	10	9	2.74
Indeterminate affinity												
Number of deciduous teeth (observable)	—		76		2,244		652		95		3,067	
Hypoplasia (number of teeth)	—		4	5.26	110	4.9	39	5.98	7	7.36	160	5.22
Total number of deciduous teeth (observable)	—		91		2,719		759		115		3,684	
Total hypoplasia (number of teeth)	—		4	4.4	119	4.38	41	5.4	9	7.83	173	4.7

Table 210. Enamel Hypoplasia Rates, by Age, Sex, and Biological Affinity for the Alameda-Stone Cemetery Sample

Biological Affinity	Absent		Present		Total
	n	%	n	%	
	Adults				
African American					
Male	1	100.00	—		1
Female	—		—		—
Indeterminate sex	—		—		—
Subtotal	1	100.00	—		1
Native American					
Male	12	80.00	3	20.00	15
Female	13	81.25	3	18.75	16
Indeterminate sex	—		—		—
Subtotal	25	80.65	6	19.35	31
Apache					
Male	—		—		—
Female	1	100.00	—		1
Indeterminate sex	—		—		—
Subtotal	1	100.00	—		1
Euroamerican					
Male	34	69.39	15	30.61	49
Female	13	76.47	4	23.53	17
Indeterminate sex	10	83.33	2	16.67	12
Subtotal	57	73.08	21	26.92	78
Hispanic					
Male	73	74.49	25	25.51	98
Female	62	74.70	21	25.30	83
Indeterminate sex	2	28.57	5	71.43	7
Subtotal	137	72.87	51	27.13	188
Indeterminate affinity					
Male	46	71.88	18	28.13	64
Female	39	81.25	9	18.75	48
Indeterminate sex	23	82.14	5	17.86	28
Subtotal	108	77.14	32	22.86	140
Male subtotal	166	73.13	61	26.87	227
Female subtotal	128	77.58	37	22.42	165
Indeterminate sex subtotal	35	74.47	12	25.53	47
Total	329	74.94	110	25.06	439
	Juveniles				
Native American	1	25.00	3	75.00	4
Apache	—		1	100.00	1
Euroamerican	15	71.43	6	28.57	21
Hispanic	14	48.28	15	51.72	29
Indeterminate affinity	179	70.20	76	29.80	255
Total	209	67.42	101	32.58	310

Table 211. Chipped Teeth by Cemetery Area, Sex, and Biological Affinity for the Alameda-Stone Cemetery Sample

Biological Affinity	Area 1		Area 2		Area 3		Area 4		Area 5		Total	
	n	%	n	%	n	%	n	%	n	%	n	%
	Female											
Native American												
Number of permanent teeth (erupted)	—		—		394		81		—		475	
Chipping (number of teeth)	—		—		16	4.1	13	16.0	—		29	6.1
Euroamerican									—			
Number of permanent teeth (erupted)	—		89		386		—		—		475	
Chipping (number of teeth)	—		5	5.6	19	4.9	—		—		24	5.1
Hispanic												
Number of permanent teeth (erupted)	—		120		1,778		204		224		2,326	
Sum of chipping (number of teeth)	—		1	0.8	89	5.0	7	3.4	15	6.7	112	4.8
Indeterminate affinity												
Number of permanent teeth (erupted)	—		—		850		284		—		1,134	
Chipping (number of teeth)	—		—		55	6.5	14	4.9	—		69	6.1
Female total number of permanent teeth (erupted)	—		209		3408		569		224		4,410	
Female total chipping (number of teeth)	—		6	2.9	179	5.3	34	6.0	15	6.7	234	5.3
	Indeterminate Sex											
Euroamerican												
Number of permanent teeth (erupted)	39		28		116		12		—		195	
Chipping (number of teeth)	3	7.7	—		7	6.0	2	16.7	—		12	6.2
Hispanic												
Number of permanent teeth (erupted)	33		—		86		70		—		189	
Chipping (number of teeth)	—		—		4	4.7	1	1.4	—		5	2.6
Indeterminate affinity									—			
Number of permanent teeth (erupted)	90		31		57		64		—		242	
Chipping (number of teeth)	8	8.9	4	12.9	7	12.3	4	6.3	—		23	9.5

Biological Affinity	Area 1		Area 2		Area 3		Area 4		Area 5		Total	
	n	%	n	%	n	%	n	%	n	%	n	%
Indeterminate sex total number of permanent teeth (erupted)	162		59		259		146		—		626	
Indeterminate sex total chipping (number of teeth)	11	6.8	4	6.8	18	6.9	7	4.8	—		40	6.4
	Male											
African American												
Number of permanent teeth (erupted)	—		28		—		—		—		28	
Chipping (number of teeth)	—		—		—		—		—		—	
Native American	—								—			
Number of permanent teeth (erupted)	—		22		276		74		—		372	
Sum of chipping (number of teeth)	—		2	9.1	28	10.1	13	17.6	—		43	11.6
Euroamerican												
Number of permanent teeth (erupted)	8		692		540		71		32		1343	
Chipping (number of teeth)	2	25.0	44	6.4	58	10.7	8	11.3	3	9.4	115	8.6
Hispanic												
Number of permanent teeth (erupted)	53		744		1,443		289		183		2,712	
Sum of chipping (number of teeth)	1	1.9	48	6.5	136	9.4	31	10.7	14	7.7	230	8.5
Indeterminate affinity												
Number of permanent teeth (erupted)	20		168		712		544		—		1,444	
Chipping (number of teeth)	3	15.0	15	8.9	90	12.6	57	10.5	—		165	11.4
Male total number of permanent teeth (erupted)	81		1,654		2,971		978		215		5,899	
Male total chipping (number of teeth)	6	7.4	109	6.6	312	10.5	109	11.1	17	7.9	553	9.4
Total number of permanent teeth (erupted)	243		1,922		6,638		1,693		439		10,935	
Total chipping (number of teeth)	17	7.0	119	6.2	509	7.7	150	8.9	32	7.3	827	7.6

Table 212. Mean Wear Values for Adult Teeth from the Alameda-Stone Cemetery Sample

Tooth	n	Mean Wear Score	sd	Critical Value
URI1	359	3.61	1.277	0.35
URI2	355	3.06	1.420	0.46
URC	382	3.20	1.324	0.41
URP1	361	3.04	1.423	0.47
URP2	353	3.08	1.381	0.45
URM1	298	17.20	6.000	0.35
URM2	327	12.78	4.598	0.36
URM3	257	8.96	4.323	0.48
LRI1	365	3.61	1.201	0.33
LRI2	385	3.16	1.244	0.39
LRC	394	3.14	1.251	0.40
LRP1	384	2.88	1.242	0.43
LRP2	375	3.02	1.212	0.40
LRM1	296	18.03	5.739	0.32
LRM2	301	13.65	4.420	0.32
LRM3	269	10.63	4.868	0.46

Key: U = upper (maxillary), L = lower (mandibular), R = right side, I = incisor, C = canine, P = premolar, M = molar.

Table 213. Mean Wear Values for Adult Males and Females from the Alameda-Stone Cemetery Sample

Tooth	Male n	Male Mean	Male sd	Female n	Female Mean	Female sd	H	*df*	*p*
URI1	193	3.98	1.323	146	3.16	0.987	31.486	2	.00
URI2	192	3.48	1.493	146	2.59	1.124	31.393	2	.00
URC	203	3.59	1.352	154	2.71	1.078	39.006	2	.00
URP1	190	3.31	1.512	153	2.72	1.184	13.309	2	.00
URP2	183	3.26	1.444	152	2.85	1.233	7.736	2	.005
URM1	147	18.07	6.709	129	16.06	5.100	7.631	2	.006
URM2	168	13.55	5.144	138	11.84	3.581	7.501	2	.006
URM3	139	9.46	4.57	103	8.49	3.904	2.076	2	.150
LRI1	194	3.82	1.226	150	3.34	1.092	14.222	2	.00
LRI2	208	3.4	1.344	157	2.85	1.018	16.577	2	.00
LRC	213	3.44	1.252	161	2.74	1.093	31.529	2	.00
LRP1	211	3.03	1.296	154	2.71	1.096	5.69	2	.017
LRP2	204	3.14	1.294	151	2.9	1.069	2.785	2	.095
LRM1	164	18.85	6.362	120	17.1	4.778	6.622	2	.010
LRM2	177	14.2	4.7557	107	12.93	3.827	4.411	2	.036
LRM3	147	11.524	4.88	107	9.486	4.246	11.038	2	.001

Key: H = the Kruskal-Wallis test statistic, which is evaluated for significance by the chi-square distribution; U = upper (maxillary), L = lower (mandibular), R = right side, I = incisor, C = canine, P = premolar, M = molar.

Table 214. Mean Wear Values for Premolars and Anterior Teeth, by Cemetery Areas and Sex for the Alameda-Stone Cemetery Adult Burial Sample

Cemetery Area	Sex	n	URP2	n	URP1	n	URC	n	URI2	n	URI1	n	LRI1	n	LRI2	n	LRC	n	LRP1	n	LRP2
1	male	2	1.5	2	2	2	2	2	2	2	2.5	1	2	2	2.5	2	2.5	2	1.5	2	2
2	male	47	2.62	49	2.51	53	2.98	49	3	51	3.61	57	3.44	60	2.88	59	2.9	57	2.49	52	2.44
3	male	87	3.54	96	3.58	102	3.83	100	3.62	99	4.07	92	4.02	99	3.58	100	3.62	104	3.28	102	3.38
4	male	40	3.53	36	3.75	39	3.95	35	3.91	34	4.47	37	4	40	3.93	45	3.78	41	3.24	41	3.46
5	male	7	3.14	7	3.14	7	3	6	3.17	7	3.43	7	3.71	7	2.71	7	3.57	7	3	7	3.14
	H	—	19.346	—	24.053	—	20.437	—	12.192	—	13.489	—	11.007	—	22.387	—	19.123	—	20.414	—	26.17
	df	—	4	—	4	—	4	—	4	—	4	—	4	—	4	—	4	—	4	—	4
	p	—	.001	—	.000	—	.000	—	.016	—	.000	—	.026	—	.000	—	.001	—	.000	—	.000
1	female	—		—		—		—		—		—		—		—		—		—	
2	female	7	1.86	6	1.83	7	1.86	6	2.17	6	2.83	7	3.29	7	2.57	7	2	7	2.29	7	2.43
3	female	115	2.9	115	2.74	117	2.79	109	2.67	114	3.26	112	3.37	119	2.89	122	2.79	115	2.74	114	2.91
4	female	22	3.14	24	3.08	22	2.73	23	2.57	18	3	23	3.48	23	3	24	2.92	24	2.83	22	3.14
5	female	8	2.12	8	2	8	2.12	8	1.88	8	2.25	8	2.5	8	2.12	8	2.13	8	2.25	8	2.5
	H	—	9.292	—	9.028	—	8.064	—	6.332	—	10.73	—	6.679	—	7.047	—	9.528	—	5.459	—	3.615
	df	—	3	—	3	—	3	—	3	—	3	—	3	—	3	—	3	—	3	—	3
	p	—	.026	—	.029	—	.045	—	.097	—	.013	—	.083	—	.070	—	.023	—	.141	—	.306

Key: H = the Kruskal-Wallis test statistic, which is evaluated for significance by the chi-square distribution; U = upper (maxillary), L = lower (mandibular), R = right side, I = incisor, C = canine, P = premolar, M = molar.

Table 215. Mean Wear Scores for Molars, by Cemetery Area and Sex for the Alameda-Stone Cemetery Adult Burial Sample

Cemetery Area	Sex	n	URM3	n	URM2	n	URM1	n	LRM1	n	LRM2	n	LRM3
1	male	1	4.00	2	8.50	2	10.50	2	11.00	2	10.00	—	
2	male	39	7.95	47	10.87	36	13.83	41	15.73	45	12.11	34	10.03
3	male	71	10.25	81	15.05	76	19.42	79	20.23	84	15.37	78	11.97
4	male	21	9.57	31	14.03	29	19.97	36	20.00	40	14.70	30	12.13
5	male	7	10.29	7	13.43	4	20.50	6	17.67	6	11.67	5	11.00
	H	—	8.518	—	21.746	—	22.246	—	18.073	—	15.355	—	3.709
	df	—	4	—	4	—	4	—	4	—	4	—	3
	p	—	.074	—	.000	—	.000	—	.001	—	.004	—	.295
1	female	—		—		—		—		—		—	
2	female	5	9.40	7	8.57	6	12.00	5	13.40	4	11.25	5	8.40
3	female	73	8.73	100	11.97	93	16.48	89	17.57	81	13.00	80	9.44
4	female	18	7.78	24	12.83	22	16.91	18	17.44	15	13.93	16	11.00
5	female	7	7.14	7	9.86	8	11.88	8	13.38	7	11.00	6	7.00
	H	—	1.863	—	9.847	—	12.496	—	8.879	—	4.003	—	3.849
	df	—	3	—	3	—	3	—	3	—	3	—	3
	p	—	.601	—	.020	—	.006	—	.031	—	.261	—	.278

Key: H = the Kruskal-Wallis test statistic, which is evaluated for significance by the chi-square distribution; U = upper (maxillary), L = lower (mandibular), R = right side, I = incisor, C = canine, P = premolar, M = molar.

Table 216. Mean Wear Scores for Premolars and Anterior Teeth, by Cemetery Area and Age for the Alameda-Stone Cemetery Sample

Cemetery Area	Age Group	n	URP2	n	URP1	n	URC	n	URI2	n	URI1	n	LRI1	n	LRI2	n	LRC	n	LRP1	n	LRP2
1	young adult	2	1.00	2	1.00	3	1.67	1	2.00	3	1.33	2	1.50	2	1.50	3	2.00	4	1.25	3	1.33
2	young adult	29	2.03	30	1.90	31	2.29	27	2.19	28	2.93	32	3.03	33	2.39	33	2.27	33	2.00	32	2.00
3	young adult	109	2.44	113	2.35	111	2.52	108	2.30	111	3.05	105	3.01	108	2.56	109	2.55	108	2.31	110	2.46
4	young adult	28	2.54	25	2.60	27	2.85	27	2.59	27	3.37	32	3.38	27	2.89	27	2.78	26	2.31	26	2.50
5	young adult	10	2.10	10	2.00	10	2.20	9	2.00	10	2.50	10	2.80	10	2.20	10	2.30	10	2.30	10	2.60
	H	—	13.261	—	17.246	—	10.047	—	2.826	—	17.637	—	11.612	—	13.49	—	8.65	—	13.831	—	17.503
	df	—	4	—	4	—	4	—	4	—	4	—	4	—	4	—	4	—	4	—	4
	p	—	.01	—	.002	—	.04	—	.587	—	.001	—	.02	—	.009	—	.07	—	.008	—	.002
1	mature adult	1	2.00	1	3.00	1	2.00	1	2.00	1	3.00	—		1	3.00	1	3.00	1	2.00	1	3.00
2	mature adult	21	2.95	20	2.80	24	3.17	21	3.38	25	4.04	26	3.73	27	3.07	26	3.00	25	2.76	23	2.87
3	mature adult	77	3.69	79	3.63	88	3.74	78	3.64	85	4.09	83	4.19	88	3.66	88	3.44	89	3.36	81	3.44
4	mature adult	24	4.13	27	4.04	24	3.87	23	4.00	21	4.52	23	4.39	25	3.80	28	3.82	28	3.36	27	4.00
5	mature adult	3	3.33	3	3.67	3	3.67	3	3.67	3	3.67	3	3.33	3	3.00	3	3.67	3	3.00	3	2.67
	H	—	10.368	—	9.117	—	5.714	—	4.509	—	3.299	—	5.689	—	5.786	—	6.622	—	7.34	—	13.296
	df	—	4	—	4	—	4	—	4	—	4	—	3	—	4	—	4	—	4	—	4
	p	—	.035	—	.058	—	.222	—	.341	—	.509	—	.128	—	.216	—	.157	—	.119	—	.01
1	old adult	2	2.00	2	1.50	3	2.33	3	2.33	3	3.00	1	4.00	1	3.00	1	4.00	1	2.00	—	2.00
2	old adult	4	3.75	5	4.20	6	4.50	7	4.29	5	4.20	7	4.00	8	4.00	8	4.25	7	3.57	5	3.20
3	old adult	26	4.85	30	4.77	33	4.67	32	4.47	27	4.52	27	4.41	33	3.97	37	4.27	32	4.22	34	4.41
4	old adult	15	3.80	12	4.17	16	4.06	13	3.54	8	4.88	12	4.17	17	4.41	18	4.06	15	4.00	17	3.71
5	old adult	2	4.00	2	3.50	2	2.50	2	2.50	2	3.00	2	4.00	2	2.50	2	4.00	2	3.50	2	4.00
	H	—	10.472	—	8.909	—	12.931	—	9.548	—	6.026	—	0.503	—	4.808	—	0.434	—	4.844	—	9.489
	df	—	4	—	4	—	4	—	4	—	4	—	4	—	4	—	4	—	4	—	4
	p	—	.033	—	.063	—	.012	—	.049		.197	—	.973	—	.308	—	.98	—	.304	—	.05

Key: H = the Kruskal-Wallis test statistic, which is evaluated for significance by the chi-square distribution; U = upper (maxillary), L = lower (mandibular), R = right side, I = incisor, C = canine, P = premolar, M = molar.

Table 217. Mean Wear Scores for Molars, by Cemetery Area and Age for the Alameda-Stone Cemetery Sample

Cemetery Area	Age Group	n	URM3	n	URM2	n	URM1	n	LRM1	n	LRM2	n	LRM3
1	young adult	2	4.00	2	6.00	2	7.00	2	6.00	2	5.50	—	
2	young adult	26	6.92	31	9.19	27	11.33	26	13.15	29	10.48	22	7.55
3	young adult	83	7.41	97	11.21	98	15.13	89	15.90	90	11.49	79	8.14
4	young adult	23	7.57	33	11.73	28	16.96	29	16.86	27	12.74	24	9.29
5	young adult	9	7.00	9	10.33	9	12.78	10	14.10	9	11.11	7	7.57
	H	—	3.803	—	15.032	—	31.412	—	19.335	—	12.203	—	3.301
	df	—	4	—	4	—	4	—	4	—	4	—	3
	p	—	.433	—	.005	—	.000	—	.001	—	.016	—	.347
1	mature adult	—		1	13.00	1	17.00	1	18.00	1	16.00	—	
2	mature adult	18	10.00	22	12.27	15	17.20	17	18.35	16	15.38	13	13.00
3	mature adult	57	10.84	74	14.76	63	19.92	67	20.60	66	16.20	67	11.69
4	mature adult	10	8.50	16	14.94	19	20.11	18	20.89	21	16.62	16	13.25
5	mature adult	3	10.67	3	12.00	2	14.00	2	13.00	3	11.33	3	10.00
	H	—	3.193	—	5.880	—	4.128	—	5.707	—	4.191	—	3.401
	df	—	3	—	4	—	4	—	4	—	4	—	3
	p	—	.363	—	.208	—	.389	—	.222	—	.381	—	.334
1	old adult	1	6.00	1	8.00	1	13.00	—		—		1	6.00
2	old adult	1	12.00	2	14.50	1	18.00	4	17.50	5	10.80	5	12.00
3	old adult	13	14.77	20	18.45	18	24.89	19	25.58	19	18.84	21	16.52
4	old adult	9	12.33	14	16.14	13	21.62	10	22.50	12	14.83	10	15.30
5	old adult	2	13.50	2	17.00	1	34.00	2	23.00	1	13.00	1	14.00
	H	—	3.335	—	4.022	—	6.948	—	3.648	—	14.469	—	5.447
	df	—	4	—	4	—	4	—	3	—	3	—	4
	p	—	.503	—	.403	—	.139	—	.302	—	.002	—	.244

Key: H = the Kruskal-Wallis test statistic, which is evaluated for significance by the chi-square distribution; U = upper (maxillary), L = lower (mandibular), R = right side, I = incisor, C = canine, P = premolar, M = molar.

Table 218. Mean Wear Scores, by Biological Affinity for the Alameda-Stone Cemetery Adult Burial Sample

Biological Affinity	n	URM 3	n	URM2	n	URM1	n	URP2	n	URP1	n	URC	n	URI2	n	URI1	n	LRI1	n	LRI2	n	LRC	n	LRP1	n	LRP2	n	LRM1	n	LRM 2	n	LRM 3
Native American	16	10.63	27	12.37	24	17.67	31	3.26	28	3.04	33	3.33	30	3.07	31	3.52	32	3.47	30	2.97	33	3.12	29	2.83	28	3.18	29	18.24	26	12.69	22	10.00
Euroamerican	62	6.61	81	8.68	78	11.45	77	2.18	82	2.00	90	2.19	88	2.17	85	2.60	96	2.76	91	2.40	88	2.32	88	1.93	85	2.12	77	12.29	75	9.69	64	8.00
Hispanic	140	7.81	182	10.94	167	14.25	187	2.56	197	2.64	206	2.75	199	2.56	203	3.11	200	3.17	206	2.67	201	2.75	194	2.68	188	2.71	167	15.36	161	11.36	140	8.79
H	—	9.682		14.209	—	18.025	—	14.689	—	15.632	—	16.039	—	9.201	—	9.789	—	6.645	—	6.180	—	11.126	—	22.117	—	20.763	—	18.836	—	9.289	—	2.457
df	—	2		2	—	2	—	2	—	2	—	2	—	2	—	2	—	2	—	2	—	2	—	2	—	2	—	2	—	2	—	2
p	—	.008		.001	—	.000	—	.001	—	.000	—	.000	—	.010	—	.007	—	.036	—	.045	—	.004	—	.000	—	.000	—	.000	—	.010	—	.293

Key: H = the Kruskal-Wallis test statistic, which is evaluated for significance by the chi-square distribution; U = upper (maxillary), L = lower (mandibular), R = right side, I = incisor, C = canine, P = premolar, M = molar.

Table 219. Intercepts and Slopes of Paired Molar Wear Scores, by Cemetery Area and Sex in the Alameda-Stone Cemetery Sample

Cemetery Area	Sex	M1-M2 Pair	n	Intercept	Slope	95 % C.I. of Slope
All	male	maxilla	112	-1.14	1.441	1.284–1.505
All	female	maxilla	91	0.42	1.294	1.112–1.350
1	all	maxilla	3	-1.69	1.443	1.411–1.454
2	all	maxilla	35	-1.45	1.399	1.133–1.514
3	all	maxilla	137	0.22	1.345	1.204–1.391
4	all	maxilla	35	2.64	1.224	0.940–1.302
5	all	maxilla	12	-2.57	1.503	1.301–1.599
All	male	mandible	112	-0.79	1.318	1.212–1.350
All	female	mandible	91	-1.08	1.403	1.222–1.475
1	all	mandible	3	-0.393	1.155	1.106–1.162
2	all	mandible	35	1.5	1.128	0.968–1.151
3	all	mandible	137	-0.05	1.339	1.224–1.376
4	all	mandible	35	-0.77	1.396	1.145–1.502
5	all	mandible	12	0.24	1.177	0.956–1.223

Key: C.I. = confidence interval, M1= first molar, M2 = second molar.

Table 220. Mean Wear Scores for Comparative Historical-Period Cemetery Samples

Tooth	Alameda-Stone Cemetery			Freedman's Cemetery			San Agustín		
	n	Mean Wear Score	sd	n	Mean Wear Score	sd	n	Mean Wear Score	sd
Anterior				258	2.7	0.94			
URI1	359	3.61	1.277	—			13	4.08	1.188
URI2	355	3.06	1.420	—			14	3.86	1.834
URC	382	3.2	1.324	—			20	4	1.487
URP1	361	3.04	1.423	—			14	3.93	1.817
URP2	353	3.08	1.381	—			16	3.62	1.5
URM1	298	17.2	6.000	192	11.8	4.39	11	19.18	6.416
URM2	327	12.78	4.598	204	10.2	3.71	13	13.69	3.706
URM3	257	8.96	4.323	—			4	11.75	5.56
LRI1	365	3.61	1.201	—			17	5.06	1.56
LRI2	385	3.16	1.244	—			22	4.45	1.711
LRC	394	3.14	1.251	—			22	4.64	1.497
LRP1	384	2.88	1.242	—			24	4.25	1.939
LRP2	375	3.02	1.212	—			29	3.83	1.853
LRM1	296	18.03	5.739	195	13.2	4.72	18	21.11	7.275
LRM2	301	13.65	4.420	199	11	3.86	16	15.19	6.595
LRM3	269	10.628	4.868	153	2.7	1	12	10.5	6.375

Key: U = upper (maxillary), L = lower (mandibular), R = right side, I = incisor, C = canine, P = premolar, M = molar.

Table 221. Unintentional Dental Modifications in the Alameda-Stone Cemetery Sample

Grave Pit No.	Burial Feature No.	Primary (P) designation	Sex	Median Age (in Years)	Biological Affinity	Cemetery Area	No. of Permanent Teeth (erupted)	Unintentional Modification or Wear from Activity or Food Processing	Number of Chipped Teeth	Notches	Pipe Facets	Interproximal Grooves	Steep Angle	Undefined Alteration	Tobacco Stain	Drilling	All Modifications
111	1475	P	male	27.5	Euroamerican	2	29	notched lower lower canine	1	1	—	—	—	—	—	—	1
567	2728	P	female	27.5	Native American	3	27	oblique angled wear lower incisors	2	—	—	—	1	—	—	—	1
635	1233	P	indeterminate	40	indeterminate	1	6	chipped central incisors involved in activity; previously removed	4	—	—	—	—	1	—	—	1
790	3932	P	indeterminate	34	Euroamerican	1	12	crescent-shaped occlusal wear for left upper and lower canines due to clenching; previously removed	1	—	1	—	—	—	—	—	1
793	3900	P	indeterminate	27.5	indeterminate	1	8	chip of incisal edges of upper and lower incisors; previously removed	2	—	—	—	—	1	—	—	1
826	6825	P	male	27.5	Euroamerican	2	29	chipped upper incisors	2	—	—	—	—	1	—	—	1
828	6834	P	male	50	indeterminate	2	18	overall angled wear and transverse grooves for upper central incisors and lower right lateral incisor and canine; shallow interproximal groove at lower third molar	4	—	—	1	1	—	—	—	2
829	6904	P	male	40	Euroamerican	2	25	pipe facet left anterior teeth	2	—	1	—	—	—	—	—	1
857	2769	P	male	42.5	Hispanic	3	13	extreme angled anterior wear from processing fibrous plant, leather, sinew, or food consumption	3	—	—	—	1	—	—	—	1
2114	6728	P	male	22	Euroamerican	2	32	small chips of upper central incisors	2	—	—	—	—	1	—	—	1
3038	3952	P	male	35	Euroamerican	2	25	small chips of central incisors	3	—	—	—	—	1	—	—	1
3039	3946	P	male	27.5	indeterminate	2	26	pipe-facet wear for lower canines and upper left lateral incisor and canine	—	—	1	—	—		—	—	1

continued on next page

Grave Pit No.	Burial Feature No.	Primary (P) designation	Sex	Median Age (in Years)	Biological Affinity	Cemetery Area	No. of Permanent Teeth (erupted)	Unintentional Modification or Wear from Activity or Food Processing	Number of Chipped Teeth	Notches	Pipe Facets	Interproximal Grooves	Steep Angle	Undefined Alteration	Tobacco Stain	Drilling	All Modifications
3061	3905	P	male	24.5	Euroamerican	2	31	pipe facets for upper and lower left anterior dentition	2	—	1	—	—	—	—	—	1
3084	3980	P	male	30	Euroamerican	2	30	incisal notch for upper and lower central incisor from clenching toothpick or "tailor's" notch	—	1	—	—	—	—	—	—	1
3237	3931	P	male	47.5	Euroamerican	2	27	interproximal groove between lower first and second molars, therapeutic	1	—	—	1	—	—	—	—	1
3239	3799	P	male	25.5	Euroamerican	2	30	large notch in upper central incisor, "tailor's" notch?	1 (UC)	1	—	—	—	—	—	—	1
3244	3417	P3	male	50	Hispanic	2	32	grooves of mid- incisal crowns upper central and lateral incisors	1	—	—	—	—	1	—	—	1
3286	7021	P	male	22.5	Euroamerican	2	32	numerous small chips from upper anterior teeth	4	—	—	—	—	1	—	—	1
7553	9721	P	male	74.5	Hispanic	3	11	lower right canine and first premolar facets consistent with pipe facet; severe periodontitis probable	1	—	1	—	—	—	—	—	1
7609	11802	P	male	45.5	indeterminate	3	32	crescent-shape wear upper central incisor	3	—	1	—	—	—	—	—	1
7715	16727	P	female	42.5	Native American	3	29	chipped and notched upper incisor and canine	2	1	—	—	—	—	—	—	1
7750	11771	P	male	27.5	Euroamerican	3	32	matching grooves for left upper and lower central incisors	—	—	—	—	—	1	—	—	1
7765	13394	P	male	42.5	indeterminate	4	22	extreme oblique angled wear for upper central incisors	4	—	—	—	1	—	—	—	1
7782	13320	P	female	40	indeterminate	4	29	small chips from upper and lower central incisors, both sides—from opening hairpin?	2	1	—	—	—	—	—	—	1

Grave Pit No.	Burial Feature No.	Primary (P) designation	Sex	Median Age (in Years)	Biological Affinity	Cemetery Area	No. of Permanent Teeth (erupted)	Unintentional Modification or Wear from Activity or Food Processing	Number of Chipped Teeth	Notches	Pipe Facets	Interproximal Grooves	Steep Angle	Undefined Alteration	Tobacco Stain	Drilling	All Modifications
7805	16735	P	male	25	indeterminate	4	25	notched upper central incisor	6	1							1
7815	13445	P1	male	42.5	indeterminate	4	29	oblique angled upper central incisor	11				1				1
7859	18540	P	male	74.5	Native American	3	32	heavy oblique wear for first molars	3				1				1
7867	21579	P	female	25	indeterminate	3	22	shallow V-shaped grooves upper central incisors	NO					1			1
7881	18667	P	indeterminate	30	Hispanic	3	28	notched right upper and lower lateral incisors and canines- pipe facet	4		1						1
7899	19574	P	male	40	Hispanic	3	24	grooved occlusal wear upper and lower right first premolars	0					1			1
7915	18893	P	female	42.5	Hispanic	3	23	rounded and concave wear for right upper and lower incisors and canines	3					1			1
7917	18925	P	female	74.5	indeterminate	3	26	interproximal groove at lower second molar	2			1					1
7931	18928	P	male	50	Hispanic	3	30	interproximal grooves both sides of upper first premolar	NO			1					1
10430	16942	P	female	25	Hispanic	3	32	notch for upper central incisor—clench toothpick?	6	1							1
13505	25424	P	male	40	Hispanic	3	32	many teeth stained brown—tobacco?	1						1		1
13521	21835	P	female	50	indeterminate	3	21	pipe facet right upper and lower premolars	4		1						1
13534	21703	P	female	52.5	Hispanic	3	28	occlusal groove for lower canine, tooth used in clenching and stripping	0					1			1
13540	25203	P	male	22.5	Hispanic	3	32	flake and occlusal notch of upper canine	3					1			1

continued on next page

Grave Pit No.	Burial Feature No.	Primary (P) designation	Sex	Median Age (in Years)	Biological Affinity	Cemetery Area	No. of Permanent Teeth (erupted)	Unintentional Modification or Wear from Activity or Food Processing	Number of Chipped Teeth	Notches	Pipe Facets	Interproximal Grooves	Steep Angle	Undefined Alteration	Tobacco Stain	Drilling	All Modifications
13626	21833	P	female	27.5	Hispanic	3	31	V-shaped groove on upper central incisor (from thread, sewing?)	2	1	—	—	—	—	—	—	1
13656	25330	P	female	42.5	Native American	4	24	occlusal notches for left upper lateral incisor and lower central incisor (tooth-pick use?)	2	1	—	—	—	—	—	—	1
13664	25205	P	male	55	indeterminate	4	14	extreme oblique angled and transverse occlusal wear for anterior teeth (similar to basketry-processing fibrous plants?)	2	—	—	—	1	—	—	—	1
13947	29695	P	male	45	indeterminate	3	18	transverse occlusal wear for upper incisors	3	—	—	—	—	1	—	—	1
17868	28672	P	female	22.5	indeterminate	3	32	incisal notches for left lower central incisors and oblique angles to upper central incisors (task, toothpick?)	1	1	—	—	—	—	—	—	1
22157	21848	P2	male	40	indeterminate	3	18	pipe facet involving lower canine and premolar; gold bridgework and restorations	1	—	1	—	—	—	—	—	1
22354	25285	P	male	50	Euroamerican	3	29	intentional boring into carious lesion, therapeutic	1	—	—	—	—	—	—	1	1
29349	28758	P	male	47.5	Hispanic	3	26	vertical scratches, with polishing for upper central incisor; related to hygiene or enamel hypoplasia (like intentionally trying to obliterate grooves?)	6	—	—	—	—	1	—	—	1
29392	31208	P	male	38	Euroamerican	3	32	pipe-facet wear for upper and lower left canines and first premolar	13	—	1	—	—	—	—	—	1

Table 222. Individuals with Dental Fillings from the Alameda-Stone Cemetery Sample

Grave Pit No.	Sex	Age	Biological Affinity	Cemetery Area	Material	No. of Fillings
533	cf. male	middle adult	Hispanic	2	gold[a]	10
534	male	middle adult	Euroamerican	2	gold[a]	14
825	male	young adult	Euroamerican	2	tin[a]	1
952	male	middle adult	Euroamerican	2	gold	1
2117	male	young adult	Hispanic	2	gold alloy[a]	1
3230	male	middle adult	Hispanic	2	amalgam?	1
3244	male	old adult	Hispanic	2	gold	3
3287	male	young adult	Hispanic	2	gold[a]	4
3311	female	middle adult	Euroamerican	2	gold	1
3315	male	middle adult	African American	2	amalgam?	1
22157	male	middle adult	Indeterminate	3	gold & amalgam[a]	2

[a]Identified by X-ray fluorescence spectroscopy.

Table 223. Locations of Fillings within Teeth for the Alameda-Stone Cemetery Sample

Tooth	Maxilla	Mandible	Total
M3	1	4	5
M2	6	6	12
M1	1	2	3
P2	4	1	5
P1	5	—	5
C	1	1	2
I2	4	—	4
I1	3	—	3
Total	25	14	39

Key: I = incisor; C = canine; P = premolar; M = molar.

Table 224. Summary of Dental Pathology in Comparative Historical-Period Cemetery Samples

Sample	Caries (Teeth Affected) (%)	Caries (Individuals Affected) (%)	Enamel Hypoplasia (Individuals Affected) (%)	Enamel Hypoplasia (Teeth Affected) (%)
Alameda-Stone cemetery	9.2	66.4	25.1	3.3
Tucson Presidio Cemetery	4.0	33.3	76.5	
San Agustín de Tucson Mission	9.6	63.2	71.9	
Nuestra Señora del Refugio Mission	8.7		66–88	
Freedman's Cemetery		77–91		
Palace of the Legion of Honor	8[a]	43[a]		29.0
Mormon Pioneer Population		54.8		
Voegtly Church Cemetery	28.5		26.1	18.2
St. Thomas' Anglican Church Cemetery	31[a]			

[a] Approximate rate.

CHAPTER 14

Case Studies of Selected Individuals

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Introduction

Bioarchaeological investigations of cemeteries or skeletal collections often capitalize on the breadth of interpretation afforded by multiple, interconnected sets of individuals. The opportunity to scrutinize attributes among a group of individuals sharing a number of common traits—geographic, temporal, genetic, behavioral, and demographic—is one that warrants broad inclusion in order to address grand questions. Simply put, any serious attempt to understand or contemplate a group or population writ large needs as much information as is available. The caveats of small sample sizes and incomplete data are never far from the investigator's mind.

Often, however—as the data become normally distributed, appraised for outliers, collapsed into sample groups, and configured into confidence intervals—the uniqueness of the individual is sanded away. Every nuance and detail possessed by any one individual inside the sample is diluted and obscured in the process of addressing the types of questions to which no single individual could reasonably provide answers. Indeed, to the broad questions of the population, the individual is anathema.

This chapter seeks to remedy the homogenizing effects of population studies by presenting individuals as individuals. The lines of inquiry explored in the preceding chapters are narrow in their focus, as they must be to sensibly and honestly describe and assess the questions presented. The inevitable consequence of this is a disconnect of the individual from chapter to chapter. For example, a pathological condition described in Chapter 11 may have occurred on an individual featuring an injury discussed in Chapter 12. Unless these observations, events, and circumstances were inextricably related, their dual notation would only serve to frustrate the conclusions drawn for each similarly situated individual that lacked the unrelated observation. Plainly, each observation would be addressed separately, in its proper venue and chapter.

Regarding the individual, this strategy is clearly incomplete. Although many observations are discrete and independent at the cemetery level, they are certainly interconnected when considering a single set of remains. This chapter discusses individuals, and all observable characteristics thereof, irrespective of their places among the data sets for any single, specific question.

Skeletal evidence is a powerful tool for reconstructing life histories. Mortuary artifacts and other contextual information provide a glimpse into how these individuals were treated in death. Indeed, the preceding chapters are predicated on the amount of information offered by archaeological and skeletal investigations. The culmination of these multiple, archaeologically and osteologically discoverable characteristics helps to develop a clearer picture of life in nineteenth-century Tucson, as experienced by those who lived and worked, walked and fell, prevailed and suffered. Those with a great number of skeletal observations—those with evidence of a life made more difficult by injury and disease—warrant description, to be sure. But they do not represent the majority, the typical, or the average. The individual whom clinicians would call "unremarkable" is equally important to the biological story of early Tucson.

This chapter will draw from multiple lines of archaeological and skeletal inquiry to more completely describe the individual as an individual. Those chosen for this level of assessment were included for their unique contributions to the population—from notable pathology and trauma to particular biological attributes of significance, to strong representation of the totality of the cemetery. Additionally, taphonomic and depositional considerations are contemplated. Indeed, the skeletal effects of burial are important components in reconstructing life histories. The sequence from life to death to burial to discovery affords a perspective unavailable to purely populational studies.

The Alameda-Stone cemetery contained the remains of 1,386 individuals. What follows are the skeletal biographies of some of them.

Grave Pit 7792, Burial Feature 13205

Grave Pit 7792 was in Cemetery Area 4 and contained the burial of a 6–9-month-old infant of indeterminate sex and biological affinity. The infant was interred in a supine position within a trapezoidal wooden coffin placed in a rectangular grave pit, with its head oriented toward the east. Possible traces of paint were observed in association with the coffin wood, suggesting the coffin may have been painted. The southern edge of the grave pit was truncated by a utility trench. The legs and feet were disturbed, and the pelvic elements removed by the intrusive trench. The rest of the remains were in good preservation (Figure 200). One plain Prosser button was found with this individual. Colorless glass beads and fragments of wire around the head of this individual suggest a floral crown placed at the time of internment, indicating burial as an *angelito*.

The infant's remains showed evidence of growth and development hardship. There are several osteological abnormalities suggestive of a severe metabolic disorder. Most, if not all, of the appendicular elements were affected by excessive bone growth, a condition that is common to many musculoskeletal disorders and is indicated by thicker or more-robust shafts than normal for an individual of this age. Additionally, the interior tissues of the parietals, frontal, and occipital of the cranium appeared to have a pronounced thickening. The roof of the right eye socket displayed lesions referred to as cribra orbitalia, a condition often linked to metabolic deficiencies during growth (Walker et al. 2009).

A majority of the deciduous (or baby) teeth exhibited a severe form of enamel hypoplasia, or disruption in the normal formation of tooth enamel, presenting as a shelf or distinctive bulge of the crown at the point of the defect, extending to the cementoenamel junction, where the tooth root meets the crown (see Chapter 13). Horizontal grooves were also observed on the minimally developed permanent-teeth buds, near the margins of the developing crowns. Based on the development of the deciduous teeth and the locations of the defects, it appears that the disruption in enamel formation occurred shortly after birth and probably continued up to the time of death.

Many systemic disorders can lead to disruption of enamel formation or maturation, including premature birth, low birth weight, rickets, cerebral palsy, viral infections, thyroid disorders, and maternal diabetes (Bhat and Nelson 1989). Neonatal hypocalcemia is associated with many of these disorders, and neonatal tetany, muscle twitchings and convulsions often related to maternal diabetes, has been shown to lead to the development of a shelf defect similar to that exhibited by this infant (Purvis et al. 1973). The extensive disruption in enamel development, combined with the thickening of cranial and postcranial elements, is indicative of a severe systemic disorder.

Few other young children at the site displayed such evidence of childhood stress. The evidence of metabolic and systemic disorders observed on this infant's remains were a lifetime in the making, however brief that lifetime was. The causes of natural deaths are typically undiscoverable from skeletal remains. Nevertheless, there is little doubt that the hardships written on this child's skeleton during life were what ultimately ended it.

Grave Pit 10133, Burial Feature 19965

Grave Pit 10133 was located in Cemetery Area 3 and contained the well-preserved remains of a young-adult female, aged 25–35 years, of indeterminate biological affinity. This individual was placed in a supine position with her head oriented toward the northeast within a rectangular grave pit without a coffin. Burials without

coffins were rarely found during the excavation. Several types of clothing fasteners were associated with this individual, including metal sew-through buttons, plain Prosser buttons, and one plain shell button. Skeletal positioning differed from most in the cemetery, in that the right leg was slightly flexed and the knee splayed out to the right side. The right arm was tightly flexed, with the hand positioned next to the right shoulder, and the left hand was placed over the abdominal region (Figure 201). It seems unlikely that this was an intended arrangement and may be the result of shifting that may have occurred as the remains were lowered into the grave or when the grave was refilled.

A combination of disease processes, injuries that occurred not long before death, and several morphological abnormalities were evident. First, active and partially healed periosteal reactions (formations of new bone in response to injury or disease) appeared on both legs, consistent with an ongoing, general systemic infection. A lesion appeared at the midline on both maxillae of the upper jaw, extending to the nasal region (Figure 202). The likely cause of the lesion is a cyst within the nasomaxillary region. The vomer, a triangular bone within the nose, was displaced to the right and may represent bony compensation for the space taken up by the cyst.

Dental pathologies were severe, including maxillary abscesses in the molar regions on both sides, cavities in 10 teeth, and moderate periodontal disease. The teeth were unusually small, compared to those of other individuals in the burial sample.

The young woman survived a moderately severe blow to the forehead on her left side, about a centimeter above the left eye. The injury resulted in a smooth, shallow depression and was in the process of healing. Another blow to the right side of the face resulted in a fracture of the frontal process of the maxilla, adjacent to the nose. There was little to no sign of healing at this location, and it appeared that this injury may have occurred close to the time of death; however, it did not appear severe enough to have contributed to her death. Additionally, the nasomaxillary cyst mentioned above, if present, may have made the frontal process of the upper jaw especially susceptible to breakage.

There were also several morphological anomalies. The limbs appeared to be notably shorter than those of other females in the burial sample. The roof of the mouth was disproportionately small, in comparison to the rest of the cranium, and there were deep canine fossae along the canine tooth sockets on both sides of the face, which would probably have caused a "sunken" appearance (Figure 203). The nasal bridge, although partially damaged by trauma, was flattened, and the intranasal suture was obliterated. The cranial vault was mostly fragmented, but the intact frontal demonstrated that the cranial vault was probably significantly higher than normal for an average individual from this sample.

The abnormalities in the nasal region are consistent with a diagnosis of tuberculosis (see Chapter 11). Potential alternatives include leprosy, syphilis, or trisomy 21, also known as Down syndrome—none of which, of course, are mutually exclusive. The narrow or undersized palate, high cranial vault, small teeth, flattened nasal bridge and midfacial area, and unusually short limbs are characteristic of this condition. An individual with this syndrome would have experienced mild to severe impairment in cognitive abilities. Many individuals with Down syndrome have congenital heart defects and are at increased risk of respiratory infections and leukemia (Cummings 1997). Lifespan, especially without modern medical care, is significantly reduced, in comparison to individuals without this condition. The same prognosis would also apply in the cases of the other potential diagnoses.

The woman in Grave Pit 10133 led a burdensome life of disease, injury, and disability. Each of the candidates for causing the anomalies observed on her remains is severe, and any would have fundamentally affected her quality of life. In addition to compromised physiology associated with each of these conditions, the woman's appearance was affected by the craniofacial characteristics described above. A healed depression fracture above the left eye and an unhealed fracture near the right eye are not inconsistent with episodes of interpersonal violence. Reactive bone on leg elements suggests a systemic infection, and a possible nasomaxillary cyst would have impaired her breathing. Dental abscesses and cavities would have contributed to her discomfort. Although differential diagnoses are ultimately unattainable from the skeletal examination of this woman, her case presents a suite of observations unique among the individuals in the cemetery.

Grave Pit 7919, Burial Feature 18924

Grave Pit 7919 was located in Cemetery Area 3 and contained the remains of a young-adult female, aged 18–30 years, of Hispanic affinity. This individual was interred in a supine position with her head oriented toward the northeast within a trapezoidal juniper-wood coffin. White cotton fabric with green paint was recovered from the fill of the coffin, suggesting the coffin had a fabric lining. One dish-shaped plain Prosser button was associated with this individual. Fragments of wire, straight pins, and a glass bead surrounding the head of the individual suggest the presence of a floral crown, which could possibly indicate that, despite being an adult, the individual was buried as an *angelito*. The remains of the individual were complete and in good preservation (Figure 204).

A number of severe pathological and developmental conditions were apparent on this young woman's remains. Dental disease was extensive and unusually severe for an individual of this age in the burial population. There were two large abscesses of the alveolar bone and two abscessed regions in the palate. Carious lesions were present on 9 teeth. Ten teeth were lost during life, including all but 1 of the mandibular molars, and all 4 incisors. Antemortem loss of the incisors is unusual, as these teeth generally have a low incidence of caries. A preexisting enamel defect may be suspected, as this could have made the incisors especially susceptible to decay. Finally, there was extreme calculus buildup on the left side, covering the occlusal surfaces. This could have resulted from disuse of the left side of the mouth, as a result of a severe (and probably painful) cavity with pulp-chamber exposure on a left maxillary molar. The dental health of this woman was severely compromised (Figure 205).

There were periosteal reactions (the formation of new bone in response to injury or disease) on all of the long bones but the upper arm bones, or humeri. These reactions were characterized by proliferative development and a slight thickening of the shafts of most elements. There were also reactions on the exterior surfaces of the visceral aspects of the ribs (Figure 206). Congenital syphilis may be suspected, but this must remain speculative, because the teeth most commonly affected by the condition (the incisors and the first molars) were either absent or rendered unobservable by calculus or decay. Additionally, individuals with congenital syphilis typically do not survive to the age expressed by this individual.

A number of unrelated and unusual anomalies were identified. The sternum was unusually short and wide, as a result of defective development of one or both of the last sternal segments very early in the developmental period. Additionally, the clavicles were elongated and vertically oriented, as a result of the sternal morphology (Figure 207). This condition likely resulted in a misaligned shoulder girdle, affecting the posture of the young woman's upper body.

There were two sets of block vertebrae in the cervical region, which most likely indicates a mild form of Klippel-Feil syndrome. This condition is typically characterized by fusion of the second and third cervical vertebrae and usually the fifth and sixth cervical vertebrae. In this case, the second and third and the sixth and seventh vertebrae were fused. Because the expression of the condition was mild, it was likely asymptomatic and would not have limited her range of motion. In addition, there was fusion of the anterior aspect of the fourth and fifth lumbar vertebrae. However, this is the result of ossified ligaments, and the etiology could not be determined.

There was bilateral articulation of two bones within the foot (the calcaneus and navicular), representative of a nonosseous coalition of the these bones. This condition has been reported to occur with a frequency of 1–2 percent in clinical samples (Silva 2005). It may lead to a painful condition known as spastic flat foot, but in some patients, there are no symptoms. The trapezium and scaphoid of the left wrist were fused, and this is also an uncommon occurrence (Singh et al. 2003). Coalition of these bones within the wrist is generally asymptomatic, although strain may be experienced with strenuous use of the wrists. Although this individual presented an unusual combination of pathologies and developmental abnormalities, there is no reason to believe that all of these conditions were related.

Based upon the characteristics of the dentition and surrounding bone, it was determined that this individual was likely very ill for a substantial amount of time and was possibly bedridden. Periosteal reactions throughout the postcranial skeleton indicate severe and prolonged infection. The excessive buildup of calculus indicates

that this individual likely consumed a diet rich in starches and may not have had the ability to consume solid foods that aid in the breakdown of calculus deposits. In addition, this young woman may have suffered from physical disfigurement due to the anomalies in the sternum described above. However, unlike the individual in the preceding discussion, this young woman probably benefitted from long-term care.

Grave Pit 7529, Burial Feature 8941

Grave Pit 7529 was in Cemetery Area 3 and contained the well-preserved remains of a 7.5–9-year-old child of Euroamerican affinity. The age of the individual prevented any assessment of sex (Figure 208). The individual was interred in a supine position with its head oriented toward the east within a hexagonal pine coffin placed within a rectangular grave pit. The interior of the coffin was decorated with fabric and lining tacks. A roughly 1-inch-wide rectangular ferrous strap, affixed with nails, was used to aid in the joining of boards of the coffin. Clothing fasteners included three sew-through bone buttons in the pelvis, one on the lower torso, and another at the head. Five sew-through white Prosser buttons were distributed throughout the torso and pelvic area. A fired pellet was found near the right upper arm in the torso region and was associated with a partially healed gunshot wound to the right scapula. Brass wire wrapped with paper or textile was present next to the left hand, suggesting a floral arrangement. The north wall of the grave pit had a shelf (see Chapter 5 for a description of shelves), suggesting that planks may have been used to protect the coffin within the grave. The southwest corner of the grave pit was intruded upon by a large post-hole.

During his or her short life, this individual suffered and survived some rare events. The child did not show any evidence of lingering disease, and his or her long bones were rather large, compared to those of other children of similar age from the site (see Chapter 9). From a purely osteological perspective, this child appeared to be in good health prior to his or her death.

A number of injuries paint a far-different picture. First, the fifth finger of the left hand showed healed fractures between the proximal- and middle-row phalanges. The possible causes of the fractures are too numerous to list; the location and degree of the injury were relatively unremarkable. Although the fractures healed, accessory facets were produced and can be related to an altered (i.e., limited) range of motion for that finger. Apart from some limitation in mobility and possible disfigurement, the child fully recovered from this largely common injury.

Uncommon, however, was a healed gunshot wound to the right scapula. A fully healed, half-circular notch appeared on the superior aspect of the vertebral border. A lead ball (either from 000 buckshot or a .36-caliber pistol) was retrieved from the grave. The lead ball fit the healed defect perfectly (Figure 209). The direction from which the shot originated was not immediately apparent from the defect itself; however, it is difficult to support a hypothesis that the shot came from the front. In addition to a complete absence of injury to the chest, even a trajectory that could miss other skeletal elements would likely be unsurvivable. And from the level of healing associated with this injury, it is clear that the child lived at least several months after getting shot, but possibly longer.

Finally, the right temporomandibular joint, the joint of the jaw, suffered an injury of unknown cause. The right mandibular condyle, the part of the jaw that articulates with the cranium, was completely obliterated, and the resulting severe infection obscured any direct evidence of fracture (Figure 210). A new joint surface was forming to accommodate the injury, but the mandible and right temporal bone of the cranium appeared to be in the process of fusing. It was a devastating injury, to be sure.

The infection surrounding the right temporomandibular joint was substantial and active at the time of death. Although the precise nature of the injury is undiscoverable, it was not immediately fatal. The subsequent infection, however, likely contributed to the death of the individual. Such severe, negative bone response in a location associated with major circulatory and nervous-system structures has inarguable potential for lethality.

The individual in Grave Pit 7529 left skeletal evidence of unusual misfortune during his or her short life. The absence of childhood-stress markers and the length of the bones suggest relative good health and nutrition

in the first several years of life. A finger was broken and healing, creating accessory facets that would be small but permanent reminders of the event. Then, circumstances to which one could only speculate led to a shotgun wound to the back. The child also survived this event—the lead ball, intact and retained, carried as a permanent reminder. A final injury to the right side of the face was also survived, at least initially. Unlike altered motion in a broken finger or a lead ball around which a scapula healed, the vestige of this injury was a severe and pervasive infection, one to which the individual may have finally succumbed.

Grave Pit 7970, Burial Feature 19501

Grave Pit 7970 was in Cemetery Area 3 and contained the remains of a Hispanic female, aged 60 or more years. The remains were nearly complete and generally in good condition. Several ribs and vertebrae were damaged postmortem (Figure 211). The individual was interred in a supine position with her head oriented toward the west within a trapezoidal juniper-wood coffin placed within a rectangular grave pit. The exterior of the coffin was decorated with fabric and lining tacks. Wire fragments collected with the coffin materials also suggest the presence of a floral arrangement. A metal button was also recovered with the coffin materials. Sew-through painted Prosser buttons and sew-through shell buttons, including an engraved shell button, were found in the torso region and were probably used to fasten a shirt or dress. Also in the torso region were the elements of a rosary, consisting of wooden beads, attached wire, and a cross. A utility trench intruded the northwest corner of the grave pit, but the trench did not affect the coffin or individual.

This woman's remains displayed a number of notable characteristics that can be used to reconstruct some aspects of her life. First, owing to her advanced age, the woman was missing several teeth. Most molars and several anterior teeth were lost during life. The space created by the missing teeth allowed those teeth still present to shift their positions and orientations in the dental arcade. This was most prominent with her right maxillary canine. The tooth is tilted, so that it is nearly horizontal instead of vertical (Figure 212). The tilting is likely a result of the loss of the adjacent teeth, combined with extreme periodontal disease and abscessing. Because there was so little contact with the bone of the tooth socket, the remaining periodontal ligament was insufficient to maintain the tooth in a vertical position. That the tooth was retained is rare and remarkable.

The margin of the crown on this tooth was irregular and very unusual. Chipping could be the cause for some of the irregularity, but it is possible that some kind of resorption was occurring, as well. Given the orientation of this canine, it is difficult to envision where the gum line would have been during life. Additionally, a granuloma or cyst may have been present in this location. Cysts resulting from chronic inflammation around the tooth root (referred to as periapical granulomas) are common in the earliest stages of abscesses and are associated with resorption of the tooth roots; so, it is quite possible that the crown of this tooth was undergoing a similar process. Such resorption of the crown would have been more likely had an occlusal caries been present on the tooth.

Other characteristics of this woman's life were observable from persistent skeletal attributes. The left nasal passage displayed an enlarged turbinate bone, a condition known as compensatory inferior turbinate hypertrophy (Figure 213) (Kiroglu et al. 2007:67). The woman also featured a deviated nasal septum. These two findings strongly suggest a chronic difficulty in breathing. Frequent upper-respiratory-tract infections—or, more likely, allergies—reduce the airflow through one or both of the nasal passages. The turbinate bones serve to warm, humidify, and cleanse inspired air before it reaches the delicate tissues of the lungs. When breathing is hindered by chronically inflamed or irritated mucosal tissues in the nasal cavity, the turbinates respond by increasing the size of the air cells in the element, thus increasing the amount of air flowing through. This in turn increases the space taken up by the element in the nasal cavity and typically leads to a deviated septum.

The woman in Grave Pit 7970 was also among the most aged of those recovered from the cemetery. The attributes typically used to determine the age of skeletal remains (e.g., pubic symphysis morphology or changes to the sternal ends of ribs) suggest that the woman was at least 60 years old when she died. Other degenerative changes were observable, reflecting advanced years or a life history full of strenuous activity. Most of the

woman's skeletal elements exhibited osteoporosis, a condition common in—but not exclusive to—older females. The spinal column displayed severe degenerative joint disease, including additional bone growth around joint surfaces (osteophytosis). The fourth and fifth cervical vertebrae were fused together from excessive osteophytic bone growth, and the articulation between the fifth and sixth cervical vertebrae was severely degraded, showing porosity and areas of eburnation.

Joint disease appeared on other parts of the skeleton, most notably the elbows, wrists, and knees. These are common sites of joint disease for many individuals. In younger individuals, the joint disease points to strenuous activity, placing greater than usual stress on the joints. In older individuals, however, joint modification is often an expected part of the aging process, reflecting normal use. In other words, joint disease is the product of joint use. Normal joint use will eventually appear on the aged skeleton; intensive joint use will cause these changes much earlier in life. It is unclear whether the changes to this woman's joints were the product of strenuous activity, normal aging, or some combination of the two.

The woman in Grave Pit 7970 suffered from chronic breathing difficulties so sustained as to cause skeletal structures of the breathing apparatus to respond. She lost several teeth during her life. Although this is not uncommon among older individuals, one of her remaining teeth migrated, and its crown rotated toward the midline. The movement was so marked that the tooth was oriented a full 90° from its normal vertical orientation. It is unclear the extent to which this would be painful, but the unusual position would be uncomfortable, to be sure. Finally, her upper back, elbows, wrists, and knees were the sites of significant joint disease. Whether it was the result of advanced years or particular strenuous activity earlier in life, those joints and areas would have experienced some degree of pain. The woman in Grave Pit 7970 survived to a later age than most individuals recovered from the cemetery. Her final years, however, were likely not spent in physical comfort.

Grave Pit 13926, Burial Feature 28294

Grave Pit 13296 is in Cemetery Area 3 and contained the mostly complete remains of a 10.5–12-year-old child of indeterminate sex and Euroamerican affinity. The remains were in good preservation, except for severe fragmentation of the cranium postmortem (Figure 214). The individual was placed in a supine position with its head oriented toward the northeast within a hexagonal pine coffin and placed within a rectangular grave pit. Multiple clothing fasteners were associated with this individual, including plain Prosser and plain shell buttons, metal pants buttons, a hook-and-eye fastener, two eyelets, and a gaiter.

There were multiple osteological abnormalities affecting the bones and teeth of this individual. The left tibia presented a proliferative periosteal reaction on the posterior aspect of the shaft. Periosteal reactions were present on the visceral, or interior, aspects of several left and right ribs. The roofs of both eye orbits exhibited lesions consistent with cribra orbitalia, suggesting the presence of a metabolic disorder. The mandible had an unusually prominent and broad chin. Long-bone measurements indicate that he or she was of slightly below-average size for children of a similar age at the site.

Dental abnormalities were found on all eight permanent incisors and all four permanent first molars. Maxillary incisor crowns were constricted in the mesiodistal plane, near the incisal edge. The cutting, or incisal, edges of the maxillary teeth also exhibited shallow notches (Figure 215). The lateral mandibular incisors had narrowed, elongated crowns, with notches in the midline at the incisal edges. The left-central mandibular incisor was cone shaped and quite narrow. The right-central mandibular incisor was incompletely preserved but probably had a conical morphology, as well. The first maxillary and mandibular molars were reduced in size and had low, minimally worn protuberances on the occlusal surfaces instead of normal cusp morphology (Figure 216).

The incisor defects are consistent with a specific type of enamel dysplasia referred to as Hutchinson's incisors, and the malformation of the molars with minimal dentine exposure is consistent with a variant known as Mulberry molars (Robinson and Miller 1990). Many researchers consider these dental defects to be clearly diagnostic of congenital syphilis, although there are variants of the molar dysplasia that may not be diagnostic (Powell and Cook 2005). Periosteal lesions located throughout the skeleton are characteristic of an earlier stage

of congenital syphilis, but these defects may be resolved after infancy, with little or no indication of having been previously afflicted. In a later stage of the illness, from about 5 to 15 years, an affected individual may exhibit a depressed or "saddle-shaped" nasal bridge and a disproportionate size of the upper and lower jaw (Powell and Cook 2005:24–27). The authors note that the appearance of these defects may lead to social isolation, to the extent that the defects associated with the disease. A depressed nasal bridge was not recorded for this individual, although only the right nasal was observable. The abnormal morphology of the mandible is consistent with congenital syphilis.

Although this individual survived infancy and early childhood, the severity of the condition with which he or she was born made prolonged life unlikely. In addition to the inherently compromising nature of the condition, an increased susceptibility to other potentially life-threatening agents is predictable. Indeed, survival past infancy exceeds many expectations for congenital syphilis. That this individual lived past the first decade is remarkable.

Grave Pit 24758, Individual 2

Grave Pit 24758 was located in Cemetery Area 4. This grave contained, primarily, the burial of a Native American male, aged 40–50 (Burial Feature 25208). The grave also contained elements of three other individuals, one or more of whom were disturbed and disrupted by the interment of the primary individual associated with Burial Feature 25208. The disturbed individuals were enumerated as Individuals 1–4. Individual 1 was a 16–20-year-old female of indeterminate affinity; Individual 3 was 35–50 years old, possibly male, and of indeterminate affinity. A third individual (Individual 2) was a 45–55-year-old Hispanic male and will be the focus of this discussion. Due to the disturbed nature of Individual 2, no mortuary artifacts could be attributed to the remains, and the original positioning of the remains is uncertain.

This individual was represented by numerous elements, including partial skull and dentition, several ribs and vertebrae, pelvis, some long bones, and elements of the hands and feet. The remains were recovered from 11 separate contexts, including coffin fill, grave fill, sectors, and bone clusters. Recovery of elements from several proveniences was not uncommon for disturbed contexts (see Chapters 1, 2, and 4 of this volume and Volume 3 of this series for discussions of disturbances at the site).

Yet, despite the discontinuity of this man's remains, a great deal about his life can be surmised, from as early as his first or second year of life. The first cervical vertebra develops from several centers of ossification, or the laying down of new bone (Scheuer and Black 2000:197). The anterior arch of the atlas (the first cervical vertebra) typically fuses by age 1 or 2. According to Barnes (1994:293), any population can expect 5 percent of adults to present spina bifida atlantis, a failure of the posterior neural arch to fuse. Barnes added, "occasionally, clefting of the anterior arch occurs" (1994:120). The man under consideration here exhibited an atlas that failed to fuse, both anteriorly and posteriorly—a rare presentation, the expected frequency of which is still unknown on a populational basis.

There was also evidence suggesting repetitive behavior or activity later in life. The fifth lumbar vertebra featured spondylolysis, or separation of the neural arch from the main part of the vertebra, or vertebral centrum. The neural arch was completely separated from the centrum and was not recovered during excavation. The site of separation showed no evidence of reactive bone, and the vertebral body appeared unaffected. These findings suggest that the event occurred long before death and remained relatively stable.

There are several possible causes for spondylolysis. Although traumatic in the skeletal sense, many relatively innocuous activities, such as heavy lifting, can lead to separation of the vertebral arch. Additionally, those affected are frequently unaware of the trauma, at the time it occurs or subsequently, throughout life.

A far-more-dramatic injury was seen on the cranium. A large defect, 86 mm ($3^{5}/_{16}$ inches) long and 16.5 mm ($^{5}/_{8}$ inches) wide, appeared on the right parietal. The injury showed characteristics of both sharp-force and blunt-force trauma, a combination DiMaio and DiMaio called "chop wounds" (1993:204–206). These are caused by objects or weapons that are both massive and bladed, such as axes or, in the contemporary literature, airplane propellers.

More significant, however, is that the man survived this injury. The edges of the wound were actively healing. In fact, bony spicules were beginning to bridge the defect and close the wound (Figure 217). An injury of this magnitude is typically not consistent with survival, much less prolonged life. Although healing was not complete, placing the time of the injury several weeks before death, the man unquestionably survived the event. There are a number of possible causes for the injury, including those related to accidents or assault. Unfortunately, there is not sufficient evidence to advance one plausible explanation over any other.

Finally, openings in the interior surface of the lower jaw that allow nerves and vessels to pass, known as mandibular foramina, exhibited extensive infection. Infection likely communicated throughout the entire interior circumference of the mandible. Reactive bone also appeared in the sockets for the lower-left second and third molars, observable only because of postmortem tooth loss (Figure 218). Dental examination did not reveal any pathological conditions of the teeth that could have caused the infection in the mandible. Additionally, the lack of infection associated with the chopping wound on the right parietal suggests that the pathology noted in the mandible was unrelated to that traumatic episode. Indeed, the cause of the reaction in the mandible remains a mystery. Because the infection was active through the end of the man's life, the possibility remains that the infection contributed to his death.

As noted above, this individual's remains were collected from several contexts and did not compose a complete skeleton. Nevertheless, a rare developmental defect in the atlas and an activity-related injury to the lower back were discovered. Spina bifida atlantis and spondylolysis are often asymptomatic. Indeed, skeletal examination revealed two characteristics of the man's spine about which he, himself, may not have known.

The man survived a chopping injury to the cranium, truly remarkable given the location and severity of the trauma. At the time of death, however, the man suffered an extensive infection of his entire lower jaw. Neither the cause nor the result of this infection is knowable. Nevertheless, much of this man's life was reconstructed through the analysis of his disarticulated remains.

Grave Pit 10139, Burial Feature 21965

Grave Pit 10139 is in Cemetery Area 3 and contained the burials of two individuals. The first was a young-adult Hispanic female, aged 18–22 years. The second was a perinatal infant, estimated to be aged 2 months prior to or following birth. Both individuals were buried with their heads oriented toward the southwest, the opposite orientation of most burials in Cemetery Area 3. The adult female was interred in a supine position and placed within a trapezoidal pine coffin decorated with interior fabric and lining tacks. A bone button and a hook-and-eye fastener were associated with the adult female. She was also buried with leather shoes with associated eyelets, aglets, and a nail. The infant was buried on its right side in a trapezoidal pine coffin lacking in evidence for similar decoration and which was placed atop the adult coffin. The infant had a sew-through plain shell button near the chest and had evidence of having worn a floral crown, suggesting the individual was buried as an *angelito*. Both sets of remains were mostly complete. The adult was in good preservation, and the infant was in fair preservation (Figure 219).

Neither individual presented any skeletal anomalies or evidence of pathology or trauma. Indeed, the most notable characteristics of this grave pit were the presence and positioning of its two occupants. It is clear that the young woman and infant were buried at the same time, although buried in separate coffins. Figure 219 shows the positioning of the individuals: the woman was supine and fully extended, her arms folded across her abdomen; the infant was on its right side, with its head centering on the pelvis of the woman in the coffin below.

Demonstrating biological relatedness is difficult and suppositional without DNA examination. Context and skeletal attributes, however, may provide means to support a reasonable suite of conclusions.

No skeletal evidence pointed to a particular cause of death in the adult female. This is, of course, not uncommon among skeletal remains; many (if not most) physiological interruptions that result in the cessation of life leave no skeletal markers. It is unknowable what caused the death of this woman, and only gross events

like massive and catastrophic trauma can reasonably be ruled out. The infant is similarly without evidence pointing to possible causes of death.

Both individuals were possessed of demographic attributes that support a plausible, albeit unprovable, hypothesis of relatedness. Specifically, an argument can be advanced that the two represent a mother and child who died at the same time, possibly from complications during childbirth. The strongest support for this proposition lies in the biological characteristics of the individuals and their positioning in the grave. Based on the abundance of single-occupant graves in the cemetery, a reasonable observer could conclude that the individuals from Grave Pit 10139 reflect a special set of circumstances connecting them.

Across the project area, only 32 grave pits contained burials with more than one primary individual. Twenty-eight of these were burials with two primary individuals, 3 burials contained three primary individuals, and 1 burial contained five primary individuals. Focusing on the burials with just two primary individuals, 16 contained two juvenile individuals, 9 contained one juvenile and one adult, and 3 contained two adults.

Narrowing further, by examining the sexes of the adults in the 9 burials containing an adult and a juvenile, six were female and three were male. Therefore, of the 1,006 burial features, the burial in Grave Pit 10139 was 1 of just 6 containing individuals with similar demographic characteristics.

These six burials represent those with adult females buried with young juveniles. The position and location of the juvenile individual in each grave pit varied. In five of the burials, the juvenile individuals were placed somewhere between the legs of the adults. The particular locations were anywhere from near the ankles, as in Grave Pit 7963, to near the pelvis, as in Grave Pits 7849 and 10139. The juvenile in Grave Pit 29243 was placed at the left shoulder of the adult female. Any significance in the precise placement of the juvenile individual relative to the adult female was unclear.

Nevertheless, the burial of an adult female with a fetal or perinatal infant seems to suggest a relatedness between the two. Indeed, all of the multiple-individual burials likely represent some kind of nonrandom relationship among their occupants. This is not to imply, however, that such a relationship was necessarily as substantial as members of the same family. The relationship may be circumstantial, such as individuals who died at the same time from a single cause or event. In such cases, one would expect less of a compelling demographic configuration than is seen in Grave Pit 10139. Indeed, in Grave Pit 10139, as well as the other five burials described above, the biological characteristics of the individuals buried together offer evidence of a plausible and parsimonious interpretation of relationship, that of a mother and her child.

Grave Pit 3288, Burial Feature 7199

Grave Pit 3288 was located in Cemetery Area 2 and contained the remains of a male, aged 35–40 years, of European affinity. The remains were complete and in good preservation (Figure 220). The individual was interred in a supine position with his head oriented to the east within a rectangular pine coffin with no evidence of interior or exterior decoration. The orientation of this individual was unusual for Cemetery Area 2, as most individuals in this area were buried with their heads oriented to the west. No clothing fasteners or personal items were present. However, a fired pellet was found lodged in the right side of the fourth lumbar vertebra.

The skeletal remains of this man tell a compelling story of a life and death of hardship and injury. Four of the teeth had carious lesions, and one of these was severe. The crown of the first left maxillary premolar was totally decayed, exposing the pulp chamber and leading to an abscess of the tooth socket. This doubtlessly led to pain and discomfort.

There were a number of small chips on the front teeth, especially affecting the maxillary incisors, although there were no corresponding chips on the mandibular incisors. This manifestation suggests habitual manipulation of hard objects. However, dental wear overall was light to moderate. There were also brown stains on the labial surfaces of the maxillary incisors in the form of striations. One possible explanation for the brown stains is tobacco use. The chipping could indicate gripping of a pipe, but that often leaves wear facets on both maxillary and mandibular teeth, which are lacking in this case.

Another possible explanation is admittedly speculative: the small chips on the front teeth could have resulted from use of the teeth to tear open rifle cartridges. The importance of the incisors in this activity is supported by accounts that the absence of these teeth could disqualify men from military service during the Civil War (Dammann 1984). This suggests the possibility that this man may have served in the military. His grave was found near the northern the periphery of the military section, although it was not recorded in military records (see Chapter 4 for a description of the military section). No artifacts of clear military significance were encountered.

The most striking characteristic of this set of remains is the extensive evidence of trauma. The distal end of the left nasal exhibited a fairly straight transverse fracture. The fracture was well healed, with little or no misalignment. Four limb elements on the left side were also broken. There were poorly aligned oblique fractures of the left radius and ulna (Figure 221) with advanced healing. The fractures occurred approximately at midshaft. The bones were improperly set, resulting in a shortening of the radius of about 1 cm, compared to the right radius. Some overlap of the fractured ends of the ulna shaft was apparent, although the overall length of this element was comparable to that of the right ulna. These elements were likely fractured as a result of the same event. The presence of mature lamellar bone indicates that the injury occurred at least several months, and possibly years, prior to death.

There was a poorly aligned spiral fracture of the distal portion of the left tibia with advanced healing. The fracture was not set properly, resulting in a proximal displacement of the distal end and an anterior angulation of the proximal end (Figure 222). A small cloaca, or opening in a layer of new bone growth outside existing bone, was apparent on the lateral side of the distal third of the shaft. This indicates that there was an infection subsequent to the fracture that had reached the central cavity of the bone shaft. There was a poorly aligned fracture of the proximal shaft of the left fibula with advanced healing. The fracture was not set properly and resulted in the shortening of the element by about 1 cm, in comparison with the right fibula. Similar to the fractures of the left forearm, these traumata likely occurred at least several months prior to death and likely occurred as a result of the same event. The spiral fracture of the tibia suggests a twisting motion, in which the upper body rotated while the left foot was held in place.

There were unusual aspects of the right clavicle, including an irregular "gnarled" appearance of the lateral end and osteophytic growths on the sternal end. In addition, there was a deep pit at the origin of the costoclavicular ligament, on the medial end of the right clavicle. These characteristics were absent on the left clavicle, suggesting that the individual favored the use of the right shoulder girdle subsequent to the injuries to his left side. Alternatively, the pit on the right clavicle could indicate a sudden movement that overstressed the ligament insertion simultaneously with the injuries to the left forearm.

There was evidence that this man suffered two gunshot wounds at or near the time of his death. A .44-caliber bullet passed through the left intervertebral foramen, between the third and fourth lumbar vertebrae. The round impacted the articular facets of both elements, destroyed a right transverse process, and lodged in the body of the fourth lumbar vertebra. This injury likely severed or severely damaged the spinal cord (Figure 223).

A second gunshot wound was found in the right pelvis. The bullet, possibly a .55-caliber round, entered the right ilium from the front side, at a slightly oblique angle (Figure 224). The diameter of the penetration was larger on the posterior side of the ilium. New bone growth around the wound indicates that the individual survived the injury, but the level of healing is only consistent with about 3–4 weeks of survival. This wound was likely received after the shot that entered the spinal column. The angle of the shot that penetrated the pelvis indicates that the assailant was standing above and to the right of the victim, who was on his back.

In addition to these traumata, there were multiple indications of moderate arthritic development at all of the major joints. This is not an unusual development in an adult of this age range, but the number of joints affected suggests that his occupation probably involved considerable manual labor. It is possible that the stress injury to the right clavicle was related to these habitual activities rather than to the event in which the limb bones of the left side were broken. Alternatively, some of the osteoarthritis could have been caused by asymmetric mechanical stresses resulting from avoidance of the injured limbs.

The man in Grave Pit 3288 survived a great number of injuries, from broken limbs to gunshot wounds. The circumstances surrounding these injuries—how this man came upon his broken bones and how he found

himself fired upon by two different weapons—are not available for interpretation. However remarkable the events surrounding these injuries, equally remarkable is the man's survival of them. The broken limbs healed, albeit misaligned and infected. Two gunshot wounds unquestionably debilitated this man; yet he lived on for several weeks. Tucson in the mid- to late-nineteenth century was clearly a dangerous place, but one populated by some individuals with extraordinary survivals.

Grave Pit 5197, Burial Feature 8650

Grave Pit 5197 was in Cemetery Area 5 and contained the burial of two primary individuals. One was a young-adult male, aged 18–24, of Euroamerican affinity. The other individual was also a young adult aged 18–24, a Hispanic female. The grave pit was uniform throughout, suggesting that both individuals were buried at the same time. Both sets of remains were complete and in good preservation (Figure 225). Both individuals were interred in a supine position, with their heads oriented toward the east, in separate hexagonal pine and juniper coffins. Both individuals had numerous Prosser, metal, and shell buttons associated with their torso and pelvic regions.

The man presented evidence of two injuries, one earlier in his life and one around the time of death. The first appeared on the distal end of the left femur. An area of increased bone growth 54 mm ($2^{1}/_{8}$ inches) long was present on the lateral aspect of the femur, just above and outside the knee (Figure 226). This location is associated with the vastus intermedius, one of the four quadriceps muscles. The origin of this growth was most likely an injury, causing myositis ossificans traumatica, the ossification of connective tissue. The modern literature describes this injury as common among athletes when a blow is received to the knee, such as tackling in football (Booth and Westers 1989). The man in Grave Pit 5197 likely experienced a similar blunt impact to the left leg. The injury would have caused lingering pain, but not likely to a degree that would have significantly impacted his quality of life.

Closer to the time of death, the man suffered a blow to his face, just below the right eye (Figure 227). A fracture ran parallel to the bottom of the right orbit, with no evidence of healing or infection. The injury did not appear severe enough to have contributed to his death. Indeed, no skeletal evidence points to possible causes of death. The trauma to the eye occurred around the time of death and may or may not have been part of a larger lethal event.

The woman in Grave Pit 5197 displayed two unusual characteristics of the lower back—specifically her fifth lumbar vertebra. An anomaly during vertebral development led to sacralization of the fifth lumbar vertebra (Barnes 1994:108–110). In other words, the element developed attributes of, and ultimately fused to, the sacrum. As a result, the lumbar spine contained four separate elements instead of the typical five, and the sacrum contained six fused elements instead of the typical five. This configuration is known as a cranial shift during development and is often benign.

Additionally, the neural arch of this sacralized fifth lumbar vertebra was spondylolysed, or separated from the rest of the element. The most-common cause of spondylolysis is traumatic in origin, the product of strenuous activity (Arriaza 1997). The part of the spine most-frequently affected by spondylolysis is the area of the fourth and fifth lumbar vertebrae. The extent to which sacralization of the fifth lumbar vertebra affects the potential for spondylolysis—whether increasing or decreasing the likelihood of its occurrence—is unclear. Merbs (1996) examined a population suspected to have a high incidence of spondylolysis: 16 cases were reported, of which 2 were identified to have suffered separation involving a sacralized fifth lumbar vertebra. Merbs discussed the lack of cases in the clinical literature describing spondylolysis of sacral elements (including lumbar elements fused to the sacrum). This absence, however, underscores a characteristic important to the discussion of the woman in Grave Pit 5197: both sacralization and spondylolysis are asymptomatic. Indeed, in a clinical setting, both are typically discovered by accident. Physicians and patients are unlikely to seek lower-back radiographs in the absence of symptoms warranting suspicion. It appears that neither condition dramatically

impacts an individual's life. Indeed, the woman in Grave Pit 5197 likely suffered an injury of which she was unaware, to an element she could not have known was anomalous.

Tucson in the mid- to late-nineteenth century featured a particular demographic model: men, often of European or Euroamerican heritage, moved to Tucson and married and raised families with local Hispanic women (Sheridan 1986:21–40). This was well documented and certainly led to the increased biological and sociocultural diversity of the desert town. However well described the practice was, it is difficult to examine skeletally. In the absence of grave markers to suggest any relationships among the decedents—as is the case in this cemetery—inferences must be drawn from sensible interpretation of biological attributes and burial contexts.

As described in Chapters 4 and 5, the overwhelming majority (84.4 percent) of the grave-pit features contained one burial of one individual each. In other words, 84.4 percent of the grave-pit features were constructed to inter one individual each and were not used again for a similar purpose. They represent discrete events. Two neighboring graves are separated by unknown time between interments and unknown relationships between individuals.

Grave Pit 5197, however, contained evidence to suggest that the two individuals were buried together, part of the same burial event. As noted above, the grave pit was uniform throughout. Both individuals lay on the same horizontal plane; there was no disparity in depth or elevation. Their positioning was side-by-side, with no horizontal skew (i.e., each individual's head and feet aligned with those of the other). Indeed, there were few inconsistencies between the two individuals, only in the positioning of the arms and the directions the heads were facing. These do not undermine the assertion that the individuals were buried together.

Concurrent burial strongly suggests that both individuals died within a fairly limited time frame. This is a circumstance that requires no further relationship—indeed, strangers may certainly die at the same time. Nevertheless, the overwhelming number of graves with the burial of a single individual each argues against an inherent limitation to mortuary practices that would lead to two unconnected individuals' receiving a single burial. Given the proportion of single-occupant graves in the cemetery, it is difficult to support the notion that those performing the burial in Grave Pit 5197 would have deviated from the common practice for two individuals unknown to each other. In other words, it is reasonable to assume that the individuals in Grave Pit 5197 shared a common trait beyond simply expiring at or near the same time.

If we look to the biological characteristics of these individuals, a conservatively plausible explanation emerges. The configuration of an adult male of Euroamerican affinity and an adult female of Hispanic affinity is frequently documented, from the early days of Tucson. Thus, there is support for the argument that the individuals in Grave Pit 5197 were buried together for more significant reasons than simply coincident times of death. Although the means to verify this assertion are unavailable, the skeletal attributes and burial context of these individuals support the hypothesis that they may have been among the pairs of immigrating Euroamerican males and local Hispanic females who, together, began to change the demographic composition of the area toward the end of the nineteenth century.

Grave Pit 534, Burial Feature 1278

Grave Pit 534 was located in Cemetery Area 2 and contained the remains of a male, aged 35–45 years, of European affinity. The remains were complete and in good preservation (Figure 228). The individual was interred in a supine position with his head oriented toward the west and placed in a hexagonal juniper-wood coffin. Two copper coins, likely pesos, were discovered on either side of the individual's head. Several plain Prosser buttons, a plain shell button, a cinch buckle, and fragments of cotton fabric were also present.

There are two exceptional characteristics of this individual's remains, relating both to his life experience and to the manner of his death. There were 14 gold dental fillings in this man's mouth—more than any other individual in the cemetery. The quality and number of fillings present tells us that he received a level of professional dental care that very few people in Tucson at that time could afford. We cannot know for sure, but it is possible that he received the fillings somewhere other than Tucson. Overall, his teeth were in remarkably good

condition, with little wear and only one unfilled cavity. This suggests that his diet likely consisted of relatively soft or highly processed foods.

Nothing remarkable was evident from examination of the postcranial skeleton. There was no evidence of arthritis in any of the joints of the limbs or in the spinal column. This is not unknown in a mature-adult individual, but the total absence of any changes may indicate that his occupation did not include strenuous manual labor.

Examination of the cranium and mandible revealed evidence of trauma that almost certainly resulted in his death. The left parietal bone of the cranium exhibited an elongated, keyhole wound fracture on its posterior aspect located 9.2 cm superior to the left asterion, 3.8 cm lateral to the obelion, and 7.6 cm from the bregma (Figure 229). Keyhole wounds in the cranium result from ammunition that has broken apart along its flight path or tumbled as it entered or exited the cranium. External beveling on the wound categorizes it as a gunshot exit wound. The keyhole characteristic of the exit wound alters its dimension in a way that frustrates any attempts to match the injury to a particular caliber of handgun.

The trajectory of the exit wound clearly indicates that the shot entered through the mouth of this individual (Figure 230). This is further supported by damage to the mandible. The mandibular symphysis was separated from the alveolar process to approximately half the height of the body. The fracture then propagated down and right and split the mandible inferior to the right canine (Figure 231). Rapidly expanding gasses exiting a firearm when discharged often lead to injuries and fractures collateral to the path of the bullet (DiMaio 1999). The fracture to the mandible is consistent with such an injury.

Further scrutiny of the trajectory of the gunshot wound suggests that the injury was self-inflicted. The most plausible and parsimonious explanation for the pattern of injury is that the man held a firearm in his right hand, placed the barrel in his mouth, and fired the weapon. Other scenarios are possible, to be sure. None other, however, simply and succinctly explains the evidence. The massive amount of trauma caused by this gunshot wound was almost certainly fatal.

Grave Pit 22157, Burial Feature 21848

Grave Pit 22157 was located in Cemetery Area 3 and contained the burial of two individuals. The individuals were buried in separate coffins, one placed atop the other. The top coffin held the remains of a young-adult female, aged 28–35 years, of European affinity. The lower individual was an adult male, aged 35–45 years, of indeterminate affinity. Both sets of remains were complete and in good preservation (Figure 232). Both individuals were interred in a supine position with their heads oriented toward the southwest in hexagonal juniper coffins. Both coffins each had four metal double-lug, swing-bail coffin handles. The coffins were also lined on their interiors and exteriors with fine, white, ribbed fabric, which may have been velvet or velveteen, fastened with ornamental tacks. A small fragment from a coarse, grass-fiber mat of unknown function was also found in association with the woman's coffin (see Chapter 5). The coffin associated with the male individual also had nine metal plates, which were likely used as corner joinery. The level of coffin decoration and investment related to these two individuals was rare in the cemetery. Lime was placed in the grave pit, which may have been applied to the burials to aid in decomposition. The female individual had plain Prosser buttons, a plain shell button and six metal hook-and-eye fasteners with adhered fabric. The male individual had several cloth-covered metal coat buttons, metal sew-through buttons, and a shell button. The abundance and diversity of clothing fasteners found with these individuals was also unusual in the cemetery.

As noted above, one coffin was placed directly atop the other. There was no grave fill between the coffins, and the grave-pit outline was uniform throughout. These observations strongly suggest that both individuals were buried concurrently, as part of a single burial event. Examination of the man's cranium and mandible revealed evidence of extensive blunt-force trauma that occurred around the time of death, including the following:

- A line of fracture extended across the right zygomatic, or cheek bone, from the lower-right corner of the orbit to the inferior aspect of the zygomaticomaxillary suture (Figure 233).
- The zygomatic process of the left temporal (at the base of the skull) was fractured and separated at its juncture with the squama (a portion of the temporal bone).
- The alveolar crest of the maxilla (where tooth sockets are located) was intact, but the crowns of several of the teeth (including the right first molar and the right first premolar through the right-central incisor) were broken off.
- The labial (or lip-facing) half of the left maxillary incisor was cleaved in half, with the remnant left in the socket.
- A portion of the first mandibular molar where it faced the cheek was also fractured.

The left-central maxillary incisor was lost prior to death and had been replaced by bridgework consisting of a gold-alloy plate with a false tooth (Figure 234). The plate was bent on the side of the false tooth where it contacted the adjacent tooth, and an anchoring bracket attached to the plate was slightly misshapen. The damage to the bridgework likely occurred at the time of the other injuries to the maxillary region, rather than after interment.

The mandible presented two major fractures that occurred around the time of death. The left side of the mandible was broken nearly through, beginning near the middle of the horizontal ramus at the most inferior aspect. The line of fracture moved straight up until it hit a point near the center of the mandibular body and then angled in a posterior direction, toward a point ending between the left second and third mandibular molars. Some of the fracture lines exhibited peeling, or delamination, supporting the interpretation of an injury occurring near the time of death.

Additionally, there was a cut mark on the most inferior labial point of the mandible, straight down from the distal aspect of the left mandibular first molar (Figure 235). The perimortem injury suggests that the individual may also have been assaulted with a bladed weapon, such as a knife. The right half of the mandible exhibited a perimortem fracture that nearly separated the bone. The injury began near the distal aspect of the right mandibular canine and dropped nearly straight down to the inferior margin of the mandible.

Most of the damage to the man's skull involved the mandible, zygomatics, and maxilla. Postdepositional damage to the cranial vault, however, precludes assessment of potential damage to this region.

The woman also suffered from multiple injuries. Examination of the remains revealed a fracture to one greater horn of the hyoid (a bone within the neck) that occurred near the time of death (Figure 236). The fracture was jagged in appearance and situated near the middle of the element. This type of injury suggests that force was applied to the throat. The ribs were not well preserved, but at least two right ribs exhibited fractures that occurred near the time of death, and two left ribs presented evidence of being crushed near those surfaces that articulate with the thoracic vertebrae. Additionally, one of the shorter left ribs exhibited a distinct cut mark on the inferior ridge, near where it would have articulated with the spine (Figure 237).

The woman's skull presented no obvious fractures, but there was evidence that she was struck at least twice in the upper body with a solid, blunt object, crushing or fracturing several ribs. A sharp object, like a knife, must have penetrated the thoracic cavity, leaving a wedge-shaped cut mark on the inferior aspect of one of her lower left ribs, and the fractured hyoid bone suggests either manual or ligature strangulation.

There is little doubt that the individuals in Grave Pit 22157 were the victims of homicide. The man was beaten in the face, and the cut mark on the mandible suggests a stab or slash to the throat. The woman was beaten, stabbed in the chest, and strangled. The injuries sustained by both the man and the woman could not have reasonably come from any manner of death other than homicide. These individuals were likely killed during a single event, as supported by their concurrent burial. The injuries suffered by these individuals, and the brutality of the acts that caused them, were unlike any others encountered in the cemetery. Mortuary evidence suggests that mourners supplied these two individuals with a relatively lavish burial, which may be an expression of the depth of grief felt by the community over the deaths of these individuals.

Grave Pit 3238, Burial Feature 6823

This case differs from the preceding in that most of what we have learned of the individual is derived from an osteological analysis of the changes in the remains that occurred after death. Grave Pit 3238 is in Cemetery Area 2 and contained the remains of an adult male, 35–50 years of age, of Hispanic affinity (Figure 238). Grave Pit 3238 was roughly rectangular in shape, but the western half of the pit narrowed dramatically. The base of the grave pit also narrows significantly, so that the rectangular wooden coffin box was not flush with the base of the grave pit. The shape of the Grave Pit 3238 suggests a hastily excavated pit. The western half of Grave Pit 3238 was also intruded upon by Grave Pit 3239.

The remains were found in a rectangular juniper box—perhaps a shipping crate—that appeared to have been lined with tar or tar paper and filled with a white powder, tentatively identified as quicklime. Personal items associated with the individual include four metal sew-through buttons, a piece of white fabric, and a fired percussion cap found near the head of the individual.

Human remains discovered within the box not only were found in various states of articulation and jumbled throughout the box but also displayed a range of burn patterns. The following analysis details the condition in which these remains were discovered and attempts to provide some viable solutions to the rather enigmatic condition of the burial feature.

Careful inspection of skeletal elements recovered from the burial feature indicated that only one individual was present. The cranium was located in the southeast corner of the container, separated from the main concentration of skeletal elements by several centimeters. In the middle of the northern side of the container was a concentration of remains consisting of the left and right feet, the complete right femur, and portions of the left and right tibiae and fibulae. Although the remains were scattered throughout the container and not found in anatomical positions relative to one another, several sets of skeletal elements were directly observed to be articulated. In other words, portions of particular joints were still intact. These consisted of the left and right ankle, the left and right knee, the left hip, the joints of the left and right foot, the left sacroiliac joint, the fifth lumbar vertebra and the sacrum, the right proximal ulna and radius, the first through third cervical vertebrae, and elements of the cranium, excluding the mandible. Most of the elements of the hands were found in close association with one another, suggesting that they were likely articulated at the time of deposition but became disarticulated during subsequent deterioration of the soft tissue.

Several skeletal elements, most notably the right femur and both feet, exhibited areas of erosion resembling chemical weathering. If the white powder found with the remains was quicklime, this could account for the observed damage, especially if moisture had infiltrated the crate. As mentioned previously, tar was observed covering the container. During excavation, tar was also observed covering and, in some instances, encasing skeletal elements. Furthermore, the tar covered burned and broken surfaces of the remains, indicating that the application of the tar occurred after the bone had broken or burned.

As perplexing as this burial might seem, the pattern of burning provides clues as to what might have occurred. Under normal conditions, a fully fleshed cadaver with no trauma undergoes very specific changes during a thermal event. As the body burns, the larger flexor muscles contract and pull the body into what is known as the pugilistic position: "Predictable muscular reactions cause the fingers and wrists to curl inward, elbows to flex, shoulders to rotate over the body, while toes curl, ankles extend, knees and hips flex, and the spine, neck, and head arch backward'' (Pope 2003). Bone in areas of the body with shallow tissue—such as the face, cranial vault, and anterior surfaces of the knees, as well as the terminal phalanges—will be affected first. Conversely, bone in areas of the body with greater tissue depth, such as the gluteal region, are affected later; there is simply more tissue to burn through before bone is encountered. Furthermore, flexion of the elbows and knees helps protect the backs of the knees and the anterior portions of elbows by essentially doubling the tissue depth in those regions. Based on this information, one should expect the following in a "normal'' thermal event:

- Flexed limbs
- Shielded surfaces behind the knees and anterior elbows
- More destruction of bone in areas of shallow tissue depth

- Destruction of the terminal phalanges
- Progression of destruction of long bones from distal to proximal

The remains of this individual did exhibit some of these traits. Both the left and right knees did appear to be flexed. The posterior surfaces of the distal femur and proximal tibiae of both legs and the anterior surfaces of both humeri were free of burning, indicating possible shielding from flexed limbs.

Some areas with shallow tissue depth, such as the vertebrae, anterior knees, and scapulae, did exhibit more-severe types of burning, but some elements, such as the left ulna and radius, were nearly completely destroyed. Based on what we know of normal burning patterns, this pattern is suspicious, especially when one considers that contiguous elements did not exhibit similar burn patterns and, in some instances, were completely unburned.

In regard to progression of destruction, some skeletal elements were noted as exhibiting increased destruction, in the midshaft regions of bones or traveling distally, away from the body. Once again, this pattern seems fairly peculiar. Such a pattern can exist if there is trauma that allows the energy source contact with bone that would be otherwise covered. Barring this, however, such a pattern is probably not likely under normal circumstances.

Furthermore, the phalanges that were burned were only charred, whereas deeper elements, such as the right innominate, exhibited a far-greater degree of burning. This is the reverse of what is expected. Evidence of carbonized tissue and the semiarticulated nature of the remains indicates that tissue was in fact present on remains at the time of combustion. The flexure of the knees further corroborates this assessment. However, the burning was under no circumstances "normal." Several joints exhibited nonuniform burn patterns when opposite sides of the joint were compared. At the left temporomandibular joint, the mandibular condyle was partially calcined, but the temporal bone was unburned (Figure 239). The right occipital condyle was unburned, but the first cervical vertebra was completely blackened on that side. The left ulna and radius were nearly completely calcined, but the distal articular surfaces of the left humerus were unburned. Such patterns could not exist had the bones been in direct articulation.

All told, it appears the remains of this individual were in a state of decomposition at the time of combustion. The association with a tar-lined box possibly filled with quicklime suggests that the individual died at some distance from the cemetery and was shipped to Tucson for burial. This was one of only two cremations found in the cemetery; the other (Grave Pit 7736) was a secondary cremation found in Cemetery Area 4 in a small wooden box. That feature contained the remains of a 16–20-year-old male whose body had likely been incinerated while fully fleshed. There was no tar or lime associated with the remains in that instance.

Although many particulars of this unusual case cannot be fully reconstructed, the taphonomic changes to the remains do indicate a general sequence of events. The remains could not have been fully articulated when burned. Differential burning among anatomically adjoining elements confirms this. Additionally, several of the burned elements were fragmentary and featured burning along broken margins. This indicates that these elements were broken before burning. Tar covered many bone surfaces, including those that were broken and burned (Figure 240). Based on these observations, the sequence of events was as follows: first, the remains were partially disarticulated, and several elements were fragmented; next, several elements were thermally altered to varying stages of burning; last, tar and quicklime were applied to the remains, likely when the remains were placed in the container.

The remains from Grave Pit 3238 stand out, not only for their unusual treatment compared to other remains at the cemetery but also for the unusual nature of that treatment. The remains were not interred in a regularly constituted coffin but, rather, a tar-lined shipping container. The remains were generally disarticulated, although some contiguous elements forming joints were still in contact with each other. The remains were incompletely and inconsistently burned—some elements were unburned, some elements were simply charred, and some elements were burned to completion (i.e., calcined). The remains were treated with tar and quicklime, as was the container in which they were found. The circumstances that led to this remarkable and unique case remain a mystery.

Conclusions

The cemetery contained the remains of 1,386 individuals. Some components of the lives of these individuals—how they began, how they progressed, and how they ended—are discoverable by the examination of durable tissues upon which their lives and deaths were written. The individuals interred in the cemetery lived lives of varying comfort and hardship. Some died before they could enter the world; some lived decades of experiences before passing. Within the cemetery were the remains of those who came to Tucson from elsewhere and those who lived their entire lives in and around the burgeoning desert town.

Most individuals recovered from the cemetery remain nameless; the records and markers of their burial location are not available. The data collected and analyzed from their remains help to illuminate biological characteristics of those who populated and created Tucson in the middle to late nineteenth century. These data, compiled and examined, assist investigators in the reconstruction of the people in a time and place. Each particular piece of data, however—each artifact and feature attribute, each measured long bone, each occurrence of disease, each instance of trauma, and each morphological trait—is a characteristic of the life and history of an individual. The uniqueness of the individual is only fractionally knowable through bioarchaeological examination. Volume 1 of this series draws from multidisciplinary examinations—biological, material, and documentary—to cast more light on the lives and deaths of individuals buried in the cemetery.

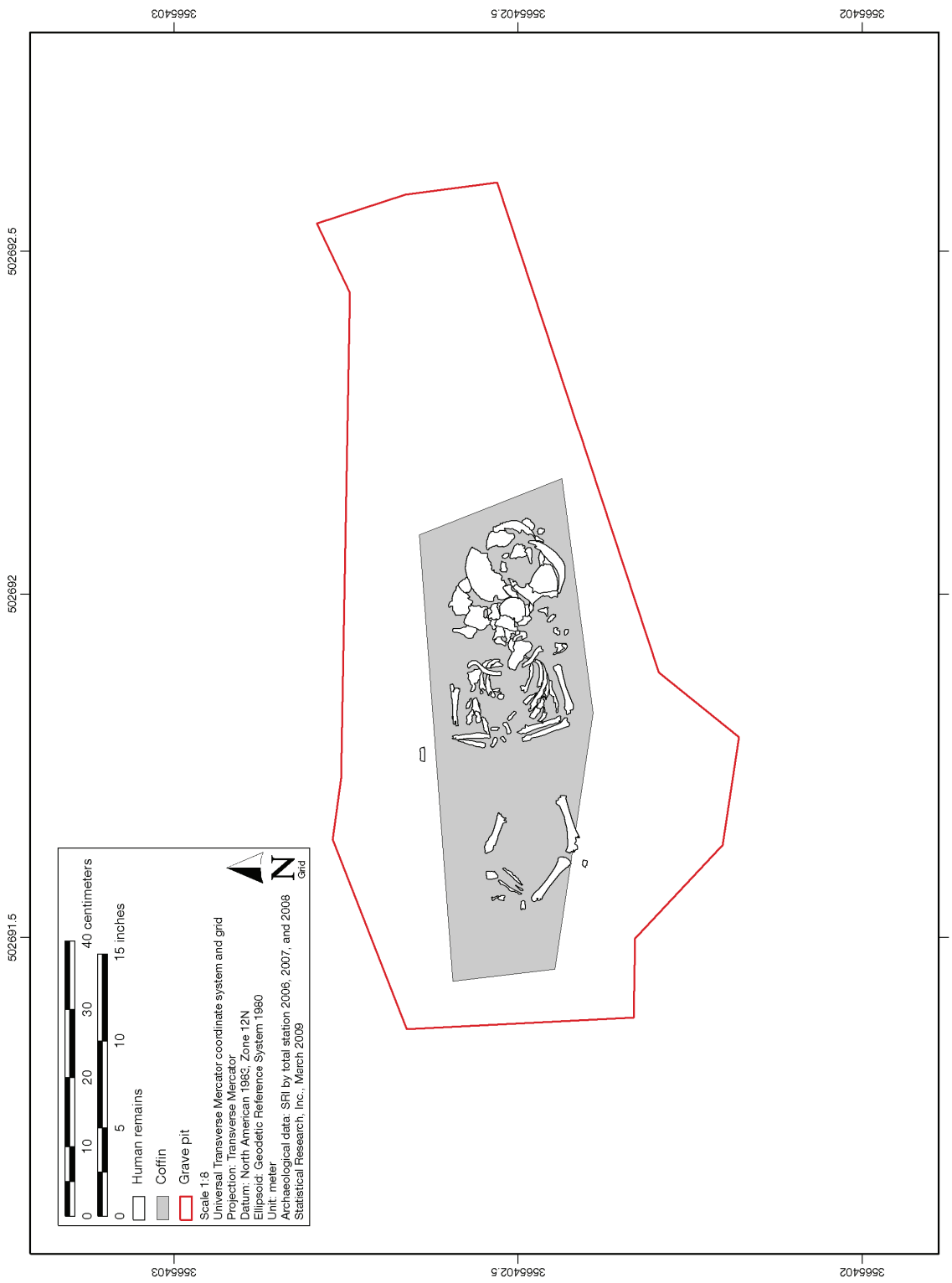


Figure 200. Digitized photogrammetry, Individual P, Grave Pit 7792, Burial 13205, an infant of indeterminate sex and biological affinity.

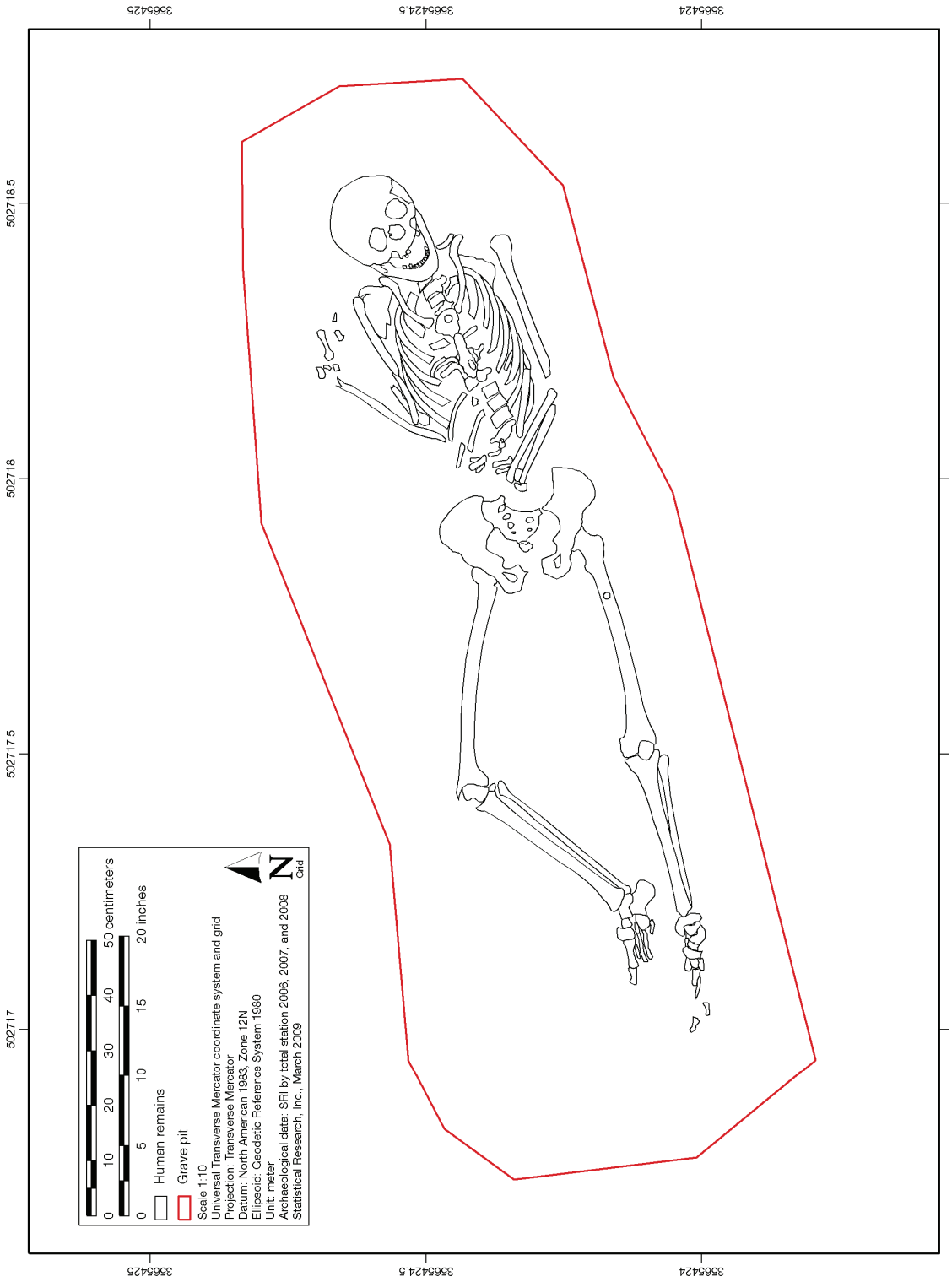


Figure 201. Digitized photogrammetry, Individual P, Grave Pit 10133, Burial 19965, a young-adult female of indeterminate biological affinity.

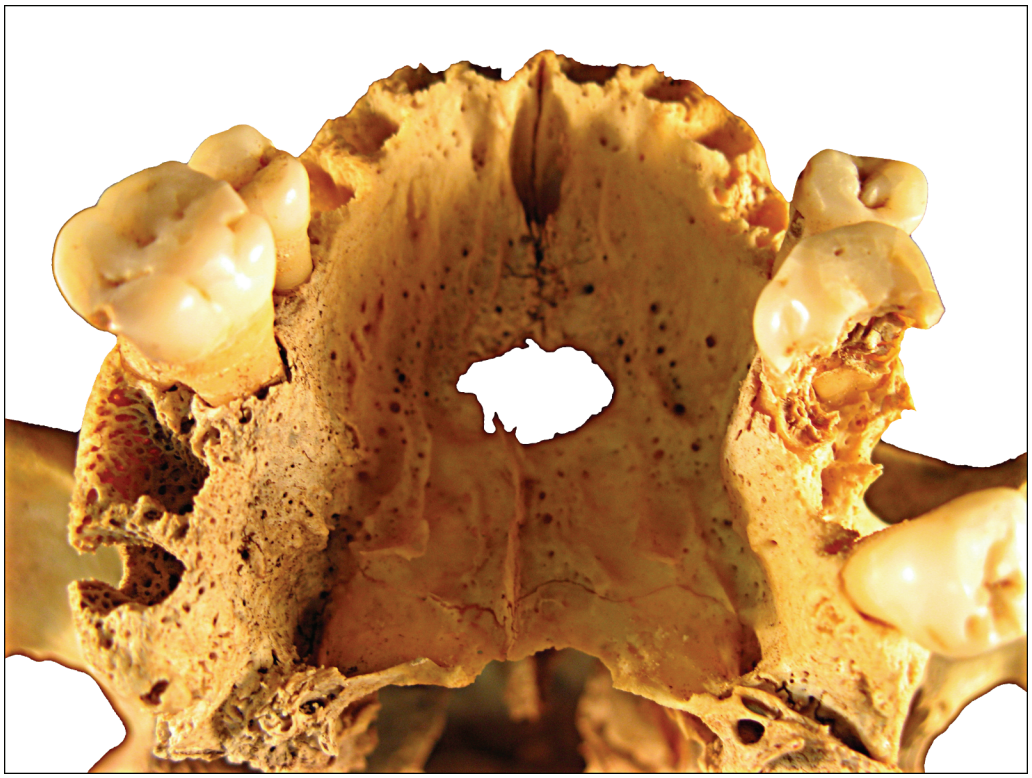


Figure 202. Inferior view of hard palate, Individual P, Grave Pit 10133, Burial 19965, a young-adult female of indeterminate biological affinity; note midline lesion.

Figure 203. Anterior view of cranium, Individual P, Grave Pit 10133, Burial 19965, a young-adult female of indeterminate biological affinity.

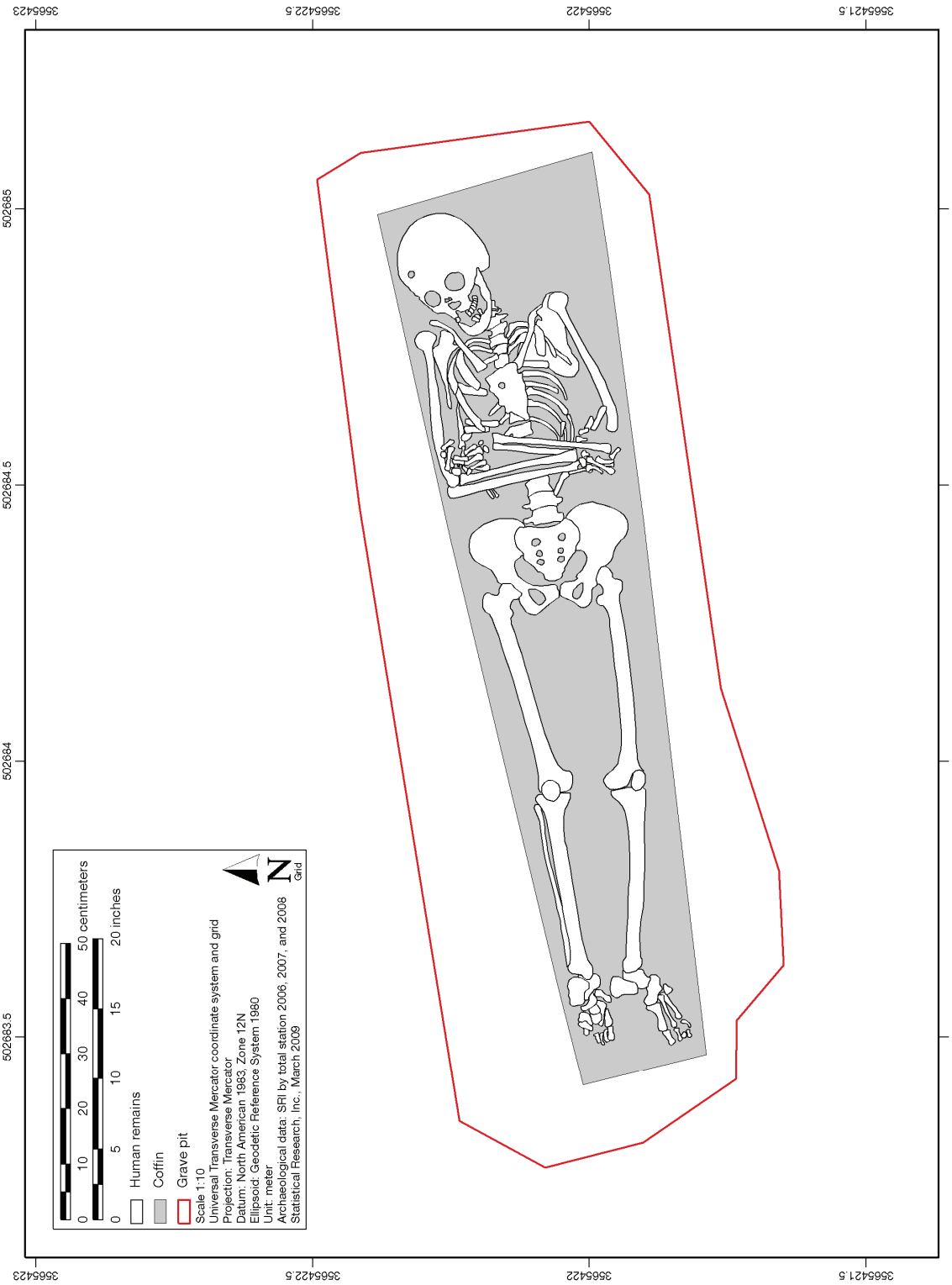


Figure 204. Digitized photogrammetry, Individual P, Grave Pit 7919, Burial 18924, a young-adult Hispanic female.

Figure 205. Mandible, right side, Individual P, Grave Pit 7919, Burial 18924, a young-adult Hispanic female; note bone resorption and calculus buildup.

Figure 206. Periosteal reactions on visceral aspect of ribs, Individual P, Grave Pit 7919, Burial 18924 , a young-adult Hispanic female.

Figure 207. Sternum and clavicles, Individual P, Grave Pit 7919, Burial 18924 , a young-adult Hispanic female.

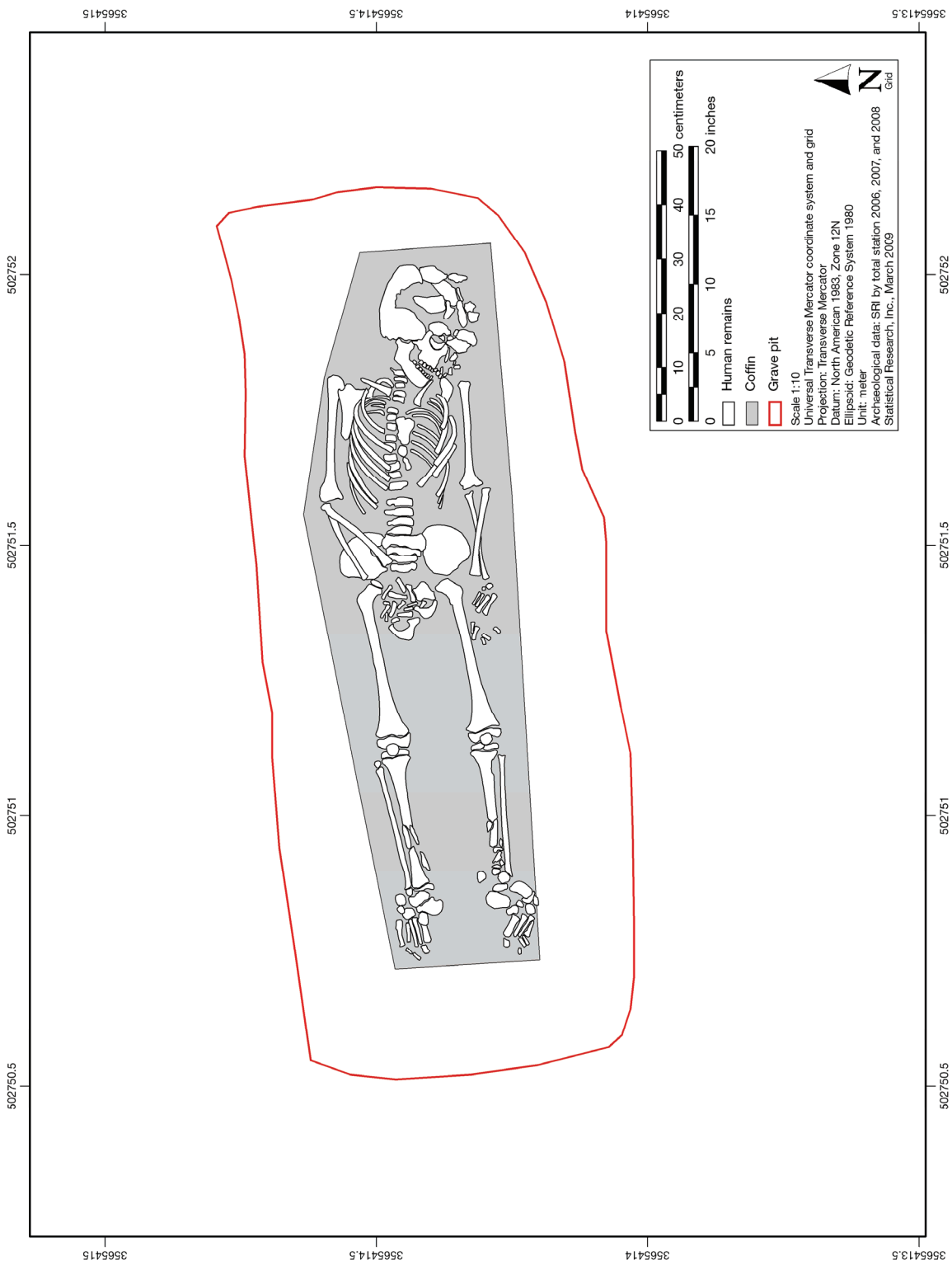


Figure 208. Digitized photogrammetry, Individual P, Grave Pit 7529, Burial 8941, a Euroamerican child of indeterminate sex.

Figure 209. Right scapula with lead ball, Individual P, Grave Pit 7529, Burial 8941, a Euroamerican child of indeterminate sex.

Figure 210. Condylar area of mandible, right side, Individual P, Grave Pit 7529, Burial 8941, a Euroamerican child of indeterminate sex.

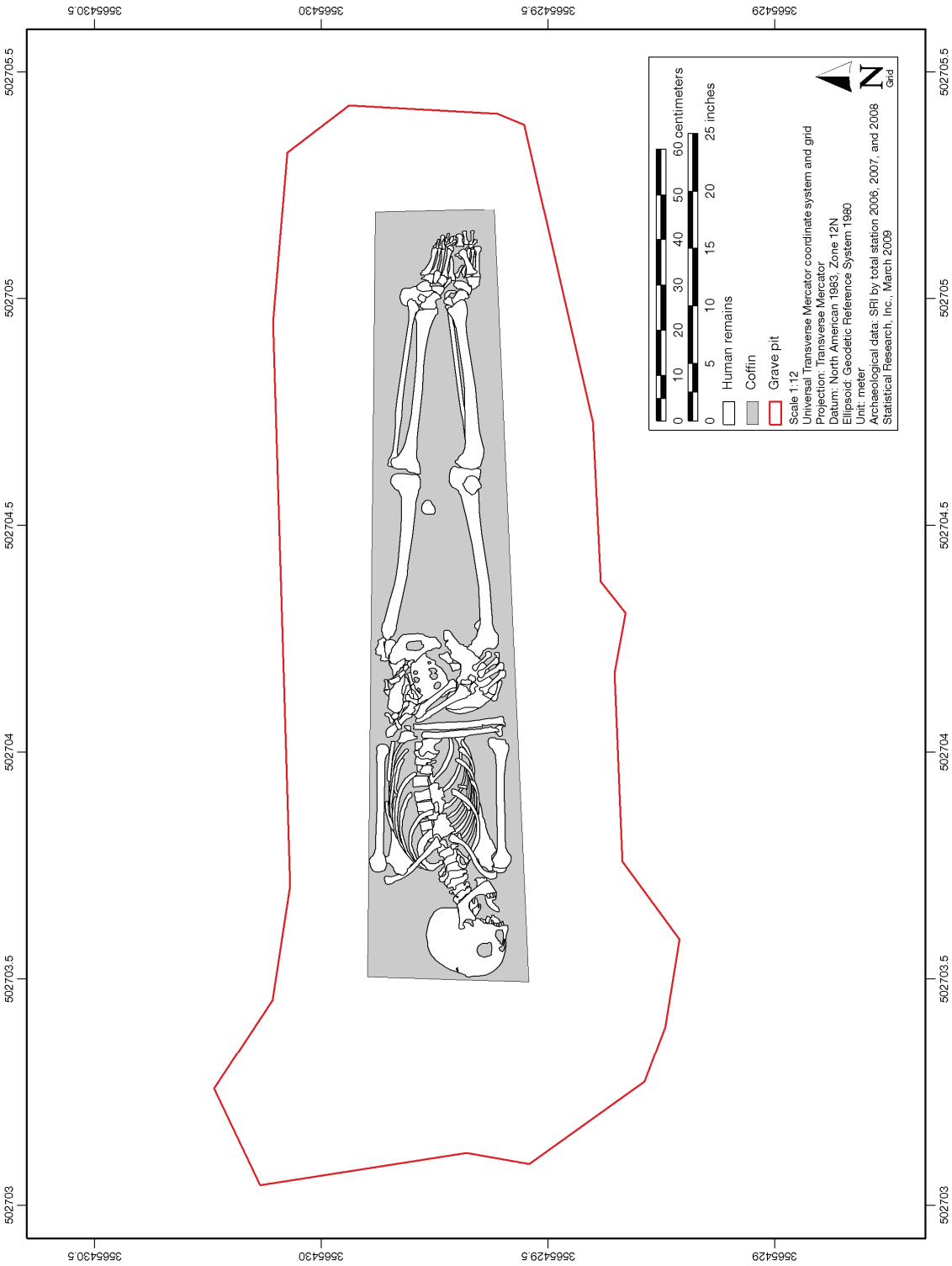


Figure 211. Digitized photogrammetry, Individual P, Grave Pit 7970, Burial 19501, an old-adult Hispanic female.

Figure 212. Maxillofacial area, anterior, Individual P, Grave Pit 7970, Burial 19501, an old-adult Hispanic female; note tilted right canine.

Figure 213. Nasal aperture, Individual P, Grave Pit 7970, Burial 19501, an old-adult Hispanic female; note turbinate hypertrophy and deviated septum.

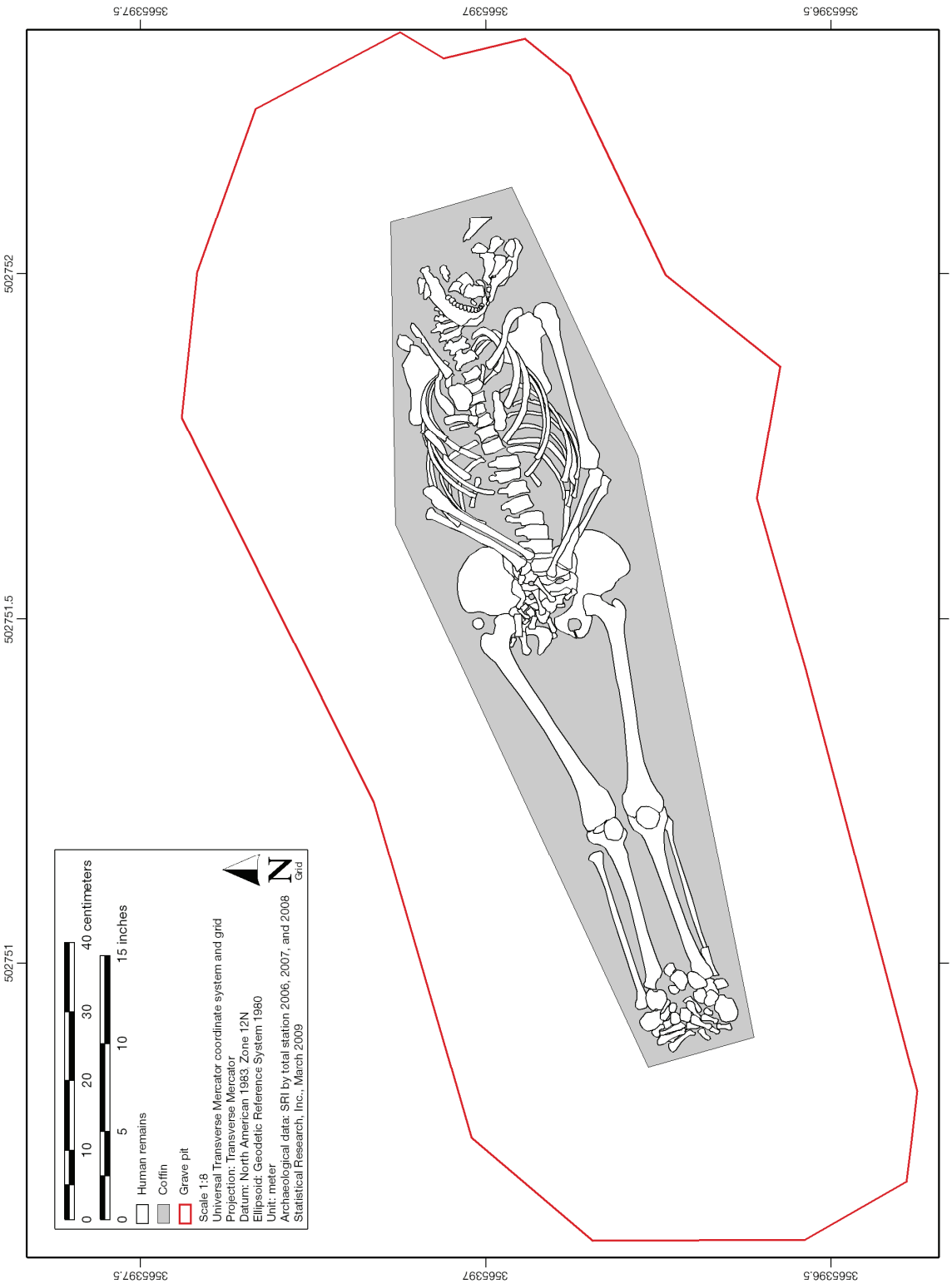


Figure 214. Digitized photogrammetry, Individual P, Grave Pit 13926, Burial 28294, a Euroamerican child of indeterminate sex.

Figure 215. Permanent maxillary incisors, lingual, Individual P, Grave Pit 13926, Burial 28294, a Euroamerican child of indeterminate sex.

Figure 216. Right maxillary dentition, occlusal view, Individual P, Grave Pit 13926, Burial 28294, a Euroamerican child of indeterminate sex; note molar morphology.

Figure 217. Right parietal, healing chopping injury, right posteriolateral view, Individual 2, Grave Pit 24758, Burial 25208, an old-adult Hispanic male.

Figure 218. Mandible, occlusal view, Individual 2, Grave Pit 24758, Burial 25208, an old-adult Hispanic male; note reactive bone.

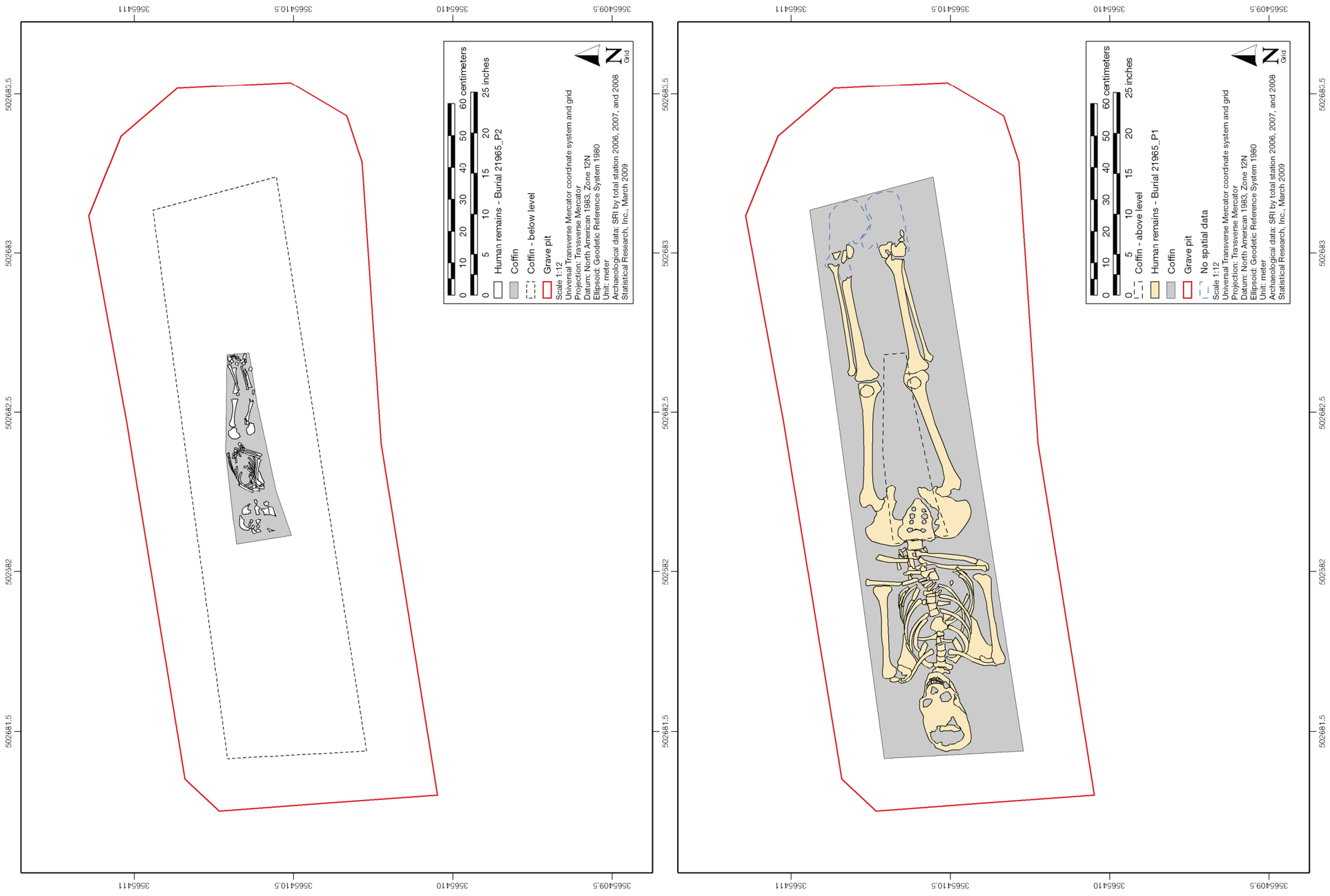


Figure 219. Digitized photogrammetry, Individuals P1 and P2, Grave Pit 10139, Burial 21965, a young-adult Hispanic female (P1, *right*) and an infant of indeterminate age and biological affinity (P2, *left*).

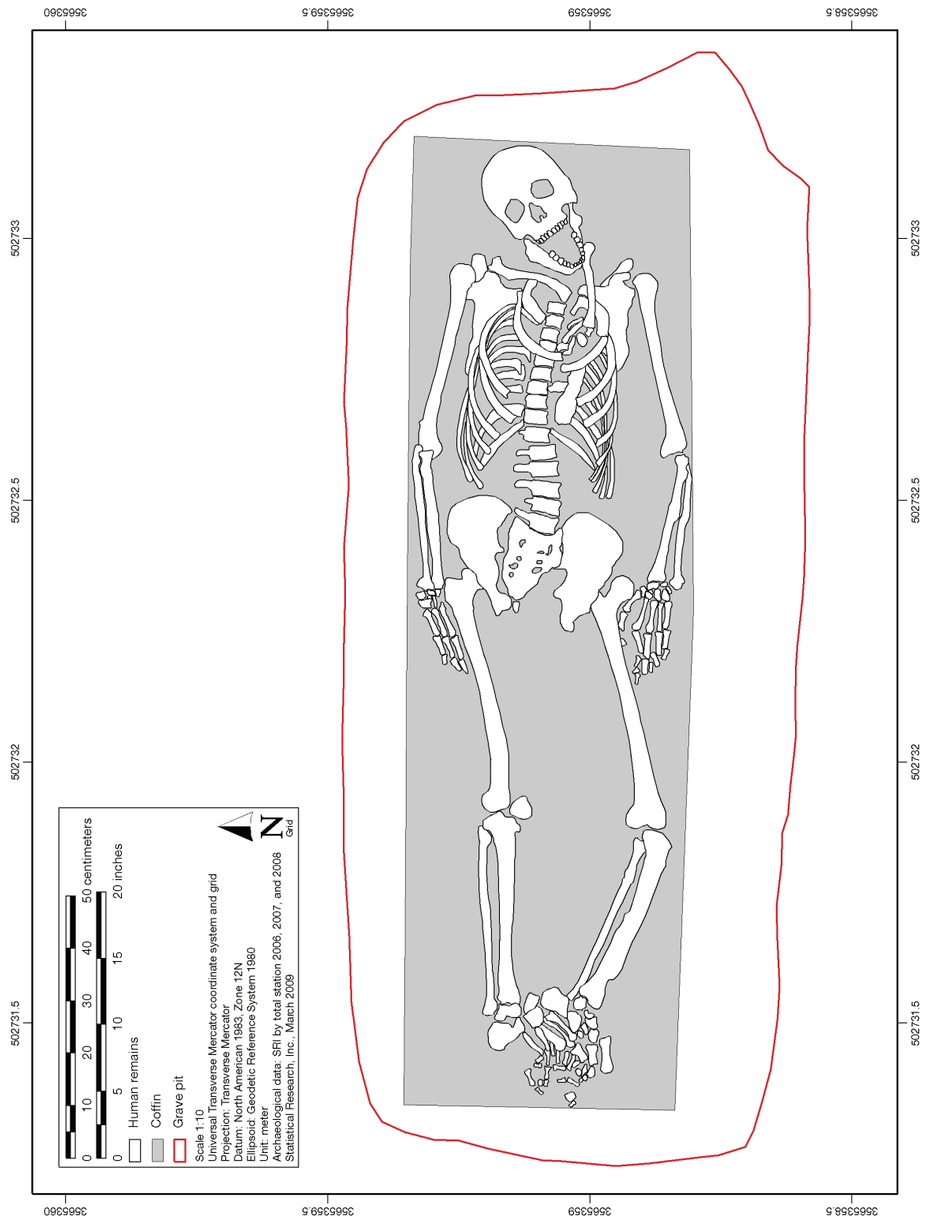


Figure 220. Digitized photogrammetry, Individual P, Grave Pit 3288, Burial 7199, a young-adult Euroamerican male.

Figure 221. Left radius and ulna, with healed, misaligned fracture, anterior view, Individual P, Grave Pit 3288, Burial 7199, a young-adult Euroamerican male.

Figure 222. Left tibia, with healed, misaligned fracture, lateral view, Individual P, Grave Pit 3288, Burial 7199, a young-adult Euroamerican male; note cloaca near distal end.

Figure 223. Third and fourth lumbar vertebrae with gunshot trauma, Individual P, Grave Pit 3288, Burial 7199, a young-adult Euroamerican male; probe indicates direction of shot.

Figure 224. Right ilium with gunshot entrance wound, Individual P, Grave Pit 3288, Burial 7199, a young-adult Euroamerican male.

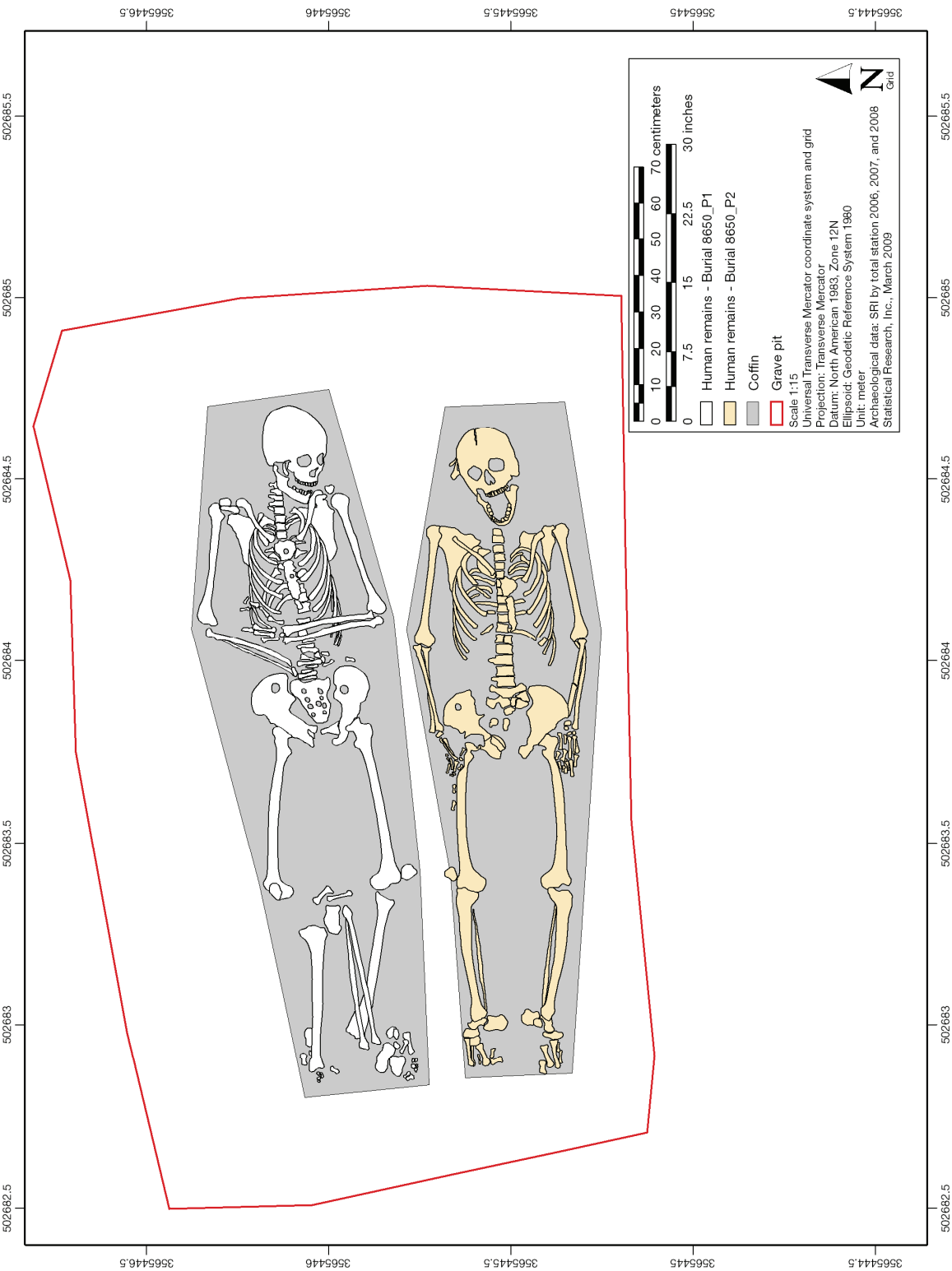


Figure 225. Digitized photogrammetry, Individuals P1 and P2, Grave Pit 5197, Burial 8650, a young-adult Euroamerican male (P1, *left*) and a young-adult Hispanic female (P2, *right*).

Figure 226. Distal left femur with myositis ossificans traumatica, posterior view, Individual P1, Grave Pit 5197, Burial 8650, a young-adult Euroamerican male.

Figure 227. Cranium, anterior view, Individual P1, Grave Pit 5197, Burial 8650, a young-adult Euroamerican male; note unhealed fracture on inferior margin of right orbit.

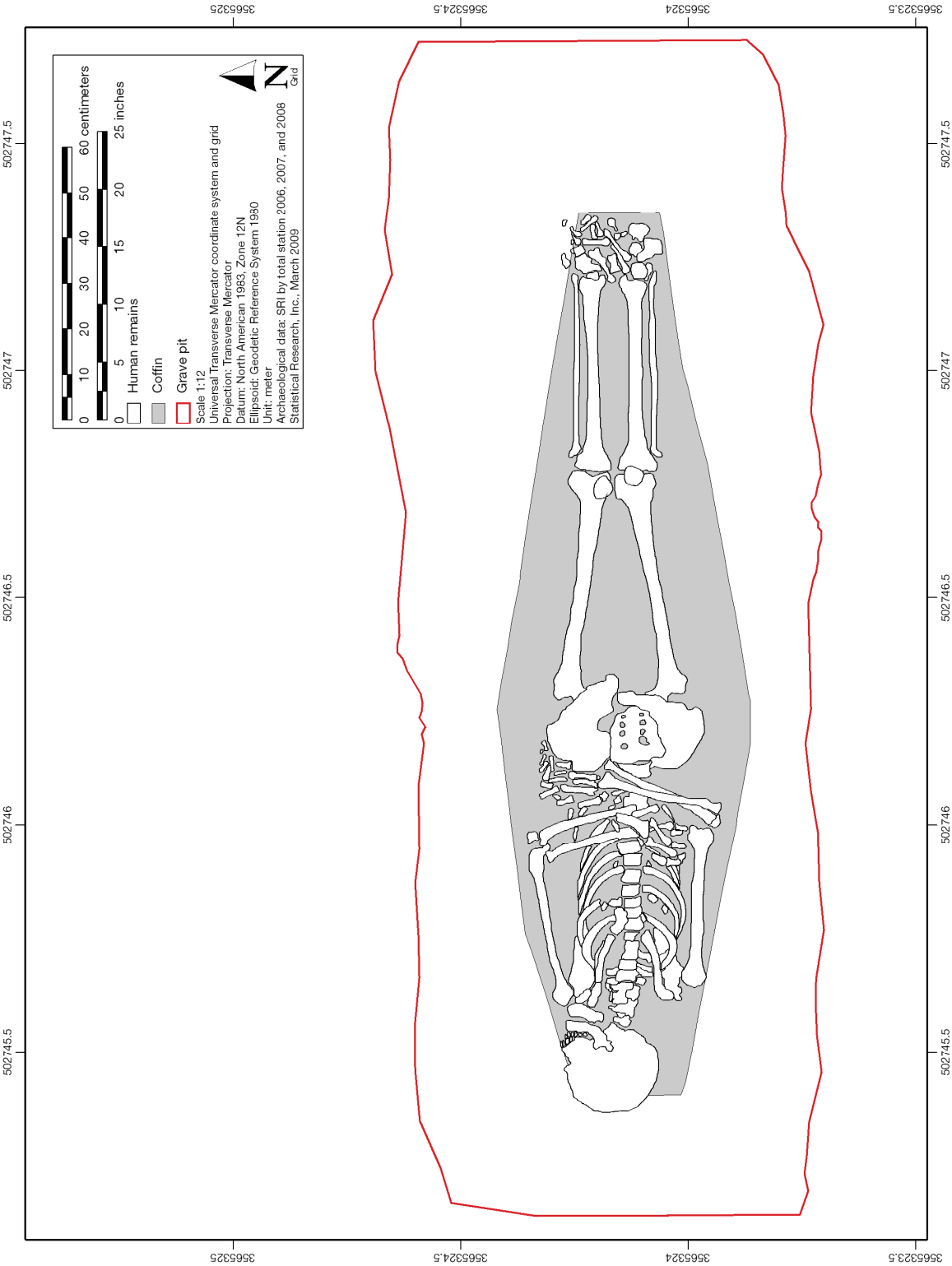


Figure 228. Digitized photogrammetry, Individual P, Grave Pit 534, Burial 1278, a middle-adult Euroamerican male.

Figure 229. Cranium with gunshot exit wound, Individual P, Grave Pit 534, Burial 1278, a middle-adult Euroamerican male.

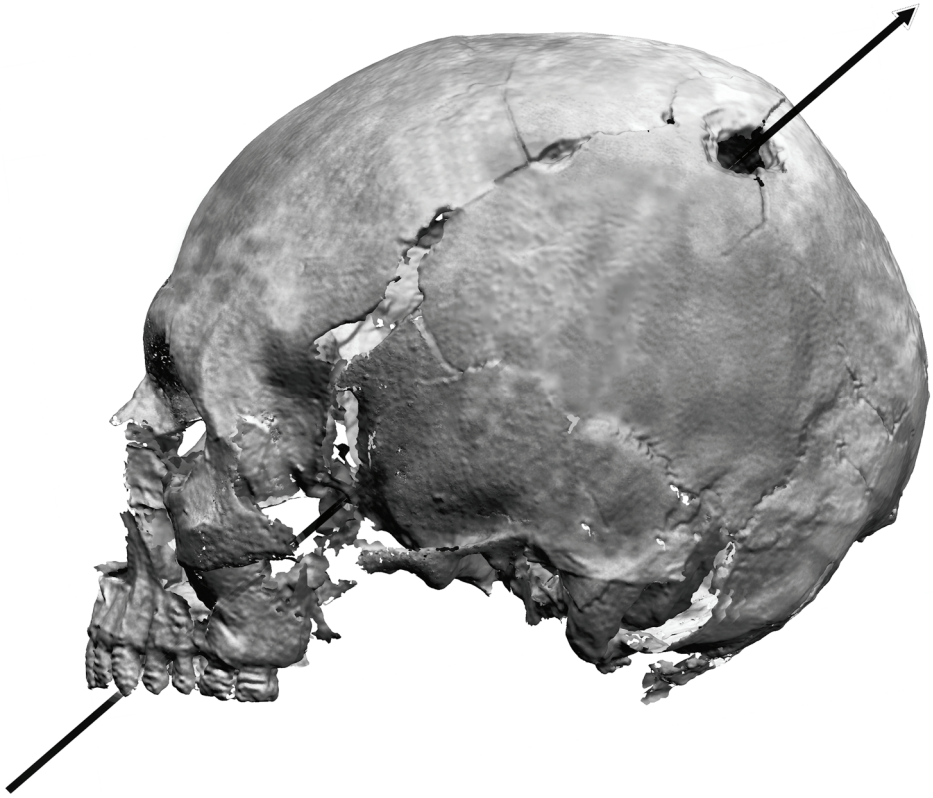
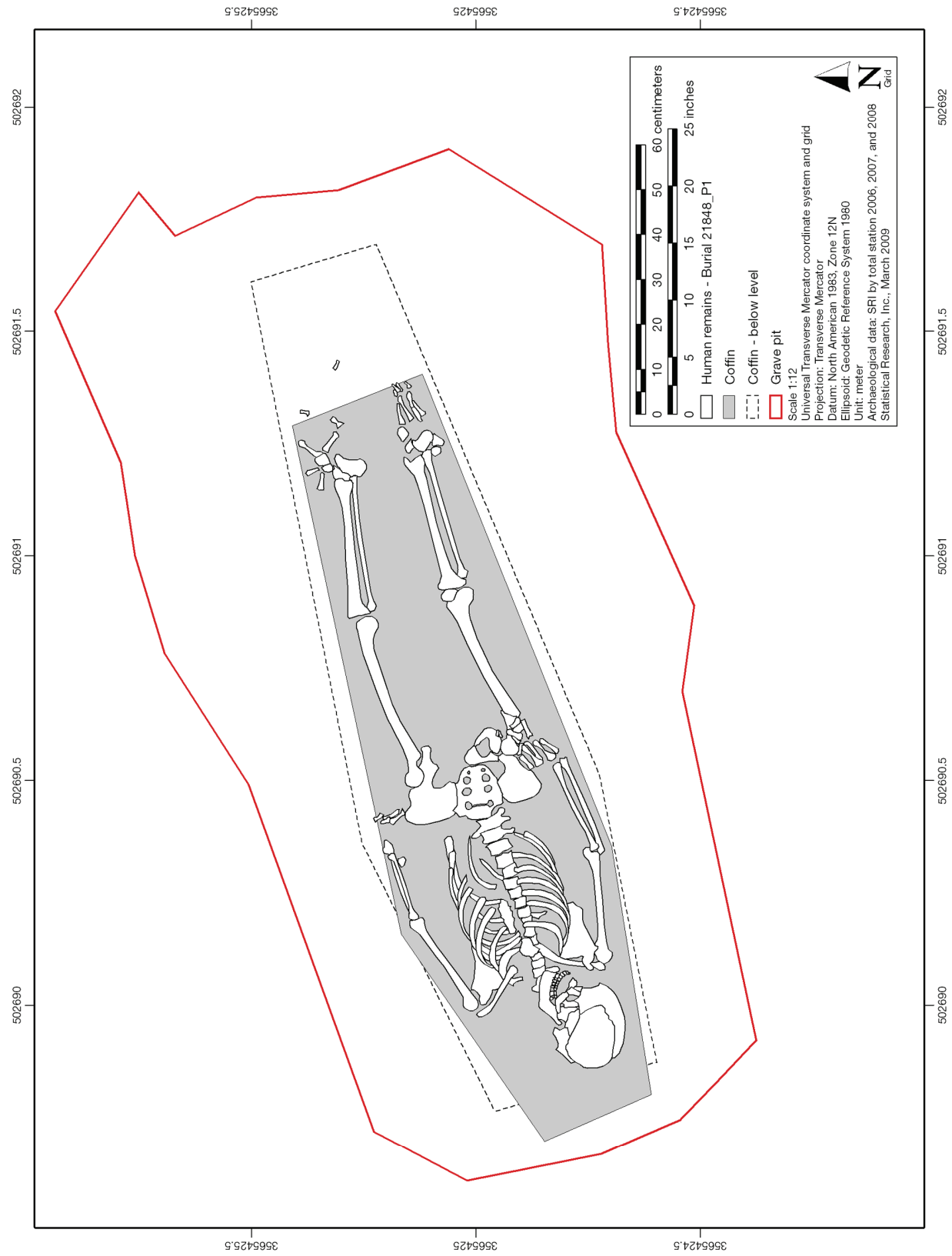


Figure 230. Three-dimensionally rendered image of cranium indicating direction of shot, Individual P, Grave Pit 534, Burial 1278, a middle-adult Euroamerican male.

Figure 231. Mandible with perimortem fracture, Individual P, Grave Pit 534, Burial 1278, a middle-adult Euroamerican male.



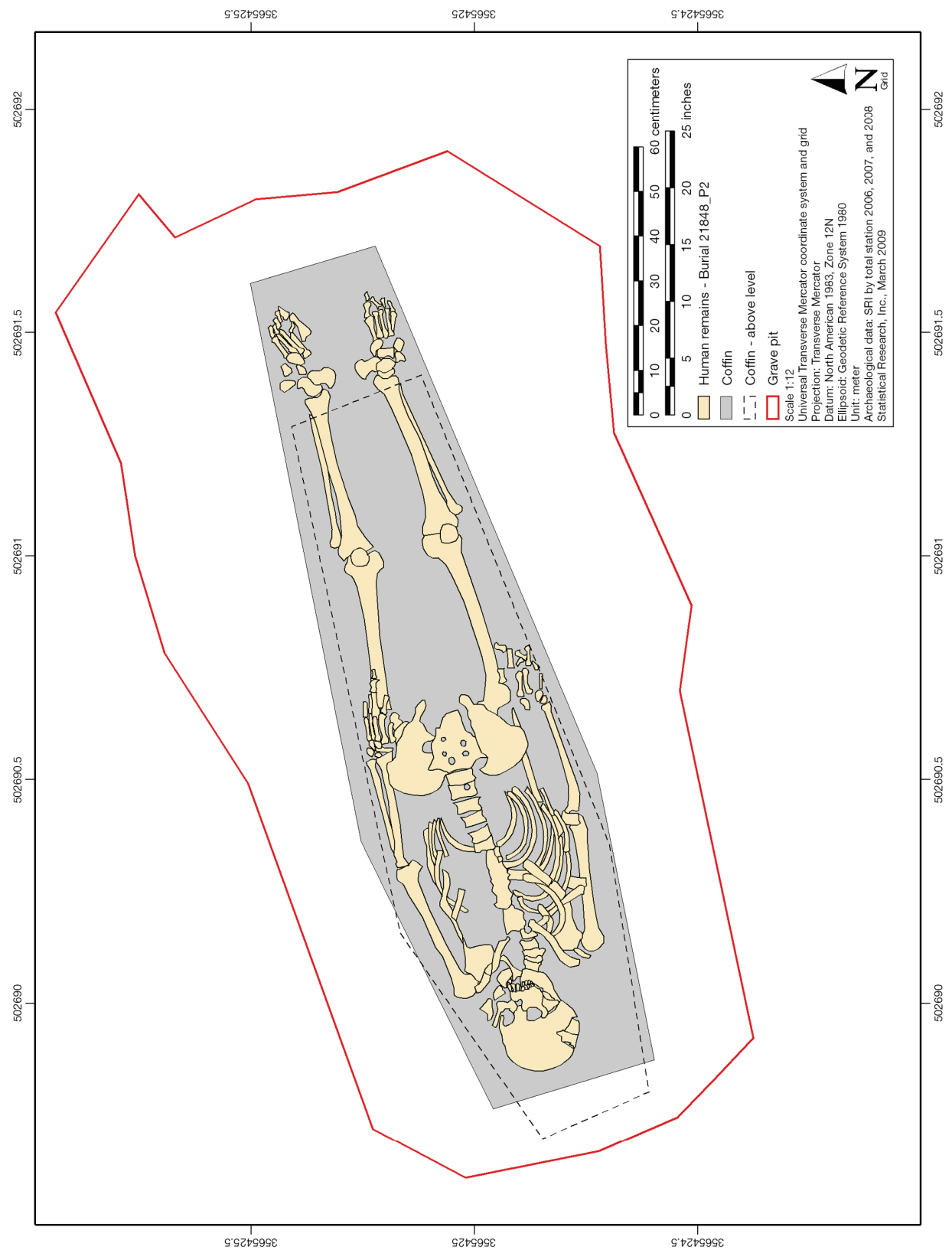


Figure 232. Digitized photogrammetry, Individuals P1 and P2, Grave Pit 22157, Burial 21848, a young-adult Euroamerican female (P1, *left*) and a middle-adult male of indeterminate biological affinity (P2, *right*).

Figure 233. Left zygomatic with perimortem fracture, Individual P2, Grave Pit 22157, Burial 21848, middle-adult male of indeterminate biological affinity.

Figure 234. Left maxilla with bridgework and perimortem damage, Individual P2, Grave Pit 22157, Burial 21848, middle-adult male of indeterminate biological affinity.

Figure 235. Left side of mandible with perimortem fracture and cut mark, Individual P2, Grave Pit 22157, Burial 21848, middle-adult male of indeterminate biological affinity.

Figure 236. Hyoid with perimortem fracture, Individual P1, Grave Pit 22157, Burial 21848, a young-adult Euroamerican female.

Figure 237. Right rib with perimortem fracture, visceral aspect, Individual P1, Grave Pit 22157, Burial 21848, a young-adult Euroamerican female.

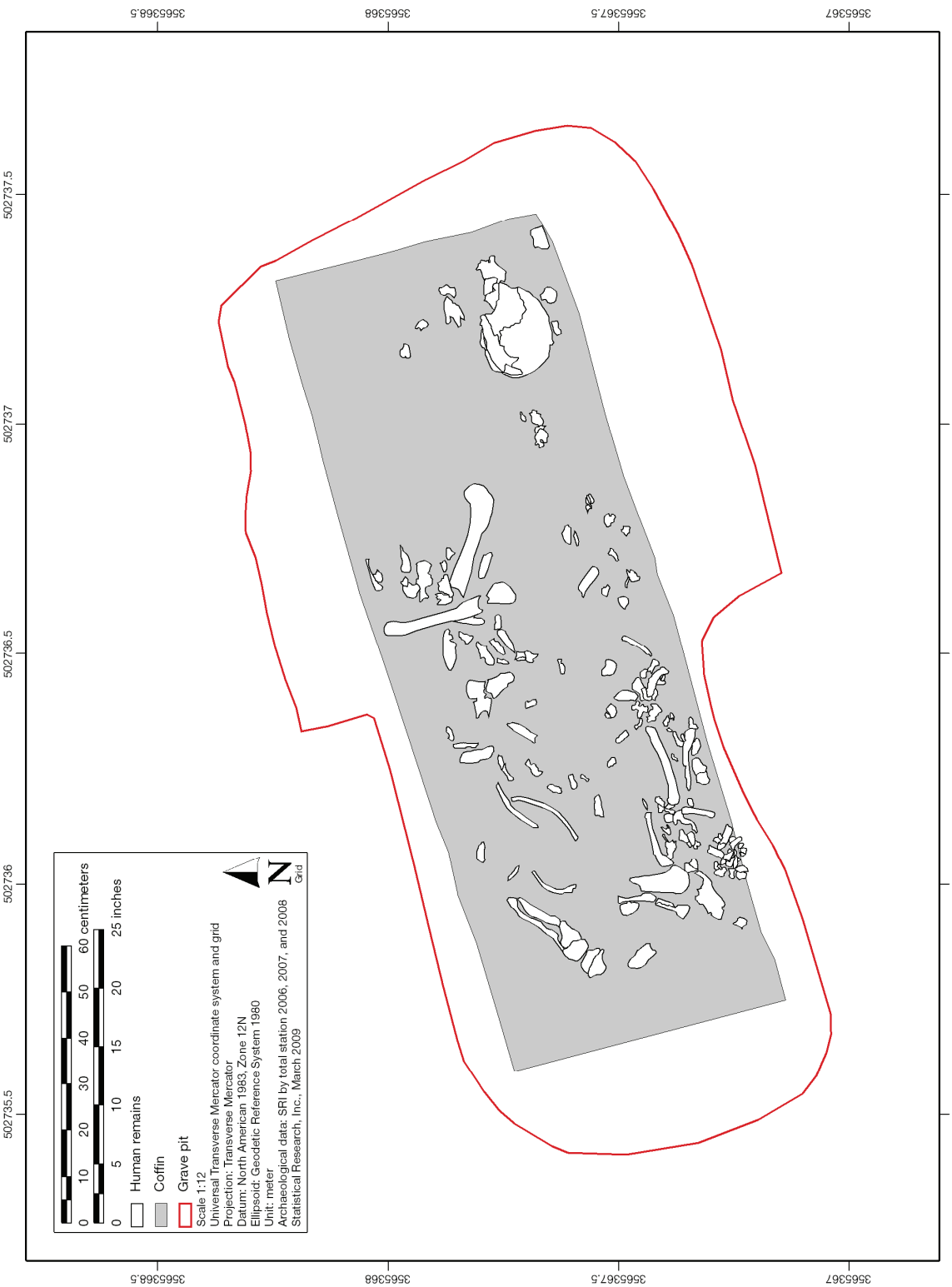


Figure 238. Digitized photogrammetry, Individual P, Grave Pit 3238, Burial 6823, a middle-adult Hispanic male.

Figure 239. Left temporomandibular joint; note disparate burning between articulated elements, Individual P, Grave Pit 3238, Burial 6823, a middle-adult Hispanic male.

Figure 240. Long-bone fragment with breakage, burning, and tar, Individual P, Grave Pit 3238, Burial 6823, a middle-adult Hispanic male.

CHAPTER 15

Conclusions

Michael Heilen, Joseph T. Hefner, Mitchell A. Keur, Amber R. Harrison, Tamara L. Leher, and Patrick B. Stanton

The Alameda-Stone Cemetery

The analysis of historical records, mortuary contexts, and human skeletal remains recovered from the Alameda-Stone cemetery provide important sources of information about the living and mortuary populations of Tucson during the nineteenth century. Historical documents inform on the history and organization of the cemetery and on the occupations, demography, and daily lives of Tucson's inhabitants; mortuary artifacts and feature attributes inform on burial treatments and attitudes towards death; and skeletal remains provide data on individual health conditions, dental disease, stature, and other biological information. Together, these sources of information can be used to gain a deeper sense of the community as a whole and the individuals composing the whole.

The purpose of this volume was to establish the historical, contextual, and biological parameters of the Alameda-Stone cemetery. The remains of more than 1,300 individuals were recovered during the project, despite the negative effects of historical-period and modern disturbance, urban expansion, and neglect on graves in the cemetery. Although not all of these remains were in pristine condition, most were in a condition that permitted extensive analyses. These individuals represent a cross section of the community during a crucial time in the history of the settlement and the history of the American West, when Tucson was being transformed from a small, fortified Hispanic and Native American town on the northern frontier of Mexico to a growing and increasingly diverse city on the expanding southwestern frontier of the United States.

The studies presented in this volume revealed much detail about the culture and biology of the Tucson population as well as contributed to our knowledge of Tucson and its place in an emerging capitalist world system associated with the westward expansion of the United States. In Volume 1 of this series, these data are combined to paint a broad and synthetic portrait of life, death, and dying in Tucson during the mid-nineteenth century as well as place the cemetery and the population of Tucson in a broad, comparative context.

Project Methods

Given the highly sensitive nature of the cemetery component and the very large postcemetery component (see Volume 3 of this series), the data requirements for the project presented a unique challenge in terms of the volume and diversity of data that needed to be collected and the need for highly accurate, spatially referenced data to be used in reporting and analysis. The analysis and interpretation of grave pits, burial features, and human remains from the Alameda-Stone cemetery employed both traditional and novel analytical techniques to ensure a comprehensive examination and synthesis of information from this extraordinarily important site. In order to achieve the goals of the project, new geospatial technologies were deployed, and novel field and laboratory methods were developed. In Chapter 2, Hall and colleagues outline these methodological advances and procedural improvements and described the analytical framework under which the analyses were conducted.

The success of the project methods rested fundamentally on use of a highly sophisticated and customized relational database system (referred to as SRID) and on the application of multiple, cutting-edge geospatial technologies. SRID is a data management system that connects every piece of data collected in the field or laboratory to a unique, spatially referenced provenience. This allows each observation made in the field or laboratory to be linked to a specific discovery context and facilitates a wide variety of spatial and aspatial analyses. SRID has specially tailored database environments for entering and organizing data on features, historical-period artifacts, lithic artifacts, ceramic artifacts, faunal bone, human bones and teeth, and other archaeological materials. Major advances in SRID were accomplished for the project in order to address its unique challenges.

Cartographic work for the project included not only conventional mapping with a total station but also orthorectified balloon photography, in situ photogrammetry of every grave pit and burial feature, and three-dimensional laser scanning of burial features and individual human osteological elements. This diverse array of geospatial technologies has allowed the development of highly detailed and accurate spatial data that can be tied to aspatial data in SRID. Among their many advantages, the geospatial technologies applied to the project permitted the creation of highly accurate and detailed maps of each burial and individual with a great reduction in field time per burial (see Volume 4 of this series). Together, mapping information and our relational database have allowed for the integration of many different data types for interpretation and analysis and provided a spatial, relational framework for conducting our cultural affinity assessments (see Appendix D, Volume 1 of this series,), military identification assessments (see Appendix F, Volume 1 of this series), and our reburial activities (see Chapter 11, Volume 1 of this series).

The Environmental, Historic, and Archaeological Context

The analysis of any archaeological context begins, of course, with an understanding of the environment of the project area and its surroundings. The environmental context is important not only to understanding the opportunities and challenges faced by a population in a particular environment, but is also important to understanding the depositional context within which archaeological materials were found. In Chapter 3, Windingstad and Hall discuss the environmental context of the project area, paying special attention to factors affecting the preservation of human bone, in addition to discussing the climate, vegetation, fauna, hydrology, and geology of the project area and its surroundings. These authors show how the project area, located approximately a half mile east of the current floodplain of the Santa Cruz River, is situated in the Sonoran Desert Life Zone on an ancient and stable Pleistocene-age terrace.

Five geological strata were recognized in the project area during fieldwork; grave pits and burial features were found in the upper two of these (Strata I and II). Surface soils in the project area, ranging from 10 to 50 cm thick, consisted of a highly disturbed and truncated Ap horizon (Stratum I). Beneath this was a Btk horizon consisting of a light brown loam with Stage III+ calcium-carbonate development (Stratum II). The level of carbonate development in Stratum II was consistent with an age within the range of 75,000–400,000 years (Gile et al. 1981), suggesting the stratum was laid down many thousands of years before human occupation of the region. Almost all cultural features, including grave pits, were intrusive into Stratum II deposits, but few penetrated beneath this layer. Beneath Stratum II were three additional layers representing an even more ancient time when the project area was situated in the active floodplain of the Santa Cruz River. Because of the age and stability of the Pleistocene terrace on which the project was located, cultural features of all ages, including prehistoric and historical-period finds, penetrated into the same surface. As a result, deeply buried cultural deposits, with the exception of privy pit deposits, were not found in the project area.

Investigations of soil chemistry in the project area were geared towards understanding their potential influence on the preservation of human bone. Windingstad and Hall (see Chapter 3) found that pH, temperature, and moisture content of soils in the project area were generally conducive to the preservation of human bone, but that there was considerable variability across the site in bone preservation. Factors that likely created variation in

bone preservation included the relative proportions of Stratum I and II included in grave pit fill (which would have affected soil pH); variation in drainage characteristics across the site; and the application of lime to deposits during burial events, which likely would have promoted the preservation of human bone. Despite variability in bone preservation across the site, bone preservation was found to generally be fair to good across the project area.

An overview of the history and archaeology of the cemetery is presented by Heilen and Hall in Chapter 4. Prior to the opening of the Alameda-Stone cemetery, individuals who died in Tucson would have been buried at a cemetery that was placed adjacent to the chapel of San Agustín within the Tucson presidio (O'Mack 2005, 2006; Thiel et al. 1995). At some point during the late 1850s or early 1860s, Tucson residents began using the Alameda-Stone cemetery to bury their dead. The military section of the Alameda-Stone cemetery was first used in 1862, shortly after the arrival of the California Column in Tucson during the Civil War. The civilian section closed in June 1875 but the military section remained open until January 1881.

Between 1,800 and 2,100 deaths occurred in Tucson while the civilian section of the cemetery was in use. Most or all of these individuals would have been buried in the Alameda-Stone cemetery because this was the only cemetery in Tucson at the time. Perhaps 75–80 percent of the individuals placed in the Alameda-Stone cemetery would have been Hispanic, and smaller percentages of individuals would have been Euroamericans, Native Americans, and African Americans. Many of the individuals buried in the civilian section of the cemetery would have been buried according to Catholic practices, but Protestant, Jewish, and Native American practices are also likely. The brief period of cemetery use, large number of burials, and the ethnic and religious diversity of cemetery users make the Alameda-Stone cemetery especially representative of the population in Tucson as well as valuable for comparison with other excavated cemeteries.

Archival evidence indicated that the Alameda-Stone cemetery was organized into military and civilian sections but did not provide information on possible divisions within the civilian section (O'Mack 2005, 2006). As a result of fieldwork, the location of the military section (Cemetery Area 1) was firmly established, and four distinct areas within the civilian section were identified (Cemetery Areas 2–5). The southern two sections of the cemetery—Cemetery Areas 1 and 2—were used mostly for the burial of adult males as well as a few juveniles and adult females; many, but not all, of these individuals were Euroamerican. Cemetery Areas 3 and 4 contained a more even distribution of individuals according to age and sex, with much larger numbers of adult females and juveniles, as well as a larger proportion of Hispanics. A variety of clues suggest Cemetery Areas 3 and 4 were used mostly by the local, Mexican American community, whereas Cemetery Areas 1 and 2 appear to have been used mostly by recent migrants to Tucson. The relatively small Cemetery Area 5 bears some similarities to both Cemetery Areas 2 and 3 and may have been used late in the history of the cemetery, as some grave pit features are aligned more strictly east-west than grave pits in other areas. Perhaps Cemetery Area 5 was an area used for the burial of strangers or another restricted group.

Among the five cemetery areas, one of the most intriguing is Cemetery Area 4. Unlike other areas of the cemetery, grave pits in Cemetery Area 4 frequently intruded into earlier grave pits and were also more often reused for later burials. These attributes bear a strong similarity to earlier Hispanic Catholic burial practices in Mexico and the American Southwest (Lomnitz 2005; Voekel 2002; Will de Chaparro 2007), including those revealed by excavations at the Tucson presidio (Thiel et al. 1995). The archaeology of Cemetery Area 4, in its resemblance to earlier Hispanic burial spaces, suggests that some aspects of traditional Hispanic Catholic burial practices were maintained in at least one area of the Alameda-Stone cemetery, despite the fact that such practices had for decades been strongly discouraged by civic authorities in both Mexico and the United States (see Chapter 4).

Analysis of grave spacing and location revealed that graves throughout the cemetery were organized in north-south rows, with graves being placed farthest apart from one another in the southern areas of the cemetery (Cemetery Areas 1 and 2). Graves were packed closest together in Cemetery Area 4, where they frequently intruded into earlier graves, but nonetheless were still placed in rows that seemed to line up with rows to the north in Cemetery Area 3. Most grave pits were rectangular in plan view, with straight vertical walls, and appear to have been dug to depths of around 3–4 feet. The dimensions of grave pits generally conformed to the size of the individual being interred, with the smallest grave pits used for infants and young children and the largest used for adults males.

Burials in the military section were exhumed in June 1884, but archaeological evidence showed that at least a few graves were likely missed and that personal artifacts and osteological materials (particularly smaller, less-recognizable elements and appendicular elements) were often left behind in exhumed grave pits. Some burials were also exhumed from the civilian section in 1882, when the City instructed Tucson residents to remove the burials of family and friends in the cemetery and rebury them in the new Court Street cemetery. However, no archival information came to light regarding how many burials were actually removed. Using the archaeological signature of exhumed grave pits in the military cemetery as a guide, we estimated that perhaps 1 of every 10 burials in the civilian section was exhumed historically. The vast majority of burials were left in the ground.

The names, ages, and sex of many of the individuals likely to have been buried in the civilian section are known from an extraordinary burial record maintained by the Tucson Catholic Diocese. The record has allowed us to reconstruct a demographic profile of a substantial portion of the population buried in the cemetery, but not to identify where specific individuals in the civilian section were buried. In addition, no other archival information has been found that identifies the location of specific individuals in the civilian section. Military records, including burial lists and plat maps of the military section, do indicate where many of the named individuals in that section were buried, however. Comparison of these records with archaeological and osteological data demonstrate a strong degree of correspondence between historical and bioarchaeological data, but a lack of definitive biological evidence (such as dental records or genetic evidence) from these grave pits prevented us from positively identifying any individual in the military section.

After closing, the Alameda-Stone cemetery soon became dilapidated and was subject to vandalism and other disturbances. By 1889, the land containing the cemetery had been sold and the ground surface was graded to make way for residential development. Grading activities appear to have destroyed all remnants of grave markers. Historical-period disturbance also appears to have destroyed the adobe wall that surrounded the military section and a wall that demarcated the western and northern sides of the civilian section. As the project area came to be used as a residential neighborhood during the late nineteenth and early twentieth centuries and then as a commercial district (see Volume 3 of this series), a large number of disturbances impacted the former cemetery, including building foundations, utilities, privies, trash pits, and landscaping features. In one area of the cemetery immediately south of Cemetery Area 4, at least several hundred grave pit and burial features were destroyed by the excavation of the Tucson Newspapers basement in the 1940s and 1950s. Despite the wide variety and long history of disturbances in the project area, the vast majority of the 1,083 grave pits discovered in the field were largely intact, and the remains within them were reasonably well preserved.

The characteristics of grave pits and burial containers are described by Sewell and colleagues in Chapter 5. Although most grave pits had straight vertical walls, a small percentage of graves had either shelves in the side wall to support planks for vaulting or had a small niche dug into the sidewall of the short-axis of the grave to accommodate the head of an individual. Individuals with head niches were interred without coffins, suggesting that the practice may have been intended to protect the head of the individual from being covered with dirt, just as vaulting was used to protect the coffin from dirt. Interestingly, grave pits with head niches were found exclusively in Cemetery Areas 3 and 4, and graves with vaulting and no head niche were found exclusively in Cemetery Areas 1 and 2, suggesting that these practices were distinctive of different segments of the cemetery population.

With the exception of two infants and two fetal individuals placed on their sides, all individuals of determinable burial position were buried on their backs, in supine position. Burials in Cemetery Areas 1 and 2 were mostly placed with the head of the individual oriented towards the west, and most burials in Cemetery Area 4 and many in Cemetery Area 3 were placed with the head of the individual oriented towards the east, in the opposite direction. However, clusters of individuals buried with their heads oriented to the west were found throughout Cemetery Area 3, particularly on the west side of Cemetery Area 3. In Cemetery Area 5, burials were oriented in either direction, suggesting a mixture of the approaches to burial seen in the other cemetery areas. Variation in orientation appears to relate to differences in religious perspectives, with some Catholic burials being placed so that the dead could rise to face their church, to the west, on Judgment Day and other Christian burials being placed so that the dead could rise to face the east.

For around a quarter of grave pits with primary individuals, artificial floral arrangements were placed in the hands, around the head, on the torso and pelvis of the individual, or around the perimeter of the coffin. Of those individuals that could be aged, 95 percent were children and a large percentage had floral arrangements suggesting that an individual was buried as an *Angelito*, or "little angel," a Catholic tradition that emphasized the purity and innocence of deceased children and infants. Lime, which may have been used to prevent the spread of disease and accelerate decomposition, was found in around 5 percent of grave pits. Most of these contained individuals under the age of 12, which could suggest these were individuals who succumbed to disease.

Most individuals in the cemetery were buried in coffins of hexagonal, trapezoidal, or rectangular shape. Two infants and one young child were buried on wooden planks, rather than in coffins. In Cemetery Areas 1, 2, and 5, coffin shapes were most often hexagonal or, less often, rectangular, whereas in Cemetery Areas 3 and 4, coffin shapes were relatively evenly distributed. Differences in coffin shape appear to have been partly related to the age of the deceased, with adult individuals more often buried in hexagonal coffins, but cultural preferences may have also played a role in determining coffin shape. Coffins were constructed of pine, juniper, or a combination of the two woods according to a variety of idiosyncratic, vernacular construction techniques. Most coffins were constructed using butted joints and cut nails, or occasionally screws or metal plates, to hold them together. Coffin construction techniques and wood use suggest that coffins were made by family members or local craftsmen as needed and were not the product of professional coffin-makers.

Coffin hardware was relatively rare in the cemetery and consisted of nine handle types, five coffin screw types, and eight ornamental tack types. The rarity of coffin hardware was likely because of its limited availability in Tucson prior to the arrival of the railroad in 1880, 5 years after the closing of the civilian section of the cemetery. Some coffins were decorated with paint or lined with interior or exterior fabric, or both. Possibly, some of these treatments were intended to beautify a coffin that was of otherwise fairly plain and simple construction. Some individuals may have been buried in shrouds or winding sheets, but evidence for such burial treatments, in the form of shroud pins or fabric, was generally lacking. Evidence for possible shrouding was confined mostly to the northern cemetery areas.

Chapter 6, by Sewell and colleagues, focuses on items that were used to dress the body or were placed with the deceased as grave goods. Adornments included small numbers of earrings, necklace chains, beaded necklaces, brooches, rings, beads sewn onto clothing, a locket, and a nonreligious pendant. Jewelry was associated most often with females and juveniles and was distributed throughout the cemetery. All metal jewelry appeared to have been made from cuprous materials. Combs, a barrette, and a braided cord were used as hair adornment in a few burial features.

Most individuals interred in the cemetery appear to have been dressed in clothing, as suggested by the large number of clothing fasteners found throughout the cemetery. The vast majority of items associated with clothing were buttons. Buttons found in the cemetery were of a great many varieties that were painstakingly documented and catalogued by the researchers. General button types included Prosser porcelain sew-through buttons, shell sew-through buttons, metal sew-through buttons, bone sew-through buttons, cloth-covered and metal coat buttons, military uniform buttons, glass shank buttons, and gaiters. One particularly unique button type was engraved shell buttons, which tended to be found with adult males or young children and infants. These were decorated with unique hand-carved designs, including sunburst patterns, loops, and a Star of David symbol in one instance. Other clothing fasteners included riveted pants studs, buckles, hook-and-eye fasteners, and safety pins.

Not surprisingly, most variation in clothing fastener use appears to correlate with age and sex and to a lesser degree with cemetery area. Painted Prosser buttons, gaiters, and hook-and-eye fasteners were more common among juveniles, in comparison to adults. Decorated buttons—including painted, transfer-printed, or molded Prosser buttons and engraved shell buttons—were more prevalent among males than females and were also more common in the northern half of the cemetery. Glass shank buttons and hook-and-eye fasteners were more commonly found with adult females. Military buttons, riveted studs, coat buttons, and cinch buckles were more commonly found with adult males. Interestingly, a few women appear to have been buried in pants, which could suggest inversion of gender roles among some women in the frontier town.

In addition to clothing fasteners, textile fragments were discovered in association with the burials of 137 individuals. Textile fragments were mostly made of either cotton or wool; examples made of silk or velvet were

also found in rare instances. Cotton was found with males and females in roughly equal proportions; silk was associated with females or individuals of indeterminate sex; wool was found most often with males, although not exclusively so; and velvet was found with two adult males and two individuals of indeterminate sex.

Some of the most interesting items included in burials were religious and ceremonial items, including rosaries, crucifixes, crosses, religious medallions, and floral crowns. Intriguingly, 95 percent of such objects were found in grave pits in the northern half of the cemetery, suggesting an exclusive preference for such items among users of the northern half of the cemetery. Frames, which may have been used to display religious images, were also found exclusively in the northern half of the cemetery. Many of the religious items found in the cemetery can be convincingly associated with Catholic religious practices and thus form an important piece of evidence supporting the idea that members of the Hispanic Catholic community of Tucson were typically buried in the northern half of the cemetery.

Other items included in burials were small numbers of bottles (which may have been used as vessels for holy water), clay smoking pipes, coins, a poker chip, a stylus, a pair of scissors, and a marble. In three cases, coins were found near the head suggesting their possible use to cover the eyes of the deceased. In other cases, coins appear to have been left in the pockets of the deceased. Together, these items present an intriguing picture of the care that went into preparing the body and placing it in the grave for burial.

Osteological Analysis

After presenting information on the history and archaeology of the cemetery, we move on in the volume to presenting information on the osteology of the recovered remains. One of the major goals of the osteological research was to gain a deeper and more thorough understanding of the individuals composing the cemetery sample. In other words, who was buried within the cemetery, and what could they tell us about the population as a whole? One informative area of research on population structure is paleodemography. However, before the population structure can be explored, one must first establish the minimum number of individuals accounted for by the skeletal remains. Only then can the demographic composition of the cemetery be inferred from the skeletal sample.

Using several familiar methods for estimating the minimum number of individuals, Trask (see Chapter 7,) demonstrates that the recovered skeletal material represented between 1,025 (traditional estimation of minimum number of individuals) and 1,386 (context-based estimation) individuals, although she believes this number was most likely closer to 1,263, the estimate arrived at using the most-likely number of individuals method, as modified and recommended by Adams and Konigsberg (2004).

Following the establishment of the minimum number of individuals, data collected during laboratory analysis (including information on age, sex, and biological affinity) were used to compare survivorship and mortality among individuals, with specific and focused emphasis on comparisons among the various cemetery areas established during excavations and discussed in Chapters 4–6.

In an effort to move away from life-table analysis—which has recently fallen out of favor among demographers—Trask employed hazard analysis to explore mortality and survivorship within the Alameda-Stone cemetery. The results of her analysis are quite promising and suggest not only differences in mortality and survivorship among biological-affinity groups and between males and females but also significant differences in survivorship among individuals interred in the various cemetery areas. Age-based survivorship models of Cemetery Areas 1 and 2 reflected the hypothesized population structures predicted for those areas: military personnel and Euroamerican adult males who immigrated to Tucson during the nineteenth century. The composition of the southern section of the cemetery biased the complete cemetery sample because it excluded the youngest and oldest members of the city; however, the demographic structure of Cemetery Areas 3, 4, and 5—which encompassed individuals of all ages, from fetal and neonate to old adult, and was composed primarily of Hispanic individuals—was more representative of the local population of Tucson during this period of time. The differences between the general demographic compositions of the southern (Cemetery Areas 1 and 2) and

northern (Cemetery Areas 3, 4, and 5) areas of the cemetery served as guides for the more-in-depth comparisons made by Trask. For example, she was able to demonstrate that females in the northern sections were not surviving as long as their counterparts in the southern section, reflecting not only differences in the hazards faced by Euroamerican and Hispanic women but also potentially reflecting the more readily available access to health care and better diets of the Euroamerican females in the southern section. Additionally, the females in the northern section were not living as long as their male counterparts in the same section. Together, these results suggest a higher hazard of mortality for females, particularly Hispanic females. Higher mortality observed among women is most often associated with the increased risks they face during pregnancy. The large number of fetal, neonate, and juvenile remains from the northern section seemed to support this hypothesis, although additional factors, such as the unequal access to resources and the hazards faced by Hispanic women during daily activities, could not be ruled out. Among males, mortality and survivorship were relatively similar, at least in the young-adult portion of the sample. Given the composition of the southern section (i.e., a large proportion of military-associated individuals), it is not surprising that there was a sudden and dramatic shift at around 30 years of age, at which point males in the southern section had a much lower probability of survivorship than did their counterparts in the northern section.

The differences between Euroamerican and Hispanic mortality and survivorship highlighted by Trask (see Chapter 7) reflected differences in the composition of the cemetery areas, but these differences also revealed somewhat surprising differences in the well-being of these two groups. Although there was not a significant difference in mortality and survivorship between Euroamerican individuals in the northern section of the cemetery and Euroamerican individuals in the southern section, Euroamerican individuals, overall, were more likely to die at any age than were Hispanic individuals of the same age. Since a large number of Euroamerican individuals were involved with the military or involved in occupations exposing them to more hazards (e.g., mining or ranching), it is unsurprising that they faced a much greater likelihood of death. Among Hispanic individuals, there were significant differences between the northern and southern sections; a Hispanic individual in the southern section was much more likely to survive to a later age than a Hispanic individual in the northern section, but only to around the fourth decade, when the likelihoods of death for these two sections were switched. The reasons for these differences are not clear, but more-in-depth analysis of the skeletal data set, combined with data from archaeological and historical sources, may provide clues to the reasons for these differences. One hypothesis, which appears to be supported by other types of biological and archaeological data and was previously proposed in Chapter 4, is that the southern portion of the cemetery represented a population of recent immigrants to the area, including Hispanic as well as Euroamerican individuals.

Dental, craniometric, and nonmetric data also suggested a division between the northern and southern sections of the cemetery, most likely related to migration and the presence of a local Hispanic population. Hefner (see Chapter 8) used several multivariate analyses to assess variation within and between the major biological-affinity groups represented within the cemetery. Although Hefner noted a certain level of morphological similarity among the major biological-affinity groups interred within the cemetery, the distinctiveness of each of these groups and their distributions within the cemetery supported the hypothesis that the southern and northern sections were indeed used for interment by distinct groups. Using dental, craniometric, and nonmetric data, Hefner demonstrated that Hispanic (as well as Euroamerican and Native American) individuals were, at a certain level, distinct in their shared morphologies. This result was expected, particularly among Hispanic individuals, because many of these individuals were known to have immigrated to Tucson primarily from Sonora and Sinaloa, Mexico. Likewise, the few Native American individuals recovered from the cemetery were likely drawn from local populations, with the exception of the Apache, who are morphologically and culturally distinct from more-local Native American populations, such as the Tohono O'odham. Although the historical record clearly indicates that Euroamerican individuals in Tucson during the nineteenth century were largely immigrants from the eastern United States and northern Europe, particularly the United Kingdom, Germany, and Scandinavia (see Chapter 4), it was not possible to identify these subgroups at levels more specific than "Euroamerican." Given the resolution of the various analyses used in this analysis, as well as the difficulties associated with identifying an individual to a particular geographic region, this result is unsurprising. Because of the extensive data collection conducted during this project, future analyses using larger and more-appropriate

reference samples may be able to identify the Euroamerican individuals at a finer level of resolution, even though the skeletal remains have been reburied.

The presence of an immigrating Euroamerican population in Tucson is supported by the measures of biological distance employed by Hefner, which suggest that the Euroamerican sample was composed primarily of late-arriving, immigrant populations from throughout the United States, Canada, and Europe. The morphological similarities among the Hispanic sample, on the other hand, suggested a relatively stable population, representing several generations of Tucsonans (at least in the northern sections of the cemetery [Cemetery 3, 4, and 5]), along with more-recent immigrants to Tucson from northern Mexico.

In general, the identification of subgroups within the cemetery followed expectations of nineteenth-century Tucson: it was a mostly Hispanic community, with African American, Euroamerican, and Native American individuals also living and dying here. The distribution and placement of these subgroups throughout the cemetery suggested some degree of spatial patterning. Hefner plotted the craniometric and dental data against spatial distance using geospatial methods of analysis and found that the morphological similarities among individuals buried in Cemetery Areas 1, 2, and 5 were distinct from similarities found among individuals buried in Cemetery Areas 3 and 4. Hefner's analysis suggested a greater degree of relatedness among individuals in Cemetery Areas 3 and 4, further supporting the notion that long-time, local residents were more likely to have been buried in those areas of the cemetery. Unfortunately, genetic relatedness and familial patterning could not be determined; however, future efforts using the Alameda-Stone cemetery data set will surely identify such groupings.

Up to this point, we have dealt almost exclusively with adult individuals, but the juvenile data set from the Alameda-Stone cemetery sample was so unusually rich in the number of individuals and in the observability of skeletal attributes that an entire chapter was dedicated to an investigation of the juvenile skeletal remains recovered from the cemetery. Working with over 600 juvenile individuals, Keur (see Chapter 9) not only demonstrated that juveniles in Tucson were smaller than similarly situated individuals from other sites or contexts but also was able to draw two important conclusions from the data. First, indicators of childhood stress alone do not explain the differences observed within and among groups. Second, the smaller size of the juvenile sample from the cemetery did not appear to be the product of lower growth velocities. Because there were no observations to suggest that environmental factors had an effect on the Alameda-Stone cemetery juvenile sample, the most likely explanation offered by Keur is that the observed differences are genetic, rather than environmental, ones. An alternative hypothesis explored in Chapter 7, Volume 1 of this series, is that juveniles in Tucson experienced a period of dampened growth between the ages of 7 and 14 as a result of nutritional deficiencies, which themselves may have been caused by exposure to infectious disease.

Harrison (see Chapter 10) addresses the stature of adults during her analysis of adult postcranial morphology. Like juveniles, adults in the Alameda-Stone cemetery were small in stature. The mean adult height was only 156.2 cm (5 feet 2 inches) for females and 167.33 cm (5 feet 5 inches) for males. These values are moderately low for this time period, but they are not outside the normal range of variation among other Hispanic samples. Variation in stature within the cemetery provided further support for some of the previously mentioned hypotheses regarding cemetery use and social organization. Males in the southern portion of the cemetery were significantly taller than those in the northern areas. This same pattern was true for females, as well, suggesting that the southern portion of the cemetery (and perhaps parts of Cemetery Area 5) comprised an immigrant population of predominantly Euroamerican settlers who were taller than the local Hispanic population. Harrison did not limit her analysis of postcranial morphology to estimations and comparisons of adult stature but also expanded her analysis to include an examination of long-bone morphology (and associated secular trends) and sexual dimorphism, in an effort to better understand issues regarding the health, biological affinities, and activity patterns of Tucson's inhabitants. Limb-bone morphology among the Alameda-Stone cemetery sample varied among biological-affinity groups, between males and females, and between the northern and southern sections of the cemetery. Varying magnitudes of sexual dimorphism suggested not only some degree of sexual division of labor but also different intensity levels in those activities in which men and women of all ethnicities were participating.

Disease is often associated with aggregation and urbanization. Nineteenth-century Tucson was not immune to such hazards, and evidence of a wide variety of pathological conditions was noted. Leher et al. (see

Chapter 11) identified a diverse assortment of pathological conditions in the Alameda-Stone cemetery sample, and they used these data as gauges for assessing the health of the residents of Tucson. Infectious disease most commonly manifested as nonspecific infection, broadly affecting adult individuals more than children, although this may also reflect accumulated pathologies over the course of a lifetime rather than age-specific susceptibility. However, the authors demonstrated that the children found in the cemetery suffered more from systemic infections than from localized infections, whereas adults suffered equally from systemic and localized infections. A significantly greater number of males than females exhibited infection, although males were comparatively evenly divided between those with active lesions and those showing some degree of healing. Females, on the other hand, were more likely to exhibit evidence of healing. Other infectious diseases recorded in limited numbers among individuals from the Alameda-Stone cemetery included osteomyelitis, endocranial reactions, sinusitis, tuberculosis, and treponemal infections, such as syphilis.

Changes to the skeleton associated with generalized degenerative joint disease unsurprisingly affected older individuals, although the distribution between men and women suggested a sexual division of labor (see Chapter 11). Males expressed degenerative joint disease more commonly in the arms and lower back, whereas females showed greater expression in the legs. These differences were likely related to differences in the day-to-day activities in which men and women participated. Differences in the frequency of degenerative joint disease were also noted among biological-affinity groups. The Native American sample had the highest incidence of the condition (74 percent), followed by Hispanic (69 percent) and Euroamerican (55 percent) individuals. Hispanic individuals displayed significantly more degenerative joint disease in the joints of the arm. The occupational demands and behaviors contributing to the distribution of degenerative joint disease between the sexes and among biological-affinity groups are also explored in Chapter 7, Volume 1 of this series. Other pathological degenerative diseases encountered in the Alameda-Stone cemetery sample included rheumatoid arthritis, diffuse idiopathic skeletal hyperostosis, reactive arthritis, and gout.

Cribra orbitalia and porotic hyperostosis, two skeletal conditions associated with metabolic disorders and nutritional deficiencies, were observed at low frequencies. Juveniles in the sample were more affected than adults, but not significantly so.

The individuals recovered from the Alameda-Stone cemetery displayed a variety of pathological conditions. Illness was common, but not to an extent beyond what was predictable for an urbanizing mid-nineteenth-century settlement. Disease was most frequent among juveniles, the more vulnerable segment of the population. Differing patterns of activity and occupational demands likely contributed to disparate impacts of disease among adult individuals. The observations detailed above, although clearly unique to the population under consideration—influenced by their demographic composition, environment, behavior, hazards, and resources—were not dramatically dissimilar to theoretical expectations or comparable data sets. Skeletal observations from the Alameda-Stone cemetery sample helped to reveal the health status of these individuals and the manner in and extent to which it was compromised.

Keur et al. (see Chapter 12) observed that the skeletal trauma documented in the cemetery sample followed general patterns but also featured unique and unusual cases. Skeletal trauma was observed in remains from 181 adults and 16 children. Most of these episodes were limited to fractures that occurred well before death. Life-threatening injuries were uncommon, and evidence for interpersonal violence was not abundant. The long-established view of Tucson as a violent community was not borne out by the osteological data. The greatest number of cases of trauma suggestive of violence were found in the southern portion of the cemetery, which we infer to have mostly been used by immigrant populations. Perhaps the interpersonal violence for which nineteenth-century Tucson was famous was concentrated mostly within the immigrating adult-male segment of the community, for whom Tucson was an economic and political frontier rather than an ancestral home. Osteological evidence for violent trauma is further explored in Chapter 7, Volume 1 of this series, along with historical and contextual information.

Lincoln-Babb and McClelland (see Chapter 13) noted that dental health in nineteenth-century Tucson was consistent with that of other frontier settlements. Caries and hypoplasia were fairly common conditions but were not detrimental to the overall health of the population. Limited evidence of professional dental care in the Alameda-Stone cemetery sample is also consistent with a prerailroad frontier community. Dental fillings were almost exclusively found in men in the southern portion of the cemetery, and then only in Euroamerican and

Hispanic individuals. Although dental care may have been more accessible to men, males and females experienced similar levels of dental pathologies. Significant differences were detected in all these factors between the northern and southern portions of the cemetery, lending further credence to the distinctions mentioned earlier between these two cemetery sections. Throughout the cemetery, the authors found that males were more likely to have extensive tooth wear than were females, suggesting underlying differences in diet. Dental wear was also comparatively more frequent in the northern portion of the cemetery, and caries formation was more frequent in the southern portion of the cemetery, suggesting differences in diet between local and immigrating populations.

Antemortem tooth loss was not a major problem among the inhabitants of Tucson, only affecting about 12 percent of the sample. Native American individuals suffered less tooth loss than any other group, but had a higher level of abscesses, suggesting that diseased teeth may have less often been removed from Native Americans. Hispanic individuals, on the other hand, had the highest incidence of antemortem tooth loss. These differences reflect variation in the relative cariogenicity of their diets as well as access to dental health care. The dental health of the Alameda-Stone cemetery sample was not perfect by any means, but the low caries rates, generally mild cases of periodontal disease, and low to moderate rates for enamel hypoplasia suggest that it was a generally healthy population, overall.

Finally, Keur et al. (see Chapter 14) provide anecdotal evidence of identity in this burial sample, shedding light on the population as a whole by focusing on individuals as individuals. The data collected and analyzed from mortuary contexts and skeletal remains illuminate the cultural and biological characteristics of an entire population, but the characteristics of the life and history of an individual are often overlooked or completely ignored. Keur et al. (see Chapter 14) did not ignore the individual but placed individuals in their proper context: Tucson, Arizona, in the nineteenth century, in graves within the Alameda-Stone cemetery.

Concluding Thoughts

Excavation and analysis of a large proportion of the Alameda-Stone cemetery during this project has led to important insights into life in frontier Tucson during the 1860s, 1870s, and early 1880s. Studies of the cemetery have contributed to a greater understanding of the health hazards faced by the population as well as how different segments of this multiethnic and religiously diverse community organized the cemetery and treated their dead.

Altogether, the various differences we have seen in where and how individuals were buried in the cemetery as well as in their life experiences and health conditions suggest the cemetery was organized according to a number of demographic variables. The most obvious division within the cemetery appears to have been a division between the local Hispanic community and outsiders, most of whom were probably not active in the Catholic Church and who likely affiliated themselves with outside populations. In some ways, this division appears to correspond to what Sheridan (1986) refers to as a "demographic duality" among Tucson residents, which corresponds in a general sense to a growing political, economic, and social division between Mexican Americans and Euroamericans in Tucson that only became wider after the cemetery closed. Sheridan wrote that

> In a sense Tucson in 1860 [around the time the cemetery opened] was a dual, almost schizophrenic, settlement, one divided between Mexican families rooted in the land and male Anglo immigrants seeking fame and fortune on the Apache frontier. This demographic duality in large measure determined Tucson's destiny for the next 20 years. [In other words, the same period in which the cemetery was used] [Sheridan 1986:38].

Perhaps this duality explains the major differences we see between the northern and southern portions of the cemetery in both osteological and contextual variables. Differences between Cemetery Area 3 and Area 4

in burial practices are also of interest and appear to possibly pertain to differences within the local Catholic community in their attitudes towards death and burial (see Volume 1 of this series).

Many questions remain concerning the Alameda-Stone cemetery and the people who were buried there. After nearly 2 years of fieldwork and a year and a half of intensive laboratory analysis, we know a great deal about the population of Tucson in the nineteenth century. This volume has focused on establishing the baseline information for interpreting the cemetery and the burial population. The data discussed in this volume are synthesized and integrated in Volume 1 to further explore behavioral and spatial patterns established in this volume; place the cemetery in broad, comparative context; and to understand the factors influencing life and death in Tucson during a crucial time in the settlement's history.

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