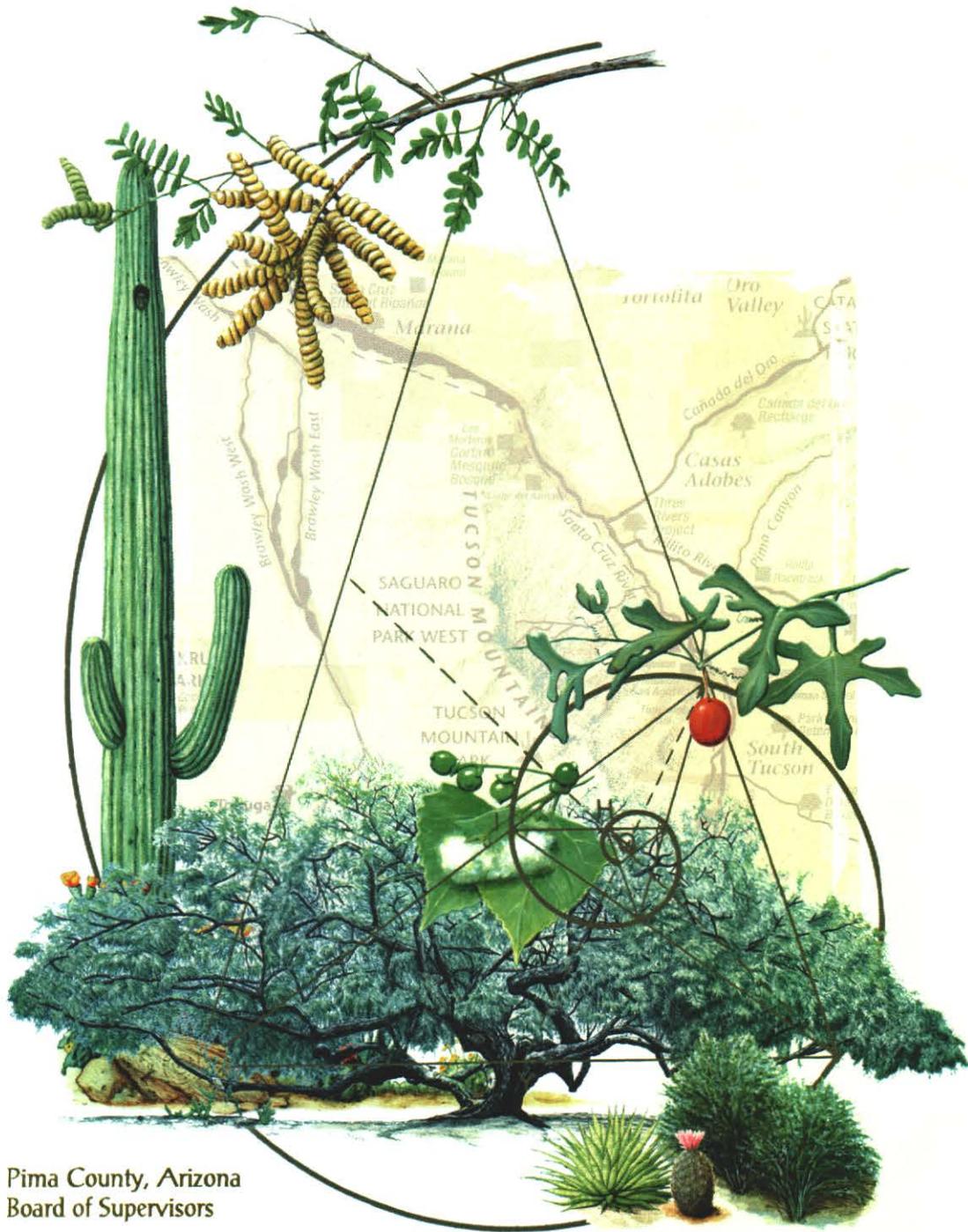


DRAFT

Native Plant Program Report

Sonoran Desert Conservation Plan

January 2001



Pima County, Arizona
Board of Supervisors

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County Administrator

Chuck Huckelberry



MEMORANDUM

Date: December 29, 2000

To: The Honorable Chair and Members
Pima County Board of Supervisors

From: C.H. Huckelberry
County Administrator

A handwritten signature in black ink, appearing to read "CHH", is written over the printed name "C.H. Huckelberry".

Re: **Native Plant Program Report**

Background

On September 26, 2000, the Board accepted a recommendation as part of the draft *Preliminary Sonoran Desert Conservation Plan* to charge the Wastewater Management Department with the task of developing a high volume Sonoran Desert plant nursery within buffer areas of outlying treatment facilities or other regional treatment plants. In early October I asked three members of County staff, who are also leading members of the Native Plant Society, to work as a cross-departmental team in formulating recommendations about how to best establish a Native Plant Program within Pima County. The attached report is the result.

Mr. Jeff Kreamer of the Wastewater Management Department, Mr. Gary Bachman, from Community Services, and Ms. Julia Fonseca, from the Transportation and Flood Control District are the primary authors of the study, and they have done an outstanding job. I find the document to be an accomplishment that is astonishing in at least these two ways. In a direct sense, the report provides a link between the sometimes difficult-to-access worlds of native plant conservation and County operations.

In an indirect sense, the document illustrates that in Pima County, the spirit of the pioneer naturalists which led to the discovery and description of Sonoran Desert has not died or been isolated in fragmented cliques within the expert community. We have County employees in seemingly unrelated areas of the organization who possess expertise and enthusiasm that places them in line with the great conservationists and naturalists of early Tucson. Providing some creative license to those members of County staff and members of the community who bring a native talent and their love of the subject matter to build programs like the Native Plant Nursery will be the success of the Sonoran Desert Conservation Plan for Pima County.

In this memorandum I will briefly summarize the attached *Native Plant Program Report* and emphasize recommendations from the report that I would like to pursue, particularly in the area of redesigning the approach to public works projects and landscape decision making.

I will also describe certain steps that I think will allow Pima County to not only accumulate a resource inventory and be stewards of the past and present resource values through the creation of the Sonoran Desert Conservation Plan, but to realize that we have a role in the grand tradition of natural history which we can institutionalize as planning evolves into program implementation.

Report

The pages of the *Native Plant Program Report* give us sensible and specific recommendations about topics as various as:

- What plants to reintroduce
- How to improve native plant salvage and re-establishment attempts
- Steps that would improve the conservation of native plants in public works projects
- Recommendations to improve the practices of landscape and design professionals
- Skills that will be required for future staff at the Pima County Native Plant Nursery
- The rationale for locating native plant nurseries at waste water facilities
- The near term and long term potential of treatment facilities to accommodate nursery sites
- Recommendations for the location and acreage of nursery sites on the premises
- Proposals complete with facility and personnel requirements for phased-in programs
- Moving from demonstration reintroductions to a high volume nursery
- The ability to establish research centers around the plant facility
- The uses of nursery plants
- Suggested trees and shrubs for nursery cultivation
- Social and educational opportunities
- Potential collaborative partners in program development

The authors bring these topics into the urban realm through the purpose of the report, which is to outline a native plant program for Pima County's urbanizing lands. They correctly state that "every part of Pima County's land base can contribute in some way to minimizing or mitigating the problems that will occur as native plant communities are lost to future urbanization." (P. 3) Some highlights from these major topical areas of the report include the following.

1) Reintroductions -- Pages 4 through 8 of the report propose that Pima County begin its Native Plant Program with the reintroduction of three extirpated species: the Huachuca water umbel, now listed as endangered, the screwbean mesquite, and the arrowweed.

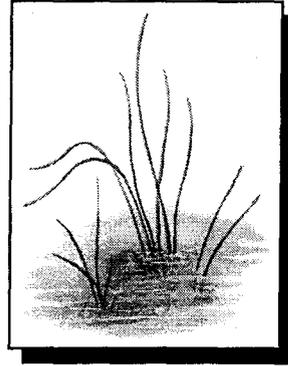
- Arrowweed is a native riparian plant with a shrubby appearance. Opportunities exist to reintroduce it in the Santa Cruz River and provide a seed source that may lead to the successful reestablishment of arrowweed along the effluent dominated reaches.

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- The Huachuca Water Umbel, last seen in Pima County at Empire Gulch in 1996, has potential habitat along the Cienega Creek. Typically requiring a depth of water of two to six inches, this endangered plant is being considered for reintroduction in the Upper Santa Cruz and along the San Pedro River by federal resource agencies.



Huachuca water umbel

- The screwbean mesquite might also take hold in the effluent dominated reach of the Santa Cruz river.

2) How to improve native plant salvage and re-establishment attempts -- Pages 8 through 11 describe the ways in which plant salvage, on site conservation, and reestablishment can combine to improve how native plants succeed in the developed landscape. These specific suggestions are offered by the authors and I will direct the public works departments to improve conservation of native plants in project design and implementation by taking the following steps:

- "Minimize the impacts of route selection for utilities and site selection for public works projects by working with biologists and considering the biological information generated from the Sonoran Desert Conservation Plan. Minimize impacts again in the concept design process, and at the 30% and 50% stage of plan development by superimposing recent aeriels."
- "Later in the design process, conduct ground surveys of vegetation after minimization efforts, to determine the amount and species of native vegetation present."
- "Minimize impacts of maintenance activities on native plant communities, with particular consideration given to maintaining canopy structure and escape cover."
- "Use native species identified in the survey to guide revegetation efforts."
- Salvage native plants.
- "Do not use non-native species suspected of being invasive in revegetation. Maximize the use of native plants."
- "Minimize the use of decomposed granite and crushed rock materials as ground cover. Consider instead the opportunities to provide escape cover for wildlife, while minimizing the need for future irrigation. "
- "Ensure that design professionals in the public works departments receive training in native plant issues."

3) Recommendations to improve the practices of landscape and design professionals -- Pages 11 and 12 of the *Native Plant Program Report* suggest these ways to increase awareness in design professionals. Again, I will direct the public works departments to improve conservation of native plants in project design and implementation by taking the following steps:

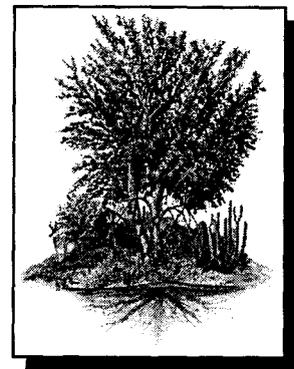
- Bring landscape architects into the project design sequence in time to effect major site decisions.
- Recognize projects and practices that uphold the conservation of native plants.
- Establish classes and seminars for landscape professionals working on County projects.
- Work with the State Board of Technical Registration to establish Continuing Education requirements for landscape architects with a requirement that education components include "restoration practices, propagation and use of native plants, and ecology of riparian and other habitats that are under stress."
- "Develop pattern books illustrating preferred practices and methods that would be distributed to landscape professionals."

Collaborations are suggested with the Arizona Native Plant Society, Cooperative Extension, and local landscape professional groups.

4) Rationale for locating plant nurseries at public waste water facilities -- Pages 16 through 26 provide a detailed examination of the potential for treatment facilities to accommodate short term and long term program goals. Maps of each site are provided, with a potential nursery site identified including approximate acreage. A discussion of permit issues and the amount of available water at each site is also analyzed.

5) Pima County Native Plant Nursery proposal -- Pages 26 through 32 describe in detail a Phase One and Phase Two method of bringing the program up. In Phase One, the three extirpated or endangered plants described above would be propagated along with Ironwood. In Phase Two, a high volume nursery with six component parts is proposed:

- The Main Nursery
- Buffer Zones
- Propagation Center
- Seed Bank
- Native Plant Research Center
- Exotic/ Invasive Species Research Center



Ironwood

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6) Uses of nursery plants -- Pages 33 through 38 describe uses of plants grown in the Pima County Native Plant program. These include:

- A systematic replacement of non-native vegetation at county owned facilities
- County landscaping contracts -- roads, parks, riparian and other habitat restoration
- Other County projects -- housing, public buildings and capital improvements
- Public education purposes
- Distributed to schools for demonstration / educational projects (ethnobotany, pollinators etc)
- Salvage plants could be used for county projects or sold
- Provided to research organizations for scientific purposes
- Grown for buffer areas at the nursery and other locations
- Sold to county projects at contract rates

Two points from earlier pages of the report provide a context. The authors establish that native plant sales are not the profit makers of private sector nurseries. There is a need for a stable native plant nursery that serves a public purpose. Yet, on page 15, the authors state that Pima County's proposal "to establish a publicly owned nursery at the county level for the purpose of propagating and distributing native plants may be unusual in the United States." Citing examples for outside the United States the report suggests that the motivating factors for preserving native plants in other countries is found in the basis of the Sonoran Desert Conservation Plan: "There is growing recognition and appreciation of the Sonoran Desert as a bioregion that transcends international, cultural and economic boundaries. The interest includes materials and products that are indigenous or have a longer history as part of this region. This includes interest in architecture, crafts, foods, food crops, and natural history. There is also an increase in desert conservation."

Conclusion

One of the greatest ecologists of the Sonoran Desert was Forest Shreve, who contributed to generating -- and then brought together -- vast areas of knowledge on climate, soil moisture, temperature, and plant distribution in his vegetation studies on the Sonoran Desert. In addition to giving us the basis for mapping and classification that we rely on in part today as a foundation for the Sonoran Desert Conservation Plan, Shreve gave us a way to understand indigenous plants within the context of the entire ecology of the community. He said in one book:

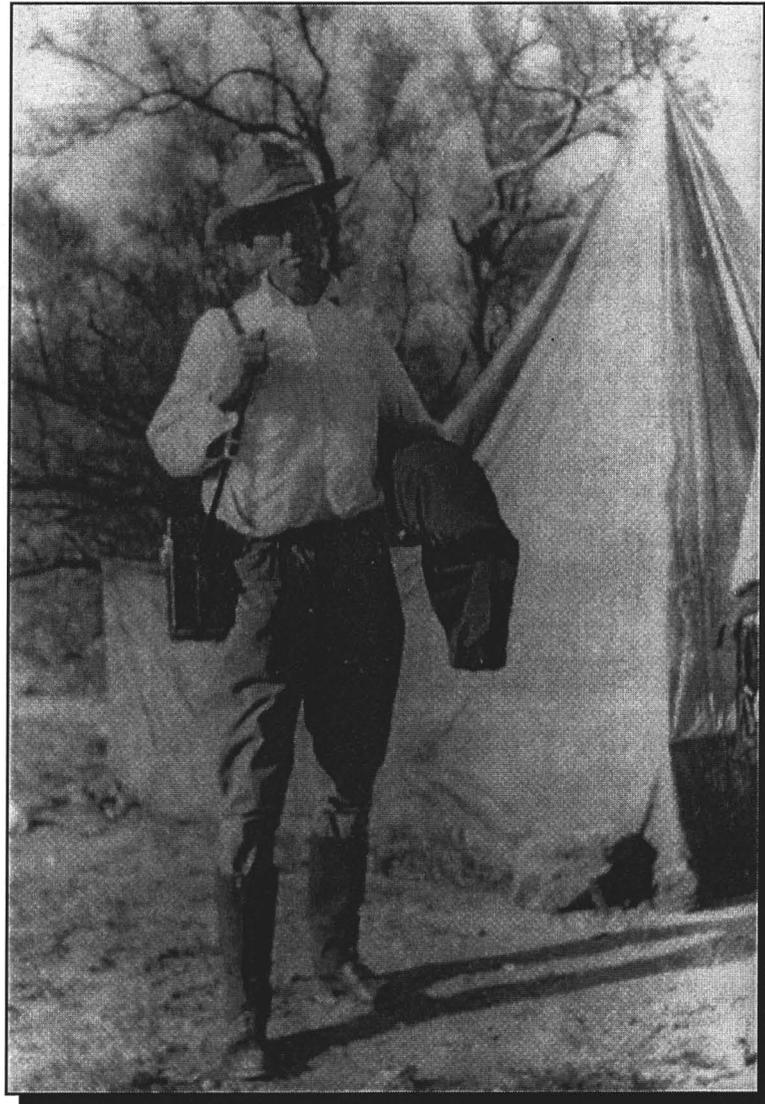
"We need to weave together the separate threads of knowledge about the plants and their natural setting into a close fabric of understanding in which it will be possible to see the whole pattern and design of desert life."

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It has been suggested that the golden age of natural history in Tucson declined after Shreve and his contemporaries left the stage around mid-century. I would suggest that the resource base has declined in the last half century as Tucson underwent steady population growth, but the desire "to see the whole pattern and design of desert life" is widely felt within the community today. The spirit of the pioneer naturalists which led to the discovery and description of Sonoran Desert resonates in this work by Jeff Kreamer, Gary Bachman, and Julia Fonseca. The opportunity to effectuate research and turn knowledge of the resource base into a program to protect it is the opportunity before us with the Sonoran Desert Conservation Plan. We are fortunate to have these gifted staff members with us and I will continue to seek such expert advice in building the programs across County departmental lines as we move toward plan completion and full program implementation.



FOREST SHREVE (COURTESY ARIZONA HISTORICAL SOCIETY)

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Acknowledgements

Authors of this report were Jeff Kreamer, Gary Bachman, and Julia Fonseca. Coordination was provided by Neva Connolly. Ken Kingsley Barbara Tellman, and Dave Bertelson reviewed this report.

Purpose

This report will outline a native plant program for urbanizing lands in Pima County. The adaptive management plan now under development for the Sonoran Desert Conservation Plan will address plant issues for existing and proposed public reserves such as County parks, and federal reserves such as the Ironwood Forest National Monument. Every part of Pima County's land base, however, can contribute in some way to minimizing or mitigating the problems that will occur as native plant communities are lost to future urbanization. This report explores ways in which the impacts of urban development on native plants can be minimized.

In addition, this report specifically responds to the initiative described in the September 26, 2000 *Preliminary Sonoran Desert Conservation Plan* memorandum, which proposed a nursery operation be established at wastewater treatment facilities. Plant stocks will be used to re-establish riparian and other Sonoran Desert plants on degraded public lands. This report develops the native plant nursery concept and provides specific information in support of it.

How Urbanization Affects Native Plant Communities

As more and more of Pima County's landscape is transformed for human use, native plant communities will change in many ways. While complete removal of native plants is the most dramatic change, there are other subtle but important ways that plant communities change with urbanization.

These changes affect plants and animals of our region, influence erosion, fires, floods and air quality, and affect the ways that people enjoy the outdoors or conduct their businesses. While it is not the purpose of this report to explore all of the consequences of these changes, we are fortunate to have research which already documents some of the ways that native plant communities change through development. Arizona Game and Fish Department and Pima County jointly funded investigations by Dr. William Shaw and others (1996) that resulted in an inventory of wildlife habitat in the urbanizing portions of eastern Pima County as of 1995.

The results of that study show that non-native species predominate in urban environments, such that most land uses provide less than 10% vegetation cover in native species (Shaw et al., 1996). Only 1% of the land cover of golf courses and cemeteries is native vegetation, despite the fact that these land uses are highly landscaped and irrigated. While non-native plants do provide habitat for some wildlife species, our native wildlife are better adapted to using native plants as food and cover (Shaw et al., 1996), and the associated physical structures that go with undisturbed ground (burrows, rock ledges, etc.) Only in low density residential housing is a substantial proportion of native vegetation retained.

The increase in non-native plants that comes with urbanization is an issue not only because of the loss of wildlife habitat in the urbanizing areas, but because some of these plants are capable of moving into adjacent natural areas. In the past, many of the non-native invasive species were introduced by the agricultural sector, ranching, erosion control, and as landscaping plants.

In the future, Pima County's urban area may be the leading source of new invasive, non-native species. Some scientists have observed that it takes at least one to two decades to identify invasive exotic species, so it is not unreasonable to think that some of the plants in wide use today will become the problem species of the future. An example may be African sumac, the hardy urban landscape tree found along the Fourth Avenue business district and many other locations in Tucson. Planted in Tucson for nearly 100 years (Tellman per communication), African sumac is a drought-tolerant, disease-free tree much loved for its shade, but it appears to be spreading into our watercourses by way of its prolific seeds (see Figure 1). Fountain grass, another landscaping plant, has already spread throughout the Catalina foothills and into the Santa Catalina Mountains. Fountain grass is also found in the Tucson Mountains.

Research has also shown that escape cover is uncommon or missing in many urban landscapes, including some areas that are otherwise heavily vegetated such as golf courses and cemeteries. Escape cover is crucial for several kinds of native wildlife, including rabbits, quail, lizards and other small animals. Shaw et al. (1996) used the total basal cover of the plants as an index of escape cover vegetation. The study found that low density residential areas (less than one house per acre) and major river corridors can often provide substantial escape cover, 18-26% of their area being covered with vegetation of this type, but most other urban land uses do not provide escape cover.

Plants which have foliage or stems at or near the ground and cover more than a 6-inch radius provide escape cover for some small mammals, birds and lizards. Types of plants which provide escape cover can include sprawling cacti such as native prickly pear, bunch grasses like sideoats grama or tobosa, fallen woody debris from trees, or certain shrubs. If you have seen quail fleeing from your footsteps, observe where they run to: there you will find examples of escape cover.

While it is an important habitat need for many animals, escape cover is problematic in the urban environment. Many people find low-growing plants and debris aesthetically unappealing. Grasses and woody debris can be a fuel source for fires, and dense vegetation of any kind obstructs the view of business signs along roadways.

Increasingly, businesses and home-owners are using decomposed granite or other crushed rock for a groundcover. While rock materials do not require water, neither do they provide habitat for wildlife. Crushed rock alters near surface temperatures and solar reflection, thus altering the microclimate. More importantly, the production of crushed rock involves destruction of rock outcrops, which is likely to destroy wildlife habitat in areas distant from the urban centers.

Reintroductions

Pima County could facilitate reintroductions of extirpated species to the wild by making available appropriate sites. At least three plant species, the screwbean mesquite, arrowweed, and Huachuca water umbel (see Figures 1 through 3), formerly occurred along riparian areas such as the Santa Cruz River and could be reintroduced. The disappearance of these plants in Pima County tell us how great the changes in the Santa Cruz River environment have been. The success or failure of reintroduced species may provide clues to past and present changes using sensitive species as keystone indicators.

Figure 1

Screwbean Mesquite *Prosopis pubescens*



The screwbean mesquite is a tall shrub or tree that disappeared from Tucson during the 20th century. It formerly grew in the Santa Cruz River bottomlands with other riparian plants, and it still can be found along the Gila and Colorado Rivers. Its range has shrunk as Sonoran Desert rivers have become dry or altered by land uses.

Today the tornillo is sometimes grown as an ornamental tree. This species is tolerant of a variety of soils, and needs no more water than an ordinary mesquite. The tightly coiled pods are sometimes used for decorations.

The O'odham people used kuujuul pods to produce a sweet beverage and a protein- rich flour. The sap was also collected and eaten. The roots were used as medicine. The O'odham and pioneers alike used the wood for fence posts and firewood. Waterfowl such as the American coot are known to eat the seeds.

In recognition of its significance to our history and river ecosystem, Pima County's Sonoran Desert Conservation Plan will restore this plant to the Santa Cruz River.

For more information about the screwbean mesquite see:

Benson, L. and R. A. Darrow, 1981. *Trees and Shrubs of the Southwestern Deserts*. University of Arizona Press: Tucson

Rea, Amadeo M., 1997. *At the Desert's Green Edge: An Ethnobotany of the Gila River Pima*. University of Arizona Press: Tucson

Turner, R.M., J.E. Bowers, and T.L. Burgess, 1995. *Sonoran Desert Plants - An Ecological Atlas*. University of Arizona Press: Tucson

Figure 2

Arrowweed *Pluchea sericea*



Arrowweed is a shrubby, native riparian plant occurring along the major rivers of the Southwest. The plant has narrow, lance-shaped leaves and slender, flexible stems. Lavender flowers clustered in thimble-shaped heads appear in the spring.

Arrowweed, which can grow as high as 10 feet, forms dense colonies on sand bars, beaches, and dunes. Each colony is a clone, created as the underground, horizontal stems send up leafy shoots. Clonal growth enables this species to aggressively occupy suitable habitat as it opens up. While the shallow rooted arrowweed colonies are easily ripped out by flooding events, the species as a whole benefits as floods deposit fresh sand. Arrowweed is among the first colonizers of sand bars and beaches, and in some riparian communities it is the dominant plant.

Native peoples have used arrowweed for weaponry, as the common name suggests. The stems are also useful in building houses and ramadas. The flexibility of the branches has made them very valuable in basket-making. Because of arrowweed's close association with water, the shrub acted as a 'flag' for native Americans and pioneers who were searching for water sources.

Arrowweed once occurred along the Santa Cruz River in Tucson during the 1800's and early 1900's. Opportunities exist to re-introduce the species in the Santa Cruz River, and provide a seed-source which is currently lacking in the watershed. With a seed source present, arrowweed may successfully establish itself along the effluent-dominated stream.

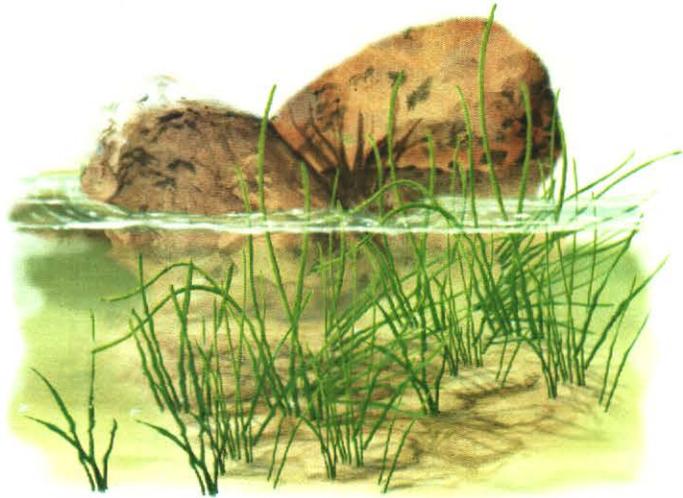
For more information on arrowweed, please refer to:

Bowers, Janice. 1993. *Shrubs and Trees of the Southwest Deserts*. Southwest Parks and Monuments Association: Tucson, Arizona.

Figure 3

Huachuca Water Umbel *Lilaeopsis schaffneriana* *spp. recurva*

The Huachuca Water Umbel is a federally listed endangered plant found at elevations from 3,500 to 6,500 feet in cienegas, springs, and other healthy riverine systems. The water umbel is usually found in water with a depth of two to six inches. The plant has bright green, hollow, cylindrical leaves which grow straight up from the root. A short umbel bears three to ten very small flowers.



This plant has been documented on 23 sites in Santa Cruz, Cochise, and Pima Counties, and in Sonora, Mexico. It is no longer found on 6 sites. The remaining 17 sites occur on the San Pedro, Santa Cruz, Rio Yaqui, and Rio Sonora rivers. The Huachuca Water Umbel may expand into optimal habitat in southeastern Arizona and northern Mexico. In Pima County, the umbel was last seen in the Empire Gulch by Dr. Peter Warren in 1996. Return visits to the area has not produced any umbel sightings, although potential habitat is prevalent along Cienega Creek.

The main threat to the Huachuca water umbel is destruction, modification, or curtailment of its habitat or range. In the southwest, cienegas and perennial streams are rare. The Arizona Game and Fish Department estimated that riparian vegetation associated with perennial streams comprised only 0.4 percent of the total of Arizona land vegetation, and that the riparian areas are remnants of what once existed. An estimated 90 percent of riparian areas in Arizona have been destroyed, degraded, or altered.

Huachuca Water Umbel has been successfully introduced into ponds in the San Bernardino National Wildlife Refuge. Other reintroductions are being considered by the U.S. Fish and Wildlife Service on the upper Santa Cruz River, and by the U.S. Bureau of Land Management along the San Pedro River.

For more information on the Huachuca Water Umbel, refer to:

National Wildlife Refuge Service Files/Species Accounts. August 30, 1999. *Lilaeopsis schaffneriana spp. recurva*, Huachuca water umbel.

US Fish and Wildlife Service. 1998. *Threatened Species of Arizona*. Arizona Ecological Field Service Office, Phoenix, AZ. pp 13-14.

US Fish and Wildlife Service. 1999. "Endangered and Threatened Wildlife and Plants; Designation of Critical Habitat for the Huachuca Water Umbel, a Plant." *Federal Register*. Volume 64, Number 132.

Roller, Tricia. 1998. "The Huachuca Water Umbel." *The Arizona Riparian Council*. Volume 11, Number 2

Suitable sites for all three species would have abundant water. Huachuca water umbel also requires periodic flooding and erosion. All three species were known to occur along the Santa Cruz River in Tucson in the late 1800s and early 1900s.

Today, the perennial portions of the effluent-dominated reach of the Santa Cruz River could be used to support these species. By planting the screwbean and arrowweed in public projects along the Santa Cruz River, a seed source would be provided to the watershed that today is lacking. Arrowweed could be planted along the edges of ponds, and the screwbean mesquite can be planted in public projects along the river. If the seed source is present, it is possible that these species would establish themselves in the wild naturally where the water is sufficient and erosion is not too severe. If the species will not establish themselves along the effluent-dominated stream once seed sources are successfully established in public projects along the river, then factors other than loss of the seed source are preventing the restoration of these plants. It will not be necessary or advisable to plant these species in the river bottom, nor to promote them for home landscaping purposes.

Reintroducing Huachuca water umbel would require different methods, because the plant primarily propagates vegetatively from its rhizomes. The Huachuca water umbel is already being grown at the University of Arizona Environmental Research Laboratory. According to Frye (2000), the plant is also easy to re-establish in the field if desired. Suitable sites would include the effluent-dominated Santa Cruz River, Cienega Creek and the San Pedro River. Smaller wetlands such as Agua Caliente Spring and springs in the Las Cienegas National Conservation Area might also offer sites. Direct transplantations to suitable sites would be needed for this species.

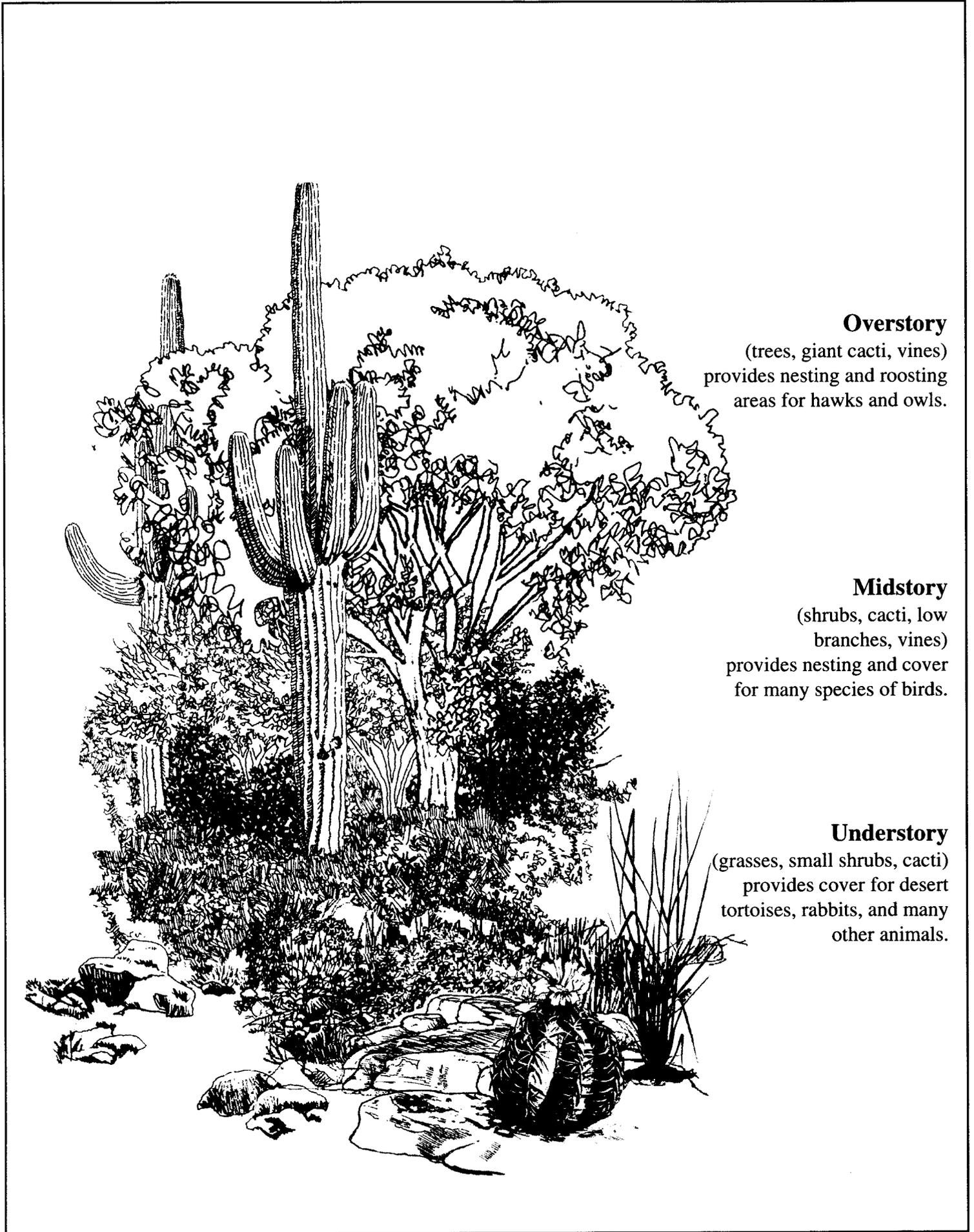
Plant materials for the screwbean mesquite and arrowweed are available commercially. Care should be taken to obtain plant material from appropriate ecosystems. The screwbean mesquite is still found along the Colorado, Gila and Rio Grande river systems of the Southwest. Screwbean mesquite seeds should be obtained from a site in the Gila watershed, for example, not from the Rio Grande. Arrowweed can be obtained from the Gila watershed as well. Arrowweed is such a common shrub in some riparian systems that it is the dominant plant for some plant communities. Plant material for Huachuca water umbel would first require a permit from U.S. Fish and Wildlife Service. If possible, the umbel should be propagated from the remnant population in the Cienega Creek watershed.

Opportunities to Improve

We have many opportunities to both conserve native plant communities as well as to improve how plants are re-established and maintained in the developed landscape. Probably no place illustrates the opportunities and problems so well as the northwest side of Tucson, where urban development is occurring in the midst of an ironwood forest which provides habitat for cactus ferruginous pygmy-owls as well as many other species.

Pima County already plans to revise its native plant preservation ordinance to increase the *in-situ* and salvage conservation of ironwood and other trees which provide structural diversity for wildlife (see Figure 4). Plant salvage alone will not address all of structural, floristic and soil damage done during development. Additional ways to align incentives to maximize the *in situ*

Figure 4



Overstory

(trees, giant cacti, vines)
provides nesting and roosting
areas for hawks and owls.

Midstory

(shrubs, cacti, low
branches, vines)
provides nesting and cover
for many species of birds.

Understory

(grasses, small shrubs, cacti)
provides cover for desert
tortoises, rabbits, and many
other animals.

preservation of native plants would benefit wildlife. Review of the County's grading and landscaping ordinances is also needed to see if they are performing as intended. Minimizing disturbances to natural landscape during grading will reduce erosion and the potential for spread of invasive exotic plants.

Pima County as an agency needs to set the best possible example to the public in our conduct of public works. When we build roads and wastewater treatment facilities, public buildings and parks, we must strive to minimize our impacts. Pima County should provide leadership in maximizing the use of native plants and successfully revegetating disturbed areas.

Already, the Pima County Natural Resources, Parks and Recreation Department has successfully reduced impacts to native vegetation along Gates Pass Road in Tucson Mountain Park. Instead of utilizing a graded roadway, they have installed paved pullouts with curbs to prevent motor vehicles from extending into the desert. Staff and volunteers have successfully revegetated the roadway shoulders in a manner that encourages native vegetation. Active measures to eliminate invasive plants along the roadways in the Tucson Mountain are underway by volunteers with Pima County and Saguaro National Park.

Several actions that Pima County could take to improve the conservation of native plants in public works projects are:

1. Minimize the impacts of route selection for utilities and site selection for public works projects by working with biologists and considering the biological information generated from the Sonoran Desert Conservation Plan. Minimize impacts again in the concept design process and at the 30% and 50% complete stage of plan development by superimposing designs upon recent aerial photographs.
2. Later in the design process, conduct ground surveys of vegetation after minimization efforts, to determine the amount and species of native vegetation present. Superimposing designs upon recent aerial photographs can also be helpful but will not replace ground surveys in determining actual impacts.
3. Minimize impacts of maintenance activities on native plant communities, with particular consideration given to maintaining canopy structure and escape cover.
4. Use native species identified in the survey to guide revegetation efforts.
5. Encourage a plant salvage program.
6. Do not use non-native species suspected of being invasive in revegetation. Maximize the use of native species.
7. Minimize the use of decomposed granite and crushed rock materials as a ground cover. Consider instead the opportunities to provide escape cover for wildlife, while minimizing the need for future irrigation.

8. Ensure that design professionals (landscape architects and engineers) in the public works departments receive appropriate training in native and invasive non-native plant issues.

Design Professionals

In recent years landscape architects, landscapers, and other plant professionals have responded to the need to incorporate the use of native plants in their practice and combine a broader consideration of environmental concerns. The challenges for designing in the Sonoran Desert and assumptions that the designer carries with them are very different than those in wetter regions in North America. Differences include:

- extremes in temperature govern plants that can be used;
- natural cycles of drought;
- plant communities – the inventory of plants include a high number of plant species that are tropical in origin and a lower number of species that are from temperate zones;
- soils are organically depauperate, tending to be alkaline with extensive layers of caliche; soil variability also plays a more important role in determining the soil moisture available to the plant;
- the importance of vegetation structure (canopy, understory, woody debris) and natural soil structures (soil litter, burrows, rock outcrops) in providing shelter from extreme heat and frost to plants and animals.

Notwithstanding these challenges, landscape architects may be trained and licensed out-of-state, and may immediately begin to practice upon relocating to Arizona if they originate from a state that reciprocates and recognizes Arizona's licensing requirement.

An additional challenge for landscape architects is the design sequence, whereby landscape designers are consulted after other project professionals have made major site decisions that effect what can be done on a particular site or may have consequences for preserving habitat on an existing site. The expectations of a client, particularly an out of state developer, may also affect design choices.

Recommendations to increase awareness in native plant designs for landscape professionals include:

- Pima County should provide recognition for projects that adhere to the principles that have been established throughout the Sonoran Desert Conservation Plan. The recognition could be through awards that are given to the best installations, or through the description of best practices that have been implemented each year. Recognition should not only include very ambitious projects, but modest projects where an important technique or principle is illustrated. The 'awards' should not be limited to Pima County projects, but could cover private, commercial, and projects funded by other government agencies.
- Establish classes and seminars for landscape professionals working on County projects. Inducements for private sector professionals could be developed and enforced through

Pima County's procurement system. Classes would include curriculum related to Pima County's development ordinances.

- Work with the State Board of Technical Registration to establish Continuing Education Unit (CEU) requirements for landscape architects to retain licensing. The continuing education component could include courses in restoration practices, propagation and use of native plants, ecology of riparian and other habitats that are under stress. Incentives must be in place to encourage this.
- Seminars and training programs developed by Pima County oriented specifically for landscape architects, in cooperation with Arizona Native Plant Society, Cooperative Extension, etc.
- Develop pattern books illustrating preferred practices and methods that would be distributed to landscape professionals. This could be developed through a collaboration between local institutions, the University of Arizona, and landscape professionals.

Pima County Resources – Conservation Lands Management: Tasks for Resource Managers

As additional lands are purchased through the Pima County Conservation Funds, the management responsibilities of the Pima County Natural Resources, Parks and Recreation Department will increase. Job descriptions will need to be developed; positions will be added to the department and training programs implemented by Pima County or by affiliation with local learning institutions.

There will be resource management activities that are relevant to conservation practices that will need to take place outside of the lands that are owned by Pima County. This will include cooperative arrangements that will occur with federal and state land management agencies, as well as private owners.

Resource managers may also be responsible on a countywide basis for habitat monitoring, enforcement of noxious weed and native plant ordinances, observation of storm water flows, and other tasks that can be added to the list as the county's conservation program evolves.

A list of tasks and skills for these positions include:

- Nursery propagation and management
- Habitat restoration
- Landscaping/ maintenance
- Outdoor recreation management
- Noxious weed eradication
- Law enforcement
- Public relations
- Nature interpretation
- Trail maintenance
- Wildlife resources
- Land management

Training programs could be developed in conjunction with Pima Community College and other learning institutions. Courses in the program could include:

- Biology/Ecology
- Landscape maintenance and management
- Law enforcement
- Land and resources management
- Botany and plant identification
- Natural and Cultural History of the Sonoran Desert
- Anthropology
- Geology, and other earth sciences

Increasing Public Awareness of the Environment and the Sonoran Desert Conservation Plan

The Sonoran Desert Conservation Plan cannot succeed without the understanding and support of Pima County residents. Reversing the land use patterns of the past century will involve creating a new ethic and view of natural communities.

Each component enacting the Sonoran Desert Conservation Plan must be seen as an educational opportunity to develop more sensitivity and understanding. Population growth will continue to impact many species habitats even as more land is set aside for conservation.

An example of the potential to educate the public to alter use patterns is the problem of protecting the herd of sheep in the Santa Catalina Mountains. The National Forest Service prohibits dogs on trails in the Front Range, and has publicized this ban by posting signs at the trail heads leading to sensitive areas. At the Finger Rock Trail trailhead, initially 40-60 dog owners were either warned or cited by the Forest Service each month for violations of the regulations. In recent months citations have dropped to one or two each month. Owners are usually cooperative when the reason for the regulation is explained (Bertelson, 2000). This example shows an interest and willingness by users of trails to comply with regulations that have the purpose of protecting wildlife.

The other important lesson from this example is the expectation that those using wild areas will need to be self-policing. Continuous presence of enforcement personnel is not possible on hundreds of miles of trails and at the range of recreation and natural areas that are being considered for the Sonoran Desert Conservation Plan.

Educational efforts must extend beyond residents to tourists and visitors who are also use Pima County conservation areas. Education programs will need to include materials supplied through the local tourist bureaus, tour operators and hotels, and at the trailheads.

Growing Native Sonoran Desert Plants

The conditions that create the incredible diversity of the Sonoran Desert--the extreme temperatures, low rainfall, and the unpredictability of both, in addition to difficult soils--also provide challenges to growers and propagators attempting to understand and grow species from the desert. For instance, our spectacular spring desert wildflower displays are

dependent on many unknown variables. Several of those variables are known: fall germination is necessary; fall rain is required; and regular rainfall is needed until March (Dimmit, 2000). These factors are difficult to replicate in a garden to stimulate the kind of display that causes traffic jams at Picacho Peak. The variability that produces the Sonoran Desert landscape are not characteristics the public and the nursery industry seeks. The industry has educated the public to expect plants that are as predictable as night and day.

Nurseries generally rely on their ability to sell showy, dependable, easily maintained plants. Some Sonoran Desert plants fit that mold, and are reliable, predictable and as spectacular as any in the world. These particular plants have been captured by propagators and are found in many of our landscapes. An example of this is the broad acceptance and promotion of the xeriscape landscaping model of plants that are more compatible with local conditions. Still, we tend to depend on the selection of plants from other arid localities that are developed and sold with a perhaps misleading impression that these are "native" plants.

Nurseries typically operate as small to large, privately operated businesses. Many are family owned and operated, although there are examples of large nurseries which are operated along industrial models. Plant nurseries satisfy a variety of needs and purposes, from highly specialized nurseries catering to a very specific need such as orchid specialists, to the general retail nursery catering to domestic house plants.

Like most businesses, plant nurseries are dependent upon repeat customers. It is important, especially when selling a living item, to insure to the greatest degree possible that the plant will survive. Therefore, most nursery inventory and sales are oriented towards plants that are most likely to survive. A second factor in marketing plants is plant survivability coupled with the use of showy flowers and other features. Nurseries tend to sell for short-term results, such as the immediate bloom of pansies.

As the horticulture industry seeks to develop plants for mass propagation, there is less interest in maintaining the genetic diversity – the qualities that allow plants to adapt to very specific conditions such as soils, microclimate, elevation, and different pollinators. A native plant nursery with a restorative role serves a different function than the commercial nursery. Preserving the diverse genetic composition of plants is essential to providing plants that will be placed in situations where they will receive a minimum amount of maintenance.

A restorative nursery should select plants to propagate, grow and distribute based upon the following qualities:

- preservation and mitigation of rare and endangered species and varieties;
- unusual and unique plants, not commonly available commercially;
- plants that are common, yet may not be propagated commercially, for revegetation of disturbed areas and other uses;
- species for study and research;
- plants grown for a specific purpose or use:
 - habitat restoration;
 - food for wildlife;
 - wildlife habitat;
 - medicinal purposes/ ethnobotanical interests;

- preservation of genetic variety;
- educational purposes combined with any of the above qualities.

Public Sector Plant Nurseries

Public sector nurseries have a limited role in the United States. State forestry plant nurseries produce seedlings for reforestation and timber production. The proposal to establish a publically owned nursery at the county level for the purpose of propagating and distributing native plants may be unusual in the United States. Because no example could be found in the United States, the following paragraphs describe a case history of publically owned nurseries in Australia.

Australian nationalism was revived during the 1970's. This emerging identity turned focus away from European traditions towards discovery of itself as a Pacific nation. Evidence of this new culture is most recognized in films, literature, visual arts, design and an increasing interest in understanding and protecting its very unique flora and fauna. In Australia, plant nurseries operated by State Forestry Nurseries have played an important role in distributing native plants for public and private use.

The State of New South Wales operates nine nurseries throughout the state. Nursery sales totaled 1.4 million seedlings in 1998(State Forest Facts and Figures 1998-99. New South Wales Forests) in a state with the population approximating that of Arizona. Plants are distributed in inexpensive tubestock, which are metal sleeves approximately 8 inches long and 2 inches in diameter containing young seedlings. The retail price for tubestock is now less than US\$2. At this price consumers feel safe in taking risks, especially with some of the more difficult to grow species. This price is affordable for the sale of large quantities, which are distributed for mass planting in revegetation projects. Plants are propagated for a variety of purposes including windbelts for farms, land stabilization, fodder, revegetation and domestic ornamental horticulture.

One of the nurseries is located in a Sydney suburb, the country's most populated metropolitan area. The nursery's catalogue contains 217 species and varieties. Many plants in the catalogue are not native to Australia, and the selection of species is not restricted to locally derived species. As in the United States, the argument over what is considered a native plant has become obscure and confusing.

In the Sonoran Desert there is a parallel to the self-discovery that is evidenced in Australia for the last 30 years. There is growing recognition and appreciation of the Sonoran Desert as a bioregion that transcends international, cultural and economic boundaries. The interest includes materials and products that are indigenous or have a longer history as part of this region. This includes interest in architecture, crafts, foods, food crops, and natural history. There is also an increase in desert conservation.

Non-profit enterprises have developed as a result of this increasing appetite. Native/SEED Search, Arizona Sonoran Desert Museum, Tohono Chul Park are a few of the examples of agencies which continue to grow as they develop programs that respond to as well as increase the public appetite for knowledge about the Sonoran Desert and its cultures.

While public sector nurseries generally cater to the needs for commercial reforestation and production purposes, in Pima County and elsewhere in the United States, non-profit enterprises have stimulated interest in native plants by offering sales and education as a means of raising funds and augmenting the mission of the organization. In the Tucson area, organizations such as the Tucson Botanic Gardens, Desert Survivors and Tohono Chul Park, raise funds through plant sales while filling a broader purpose through education about native desert-adapted plants. Additionally, Desert Survivors provides employment opportunities for the physically and mentally impaired.

Local generalist nurseries are offering increasing numbers of native plants. The market does not appear large enough to support a nursery specializing in local native plants. Most nurseries augment income through sales of desert adapted plants from a variety of continents. Many nurseries still cater to the expectations of the thousands of migrants to the Sonoran Desert with their expectations of lush habitats by offering water guzzling, broad leafed plants that are marginal to the desert habitat. A Pima County plant nursery could stimulate interest in local native plants while making plants available to fulfill a number of specific purposes.

Las Artes as Model for a Public Sector Enterprise

Pima County operates the *Las Artes* Youth Art Program through the Community Services Department. Located in the City of South Tucson, this successful enterprise which incorporates public benefits with production goals can serve as a model for the nursery.

Los Artes produces public mural tile art. Professional artists coordinate production of the murals with at-risk youth hired to carry out the tasks related to production of the art. The program is maintained through grants and commissions for products.

The core of the program is oriented to production. Youth participating in the *Los Artes* program are part of a business. Support and enrichment activities are included in the program, but do not dominate over the main activity. Employees participate in a range of activities and have opportunities to experience a variety of tasks, but do not have control over the end product or the production schedule.

Whether or not a youth training component is incorporated into the nursery program, study of the *Las Artes* model is useful for the following reasons:

- production is not sacrificed for other needs or programmatic goals;
- the program survives through a combination of grants and commissions for products;
- the end product is visible in the community and is a means to gain support for the program.

Adherence to these principles could be the key to operation of a successful Pima County Nursery Project (Harmon, per.communication).

Rationale for a Waste Water Management Plant Nursery

The responsibility for providing the nursery site and infrastructure has been assigned to the Pima County Wastewater Management Department. Nursery operations and administration

responsibilities have been assigned to the Pima County Natural Resources, Parks and Recreation Department. The decision to use Wastewater facilities for the nursery is based primarily upon space, and the availability of water. A native plant nursery represents a wise use of wastewater effluent, benefitting both the nursery and the treatment facility. In addition to the nursery, large buffer zones should be planted around the facilities providing propagation material for the nursery, noise and odor reduction for the treatment plant, and enhanced visual aesthetics.

With careful planning, the buffer zones can be created to provide significant habitat, especially for birds. Wastewater facilities have long been enjoyed by birds, and birders alike. The development of native habitat buffer zones may be particularly important if located near critical habitat such as that needed by the endangered cactus ferruginous pygmy-owl.

Wastewater effluent can be used to irrigate the nursery, and the surrounding buffer zone. The available effluent from the treatment plants is of "controlled access irrigation quality", (secondary treated and chlorinated). As a result, measures will be necessary to restrict public access, and monitor the effluent for any potential harm to the nursery plants,

At this time, Wastewater Management personnel have identified facilities that could serve as plant nurseries following the necessary infrastructure development.

Introduction and Purpose

A county operated nursery is a beneficial use of treated wastewater effluent. Wastewater facilities are located in areas with good access for the transportation and distribution of native plants. The nutrients in effluent may be very conducive to growing vegetation. There are currently no nursery programs at the treatment facilities, although there are vegetative buffers at some of the facilities. These buffers were created as a way to use some of the effluent produced at the facility, as well as for aesthetic purposes.

In terms of division of responsibilities, Wastewater Management could be responsible for setting up the irrigation piping and maintaining the buffer zone, with Natural Resources, Parks and Recreation administering and operating the nursery.

Re-vegetated buffer zones around the facilities will serve four main functions:

- The buffer zones will be used as a propagation field - providing seed, cuttings and root stock when needed;
- The buffer zones will provide an educational component on the use of native plants;
- Buffer zones will serve to reduce the noise, odor and visual impacts of treatment facilities; and,
- Planted buffer zones will have some habitat value.

The nursery and buffer zone plantings could also provide ongoing research in the use and effects of treated effluent.

The design of buffer zone planting must include the input of treatment plant operators to avoid any harmful effects to the wastewater facility such as "leaf fall" or "root intrusion".

This report addresses three areas where immediate establishment of nurseries could begin, and two larger areas where nurseries could be established in the future. The Department is gathering detailed information about the precise locations of buffer areas, and the primary plant species currently in use, and will provide more specific data as we proceed .

Description and Location of Treatment Facilities - short-term nursery potential

Avra Valley Wastewater Treatment Plant

The Avra Valley Wastewater Treatment Facility, one of the Department's outlying facilities, is located north of Ryan Air Field and east of Sandario Road (Figure 5).

Green Valley Wastewater Treatment Facility

The Green Valley Wastewater Treatment Facility, one of the Department's outlying facilities, is located just north of Duval Mine Road and approximately one mile east of I-19 on the east bank of the Santa Cruz River (Figure 6).

Marana Wastewater Treatment Facility

The Marana Wastewater Treatment Facility, one of the Department's outlying facilities, is located north of Trico-Marana Road near the Santa Cruz River (Figure 7).

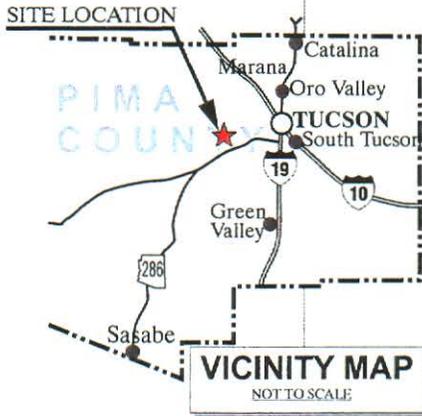
Quantity of effluent available

Avra Valley Wastewater Treatment Plant

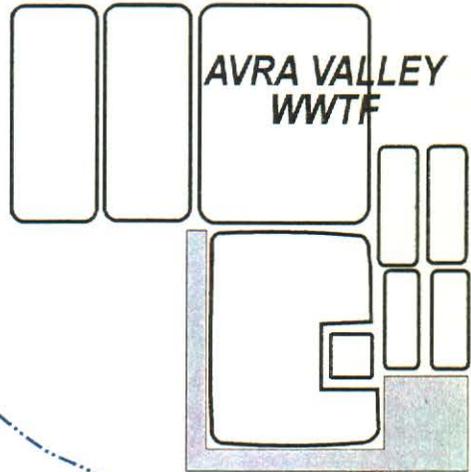
About 200,000 gallons per day (gpd) are available under the current reuse permit and could potentially be used for the nursery.

Green Valley Wastewater Treatment Facility

It is anticipated that about 1 million gallons per day (mgd) of effluent will be available from the Green Valley plant upon completion of construction in January 2002. This is in addition to the 1 mgd already contractually guaranteed to Quail Creek. As part of this agreement, Quail Creek does have the right to request additional effluent. Therefore, the amount of available effluent depends on Quail Creek's needs.



36



BLACK WASH

SNYDER HILL ROAD



LEGEND

 POTENTIAL NURSERY SITE

APPROXIMATELY 1.5 ACRES

1



**PIMA COUNTY
WASTEWATER MANAGEMENT
DEPARTMENT**

PROJECT: AVRA VALLEY WWTF
EFFLUENT REUSE

TITLE: POTENTIAL NURSERY SITE

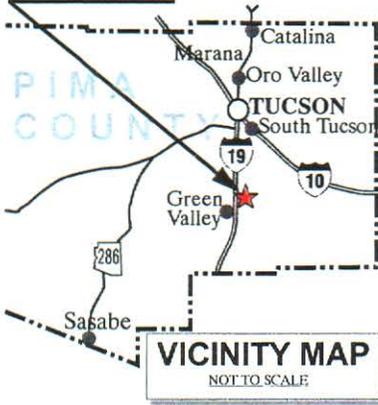
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DATE: NOVEMBER 2000

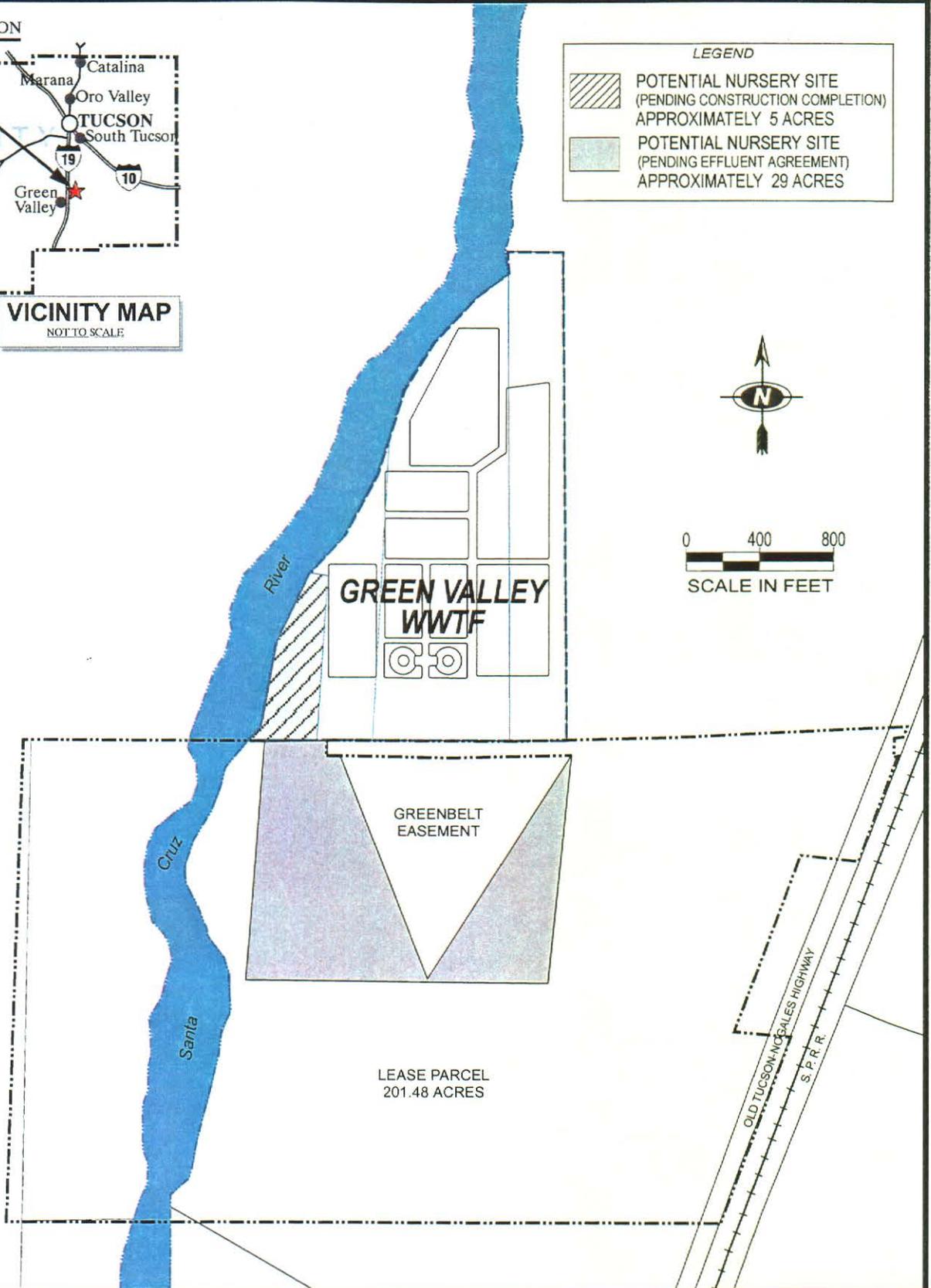
Figure 5

SITE LOCATION



LEGEND

-  POTENTIAL NURSERY SITE (PENDING CONSTRUCTION COMPLETION) APPROXIMATELY 5 ACRES
-  POTENTIAL NURSERY SITE (PENDING EFFLUENT AGREEMENT) APPROXIMATELY 29 ACRES



**PIMA COUNTY
WASTEWATER MANAGEMENT
DEPARTMENT**

TITLE:

**POTENTIAL NURSERY SITE
(PENDING EFFLUENT AGREEMENT)**

PROJECT:

**GREEN VALLEY WWTf
EFFLUENT REUSE**

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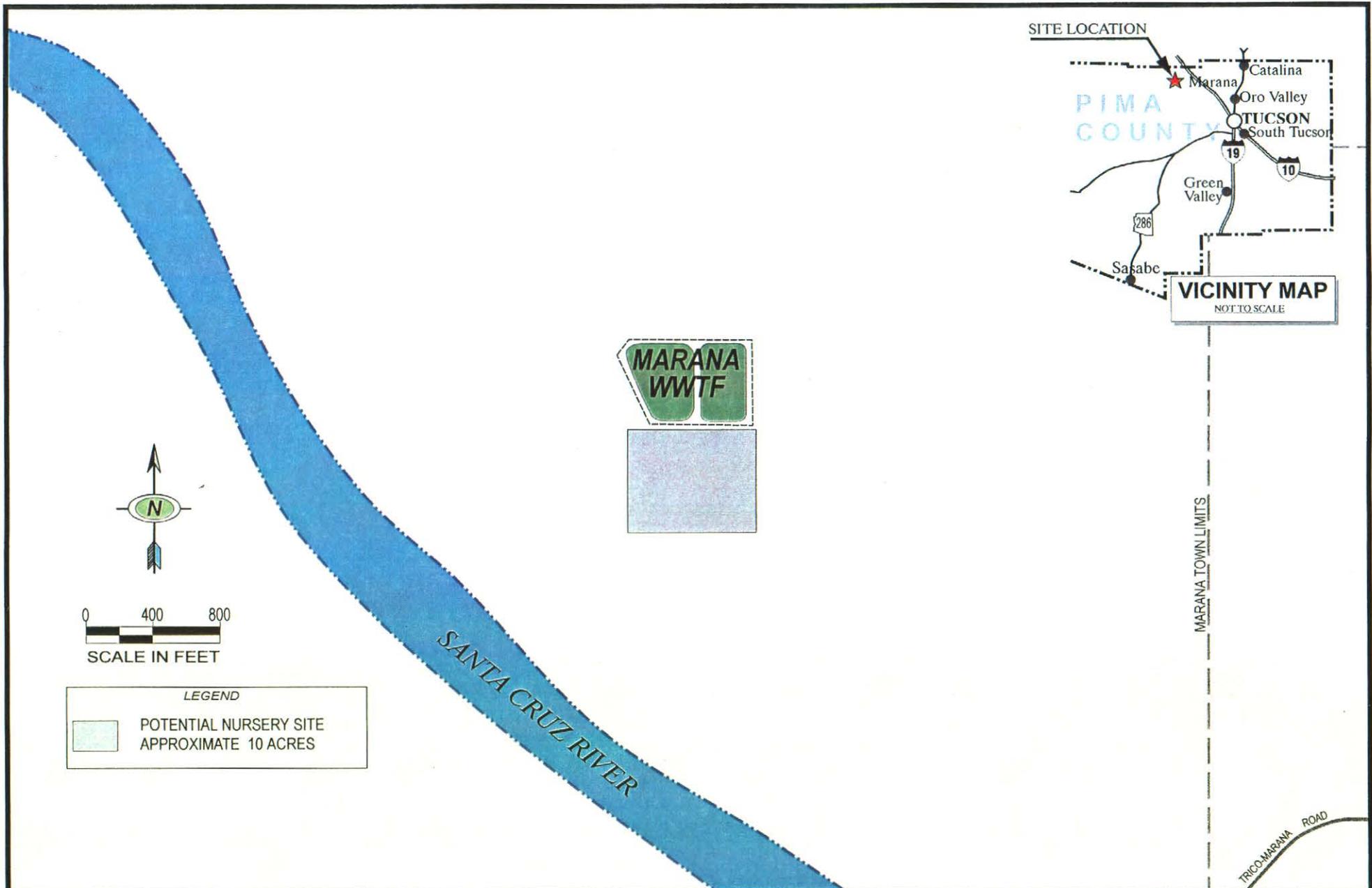
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DATE:

NOVEMBER 2000

Figure 6



PIMA COUNTY
WASTEWATER MANAGEMENT
DEPARTMENT

PROJECT: MARANA WWTF
EFFLUENT REUSE

TITLE: POTENTIAL NURSERY
SITE

DRAWN BY:

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DATE: NOVEMBER 2000

Figure 7

Marana Wastewater Treatment Facility

It is projected that the Marana facility will have an average of 30,000 gpd available for nursery purposes.

Amount of land available for nurseries

Avra Valley Wastewater Treatment Plant

Avra Valley will soon have a project under construction to create a spray irrigation system for an open area encompassing approximately 13 acres. The contract was awarded a few weeks ago, with construction expected to be complete in about one to one and one-half years. This project includes the construction of piping and plumbing for a large volume irrigation system (discharging 200 gpm), intended to discharge large quantities of effluent. As such, the spray guns might require modification for nursery purposes. Use of this spray field for a nursery might result in complications under the NPDES permit, and as such, would not be advisable.

However, there is a total of about 1.5 acres of land at Avra Valley WWTF along the south fence and at the turf area which could be used for a nursery.

Green Valley Wastewater Treatment Facility

Green Valley WWTP currently sprays effluent onto about 200 acres of leased land south of the plant, and the amended Emerald Fico agreement would deed the County a 29 acre parcel south of the plant. A portion of the acreage included in the effluent agreement could be a nursery site. There is approximately five acres of land between the river and the fenced area around the treatment plant. This property is currently being used as a staging area for the ongoing construction. However, once the construction is complete around January 2002, this land will need to be restored, and a nursery could be placed here - within a convenient distance from the effluent supply.

Marana Wastewater Treatment Facility

It is projected that there will be about 9.5 acres of land adjacent to the Marana facility which could be used for nursery purposes. There is a main line in this area, but no irrigation sprinklers have been put in place yet. As there are several application alternatives, and the system is temporary until the new plant is built, sprinklers could be rented until the permanent system could be put in place.

Quality of effluent - permits in place and modifications required

Avra Valley Wastewater Treatment Plant

The available effluent meets restricted access irrigation quality (secondarily treated, denitrified and chlorinated); the plant is already fenced to restrict public access. The existing reuse permit allows irrigation of 19.13 acres of alfalfa, trees, turf and groundcover vegetation. We are currently growing groundcover, landscaping and turf. A modification of the existing permit

will be required to include a recalculation of the consumptive water use rate for the nursery vegetation.

Green Valley Wastewater Treatment Facility

The available effluent will be restricted access irrigation quality (secondarily treated and chlorinated - when the new plant is completed some effluent will also be denitrified). The plant is already partially fenced to restrict public access, and construction of additional fencing has been planned. The existing reuse permit allows landscape irrigation; we are currently growing natural vegetation in this area. A modification of the existing permit will be required to include a recalculation of the consumptive water use rate for the nursery vegetation.

Marana Wastewater Treatment Facility

The available effluent will be restricted access irrigation quality (disinfected - when the new plant is completed some effluent will also be denitrified); the plant is already fenced to restrict public access. An application for a reuse permit has been made, however, to date, there has been no final reuse permit issued. The reuse permit would allow irrigation of riparian landscape.

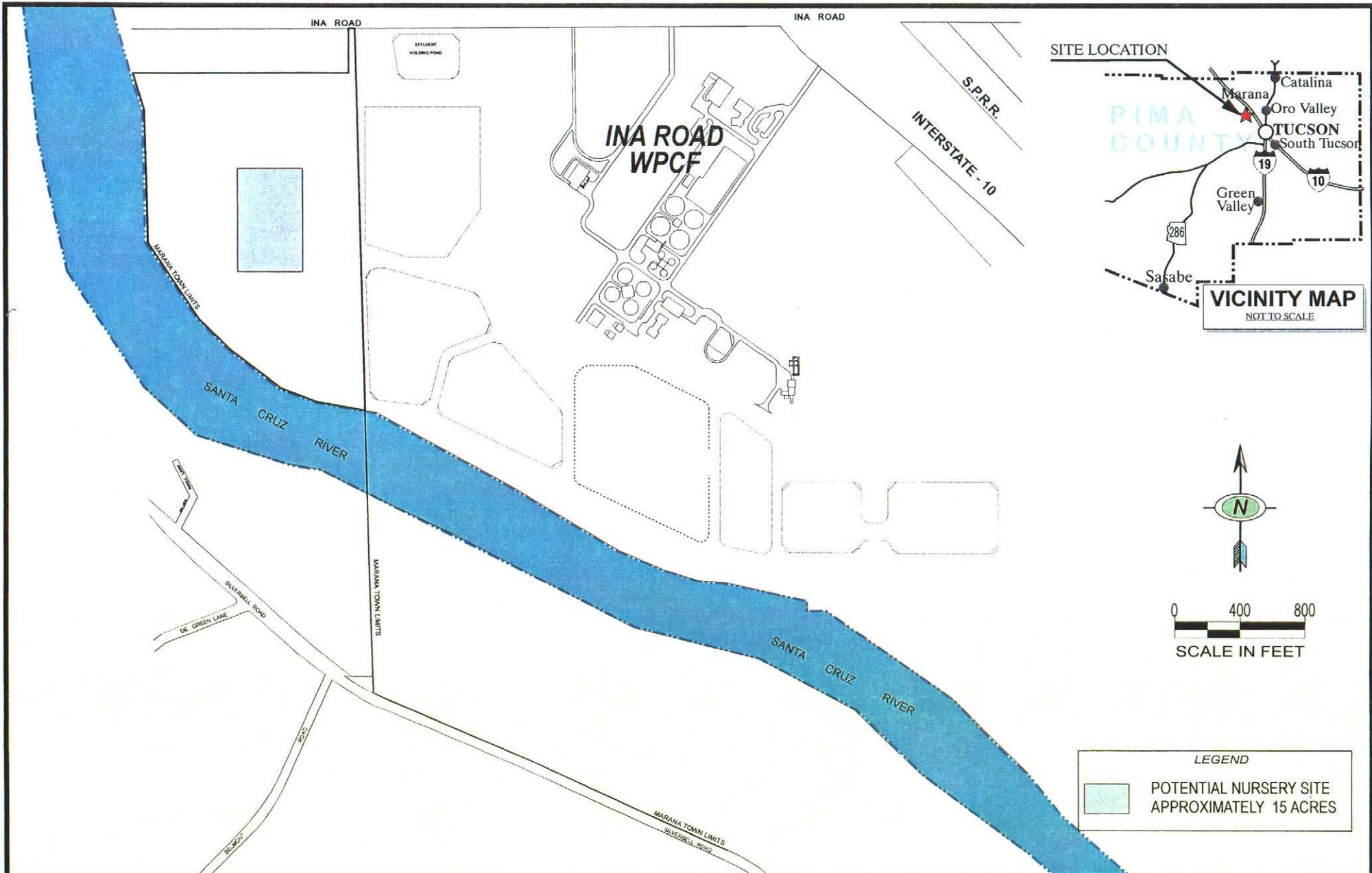
Opportunities for long-term nursery establishment

Ina Road Water Pollution Control Facility

Located at Ina Road and I-10 (see Figure 8), the Ina Road Water Pollution Control Facility has a current capacity of 25 mgd. Construction to increase the facility's capacity to 37.5 mgd is underway, with completion projected for summer 2002. This facility, established in 1977, serves the northern parts of the Tucson metropolitan area, Oro Valley and a major portion of the Town of Marana. Although the Department has filed for a re-use permit, to date it has not been issued by ADEQ. The reuse permit application included irrigation, agricultural use and golf course (restricted access). It could be modified for nursery irrigation. There is 25 mgd that is currently being discharged to the Santa Cruz River; 10% of the total effluent is allocated to the County and may be made available for nursery purposes.

There are about 15 acres of land between the facility and the Santa Cruz River which could be a potential nursery site. However, it is on the floodplain and some of the property is not very stable. The land closer to the facility could be more useable. The 10 acre land transfer to the City of Tucson could affect the siting potential for the nursery.

As the available effluent will be controlled access irrigation quality (secondarily treated, disinfected and dechlorinated), we would need to address the issue of fencing or other measures to restrict public access. In addition, construction of an access road and irrigation piping would be required.



PIMA COUNTY
 WASTEWATER MANAGEMENT
 DEPARTMENT

PROJECT:

INA ROAD WWTF
 EFFLUENT REUSE

TITLE:

POTENTIAL NURSERY SITE

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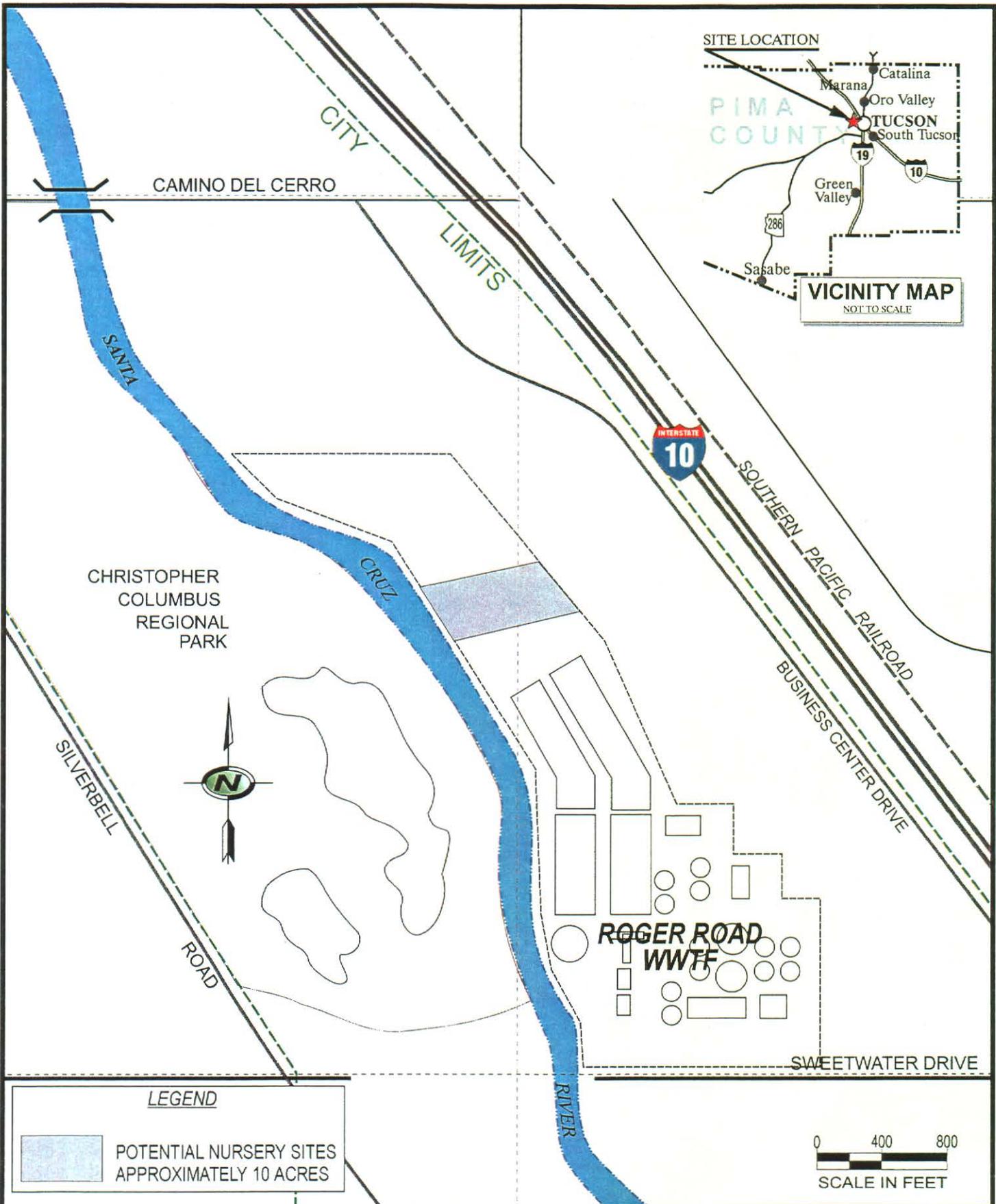
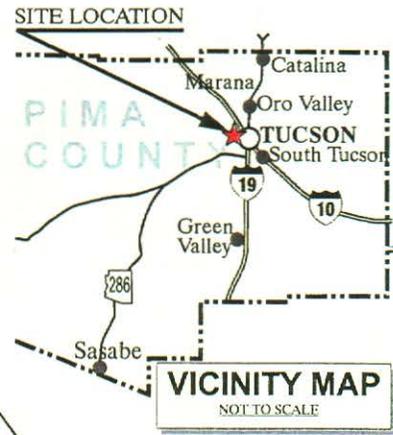
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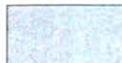
DATE:

NOVEMBER 2000

Figure 8



LEGEND

 POTENTIAL NURSERY SITES APPROXIMATELY 10 ACRES



	<p>PIMA COUNTY WASTEWATER MANAGEMENT DEPARTMENT</p>	<p>PROJECT: ROGER ROAD WWTF EFFLUENT REUSE</p>	<p>TITLE: POTENTIAL NURSERY SITES</p>
<p>DRAWN BY:</p>	<p>FILE: ROGRNRS1.CDR</p>	<p>DATE: NOVEMBER 2000</p>	<p>Figure 9</p>

Roger Road Wastewater Treatment Plant

The Roger Road Treatment Plant was established in 1951. It serves the urban Tucson area that lies south of the Rillito Creek (see Figure 9). Although the Department has filed an APP application, we do not have a re-use permit. However, we would need our own reuse permit to allow for use of effluent for a nursery.

On average, the Roger Road plant currently treats 39 mgd. The City of Tucson currently takes about 12.5 mgd, and has the right to take additional effluent. Nursery needs could be supported by the County's 10% allocation of total effluent.

Roger Road Treatment Plant is located on 100 acres. There is a land exchange called for under the Supplemental Intergovernmental Agreement (IGA) between the County and the City. Once this occurs, the nursery site can be selected.

The available effluent will be controlled access irrigation quality (secondarily treated and chlorinated). The Roger Road property is fenced except for the berm by the river. Currently, there is some irrigation system in place at the Treatment Plant, as the lawn is flood irrigated. However, most of the irrigation system has been dismantled.

Pima County Native Plant Nursery

Initially, the county nursery should specialize in growing a very limited variety of plants, eventually expanding variety and inventory as the facilities are developed. This will provide an opportunity for the involved departments to adjust to their new roles while the nursery evolves, and to phase in nursery expansion based on initial performance. As a result, the nursery program can be divided into two distinct phases as follows:

Phase One

Establish a growing program for a limited number of species, targeting the growth of rare, endangered, or vulnerable species including plants that have been extirpated from Pima County.

The initial phase could also include those plants and trees required to establish the buffer/propagation zones once the site infrastructure is established.

The phase one portion of the plan can be implemented in concert with the construction and improvement of nursery infrastructure, such as an irrigation system, thereby insuring that plants chosen will have the basic requirements for successful growth.

Following is a list of plants suggested for initial trial:

- **Huachuca water umbel** (*Lilaeopsis schaffneriana ssp. recurva*)--may require a controlled environment for propagation.
- **Screwbean mesquite** (*Prosopis pubescens*)--for Santa Cruz River re-introduction.

- **Arrowweed (*Pluchea sericea*)**--for re-introduction.
- **Ironwood (*Olneya tesota*)**--to supplement limited natural regeneration where frost conditions permit (Figure 10). This species is not suitable to grow at the Green Valley facility because of the higher elevation and the species sensitivity to frost.

The unimproved facilities are already capable of growing seed sources for many native plants including the native grasses, (sacaton, tobosa, etc.). The planting of native grasses on open irrigated fields would also help to prevent the proliferation of non-native weeds such as Russian thistle which is already prominent in some fields.

In order to execute the initial phase of the nursery plan, experienced personnel must be hired for the nursery, or a temporary task force must be established to plan, manage, and operate the initial nursery effort. Staff can be increased as needed.

Phase Two

This phase consists of the establishment of a high volume native plant nursery supplying plants and trees for county landscaping, mitigation projects, and habitat re-vegetation projects. The variety of plants grown, should be based in part on the types of plant associations found within the county. Examples would include certain native grasses, or plants from the different types of riparian habitats. Until a specific site is chosen, this proposal is based on the assumption that a high production nursery would consist of approximately five acres, fully secure, and with ample effluent and ground water (for flushing salt build-up, and for liquid based root or foliar feeding).

The high volume nursery is composed of six principal components :

- The Main Nursery
- Buffer Zones (also serve as a source for propagation material)
- Propagation Center
- Seed Bank
- Native Plant Research
- Exotic Invasive Species Research Center

With the exception of number six, all components function together, and should be located at the same facility. There is some benefit to establishing a production nursery fairly close to town to minimize plant damage while transporting, and to provide a central work site for nursery personnel. Considering this, the Avra Valley Facility would be better suited than Green Valley for any high production nursery program. Other outlying facilities, including the Green Valley Facility can be used for special projects such as using effluent irrigated open space for seed production. This would be particularly helpful for generating a productive seed source for native grasses, native perennial and annual wildflowers, and large container trees that can utilize low maintenance drip irrigation methods.

Ironwood *Olneya tesota*

Ironwood is one of the largest and longest-lived Sonoran Desert plants, reaching 45 feet in height and persisting as long as 1,500 years. It is a single or multi-trunked tree, and displays lavender to pink flowers starting in March. By early summer, the pods mature. Each 2-inch pod contains one to four shiny brown seeds that are relished by many Sonoran animals, from small mammals and birds to humans. Its iron-like wood is renowned as one of the world's densest woods.



The shaded sanctuary and richer soils created by the ironwoods increase plant diversity and provide benefits to wildlife. Some 160 species of plants and 80 species of birds use ironwoods in some way. Ironwoods are too hard to provide nesting cavities for birds, but the cacti that grow beneath them provide such opportunities. Insects abound within the ironwood complex, attracting birds and reptiles. As with other legumes, the ironwood's leaf litter supplies nitrogen to the soil and its seeds provide a protein-rich resource for doves, quail, coyotes, and many small rodents.

This tree is found only in the Sonoran Desert. Ironwood functions as oases of fertile and sheltered habitat within a harsh and challenging desert landscape. As a tree becomes established, it tempers the physical environment beneath it, creating a micro-habitat with less direct sunlight, lower surface temperatures, more organic matter, higher water availability, and protection from herbivores. Air temperatures may be 15 degrees cooler under ironwoods than in the open desert sun five feet away. Ironwood also shelters frost-sensitive young saguaros, organ pipe cactus, and night-blooming cereus.



For more information on ironwood, refer to:

Lipsky, Andrew A. "Ironwood (*Olneya tesota*)." *Non-game Field Notes*. Arizona Game and Fish Department. Non-game Branch. 11/17/00 Website <http://www.gf.state.az.us/frames/fishwild/ngame_d.htm>

The Main Nursery

The main growing grounds comprise the largest portion of the site and must be laid out with consideration for irrigation run-off, microclimate generation, and container mobility. The growing area should consist of 10 feet wide, crowned rows, with access lanes between rows. Each crowned row should be bounded by drainage tiles that will transport excess irrigation or storm water to surrounding buffer zone plants, thus minimizing a constant mud problem, and the potential for limiting conditions favorable for soil born fungal growth. Plant containers should be evenly spaced within the rows, which should be slightly graveled to lift containers off of the bare ground. The growing area, and the wastewater facility, should be surrounded by a vegetative buffer zone of native plantings that will support the propagation function, reduce waste-water facility odor, serve as a wind-buffer, and will demonstrate the beauty of native plant landscaping.

Nurseries generally operate using a "bump-up" methodology whereby plants and trees start out in small containers, and are bumped-up into larger containers as they grow. This allows the root systems to infiltrate and utilize the entire soil mass. If the growing area for container plants consists of 2.5 acres, then the nursery is capable of nurturing over 3,000 5 to 15 gallon size trees, and over 30,000 1 gallon shrubs and perennial plants at one time. Many large box trees can also be stored and utilized for shade and frost protection. These figures allow for access lanes, and enough space between plants to provide unimpeded growth and ventilation (which stimulates full luxuriant growth, stronger trees due to wind action, and limits the spread of diseases).

Due to the expensive machinery requirements, limited transplant viability, and the care needs of plants and trees that have been grown in the ground, dug up, and then boxed, it is suggested that most plants be container grown including 4 foot box trees. Trees that are field grown require the use of root balling machines, and suffer extended periods of transplant shock. Container grown plants suffer little, if any, transplant shock. Given the fast growth rate of most native trees, it may be advisable to limit container trees at the 15 gallon size, thus eliminating the need for the expensive machinery required for larger containers such as 4ft. box trees. It would also make it easier for the people planting the trees. On the other hand, salvaged trees will require large containers, forklift capability, and long transplant care to avoid any shock decline. Smaller plants and shrubs should be grown in 1 to 5 gallon containers. There is no point in using oversized containers for small plants as root systems will rarely occupy the entire soil mass. Roots hold the root ball together when transplanting, otherwise the root ball will fall apart during handling and shock or kill the plant.

Irrigation needs of container plants vary widely. Over-watering is as destructive as insufficient water. As a result, watering schedules are created for each species on an "as needed" basis, rather than a routine daily watering of all plants. For instance, all riparian trees and shrubs will require considerably more water than mesquites and ironwoods. Larger plants may be placed on drip irrigation, but a scheduled flushing of containers is suggested to reduce salt and chemical build-up in the soils. Each growing row should be provided with its own water source for hoses and drip methods.

Fertilization of plants can be accomplished using any one of several methods and products. The correct product and application method can be determined once the nutrient potential of the effluent is determined. All native plants can be sensitive to excess feeding. As a result, the feeding program should be carefully planned.

The light requirements of shade loving plants can be met by creating microclimates with the use of lath-houses, shade cloth covers, or the strategic planting of certain trees that provide filtered shade and some frost protection. Native mesquites are ideal for this purpose since their canopy allows light penetration. Non-native hybrid mesquites are of no use due to their heavy canopy and the deep shade they create. Also, depending on the orientation of the rows, the container trees can also be used to shield smaller plants.

The nursery can also contain smaller sections for container or tube grown native grasses, cacti, and salvaged native plants of all kinds. This section can also be used for special projects such as growing large numbers of plants in 2 inch tube containers designed for large project plantings (i.e., road easements, etc.).

Plant diseases and other problems can be reduced using wise nursery planning. Most nurseries suffer problems due to overcrowding and poor watering practices that rapidly spread disease, especially if the plants are stressed. If planned properly, most problems can be avoided, thus reducing the need for constant chemical applications.

The following list briefly describes some of the facility requirements and labor needs for the nursery.

Facility Requirements (Pima County Wastewater Management Department, and Natural Resources, Parks and Recreation Department)

- Acreage for the growing areas, and the boundary buffer zones, complete with security fencing, and adequate water (effluent and fresh ground water).
- Graded lot with crowned rows and drainage tiles installed.
- Building for office, crew room, restrooms, and the seed bank (with chest freezers). The buildings may be portable or modular.
- Storage for fertilizers, tools, etc.
- Contract for 5 part soil mix delivery (AAA fertilizer can custom mix soils).
- Soil storage bins, portable potting ramada, potting benches, nursery carts and tools.
- Nursery containers of all sizes and types, including tree boxes.
- Trailer mounted tanks with pumps.
- Forklift or small bobcat.
- Flat bed truck with lift gate, and tree carts.
- Propagation facilities (listed in this section).

Personnel Requirements (Pima County Natural Resources, Parks, and Recreation Department)

The nursery will require the following personnel (at the minimum):

- Nursery manager (experienced with native plants)

- Propagator
- Two trained nursery workers
- Lead irrigator
- One or two seasonal irrigation helpers

All full-time personnel shall be safety certified for machinery, chemical, and wastewater effluent use.

Propagation Fields - Buffer Zones

Nurseries that propagate their own plants must have adequate supplies of seed, cuttings, and root stock necessary for in-house propagation. The use of the buffer zones that surround the nursery and treatment facilities, as one of the sources for this material is recommended. The buffer zones will be planted with native trees and under-story plants from which propagation material can be acquired. This should be combined with specialized growing areas designed specifically for seed and cutting stock, and material obtained from other areas for genetic variety.

Besides providing propagation material, the buffer zones can serve as an educational tool for native landscaping classes, increase habitat for birds, reduce noise and odor, and enhance the appearance of the facilities.

Outlying facilities such as the Green Valley plant, have effluent irrigated open fields that could be planted with native grasses, and desert perennial and annual wildflowers. The field could be used to generate a substantial seed source for plants such as sacaton, tobosa, and other native bunch grasses. The seeds can then be used on county re-vegetation projects in an attempt to restore native plant associations and habitat.

Outlying facilities can also be used to store and grow extra large box trees that can be drip irrigated with minimal care. One acre of land can support over 150 large 4 ft. box trees.

Propagation Center

The propagation center is a small complex of green houses (portable), a lathe-house, potting benches, and a small green house with a timer activated misting array for small cuttings. Once new plants have grown sufficient root systems, they are then transplanted into larger containers and moved to the growing areas.

Depending on funding for the nursery, the propagation center might also add a section to experiment with aquatic flora and fauna. However, this task could be performed using a research agreement with other groups or agencies such as the Environmental Research Lab.

The propagation center is the heart of any nursery, providing an continuous supply of plants, and experimentation with native plant species that are endangered or extirpated from Pima County. The propagation of native plants requires experience and expertise, and should not be performed by amateurs.

Seed Bank

Seed banks are used to store all seeds acquired through purchase, or harvested from the propagation fields. Seed banks usually consist of chest freezers, storage containers, and a small lab bench to monitor seed viability. Seed banks are valuable tools for native plant conservation. If enough seed is harvested, then extra amounts can be made available to the public, and for government and non-profit restoration projects. However, since the seed industry is heavily regulated, all seed made available outside the nursery should be distributed free of charge. Providing homeowners with small packets of native seed, along with educational materials, could be an interesting public outreach and education program.

Native Plant Research at the Constructed Ecosystem Research Facility

Pima County's existing Constructed Ecosystem Research Facility (CERF), located on a three-acre site next to the Roger Road Treatment Plant, is ideal for riparian and aquatic plant research. CERF consists of six pilot-scale lined ponds with pumps to use secondary effluent that has not been chlorinated. CERF has an on-site water quality laboratory. Past research has included study of mosquito control using subsurface wetlands and plant response to potable versus secondary effluent. Ongoing research includes studies of the suitability of tobosa and salt grass, two native grasses, for use as filter strips for stormwater. These plants can withstand prolonged periods without water and are adapted to periodic flooding. When available, stormwater will be obtained and delivered to the plants.

Some of the topics that can be considered for future research at CERF may include:

- Water quality issues using effluent, including chlorinated effluent, for nursery irrigation.
- Propagation and transplant techniques for the Huachuca water umbel.

A separate facility to facilitate salvage and transplants of upland species is also needed. Topics for research are many. The potential for research grants and cooperative studies may be quite high.

Exotic Invasive Species Research Center

The facility can be used to set up carefully designed growing areas for invasive exotics such as buffel and fountain grasses, African sumac, and other species harmful to native ecosystems. These sites can be used to evaluate seed dispersion and to experiment with eradication methods. If office space is adequate, then the facility can be used as the mapping and research headquarters for the exotics species task forces that are currently forming and beginning to generate public outreach programs.

Summary

The creation of a native plant nursery may generate grant monies that can minimize the county's funding obligations. In so doing, the nursery may become fairly self-sufficient. If the county agrees to establish a systematic replacement of non-native vegetation at county owned facilities, then the nursery can provide all of the plants necessary for the project.

Uses of Nursery Plants

The Pima County Nursery will offer plants for specific purposes such as:

- County landscaping contracts – roads, parks, riparian and other habitat restoration - County nursery should be source of first refusal to provide plants for county projects.
- Other county projects – housing, public building, etc. Nursery plants should be available for county-funded housing developments.
- For public education purposes – displays at Tucson Botanic Gardens, Arizona Sonoran Desert Museum and other locations as well as parks.
- Plants distributed to schools for demonstration/educational projects such as migratory pollinators, ethnobotany, etc. – this could be in conjunction with, Arizona Sonoran Desert Museum, and other organizations. Agencies like Pro Neighborhoods could distribute plants to neighborhood organizations.
- Salvage plants could be used for county projects or sold.
- Plants could be provided to research organizations for scientific purposes – for study, monitoring and other needs.
- Plants could be grown for buffer areas at the nursery and other locations. These plants in turn could serve as sources for seed and cuttings.
- Plants could be sold to county projects at contract rate by means of cost transfers.

Plants that will be selected for propagation through the nursery project will be based on the following criteria. To be considered for nursery propagation, the species should have successful propagation history:

- plants that have grown or are growing on habitat that has been lost in or is in danger of being lost in Pima County;
- plants that are potentially impacted by development and future development;
- Pima County native plants that show promise for horticulture;
- Pima County native plants that are needed in the nursery industry or on Pima County projects but are not available;
- plants for demonstration, experimentation, or special projects.

Tables 1 and 2 list suggested shrubs and trees for native plant nursery cultivation.

Table 1: Suggested Trees for Nursery Cultivation

Botanical Name	Common Name	Water Use	Propagation Method	Growth Rate	Cultivation Problems
<i>Acacia constricta</i>	Whitethorn Acacia	Low	Seed	Fast	None
<i>Acacia greggii</i>	Catclaw Acacia	Low	Seed	Fast	None
<i>Celtis reticulata</i>	Canyon Hackberry	Low	Seed	Fast-Moderate	None
<i>Cercidium floridum</i>	Blue Palo Verde	Low	Seed	Moderate	None
<i>Cercidium microphyllum</i>	Littleleaf Palo Verde	Low	Seed	Moderate	None
<i>Chilopsis linearis</i>	Desert Willow	Low	Seed	Moderate	None
<i>Cupressus arizonica</i>	Arizona Cyprus	Low	Seed - Cuttings	Slow	Insect Damage
<i>Fraxinus velutina</i>	Arizona Ash	High	Cuttings	Fast	None
<i>Juglans major</i>	Arizona Walnut	Moderate	Seed	Moderate	Rodent Damage
<i>Lysiloma thornberi</i>	Feather Tree	Low	Seed	Fast	Frost Tender
<i>Olneya tesota</i>	Ironwood	Low	Seeds	Moderate	Frost tender
<i>Platanus wrightii</i>	Arizona Sycamore	High	Cuttings	Fast	None
<i>Populus fremontii</i>	Fremont Cottonwood	High	Cuttings	Fast	Minor Insect Damage
<i>Prosopis velutina</i>	Velvet Mesquite	Low	Seed	Fast -Moderate	None
<i>Psoralea argophylla</i>	Smoketree	Low	Cuttings	Moderate	None
<i>Quercus arizonica</i>	Arizona Oak	Moderate	Seed	Slow-Moderate	None
<i>Quercus emoryi</i>	Emory Oak	Moderate	Seed	Slow-Moderate	None
<i>Salix gooddingii</i>	Goodding Willow	High	Cuttings	Fast	None
<i>Sambucus mexicana</i>	Mexican Elderberry	High	Seed-Cuttings	Fast	None
<i>Sapindus saponaria</i>	Soapberry	Low	Seed	Moderate	None

Table 2: Suggested Shrubs for Nursery Cultivation

Botanical Name	Common Name	Water Use	Propagation Method	Growth Rate	Cultivation Problems
<i>Ambrosia ambrosiodes</i>	Canyon Ragweed	Moderate	Seed-Cuttings	Fast	Invasive, Allergen
<i>Ambrosia deltoides</i>	Triangle Leaf Bursage	Moderate	Cuttings	Moderate	None
<i>Aniscanthus thurberi</i>	Desert Honeysuckle	Moderate	Cuttings	Fast	Frost tender in containers
<i>Asclepias tuberosa</i>	Butterfly Flower	Moderate		Moderate	None
<i>Aster tanacetifolius</i>	Purple Aster	Low-Moderate	Seed-Cuttings	Fast	Frost tender
<i>Atriplex canescens</i>	Fourwing Saltbush	Low	Cuttings	Slow-Moderate	None
<i>Atriplex lentiformis</i>	Quail Bush	Low	Cuttings	Slow-Moderate	None
<i>Berberis haematocarpa</i>	Red Mahonia	Low	Seed-Cuttings	Moderate	None
<i>Calliandra eriophylla</i>	Fairyduster	Low	Seed	Moderate	None
<i>Rumex hymenosepalus</i>	Canaigre	Moderate	Seed	Fast	Grow from seed on demand
<i>Celtis pallida</i>	Desert Hackberry	Low	Seed	Moderate	None
<i>Ceanothus greggii</i>	Desert Ceanothus	Low	Cuttings	Slow	None
<i>Chrysothamnus nauseosus</i>	Rabbitbrush	Low	Cuttings	Moderate	None
<i>Dasyilirion wheeleri</i>	Sotol	Low	Seed	Slow	None
<i>Dodonaea viscosa</i>	Arizona Hopbush	Moderate	Seed	Fast-Moderate	None

<i>Encelia farinosa</i>	Brittlebush	Low	Cuttings	Moderate	Insect Damage to young shoots
<i>Ephedra trifurca</i>	Joint Fir	Low	Cuttings	Slow	None
<i>Ericameria laricifolia</i>	Turpentine Bush	Low	Cuttings	Moderate	None
<i>Eriogonum fasciculatum</i>	Flat Top Buckwheat	Moderate	Seed	Moderate	None
<i>Garrya wrightii</i>	Silk Tassel	Moderate	?	?	?
<i>Gutierrezia sarothrae</i>	Snakeweed	Moderate			
<i>Hymenoclea monogyra</i>	Burro Bush	Moderate	Cuttings	Moderate	None
<i>Jatropha spp.</i>	Limber Bush	Low	Cuttings	Moderate	None
<i>Larrea tridentata</i>	Creosote Bush	Low-Moderate	Cuttings	Slow	Hard to Propagate
<i>Lobelia cardinalis</i>	Monkey Flower	High-Moderate	Seed-Cuttings	Fast	Sun protection
<i>Lycium spp.</i>	Wolfberry	Low	Seed-Cuttings	Slow-Moderate	None
<i>Mimosa biuncifera</i>	Wait-a-Minute Bush	Low	Seed	Fast	None
<i>Nolina microcarpa</i>	Beargrass	Low	Seed	Moderate	None
<i>Parthenium incanum</i>	Mariola	?	?	?	?
<i>Proboscidea parviflora</i>	Devil's Claw	Moderate	Seed	Fast	None
<i>Prosopis pubescens</i>	Screwbean Mesquite	Low	Seed	Fast	None
<i>Rhus glabra</i>	Smooth Sumac	Moderate	Cuttings	Fast-Moderate	None

<i>Rhus ovata</i>	Sugar Bush	Moderate	Cuttings	Fast-Moderate	None
<i>Rhus trilobata</i>	Squawbush	Low	Seed-Cuttings	Moderate	None
<i>Ribis aureum</i>	Wax Currant	Moderate	Seed-Cuttings	Moderate	None
<i>Senecio salignus</i>	Senecio	Moderate	Cuttings	Moderate	None
<i>Simmondsia chinensis</i>	Jojoba	Low	Seed	Moderate	Requires male /female plants
<i>Vauquelinia californica</i>	Arizona Rosewood	Low	Cuttings	Moderate	None
<i>Vitis arizonica</i>	Canyon Grape	High	Seed-Cuttings	Fast	None
<i>Zinnia acerosa</i>	Desert Zinnia	Moderate	Seed-Cuttings	Fast-Moderate	None
<i>Zizyphus obtusifolia</i>	Graythorn	Low	Cuttings	Slow-Moderate	None

NOTES

1. This list represents a "core group" of plants that should be grown regularly at the nursery.
2. This list covers plants for several natural plant associations or biomes except cacti, grasses, and aquatic plants.
3. The water use and growth rates are based upon container plantings.
4. Only significant cultivation problems are listed.

Horticultural Practice

Sonoran Desert plants are treated poorly when placed in public spaces and in backyards. Practice tends to mimic the tightly controlled designs of European gardens, with sculpted bushes and shrubs. Such practices do not take advantage of the qualities found in Sonoran desert/native plants. Flowering is inhibited, and the genetically determined form of the plant may be discouraged with pruning maintenance. To encourage the planting of native species in public areas, the County nursery research and development components can include:

- Research and develop lists of plants that are more appropriately planted in public spaces and are likely to retain a predictable form and size. Low desert composite species tend to develop into rounded sculpted shapes.
- Provide better and more frequent training in horticultural practices such as correct pruning, irrigation and fertilization techniques.

- Public education about appropriate practices with a goal to alter the expectations when native plants are used.
- Experimentation, studies and research on the growth habits and forms of Sonoran Desert plants under different conditions when cultivated.
- Introduction of new plants to replace those which may not be appropriate for public projects.
- New or redesigned landscape installations on all county projects should include guidelines that encourage the use and appropriate maintenance of Sonoran Desert native plants – training of groundskeepers should be provided to insure continued and appropriate practices are employed.
- Plants grown as part of the Pima County nursery should be considered for county projects.
- Plants that are grown in the nursery should consider the future landscaping needs for Pima County Public Works projects.
- Identify and evaluate the biologic impacts of the materials sources (borrow pits, channel excavation) used in public works projects.

Invasive Exotics

An ambitious component of this project will related to education on the issue of invasive exotics and their effect on natural areas.

There are five major components to developing an educational program:

1. Soliciting cooperation of the nursery industry to cease sales of invasive exotic plants and assist in the education campaign.
2. Developing alternative plants that will be promoted to replace the invasive exotics. Replacement plants may have some of the qualities of the exotics. Example: *Muhlenbergia spp.* can be promoted to replace Fountain Grass. *Vaquelinia* (rosewood) can be promoted to replace African sumac.
3. Education of the public about problems caused by invasive exotics – the biology of exotics, and promoting replacement species.
4. Development of ordinances and their enforcement for the more noxious species.
5. Research on predicting the invasiveness of exotics and new introductions. Attempting to determine what qualities will lead to an introduced species becoming competitive in the Sonoran Desert landscape.

Social and Educational Opportunities

Pima County's Native Plant Nursery will fulfill a significant strategic purpose under the Sonoran Desert Conservation Plan. To become a successful operation that will endure public scrutiny, its purpose must extend beyond the very specific needs and requirements of the SDCP.

The nursery can achieve its purpose when it creates excitement, as well as inspiring interest and curiosity about native plants. This excitement in turn will stimulate interest by residents to grow plants and insure their survival not only in their native habitat, but also throughout urbanized Pima County. One role will help fulfill the other. The Pima County Nursery can incorporate a number of public purposes to meet this mission.

The following list may be considered examples, and are not definitive, but intended to be indicative of potential links that can be established with local institutions and projects. These examples are indicative of the overlapping purposes that are contained within the Sonoran Desert Conservation Plan.

- The Arizona Sonoran Desert Museum (ASDM) has expert horticulturists and naturalists on their staff. ASDM has played an important role in public education about desert habitat. In recent years it has embarked on ambitious campaigns on Ironwoods and Migratory Pollinators which have had an impact on public understanding and appreciation of the environment. The Pima County Nursery could propagate or grow plants that could be distributed in conjunction with programs undertaken by ASDM.
- The Native Plant Nursery can be an integral part of the Pima County Resources Management projects. In addition to providing plants for landscape and restoration projects, the nursery could provide an opportunity to introduce youth into the field. A summer/year round program could be developed where youths could be rotated through the various projects that are related to implementation of the Conservation Plan. Participants in this program who show an interest in resource management could be encouraged to continue in the field by taking courses that are offered at local institutions. Recruitment would include at-risk youth from targeted neighborhoods through the Youth Opportunity Program or other projects administered by Pima County Community Services Department's Employment and Training Division.
- Plants could be grown and distributed as part of research projects. This could include research based upon plants that are grown in specific localities or habitats. Monitoring will need to be conducted on a formal basis. More general research could be based upon distribution of plants to homeowners. Results for the general research will be based upon less formal monitoring.
- Educational programs and projects could be developed in conjunction with the Cooperative Extension Service and Tucson Botanic Gardens. Both organizations are funded in part by Pima County and have educational missions. Projects could be developed that flow directly from SDCP but could also incorporate promotion of specific plants that are grown in the nursery, appropriate landscape gardening practices, etc.
- As a way to promote the nursery component in schools and to the public, a web page and quarterly newsletter could be developed, containing specific information on plants, nursery projects, habitats, and issues. The nursery web page would have links to different projects and programs. School children could implement projects or write

reports based upon information provided through the website/newsletter. Fact sheets on plants that are grown in the nursery would be posted and published.

- The nursery could affiliate with Tucson Audubon Society's Simpson Farm project. The goal of this project will be to restore this retired degraded farm for wildlife habitat. Pima County could assist the project by supplying plants. This could be a site for monitoring results of planting under controlled conditions.
- The Tohono O'odham Nation may contribute extensive ethnobotanical knowledge and cultural uses of native plants.

Questions-Items Needing Further Study

- Study/review is needed to determine start-up costs and budget for nursery – which sites are most feasible.
- Questions remain concerning the quality of water at Wastewater Management.
- What funds would be used for initial capital and operating costs?
- Development of management plan – job descriptions.
- Development of strategic marketing plan – what does it make sense to grow – what needs to be grown to sustain the nursery?
- Research to determine appropriate nursery plants; species and numbers needed, etc. Refinement of the list of potential plants.
- Exploration of potential links to county projects –
 - Restoration
 - Public works
 - Nursery sales
 - Public sales
- Developing a list of plants that are worthy of study/propagation – feasibility of plant on current list.
- Interest from other institutions and possible partnerships – Tucson Botanical Gardens, Arizona Sonoran Desert Museum, Tohono O'odham Nation, Desert Survivors, etc.
- Develop inventory of Pima County native plants in nursery cultivation – why are some not propagated – what are difficulties – what is needed to increase sales of native plants. What are the perceived barriers to using native plants?
- Research cultivation and propagation needs.
- How can this project help the nursery industry – how can the nursery industry help the project?

Institutional Links/Potential Collaborators-Partners

- Native plant and seed sources from Arizona Native Plant Society web site <http://azstarnet.com/~anps/html/az_plant_sources.html> (also see Appendix A).
- Arizona Sonoran Desert Museum- expert horticulturists/propagators-have a migratory pollinator program.
- University of Arizona
 - cooperative extension service-important education role
 - Landscape Architecture Program

- Natural Resources-agriculture department/Office of Arid Land studies
- Water Resources Research Center
- U.S. Geological Survey--Tumamoc Hill Laboratory
- Desert Survivors
- Tucson Botanic Gardens-interested in selling new and interesting plants
- Tohono Chul Garden
- Native Seed/SEARCH
- Arizona Native Plant Society
- Southern Arizona Water Resources Center
- Desert Botanic Gardens-Phoenix
- Pro Neighborhoods
- Boyce Thompson Arboretum
- Pima College-environmental training programs
- Arizona Game and Fish Department
- Arizona Department of Agriculture
- Arizona State Lands Department
- U.S. National Park Service-Saguaro National Park, Organ Pipe Cactus National Monument
- U.S. Fish and Wildlife Service
- Coronado National Forest
- U.S. Bureau of Land Management
- The Nature Conservancy
- Trees for Tucson/ Global Releaf
- Tohono O'odham Nation
- Pima County jurisdictions
 - City of Tucson
 - City of South Tucson
 - Town of Marana
 - Town of Oro Valley
 - Town of Sahuarita
- Private nurseries
- Leverage on Pima County funded programs to work closely with project.
- Local lifestyle magazines-for example *Tucson Lifestly Home and Garden*
- Natural Resources Conservation Services

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Harmon, Dorothee. Pima County Community Services Department. Interview, 11/3/99.

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Appendix A

Arizona Native Plants and Seed Sources

The Arizona Native Plant Society is providing this list as information only. ANPS does not endorse or recommend the sources listed here. If you know of other sources for Arizona native plants and seeds or have any corrections to this list, please email anps@azstarnet.com.

ST	City	Name/Address	Contact Information	Comments/ Specialty
AZ	Chandler	<u>Arizona Cactus Sales</u> 1619 S. Arizona Ave Chandler, AZ 85248	(480) 963-1061	Cacti and Succulents
AZ	Clarkdale	Arizona Botanical Gardens 1601 W. Hwy 89-A Clarkdale, AZ	(520) 634-2166	
AZ	Douglas	Zamp Country Nursery 3925 N. Kings Hwy Douglas, AZ 85607 (1 1/2 miles off Hwy E. 80)	(520) 364-3809	
AZ	Flagstaff	<u>The Arboretum at Flagstaff</u> 4001 S. Woody Mountain Road Flagstaff, AZ 86001	(520) 774-1442 FAX (520) 774-1441	Plants available May-November. Seed available March-December. Annual outdoor plant sale event 3rd weekend in June. Holiday plant sale 1st Saturday in December.
AZ	Flagstaff	<u>Flagstaff Native Plant and Seed</u> 400 E. Butler Ave. Flagstaff, AZ 86001	(520) 773-9406 FAX: 520-773-0107 info@flgnativeplant.com	
AZ	Flagstaff	Sinagua Nursery 7800 Rain Valley Road Flagstaff, AZ 86004	(520) 527-1595	Wholesale
AZ	Morristown	Desert Enterprises P.O.Box 23 Morristown, AZ	Attn: Judith A. Clement	Large quantities of seed available
AZ	Parker	Ahakhav Native	520-669-2664	Hours: M-F, 7:00-4:00

		Plant Nursery Route 1, Box 23 B Parker AZ 85344	520-669-2425 (fax) nativenursery@redrivernet.com Jennifer Kleffner, Nursery Director	(8:00-5:00 in winter, 6:00-3:00 in summer) or by appointment. Call to confirm hours.
			<i>Location: just south of Parker, take Mohave Drive toward Poston. Then right on Rodeo Road (watch for brown 'Ahakhav Tribal Preserve' signs and PIRA - Parker Indian Rodeo Association - sign). Road turns to dirt and curves to left. Nursery is on right side.</i>	
AZ	Pearce	Spadefoot Nursery/Plants of the Apacheria HC1 Box 347C Pearce, AZ 85625	(520) 824-3247	Wholesale nursery & consulting
AZ	Phoenix	<u>Desert Botanical Gardens</u> 1201 North Galvin Parkway Phoenix, AZ 85008	(480) 941-1225	Nursery; Spring and Fall plant sales
AZ	Phoenix	Desert Tree Nursery Cave Creek Road Phoenix, AZ 85024	(602) 569-1300	
AZ	Phoenix	Hubbs Brothers Seed Company 40 N. 56th St., Phoenix, AZ 85034	(602) 267-8132.	Carry seeds for plants native to the Mohave and Sonoran Deserts
AZ	Phoenix	Jorn Ake 1805 N 16th Ave. Phoenix, AZ 85007	jorn.ake@mindspring.com	Seeds
AZ	Phoenix	Mountain States Wholesale Nursery 10020 W. Glendale Ave. Glendale, AZ 85307	(800) 840-8509 Sales@mswm.com FAX: (623) 247-6354	Wholesale
AZ	Phoenix	<u>Western Tree Company</u> 3401 East Southern Ave. Phoenix, AZ 85940	(602) 243-6125 FAX: (602) 243-3764	Wholesale
AZ	Prescott	Garden Mart 747 N 6th St. Prescott, AZ	(520) 771-9410	
	Prescott	Central Arizona	(520) 775-0585	Landscaper; stresses

AZ	Valley	Native Landscape 8541 E. Ramble Way Prescott Valley, AZ 86314	aloga01@ycpo.yavapai.cc.az.us	the use of Arizona's Native flora and natural surroundings.
AZ	Sonoita	Diamond JK Nursery S. Hwy 83 Sonoita, AZ (next to Eagle Milling Feed Store)	(520) 455-9262 or (520) 455-5387	Tree grower; native trees and native adapted trees available. April through September.
AZ	Superior	Boyce-Thompson Arboretum 37615 U.S. Highway 60 Superior, AZ 85273	(520) 689-2723 FAX: (520) 689-5858	Nursery; Spring and Fall plant sales
AZ	Tempe	Desert Seed Source Chuck LeFevre P.O. Box 25555 Tempe, AZ 85285	(602) 226-4886	May be wholesale; seed list
AZ	Tempe	Wild Seed Inc. Rita Jo Anthony P.O. Box 27751 Tempe, AZ 85285-7751	(602) 276-3536 FAX: (602) 276-3524	Any mixture in any amounts necessary from yards to large-scale revegetation.
AZ	Tucson	B&B Cactus Farm Inc. 11550 E. Speedway Tucson, AZ	(520) 721-4687	Wholesale and retail; Cacti and succulents
AZ	Tucson	Bach's Greenhouse Cactus Nursery 8602 N. Thornydale Rd. Tucson, AZ	(520) 744-3333	Wholesale and retail; cacti and succulents
AZ	Tucson	Catalina Heights Nursery 6074 E. Pima Tucson, AZ 85712	(520) 298-2822	Limited number of native plants
AZ	Tucson	<u>Civano Nursery Garden Center</u> 5301 S. Houghton Road Tucson, AZ	(520) 546-9200	Check their website for a list of plants they have available.
AZ	Tucson	<u>Desert Survivors</u>	(520) 791-9309	Open year round;

		Nursery 1020 W. Star Pass Tucson, AZ		Spring and Fall plant sales
AZ	Tucson	Desert Trees Nursery 9559 N. Camino Del Plata Tucson, AZ 85741	(520) 297-5664 (800) TREE-041	Wholesale
AZ	Tucson	Doug Moore P.O. Box 114 Cortaro, AZ 85652-0114	520-682-0459 featherstonetr@aol.com	Desert landscape design specializing in cactus and low water- use plants, particularly native plants.
AZ	Tucson	Elephant Tree Greenhouses 130 W. Armijo Street Tucson, AZ 85701	Marya C. Olsen, proprietor (520) 360-2056 or 882-8335 Please call for appointment	Locally grown native and arid-friendly plants
AZ	Tucson	Landscape Cacti 7711 Bopp Road Tucson, AZ 85735	(520) 883-0020	Wholesale and retail; cacti and agaves
AZ	Tucson	Magic Garden Nursery 7909 E. 22nd Street Tucson, AZ	(520) 885-7466 magicg@azstarnet.com	
AZ	Tucson	Mesquite Valley Growers Nursery 8005 E. Speedway Blvd. Tucson, AZ 85710	(520) 721-8600	
AZ	Tucson	<u>Native Seed Search</u> 526 N. 4th Ave. Tucson, AZ 85705-8450	(520) 622-5561 FAX: (520) 622-5591	Non-profit organization preserving Native American crop seeds
AZ	Tucson	<u>Plants for the Southwest</u> 50 E. Blacklidge Dr. Tucson, AZ 85705	(520) 628-8773	Cacti and succulents; native plants
AZ	Tucson	Starr Nursery 3340 W. Ruthann Road Tucson AZ 85745	(520) 743-7052 starrnursery@worldnet.att.net	Wholesale (specializes in Chihuahuan Desert introductions)

AZ	Tucson	Sticky Situations	(520) 743-9761 Open by appointment only	Wholesale and retail; cacti
AZ	Tucson	<u>Tohono Chul Park</u> 7366 N. Paseo del Norte Tucson, AZ 85704	(520) 742-6455	Nursery; Spring and Fall plant sales
AZ	Tucson	<u>Tucson Botanical Gardens Nursery</u> 2150 N. Alvermon Way Tucson, AZ 85712	(520) 326-9686, ext. 27	Nursery (Oct. to May); Spring and Fall plant sales