City/County
Water and Wastewater Study

June 15, 2009

To: City/County Water and Wastewater Study Oversight Committee

From: C.H. Huckelberry
County Administrator

Mike Letcher
City Manager

Re: **Growth Technical Paper**

Introduction

One of the goals included in the Scope of Work for Phase II of the City/County Water and Wastewater Study was for the City and County to come to agreement on population growth, water, urban form, infrastructure and land use planning. The scope states:

> *The City and County need to come to common agreement on the location of our future population growth increment to 2050. Urban form, water and infrastructure planning will directly influence where this future population growth increment will occur. Locating this future population should be done in a manner so as not to disadvantage or adversely impact existing residents. New growth must be located where it is beneficial to the environment, economy, and conservation of our resources. Large-scale infrastructure systems will be necessary to support the growth centers and integrate with the existing urban infrastructure systems that are in place. Most importantly, long-term future water supply cannot occur at the expense of our existing residents or the environment.*

Stantec Consulting Inc. and Curtis Lueck & Associates, who recently have conducted work for Pima County in the areas of infrastructure and land use planning, were hired to work with a team of City and County staff to develop the attached technical paper.

The paper does not attempt to predict if, how much, or when growth will occur, but rather attempts to answer the question: *If growth does occur, how can we accommodate it in the most sustainable manner possible?* The paper looks at both the location of growth and the form of growth, and discusses criteria that can be used to evaluate areas most suitable for future development and the positive and negative aspects of various forms of development. The next paper that the Committee receives will build off of this paper, and will deal with specific issues of integrating land use and water resources planning.

The key finding of this paper is that the City and County can plan for future development in a way that increases choice in housing types and transportation modes for both existing and future residents, increases access to jobs and services, decreases costs to tax payers, and decreases water use, energy use, and land consumption.

Technical Paper Highlights

Form of Growth

One aspect of the scope question focuses on ensuring that growth does not adversely impact existing residents, and is sited in a manner that is most beneficial to the environment, economy and conservation of resources. These issues are affected by the form that development takes. The technical paper uses the term "urban form" to describe the arrangement, appearance and functionality of a community, which relates to the pattern of the built environment. Urban form includes such things as how compact or spread out development is, the amount and types of land uses whether separated or co-located together, the amount of public open space, the size of lots, the amount and location of roads, parks, and other infrastructure, how far people have to drive, the availability of transit, the walkability of the area, etc.

The paper uses benchmark data from other regions to analyze the pros and cons of various urban form patterns from a sustainability perspective. An important aspect of urban form is density, but it is only one consideration. Density in metropolitan Tucson presently averages about 4 people per acre or 2,560 people per square mile. The paper points out that as we grow, we have the opportunity to implement sustainable development approaches including good urban design, increasing density, and integrating a mix of land uses in selected locations as many other regions have done, which can have a variety of benefits such as:

- Reduced car passenger miles
- Fewer miles of road per capita
- Lower water consumption
- Lower energy consumption and greenhouse gas emissions
- Improved public health
- More walkable neighborhoods and urban spaces
- Public services at lower cost to taxpayers
- More transit opportunities
- More types of housing choices

Future Growth Locations & Scenarios

Another aspect of the scope question refers to location of future population growth. The paper models several growth scenarios for a hypothetical doubling of our population to two million people. This represents 973,000 more people than the current metropolitan area population of 1,027,000 (2008). This population threshold was chosen primarily for discussion purposes, but is consistent with (1) the water resource availability analysis done by Sharon Megdal showing current water resources to support 1.8 to 2.3 million people and (2) a buildable land analysis done by PAG showing land available to support 2.2 million people. Although the Scope of Work for the City/County study citied a date of 2050, this paper does not try to anticipate a date for when such a population increase may occur.

This paper focuses on the Water/Wastewater Study Area defined as the Tucson city limits plus the Tucson Water Obligated Service Area, plus unincorporated Eastern Pima County, excluding other cities and towns and tribal lands. Of the 973,000 new people modeled in the growth scenarios, 238,000 (based on Arizona Department of Economic Security (DES) projections) were subtracted and allocated in lump sum fashion to the towns of Marana, Oro Valley, and Sahuarita, with the remaining 735,000 allocated to the Study Area.

Factors and constraints were identified and GIS modeling was applied to vacant and underdeveloped land in order to determine the areas most suitable for future development. Factors are defined as preferentially weighted variables such as proximity to infrastructure and employment centers, while constraints eliminate certain lands from consideration such as parks, federal lands, protected open spaces, airports, hillsides, and floodways.

Various factors were combined into four different urban form scenarios that were used to place population within the suitable areas. The four scenarios include:

1) Status quo scenario (growth continuing as is)
2) Enhanced habitat protection scenario
3) Infrastructure efficient/taxpayer savings scenario
4) Transit oriented development scenario

These scenarios are hypothetical and meant to illustrate different ways the community could grow and different results that would be achieved. The scenarios are not meant to be mutually exclusive and elements of each could be used in conjunction with each other. Note that the amount of future growth allocated to the towns of Marana, Oro Valley, and Sahuarita was held constant for all four scenarios.

The major difference in inputs to the four scenarios is the density of future growth allocated to the suburbs, outside of already planned but unbuilt or partially built communities. The exception to this is the Transit Orientated Development Scenario, which also increased densities within the urban area along rapid bus transit lines, the street car alignment, and alignments for light rail and commuter rail.

The table below describes the relative benefits of the four scenarios across various indicators, and also includes the density averages used to place development in new growth areas. The indicators show that siting future development in a way that is different from the status quo could increase choice in housing types and transportation modes for both existing and future residents, increase access to jobs and services, decrease costs to tax payers for public infrastructure, and decrease water use, energy use, and land consumption.

	Status Quo	Enhanced Habitat Protection	Infrastructure Efficient/Tax Payers Savings	Transit Orientated Development
Density within new growth areas*	2,500 pers/sq mile or 1.56 residences per acre (RAC)	3,600 pers/sq mile or 2.25 RAC	8,000 pers/sq mile or 5.0 RAC	8,000 pers/sq mile (11,000 – 23,000 pers/sq mile along urban transit lines and nodes) or 5.0 RAC (6.9-14.4 RAC)
Housing type choice	–	√	√√	√√√
Transportation mode choice	√	√	√√	√√√
Access to jobs & services	√	√	√√	√√√
Cost of services/tax levels	–	√	√√	√√
Water, resource, energy and land consumption	–	√	√√	√√√
Walkable communities	–	√	√	√√

*Outside of already planned but un-built or partially-built communities

Looking across all four scenarios, and in particular the areas that are either within the City of Tucson, or within the City of Tucson's metropolitan planning area, four possible focused growth areas emerge:

- Infill within the Existing Built Environment
- Houghton Corridor
- Southlands
- Southwest Area

These are consistent with growth areas identified in the City General Plan and identified in regional growth modeling done by Pima Association of Governments (PAG). In addition, these areas are consistent with the County's efforts to support new development in areas outside of the Conservation Lands System. What is different from one scenario to another is the amount and intensity of growth in each of these four areas.

City of Tucson Considerations

- In the four scenarios modeled, the population build-out for the Tucson Water Obligated Service Area ranges from approximately 330,000 in the status quo scenario to just over 500,000 in the transit-oriented development model. The Phase 1 report indicated that based on conservative (high) gallons per capita per day numbers, Tucson Water can serve 366,000 more people with currently available renewable water resources. Population build-out is a factor the City of Tucson must consider in deciding if Tucson

Water should extend service beyond its obligated area and whether additional water resources need to be acquired. It is important to also consider that more compact development forms and higher density development uses less water per capita and are less expensive in terms of water infrastructure. The issue of providing water service to future growth areas will be explored further in the July technical paper on *Integrating Land Use Planning with Water Resources and Infrastructure*.

- The City of Tucson would prefer that future growth and development take place within incorporated areas to ensure fiscal sustainability. When development occurs adjacent to but outside City limits, residents drive into the City and use City infrastructure and services but the City doesn't receive the revenues needed to pay for this. For example, non-city residents may come into the City to shop and the City does receive sales tax, however the City misses out on property tax, state shared revenue, impact fees, and sales tax from unincorporated areas. We need to look at future growth from a fiscal sustainability perspective. In recent years we've implemented impact fees which fund the initial construction of infrastructure needed to serve growth, however we must also consider how the ongoing provision of public services and maintenance of facilities are funded. We must ensure that future growth areas are self-sustaining and are not subsidized by current residents.

- An economically vibrant downtown is an important priority to the City of Tucson in any future growth scenario. The need for an urban walkable place with housing, employment and entertainment opportunities that are accessible to transit is critical to the future viability and sustainability of a community our size. As the paper points out, creating an urban walkable place is achievable given the amount of available developable land in the downtown area and the proximity of the University which is a connection that can be strengthened.

- Re-investment and revitalization of Tucson's existing built environment is a high priority for the City in any future growth scenario. Vacant and underdeveloped land exists throughout the built environment. Infill can bring investment, resources, jobs, services and transit to older and stressed areas of the City that most need it. Infill in the existing built environment is key to a sustainable future for Tucson. However infill must be well-designed and considered in context. It should help strengthen existing neighborhoods and contribute to maintaining and improving our sense of place. Future growth should benefit existing residents and improve the quality of life in the built environment.

<u>Pima County Considerations</u>

- The Conservation Lands System (CLS) implements the Sonoran Desert Conservation Plan and in doing so provides a regional framework for identifying lands suitable for development versus lands suitable for conservation. Lands most suitable for development are located outside of the CLS. Agreement between the City and County on target growth areas outside of the CLS prior to the upcoming City and County General/Comprehensive Land Use Plan updates will provide an important starting point for these planning efforts.

- During 2007, the County undertook land use, infrastructure, and employment center studies for the Southwest planning area. These studies assumed higher concentrations of housing and employment densities than the average for the County, and estimated 120,000 more people would reside in this area over the next 45 years. The studies also included cost estimates for the necessary infrastructure and services to support such an increased population. The County is currently developing financing strategies, such as increased roadway development impact fees for this area, to ensure that the infrastructure is primarily developer-funded. Assuming the City and County can reach agreement on target growth areas, similar land use, infrastructure, and financial planning efforts could occur and be reflected as part of the Cost of Development Elements of the City General and County Comprehensive Plans.

- A significant portion of the County's funding sources for providing services are property taxes, State shared revenues, and costs for services. As the State continues to decrease funding to local governments, the County must ensure that future development occurs in the most fiscally responsible manner. This includes adding value to the tax base and ensuring that affordable transportation and housing choices exist for residents such that residents can afford to continue paying for other goods and services.

- A significant amount of industrial land is located near the airport, Davis Monthan Air Force Base, and along I-10. To make these parcels "shovel-ready" as part of our regional economic development strategies, the City and County need to make sure utilities (including water, wastewater, and electricity) are planned and available for these properties.

- The County faces similar challenges to the City in ensuring that new development projects are compatible with surrounding neighborhoods and offer existing residents beneficial amenities and services that make them an asset to the neighborhood and community. Often it is the design of the new development, not the density, that results in whether adjacent neighborhoods find value in the project.

- The State statutory constraints that permit lot splitting/wildcatting in unincorporated Pima County continue to impact the ability of this region as a whole to manage growth in a sustainable manner. Dirt roads, exempt wells, and septic tanks degrade the region's environment and expose the eventual property owners to substandard health conditions in some cases. Incentives and legislative actions must be explored to prompt land owners into either rezoning land to higher densities or undergoing subdivision platting.

- With the support of voters, the County will continue funding the acquisition of natural areas for conservation, recreation, and the protection of water resources. These acquisitions help to define an urban form by acting as constraints to development.

Recommendations

- City General Plan/County Comprehensive Plan Updates and Land Use Regulations

  1. The City and County should direct future growth to areas identified as most suitable for development, outside of the Conservation Lands System, which include infill opportunities in the existing built environment, Houghton Corridor, Southlands, and the Southwest Area.

  2. The City and County should require new development and redevelopment projects to implement smart growth and sustainable urban form concepts with minimum densities, mix of uses, and open space preservation to achieve the benefits described in this paper. The City and County should implement "density by design" to focus on creating as vibrant a built environment as the natural environment that defines us.

  3. The City and County should evaluate new development and redevelopment projects proposing a land use change on their ability to provide housing and transportation choices, access to jobs and services, reduced water and energy consumption, infrastructure efficiencies, amenities offered to surrounding neighborhoods, and fiscal sustainability.

  4. The City and County should work to support the emerging regional visioning process that will ultimately contribute to reaching a broad consensus on community values, and eventually urban form as one of the potential goals.

- Capital Improvement Planning and Fiscal Sustainability

  1. The City and County should establish a joint capital improvement planning coordination process for the targeted growth areas to direct land use planning, phasing of development, timing and funding of public services and infrastructure, and construction sequencing in the targeted growth areas. City and County Capital Improvement Programs should implement City and County General/Comprehensive Plans.

  2. Future development in new growth areas should be evaluated in terms of fiscal sustainability from both the capital (initial construction of infrastructure) and operating (ongoing public services and maintenance of infrastructure) perspectives to ensure that new development is self-sustaining and not being overly subsidized by existing residents.

  3. The City and County should pursue efforts at a regional level to develop an impact fee structure that provides incentives for development in targeted growth areas, including downtown and infill redevelopment areas, and disincentives outside of these areas.

- Open Space Acquisitions

  1. Natural preserves assist in defining the urban form, as well as providing multiple benefits such as recreational opportunities, conservation of water resources and natural floodplain functions, and protection of scenic views. In some cases, purchasing land outright or through conservation easements is the most realistic way to preserve areas not suitable for development. The City and County should continue to pursue land acquisition efforts.

It is respectfully recommended that the Committee consider this report and provide input to the City and County on its recommendations.

c: Richard Miranda, Deputy City Manager
Nicole Ewing Gavin, Assistant to the City Manager
Albert Elias, City of Tucson Planning Director
Leslie Liberti, Director City of Tucson Office of Conservation and Sustainable Development
Jeff Biggs, Director of Tucson Water
Chris Avery, Acting Deputy Director, Tucson Water
Nicole Fyffe, Executive Assistant to the County Administrator
Melaney Seacat, County Coordinator, City/County Water and Wastewater Study
John Bernal, Deputy County Administrator, Public Works
Arlan Colton, Pima County Planning Director
Tedra Fox, Sustainability Manager, Pima County Administrator's Office
Mike Gritzuk, Director, Regional Wastewater Management

Location of Growth, Urban Form, and Cost of Infrastructure

Curtis Lueck & Associates

Stantec

A White Paper supporting ***Phase 2*** *of the* ***Water and Wastewater Infrastructure, Supply and Planning Study***

June 15th, 2009

ACKNOWLEDGEMENTS

This White Paper was prepared through the efforts of a joint public and private sector team. The team included staff from the City of Tucson, Pima County, Stantec Consulting Inc., and Curtis Lueck & Associates.

Principal authors on the White Paper were John Take, Nicole Fyffe, Nicole Ewing-Gavin, Mike List, Debra Mollet, Josh Pope, and Alice Templeton.

City of Tucson department and staff involvement included:

- City Manager's Office – Nicole Ewing-Gavin
- Tucson Water – Chris Avery
- Urban Planning and Design – Albert Elias, Chris Kaselemis, and Anna Sanchez
- Information Services – Josh Pope
- Office of Conservation and Sustainable Development – Leslie Liberti

Pima County department and staff involvement included:

- County Administrator's Office – Nicole Fyffe, Tedra Fox
- Regional Wastewater Reclamation Department – Melaney Seacat, Mary Hamilton, and Greg Hitt
- Development Services – Arlan Colton, Marc Fink, Jim Veomett
- Transportation (Geographic Information Services Division) – Mike List

Consultant participants included:

- Stantec Consulting Inc. – John Take, Alice Templeton, Debra Mollet, Rebecca Holt, and James Patrick
- Curtis Lueck & Associates – Curtis Lueck, Marcos Esparza

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EXECUTIVE SUMMARY

As eastern Pima County and the City of Tucson grow, the continuing influx of people into the area presents planning and infrastructure challenges. How can we grow wisely? What limits do we face? How much can we really modify the existing pattern of growth and its probable extension, and what might that look like?

The future will change Tucson in many ways – and our choices will have a strong influence

This White Paper was intended to encourage City and County agreement on a number of planning and infrastructure policy issues related to future growth and urban form. Section 1 beginning on page 9 explains how this was accomplished and provides a brief introduction to the entire White Paper.

By examining both the form of urban growth and its location through benchmarking and land absorption modeling, our process has identified four unique alternate scenarios that can now be examined simultaneously in a blended fashion.

The study focused on examining probable outcomes if our future is focused on lower density single family residential developments being built in unincorporated Pima County – and the alternative outcomes if we choose to build more compact mixed land uses within the City core.

Section 2 defines urban form factors beginning on page 16, and then quantifies many of their effects, impacts, and costs.

We are not alone as we consider which scenario is in our best interests. Other communities across North America have sought answers to these same questions. They have made choices we can learn from. These peer communities are valuable resources that can be tapped via the benchmarking process. They have provided insight on which factors and choices lead to an urban form that serves the region well.

Page 5 Low angle photography © 2009 Curtis SW Images.

As growth occurs, the Tucson area will take on an evolving urban form – how our communities and employment centers and amenities stitch together to create the landscape of our city. There are many factors that affect this urban form. Significant dynamics include the proximity of housing to basic needs and public facilities, such as sewer, water, and roads. They also include land use mix and diversity, street layout, and housing density. Each and every choice made that changes these urban form factors leads to tangible long-term impacts to our community, and defines our options for living. How much energy and resources we consume, or the time we spend in our cars in traffic, and our ability to afford adequate housing are all real impacts of our decisions about urban form.

Some factors have a greater impact than others. The varying population densities of our future residential communities and their location with respect to today's built environment stand out as key indicators of how our region will grow. Across the board, increases in density bring the benefits of lower infrastructure costs, fewer trips in the car to meet our daily needs, and a reduction in consumed land resources. The choice as to how much we grow closer to our established environment, versus outlying areas farther from existing amenities and service, will have a broad range of effects on what our region would look like if it doubled in population.

Urban form and its design is critical

This paper provides insight into the most measurable factors that appear to highly influence Tucson's urban form, and investigates options for future growth in our region.

For example, increasing the population density of new developments to 10,000 people per square mile (up from its 1990—2000 average of about 4,400 people per square mile) would reduce annual car passenger miles traveled *per person* by *55%*, *per capita* water consumption by *45%*, *per household* municipal infrastructure and servicing costs by 20%, *per household* energy use by *7%*, and *per household* CO_2 emissions by 2%. Of course, with this increase in density we would also consume much less land and resource materials to accommodate each new resident!

Other benefits would include improved public health, increased access to services, amenities, transportation choices, employment opportunities, and more walkable neighborhoods.

We can control and manage the impact of our future growth.

With specific goals and results in mind, we built four different population location and density model scenarios that highlight some of the options and issues facing us, our leaders and decision-makers. Section 3 describes our examination of future growth locations and alternate scenarios, beginning on page 60.

We started with an exercise examining what the study area would look like if we simply continue to make decisions according to the existing state of affairs. This first Status Quo scenario served as a comparative baseline. When the assumed levels of growth occurred in this scenario, the size of our community footprint grew significantly – indicating that household transportation costs would increase significantly in this future.

Growth can be directed differently to our benefit

We learned that growth will occur in predictable locations and patterns should the status quo prevail, and then we proved that both can be readily influenced and changed as we desire.

In our second scenario we modeled the effects of focusing on Enhanced Habitat Protection in our surrounding environs. Purchasing land for conservation also increased the density and centrality of our community. Next, we analyzed a third scenario that placed Infrastructure Efficiency and Taxpayer Savings at the forefront of our growth and development decisions. The model indicated that the current supply of planned but un-built or partially built land would develop first at today's lower densities, diminishing the expected benefits of this scenario. This scenario effectively reduced suburbanization while creating infrastructure efficiencies and savings.

Finally, we built a fourth alternate scenario that examined Transit Oriented Development by using current and future high capacity transit corridors as prime locations for locating incoming future residents. Investing in transit infrastructure and denser mixed land uses further reduced the amount of rural land loss while increasing the centrality and travel mode choices in our community. The results below are discussed in detail beginning on page 78.

Scenario	Total Population	Total Area (square miles)	Average Density (people/mile^2)
Current Built Environment	919,998	336	2,737
Scenario #1: Status Quo	1,654,998	642	2,578
Scenario #2: Enhanced Habitat Protection	1,654,998	545	3,037
Scenario #3: Infrastructure Efficient/Taxpayer Savings	1,654,998	554	2,989
Scenario #4: Transit Oriented Development	1,654,998	515	3,212

Qualitatively speaking, the four alternate scenarios each provide varying levels of benefit as shown below. It is suggested that various key elements of these four scenarios could be combined to yield an optimal future growth scenario.

Comparator	#1 Status Quo	#2 Enhanced Habitat Protection	#3 Infrastructure Efficient/ Taxpayer Savings	#4 Transit Oriented Development
More Walkable Communities	—	✓	✓	✓✓
Higher Infrastructure Efficiencies	—	✓	✓✓	✓✓✓
Lower Cost of Services and Tax Levels	—	✓	✓✓	✓✓
More Transportation Mode Choices	✓	✓	✓✓	✓✓✓
More Housing Type Choices	—	✓	✓✓	✓✓✓
More Housing and Transportation Affordability	—	✓	✓✓	✓✓✓
Lower Water, Resource, Energy and Land Consumption	—	✓	✓✓	✓✓✓
More Access to Jobs and Services	✓	✓	✓✓	✓✓✓
More Easily Implemented	✓✓✓	✓	✓	✓

In summary, this White Paper has emphasized the importance of urban form factors and strong community design practices. It has also confirmed our ability to encourage optimal growth locations and forms.

Now we must choose our future wisely.

SECTION 1 - INTRODUCTION

Tucsonans have dealt with growth for at least six decades as they settled here, reacted to the growth, or commonly did both. As Pima County, the City of Tucson, and nearby municipalities continue to grow, people are becoming more and more aware of the planning and infrastructure challenges that this population growth represents. We are also keenly aware of the tangible results, both positive and negative, that earlier urban planning decisions have produced. The community that surrounds us today has been shaped by these past decisions that have been made about where to grow, how to develop, and what infrastructure to provide. Our judgements will carry the same weight. Let us decide wisely.

As our community develops, should we stay focused on our present course?

Deciding upon solutions begins with asking a number of questions that would benefit from common answers by the City and County. How can we grow in a way that reduces our impact on the environment and conserves resources? What limits do we face? How can we develop differently so that our standards of livability and affordability are maintained or even improved? What forms of housing should be encouraged, and where? How can the costs of new growth not burden existing residents? Should we expand further into the desert, or intentionally increase density? How can we connect land use and infrastructure planning? What effects will follow these causes?

Ideally the answers to these questions will be equally informed by what we have done well in the past, and by an awareness of where improvements are necessary and possible. We are not alone. Many cities and counties in North America are also seeking better levels of quality and choice. Lessons can be learned from examining the situation and future plans of our peers.

"A hundred years after we are gone and forgotten, those who never heard of us will be living with the results of our actions." - Oliver Wendell Holmes

It is encouraging to realize that our collective desire and ability to change and evolve is far more decisive and important than our circumstances – our trends are not equal to our destiny.

This White Paper identifies various factors, constraints, and inter-relationships that define the suitability of growth areas. It presents a number of alternate quantitative growth scenarios and identifies various means of simultaneously achieving qualitative development. It discusses urban form factors and their effects on infrastructure costs and other issues. Finally, this White Paper suggests ways for land use decisions to be factored into the City and County's water supply and infrastructure provision deliberations. It confirms that solutions exist for our challenges.

1.1 Overview of White Paper

This White Paper forms part of Phase II of the City/County Water and Wastewater Infrastructure, Supply, and Planning Study. Phase I of this Study consisted of inventorying, assessing, and conceptual planning of water and wastewater infrastructure and resources. Phase II is intended to encourage City and County agreement on a number of planning and infrastructure policy issues.

This paper is divided into five sections. Following this first introductory section, a second section documents the importance of urban form factors and describes the results of our best and emerging practices benchmarking process. The third section discusses the modeled variety of future growth locations, and the fourth section suggests mechanisms for encouraging change based on the previously presented results. The fifth and final section concludes the document with a compact summary.

The geographic scope of this document focuses on examining an area including unincorporated Pima County, the Tucson Water obligated service area, and Tucson city limits.

The primary audience for this White Paper is the joint City/County Regional Water Study Oversight Committee. Other interested parties may include community leaders, City and County administrations, and the involved public.

Figure 1 illustrates the White Paper development process and its combination of core tasks 1 through 6 and parallel tasks A through C. These tasks are described in detail on the following page.

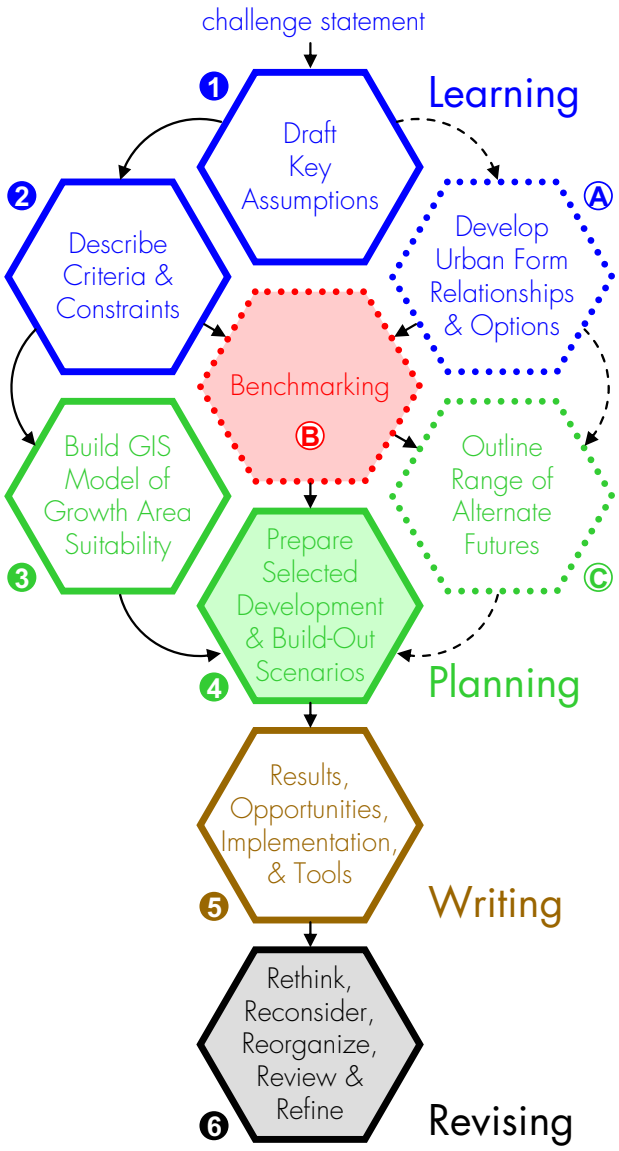


Figure 1: White Paper Process Flow

1.1.1 White Paper Development Process

The White Paper team deployed a classic analysis procedure. They prepared a challenge statement, and agreed upon clear objectives. They established a responsive plan, taking advantage of relevant research and existing work completed by others. They generated alternatives, evaluated and prioritized results based on their merits, and prepared coherent documentation. Finally, they revised their way through draft and final output iterations to build consensus. The analysis relied heavily on geographic information system (GIS) tools. The White Paper process included six core tasks, each with a simple goal:

Task 1 Draft Core Assumptions	*Goal: "Build a firm shared foundation"*
Task 2 Describe Criteria and Constraints	*Goal: "Know our limits"*
Task 3 Build GIS Model of Growth Area Suitability	*Goal: "Develop GIS layers to discretely analyze appropriateness of growth across the metro and select sub-areas"*
Task 4 Prepare Selected Development and Build-Out Scenarios	*Goal: "Pinpoint select growth areas having fewer disadvantages & more benefits"*
Task 5 Document Results, Opportunities, Implementation, and Tools	*Goal: "Record detailed results and prepare for the next steps"*
Task 6 Rethink, Reconsider, Reorganize, Review and Refine	*Goal: "Think twice to deliver polished outputs"*

Tasks 1, 2, and 3 concentrated on illuminating the transition between the reality of our existing urban form and the destination created by known criteria and constraints. It produced solid intelligence regarding advantageous locations for quantitative growth. This involved an obvious focus on our community's built environment.

Before completing Tasks 4 through 6, the team completed a stream of parallel tasks that looked outwards across North America to ensure a more complete exploration of the solution set available to Pima County and the City of Tucson. These Tasks A, B, and C had simple goals:

Task A Develop Urban Form Relationships & Options	*Goal: "Explore cause and effect interactions between urban form comparators"*
Task B Benchmarking	*Goal: "Establish best and emerging practices, create comparisons and targets"*
Task C Outline Range of Alternate Futures	*Goal: "Consider a broad range of solutions and their impacts"*

The combined outputs from Tasks 1-3 and Tasks A-C created a more meaningful analysis in Task 4. Tasks 5 and 6 finished the White Paper.

1.1.2 Best and Emerging Practice Benchmarking

Best and emerging practice benchmarking is a process in which organizations evaluate various aspects of themselves in relation to the most efficient (least amount of effort) and effective (best results) practices using specific indicators, usually within a peer group defined for the purposes of comparison. It is often treated as a continuous process in which organizations continually seek to challenge their practices in order to identify changes leading to an improved situation.

Benchmarking is more than merely identifying reference points; it also identifies existing performance in terms of average, best, and emerging practices. This range of values creates meaning and substance for the indicator, and can create awareness of improvements that are orders of magnitude beyond what is generally thought possible. Benchmarking also promotes the fact that performance ranges are valid and acceptable. This approach replaces "bad" and "good" with "opportunity" and "improvement" and triggers dynamic assessments rather than static criteria. We can always do better, and benchmarking tends to generate focus and helpful motivation.

The White Paper team first identified groups of peer communities across North America. Two groups each consisting of six urban areas were formed; the first included Tucson and those cities that were felt to be similar to our present state in terms of urban form: Colorado Springs, Colorado; Edmonton, Alberta; Albuquerque, New Mexico; Austin, Texas; and El Paso, Texas.

The second group included cities the team wanted to examine closely for emerging practices: Portland, Oregon; Calgary, Alberta; Sacramento, California; Salt Lake City, Utah; Denver, Colorado; and Vancouver, British Columbia. Urban form parameters of interest were selected and benchmarked externally using these communities.

A second round of benchmarking then looked at the internal variation of these parameters across the City and County.

Finally, a series of maps from the peer communities was obtained (where possible) to illustrate their internal urban form factor variations and patterns of distribution.

Section 2 beginning on page 16 documents the best and emerging practice benchmarking results.

1.1.3 Growth Area Suitability and Land Absorption Modeling

One of the goals of this White Paper was to map alternatives for what our future developed footprint might look like. Incorporated and unincorporated Pima County (east of the large portions of the Tohono O'odham Nation that have the same borders) covers almost 2.5 million acres of ground. Modeling and thematically mapping the relative suitability of projected growth and land absorption for such an expanse is best done at a high level and a broad scale.

The techniques used for this White Paper built upon the analytical routines and lessons learned from three previous studies completed by Pima County staff. The analysis methodology uses a grid cell format rather than more familiar map elements such as points, lines, and shapes. Because grid cells use a regular mapping unit, mathematical overlays and transformations are easily applied.

The selected modeling methodology included two distinct stages. First, a growth area suitability surface was defined across the grid cell landscape. Secondly, projected populations were absorbed by the individual grid cells using a series of rules unique to each scenario being modeled. Each acre of land was roughly equal to 4.5 grid cells.

Figure 2 displays how the growth area suitability model relies on two types of criteria: factors and constraints. Factors are preferentially weighted quantitative variables that enhance or reduce development suitability on a continuous scale. Constraints limit alternatives; they mask certain portions of the landscape from consideration.

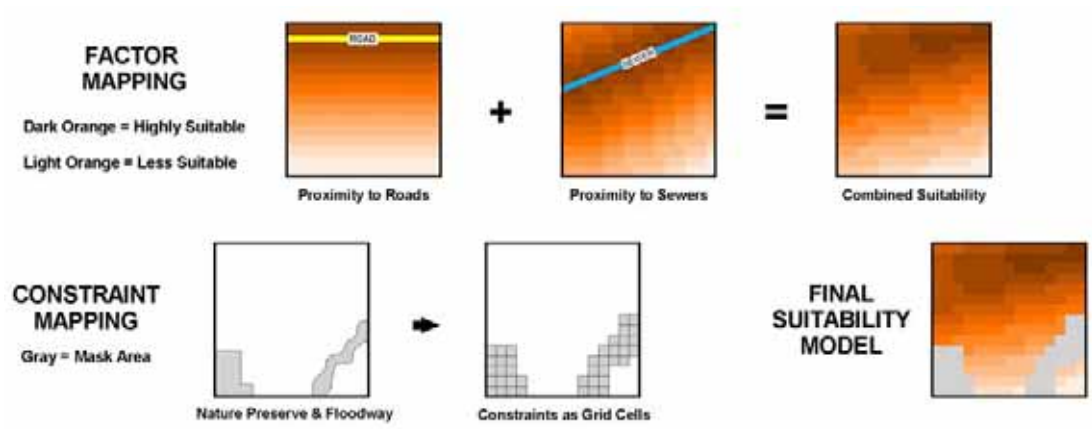


Figure 2: Growth Area Suitability Model Factors and Constraints – Example of GIS Techniques

Initially, a Status Quo model and scenario was built to examine the logical progression and extension of current growth and development practices. Additional models were then built to examine an Enhanced Habitat Protection scenario, an Infrastructure Efficient / Taxpayer Savings scenario, and a Transit Oriented Development Scenario. These later scenarios each varied one major assumption to examine its effect.

1.1.4 Key White Paper Assumptions

Examining the appropriateness of future growth and development across the metropolitan and select sub-areas required several key assumptions as shown in Table 1 below.

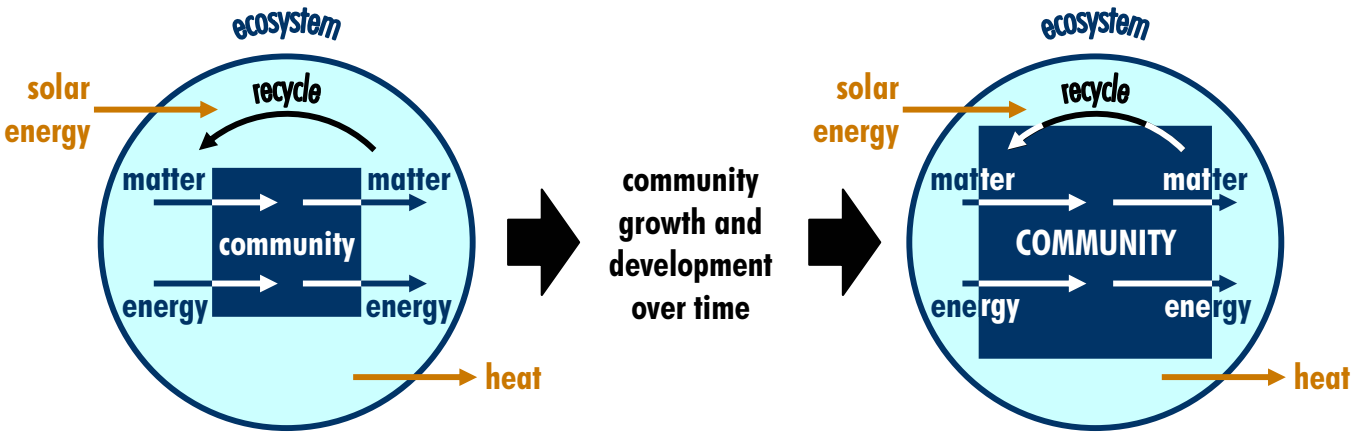
Table 1: White Paper Assumptions

Topic	Key Assumption
Study Area	Study area focuses on the eastern portions of Pima County where the City and County have land use planning authority.
Adjacent Areas of Importance	For adjacent incorporated communities such as the towns of Oro Valley, Marana, and Sahuarita; southern Pinal County; and Tribal and Federal lands – population growth was projected to follow Arizona Department of Economic Security forecasts.
Policy Domain	Envisioned scenarios can alter City and County enforced policies but do not alter or change state or federal statutes and laws.
Absolute Residential Development Constraints for Growth Area Suitability Modeling	• Land with slope over 25%. • Natural preserves (local, state, federal). • Federal lands (except Bureau of Land Management disposable lands outside the Conservation Lands System). • Urban Parks, floodways, and golf courses. • Public rights-of-way and cemeteries. • Landfills, mines and quarries. • Tucson International Airport and Davis-Monthan Air Force Base approach and departure corridors. • City of Tucson lands in Avra Valley.
Future Population	To examine growth dynamics, the White Paper allocated a total future population of two million people in eastern Pima County. No specific time period or year is assumed.
Components of Growth and Development	This White Paper focuses on gross land consumption for residential uses. Fulfilled future needs for other land uses, services, and amenities were inherently assumed.
Occupancy Rate	Future residences are occupied by 2.4 people.

Of these key assumptions, none might be the focus of more conversation than the decision to map an allocation of two million people, versus some other future population number. While long range trends and available population projections do extend towards this threshold, this White Paper assumption was primarily established for the purposes of backcasting. While forecasting is the process of predicting the future based on current trends, backcasting approaches the challenge of discussing the future from the opposite direction. It allows us to consider what needs to be done in the "here and now" in order to reach a desired end situation. As part of long-term planning, sustainable communities often look ahead three generations (about 60 to 100 years) to investigate, test, and examine their ideal end situations.

As Figure 3 suggests, the growth (defined as quantitative expansion) and development (defined as qualitative improvement) of our community occurs within the context of our natural capital and ecosystem. As a result, growth must have some optimal scale relative to our ecosystem – while development improvements can continue until some optimal situation is reached. The presence of these natural limits underlines the crucial nature of our growth and development decisions.

Figure 3: Natural Capital Limits to Growth but not Development



The White Paper team believes these natural limits are best understood and managed by examining a range of alternate future scenarios at a total eastern Pima County population of two million people. Decisions about where to grow and how to develop are amplified at this threshold, with readily apparent causes and effects. Readers who are firm proponents of a smaller Tucson community with a total population less than two million people (or a larger one of over two million people) will still derive insight from the benchmarking and alternate growth and development scenario modeling results. Scaled appropriately, they are informative at many levels.

At any threshold of development, the real challenge is sustainability.

SECTION 2 - THE IMPORTANCE OF URBAN FORM

Urban form refers to the spatial distribution and design aspects of built-up land areas. This section demonstrates urban form, its causes and effects, and describes how our community compares to other peer cities. Many choices for our future will become evident.

2.1 What is Urban Form?

The mix of land uses, density of development, and pattern of streets in an area begin to describe a unique neighborhood pattern. These patterns aggregate all the way upwards from the lot, block and neighborhood levels to the municipality and county levels. This photo shows a distinct urban form transition across N. Euclid Avenue from a historic district to the University of Arizona.

Various configurations emerge, whether they are rural, village, urban – or auto-oriented, landscape oriented, pedestrian oriented, or transit oriented. Each combination can exist with distinct land uses, at different levels of population and housing density, and at varying degrees of design success – from exceptional to average, and sometimes worse.

Urban form can be described by primary and derivative (or secondary) factors which include (but are certainly not limited to) the following:

Table 2: Typical Urban Form Factors

Primary Factors	Derivative Factors
Development Location	Centeredness, Centrality
Land Area	Housing Unit Density
House, Lot, and Block Size	Floor Area Ratio
Land Use Mix and Diversity	Open Space Index
Population	Population Density
Street Layout	Walkability
Transportation Networks	Transportation Mode Splits

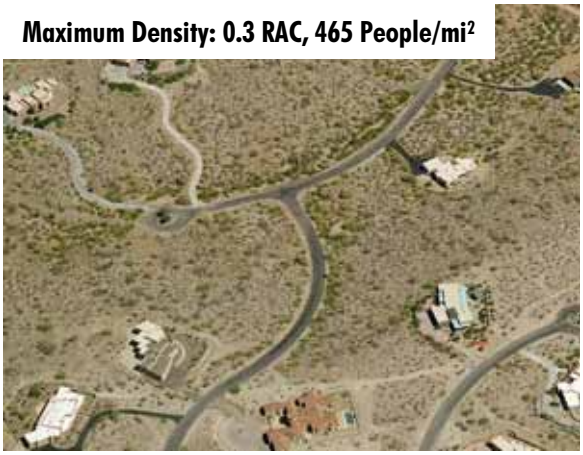
2.1.1 Urban Form Variety in Tucson and Pima County

This page presents multiple views of typical lower density residential developments. These communities have a distinct look and feel given their larger lot sizes. These two examples are located in unincorporated Pima County.

Page 17 Low angle photography © 2009 Curtis SW Images.

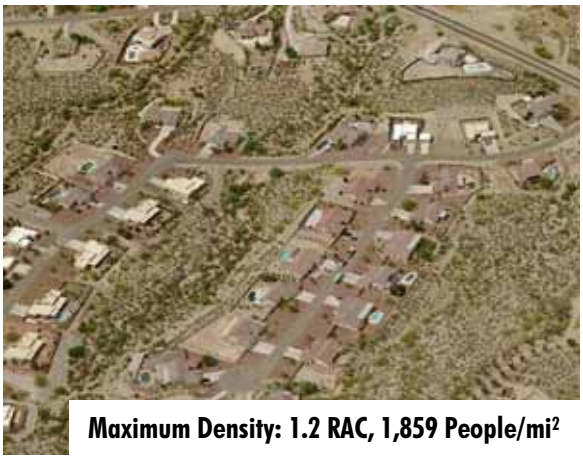
Urban Form: Suburban Ranch (SR Zoning)

Maximum Density: 0.3 RAC, 465 People/mi²

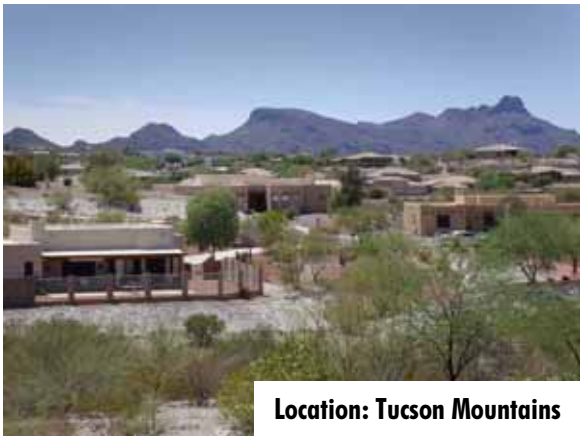


Location: Tucson Mountains

Urban Form: Single Family Residential (CR-1 Zoning)



Maximum Density: 1.2 RAC, 1,859 People/mi²



Location: Tucson Mountains

This page presents multiple views of typical medium to medium / high density residential developments. Strong design elements can readily over-come potential perceptions of crowding. These two examples are located within the City of Tucson.

Page 18 Low angle photography © 2009 Curtis SW Images.

Urban Form: Medium / High Density Residential

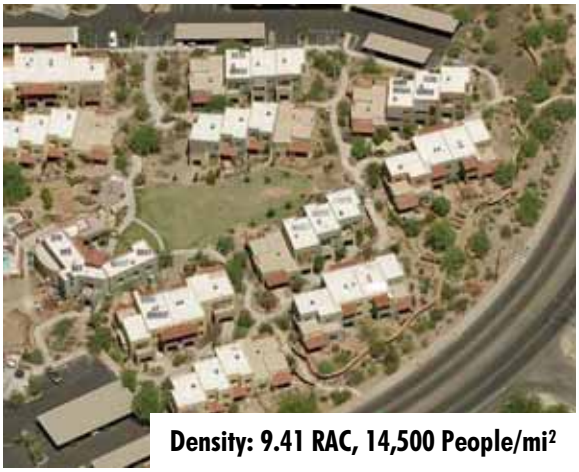
(R-3 Zoning)

Density: 7.08 RAC, 10,900 People/mi^2

Location: Armory Park del Sol, S. 3rd Ave. & E. 16th St.

(R-2 Zoning)

Urban Form: Medium / High Density Residential



Density: 9.41 RAC, 14,500 People/mi^2

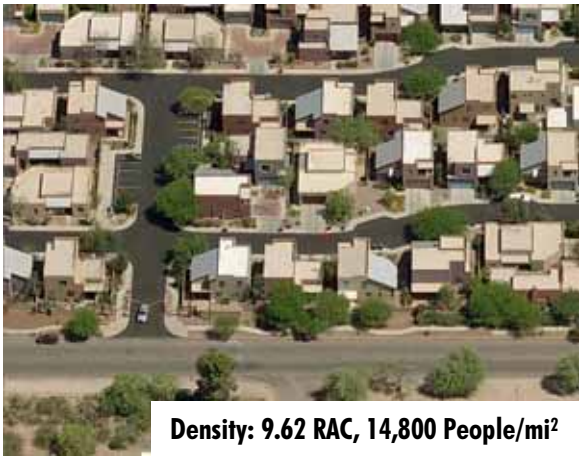
Location: Stone Curves, Stone Ave. & Limberlost Rd.

This page presents multiple views of typical medium / high to high density residential developments. Many feature open garden-type areas and additional community and landscaping amenities. These two examples are located within the City of Tucson.

Page 19 Low angle photography © 2009 Curtis SW Images.

Urban Form: Planned Area Development (PAD-1 Zoning)

Urban Form: High Density Apartments (PAD-1Zoning)



Density: 9.62 RAC, 14,800 People/mi^2

Density: 22.92 RAC, 65,200 People/mi^2

Location: The Presidio, Craycroft Road & E. 16th Street

Location: Williams Apartments on Craycroft Road

This page presents multiple views of typical higher density mixed use centers and employment centers. These successful developments are flourishing, in part due to their deployment of positive design principles. These two examples are located within the City of Tucson.

Page 20 Low angle photography © 2009 Curtis SW Images.

Urban Form: Mixed Use (OCR-1 Zoning) Office/Commercial/Residential

Urban Form: Office (O-2, O-3 Zoning)

Density: 14.06 RAC, 21,600 People/mi^2

Location: Sam Hughes, Campbell Ave. & E. 6th St.

Location: Camp Lowell Dr. & Swan Rd.

2.1.2 Effects and Impacts of Urban Form

Through a number of causal pathways, urban form factors have many effects and impacts. Below, Figure 4 displays several typical examples that flow from an urban design. Although far from comprehensive, this diagram illustrates how existing amenities and infrastructure assets combine with urban form factors to influence many activities and their outputs. In turn, these outputs have a number of effects that contribute to an outcome that may or may not be the desired impact being sought.

Good urban design has a critical role in creating favorable urban forms.

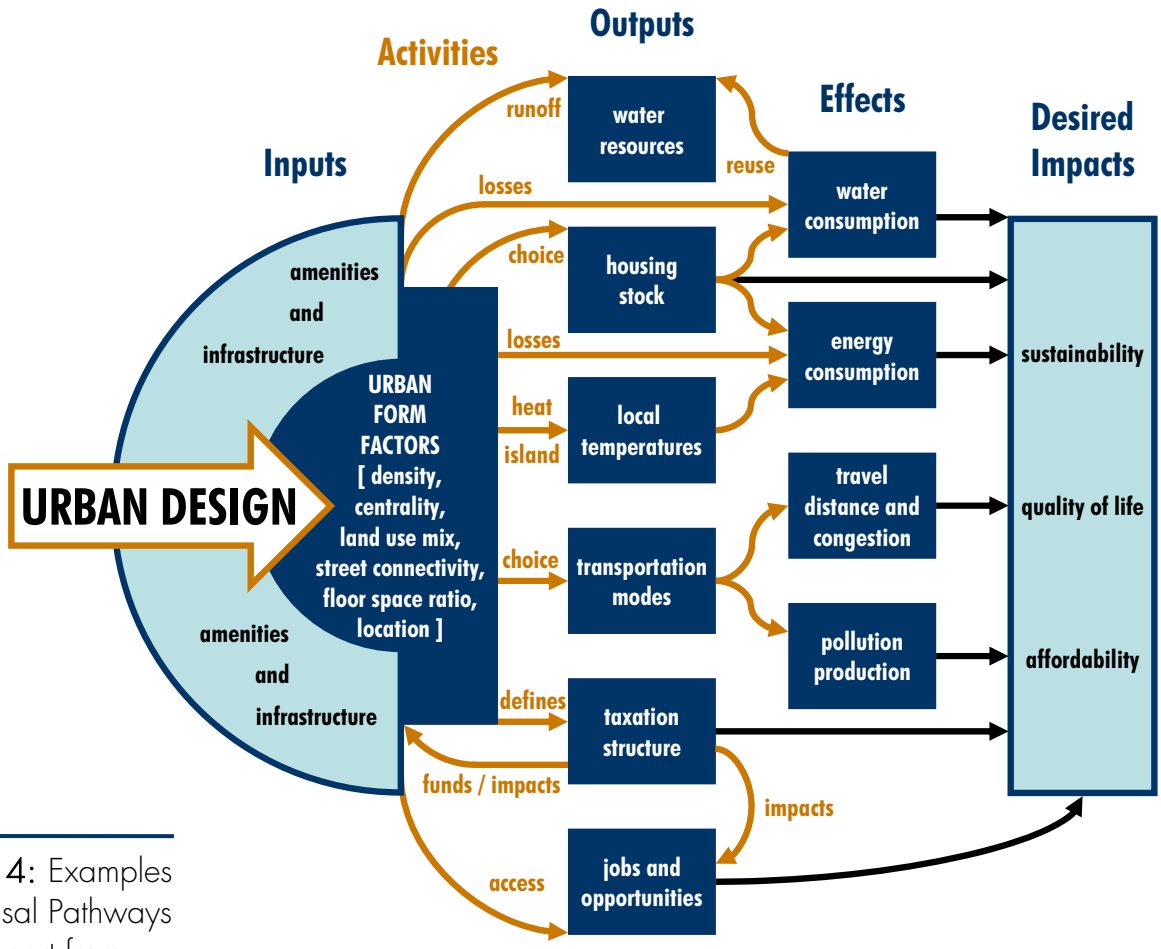
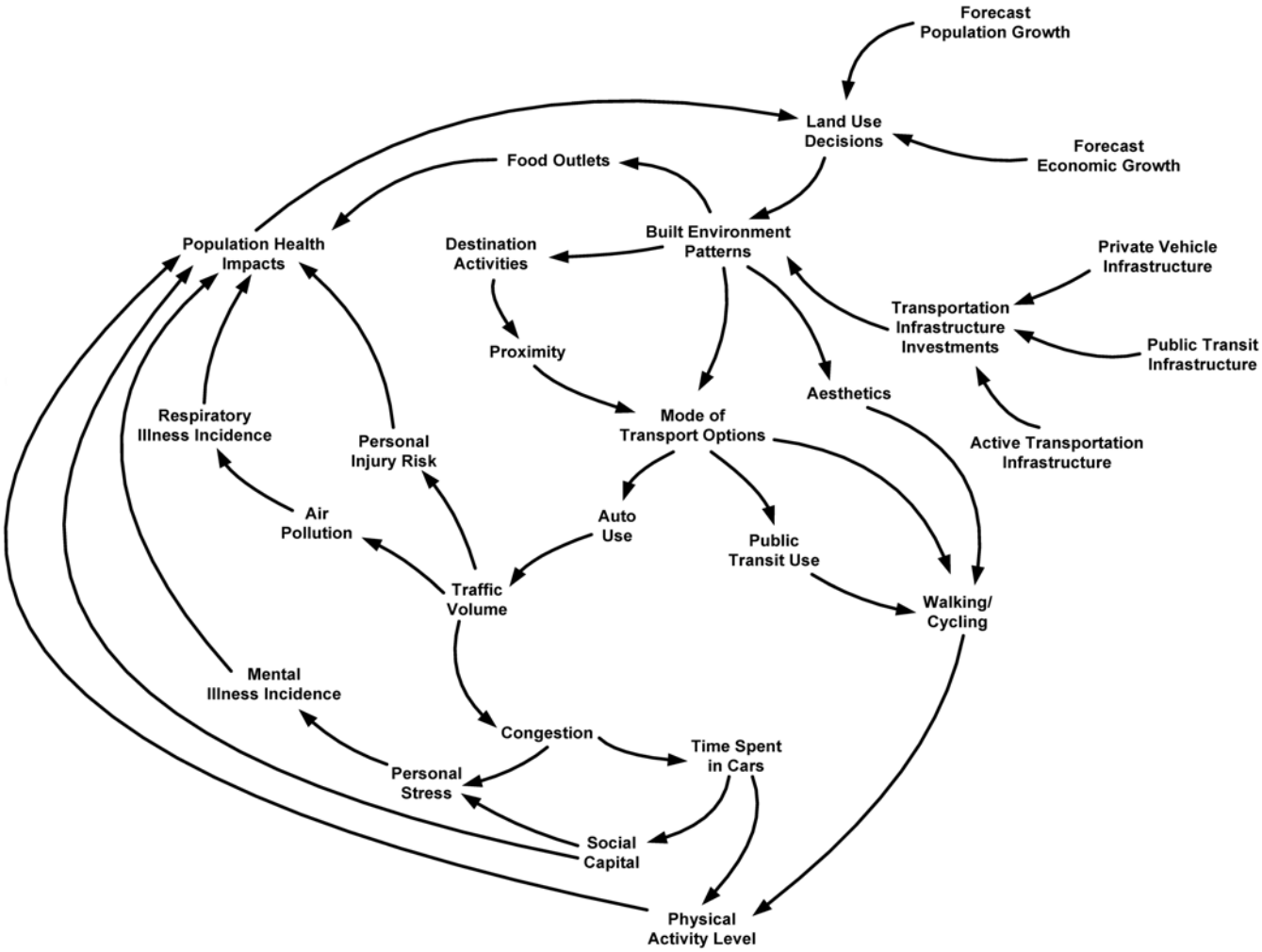


Figure 4: Examples of Causal Pathways that Depart from Urban Form Factors

Emerging research has also tied the cause of urban form directly to effects upon our own **health**. The graphic below is one of a collection of more than twenty conceptual models created in January 2008 for the Region of Peel in Ontario, Canada by Paul Conway of the Public Health Agency of Canada.

These models build from source work documented in "*From Built Environment to Health: An Evidence and Best Practices Based Review*" completed by Lawrence Frank and Company in December 2007. Other more detailed conceptual networks in this work tie together floor-space to area ratios, neighborhood design, transit service, street design, physical activity, and health impacts of obesity in much greater detail.

Page 22 Data Source and Graphic Credit: Region of Peel



Urban form factors and auto dependence are also related.

The concept of "Smart Growth" has been an important component of urban planning for several years. Indeed, Arizona statutes mandate Smart Growth initiatives for municipalities and counties. Resources are available on the Arizona Department of Commerce website, including a scorecard for jurisdictions to use. A tenet of smart growth is the deliberate inclusion in a land use plan of alternate modes within and between neighborhoods and communities. Alternate modes include sidewalks, bike lanes and transit routes within a land use plan for a neighborhood, community or sub-region.

These facilities help reduce the levels of congestion that continue to rise within our large and growing communities. This congestion is benchmarked in Section 2.3.3 on page 41.

The urban form of any community that wishes to encourage pedestrian, bicycle and transit use must have amenities for these alternate modes. To encourage transit use, there should be a strong relationship between the location of employment centers and residential areas. Employment centers need not be with an established central business district, such as downtown Tucson. Employment centers can be "sub-centers", defined by Florida's Center for Urban Transportation Research (CUTR) as a set of contiguous tracts with significantly higher employment densities than surrounding areas.

In 2008, CUTR documented the relationship between transit and urban form for Florida's Department of Transportation. This report, "*Integrating Transit and Urban Form*", is cited in the bibliography and includes an exhaustive literature and research review of previous studies identifying the link between density, urban form and transit use. The following is an excerpt from this CUTR report:

> "The findings of this review show that there has been a shift from the study of density threshold levels that make transit cost feasible to an analysis of the effect of urban design and land - use mix on travel behavior, after controlling for density levels. The issue is no longer at what density thresholds it makes sense to implement transit, but what is the best set of policies affecting urban design and land - use mix that most influences the spatial arrangements of activity locations, so that individuals are more likely to utilize transit."

The important finding in this report is that there does not appear to be a density "trigger", per se, that can determines when, or what type of, transit service should be implemented. Rather, the study indicates that the provision of transit service should be a deliberate goal sought by urban

planners (usually within a jurisdictional agency) based on the location of activity centers (employment, entertainment, retail) within a specific urban or suburban area in a land use plan.

The following additional excerpt from the CUTR report explains why home to work distance is a major factor in transit use (or non-use):

> "Households living farther from work…use less transit, which is due to "trip chaining" behavior. Such households engage in complex trip chains and have, on average, a more dispersed activity space, which requires reliance on more flexible modes of transportation. Policies that reduce the spatial allocation of activities and improve transit accessibility at and around sub-centers would increase transit demand. Similar results can be obtained by policies that increase the presence of retail locations in proximity to transit-oriented households. Centrality and the strength of an established CBD are relevant drivers of transit use, as highlighted by the elasticity of transit demand with respect to distance from the CBD. Sub-centers also play a relevant role, indicating the need to provide services in decentralized employment and residential areas to increase ridership."

There does appear to be a relationship however between the size of a community and transit use. The 1995 "*National Personal Transportation Survey*" completed by the US Census Bureau revealed this relationship, as shown below in Table 3:

Table 3: Relationship between City Size and Transit Use

City Size (Thousands)	Residents Riding Transit Monthly
Under 250	1.4%
250–499	5.4%
500–999	6.4%
1,000–2,999	10.0%
3,000+	21.0%
Nation–wide	11.6%

For comparison, the Pima Association of Governments Regional Transportation Plan 2030 indicated that the average one-way work commute in Pima County is now 13 miles; the mode split is 74 percent single-occupant driving, 14.7 percent carpooling, 2.6 percent walking, 2.5 percent transit, 3.7 percent working at home, and 2.7 percent other modes, including bicycling. Our transit mode split is quite low.

The 2009 document "*Evaluating Public Transit Benefits and Costs: Best Practices Guidebook*" by the Victoria Transportation Policy Institute cites previous studies in its analysis of transit operations, feasibility and implementation recommendations. The document indicates that in for land use planning:

> "Various land use factors affect transit use… Per capita transit ridership tends to increase with city size, population and employment density, and the quality of the pedestrian environment.
>
> One study found the elasticity of transit ridership with respect to residential densities to be +0.22 in U.S. urban conditions, meaning that each 1% increase in density increases transit ridership by 0.22%. Destination density (e.g., clustering of employment) tends to have a greater impact on transit ridership than residential density. Transit ridership tends to increase if more people live and work near transit stops."

This document indicates that appropriate land use policies, transit ridership incentives and consumer acceptance are necessary to be effective. The following types of transit improvements were suggested to have the greatest positive land use impacts:

- Transit programs that are part of an overall smart growth land use program.
- Transit oriented development, which intentionally integrates transit improvements with compatible land use development.
- Transit improvements that encourage infill and redevelopment of older urban neighborhoods.
- Transit stations located at major commercial centers with large numbers of commuters.
- Transit improvements as an alternative to roadway capacity expansion.
- New urbanism, parking management and other demand management policies implemented in conjunction with transit improvements.

Transit is not a panacea, because it can also have some negative land use impacts. Rail facilities require land, can divide neighborhoods, and can be unattractive. In some situations, transit improvements can increase urban sprawl by facilitating longer-distance commutes. Accordingly it is best to plan and implement a viable transportation system concurrently with land use and infrastructure planning.

Table 4: Potential Results of Urban Form Factors

Table 4 outlines a longer list of the potential results (both impacts and effects) of urban form factors. Each of these results can vary in their magnitude. Some are positive while others are negative.

Potential Results of Urban Form Factors	
Auto Use	Traffic Congestion
Transportation Mode Split	Walkable Urban Spaces
Greenhouse Gas Production	Urban Pollutant Generation
Accessibility and Affordability	Cost of Community Services
Domestic Water Use	Wastewater Generation
Energy and Resource Use	Infrastructure Efficiency
Continuity of Development	Land Availability
Employment Density	Jobs to Housing Ratio
Infrastructure Density	Level of Infill Development
Stress and Health Indices	Opportunity Index
Housing Mix and Choice	Social and Community Ties
Effective Permeable Area	Quality of School District
Tax Assessments and Structure	Population Growth Rate
Community Sustainability	Rural and Open Space Loss

"Smart growth is preserving natural habitat by creating better human habitat." – Smart Growth America

The "Smart Growth" movement has developed many planning principles that (once customized for local application) can form a strong framework for achieving more beneficial urban forms. The State of Arizona has established its Growing Smarter legislation that will impact future General and Comprehensive Plans.

Smart growth principles have already informed the development of plans such as the County's Southwest Infrastructure Plan (SWIP) and the City's Houghton Area Master Plan (HAMP). In addition, the Tucson Modern Streetcar, downtown redevelopment, and Regional Transportation Authority (RTA) roadway planning work that integrates land use have all incorporated smart growth approaches.

Readers interested in the detailed research behind the impacts and effects listed in Table 4 are directed to the list of published articles and references contained in the bibliography.

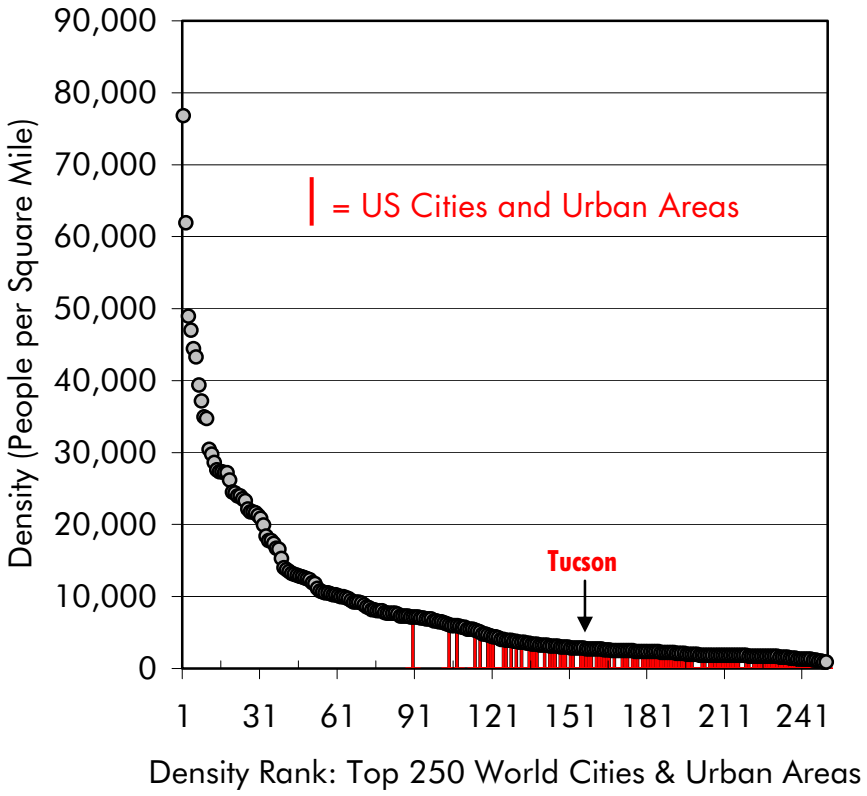
2.2 Selection of Peer Communities for Benchmarking

The White Paper team began a substantial best and emerging practices benchmarking process by identifying peer communities of note.

A successful benchmarking process begins with self analysis. This is followed by the identification of best and emerging practices among the surveyed peer group. This allows for performance differences to be quantified, and leads to the development of go-forward actions that implement the findings. The result of a successful process is narrowed performance gaps and obvious improvements.

It was important to recognize the relative positioning of our City and County within North America at the outset. Figure 5 displays the density of the Top 250 World Cities and Urban Areas, with 2000-2005 era data sourced from the United Nations and national statistical offices via www.citymayors.com.

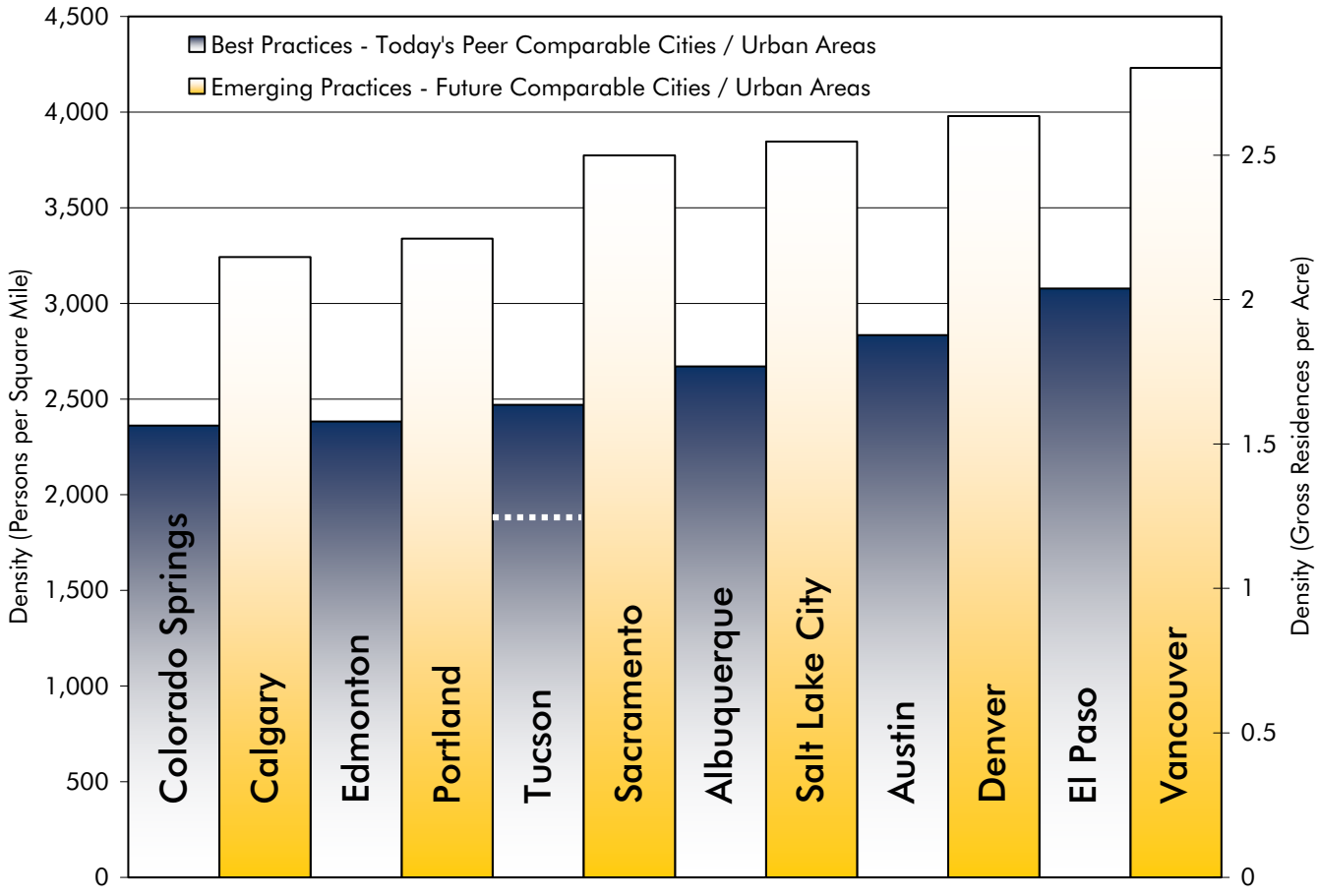
Figure 5: Context for Benchmarking Process: Top 250 World Cities and Urban Areas



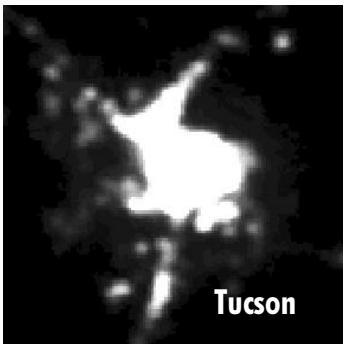
The range of population densities in the United States inhabits an easily identified portion of Figure 10. The Tucson "Urban Area", defined in this dataset as 720,000 people in metropolitan Tucson occupying 291.5 square miles, lands within the middle ground of the American city and urban area range. This relative position would skew to the right if any of the hundreds of square miles of Tucson's fringe areas were included. Exact comparisons require the use of truly equivalent statistical areas.

The peer communities were initially identified solely on the basis of the White Paper team's knowledge and experience. Although one community (Raleigh, Durham, and Chapel Hill in North Carolina) was discarded as a peer, the two groups were remarkable when their relative densities were compared. Figure 6 displays how the ranked "emerging practices" comparable urban areas were each approximately 40% more dense than the identified "best practices" communities that the group felt were Tucson's closest peers.

Figure 6: Density of Selected Peer Cities and Urban Areas

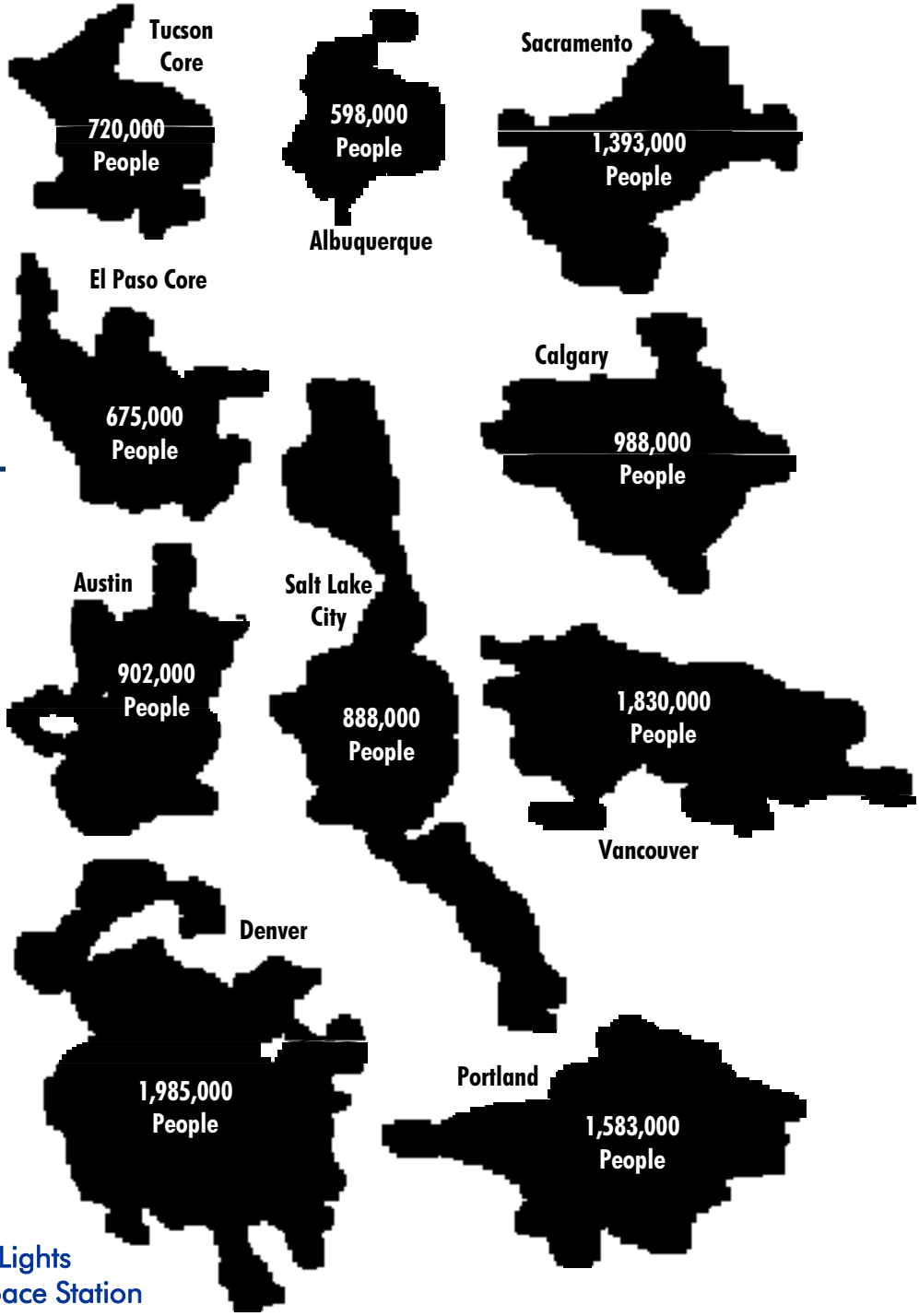


Like the circumference of an island, community populations and densities can be measured at many levels of detail with varying results. For example, the calculated Tucson population density of 2,470 people per square mile shown above drops to a density of 1,873 people per square mile indicated by the white dashed line when the density is calculated using a population of 1,023,320 over a corresponding area of 546 square miles. These larger figures include the four primary local municipalities and larger portions of unincorporated Pima County. Both are valid computations; it is merely noted that the parameters we are examining inhabit a natural range of variation.



The shape and aspect ratio of communities is highly evident at night when viewed from the great altitudes of space. Although not purely equivalent given small variations in viewing altitude and angles, night-time photography from the International Space Station is of qualitative interest in comparing the evidence of the extent of human activity as it relates to urban area population.

Original night views of city lights from the International Space Station © NASA.



"The unaided eye sees incredible detail when gazing upon cities during a 40-minute pass around the dark side of the planet. Efforts to record this beauty on film are only a natural extension of human desire." – Astronaut Don Pettit

Night Views of City Lights
From the International Space Station

Table 5 provides another measure of comparing the peer communities; in this case density-calculating statistics were collected strictly for the land area within the named City limits. This method naturally yields the highest stated density for Tucson, while densities for Edmonton and Salt Lake City were skewed lower than their metropolitan area values.

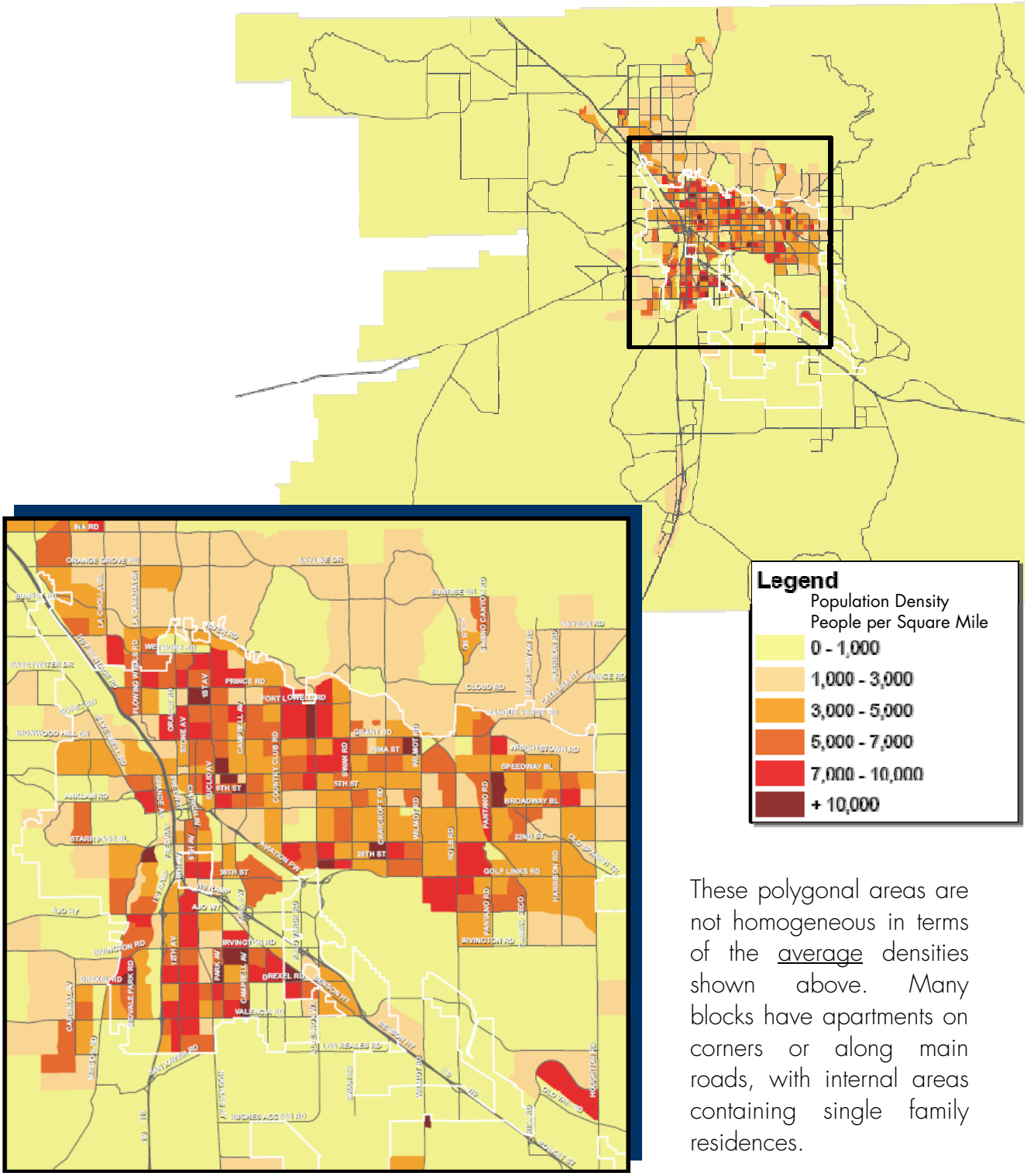
While the city densities vary somewhat from the urban area densities, it is still apparent that the selected communities are both peers and interesting comparisons for the future of the City and County.

Table 5: City-Based Population Density Statistics

"Today's" Peer Cities	Population Estimate ('06-'07')	Land Area (Square Miles)	Density (People per Square Mile)
Colorado Springs	466,000	197.3	2,362
Edmonton	782,000	328.2	2,383
Tucson	720,000	291.5	2,470
Albuquerque	598,000	223.9	2,670
Austin	902,000	318.1	2,835
El Paso	675,000	219.3	3,078
"Future" Peer Cities	**Population Estimate ('06-'07')**	**Land Area (Square Miles)**	**Density (People per Square Mile)**
Calgary	879,000	271.0	3,243
Portland	1,583,000	474.1	3,339
Sacramento	1,393,000	369.1	3,774
Salt Lake City	888,000	230.9	3,846
Denver	1,985,000	498.8	3,979
Vancouver	1,830,000	432.4	4,232

As Tucson grows, there are many multiple pathways forward. Beyond the status quo scenario, densities could reduce or increase over time. In terms of densification, the peer community data suggests that moving from today's average of 2,000 to 2,500 people per square mile up to an average of 4,000 to 5,000 people per square mile and beyond represents a clear possibility given the choice of peer communities.

The variation of population density across the study area and in Downtown Tucson is illustrated with the maps below. In general, population densities above 3,000 people per square mile are located within the City of Tucson, while suburbs in unincorporated Pima County and other municipalities have lower density.



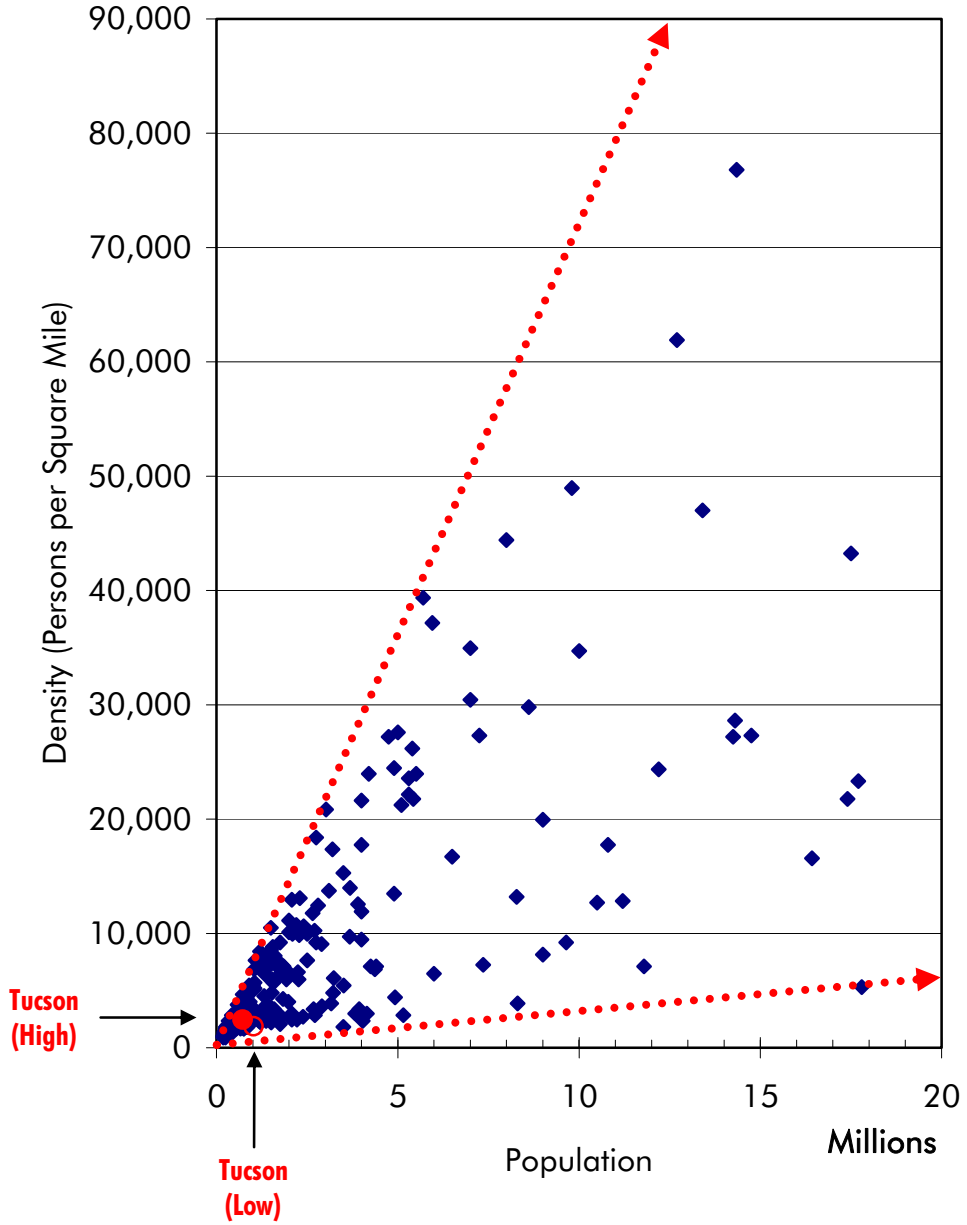
These polygonal areas are not homogeneous in terms of the <u>average</u> densities shown above. Many blocks have apartments on corners or along main roads, with internal areas containing single family residences.

2.2.1 Pathways to Locating a Future Population

Referring again to the Top 250 World Cities and Urban Areas dataset, Figure 12 outlines a very broad view of alternate pathways forward. There is an evident densification trend with increasing population; however the range of densities for similarly populated urban areas is significant.

Given our present position – whether using the high or low estimates of population and density – it is necessary to examine the lower left hand corner of Figure 7. Refer to Figure 8 for a closer view.

Figure 7: Top 250 World Cities Density Trends with Increasing Populations

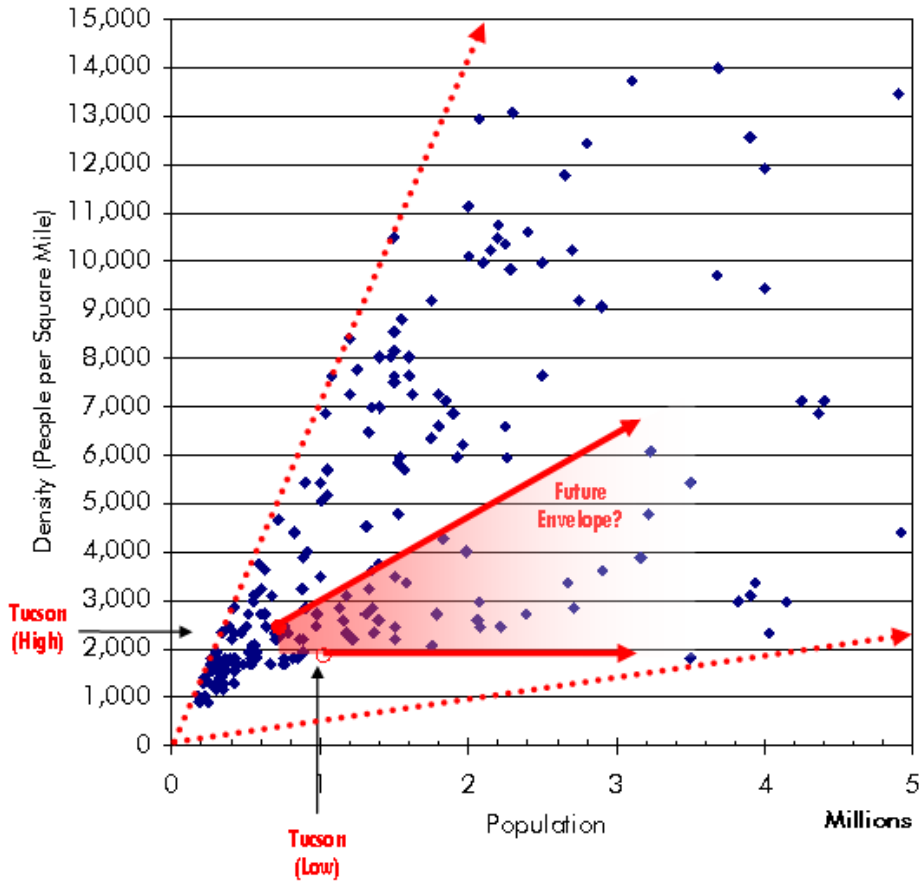


As Tucson grows, it will move to the right from either of the existing population statistics shown on Figure 7. If the status quo holds in terms of population density, it will move precisely to the right – and there are U.S. cities that have done just that. It is also possible that our community could grow to the right and upwards in terms of density and population.

There are also cities in that direction; it is a plausible future.

Figure 8 contains one likely envelope of future scenarios; in theory the entire solution space is reachable – with some locations being much more probable than others given our particular opportunities and constraints. This envelope ranges from the status quo density to a doubling of the overall average density and beyond.

Figure 8: Likely Envelope of Future Population and Density Scenarios

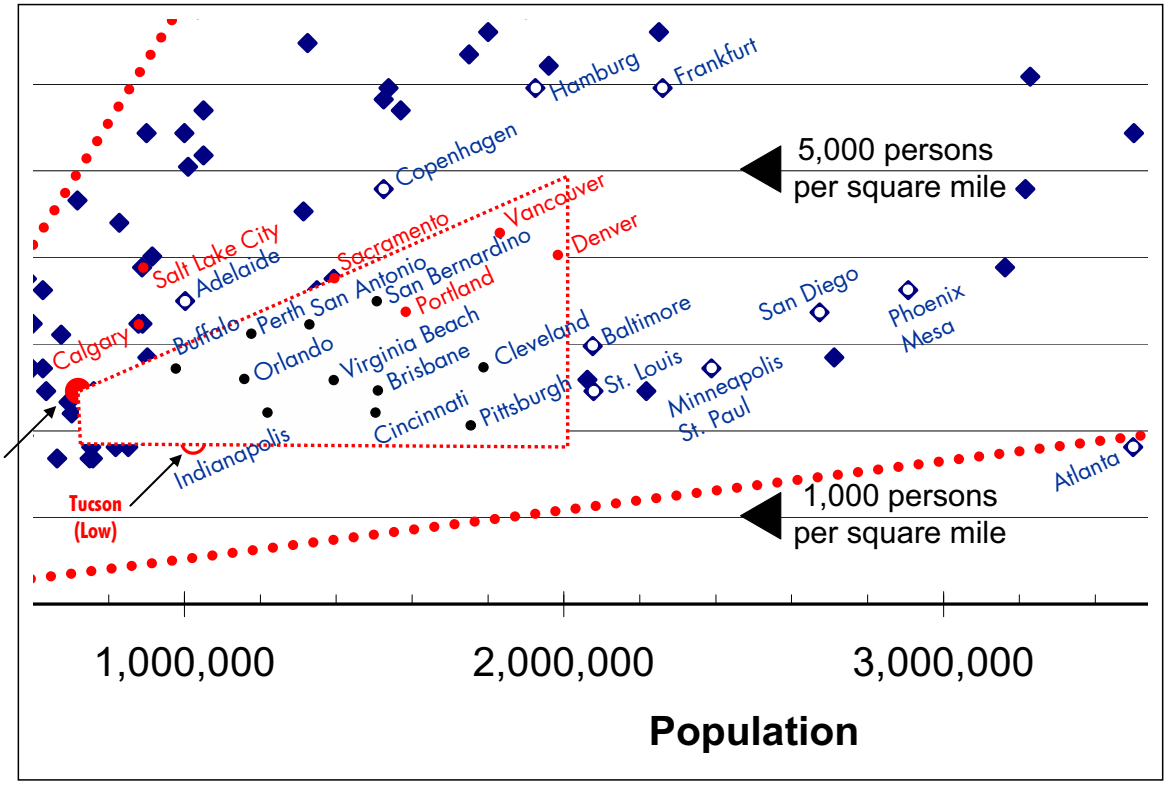


In terms of benchmarking, we are immediately interested in the identities of the cities within the likely future envelope.

Figure 9 examines a small subset of Figures 8 and 7. It identifies several of the urban areas by name. It is revealing to examine where the six "emerging practices" peer communities are located. For clarity, please note that the name labels refer to those diamond symbols with superimposed circles. Red circles are peer communities, while white and black circles were used to increase visual impact.

One of our important questions now becomes one of choosing the best pathway forward, and informing that decision with a strong awareness of the probable causal pathways created by that choice. The trail we end up tracing on this type of graph will have many real consequences for the citizens of Tucson and Pima County. The remaining portions of Section 2 will delve into many of these outcomes in detail.

Figure 9: Peer Communities In and Adjacent to Likely Future Envelope



2.3 Comparing Urban Form and Design: Benchmarking Results

This section documents the best and emerging practices benchmarking. Three levels of comparisons were completed to varying extents depending upon the urban form factor being examined. The City and County were compared to their peer municipalities. For certain factors, data from over 800 Transportation Analysis Zones (TAZ) within the City and County were compared to each other. When available, similar internal breakdown maps of the key urban form factors were collected from planning staff at the peer communities.

2.3.1 Benchmarking Population Density and Your Commute

"When you're making a housing decision, you're also making a decision on transportation." - Barbara Lipman

The cumulative housing type and location choices made by community members create population density trends and patterns. These density patterns have a direct correlation with the average annual car passenger miles these same community members then travel in their automobiles. Figure 10 displays this relationship for more than 50 higher-income world cities, the City of Tucson, and most of the selected peer communities.

Several scales of density are provided, including gross residences per acre at the average occupancy rate of 2.4 people per residence.

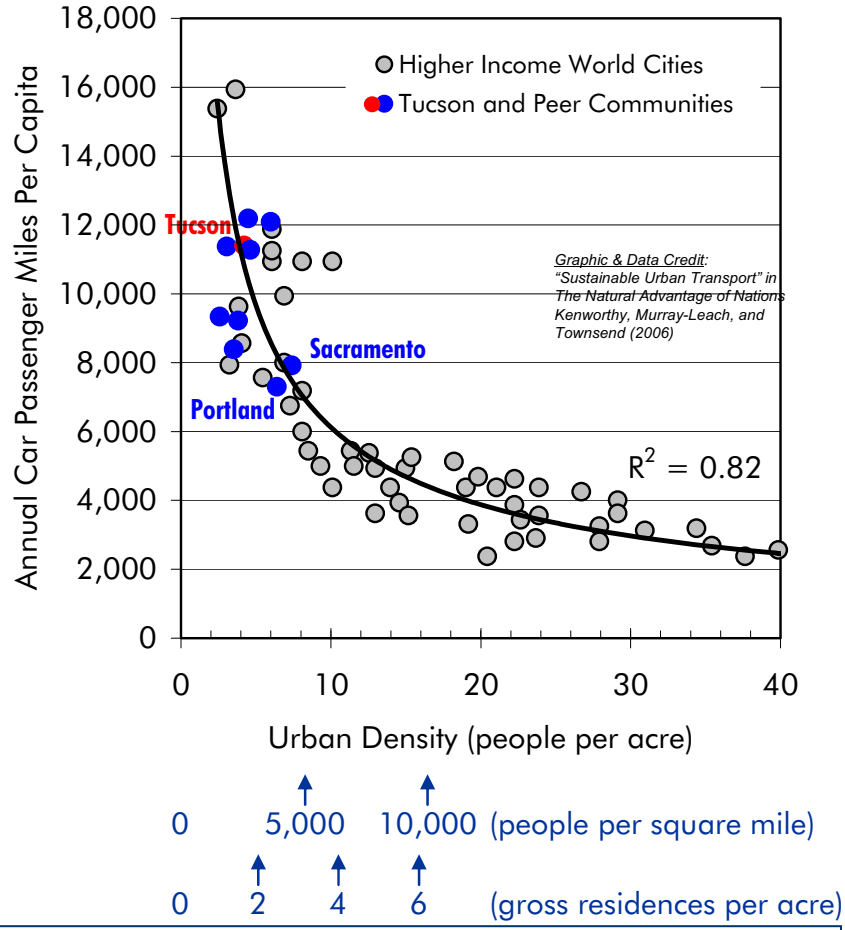


Figure 10: Density and Annual Car Passenger Miles Per Capita

Of interest to this White Paper is the relative position of the City of Tucson community, and the strong relationship between urban form and transportation behavior. The shape of the best-fit curve indicates that significant gains in trip reduction should be expected as densities increase to about 9 people per acre, or 6,000 people per square mile.

If the City of Tucson presently averages about 4 people per acre today, what might such an increase in density look like? The photograph to the left depicts a typical Tucson subdivision with 2.5 residences per acre, or a total of 6 people per acre.

Page 36 Graphic Credit: Excerpt from Visualizing Density by Julie Campoli and Alex S. MacLean. © 2007 by the Lincoln Institute of Land Policy, Julie Campoli, and Alex S. MacLean.

Aerial photographs © 2007 Alex S. MacLean.

Compare this density to the photograph below to see the influence of a different urban form and design; this Longmont, Colorado subdivision yields 7.7 residences per acre, or a total of 18.5 people per acre.

Note the variation of density and the floor space to area ratio (FAR).

Figure 7 indicates that over the range of these two photographed urban forms one might expect the annual car passenger miles traveled per capita to be reduced in half. This tells us that urban form is important.

"What really matters is how the streets are laid out, how the land is subdivided, how the buildings are arranged and detailed… These are all functions of design." – Lincoln Institute of Land Policy

This reduction in car passenger miles has obvious and significant impacts on affordability that will now be discussed.

Assuming population densities in large portions of our community can increase to 6,000 people per square mile, the expected annual car passenger miles per capita would drop from 11,400 miles to about 7,000 miles.

In the City of Tucson and Pima County, this effect of urban form causes wide variations in the amount of household income spent on housing and transportation. A recent study entitled "*Housing + Transportation Affordability in Tucson Metropolitan Area, Pima County, and Pinal County*" by the Center for Neighborhood Technology (CNT) and the Drachman Institute is available at http://www.drachmaninstitute.org/.

This study documents how housing and transportations costs in the central city can be less than 30% of the area median income, and greater than 60% of the area median income in outlying areas.

On a daily rather than an annual basis, this is a drop of almost 40% from 31.2 miles per day to 19.2 miles per day. This is highly significant in light of CNT research that suggests transportation costs (as a percentage of income) begin to exceed housing costs when average commute distances lengthen past a distance of 15 miles.

Similar research has been completed for other centers, with many more communities being studied at present. The combination of housing and transportation affordability is a strong emerging benchmark.

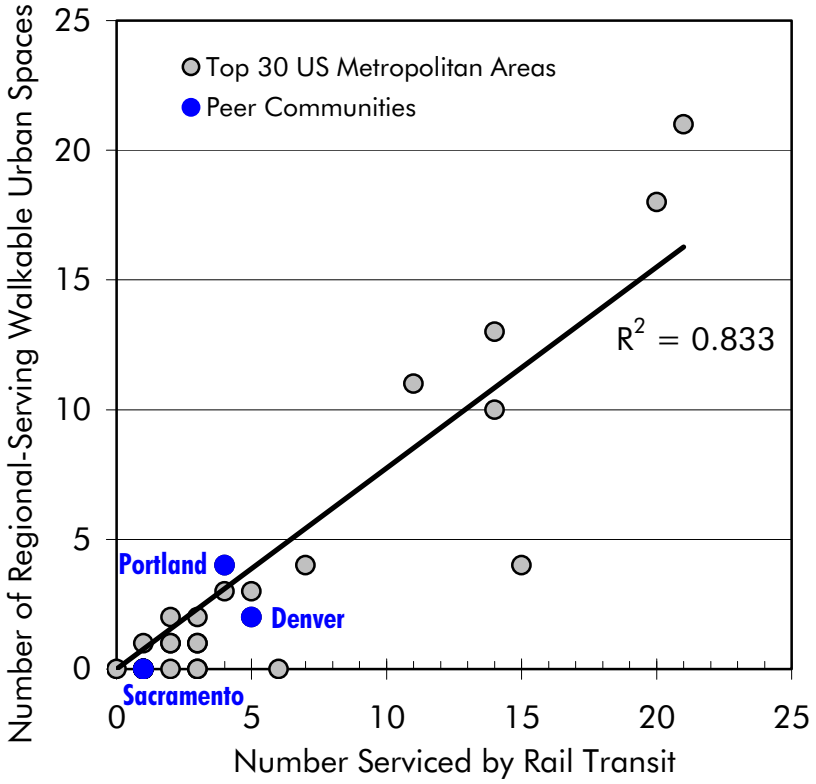
2.3.2 Benchmarking Rail Transit, Density, and Walkable Urban Spaces

A recent survey of regional-serving walkable urban spaces identified 157 such spaces in the largest 30 metro areas in the United States. The survey defined walkable urban spaces to be at least five times as dense as typical suburbia (requiring a FAR of at least 0.8 and upwards to 40.9), include mixed uses, be compact (between 100 and 500 acres in size), be accessible by multiple transportation modes, have regional more than local significance, and to be completely walkable from within. The survey excluded institutions that by their very nature are regional walkable urban spaces, such as medical, corporate, and university campuses, and theme parks.

The survey found most such places are adjacent to downtown, while others were in suburban town centers, formed during suburban redevelopment, or were developed as lifestyle centers.

The survey also noted that rail transit or even being "rail transit ready" apparently plays a large role as a catalyst, as shown on Figure 11.

Figure 11: Role of Rail Transit in Serving Walkable Urban Spaces



Two potential regional-serving walkable urban spaces within our community were quantified. This included Downtown Tucson and the University of Arizona campus, although campuses were specifically excluded from the original survey.

The University of Arizona campus meets most of the technical criteria; however it has a current gross land area of 590 acres and a stated net future land area of 355 acres. According to the 2003 Comprehensive Campus Plan Space Needs Forecast, it has a gross floor space square footage of 7.7M square feet. Using these areas yields a FAR between 0.3 and 0.5, both of which fall short of the minimum FAR of 0.8.

Downtown Tucson is closer to qualifying as regional-serving walkable urban space. It has a combined residential and commercial FAR of 0.6 over 338 acres. A smaller boundary and area of 231 acres had the maximum FAR, with a slightly higher ratio of 0.7.

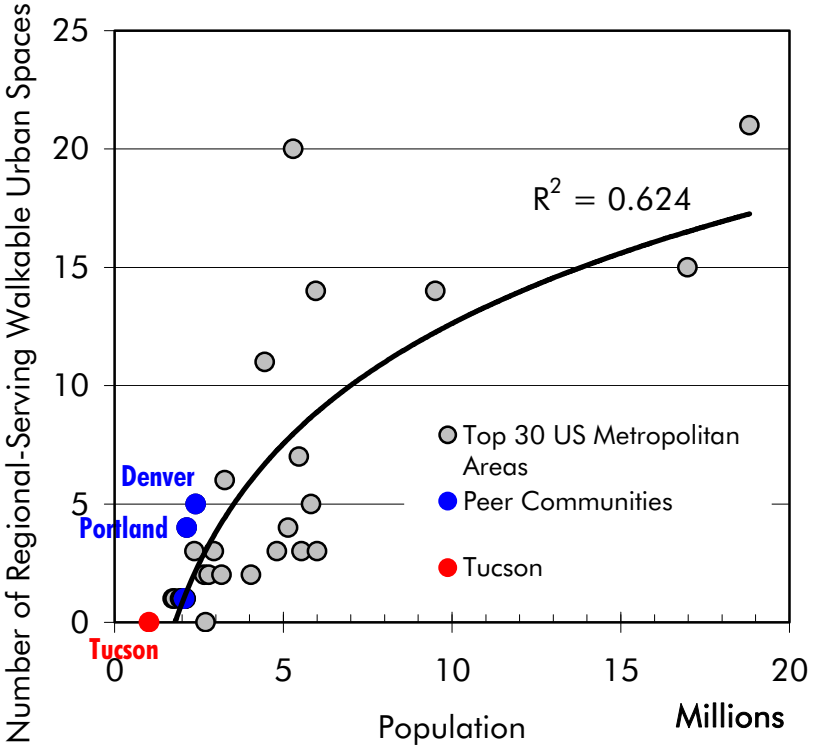
With the arrival of the Tucson Modern Streetcar, it is likely that the additional energy and final ingredients imparted to Downtown Tucson will create a vibrant regional-serving walkable urban space.

Extension of high capacity transit can be encouraged by higher densities. Densities of six to eight residences per acre (about 11,000 people per square mile) are needed to encourage even bus rapid transit, let alone light rail or commuter rail transit.

Figure 9 below highlights the forward-looking nature of conducting benchmarking in terms of emerging practices. The smallest of the Top 30 US Metropolitan Areas surveyed had 1.7 million residents, so it is suggested that including Tucson is premature, yet revealing.

Although the population of Pima County has just surpassed one million, it is possible to look ahead and identify points of difference with other peer communities. Seen far enough in advance, it is possible to adjust course and reach a new destination if desired.

Figure 12: Urban Population and Walkable Urban Spaces



Photograph © 2008 Audrey Bonnet. Used With Permission.

For a population of two million residents, the survey suggests that following these emerging practices would see Tucson develop anywhere between one and five qualifying regional-serving walkable urban spaces. The photo at left depicts the dense Streetcar-catalyzed Pearl District in Portland, Oregon.

This is an opportunity that our community can readily seize within a few decades.

2.3.3 Benchmarking Transportation Congestion

Tucsonans are aware that their time spent in traffic congestion is increasing. The Texas Transportation Institute (TTI) has been assessing urban congestion and use of various modes for two decades. Its annual report on congestion trends usually makes the headlines and the national television news. The TTI "*2007 Urban Mobility Report*" indicates that:

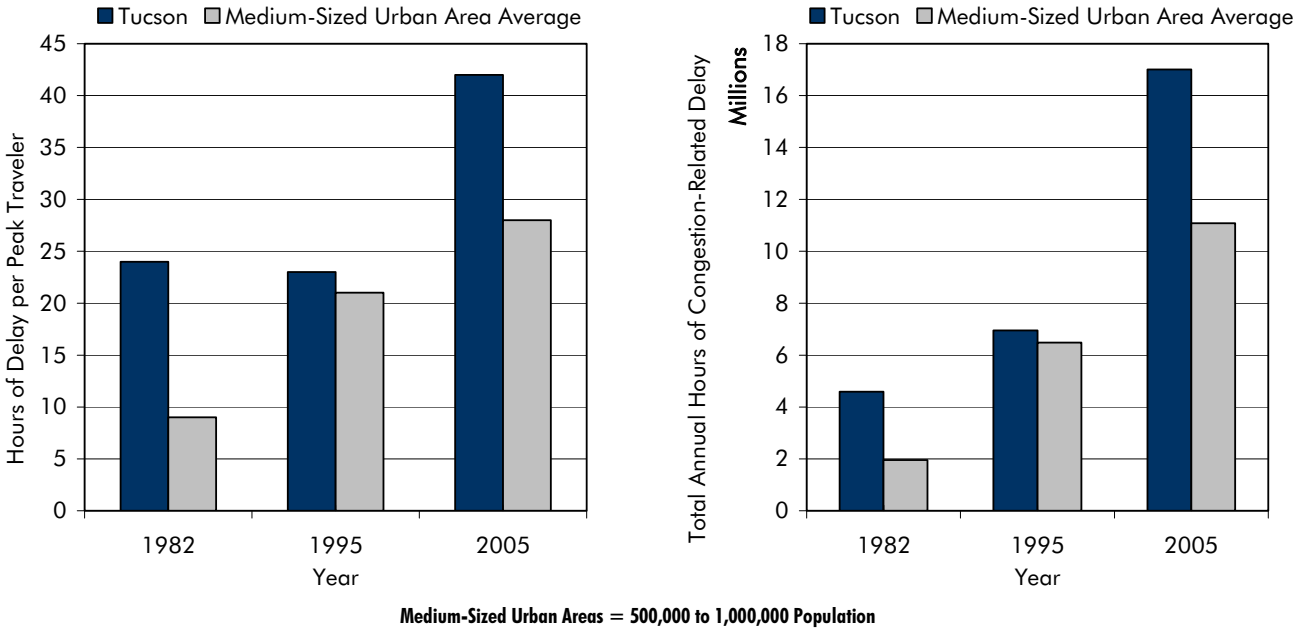
> "Congestion has increased even though there are more roads and more transit service. Travel by public transportation riders has increased 30 percent in the 85 urban areas studied in this report. The contribution of the road growth effect to the congestion problem is difficult to estimate…"

The report estimates that travel has increased 105% in large metropolitan regions while road capacity on freeways and major streets has grown by only 45 percent. We clearly are not able to, and in fact probably cannot, build our way out of congestion through increased road construction.

The 2007 Urban Mobility Report has been updated yearly and contains transportation data for most major cities. Congestion data is provided for each city based on several metrics, including delays, wasted fuel, and travel time. Figure 13 shows the growth in delay per traveler and total delay in Tucson from 1982 to 2005 and provides comparison with other "medium size" cities including many of our peer communities.

Page 41 Data Source: Texas Transportation Institute, 2007.

Figure 13: Growth in Tucson Delay from 1982 to 2005



The following Tables 6, 7, and 8 show 2005 key mobility measure data for the peer cities within the United States identified earlier in this White Paper. Data is shown in ascending order of the rank of each peer city. Information for the Tucson area is shown in red. Ranking is shown only for the peer cities, based on 85 urban areas listed in the TTI 2007 Urban Mobility Report.

Table 6: Annual Delay per Traveler per Year

Peer City	Annual Delay per Traveler	
	Hours	Rank
Denver, CO	50	11
Austin, TX	49	13
Tucson, AZ	42	25
Sacramento, CA	41	27
Portland, OR	38	33
Albuquerque, NM	33	36
Colorado Springs, CO	27	45
Salt Lake City, UT	27	45
El Paso, TX	24	51

The Travel Time Index shown in Table 7 is the ratio of travel time in the peak period to travel time at free–flow conditions. A Travel Time Index of 1.35 indicates a 20-minute free-flow trip takes 27 minutes in the peak, and a Travel Time Index of 1.00 indicates no congestion.

Table 7: Travel Time Index Benchmarking Results

Peer City	Travel Time Index	
	Index Value	Rank
Denver, CO	1.33	13
Sacramento, CA	1.32	14
Austin, TX	1.31	15
Portland, OR	1.29	21
Tucson, AZ	1.23	28
Salt Lake City, UT	1.19	36
Albuquerque, NM	1.17	42
El Paso, TX	1.17	42
Colorado Springs, CO	1.14	51

Page 42 and 43 Data Source: Texas Transportation Institute, 2007.

Congestion also wastes extra fuel consumed during peak period travel, as shown in Table 8.

Table 8: Wasted Fuel per Traveler per Year

Peer City	Annual Wasted Fuel per Traveler	
	Gallons	Rank
Austin, TX	33	15
Denver, CO	33	15
Sacramento, CA	30	21
Portland, OR	27	27
Tucson, AZ	26	31
Albuquerque, NM	21	39
Salt Lake City, UT	18	44
Colorado Springs, CO	16	46
El Paso, TX	16	46

Puget Sound Regional Council's "*Vision 2020 + 20 Update: Information Paper on the Cost of Sprawl*" documents that unchecked urban sprawl is more costly than smart growth. The document cites prominent research papers dealing with comparing the costs of alternative development patterns and summarizes the findings to draw general conclusions about the costs of sprawl. One of the important studies cited in the report was "Measuring Sprawl and Its Impacts" written by Reid Ewing, Rolf Pendall, and Don Chen in 2002. This effort surveyed 83 metro areas and ranked them by their "Sprawl Index". He then compared the top ten most sprawling metro areas with the ten least sprawling in the following travel and transportation related outcomes:

- *Daily vehicle miles traveled per capita.*
- *Average vehicle ownership.*
- *Percent of commuters taking transit to work.*
- *Percent of commuters walking to work.*
- *Average commute times.*
- *Average annual traffic delay.*
- *Traffic fatalities per 100,000 people.*
- *Ozone pollution levels.*

The least sprawling metro areas were found to perform better than their sprawling counterparts in nearly every parameter: fewer miles driven per day, fewer cars owned, greater percentage of commuters walking or taking transit to work, fewer traffic fatalities and lower ozone levels. Interestingly, sprawling and compact regions were not found to have a significant difference in commute time or traffic delay per capita, dispelling the belief that we can sprawl our way out of traffic congestion.

2.3.4 Benchmarking Centrality

Figures 14 and 15 provide benchmark data for growth and development locations. Our community is running in the middle of the pack both when compared to the peer communities and nationally. This represents an opportunity to encourage greater levels of infill and redevelopment.

"In half of the fifty largest US metro regions, urban core communities increased their share of new building permits from 1990 to 2007. People want homes close to high-paying jobs." – USEPA

Figure 14: Building Permit Locations (2000–2008)

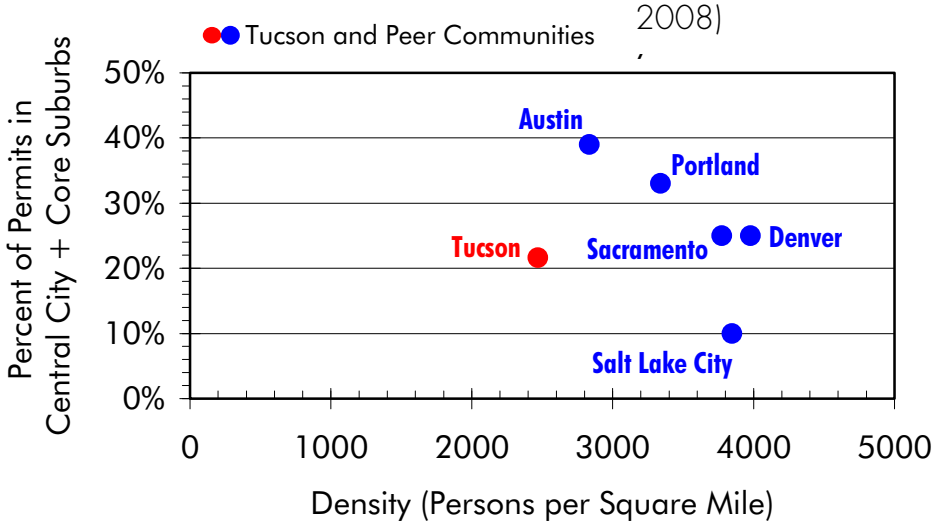
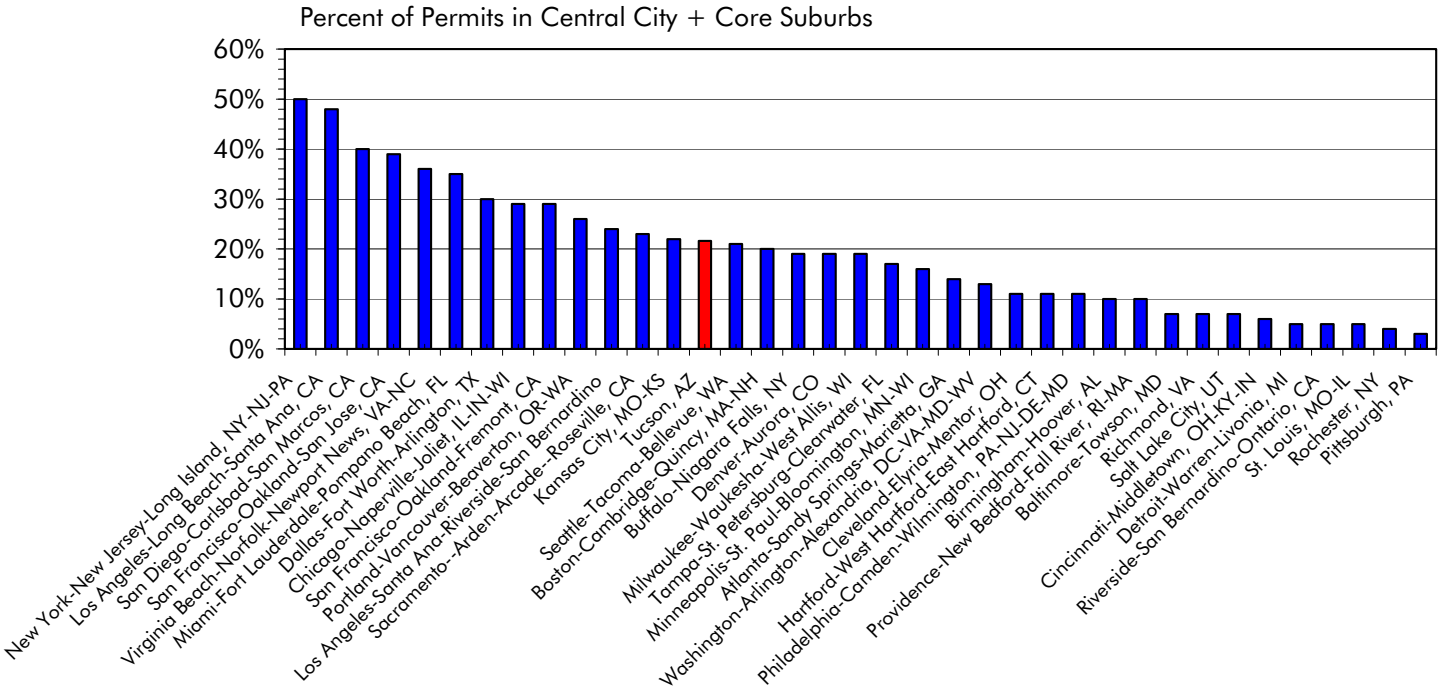


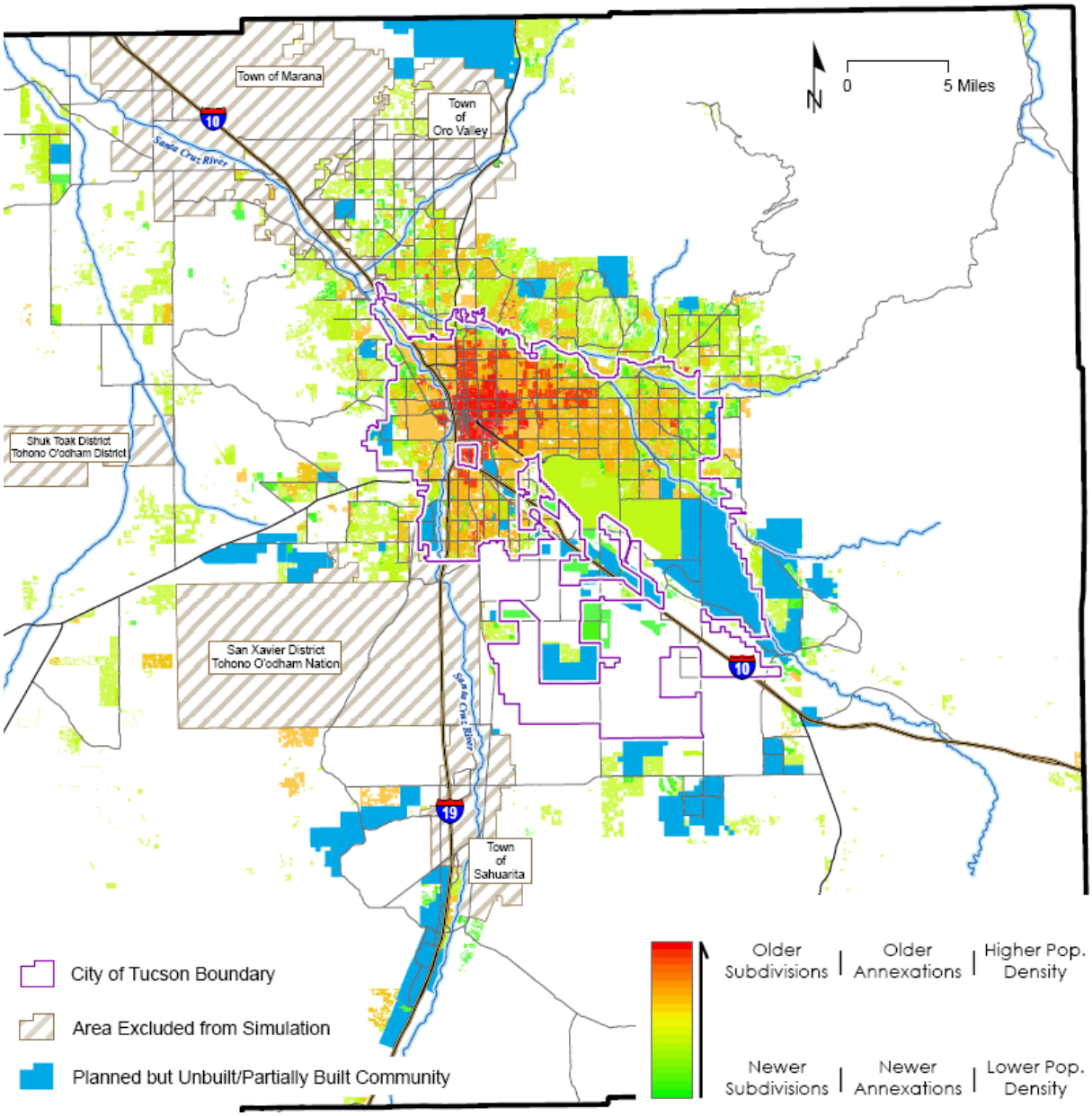
Figure 15: Residential Construction Centrality (2002–2007)



The map below depicts a blend of our community's density, location, and history. It simultaneously outlines the spectrum of older versus newer annexations and legal subdivisions, and the spectrum of higher versus lower population densities. This data formed the basis of the areas defined in Figure 4.

The location of the blue newer planned communities and green subdivisions and annexations is shown in clear contrast to the orange and red denser older areas. Our recent growth direction is not inwards, and is not aligned with centrality.

Centrality and a vital central business district can drive transit use.

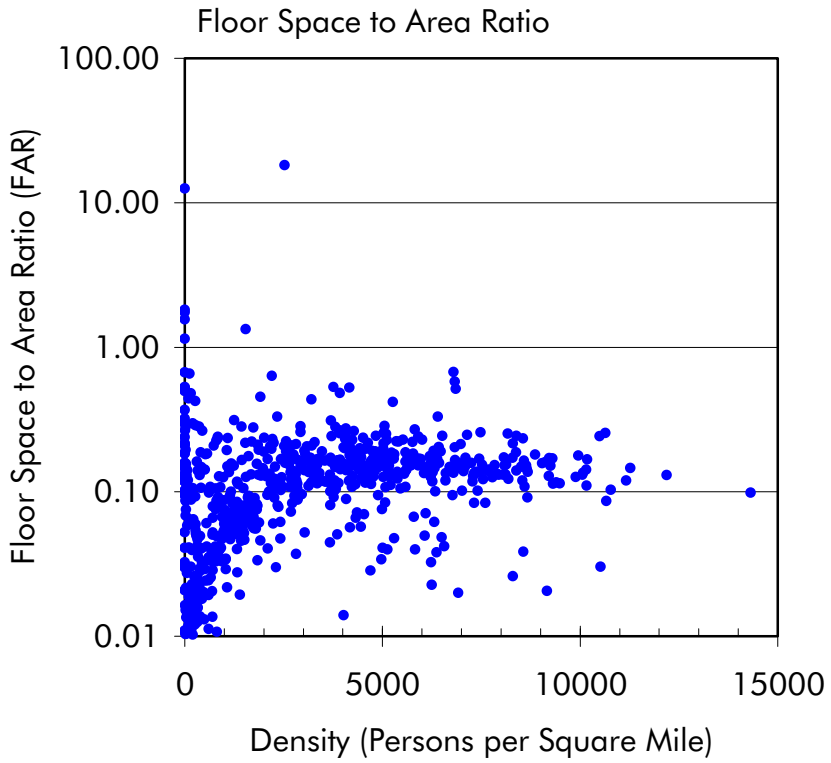


2.3.5 Benchmarking Floor Space to Area Ratio (FAR)

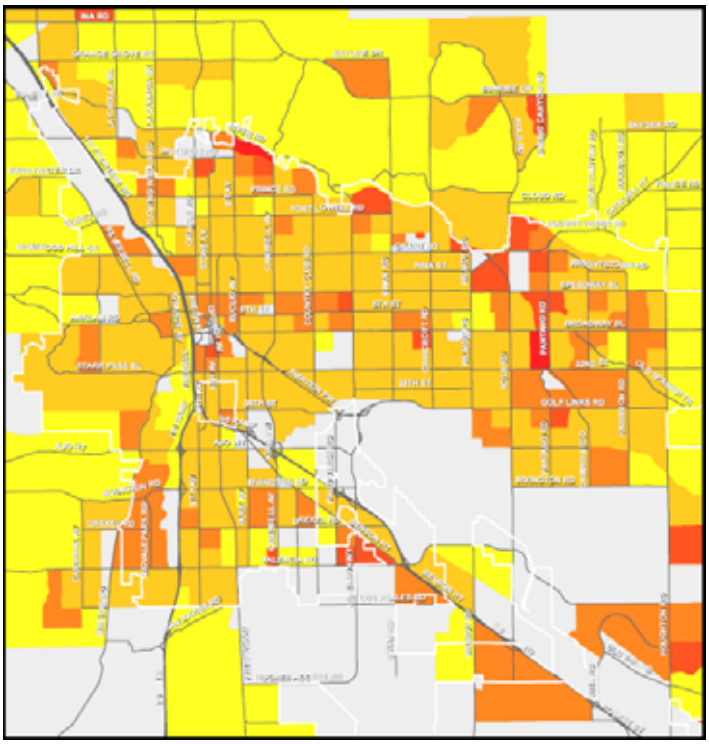
Section 2.3.2 introduced the importance of FAR in defining walkable urban spaces; it has other consequences as a metric. Tradtional economic models of monocentric cities predict that FAR, density, and land costs all become smaller with increasing distance from a central business district. Many municipalities use maximum FAR regulations to control density at its highest levels. Our community does not necessarily follow that trend, as our central FAR statistics are relatively low.

Figure 16 displays the distribution of FAR across the eastern Pima County TAZ dataset. Only four percent of the 809 TAZ areas have an aggregate residential and commercial FAR in excess of 0.4.

Figure 16: FAR Distribution across Pima County TAZ Database



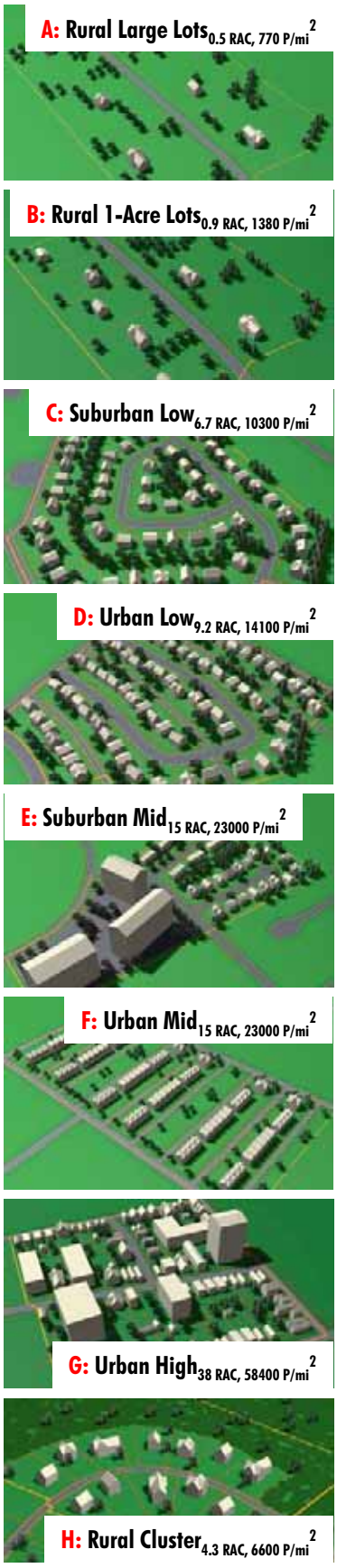
Should our community use minimum FAR regulations to manage density efficiencies?



Mapped to the left is the variation of residential FAR in the central core. Portions of more distant activity centers and suburbs in Oro Valley and Rancho Sahuarita also have TAZ FAR of between 0.3 and 0.5. The FAR pattern is discontinuous and non-uniform in its gradient away from downtown.

Residential FAR

- 0.01 - 0.09
- 0.10 - 0.18
- 0.19 - 0.27
- 0.28 - 0.49
- 0.50 - 0.95

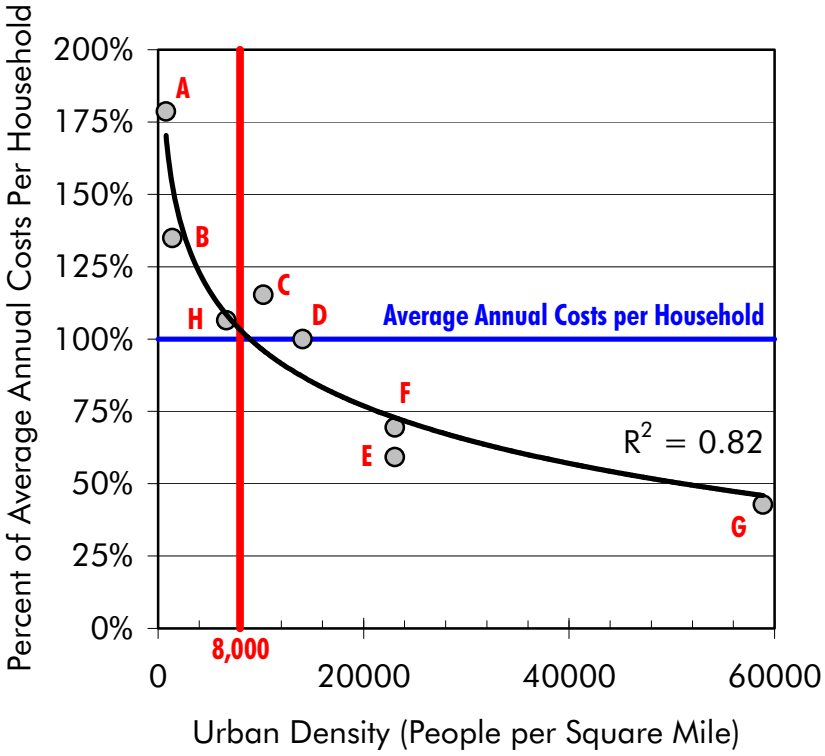


2.3.6 Benchmarking Infrastructure and Service Costs

Many studies have linked urban form factors and their direct impacts on costs and affordability. Several of these are listed in the bibliography. One of the most comprehensive studies completed recently by the Halifax Regional Municipality (population 370,000) examined the costs per household for the eight settlement patterns shown to the left with their corresponding net residences per acre statistics. The costs examined were comprehensive: roads, transit, solid waste, stormwater, libraries, parks and recreation, police, fire, culture, governance, costs paid to higher levels of government, school bussing, and either private or public water and wastewater servicing depending on the settlement pattern. The study considers both the operational and capital replacement costs required for each service.

Figure 17 displays the reduced costs per household for the settlement patterns with higher population densities. The largest cost savings are realized as densities increase to 8,000 people per square mile. Beyond this point it requires larger density increases to achieve similar savings.

Figure 17: Costs per Household for Eight Settlement Patterns with Increasing Density



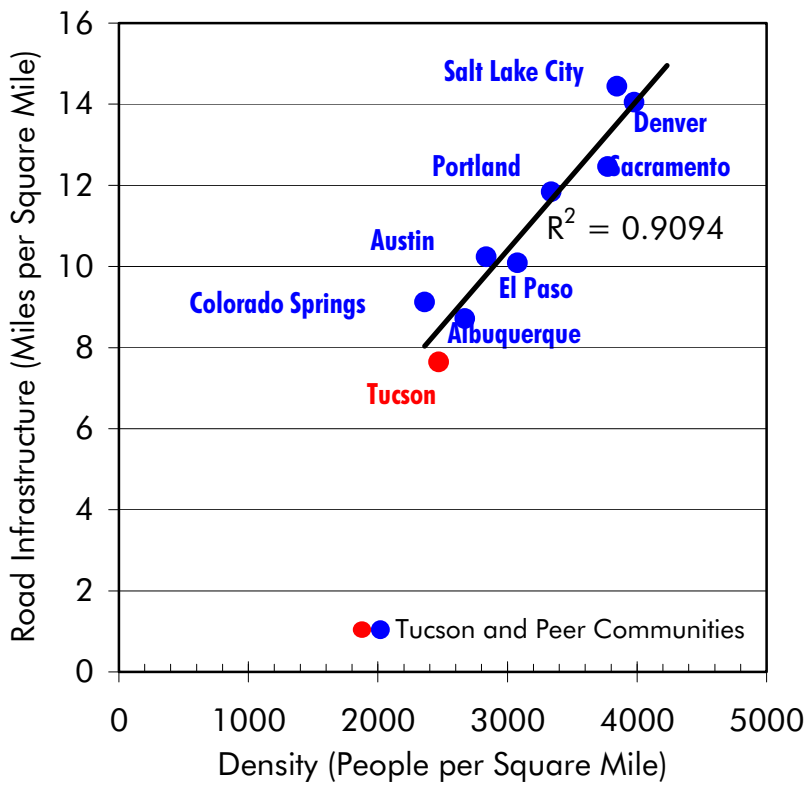
The other studies examined confirm these general results. They also highlight the cost and affordability impacts of increasing development dispersion and a lack of centrality. Our density is low on this scale.

Page 47 Data Source and Graphic Credit: Halifax Regional Municipality

North American municipalities invest heavily in transportation and other infrastructure networks, although not as much in the recent past. From 1950 to 1970, the United States devoted 3 percent of its gross domestic product (GDP) to infrastructure spending. Since 1980, spending on infrastructure has been cut by a third, to just 2 percent of GDP. This drop in funding has served to greatly increase the importance of efficient urban form, design, and land use planning decisions.

Figure 18 highlights how our community currently has the lowest density of road infrastructure among the peer communities. It also depicts a trend of higher road densities with increasing population density.

Figure 18: Road Network Density of Peer Communities



These statistics are valid at a city or county scale, and are made up of varying mixes of interstate highways and freeways and expressways, principal and minor arterials, collector roads, and local roads.

Figure 19 highlights the benefit of peer community benchmarking. A relatively unique characteristic of our community has been identified. Going forward, our planning decisions will strengthen or weaken this uniqueness on the basis of our answers to a simple question:

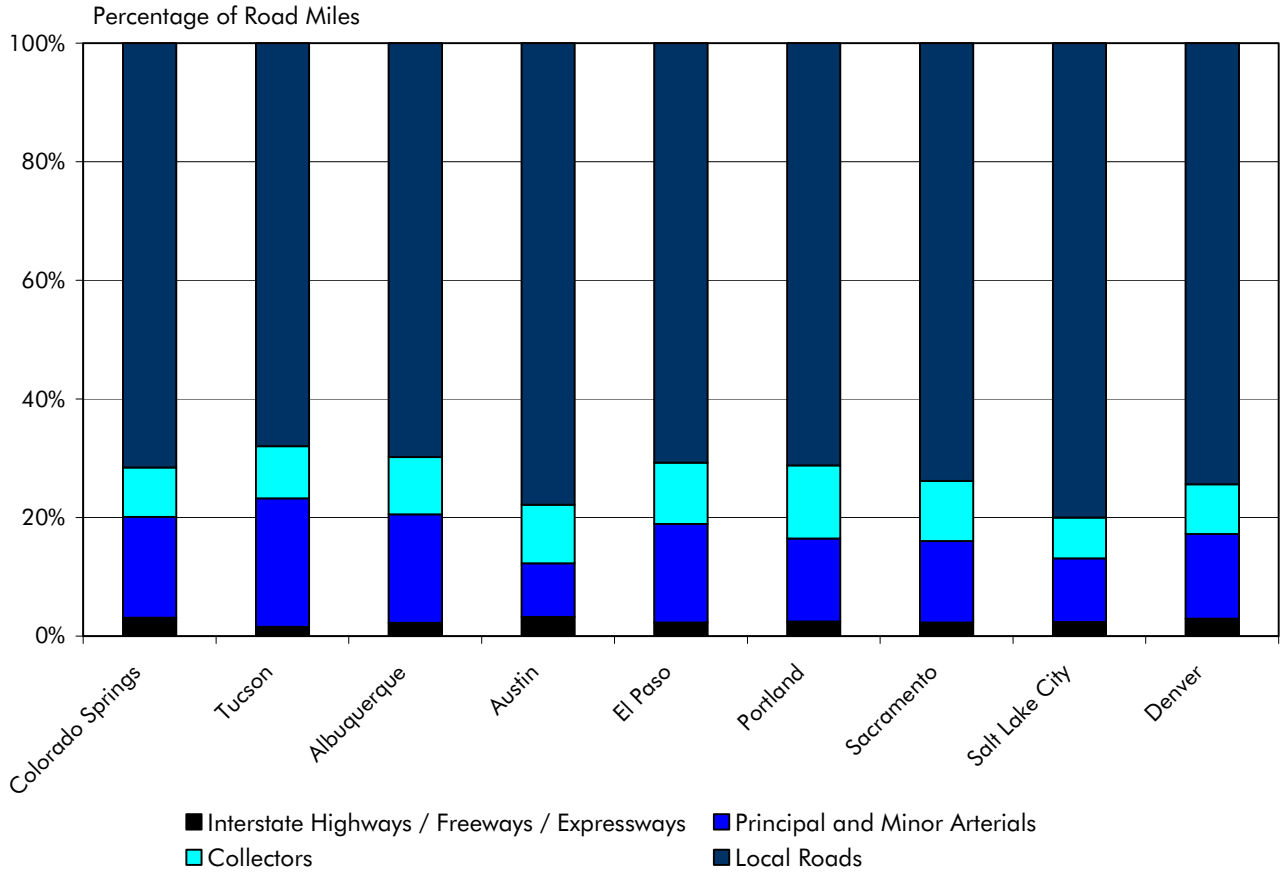
Over time, will Tucson build more roads – or include other modes?

Later investigations provided additional context for Figure 18; see Figure 20 on page 50.

Figure 19 outlines the breakdown of the peer community road network data. Our community has the smallest percentage of interstate highways and freeways and expressways, roughly less than half of the equivalent percentage share in Colorado Springs, Austin, and Denver. Conversely, our community has the greatest percentage of principal and minor arterials – more than twice the share found in Austin and Salt Lake City.

Page 48 and 49 Data Source: U.S. Department of Transportation, Federal Highway Administration, Highway Statistics, 2000

Figure 19: Peer Community Road Network Structure

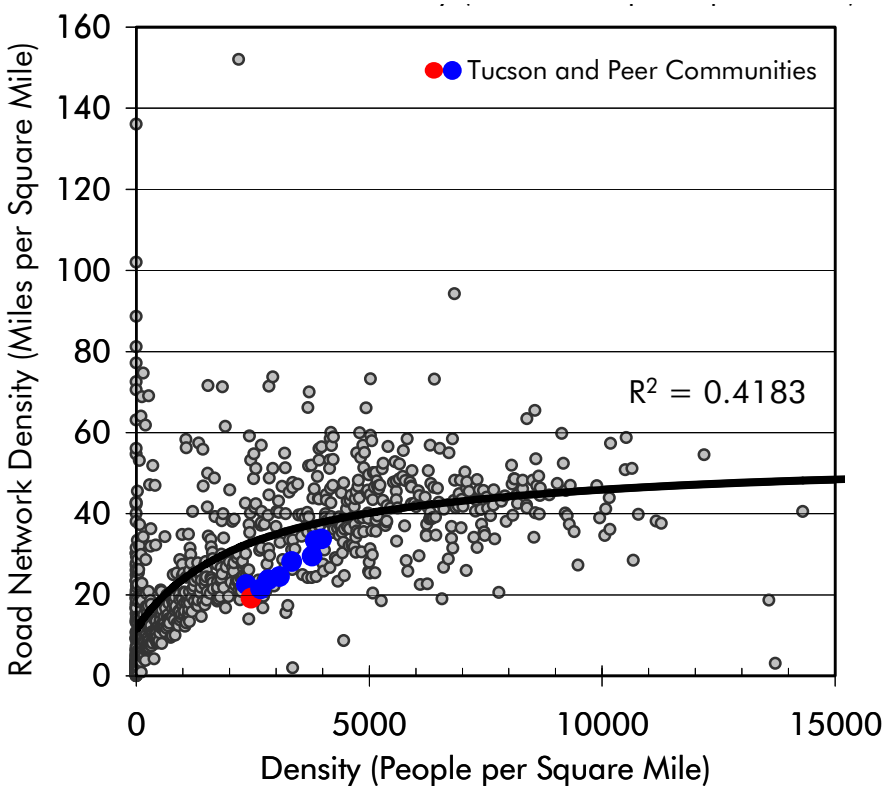


Although local roads are the great majority of the overall network, Tucson and Pima County have the smallest percentage of local roads – a full ten percent less than Austin and Salt Lake City. When its roadway infrastructure compared to the peer communities, Tucson is similar to Albuquerque in its makeup – and distinct from Austin and Salt Lake City.

The above road hierarchy is traditionally concerned with a range of mobility and access functions. However, each class of roadway can also be closely tied to place functions: regions, cities and districts, neighborhoods, and housing. As a result, road infrastructure should be judged as much for its ability to serve unique types of places as much as for capacity and traffic flows.

At the TAZ level, more perspective is gained. Figure 20 displays this data, while switching from units of miles of roadway per square mile to the more complete currency of lane-miles of roadway per square mile.

Figure 20: Road Network Density at the Community and TAZ Levels



The community-level average data from Figure 19 was roughly converted to lane-miles (by assuming typical lane counts for each class of roadway) and is displayed with blue and red circle symbols on Figure 21. The trend from Figure 19 now is given relevance in terms of the more granular TAZ trend between road network density and population density. Increasing population density does require more road infrastructure, however once population density has increased past at least 3,000 (and even more so 5,000) people per square mile, less additional roadway is required for greater density. It is interesting to note that some of the TAZ's with the most lane-miles of roadway support the lowest population densities.

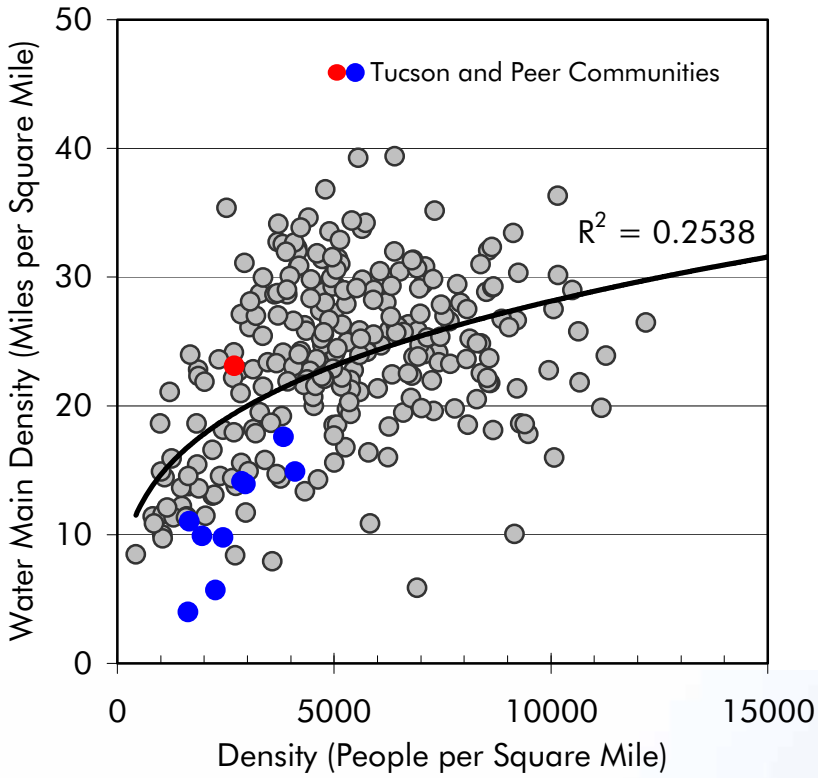
For purposes of comparison recall that 5,000 people per square mile is equivalent to 3.3 residences per acre – nearly twice our average today.

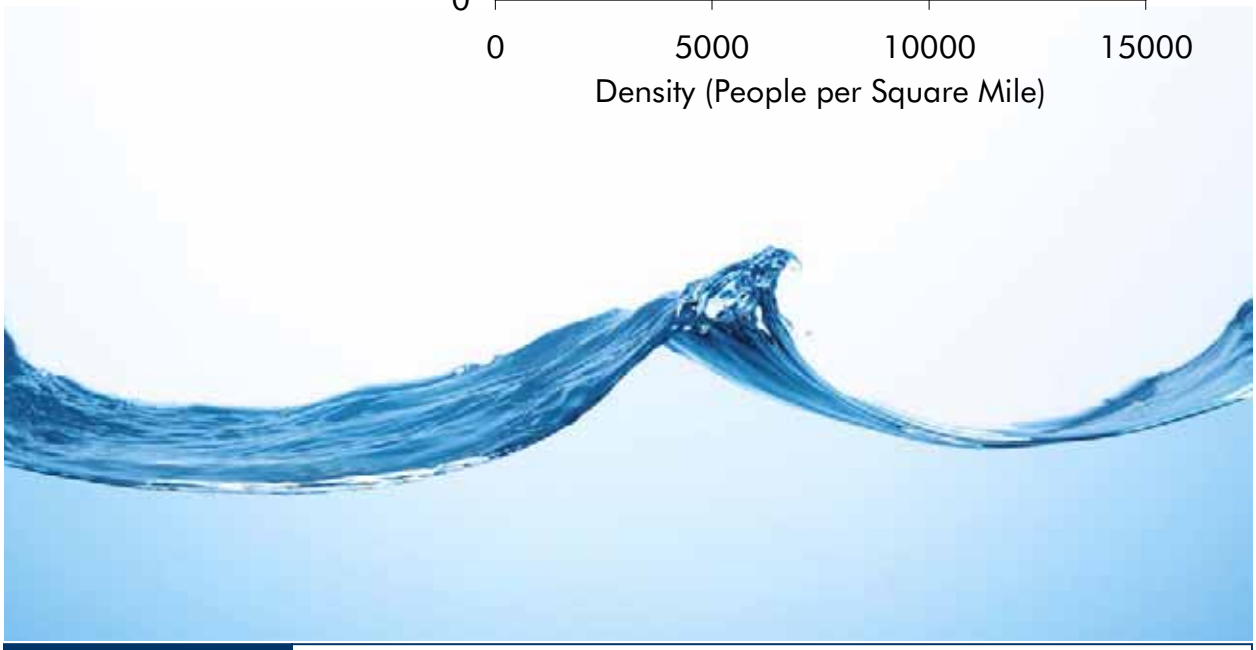
In conjunction with the earlier example of Figure 7, where population density was seen to have a dramatic impact on the use of automobiles, this result emphasizes the impact of urban form factors on infrastructure.

The Tucson Water network has a significantly higher water main network density compared to the peer communities, as shown by blue and red circular symbols on Figure 21. When the potable water transmission and distribution network TAZ data (in gray) is examined for trends with respect to population density, there is less of a correlation and an apparent relative benefit with increasing numbers of people per square mile. Only those TAZ located completely within the Tucson Water service area are graphed.

Community infrastructure assets must be right-sized and operated and maintained effectively

Figure 21: Water Main Network Density at the Community and TAZ Levels



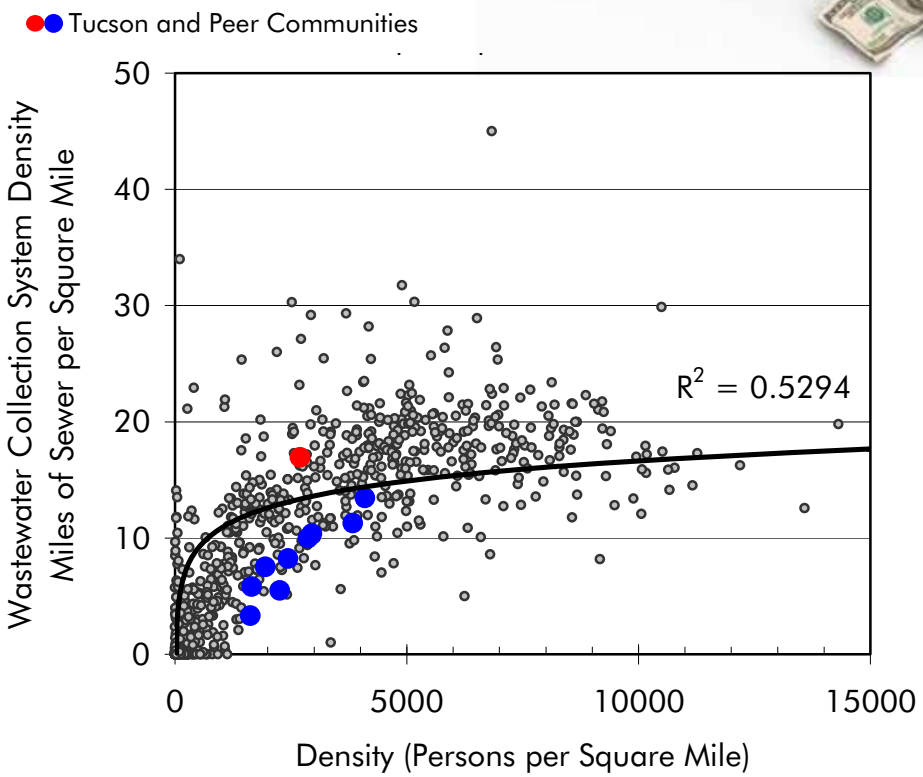


The Pima County Regional Wastewater Reclamation Department sanitary sewer network has a higher collection system density compared to the peer communities, as shown by blue and red circular symbols on Figure 22. The wastewater collection and conveyance network TAZ data (in gray) was examined for trends with respect to population density. There is an apparent benefit with increasing numbers of people per square mile, particularly when densities increase over 5,000 people per square mile.

Higher densities implies higher infrastructure efficiencies; and result in lower costs for the customers

Similar to its water system, Tucson has the highest wastewater collection system density of the identified peer communities. Many factors likely contribute to this status, and further examination of network efficiencies may be warranted.

Figure 22: Wastewater Collection System Network Density at the Peer Community and TAZ Levels



2.3.7 Benchmarking Resource Consumption

In addition to the raw resources consumed by the construction of the infrastructure systems discussed above, other resources are notably consumed by growth and influenced by urban form.

Water consumption is clearly influenced by population density as shown in Figure 23. The denser the community, the less water it uses.

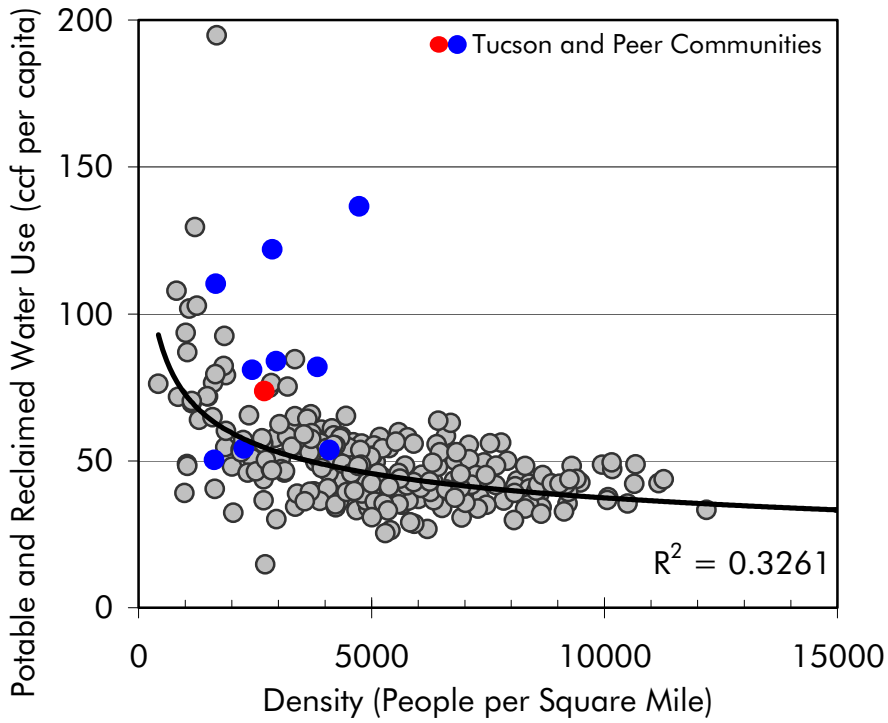


Figure 23: Water Consumption Data at the Community and TAZ Levels (Tucson Water 2005 Data)

This per capita demand reduction with size phenomenon is also evident on Figure 24, which shows the peer community utility sizes and per capita water consumptions statistics.

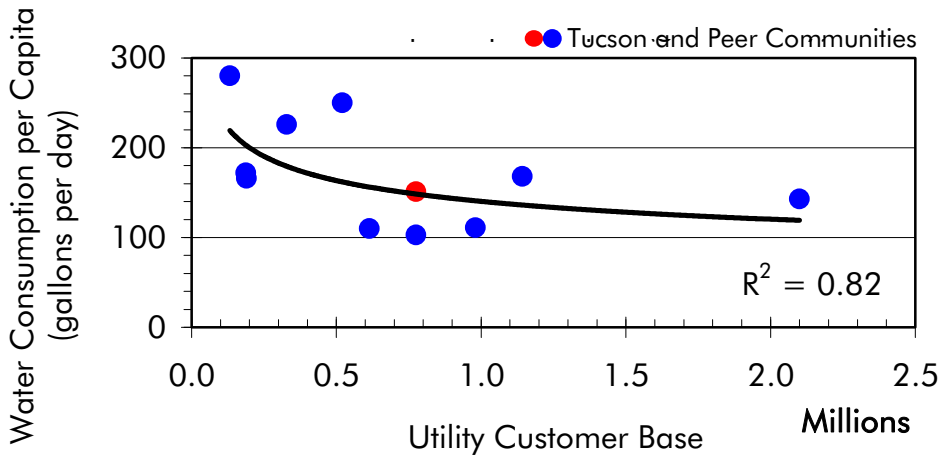
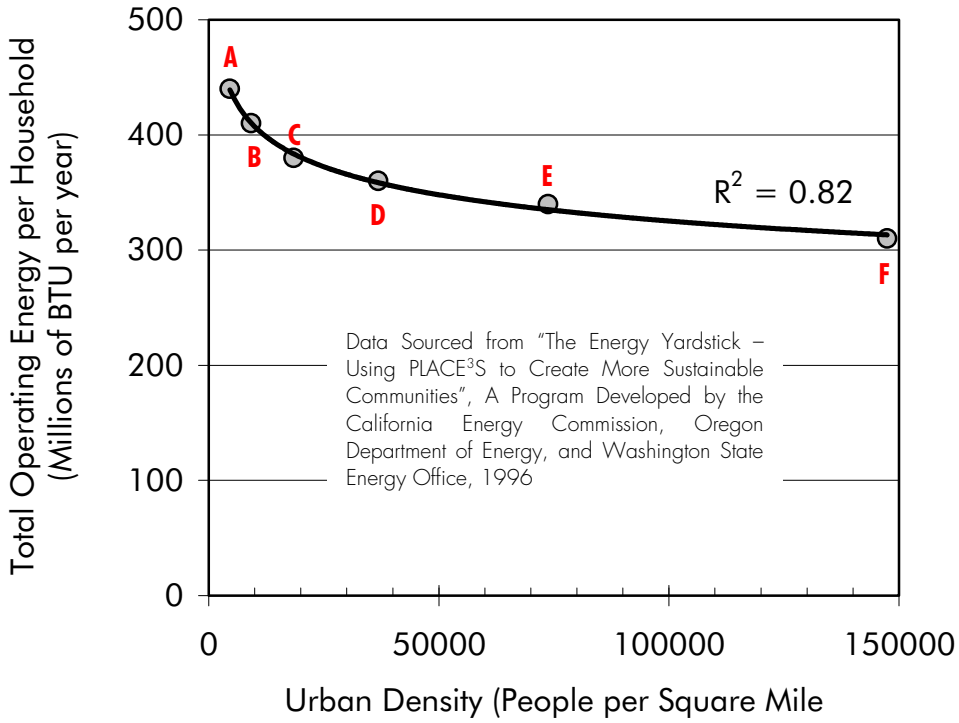


Figure 24: Per Capita Water Consumption and Utility Customer Size Relationship

Residential density has a direct impact on energy consumption. Figure 25 displays the total operating energy for six forms of development with increasing population densities. Table 9 defines the six urban forms.

Figure 25: Urban Form Factors and Total Operating Energy per Household



The energy shown in Figure 26 includes building, travel, and community fractions. Strong energy savings accrue from increasing densities up through 20,000 people per square mile, where diminishing returns start.

Table 9: Urban Form Definitions for Figure 25 and 26 Households; See Page 56 for Photographic Depictions of Similar Densities

Urban Form	Residences Per Acre	Defining Characteristics
A	3	Auto dependent, single family subdivision on 10,000 square foot lot
B	6	Detached housing on 5,000 square foot lot, commuter transit service
C	12	Townhouse on 2,500 square foot lot, high level of transit to employment
D	24	Low-rise apartments, walking and transit trips equal to auto use
E	48	Energy-saving mid-rise apartments, transit/pedestrian trips exceed auto use
F	96	Efficient high-rise apartments with very high transit and pedestrian activity

It is not just the urban form factor of population density that impacts residential energy use. Other influencing factors were documented in a recent study "*The Impact of Urban Form on U.S. Residential Energy Use*" authored in 2008 by Reid Ewing and Fang Rong of the University of Maryland and Milken Institute. Key findings from the regression modeling in this paper and its accompanying literature review include:

- Compared with households living in multi-family units, otherwise comparable households living in single family detached units consume 54% more energy for space heating and 26% more energy for space cooling.
- Compared with a household living in a 1,000 square foot house, an otherwise comparable household living in a 2,000 square foot house consumes 16% more energy for space heating and 13% more energy for space cooling.
- The average household would consume 18 million few BTU's of primary energy annually (about twenty percent less) by living in a compact county than in a sprawling county.

For the last of the above findings, levels of compactness and urban sprawl were defined using an index computed from factors such as gross population density, percentage of population living at low and moderate or high suburban densities (less than 1,500 or more than 12,500 people per square mile), average block size, and percentage of blocks with areas less than 1/100 of a square mile – the size of a typical traditional urban block.

3.1 RAC
4,800 P/mi²
Phoenix, AZ

6.0 RAC
9,200 P/mi²
Tucson, AZ

12.7 RAC
19,500 P/mi²
Sun City, AZ

23.3 RAC
35,800 P/mi²
Salt Lake City, UT

44.0 RAC
67,600 P/mi²
Oakland, CA

96.1 RAC
147,600 P/mi²
Seattle, WA

2.3.8 Benchmarking Greenhouse Gases

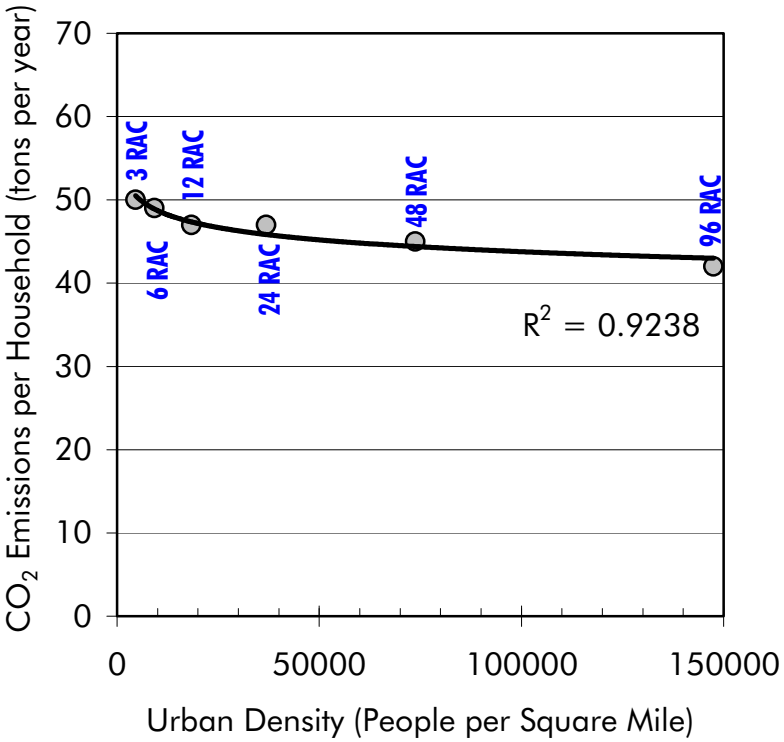
The urban forms described earlier and pictured to the left also have a correlation with greenhouse gas production. Figure 26 builds upon the same assumptions from Table 9 on page 54 and input data that created Figure 25. It displays the equivalent CO_2 emissions for each urban form. The gains in reducing CO_2 emissions are less than the energy savings gains shown on the preceding page but still significant.

The Center for Neighborhood Technology (CNT) has examined the CO_2 emissions per household from household auto use for the White Paper study area. Their results indicate that the lowest density portions of our community generate more than 9.5 tons of CO_2 per year. Conversely, the highest density portions of our community generate 3.6 to 5.6 tons of CO_2 per year.

Page 56 Graphic Credits: Excerpt from Visualizing Density by Julie Campoli and Alex S. MacLean. © 2007 by the Lincoln Institute of Land Policy, Julie Campoli, and Alex S. MacLean.

Aerial photographs © 2007 Alex S. MacLean.

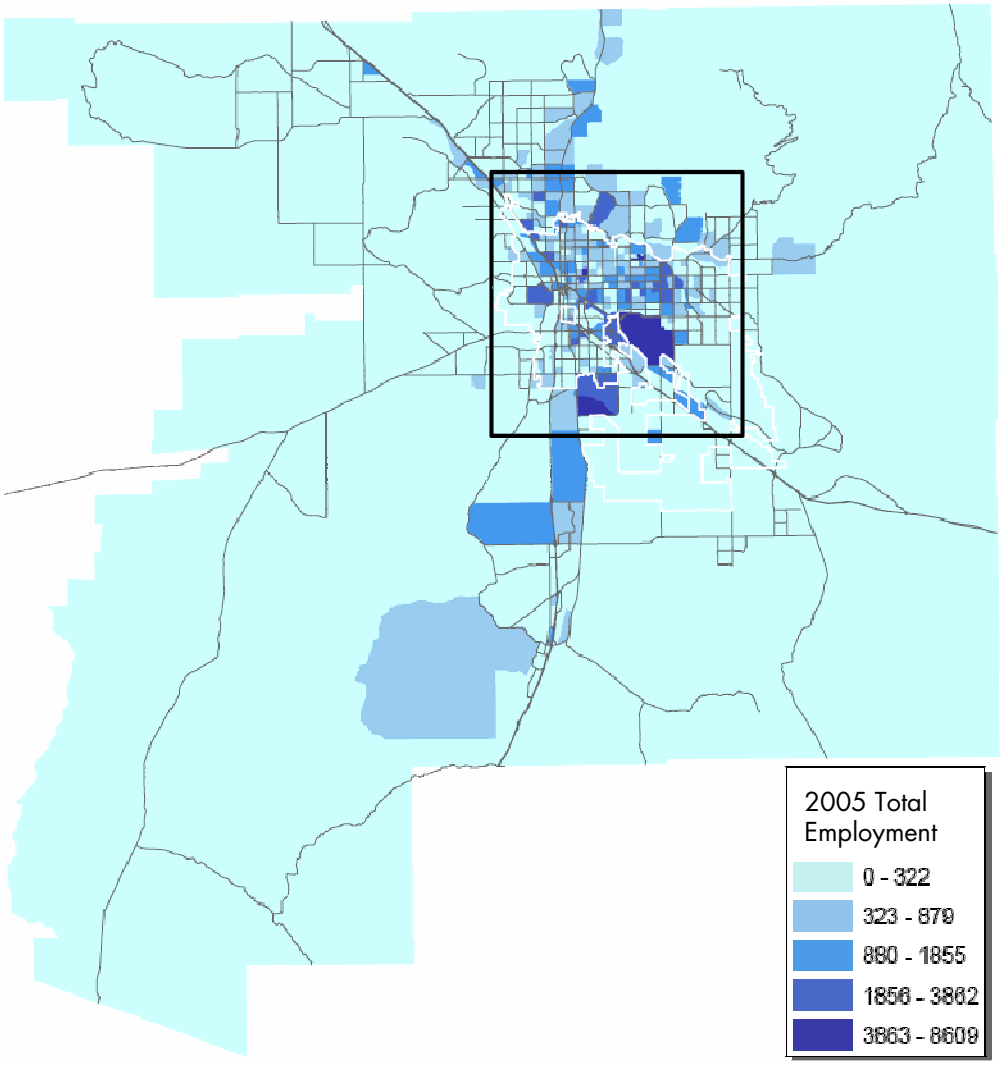
Figure 26: Urban Density and CO_2 Emissions per Household



Employment Density Plays a Large Role in Deciding Urban Form, With Transportation and Parking Issues

2.3.9 Benchmarking Employment Density and Innovation

In terms of innovation, it is employment density that drives opportunity. In their 2006 paper "*Urban Density and the Rate of Invention*", Gerald Carlino, Satyajit Chatterjee, and Robert Hunt of the Federal Reserve Bank of Philadelphia document this effect. They found that a city with twice the employment density (jobs per square mile) of another city will exhibit a 20 percent higher patent intensity (patents per capita). They suggest that patent intensity is maximized at an employment density of about 2,200 jobs per square mile. This effect is strongest at a population of about 750,000 people, with diminishing returns at higher employment densities and populations. Currently our metropolitan community has an approximate average employment density between 1,400 and 1,600 jobs per square mile. This is very similar to the average employment densities of the 280 metropolitan areas studied, and illustrates a future opportunity to rise above the average. Additional compact mixed use land use designations will help accomplish this.



2.3.10 Benchmarking Land Consumption

A recent study of rural land loss in fifteen US cities contains very useful data that helps inform the choices our community faces. The 2004 paper *"The Portland Exception: A Comparison of Sprawl, Smart Growth, and Rural Land Loss in 15 US Cities"* authored by Northwest Environment Watch provided data for Figure 27. Five of the cities are from the group of peer communities chosen for this White Paper.

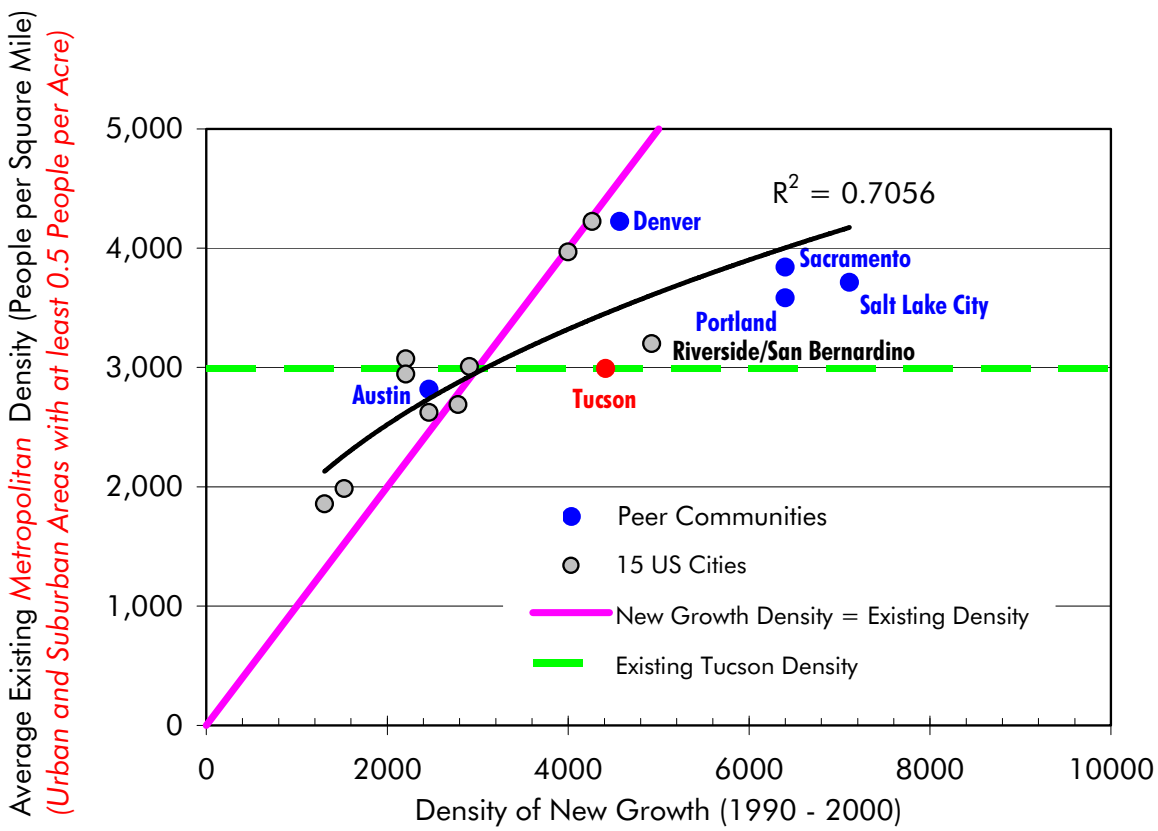
While many communities are creating new growth at their historical or even lower densities (i.e. along or to the left of the red line), Tucson and others are limiting rural land losses and adding to their communities at much higher densities than their existing average densities.

New growth densities in Salt Lake City, Portland, and Sacramento are about 80% higher than their existing average metropolitan densities. With an average existing metropolitan density of 2,991 people per square mile, we have many choices for our density of new growth.

Figure 27: Density of New Growth Compared to Average Existing Metropolitan Densities in Fifteen US Cities

Where will we land on this graph ten and twenty years from now? It will be somewhere along the green horizontal line given our existing density, and there are clear benefits to being further to the right of the red Status Quo line and red existing situation.

Clearly, our trends do not have to be equal to our destiny.



2.4 Summary of Best and Emerging Practice Benchmarking

This section of the White Paper has demonstrated many examples of apparent causal pathways and relationships that depart from urban form factors. Urban form is important, as we have learned in general that:

- A variety of growth factors has led our community growth to the suburbs; from 2000 to 2008 almost 80% of building activity occurred outside the urban core and core suburbs.
- We have grown out, not up – as more than 95% of the Pima County TAZ areas have an aggregate residential and commercial FAR less than 0.4.
- Our combination of population size and density is not unique, and there are many cities that have grown larger at both similar and higher densities.
- Building at higher densities and with efficient designs boosts the economy by saving time and money in many areas, and lowers taxation requirements.

- Density, land use mix, and design create choices.
  - Tucson now has a low density road network.

Specifically, the benchmarking curves have identified potential thresholds to grow towards with respect to population density, including:

- Increasing density to at least 6,000 people or more per square mile should greatly reduce annual car passenger miles per capita.
  - Densities greater than 3,000 people per square mile require fewer incremental lane-miles of roadway.
  - Densities greater than 5,000 people per square mile require fewer incremental miles of sanitary sewer per square mile.
  - Dense communities consume less water, particularly those over a density of 3,000 people per square mile.
  - Higher urban densities reduce energy and material consumption and lower greenhouse gas emissions.

Just as numerous are the alternate pathways forward in terms of growth, urban form, and the cost of infrastructure.

SECTION 3 – FUTURE GROWTH LOCATIONS AND SCENARIOS

Throughout the investigative and development process for this White Paper, the most widely discussed topic was which growth scenarios should be investigated during the modeling portion of the project. The project team, made up of several members of the City and County staff, was keen to see the various possibilities for Tucson's future if a few urban form factors were adjusted.

For each scenario, most of the factors and constraints remained the same as the baseline Status Quo scenario. This highlighted the impact of changing a small set of key individual variables.

The model building and GIS data collection and analysis tasks were completed by the County and City GIS departments, lead by Mike List and Josh Pope respectively. The inputs, direction, and vision for the status quo and alternative scenarios were provided by the entire team.

"Remember that all models are wrong… but some are useful." – George E. P. Box

It is noted that the modeling process is built upon many inherent assumptions and yields its best accuracy at higher levels of consideration. Its results should not be dissected and used independently at the detailed parcel, block, or even neighborhood levels of analysis.

It is also noted that other unanticipated changes will certainly occur over time within the various regional jurisdictions, such as annexations. This does not invalidate the model process or results, but calls attention to the fact that ongoing regional visioning and cooperation is paramount.

3.1 Modeling Growth Area Scenarios

Table 10 on page 61 lists the included factors used to develop the status quo scenario, while Table 1 in Section 1.1.4 (see page 14) provides a list of the assumed absolute development constraints for growth area suitability modeling.

These factors were weighted using a matched pair comparison; each factor was scored as being minimally, moderately, or significantly preferred to the other factors in terms of impact on urban form.

These weights were recalculated as shown in Table 10 after one of the original twelve factors could not be factored into the growth area suitability model due to incompatible project timelines. This combined housing and transportation affordability index could easily be introduced as a factor in future scenarios.

Table 10: Growth Area Suitability Factors and Weights – Status Quo Scenario

Status Quo Scenario Growth Area Suitability Model Factors	Relative Weighting
Proximity to Existing and Committed Road Infrastructure	14.9 %
Proximity to Existing and Committed Transit Services	0.0 %
Proximity to Existing and Committed Wastewater Infrastructure	9.0 %
Proximity to Existing and Committed Water Infrastructure	13.4 %
Proximity to "Top 100" Employment Centers	2.2 %
Proximity to Locations of 2002-2007 Building Permits and Sales	19.5 %
Proximity to Current Built Environment	6.0 %
Proximity to Trailheads and Municipal Parks	0.7 %
Proximity to Obligated Service Area of Designated Water Providers	16.4 %
Quality of School District	8.2 %
Stress Index	9.7 %

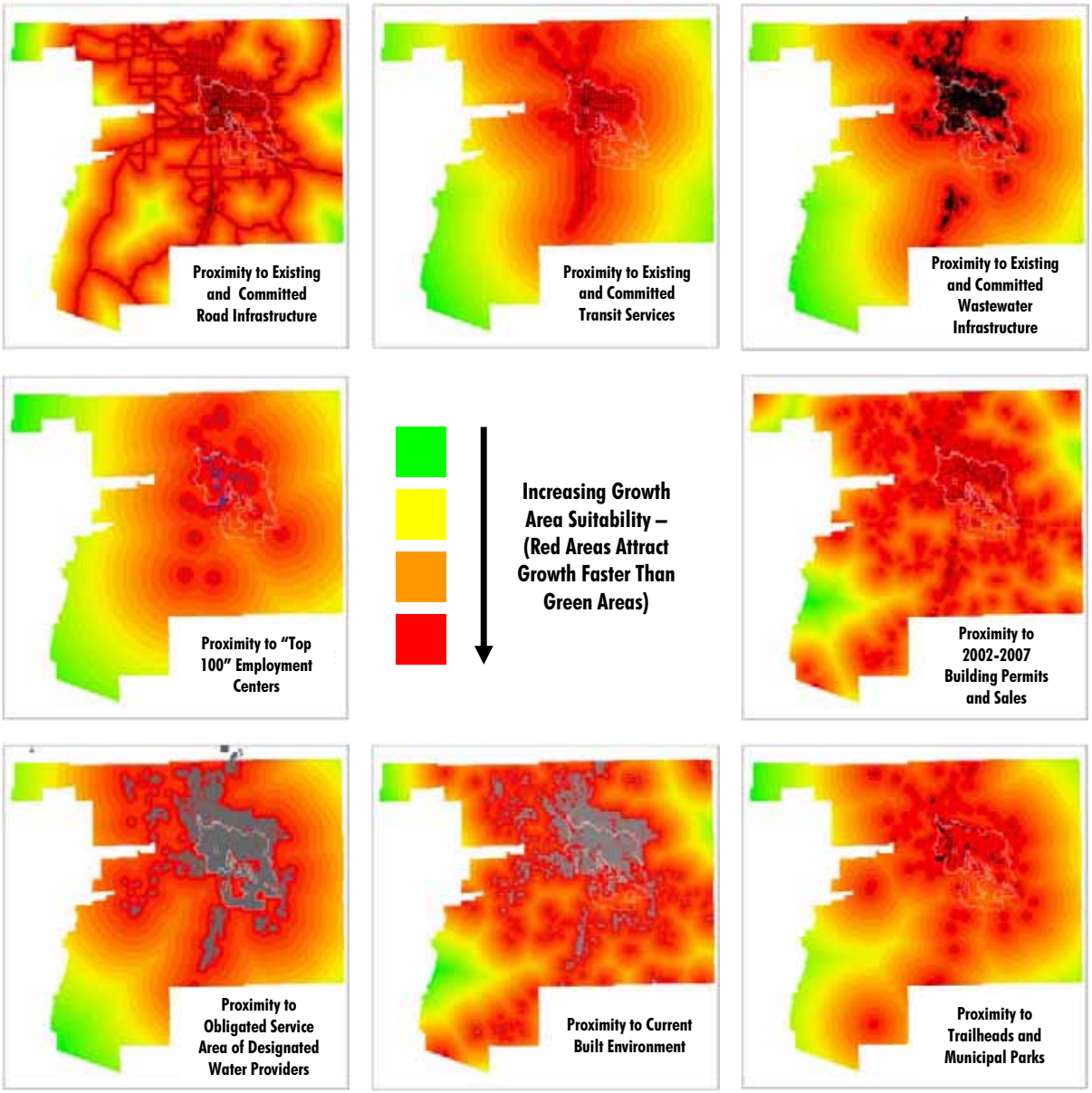
The "Stress Index" is a composite indicator previously developed by Pima County. It reflects local levels of family and housing conditions indicating dependency and need related to economic status, shelter costs and conditions, and social dependencies such as old age and disability. See http://www.dot.pima.gov/gis/data/layers/stress00/

The "Proximity to 2002-2007 Building Permits and Sales" factor was used as a viable surrogate for consumer and land developer preference.

The graphics in Figure 28 below depict eight of the eleven component factor maps that were mathematically summed to create the growth area suitability surface as defined across the grid cell landscape. For a given factor, red colored areas have the highest suitability for growth. Conversely, green colors have the lowest suitability for growth. Yellow and orange colors are moderately unsuited and suited for growth, respectively.

The inputs in Figure 28 were used for the status quo scenario.

Figure 28: Growth Area Suitability Factor Maps for the Initial Status Quo Scenario



Using the summation of the eleven factors listed in Table 10 on page 61, the land absorption mapping was completed for the scenarios. First, population projections were assigned on a status quo percentage basis to four defined planning sub-regions that make up our community. These populations were then translated into the amount of land to be absorbed into the built environment using the density assumed by the scenario. The four planning sub-regions are depicted in Figure 29. Their delineation was influenced by elements of the City of Tucson's General Plan and advice from Pima County planning staff regarding the dynamics of exurban settlement. Their recent trends in terms of land absorption share are contained in Table 11 on page 64. These trends were used to establish an approximate share of the modeled Status Quo growth.

Note that the suburbs definition includes lands defined as "planned but un-built or partially built communities". These planned but un-built or partially built areas have received some type of development approval. They range from the totally un-built (such as the lands addressed by the Houghton Area Master Plan) to those that are planned but partially built.

Figure 29: Map of Defined Planning Sub-Regions

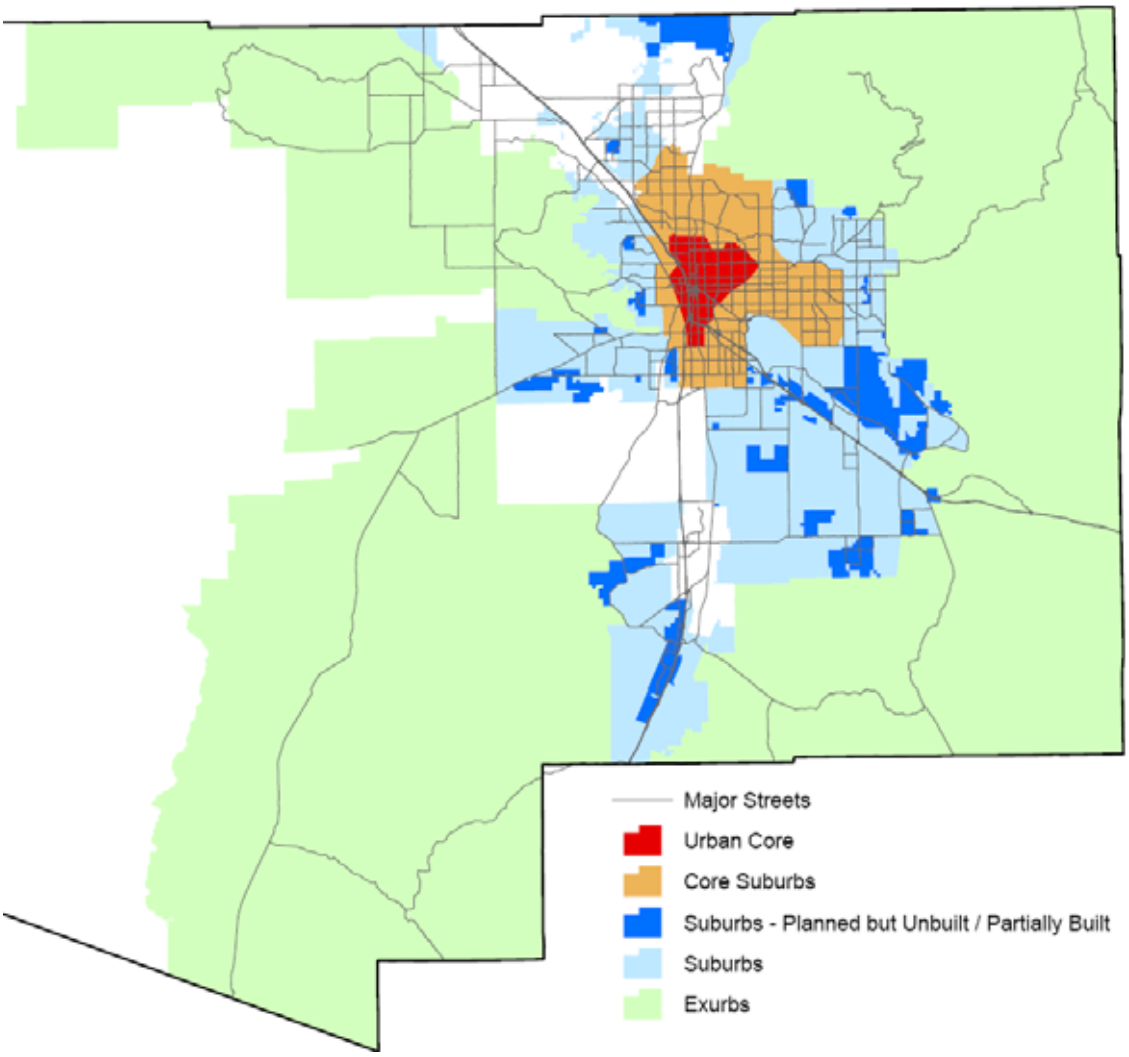


Table 11: Planning Sub-Region Trends and Modeling Rules for "Status Quo" Scenario

Planning Sub-Region	Residential Building Permits ('00-'08)	Percent of Total	Modeled Growth Share Rule
Urban Core	2,797	3.9%	5.0%
Core Suburbs	12,713	17.7%	15.0%
Suburbs	52,382	73.0%	75.0%
Exurbs	3,840	5.4%	5.0%
Totals	**71,732**	**100.0%**	**100.0%**

This acreage was then translated into an equivalent number of grid cells. The grid cells (not already eliminated from consideration by the absolute development constraints listed in Table 1 on page 14) with the highest suitability scores were iteratively chosen until the population projection was satisfied. Up to 90% of the projected growth in the suburbs was allocated to the planned but un-built or partially built communities, an absorption process that continued until that sub-region was fully developed. Vacant land was always absorbed first; if insufficient vacant land was available, the Table 11 allocations were still made but not specifically geo-referenced in the GIS model. These unmapped allocations were tracked with a separate database for later analysis.

Tucson's Urban Core at Night

This model served as the foundation for the four growth scenarios that were constructed and analyzed in relation to the extensive benchmarking that was completed.

3.1.1 Scenario #1: Status Quo

What if our community did not change the way it is growing now?

For a speculative view from this one potential future, you are encouraged to read Appendix B – "A Tale of Four Cities".

"The status quo is the only solution that cannot be vetoed." – Clark Kerr

Just because we can change does not necessarily mean we must. As a starting point for our future analyses, we developed a base scenario that reflected the status quo condition to answer the questions: What would the land form look like if we held current average densities, and how much land area would be consumed by the projected population growth? The fact is that not choosing is still a choice to be investigated.

As mentioned in previous sections, weighted factors were used to direct land absorption as population growth was applied to the model. These factors, combined with several general rules of how the land was to be made available controlled where the population was actually placed on the ground.

One of the defining rules involved how the Pima County Conservation Lands System (CLS) was to be modeled in the scenario. For the status quo model, exurban growth outside of subdivided areas (or areas of lot split activity) could not absorb more than one third of the Multiple Use Management areas as defined by the CLS. While it follows the precepts of the CLS ordinance, this rule actually did not come into play, as the land limit that this constraint imposed was well beyond the actual amount of land absorbed by the new population.

The County (and City for annexations) is currently implementing the Conservation Lands System guidelines during land use changes. The County adopted the CLS map and guidelines in 2001 to:

(1) Identify where the most important lands in Pima County are for conservation, versus the most suitable lands for development.

(2) Establish conservation set-aside guidelines that apply development within the important conservation areas.

(3) Guide County investments in public infrastructure (such as roads, sewers, and libraries) to areas most suitable for development.

The CLS was not included as a major factor or constraint in Status Quo model. CLS conservation set-aside guidelines only apply to development that requires a discretionary action of the Board of Supervisors, such as a rezoning approval.

A significant amount of development was planned prior to the adoption of the CLS. The CLS can impact the location and configuration of future planned development. However, it is difficult to estimate how much

development will occur via land use change and as planned versus unplanned development, and therefore how much future development would be impacted by the CLS. The City of Tucson has also adopted the CLS to apply during annexations and to incorporate during the upcoming General Plan update. However, similarly to the County's implementation, it is difficult to determine which future development areas will be annexed or subject to the CLS. As a result, the CLS was not included as a major factor or constraint in the Status Quo model even though it is understood it will likely have an impact on both location and intensity of growth.

The status quo model also allocated population to the four major areas being studied using a specific set of land absorption rules, based on the permit and sales activity in the region for the past several years:

- The Urban Core was assigned 5% of the incoming population, at a density of 4,500 people/square mile.
- Core Suburbs were assigned 15% of the incoming population, at a density of 4,000 people/square mile.
- Suburbs were assigned 75% of the incoming population, at a density of 2,500 people/square mile.
- Exurbs were assigned 5% of the incoming population, at a density of 500 to 2,500 people/square mile, dependent upon current zoning classifications.

Table 12 contains a breakdown of the existing urban form by population, area, and population density. The growth suitability modeling built forward from this situation.

Table 12: Existing Urban Form Statistics (2009)

Defined Growth Area	Existing Population	Existing Area (Square Miles)	Density (People per Square Mile)
Urban Core	128,724	23.09	5,575
Core Suburbs	340,456	73.36	4,641
Suburbs	422,751	189.78	2,228
Exurbs	28,067	49.89	563
Totals	919,998	336.12	n/a

Figure 30 on page 68 illustrates the results of the status quo analysis. The project land mass absorption indicates that a large amount of available vacant land space will be consumed in and around the built environment, which nearly doubles in size. A majority of the simulated growth occurs in the south, southwest and southeast sectors.

This growth is not just within the City of Tucson and unincorporated Pima County, but also in the Town of Oro Valley, the Town of Sahuarita, and the Town of Marana (recall that they are being "grown" per their respective Arizona Department of Economic Security population forecasts). Table 13 displays these growth assumptions that were held constant for all scenarios.

Table 13: Estimated Current & Forecast Populations for the Towns of Marana, Oro Valley, and Sahuarita

Municipality	Estimated Current Population	Forecast Future Population
Town of Marana	36,000	137,000
Town of Oro Valley	42,000	86,000
Town of Sahuarita	28,000	121,000

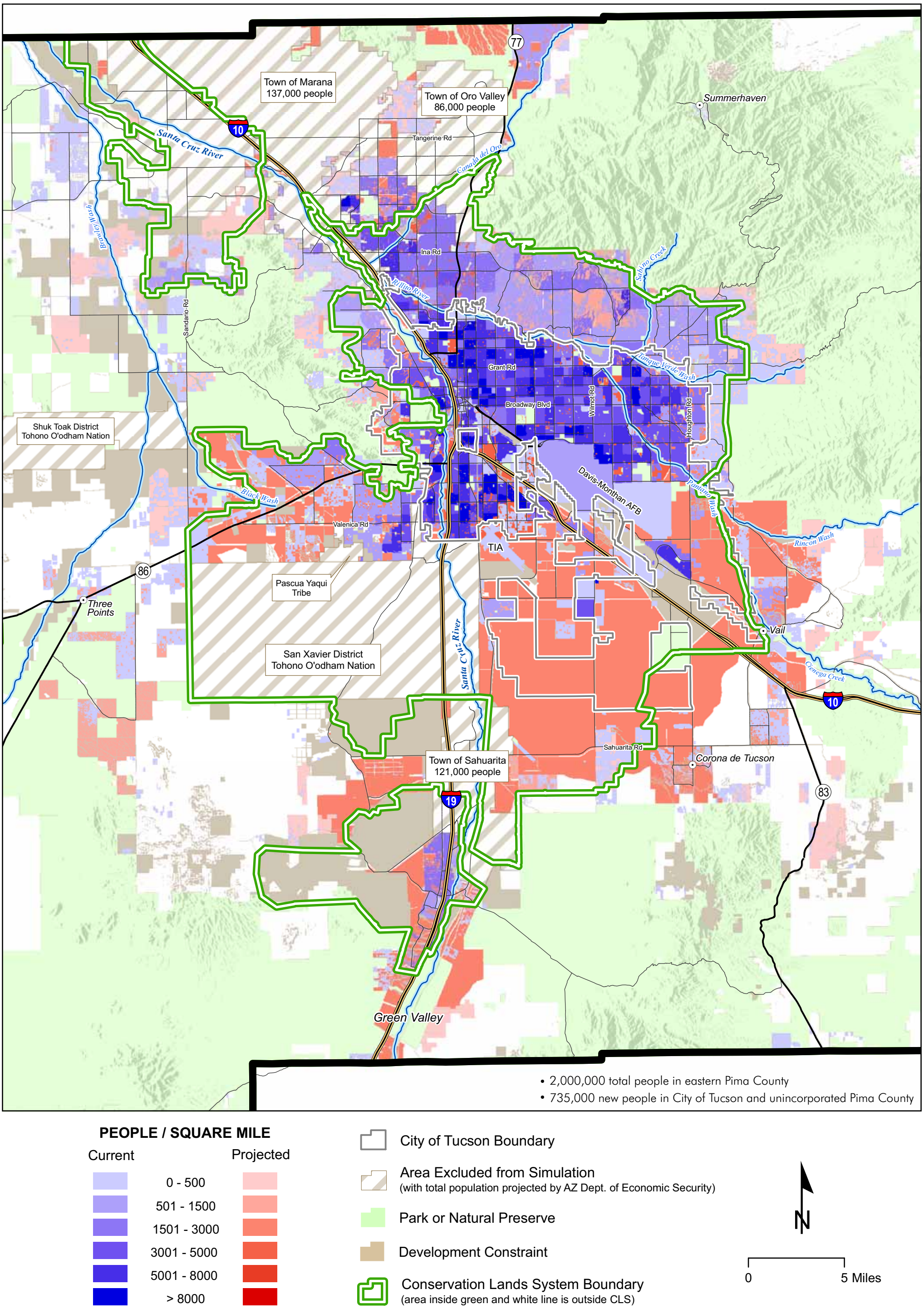


Figure 30. Scenario #1: Status Quo

3.2 Alternate Futures

Based upon their deliberations, the White Paper team held the items in Table 14 to be Top Ten considerations in developing alternate futures:

Table 14: Top Ten Considerations for Alternate Future Scenarios

Top Ten Considerations in Developing Other Choices for the Future
Benefits to existing residents
Location of growth
Density of growth
Advantages of growth
Costs of growth
Natural Environment
Quality of Life
Choice and diversity
Opportunity and equity
Community efficiency

The alternate future scenarios were built from the status quo model assumptions and weighted factors. Additional rules and alternate weightings were also applied to direct the focus of the model towards a specific goal as defined by the team. In reality, we will all have a say.

3.2.1 Scenario #2: Enhanced Habitat Protection

What if our growth patterns emphasized enhanced habitat protection? For a speculative view from this alternate future, you are encouraged to read Appendix B – "A Tale of Four Cities".

Tucson and Pima County contain lands that are rich in biological diversity, species diversification, and habitat significance. The creation of the Conservation Lands System highlights the region's commitment to preservation of these valuable resources. Given that habitat preservation is sometimes in conflict with the need to absorb incoming populations, this scenario was constructed to examine the issue.

In addition to the base assumptions that were instilled with the status quo model, this growth scenario applied some additional or modified rules to emphasize habitat protection goals. They included the following:

- The CLS categories of Biological Core, Important Riparian, and Multiple Use Areas were treated as absolute constraints to development, with the exception of planned but un-built or partially built communities, which forced suburban growth to occur at a higher density.
- Expanding suburbs were absorbed at 3,600 people per square mile, as opposed to the 2,500 used in the status quo model.

This assumes that either:

(1) All future development (excluding planned but un-built or partially built communities) voluntarily occurs outside of the CLS. One tool the County has to encourage this is the voluntary Transfer of Development Rights program.

(2) All of the CLS that is not yet conserved is purchased by the City, County, other conservation organizations, or developers seeking mitigation lands (excluding planned but un-built or partially built communities).

(3) City and County are able to develop some additional implementation enforcement, without a change in State or Federal law, which prevents development in these areas.

Figure 31 on page 71 illustrates the results of the enhanced habitat protection scenario analysis. These additional constraints resulted in the land base being exhausted. To accommodate the intended population, the expanding suburbs were settled at a density of 3,600 people per square mile. This shows that enhanced habitat protection and urban growth are not incompatible; one does not have to occur at the expense of the other. This is a key point in the County's Sonoran Desert Conservation Plan.

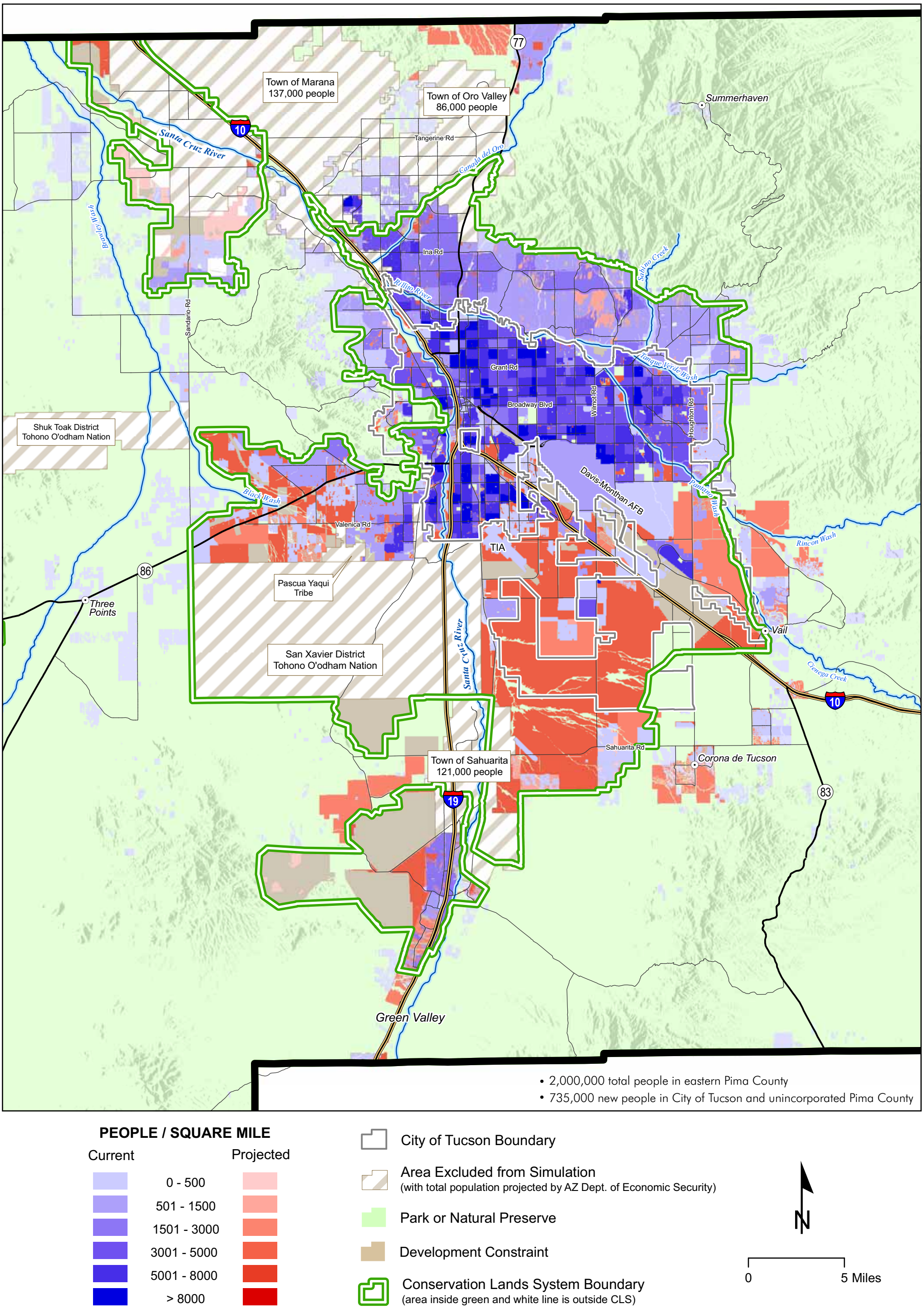


Figure 31. Scenario #2: Enhanced Habitat Protection

3.2.2 Scenario #3: Infrastructure Efficient/Taxpayer Savings

What if our urban growth patterns emphasized increased density in order to yield infrastructure efficiencies and taxpayer savings? For a speculative view from this alternate future, you are encouraged to read Appendix B – "A Tale of Four Cities".

A number of the benchmarking activities outlined earlier in Section 2 indicate that there can be meaningful efficiencies in the establishment of water, wastewater, transportation, and other infrastructure for higher population densities. With infrastructure costs continuing to rise, and capital and maintenance funds potentially limited, the effect of maximizing infrastructure efficiency was investigated. One significant end result of this scenario would be taxpayer savings.

Once again, the base assumptions and constraints that were established in the status quo model were held. In additional, the following rules were applied:

- Suburbs, outside of the planned but un-built or partially built communities and the low-density suburb developments in the Catalina and Tucson Mountain foothills, were settled at a density of 8,000 people/square mile, as opposed to the 2,500 used in status quo.
- Encroachment into the Biological Core and Important Riparian Areas of the CLS was assumed to incur off-site mitigation, but the location of that mitigation was not precisely determined. Note that the remaining (unabsorbed) land base within these two categories was sufficient to accommodate this mitigation.
- Growth locations were restricted to those contiguous pieces of land greater than 5 acres in size.

Figure 32 on page 73 illustrates the results of the infrastructure efficient/taxpayer savings scenario analysis. With these changes, we start to see less land consumed in suburban growth, with a defined attraction towards the core of the city.

In hindsight, the message from this scenario's model would have been more powerful if an additional rule had been created to increase the density of suburban development within the planned but un-built or partially built communities. Relatively speaking, more square miles of land should have been developed at 8,000 people per square mile. This would have achieved the average area densities related to the desired infrastructure efficiencies and taxpayer savings, and provided a better picture of the impact of this scenario.

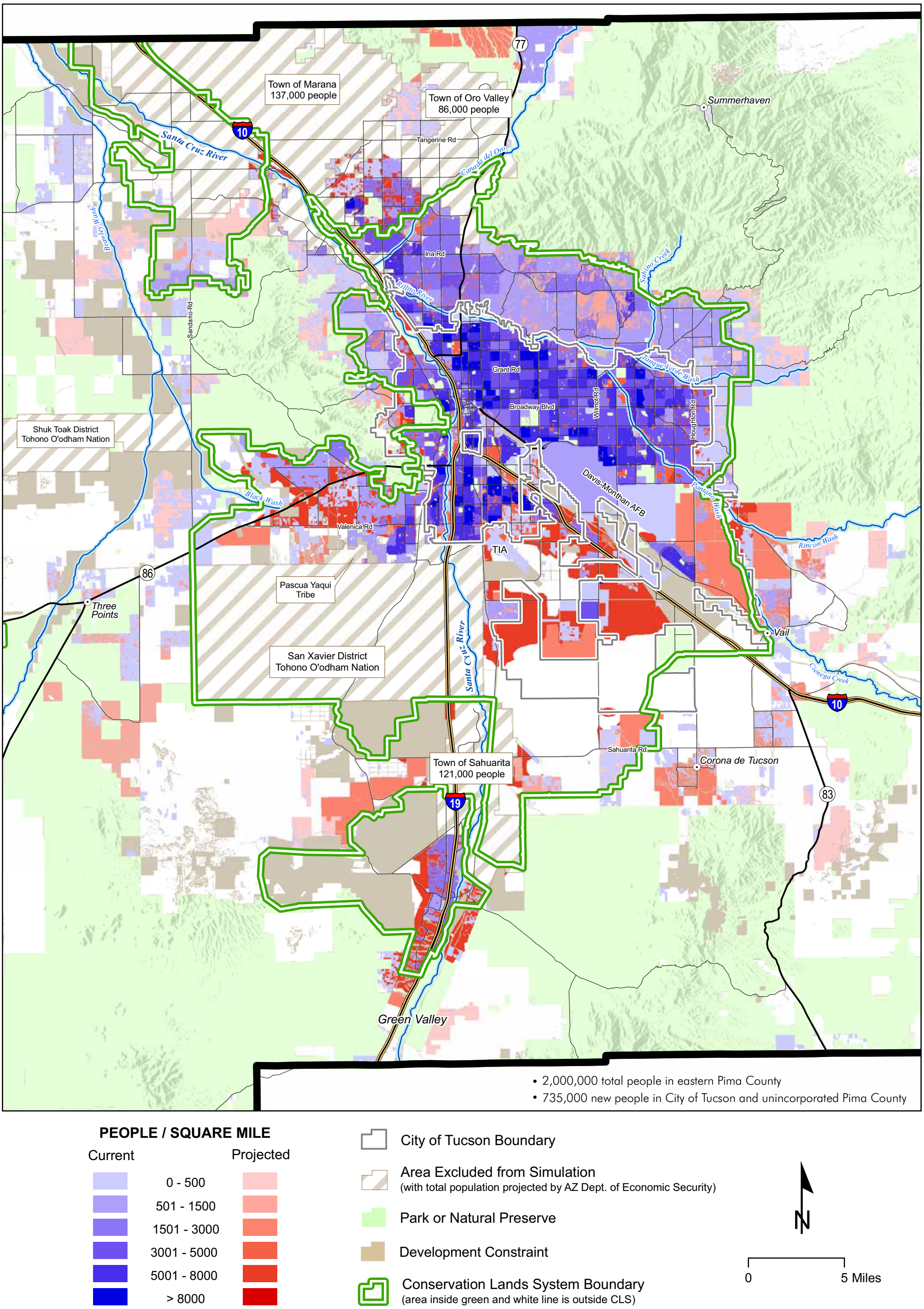


Figure 32. Scenario #3: Infrastructure Efficient/Taxpayer Savings

3.2.3 Scenario #4: Transit Oriented Development

What if our urban growth patterns were oriented to enhance mass transit? For a speculative view from this alternate future, you are encouraged to read Appendix B – "A Tale of Four Cities".

The Tucson Modern Streetcar initiative and potential light rail transit, bus rapid transit, and eventual commuter rail options highlight another option for growth: transit oriented development (TOD). In transit-oriented communities, substantial growth occurs along the transit lines and in the vicinity of the passenger stations. For the transit oriented development growth scenario, the following rules were applied:

- Re-development was assumed to occur along significant transit corridors. This included light rail lines, bus routes, and future commuter rail lines. With multiple transit options possible for the future, priority was placed on those deemed more likely in the nearer term than longer term endeavors. Locations of high capacity transit were derived from PAG study documentation and related City of Tucson Modern Streetcar documentation.
- Encroachment on the Biological Core and Important Riparian Areas of the CLS was assumed to incur off-site mitigation, but the location of that mitigation was not precisely determined. The remaining (unabsorbed) land base within these two categories was sufficient to accommodate this mitigation.
- The density rules held in the status quo model were eliminated for the most part. The only rule that remained governed how the exurb areas were populated.

The rankings of transit alternatives were as follows:

- 1st – Population was placed along the Modern Streetcar alignment in a swath one city block wide on each side of the line, with a density of 11,000 people per square mile; Streetcar stations were given emphasis, with a ¼ mile-radius sphere of influence. Density placed within this radius was applied at a rate of 23,000 people per square mile.
- 2nd – Bus Rapid Transit and Light Rail Transit lines were added, again using a swath width of one city block on each side of the alignment, and 11,000 people per square mile density; stations were handled in a similar manner, with a ¼ mile radius, and a density of 23,000 people per square mile within that radius.
- 3rd – Existing and future bus lines were added, and population was placed along the lines at a density of 11,000 people per square mile.

- 4th – Planned commuter rail lines, with a density of 23,000 people per square mile along those lines, were added.

Figure 33 on page 77 illustrates the results of the transit oriented development scenario analysis. The results show heavy infill and redevelopment in the urban core and core suburbs of the city, and reflect the lowest levels of land absorption across the various scenarios. This scenario would be highly effective at increasing the density aspects of Tucson's urban form.

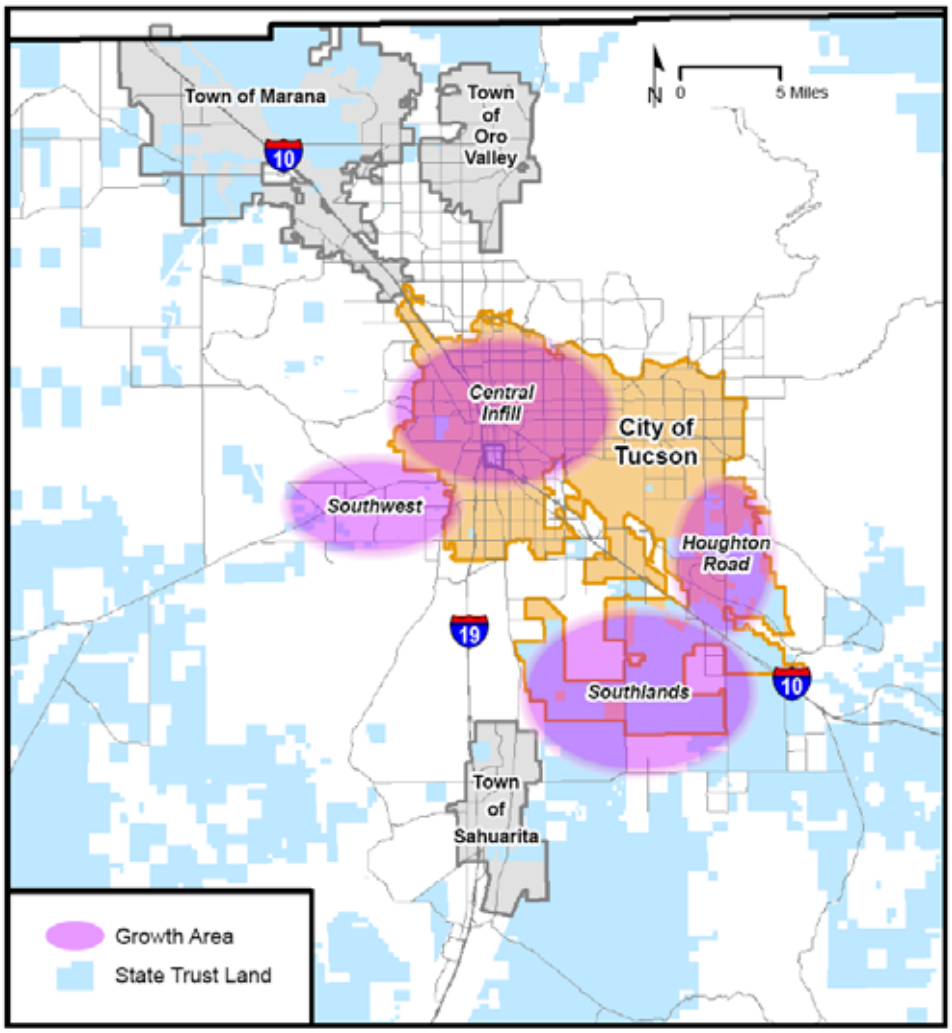
3.2.4 Identification of Growth Areas

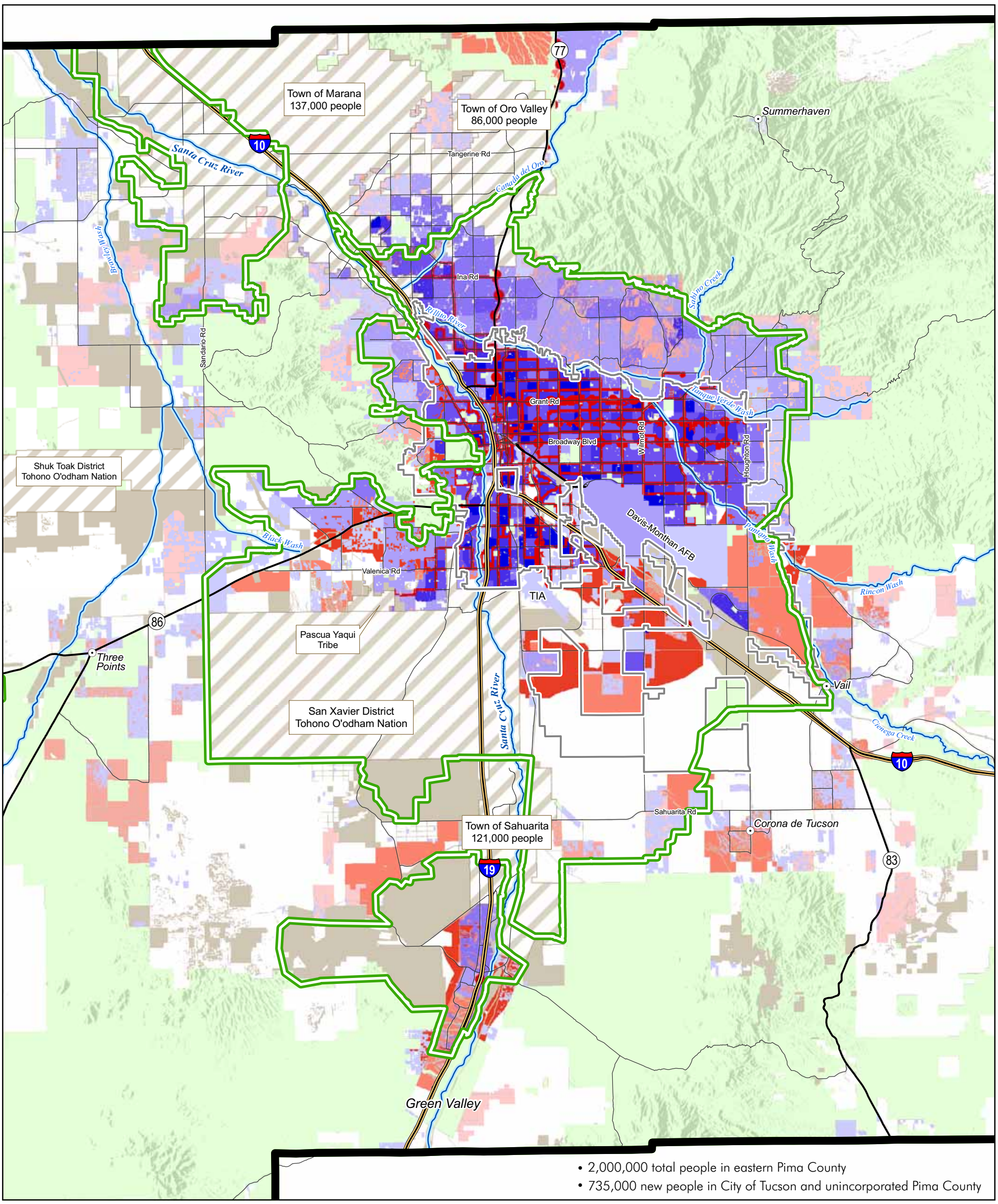
The graphical scenario results documented in Figures 30 through 33 indicate that growth within the City of Tucson metropolitan boundary will likely occur in some combination of four significant growth areas:

- Infill development throughout the current built environment.
- Houghton Road corridor.
- Southlands area.
- Southwest area.

Figure 34 indicates the general location of these growth areas.

Figure 34: Future Recommended Growth Areas





PEOPLE / SQUARE MILE

Current		Projected
	0 - 500	
	501 - 1500	
	1501 - 3000	
	3001 - 5000	
	5001 - 8000	
	> 8000	

City of Tucson Boundary

Area Excluded from Simulation
(with total population projected by AZ Dept. of Economic Security)

Park or Natural Preserve

Development Constraint

Conservation Lands System Boundary
(area inside green and white line is outside CLS)

N

0 5 Miles

Figure 33. Scenario #4: Transit Oriented Development

3.3 Quantitative Comparisons of Alternate Futures

Visual comparison of the resultant scenario maps reveals many differences between the alternate futures. Figure 35 below captures the quantitative nature of two key output variables. The colored columns indicate the total populated land area by planning sub-region in each scenario. The status quo model has nearly double the urbanized land of the current built environment. **Every other subsequent scenario creates less suburban land**. The urban core and core suburbs are fairly static.

The status quo modeling rules result in a slightly lower density than the current built environment – a drop of six percent. Densities then increased in the final three models. The transit oriented development model created an average density 17% greater than the status quo, with average densities for the enhanced habitat protection and infrastructure efficient/taxpayer savings scenario being in between the two.

Increasing the average density of our community will require a strong will and clear intentions; these four scenarios have increased overall average population densities, but not to the optimal extents envisioned.

Combined rules from the four scenarios should now be modeled.

Figure 35: Total Land Area and Population Densities Compared to Current Built Environment

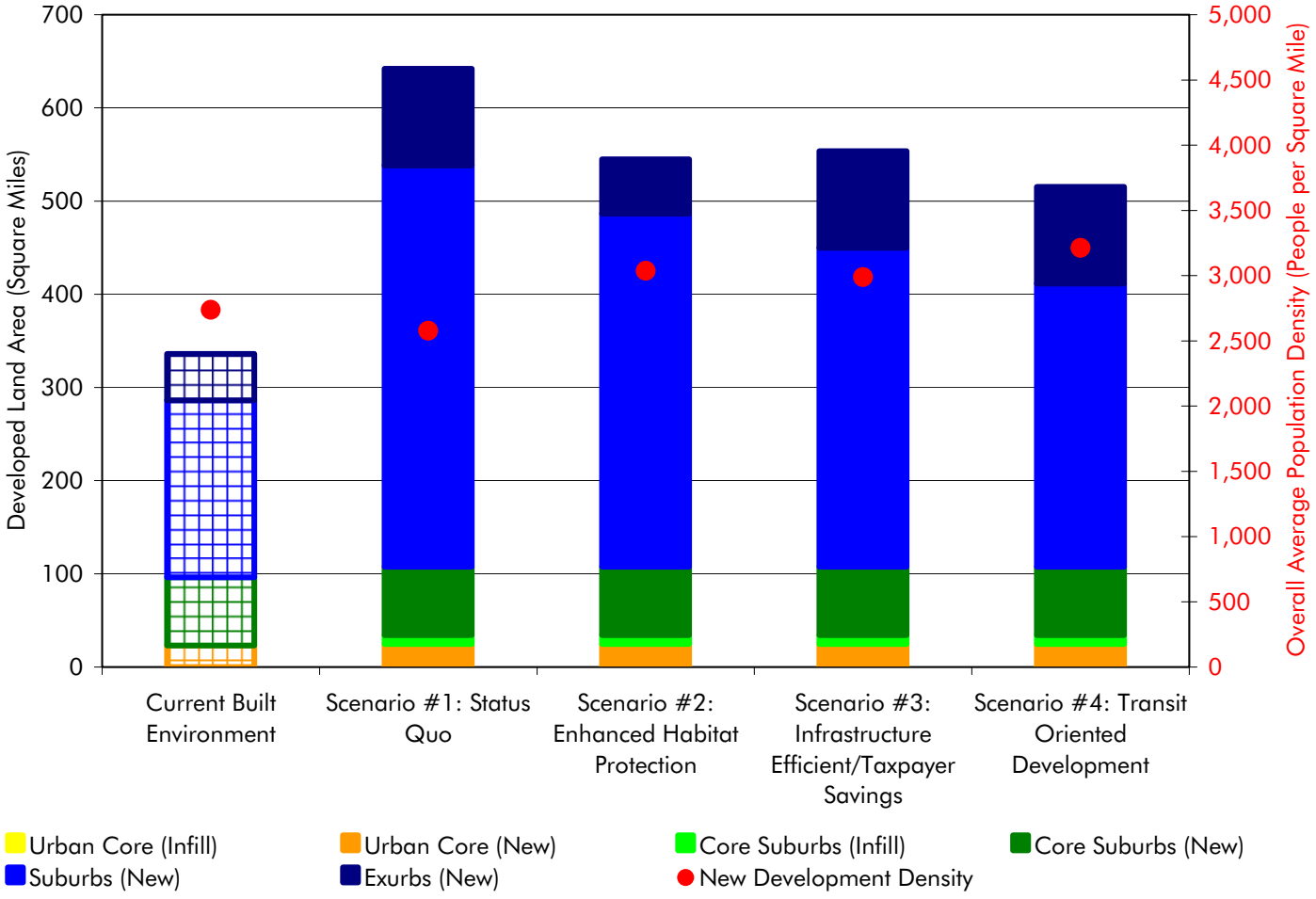
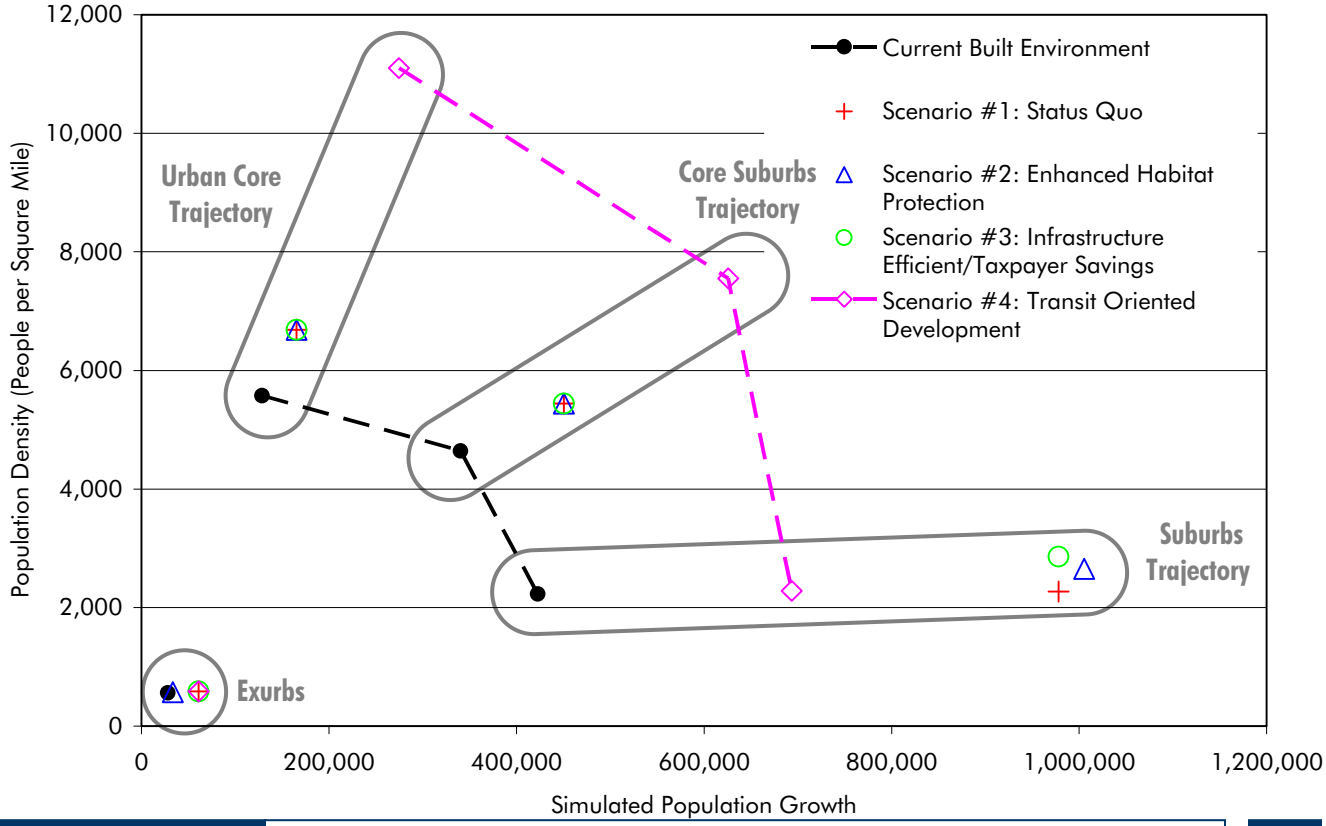


Figure 36 displays the incremental population additions simulated and their overall applied densities, visualized in a manner consistent with Figures 12, 13, and 14. The growth in each scenario is broken down into the component exurb, suburb, core suburb, and urban core areas. The apparent trajectories of each of the above four areas away from their current built environment positions are highly revealing:

- The pattern of the exurban growth and development is essentially constant from scenario to scenario. The enhanced habitat protection scenario does not lead to the doubling in exurban population seen with the other two growth scenarios. In all cases exurban density stays similarly low. Exurbs are in relative terms is the least consequential component of population growth.
- The urban core trajectory see densities increase by some 20% for most scenarios – and double for transit oriented development. Population growth for this area amounts to 29% for most scenarios, and 113% for the transit oriented development.
- The core suburbs trajectory is less vertical than for the urban core. Density gains for most scenarios drops to 17%, while related population gains increase to 32%. The TOD scenario represents density and population gains of 163% and 84%, respectively.
- For all scenarios, the suburbs trajectory indicates large increases in population with very small gains in density.

Figure 36: Modeled Trajectories for Added Land Area and Population Densities



Figures 30, 31, 32, and 33 have depicted varying growth locations across the City of Tucson and Pima County.

These modeled populations cross across several key boundaries to varying extents in the current built environment and each of the four scenarios. Figure 37 on page 81 displays the following future population splits:

- Across the City of Tucson corporate limits.
- Across the Conservation Lands System boundary.
- Across the designated service area boundary of Tucson Water.
- Across the designated and undesignated service area boundaries within the Tucson Active Management Area as mapped by the Arizona Department of Water Resources.

Note that in each future scenario, the population displayed is less than two million people, given the assumptions for future growth inside other area municipalities.

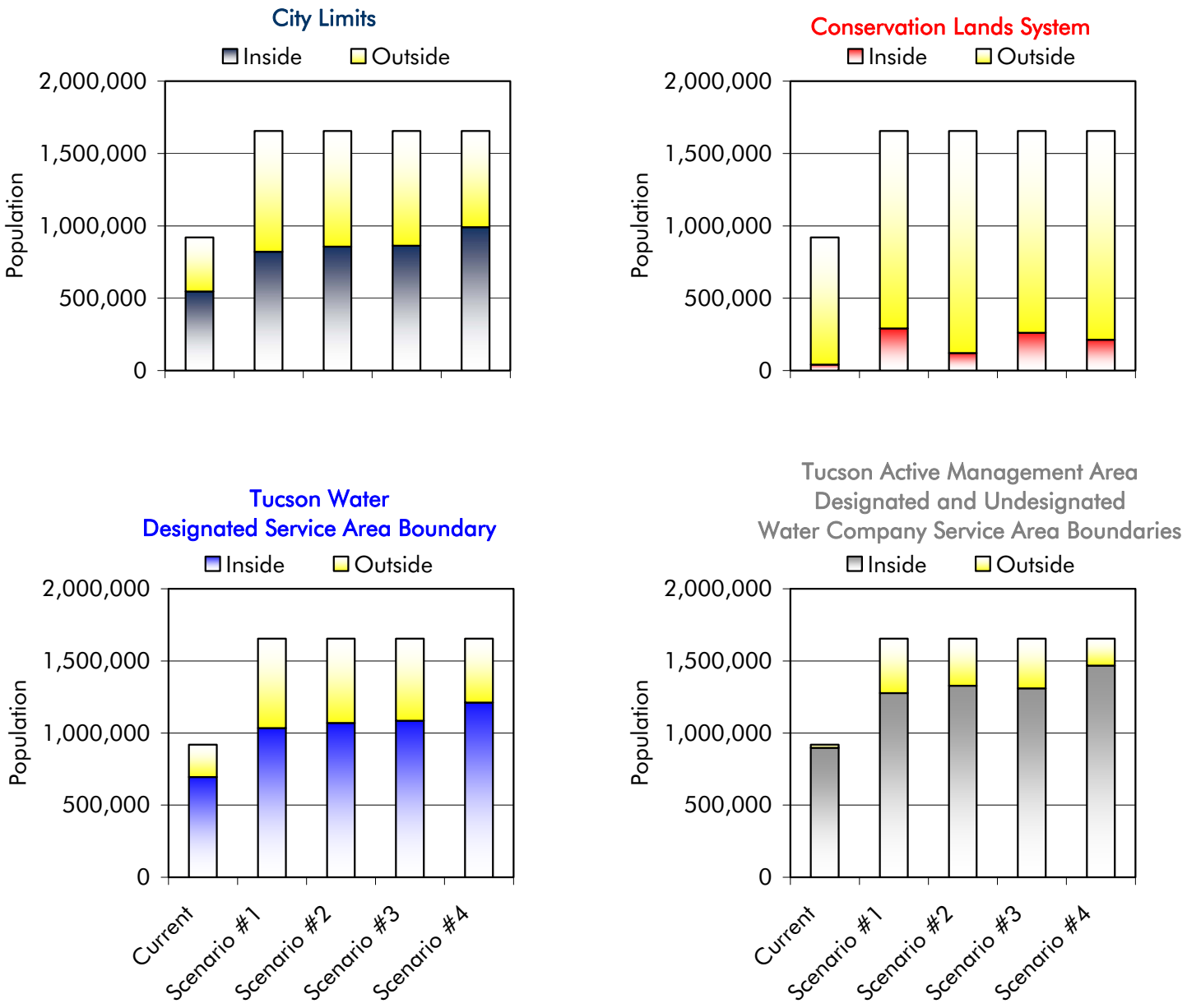
On average, 53% of the future growth is located within the City of Tucson corporate limits – compared to 59% at present.

On average, 13% of the future growth is located within the Conservation Lands System boundary – compared to 5% at present.

On average, 66% of the future growth is located within the Tucson Water designated service area boundary – compared to 76% at present.

On average, 81% of the future growth is located within the designated and undesignated service area boundaries – compared to 98% at present

Figure 37:
Modeled Splits of Population across Geographic and Utility Boundaries of Interest



3.4 Qualitative Comparisons of Alternate Futures

In addition to the simulation results that permitted the quantitative comparisons documented in the preceding section, the White Paper team qualitatively compared the scenario results.

Table 15 displays the subjective results; your personal opinions and value judgments may very well be different. This qualitative assessment used a simple scale ranging from "no checkmarks" to one, two, and finally three checkmarks for those deemed most beneficial.

The Infrastructure Efficient / Taxpayer Savings scenario would likely receive one additional "checkmark" for the Infrastructure Efficiencies, Cost of Services and Tax Levels, and Water, Resource, Energy, and Land Consumption comparators if a revised model simulation was completed as mentioned on page 72.

Table 15: Qualitative Comparison of Modeled Scenarios

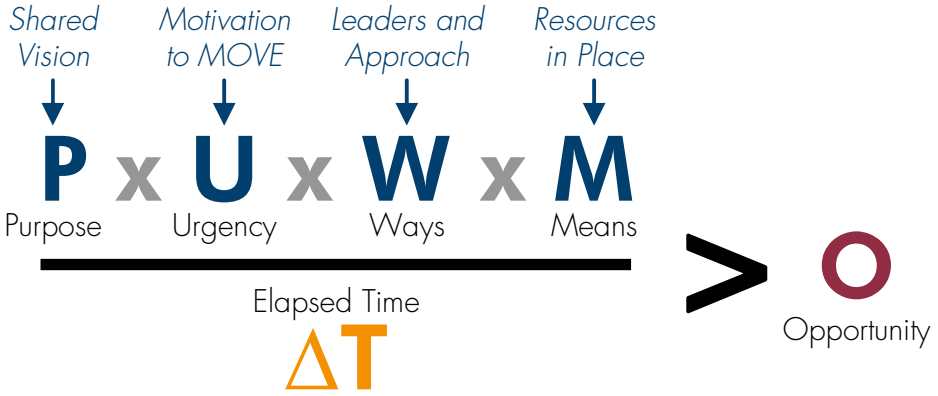
Comparator	Status Quo	Enhanced Habitat Protection	Infrastructure Efficient/ Taxpayer Savings	Transit Oriented Development
More Walkable Communities	—	✓	✓	✓✓
Higher Infrastructure Efficiencies	—	✓	✓✓	✓✓✓
Lower Cost of Services and Tax Levels	—	✓	✓✓	✓✓
More Transportation Mode Choices	✓	✓	✓✓	✓✓✓
More Housing Type Choices	—	✓	✓✓	✓✓✓
More Housing and Transportation Affordability	—	✓	✓✓	✓✓✓
Lower Water, Resource, Energy and Land Consumption	—	✓	✓✓	✓✓✓
More Access to Jobs and Services	✓	✓	✓✓	✓✓✓
More Easily Implemented	✓✓✓	✓	✓	✓

SECTION 4 – ENCOURAGING CHANGE

How can the City and County encourage positive change?

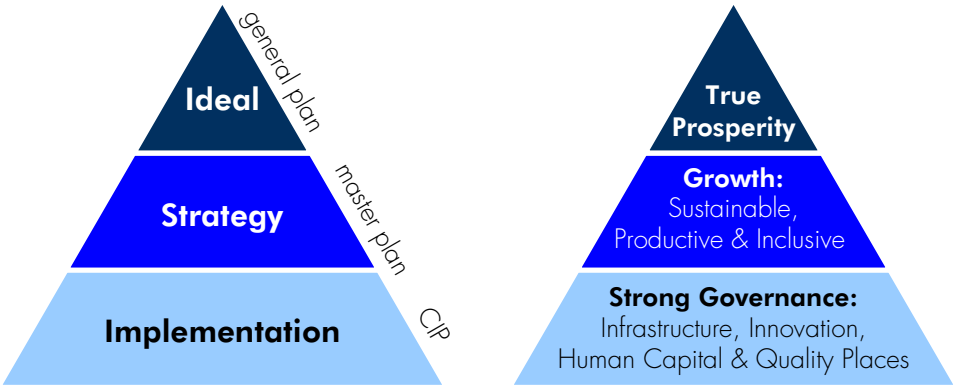
The most important success factors in ensuring successful change management involve people. These people must share a vision, have the motivation to succeed, be armed with the appropriate technical and operational skills, and propagate ownership in the proposed solutions.

The equation below contains all the key factors that will guide a successful change process for our community. If any of the blue factors in the numerator are zero at any time, the result on the left side of the equation will be zero and the opportunity will not be seized. If the time span lengthens, more effort and resources will be required to realize the opportunity; if it's too short, opportunities may be lost because of haste.



The opportunity is clear – there are new pathways to an improved Tucson and Pima County. We believe that the City and County administrations and leadership have laid the appropriate and necessary groundwork of purpose and urgency.

The mechanism of change is obvious; updated comprehensive and general plans and a contextual hierarchy of supporting plans and decisions implemented at all levels represent a strong supply of ways and means. Given time, we can mobilize our community and work together to combine these factors and realize the future of our dreams.



Process Suggestions

Based upon the research conducted during the preparation of this White Paper, the following process suggestions are provided:

- Assume that continued low density development in a relative monoculture is a major issue.
- Create joint (or separate but harmonized) City / County urban form implementation plans, timelines, and requirements. Work together to identify or create the necessary funding sources.
- Continue and intensify regional discussions of visioning, open space, water resources, and development efficiencies.
- Harmonize county and municipal land use regulations based on regional goals.
- Create evaluation measures and processes including identified benchmarking metrics and targets.

4.1 Looking Deeper Into Our Design Toolbox

Recall that this White Paper has identified six primary urban form factors: Development Location, Land Area, Block, Lot, and House Size, Land Use Mix and Diversity, Population, and Street Layout. These were related to six dependent factors: Centeredness / Centrality, Housing Unit Density, Floor Area Ratio, Open Space Index, Population Density, and Street Connectivity / Walkability.

Encouraging good design is the beginning of good urban form, and so suggested options that should be considered during future growth and development discussions are organized by the following design issues.

Development Location Suggestions

- Designate target growth areas.
- Encourage residential uses within the urban core.
- Encourage rezoning for more multi-family and attached housing.
- Concentrate development in regional and town centers plus transit corridors and station areas.
- Be prepared to manage the fact that infill development and increased densities in existing, settled residential neighborhoods often upsets established expectations and creates conflict.

Block, Lot, and House Suggestions

- Rezone for more multifamily and attached housing.
- Encourage diversity and mixed-income housing developments.

- Reinvest in neglected communities and provide more housing opportunities; rehabilitate abandoned property and buildings.

Land Use Mix and Diversity Suggestions

- Create new zoning districts for intense mixed use developments.
- Allow for compatible, small-scale neighborhood commercial uses (e.g., corner stores) adjacent to or within residential neighborhoods.
- Provide for an approximate mixture of housing and jobs, as opposed to predominantly single-family residential development with no jobs nearby.

Street Layout / Connectivity / Walkability Suggestions

- Reduce reliance on major thoroughfares.
- Enhance walking environments.
- Combine the best attributes of grid and loop/cul-de-sac designs: return to orthogonal geometry for clarity of organization and directness of pedestrian access, and provide loops and cul-de-sacs for local streets to achieve safety, tranquility, and sociability.
- Revise street standards to lower any excessive requirements for local subdivision streets.
- Include maximum parking ratios that can be built in a particular development in addition to minimum parking requirements.
- Create opportunities for sustainable modes of transport such as walking and cycling to increase their modal share.
- Link urban form to activity space-time measures to facilitate the understanding of how urban design strategies may shape individual space-time interactions.

Centeredness / Centrality Suggestions

- Encourage centralization of major amenities.

Infrastructure Density Suggestions

- Leverage infrastructure benchmarking with detailed analysis examining links between land use decisions and efficiencies; this may occur as part of White Paper examining integrated land use and water resources planning.

Housing Unit Density Suggestions

- Develop under-utilized land.
- Soften perceptions of density through exceptional design. Density does not have to equate to a feeling of crowdedness.

Floor Area Ratio Suggestions

- Raise maximum building heights in urban land use zones.
- Pay attention to the lowest vertical building elements that frame the pedestrian environment.
- Emphasize visual permeability allowing access to light (sky and sun) and fresh air.

Open Space Index Suggestions

- Continue to implement the Conservations Lands System policies.
- Encourage connection of open spaces and greenways to existing destinations and open space preservations.

Population Density Suggestions

- Establishing minimum density requirements in centers of activity, and where needed to achieve the benefits of population density.
- Pursue the evolution of Downtown Tucson and the University of Arizona campus as regional-serving walkable urban spaces.

Access to Transit Choice, Employment and Opportunities Suggestions

- Invest in rail transit.
- Consider housing, employment and transportation policies and investments together.
- Encourage development in locations that can be served by transit, and at transit-appropriate densities.
- Maintain a supply of large-lot industrial sites for major new employers.
- Provide areas suitable for expansion and retention of existing employers, and prevent excessive conversion of employment lands to retail and residential uses.

4.2 Go-Forward Planning Recommendations

This White Paper and its findings are intended to inform the outputs of the City/County Water and Wastewater Infrastructure, Supply, and Planning Study.

It should also initiate several direct actions. To that end, the following important go-forward planning recommendations are made:

- The City and County should agree on future growth locations and continue to actively facilitate consensus on regional growth locations amongst the area municipalities.
- The City and County should identify efficient and sustainable urban form concepts to be implemented in these future growth locations. These concepts should be developed at the general and comprehensive plan levels, quantified through infrastructure and urbanization master plans, and supported by coordinated capital improvement programs and infrastructure investments.
- The City and County should work with all eastern Pima County jurisdictions; a regional approach should culminate in local implementations.

SECTION 5 – SUMMARY

This White Paper does not require an overly elaborate or lengthy summary. Based upon the best and emerging practices benchmarking and growth area suitability modeling, the team has developed and presented clear evidence to support three key conclusions.

Urban Form Is Important to our Lives

Every resident of the City of Tucson and Pima County is surrounded and impacted daily by our existing urban form. These personal impacts range from the physical to the financial and from the emotional to the social.

"Destiny is not a matter of chance, but a matter of choice. It is not a thing to be waited for, it is a thing to be achieved." – William Jennings Bryan

Our future urban form will have pronounced economic, social, and environmental impacts upon our community, and will define the quality of life for our children and many generations to come.

Growth Can Be Directed Differently To Our Benefit

The four alternate choices presented are just the beginning of our considerations; they can be combined in many ways, and augmented with other choices. Each scenario will have a mix of costs, benefits, and detriments. It is important to do our best to direct growth and development so that form and function are unified to benefit our lives.

Let's Choose our Future Wisely

The call to action is being sounded. Now is the time for us to unite in commitment to a new and wonderful urban form, and move with intention from ideas to action.

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APPENDIX A – ON THE TRUE DENSITY OF TUCSON

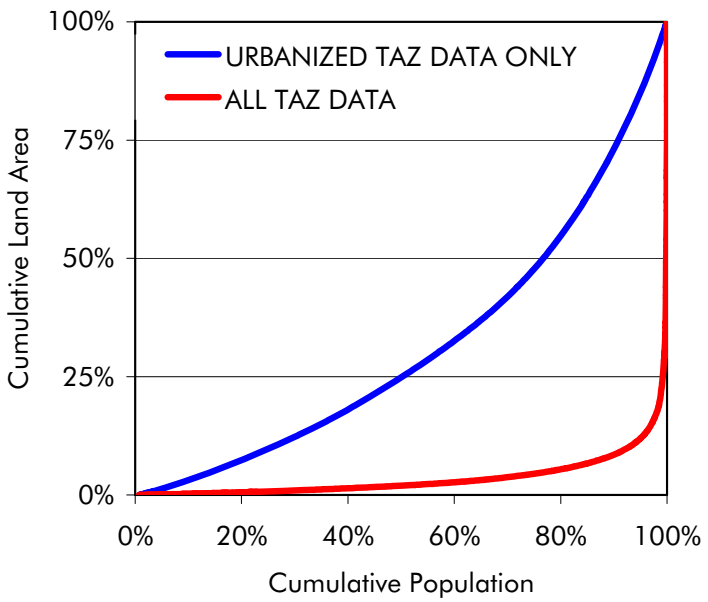
Throughout this White Paper, population densities are calculated at varying scales. This begs the question as to what precise urban area limit should be used to define population densities.

If the urban area only includes built-up areas within the municipality, then higher densities will be calculated. If a wider urban area is used that includes fringes and less developed parts of the municipality, then lower densities will be calculated.

For example, it is possible to calculate the density of our community by simply summing the TAZ areas and 2005 population statistics for the 853 zones to arrive at totals of 3,884 square miles and 943,044 people. This yields a very low density of 242.8 people per square mile.

Reference 1. in the Bibliography addresses this effect explicitly:

> "If one conducted a survey of residents to find out the density they experience, one would obtain a higher value of residential density than by simply dividing the total residents by the total land area of the "urban area". There are more people who live in high density situations (per unit of land) than there are people living in low density areas. A "population-weighted" average of residential density will therefore give a higher residential density than an "area-weighted" density.
>
> More importantly, a "population-weighted" average of residential density will give a value of residential density which is not affected by the addition of spurious empty regions to the outskirts of the urban area, because their lack of population means that they won't be counted in a "population-weighted" calculation, thereby removing a major source of potential bias in the calculation of residential density."



The graph to the left reinforces this fact; in reality when the full TAZ dataset is used, 90% of the total population can be seen to live in only 8.5% of the total land. This is a highly non-uniform relationship between land and people.

Restricting the dataset to "urbanized" TAZ (here assumed to be any TAZ over a threshold density of 1,000 people per square mile) results in the blue curve at left, which indicates a more uniform relationship between the land and the people occupying each TAZ.

Moving our City of Tucson and Pima County density calculation down to the TAZ level and calculating a "population-weighted" average of residential density yields a density of 4,440 people per square mile.

If the TAZ data set is restricted to only those TAZ with "urbanized" levels of density (again assumed to be 1,000 people per square mile) then the simple traditional "area-weighted" density of 3,392 people per square mile. Calculating a "population-weighted" average of residential density from this reduced data set yields a density of 5,308 people per square mile.

For purposes of comparison with other cities, however, it is relatively rare to find densities calculated using "population-weighted" methods or even standardized to a common value for the size of a populated area.

As a result, population densities quoted throughout this White Paper are not "population-weighted" so as to maintain accurate benchmarking.

APPENDIX B – "A TALE OF FOUR CITIES"

This Appendix provides the reader with four tales from possible futures, as we imagine what life might be like in the White Paper's different scenarios. We acknowledge that these suppositions are only partial snapshots of the future, and could be further elaborated upon from both economical and social standpoints with the dedication of more time and effort. The future is always a ripe target for speculation, however, and it is in the spirit of deductive imagination that these four tales are presented for your consideration.

A VIEW FROM THE FUTURE: SCENARIO #1 – THE STATUS QUO

It is the year 2060 and our community has stayed on a consistent course over the last 50 years. While our region is now home to roughly two million people, the City of Tucson's historic annual growth rate has slowed to less than one percent. In addition to the other incorporated areas, most growth is now occurring in the outlying master planned communities that have flourished in the southwest corridor (known as the SWIP), in the Southlands and along the Houghton Corridor southeast of the City. The low cost of housing in these areas has made them far more attractive than the relatively expensive housing available in the City, and they have been growing for decades at 2.3 percent per year.

"There's one thing worse than change and that's the status quo." – John Le Carré

The stock of vacant land in the valley has dwindled as the majority of new housing is single family tract housing that occupies a relatively large amount of land. To attract home buyers, master developers have worked tirelessly to introduce necessary service amenities such as retail centers, restaurants, schools and medical centers. Large national retailers continue to take an interest in the areas as market-driven demand has increased. Far from downtown, large outdoor malls service the residents of these outlying communities.

To reduce the social and economic costs of driving long distances to get to work, many people living in the suburban communities are looking for jobs in the diffused employment centers that are springing up. Traffic is heavy along the I-10 corridor, which was widened years ago to 6 lanes in each direction in an attempt to relieve the heavy traffic congestion during rush hour. Toll roads, built at significant costs due to land purchases and right-of-way acquisitions, are being planned to traverse the City and connect the suburban communities. Most suburban residents now bundle their in-City travels into weekend trips to save on automobile and fuel costs.

To attract new residents and infill development, the City has embarked upon a dramatic effort to re-brand itself as a center of knowledge, focusing on its largest employers including the University of Arizona. As traffic congestion issues continue to hurt the University's ability to attract students, they are now focusing marketing efforts in offering virtual e-classes despite the associated reduction in personal contact with professors and other students.

City tax increases, enacted in an attempt to pay for the costs of new infrastructure and infrastructure repair, have further discouraged both commercial and residential development in the City. The hike in taxes has also created an increased vulcanization of the area leading communities to compete over scarce resources. Outlying areas, such as the Southlands, are opposed to paying for improvements and other services within the City's core (since they generally don't visit the City anymore) and are now actively engaged in reverse annexation movements.

Downtown Tucson continues to serve primarily as the center of government for both the City and County. Planning has become de-centralized and urban planners continue to react and respond to emergent development needs and propositions. They struggle with alleviating the negative aspects of continued low density suburbanization.

A VIEW FROM THE FUTURE: SCENARIO #2 – ENHANCED HABITAT PROTECTION

It is the year 2060 and our community is well known for placing a high priority on habitat protection in order to preserve our natural resources. Years ago, the City and County purchased large expanses of native desert lands and ranches in a regional program to support native plants and wildlife, expand recreation areas, and protect natural floodplain functions and water sources.

"Study nature, love nature, stay close to nature. It will never fail you." – Frank Lloyd Wright

The City and County are now known as havens for nature lovers. The regional trail systems built throughout the area are attracting hikers and bicyclists from all over the United States. Much of the population is enjoying the opportunities for exercise and relaxation that are available at the plentiful outdoor recreation sites in and around the City. Tourism is enhanced by opportunities to view the robust wildlife populations that have successfully returned to the area.

Private lands adjacent to purchased open space have increased in land value, spurring increased pressure to develop them.

Long ago, City and County leaders designated with foresight several specific target growth areas. These included the southwest area of the City (known as the SWIP), the Southlands, and the area along the Houghton Corridor southeast of the City – as well as infill development within the built environment of the day.

Voters continue to support dedicating tax dollars to pay for the conserved open spaces. The City and County have also created initiatives that provide incentives to developers to build in the most suitable areas, particularly inside the existing urban footprint. Developers have found ways to be creative and innovative in their planning efforts. Flexible multi-use zoning has encouraged re-development and two to four storey buildings are more common than ever. Denser residential developments are proceeding without public investment given the higher returns they now generate.

Rainwater harvesting, renewable energy initiatives, and water and energy-conservation technologies enacted over the last 50 years have resulted in remarkable per capita drops in resource consumption. Regional leaders and planners have been able to focus on supporting and encouraging development efforts that focus on sustainability (such as green housing, distributed energy, and infrastructure systems) making efficient usage of available land and ensuring that our region continues to live up to its reputation as a sustainable area.

A VIEW FROM THE FUTURE: SCENARIO #3 – INFRASTRUCTURE EFFICIENT/TAXPAYER SAVINGS

"Efficiency is doing better what is already being done." – Peter Drucker

It is the year 2060 and our community is now enjoying the benefits of the emphasis they placed years ago on increasing densities and clustering development in designated growth areas. This was done to establish infrastructure efficiency in the areas of water delivery, wastewater service and the transportation systems that remain largely auto-dependent. Our relatively lower tax structure and cost of living is continuously attracting new residential and commercial development.

Mixed use neighborhoods are thriving in metropolitan Tucson, the SWIP area, Houghton Road Corridor and the Southlands area. New developments are occurring at average densities several times greater than historic rates. Concentrating growth around planned and existing infrastructure, as well as infill development incentives offered by the City

and County, has resulted in minimal encroachment into major biological corridors and important riparian areas. Opportunities for appropriate off-site habitat mitigation are readily available and evaluated on a case-by-case basis.

The sense of community encouraged by the high density, mixed use development is resulting in strong neighborhood centers. The communities are enjoying high qualities of life and a strong sense of place. Well designed public areas and open spaces have been developed to offer opportunities for informal and formal interaction, recreation, gardening, and the enjoyment of scenic vistas.

Many residents still live in large houses and drive automobiles to their jobs, services and entertainment. As the region expands, planners continue to advocate the expansion of roadway infrastructure as opposed to alternate transportation systems. Some residents are able to live in smaller houses, closer to their work and amenities, saving money by reducing or eliminating their need for cars.

The increased densities have attracted retail businesses and employment centers to neighborhoods in proximity by providing a readily available local workforce. Infrastructure efficiency has resulted in per capita drops in water use and resource consumption. The region enjoys the reputation of providing highly walkable, close-knit neighborhoods.

A VIEW FROM THE FUTURE: SCENARIO #4 – TRANSIT ORIENTED DEVELOPMENT

"Transit-oriented development is not a one-size-fits-all phenomenon; it is a flexible form of development adapted to local circumstances." – Bay Area Metropolitation Transportation Commission

It is the year 2060 and our community is enjoying the benefits of the emphasis placed years ago on transit oriented development combined with alternative forms of transit systems. The result has been increased housing options and diversity of choices in the community, as well as vibrant mixed-use retail, housing and service hubs along the major transit corridors established by regional planners.

Lively pedestrian neighborhoods comprised of new and existing housing and mixed use redevelopment now flourish along transit corridors. Drawn by convenience and amenities, heavy infill and re-development has occurred within the urban core and core suburbs of the City and County. The combination of the modern street car, light rail and efficient rapid transit bus routes have served to densify those city blocks along major transit corridors. Some of the most desired neighborhoods are within a quarter mile of the streetcar stations where residents can enjoy a great

variety of services, employment and entertainment options. Older neighborhoods that were struggling years ago have now been preserved and strengthened as people have reinvested in these areas.

Concentrating growth around planned and existing transit corridors has resulted in minimal encroachment into major biological corridors and important riparian areas as designated by the Conservation Land System (CLS). The successful infill development incentives offered by the City have helped this occur.

The transit choices the population now enjoys are being supported through taxes and user fees that are being generated primarily by the benefitting high density neighborhoods.

The expansion of the community is significantly based on the expansion of the transit system. In order to achieve the targeted densities, regional planners offered flexible multi-use zoning. Parking structures have been removed or re-purposed as demand decreased. Vertical development of two to four storeys (including residential and commercial components) have carefully considered the retention of critical view sheds.

The City enjoys the reputation for providing highly connected and close knit neighborhoods with local employment opportunities. Planning is focused on mixed use development with interspersed pockets of open space such as parks and pavilions. The high densities have also resulted in per capita drops in water use and other resource consumption.

Many residents still choose to live in large house and drive cars multiple times each day. Others enjoy the saving of time and money they realize from taking shorter trips and not owning a car.

White Paper Team

seated left to right: Alice Templeton, Debra Mollet, Nicole Fyffe, and Melaney Seacat

standing left to right: Chris Avery, Nicole Ewing-Gavin, Albert Elias, Marc Fink, Mike List, Arlan Colton, Greg Hitt, John Take, and Curt Lueck

not pictured: Chris Kaselemis, Anna Sanchez, Josh Pope, Leslie Liberti, Mary Hamilton, and Jim Veomett

Photographer: James Patrick

Curtis Lueck & Associates

Stantec