GP2100

GREATER PHOENIX REGIONAL ATLAS

A Preview of the Region's 50-Year Future

ASU Arizona State University

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IN ASSOCIATION WITH

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Foreword

The sustainability of our planet, our nation and our region remains in doubt. We live today with the realization that human impact on natural systems has long-term outcomes – both positive and negative – for our social, economic and cultural futures. The dynamics of understanding sustainability and the development of knowledge and tools to advance economic and environmental well-being will be a critical area of interest to academic communities, as well as to the broader public and private sectors.

To think clearly about moving toward sustainability we must begin the process of mapping past, present and future human interactions with natural systems along multiple, interconnected dimensions. We know, for instance, that there is a direct correlation between distribution of air pollution particles and the emergence of human ailments such as asthma. In the southwestern United States, we appreciate the complex and interrelated issues surrounding the acquisition, transportation, distribution, use and reuse of water. We cannot help but see on a daily basis changes in land use, air quality and water consumption that dramatically affect our personal lives and the broader physical world.

We must begin to develop the tools to see the past, evaluate the present and speculate with some clarity about the future. Over the last several years, Arizona State University has begun to take on the complicated and challenging task of developing such tools in order to see more clearly the metropolitan area we are building. In the last 100 years, Greater Phoenix has undergone unprecedented growth, transforming this place from a remote desert outpost to an emerging global city. We are growing rapidly along a trajectory toward a massively transformed and human-engineered environment. This transformed environment is beginning to experience serious stress points. To keep such stresses from becoming fractures, we need greatly enhanced decision making by those involved in shaping the outcomes and the growth of Greater Phoenix.

Here at the beginning of the 21st century, the human race is responsible for the following:

- We have transformed half of the land use on the planet to human purposes;
- We have increased carbon dioxide in the atmosphere, bringing about dramatic atmospheric changes, both chemical and thermal;
- We have doubled the amount of nitrogen fixed into the planetary biogeochemical cycle;
- We use and chemically alter more than half of all the potable water freely available on the planet;
- Human activity has increased species loss in the last 100 years between 100 and 1,000 times.

Each of these indicators is the result of more than 300 years of industrialization and development around the planet. These indicators measure global change, and might seem remote to the desert dwellers of Greater Phoenix. But if measured here in Arizona, in exactly the same way over the last 100 years, each of these indicators would show dramatic transformational impact. We really are all parts of the same system, and with modern measuring technologies, we can monitor global changes on a local scale.

Greater Phoenix occupies a particularly challenging natural environment that was not well suited to large scale human habitation until technology tamed the heat and aridity. Today, because of its speed of growth and overall level of impact on the environment, our city is moving in the same direction as the rest of the world but at an even faster pace. Our region is wildly popular because of its natural beauty, natural assets and quality of life. These three features must be maintained and enhanced as our population grows from 3.5 million people to as many as 12 million or more over the next few decades. We must begin a process now to lay down the foundation to insure we can grow while remaining true to who we are, what we do, and where we are headed.

It is the interrelationship between environmental sustainability, socio-economic development and the economic well-being of this region that makes outlining the basis of information for decisions so critically important. What we decide about transportation systems affects the distribution of future population, and subsequently the distribution of property values, of wealth and poverty, and ultimately of crime and disease or of stability and health. And in the complex matrix of our pluralistic democracy, transportation systems represent only one of the hundreds of decisions on which a community is built.

Arizona State University, as a center for intellectual discourse and transdisciplinary thinking and as an institution with the capacity to look at the long term, seeks to help lay the foundation of understanding that will enable us to address the issues and constraints associated with our environmental, social and economic future. ASU wants to fully engage the larger community in every way we can to help illuminate the potential outcomes of different decisions about our future.

In the past, atlases have helped us to understand the natural landscape, the distribution of populations and the locations of infrastructure such as roads, water systems and power grids. Graphic representations of geographic systems have long helped give shape and dimension to human decisions. Today we can build on that foundation and advance the atlas as a tool for more comprehensive decision making – a tool that collates the interrelated topics that contribute to the ultimate success of a place.

This Atlas is the first iteration of such a tool. It is the first product of intellectual efforts to broaden the scope of mapping and thinking about this region. Our hope is that it can serve as a first step toward decisions that can improve the likelihood of this region making a transition toward a sustainable future. We are not yet on such a path, but at least we are talking about it.

This Atlas has been prepared by an interdisciplinary team of scholars, analysts and planners working beyond their individual fields to contribute to our stock of knowledge. I hope you will enjoy the Atlas and will help refine its data so that future editions will bring greater detail and clarity to the critical issues of sustainable growth for Greater Phoenix. Our challenge is great, but meeting it is absolutely necessary.

Michael M. Crow
President
Arizona State University
March 2003

Above: Golden Barrel Cactus (Echinocactus grusonii)

Left: Squaw Peak Mountain Preserve, Phoenix

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Left: Desert cottontail (Sylvilagus audubonii) in Prickly Pear (Opuntia sp.)

The Greater Phoenix 2100 Project

Like many of the largest urban areas in the United States, the whole of the Phoenix region has become greater than its parts. Over the past 50 years, the Phoenix area has become a major urban region facing a wide range of issues critical to its future. With its rapid growth – the fastest in the country over the last ten years – it has transcended the traditional definition of a region with clearly defined boundaries. Issues of growth, economy, open space and sustainability are now regional issues over which no single local governmental agency has authority.

This central Arizona urban region, consisting of the counties of Maricopa, Pinal and southern Yavapai, is referred to throughout this publication as Greater Phoenix, a descriptive term that emphasizes the regional context of the issues explored by this publication. Thus defined, Greater Phoenix is an area that lends itself to study at a regional scale. It is the natural scale to address the problems faced by the city of Phoenix and surrounding communities.

Having the information to analyze and understand regional issues will be important in making decisions on how to resolve them. Currently, there is no single organization that provides information about the range of issues critical to the region's future at a geographic scale that encompasses future urbanized areas. Nor is there any single organization that provides information on all topics of regional importance. Gathering information about these topics and geographies requires knowledge about the numerous organizations that collect and distribute local and regional data. This difficult task can pose a barrier to fostering well-informed regional policy making.

In April of 2001, the Lincoln Institute of Land Policy and Arizona State University (ASU) sponsored a symposium, "Greater Phoenix 2100," that brought together ASU faculty and staff, community leaders and national participants from institutions such as the Los Alamos National Laboratory and the National Research Council. Four distinguished speakers stimulated debate and discussion. The panelists were ecologist and author Dan Botkin, professor emeritus of the University of California, Santa Barbara; Michael Crow, an authority on science policy, executive vice provost at the time at Columbia University and now president of ASU; political scientist Helen Ingram, formerly director of the Arizona Water Resources Research Center and now professor of human ecology at the University of California, Irvine; and Bob Yaro, executive director of the Regional Plan Association in New York City. The participants at this event concluded that there was a need for some organization to provide region-wide data and analyses of regional issues to help decision makers make wise choices about the future.

These discussions led to the Greater Phoenix 2100 (GP2100) project, initiated by ASU. The project's aim is to make the best possible scientific and technical information available in ways that will enable wise, knowledge-based decision making that can shape the region during the next 100 years. This Atlas is one of the first products of the GP2100 project.

For more information about GP2100 and other projects, please visit www.gp2100.org. An electronic version of the Atlas is available at this site. ■

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Above: Greater Roadrunner (Geococcyx californianus)

Left: McDowell Mountain, Salt River Pima-Maricopa Indian Community

A Regional Atlas for Greater Phoenix

Expanding Our View of Region, Farther Than The Eye Can See

Rob Melnick, *Director, Morrison Institute for Public Policy*

Many of the public issues critical to the future well-being of metropolitan Phoenix are regional in nature. These issues will significantly impact the environment, social institutions and economies of individual cities and organizations throughout the region. Yet, while each city should be thinking about how these issues affect them and what might be their response, potential solutions also need to be considered in light of regional political geography. Such region-wide solutions must, by definition, involve multiple governmental and non-governmental organizations with overlapping and sometimes conflicting jurisdictions. And to make things even more difficult, the regional geography of the future will not be the same as today's because the region is expanding, and expanding fast. Clearly, both market forces and public sector decisions will require residents of the area to outgrow their current concept of where "Greater Phoenix" ends. Whether you consider the geography of the region to be the urban parts of Maricopa County or all of Maricopa County, Greater Phoenix has already moved beyond those boundaries. Thus, an enormous challenge to our public policy decision-making process is the fact that the future 50-year geography of Greater Phoenix will extend beyond the reach of today's regional institutions. As leaders discuss, study and shape the future of this region, they need to be sure that institutions that represent this expanding geography of Greater Phoenix are at the table. This Atlas provides a tool that institutions and individuals can use to better understand the challenge of this new regional paradigm. And, the GP2100 project is planning to produce and make available other useful tools, as well, by drawing upon the diverse intellectual and data resources at Arizona State University and other institutions throughout the region. Combining efforts and sharing resources with an eye toward the future of the region can go a long way toward ensuring that our long-term growth is both healthy and prosperous.

An atlas can contain information about a place's natural environment, including its geology, topography, vegetation and wildlife; information about natural processes such as its climate and hydrology; or information about the human environment such as that concerning demographics, transportation systems and land use. A regional atlas must include all these factors based on an accurate definition of region. Regions do not usually have natural boundaries, but instead are formed by a combination of natural features such as geology and topography and human-made features such as freeways and city limits. This atlas defines the region of Greater Phoenix as the geography that encompasses the physical and political features relevant to the important issues of the Phoenix area for the next 50 years. In so doing, it will serve as a resource for people to understand the regional context of issues and possible solutions to regional problems.

With the Greater Phoenix Regional Atlas, the GP2100 project hopes to accomplish four specific goals:

1) Introduce a new geographic entity called Greater Phoenix that establishes the extent of the region's potential urban growth in the next 50 years.

2) Begin to define a regional context for a variety of urban and rural issues related to the area's growth, function and quality of life.

3) Shed light on the tangled network of agencies that collect and maintain the data needed to understand and develop solutions for regional issues.

4) Encourage business, governmental bodies and not-for-profit agencies to partner in the development of tools to simplify regional data collection and analysis.

The Atlas is organized around 10 issues of regional importance. This list of regional topics is not intended to be comprehensive, but rather is a survey of major issues raised during various policy discussions conducted by different governmental and public organizations over the last few years. Each issue is described by a set of maps and an issue brief. Several issues include commentaries written by local community and business leaders. These commentaries are not intended to exhaustively examine each issue, but to foster dialogue about its 50-year importance in the regional context.

The Atlas is being made available in both a printed format, this book, and an electronic format. The electronic version of the Atlas can be found on the Internet at www.gp2100.org. The maps in the printed Atlas are not scaled to allow a detailed examination of local variances in data. Rather the maps in the printed Atlas are designed to visually entice people to read the issues and examine the maps for regional trends and patterns. They provide a general visual and spatial context for the discussion of each issue in the Atlas. However, the Atlas can be used for more detailed analysis by using its electronic version. The electronic version of the Atlas is supported by a set of geographic information system tools that allow the map data to be viewed in a variety of ways. An additional set of geographic features, such as an expanded set of highways, city boundaries, and rivers can be displayed over each map in the Atlas. Each of the maps can be zoomed and panned to provide a more detailed examination of the data either at a regional or a local scale. Though the printed Atlas as released represents a static point-in-time view of the issues, it is ASU's intent to maintain the electronic version of the Atlas and over time enhance its capabilities and expand the scope of issues addressed. Hopefully in the near future, a GP2100 dynamic electronic atlas will provide a common platform for an extensive array of data sets from a wide range of regional academic and policy institutions.

It is hoped that this Atlas will shed new light on the concept of region in Greater Phoenix and the issues it will face over the next 50 to 100 years. It is a goal of Greater Phoenix 2100 to provide an ever-expanding atlas of regional information that can be used to support dialogue and generate new ideas for resolution of these issues. This Atlas, in both its printed and electronic format, is the first step.

Above: GP2100 online electronic Atlas - www.gp2100.org/eatlas

Left: Development at base of McDowell Mountain, Scottsdale

A Changing Awareness of Region

All across the country, the concept of region is being reintroduced into discussions of urban growth and quality of life. Though region is not a new concept – it has been discussed for over 100 years – the regions that we are talking about now are significantly different than those discussed in the past.

During the first 50 years of the 20th century, urban leaders and analysts disenchanted with the urban experience proposed new models for thinking about urban growth. By the 1950s, two distinctly different visions had emerged. Robert Fishman, in his essay "The Death and Life of American Regional Planning," describes these two visions as the *metropolitanist* and the *regionalist* traditions.

The metropolitanist view of region was of a large central city with an industrial economy, surrounded by agricultural and/or natural landscapes. As the region grew, it would still be defined by a downtown as its economic and cultural heart. People would live in an expanding dense urban environment and industry would grow in massive factory zones that would be the productive core of the region. A network of mass transit systems would connect people from the downtown and industrial areas to the surrounding open space so that urbanites could enjoy these unspoiled places. Daniel Burnham and Edward Bennett's *Plan of Chicago* and *The Regional Plan of New York* pioneered the metropolitanist tradition.

Regionalists had the opposite vision. They envisioned a decentralized pattern of dispersed new towns connected and served by regional networks of highways and electrical power. Led by such notable 1920s designers and social critics as Lewis Mumford and Clarence Stein, regionalists wanted all the economic benefits of living in a technologically advanced society while retaining the human scale of small-town America. They envisioned these new towns as independent self-sustaining communities linked together in a vast regional city.

During the next 50 years, urban and federal policy, as well as private investment, began to implement both approaches. The metropolitanist view was reflected by industry, which continued to grow within large industrial areas, and by business, which continued to concentrate large corporate organizations in downtown cores. Federal and central city policy embraced urban renewal as the solution to urban blight, leveling whole neighborhoods with the intent of rebuilding them as modern superblocks. Slowly, the fabric of America shifted from rural to urban. In 1950, only 30 percent of the U.S. population lived

Indian Bend Wash, Scottsdale

in urban areas. By 1990, slightly more than 50 percent of the population lived in metropolitan areas with populations of more than a million people.

During this same 50 years, there were also factors that led to greater decentralization. Federal funding created a national network of highways. The automobile became part of the American dream, allowing one to move away from the crime and blight of the central city to the bright and shiny suburbs. Tract home construction techniques brought the American dream of home ownership into the reach of the middle class. These three events sparked an explosion of low-density suburban growth. People could live in the country and commute to a job in the central city. Several experiments in new town development were financed in part by the federal government. Closer to the end of the century, some corporations, particularly the emerging technology industries, began to build large campus facilities at the edge of urban areas.

Today urban regions are a mish-mash of centralized urban cores and decentralized regions. Most central cities are now surrounded by miles of suburban development that is governed by many small jurisdictions. These suburban communities now house most of the region's population and, in some cases, its industry as well. Even the great cities of the twentieth century, such as Chicago, New York and Boston, are now part of vast inhabited regions. The central city, though still the largest single regional entity, no longer dominates the region, nor does any individual suburban community. Though many of these smaller communities have become quite urban, rarely are they autonomous or self-sustaining places. They still are dependent on the economy of the region as a whole and the culture of the central city for their existence and vitality.

Citistates

In 1993, Neal Peirce coined the word *citistates* to describe the new urban regions. Peirce's view is that urban regions are not defined by political boundaries but rather by how they function, their labor market, their commute-sheds, the circulation area of the lead newspaper and the structure of their economy. Peirce defines a citistate as "a region consisting of one or more historic central cities surrounded by cities and towns which have a shared identification, function as a single zone for trade, commerce and communication, and are characterized by social, economic and environmental interdependence."

The renewal of interest in region has been sparked by a realization of the interdependence of today's citistates. Over the last ten years there has been a national refocus on the challenges of rapidly urbanizing regions. People have grown intolerant of traffic congestion, declining air quality, loss of open space and natural areas, crowded and underfunded schools, cookie-cutter houses, a perception of increased crime, pedestrian-unfriendly communities and a declining sense of neighborhood. There also is a growing understanding that most growth-related problems are regional, not local, and that single communities cannot solve these problems alone.

Many people, from academics to corporate leaders to political activists, are beginning to argue that regionalism is relevant. They realize that large numbers of people commute across city, county and even state borders every day. Broadcast and print media rely on a regional market. Businesses of all sizes rely on workers, suppliers and customers who come from all parts of the region. Much of the infrastructure that supports the urban area seamlessly crosses all political boundaries. Symphony halls, arenas, stadiums, universities, and museums located in various parts of the region serve and provide an identity to the entire region, not just the city they happen to be located in. Air pollution, traffic congestion, flooding and crime do not stop or start at the city limits. Most people, as they travel about a region, do not even know exactly when they cross a political boundary. People are beginning to realize the solutions to many of these issues will require some type of regional effort. Understanding the dynamics and trends of the region and understanding these issues in a regional context will be critical to effectively solving them.

Defining Greater Phoenix as a 50-Year Region

Fifty years into the future is a long time. Given today's advanced knowledge of urban areas, making estimates about even a 20-year expanse of growth and where it will locate is primarily guesswork. Our primary tools for estimating future conditions remain dependent on our knowledge and understanding of past trends and events. These trends in technology, health and national and world economics can have a profound effect on future growth and patterns of habitation. Yet if our experience of the last decade tells us anything, the next 50 years likely will be marked by trends that are more turbulent, cycles that are shorter in duration and technology advances that come at faster rates, leading to more rapid social/cultural changes than those of the last 50 years. This is complicated by the fact that a number of the resources whose abundance has sustained growth for the last 50 years, such as fossil fuels and water, are not unlimited and consumption of these resources during the next 50 years may reach their limits.

Yet, as difficult as it is, we need such future estimates. They are essential to planning for the growth or decline of urban regions. Short-term and long-term projections are needed to plan basic infrastructure, which, for some facilities, can have lead times of decades. One approach is to use past trends to identify a range of future possibilities, which can then be used to create scenarios that can frame future possible conditions. To create these possibilities, we must understand past trends.

Table 1 provides an overview of population growth in Maricopa and Pinal counties from 1900 to 2000 and compares this to the total growth of major national urban regions with a population of over one million in the year 2000. In the past 100 years, this area has grown at an annualized

Table 1: 100-Year Population Growth

	MARICOPA & PINAL COUNTIES		TOTAL OF MAJOR NATIONAL URBAN AREAS (2000 POPULATION OVER 1 MILLION)	
Year	Population	Annual Growth Rate	Population	Annual Growth Rate
1900	28,236		20,439,707	
1910	43,533	4.4%	27,316,248	2.9%
1920	105,706	9.3%	34,429,902	2.3%
1930	173,051	5.1%	44,613,809	2.6%
1940	215,034	2.2%	48,677,906	0.9%
1950	374,961	5.7%	59,922,430	2.1%
1960	726,183	6.8%	76,934,142	2.5%
1970	1,035,438	3.6%	91,258,448	1.7%
1980	1,599,970	4.4%	99,239,037	0.8%
1990	2,238,480	3.4%	111,908,809	1.2%
2000	3,251,876	3.8%	127,353,534	1.3%
100-Year Average		4.9%		1.8%
50-Year Average		4.4%		1.5%

rate of just under 5 percent, which is more than twice the rate of all national urban regions of similar size. During the last 50 years, the region has grown at a slightly lower average rate of about 4.4 percent, which is three times the national rate. During the last decade, the region grew at an annualized growth rate of 3.8 percent, again three times the national rate.

Table 2 uses these historical annualized growth rates to create three scenarios of how the population of Maricopa and Pinal counties might grow over the next 50 years. The first scenario uses the annualized growth rate over the last 50 years, 4.4 percent, as the rate for the next 50 years. The second scenario uses the lowest annualized growth rate during the last 20 years, 3.4 percent. The third scenario uses the lowest annualized growth of all decades during the last 100 years, 2.2 percent. These scenarios establish a range of future possibilities for regional growth, with the population in 2050 ranging from a high of 28 million under Scenario 1 to a low of 9.6 million under Scenario 3. Chart 1 shows these three scenarios and how they relate to historic regional growth.

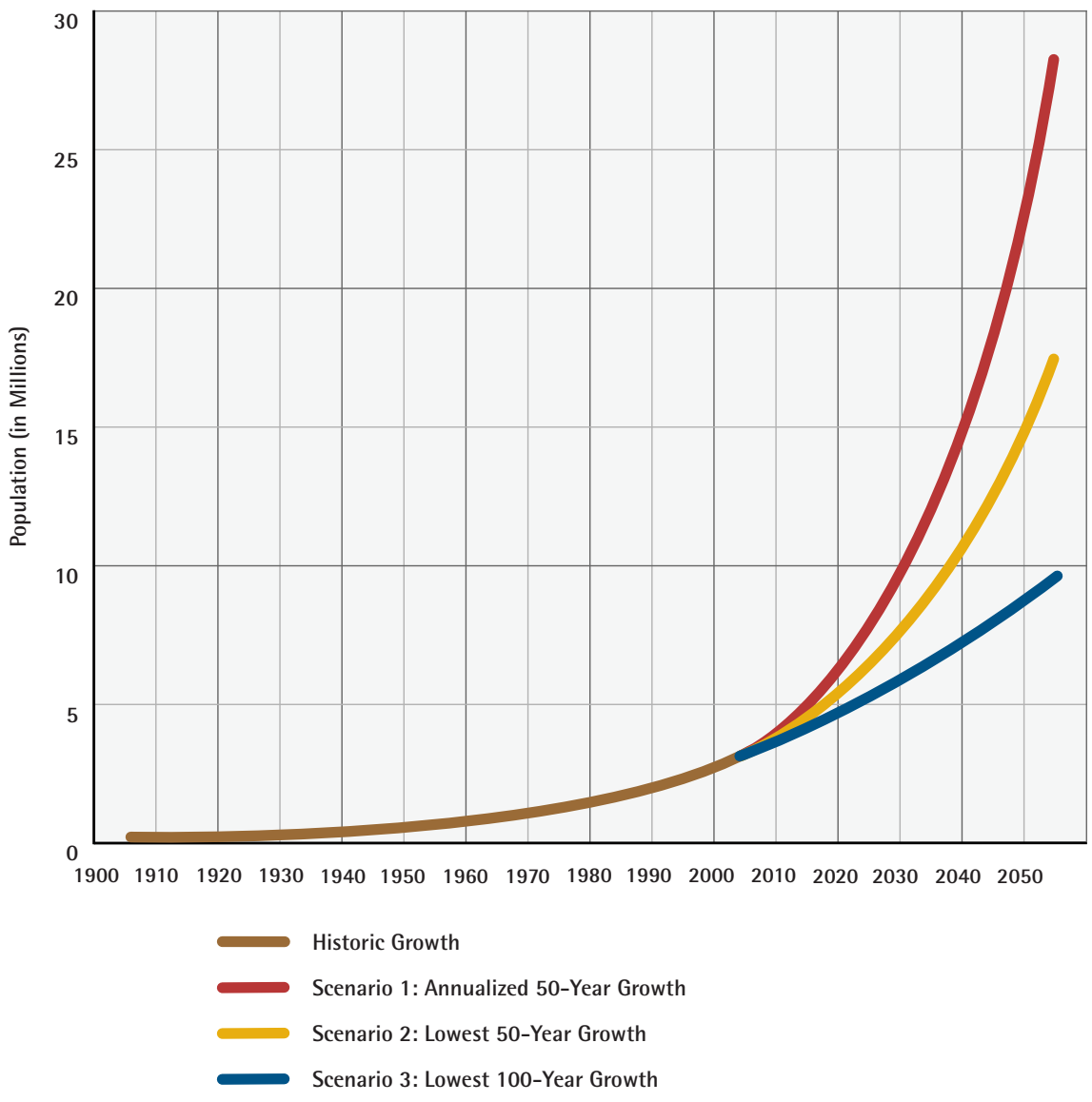
Given these scenarios of regional growth, just what would the extent of the region's urbanized area be in 50 years? Table 3 shows the size in square miles of Maricopa, Pinal and Yavapai counties and the percentage of each that is potentially available for urban development. Maricopa County is about 9,000 square miles in size, of which half cannot be developed because of its extreme topography or because it is owned by the federal government. The other two counties are similarly limited. If either Scenario 1 or 2 (Table 2) were to become a reality at existing densities, the urbanized area would exceed the potential urban land available in Maricopa County.

Table 3 shows that Maricopa, Pinal and the southern portion of Yavapai counties combined have an estimated 7,800 square miles of potential urban land. This is sufficient for the 6,500 square miles estimated as the size of the urban area needed at existing densities for Scenario 2 (population of 17 million) but it is smaller than the 10,000 square miles estimated for Scenario 1 (population of 28 million). In Scenario 3, the estimated 3,500 square miles of urban land area needed for a population of just under 10 million could be accommodated within Maricopa County: based on current trends, it would also extend into Pinal County.

Table 2: Scenarios For Future Growth of Greater Phoenix

	SCENARIO 1: ANNUALIZED GROWTH RATE OVER THE LAST 50 YEARS (4.4%)		SCENARIO 2: LOWEST ANNUALIZED GROWTH RATE OF ANY SINGLE DECADE OF THE LAST 50 YEARS (3.4%)		SCENARIO 3: LOWEST ANNUALIZED GROWTH RATE OF ANY SINGLE DECADE OF THE LAST 100 YEARS (2.2%)	
Year	Population	Land Area	Population	Land Area	Population	Land Area
2000	3,251,876	1,207	3,251,876	1,207	3,251,876	1,207
2010	5,009,144	1,859	4,549,622	1,688	4,040,797	1,500
2020	7,716,016	2,864	6,365,269	2,362	5,021,113	1,863
2030	11,885,644	4,411	8,905,496	3,305	6,239,259	2,316
2040	18,308,480	6,795	12,459,468	4,624	7,752,933	2,877
2050	28,202,126	10,467	17,431,745	6,469	9,633,832	3,575

Chart 1: Historical Growth and Scenarios of Future Regional Growth



Western Diamondback (Crotalus atrox)

Table 3: Land Area of Maricopa, Pinal, and Southern Yavapai Counties

		ESTIMATED LAND AVAILABLE FOR URBAN DEVELOPMENT	
County	Sq. Miles	Percent	Sq. Miles
Maricopa	9,200	50%	4,600
Pinal	5,400	50%	2,700
Southern Yavapai	3,100	15%	500
Total	17,700	44%	7,800

Using these scenarios, the patterns of topography and land ownership of central Arizona, and Neal Peirce's definition of citistate, it seems reasonable to define a region appropriate for a 50-year study such as this. The region, which is here called Greater Phoenix, consists of the southern portion of Yavapai County and all of Maricopa and Pinal counties (Figure 1).

Greater Phoenix and the Nation

Comparing the demographics of regions is difficult. Currently, data are collected based on a geopolitical definition of place. This can vary from a census block group (about the size of a city block) to a county. Typically, the geopolitical boundaries of a region are defined by the larger governmental units of city and county, but these boundaries are just rough approximations of the region because they can exclude emerging urban areas at the region's fringe or include vast areas of undeveloped land.

To compare regions using a standard format, the 2000 census data for counties and places and Neal Peirce's definition of citistate were used to define 34 regions throughout the United States. Each region consists of the densest counties surrounding a central city, plus the surrounding counties that had communities with densities similar to these counties, but for which the county as a whole was less dense. Only regions with populations of over one million in 2000 were included, except Tucson, Arizona, which was included for comparison with Greater Phoenix. These regions are shown in Figure 2 and Table 4.

Within the top 20 regions by size, there are four distinct groups of regions. First are the West Coast/East Coast citistates of Los Angeles and New York, which are now equal in population at 16 million. The second group, consisting of San Francisco and Chicago, have populations of 7 to

Figure 1: Regional Extent of Greater Phoenix

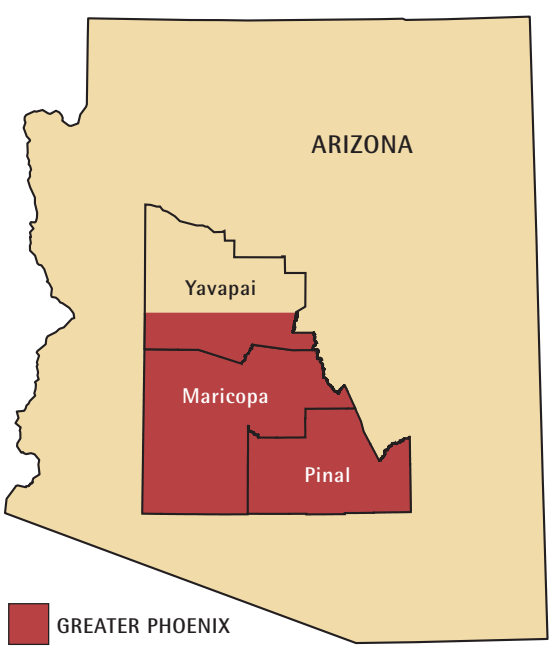
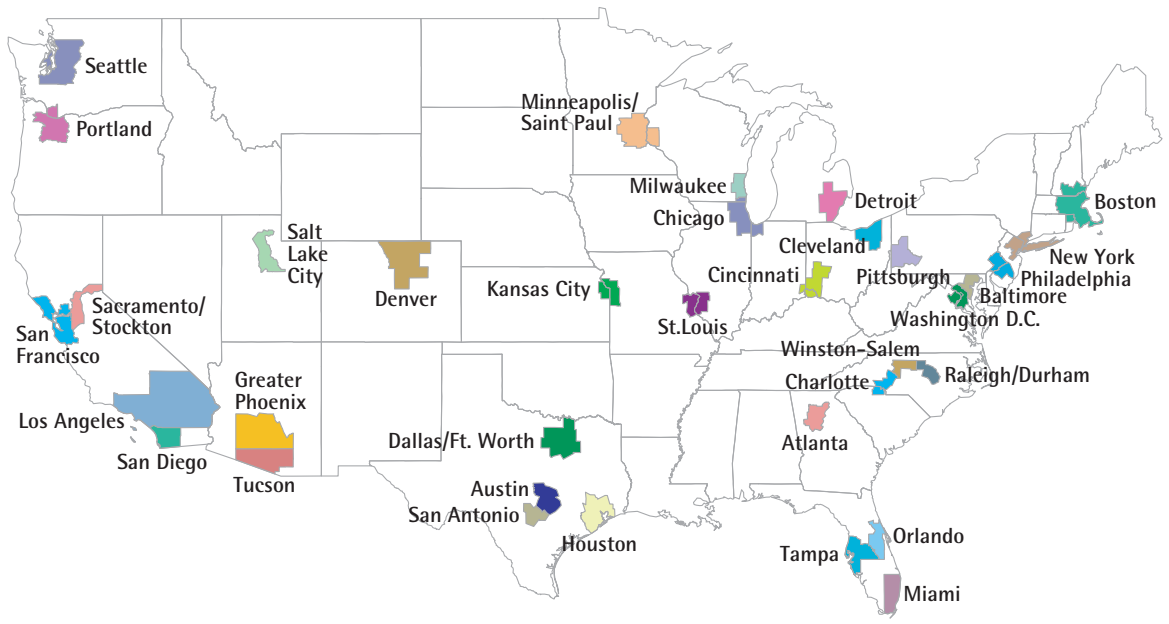


Figure 2: National Urban Regions with Populations of Over One Million in 2000



Source: 2000 U.S. Census

Table 4: Top 20 Regions in the United States With Populations of Over One Million in 2000 (Plus Tucson)

Region Name	POPULATION		Annualized Growth Rate 1990–2000	RANK		
	2000	1990		Population Size	Growth Rate	Population Change
New York City	16,491,093	15,268,814	0.8%	1	26	2
Los Angeles	16,373,645	14,531,529	1.2%	2	20	1
Chicago	8,872,659	7,993,883	1.0%	3	25	8
San Francisco	6,915,083	6,142,546	1.2%	4	22	9
Boston	5,416,860	5,058,665	0.7%	5	27	19
Dallas/Ft. Worth	5,190,216	4,015,115	2.6%	6	8	3
Detroit	5,105,399	4,875,320	0.5%	7	31	25
South Florida (Miami)	5,007,564	4,056,100	2.1%	8	13	6
Houston	4,636,908	3,707,741	2.3%	9	12	7
Philadelphia	4,603,145	4,480,485	0.3%	10	34	31
Washington D.C.	4,013,059	3,574,629	1.2%	11	23	13
Atlanta	3,667,063	2,653,577	3.3%	12	4	4
Seattle	3,483,202	2,910,133	1.8%	13	15	11
Tampa	3,469,880	2,962,824	1.6%	14	18	12
Cleveland	3,332,765	3,228,869	0.3%	15	33	32
GREATER PHOENIX	3,251,876	2,238,480	3.8%	16	2	5
Minneapolis/Saint Paul	2,927,705	2,508,313	1.6%	17	19	16
Denver	2,852,872	2,175,922	2.7%	18	5	10
Cincinnati	2,837,208	2,695,394	0.5%	19	29	29
San Diego	2,813,833	2,498,016	1.2%	20	21	20
St. Louis	2,389,128	2,309,013	0.3%	21	32	34
Baltimore	2,361,534	2,224,847	0.6%	22	28	30
Pittsburgh	2,210,051	2,249,460	-0.2%	23	35	35
Portland	2,074,291	1,640,827	2.4%	24	11	15
Orlando	1,877,376	1,443,460	2.7%	25	6	14
Sacramento/Stockton	1,787,097	1,521,847	1.6%	26	17	23
Salt Lake City	1,702,450	1,335,817	2.5%	27	9	18
Milwaukee	1,689,572	1,607,183	0.5%	28	30	33
Kansas City	1,672,418	1,489,736	1.2%	29	24	26
San Antonio	1,583,718	1,316,688	1.9%	30	14	22
Austin	1,283,910	868,904	4.0%	31	1	17
Charlotte	1,139,542	878,392	2.6%	32	7	24
Raleigh/Durham	1,091,352	780,372	3.4%	33	3	21
Winston-Salem	1,005,161	848,188	1.7%	34	16	28
Tucson	843,746	666,880	2.4%	35	10	27

9 million. The third group includes both old and new regions with populations of 4 to 5 million, including, in order by size: Boston, Dallas, Detroit, South Florida (Miami), Houston, Philadelphia and Washington, D.C. The last group are regions with populations around 3 million that are spread across the country including, in order of size: Atlanta, Seattle, Tampa, Cleveland, Greater Phoenix, Minneapolis/Saint Paul, Denver, Cincinnati and San Diego. Within this last group, the largest region is 5 million and the smallest is just over one million. Most are new-growth cities of the West and South.

Among these 35 major urban areas, Greater Phoenix ranks sixteenth in size but second in rate of growth from 1990 to 2000.

The Next 50 Years: A Preview

Over the last 50 years, Greater Phoenix has emerged from its agricultural roots to become one of the 20 largest urban regions in the United States. With this change from agricultural to urban came changes in the form and function of the region, the demographics of the residents and visitors and the issues the region has had to address to maintain a high quality of life and vibrant economy. Though it is still less than half the size of major citistates such as Chicago, Los Angeles, New York and San Francisco, its past indicates that, over the next 50 years, it could grow to the size of these urban regions. This Atlas provides a preview of this 50-year future and the potential issues Greater Phoenix may need to resolve to maintain its high quality of life and vibrant economy. ■

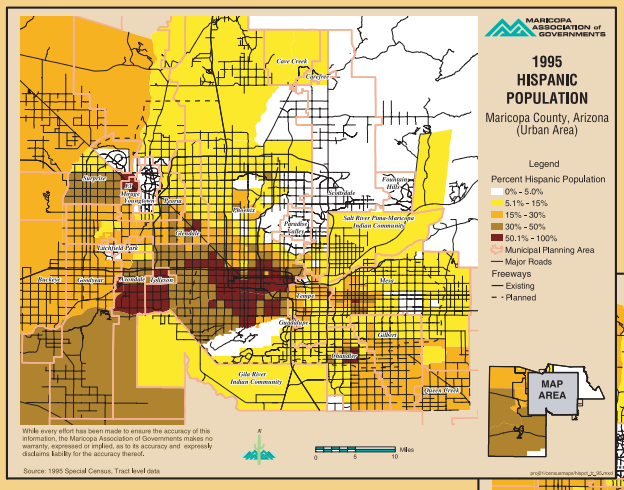
Cactus Wren (Campylorhynhcus brunneicapillus)

The Importance of Updating Data

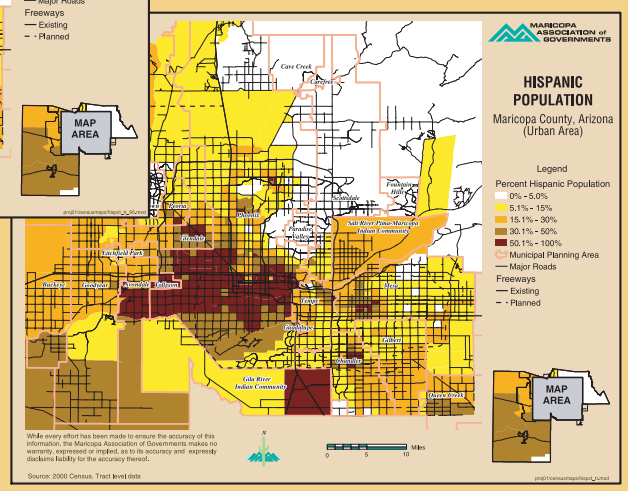
Rita Walton, *Manager, Information Services, Maricopa Association of Governments*

Accurate information about the current conditions and dynamics of a community is an essential element of urban policy analysis. Keeping this information up to date is an important but difficult task. Most agencies rely on the U.S. Census for regional demographic information such as age and ethnicity. Census data, updated on a regular basis every ten years, are adequate for most regions, but for regions that are growing or declining rapidly, the data can become stale in just a few years. In 1995, in an effort to keep information about population in Maricopa County up to date, local government agencies paid the U.S. Census to conduct a limited five-year update to the 1990 census. The data collected proved critical to keeping track of where population growth was occurring, but for some characteristics of the region's population, even this five-year update could not keep pace with the region's rapid change.

A good example of this was recently demonstrated in the release of the 2000 census data. Between 1995 and 2000, the Hispanic population of Maricopa County increased from 20 percent to 25 percent. This is a significant increase, yet it did not come as a surprise. Though there was other evidence that the Hispanic population was increasing rapidly, it was not known exactly where this change was occurring. As the 2000 census revealed, this increase was not uniform throughout the county. For example, in Surprise, Arizona, the Hispanic population declined from 46 percent of the population in 1995 to 23 percent in 2000. Maps A and B show the composition of the Hispanic population in 1995 and 2000 respectively, with the darkest colors being the highest percent Hispanic. As can be seen, using the 1995 information as a base would have resulted in incorrect conclusions about the distribution and count of the Hispanic population in the area.



Map A:
Percent Hispanic
Population 1995



Map B:
Percent Hispanic
Population 2000

Greater Phoenix: A Regional Description

Looking to the Third Phase of Land Use

Charles L. Redman, *Virginia M. Ullman Professor of Natural History and the Environment*
Director, Center for Environmental Studies, Arizona State University

Where the Salt, Gila, and Verde rivers flow out of the eastern mountains into their broad floodplains, the Hohokam Indians used relatively simple technology to create the most ambitious irrigation system in prehistoric North America. When nineteenth-century American settlers laid out their farms, they reutilized many of the old channels, keeping fields and settlements close to the rivers.

Farmland expanded through the mid-1970s as the availability of reliable water increased due to the damming of the Salt and Verde rivers, the formation of the Salt River Project, and projects along the Agua Fria and Gila rivers. Pumped groundwater, now further supplemented with Colorado River water imported by the Central Arizona Project, also enhanced the expansion of farmland.

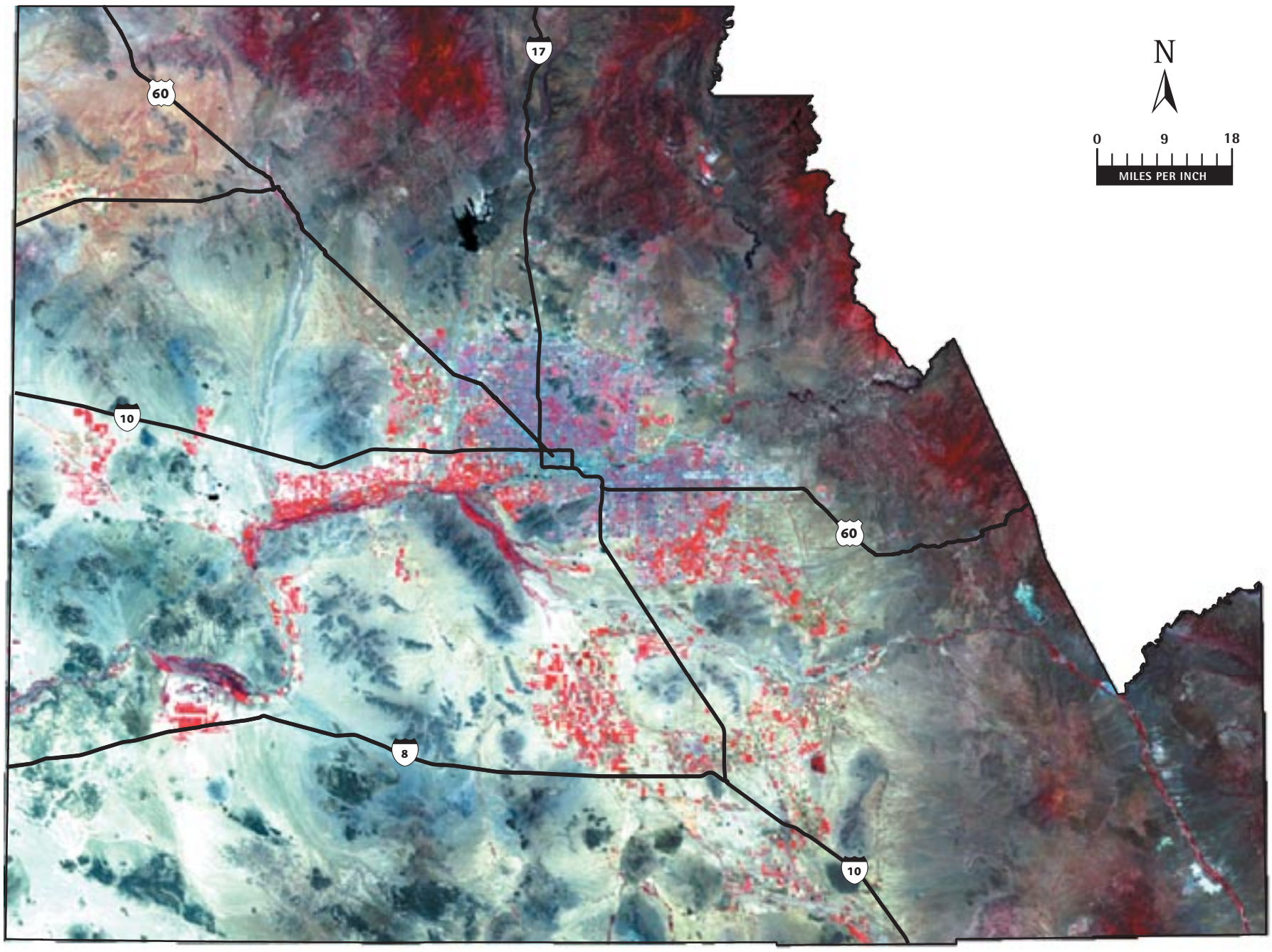
From 1860 through the 1950s, nearly every town in central Arizona was built on former farmland, spreading in a contiguous fashion. This made for cost-effective infrastructure and stabilized total water use because it takes less water to service the same area of homes than it does cotton or alfalfa fields. As a result, irrigated farmland could increase slowly and urban population could grow rapidly on about the same amount of water.

As the metro Phoenix population passed 500,000, we entered a second phase of growth that continues to the present. Development has intensified, and building on former fields has been supplemented increasingly by land far beyond the farm perimeter. By the mid-1970s, new housing and development took about as much desert as farmland. Both patterns persist today, but desert lands are being consumed at a faster rate than are farmlands.

The third phase in the growth of metropolitan Phoenix lies before us. How will we shape it? How will we retain our treasured landscape and maintain our quality of life? Everyone must play a part in considering these questions and determining our, and our environment's, future.

Above: Irrigated fields, Maricopa County

Map 1: False Color Landsat Image of Greater Phoenix



Urban Area

Agricultural Area

Desert Mountains
Lower Colorado River Valley

Desert Mountains / Arizona Uplands

Desert Flat

Lake

Riparian Vegetation Along Desert Wash / River

Dry Desert Wash / River

U.S. Highways and Interstates

NASA

ASU Arizona State University

Data: 2000 Landsat Data, National Aeronautics and Space Administration (NASA); Remote Sensing Lab, Arizona State University

Source: Greater Phoenix 2100, Arizona State University

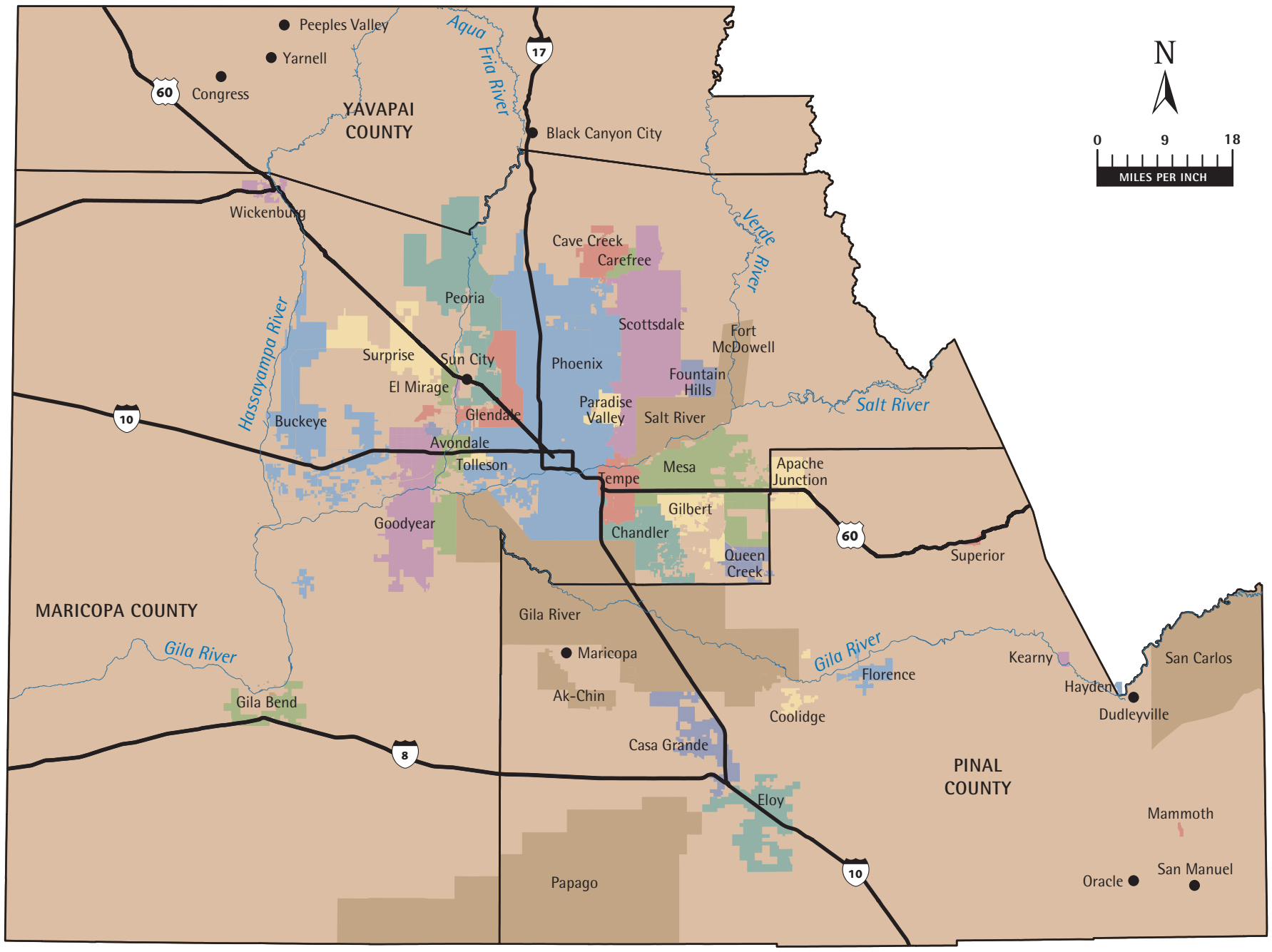
Greater Phoenix encompasses 33 municipalities, six Native American nations and communities, three counties and a number of unincorporated communities. A host of historical and natural forces that have shaped the way the region was settled continue to influence how it is inhabited today and how it will change in the future. The maps in this section show the natural and human environment of the region, the land use and population changes and how current planning efforts might affect the future.

The 17,000 square miles of Greater Phoenix include a wide range of human and natural environments. Natural environments range from the northern vegetated desert mountains of the Arizona uplands to the desert mountains of the central and southwest region to the riparian areas that border some of the perennial streams and rivers. Human settlement patterns range from the rural desert communities in the northwest to rural agricultural communities in south central areas to suburban communities surrounding the urban core of Phoenix. These diverse natural areas and human settlement patterns can be clearly seen on Map 1, a false color infrared satellite image.

The use of false color, near infrared, high altitude aerial photography and satellite imagery has been an important tool for urban and natural resource planners for several decades. Near infrared wavelengths, though invisible to the human eye, reflect off various materials in different ways, registering on infrared film as false color. Similarly, near infrared reflectance measured by satellites is typically assigned the color red to produce a false-color image. Green vegetation, which has a high reflection level, appears red, and the shade of red reflects the density and type of vegetation: grasslands appear light red, deciduous trees and croplands appear bright red and coniferous forests appear dark red or maroon. Desert areas appear white and urban areas appear bluish green. Lakes and rivers are shades of black and blue. Exposed bedrock appears in dark blues and greens. In general, areas with high moisture content are darker than those with low moisture. Man-made features, which are dominated by asphalt, concrete, and roofing materials, reflect a wide range of visible through near infrared wavelengths and appear as varying shades of blues and grays.

The most obvious features on Map 1 are the bright red agriculture fields. The higher altitudes of the north and east are also noticeable as a dark band that embraces the region. Here the ground contains more moisture and has more vegetative groundcover than drier desert areas, which gives it a reddish cast. The urban areas around Phoenix can be seen as zones of blue and gray, sprinkled with red areas of lush urban vegetation. When compared to the brighter red in central urban areas, the absence of red in northern urban areas

Map 2: Current Greater Phoenix Geopolitical Features



Incorporated City Limits
Indian Communities
Unincorporated Places
Rivers
U.S. Highways and Interstates

Data: Maricopa County; Arizona State Land Department

Source: Greater Phoenix 2100, Arizona State University

demonstrates a change in the human settlement pattern. The newer urban areas to the north use more low water landscaping than the traditional landscapes of the urban core.

Political Boundaries

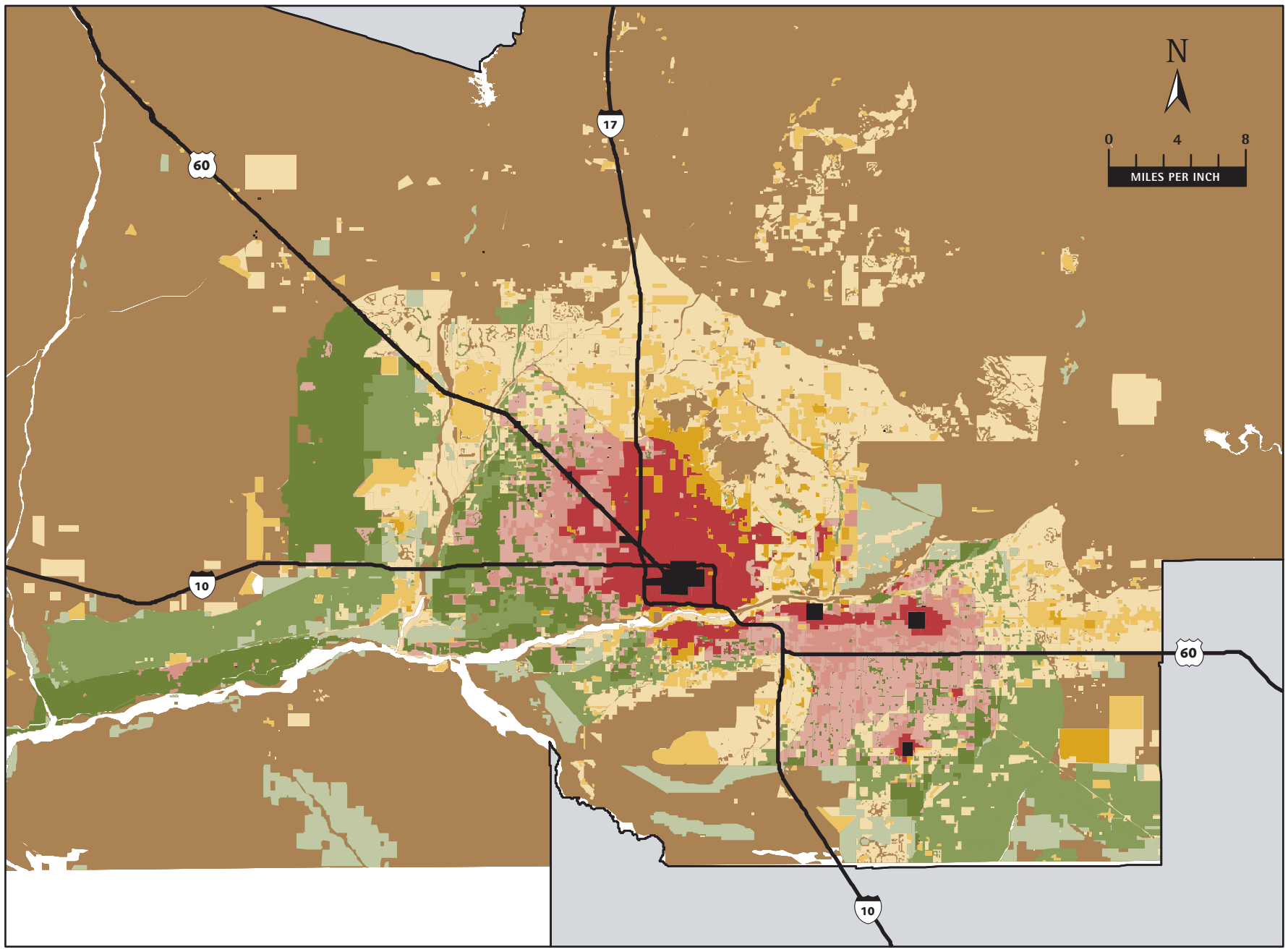
The geopolitical boundaries of Greater Phoenix are shown on Map 2. Yavapai County is one of the four original Arizona counties formed in 1864. Roughly one-fourth of it is located in Greater Phoenix. Maricopa County, named after the Maricopa tribe, was formed from parts of Yavapai and Pima counties in 1871 and is 9,222 square miles in size. Pinal County was founded in 1875 from parts of Maricopa and Pima counties and is about 5,378 square miles in size.

Cities and towns are the political corporations of the state, each having a defined corporate boundary and its own government that can pass and enforce laws, tax property within their corporate limits and receive a share of state sales tax. Everything outside these cities is under the jurisdiction of the county, with the exception of the Native American communities. Unincorporated communities are unofficial places that historically developed around mines, stagecoach stops, railroad depots or way points on established roads. Such places may have a post office and may be recognized by the Census Bureau, but they are under the governmental jurisdiction of the county. Map 2 shows the location of the region's cities and towns, Indian reservations and a few of the unincorporated communities.

Of the 33 cities and towns in Greater Phoenix, 26 are within Maricopa County, including: Apache Junction, Avondale, Buckeye, Carefree, Casa Grande, Cave Creek, Chandler, El Mirage, Fountain Hills, Gila Bend, Gilbert, Glendale, Goodyear, Guadalupe, Litchfield Park, Mesa, Paradise Valley, Peoria, Phoenix, Queen Creek, Scottsdale, Sun City, Surprise, Tempe, Tolleson and Wickenburg. Two of these, Queen Creek and Apache Junction, also are located partially in Pinal County. The seven other cities and towns in Pinal County are Casa Grande, Coolidge, Eloy, Florence, Kearny, Mammoth and Superior. Peoria also extends across two counties, with a small portion crossing into Yavapai. This is the only city with corporate limits within the Greater Phoenix portion of Yavapai County. These cities and towns cover about 1,500 square miles and represent over half the population of Arizona.

There are six Native American communities in Greater Phoenix, each with its own tribal government: the Ak-Chin Indian Community, the Fort McDowell Mohave-Apache Indian Community, the Gila River Indian Community, the Salt River Pima-Maricopa Indian Community, the San Carlos Apache Tribe and the Tohono O'Odham Nation. The economy of these communities was

Map 3: Historic Land Use Change, 1912–1995



LAND USE CHANGE BY TIME PERIOD

- Urban Since 1912
- 1912 Agricultural
- 1912 Desert

Desert to Urban Conversion
- 1912–1955
- 1955–1975
- 1975–1995

Desert to Agricultural Conversion
- 1912–1955
- 1955–1975
- 1975–1995 No Change

Agricultural to Urban Conversion
- 1912–1955
- 1955–1975
- 1975–1995

- No Data
- U.S. Highways and Interstates

Data: Central Arizona–Phoenix Long-Term Ecological Research, Arizona State University

Source: Greater Phoenix 2100, Arizona State University

historically based on ranching and agriculture, but in recent years this has changed. The Gila River and Salt River Indian communities are located near expanding urban areas and have leased some of their land for industrial and commercial use. All six of these Indian communities now operate casinos, of which four are located in Greater Phoenix.

The Changing Nature of Growth

The location and size of these cities reflect 150 years of urban and agricultural development. During the latter part of the nineteenth century, Maricopa County was a patchwork of desert, farms, ranches and small rural towns. Yavapai was mostly untouched forest and range lands with a sprinkling of mines. Pinal was mostly grasslands that supported large ranches and the Indian communities. The introduction of a more reliable supply of water to the region resulted in the expansion of agricultural activities, followed later by urban growth. Map 3 shows the progression of these regional changes from 1912 to 1995.

Table 5: Land Use: Urban, Desert, Agriculture, 1912–1995

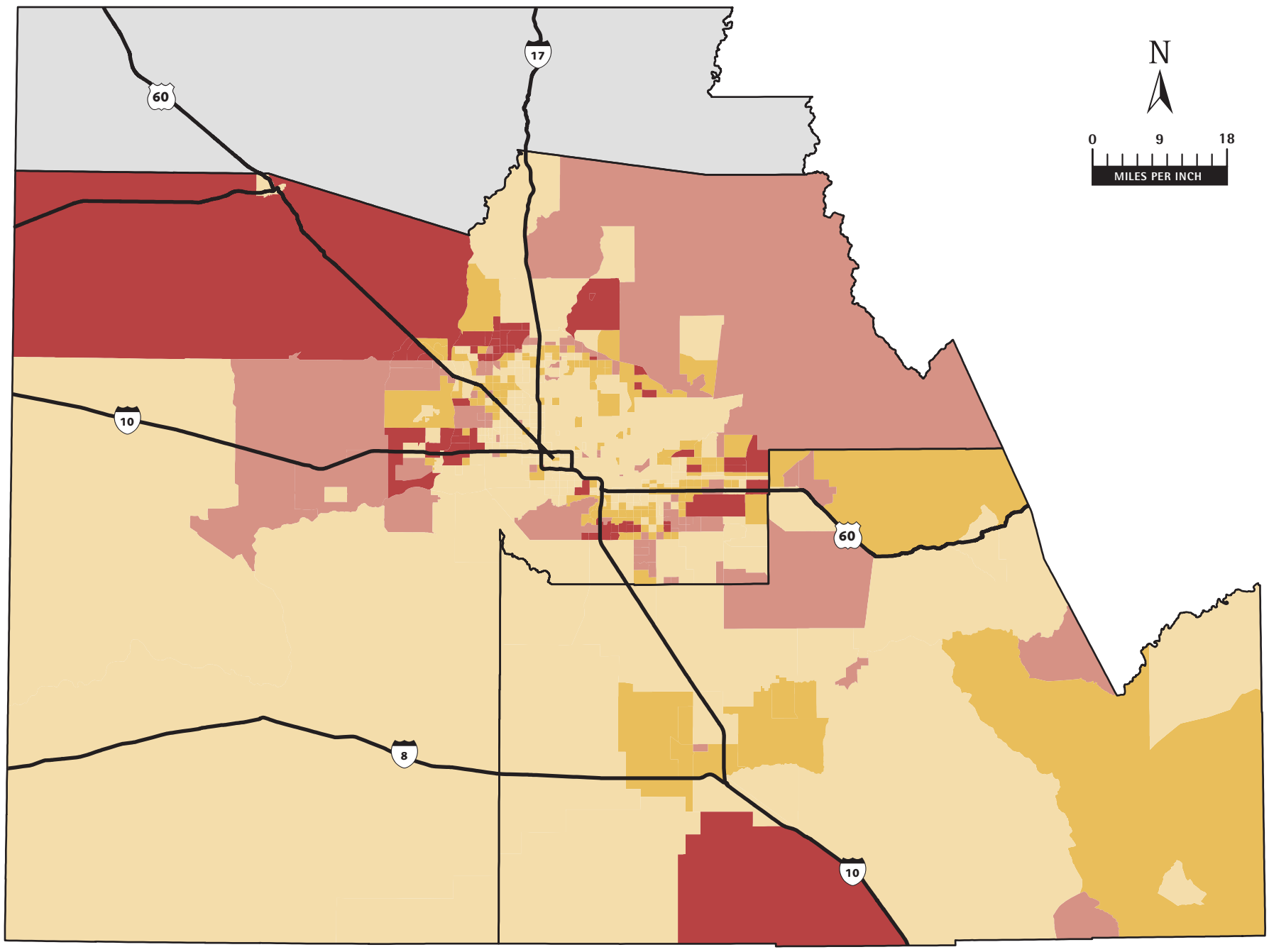
Year	Urban	Desert/ Recreational	Agriculture
1912	0.2%	90.9%	9.0%
1934	0.4%	83.9%	15.7%
1955	2.7%	83.5%	13.8%
1975	6.6%	77.4%	16.0%
1995	18.0%	70.7%	11.3%

Source: Central Arizona–Phoenix Long-Term Ecological Research, Arizona State University

The first people to cultivate crops in the region were the Hohokam Indians, farmers who inhabited the Salt River Valley from A.D. 300 to 1450. They constructed a system of canals and irrigation ditches to bring water from the Salt River to their fields. The Hohokam canal system traversed nearly 500 miles and may have served as many as 50,000 people at a time. These canals were eventually abandoned when the Indians left the region.

During the latter half of the nineteenth century, residents of the region began to use the abandoned Hohokam canals to once again divert Salt River water to farmlands. For almost 40 years, private companies and associations, which assessed members a fee for construction and maintenance, built and restored the canals. By the turn of the century, this system of canals was reaching its limit. It could not take advantage of floods in the river, nor could it provide water during periods of drought and low river flow. Just after the turn of the century, local farmers created the Salt River Project (SRP) and built the Granite Reef Dam to

Map 4: Population Change, 1980–2000



AREAS WITH GREATER THAN 100% CHANGE IN POPULATION

- Less Than 100%
- Greater Than 100% for 1980-1990
- Greater Than 100% for 1990-2000
- Greater Than 100% for 1980-2000
- Partial Tracts – Change Not Mapped
- U.S. Highways and Interstates

Data: 2000, 1990, 1980 U.S. Census

Source: Greater Phoenix 2100, Arizona State University

help stabilize their ability to deliver water from the Salt River.

By 1912 when Roosevelt Dam opened, agricultural uses served by a system of canals were spread across the central region. Over the next 40 years, as the SRP expanded its ability to deliver reliable water supplies, agriculture continued to expand and fill in lands that required more canals to reach. As the agricultural economy expanded, the need for services also expanded and Phoenix began to grow and become more urban, though it still remained primarily an agricultural town. During this time frame, most urban development occurred on converted agricultural lands. However, there was some ranching and resort development just beginning to occur in the north central and east central parts of the region.

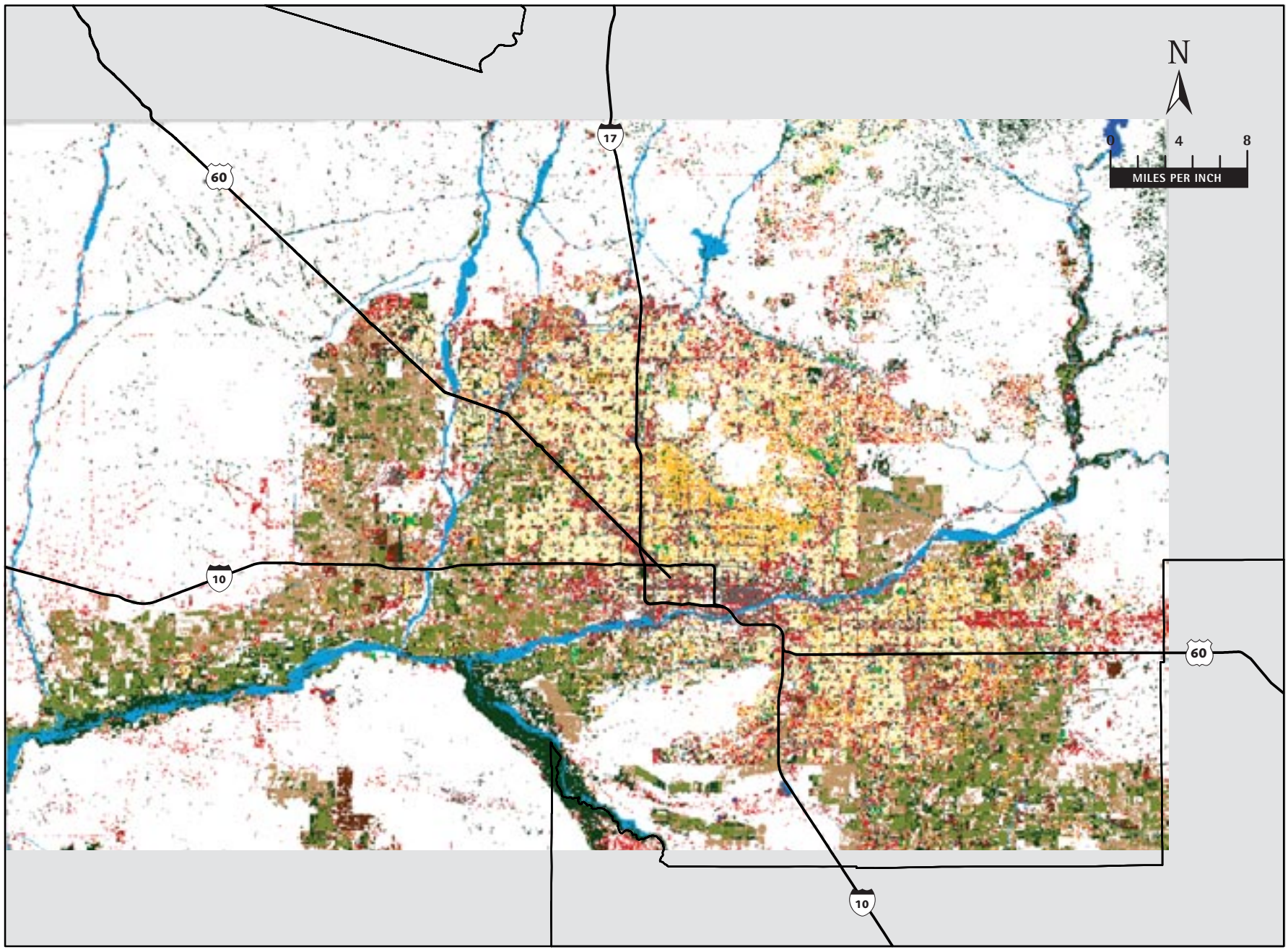
After World War II and the invention of air conditioning, the population of Phoenix began to explode. Though agriculture was still expanding, urban development was expanding at a faster rate. Urban growth became concentrated in agricultural areas of west Phoenix and the eastern part of the region. Urban development also began to expand into the undeveloped desert areas of the north and northeast parts of the valley. By 1975, land use had shifted from predominantly rural and agricultural to largely urban. There has been little expansion of agricultural land since that time. While the conversion of agricultural land to urban uses has continued in the southeastern part of the region, the greatest amount of urban development has taken place on the undeveloped desert land in the north and northeastern areas.

Population Explosion

Since 1980, most of the region's population growth has been at the fringes of urban development. Map 4 shows the census tracts that have experienced a doubling of population between 1980 and 1990 and between 1990 and 2000. All parts of the region except the southwest quadrant have areas of high population growth that are located at the urban fringe. The map shows some evidence of rings of growth expanding out from the urban core, with a band of 1980 to 1990 growth areas (dark yellow) surrounded by a ring of 1990 to 2000 growth areas (shades of red). But this is not an exclusive pattern. There are areas of growth in all time frames, including some with high growth over the full 20 years sprinkled throughout the urban fringe. This reflects the region's checkerboard pattern of two types of growth.

First, development would move out beyond what was the urban limit at the time and develop in a patchwork pattern, leaving holes of desert or agricultural lands. At the same time, development would begin filling the holes that had been left behind in the expansion areas of the previous decades. Although Map 4 shows that all parts of

Map 5: Current Land Cover, 1998



- Compacted Soil
- Compacted Soil (Prior Agricultural Use)
- Cultivated Grass
- Cultivated Vegetation (Active)
- Natural Vegetation
- Water
- Asphalt and Concrete
- Commercial/Industrial
- Mesic Residential
- Xeric Residential
- Fluvial and Lacustrine Sediments (Rivers & Canals)
- Undefined
- Undisturbed
- No Data
- U.S. Highways and Interstates

ASU Arizona State University

Data: Geological Remote Sensing Laboratory, Arizona State University

Source: Greater Phoenix 2100, Arizona State University

the urban fringe experienced growth in all decades, this expansion was not continuous. During the last two decades, growth has favored different parts of the region at different times. This pattern was driven by the timing of construction of new water, sewer and transportation infrastructure, changes in the economy and market demand and decisions about what state land would be sold in any one year.

Because of the large size of the census tracts in rural areas, the exact location of the population growth can be difficult to determine. For example, there is a large dark red area in the northwest part of the map. This represents one large census tract that includes all the rural areas around the Town of Wickenburg, which can be seen as a light yellow area at the northern edge. Although the population for this census tract doubled in the 1980s and 1990s, the growth was not evenly distributed. It is likely the increases were concentrated in areas near Surprise and Sun City, two growing cities south of Wickenburg. This demonstrates one of the problems of using census data in rural areas. As urban areas expand, the Census Bureau redefines the boundaries of census tracts, but these often lag behind the growth. This can make it difficult to analyze demographic trends at a small geographic scale within the expanding urban border.

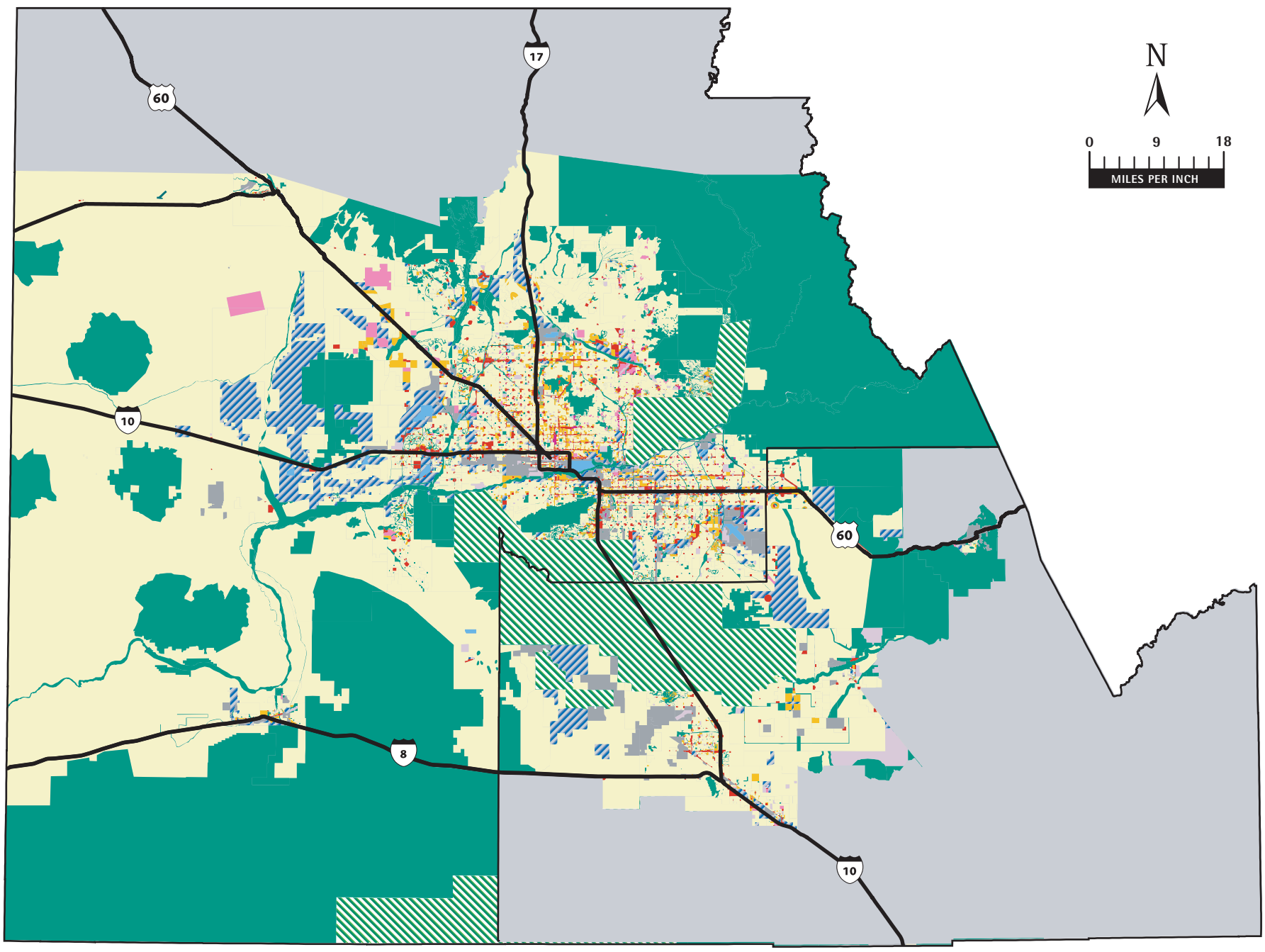
Forcing a Pattern of Growth

There are several significant regional features that have affected and may continue to affect both urban and agricultural development. The Indian tribes have a culture very closely tied to their land. To date they have not sold their lands for non-Indian community use and only in the last few decades have they begun to lease their lands for commercial and industrial development. This has caused urban expansion to stop or slow substantially as it reaches the Salt River Pima-Maricopa Indian Community to the east and the Gila River Indian Community to the south.

The region also has some mountain ranges that act as barriers. As development has reached some of the region's mountain ranges, it has flowed around them, leaving islands of open space. South Mountain, Squaw Peak, Camelback Mountain and North Mountain are now such pockets of preserved wilderness within the urban portions of the region. Today the White Tanks, Estrella, Superstition and McDowell mountains are at the edge of the urban area.

A substantial portion of the region is owned by the federal government. To date these areas have not had a major influence on the regional development. But now, as urban expansion draws closer to the federal lands of the north and west, they are likely to have an impact.

Map 6: Proposed (Planned) Future Land Use



LAND USE

- Single-Family Residential
- Multi-Family Residential
- Retail
- Industrial
- Office
- Public
- Other Employment
- Transportation
- Airport
- Open Space
- Multiple Use
- Indian Communities
- No Data
- U.S. Highways and Interstates

MARICOPA ASSOCIATION of GOVERNMENTS

Data: Maricopa Association of Governments

Source: Greater Phoenix 2100, Arizona State University

Water has also had a major influence. The areas to which SRP serves water (see "Water: Supply, Use and Quality") are mostly within the central portions of the region. The Central Arizona Project (CAP) delivers water a little further north than SRP, but it still does not reach the far northern areas. This has had a major influence on the pattern of agricultural development, which has followed water availability and is thus concentrated toward the center of the region.

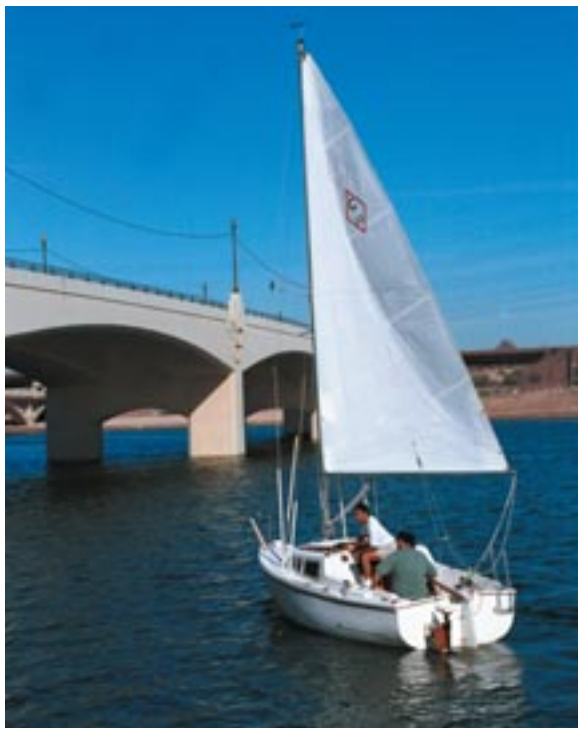
The combination of these factors – water, mountains, Indian communities and federal lands – is beginning to force the pattern of urban development in to a slanted figure eight that is bordered by agricultural areas to the south and desert areas to the north. This can be seen in Map 5, which shows land cover in the central part of the region in 1998. This map was created by combining false color satellite images and geopolitical information such as zoning and ownership. Yellow areas represent residential lands, green indicates developed agriculture and open space areas, red is commercial and industrial land and white represents areas of natural land cover, desert and mountains.

This map shows the pattern of residential and commercial development with islands of open space. The urban area is being pinched at the center by mountains and the Indian communities and is now reaching new barriers of mountains and federal lands in all directions.

Planning For the Future

Zoning and general plans significantly affect patterns of human settlement and can provide insight into what may happen in the future. Map 6 is a consolidation of various communities' general plans for the region. The color scheme is similar to that of the existing land use cover in Map 5. Map 6 reflects one possible future pattern of urban use. The individual plans used to create this map are considered to be for full build-out of each community, when all developable land within each community's current planning area is developed. This map represents a desired, not predicted, outcome. Map 6 reflects persistence of the figure eight pattern and shows urban development beginning to flow around new natural and political

Central Arizona Project, near Florence



Tempe Town Lake

barriers, creating new open space islands. This envisioned future does not use all the potentially developable land in the region: within all three counties, there remains land that could be developed but is not.

In the introduction, several future population scenarios, and the amount of land area needed to accommodate these populations, were presented. Map 6, even though it represents each community's current vision of its build-out state, does not show sufficient growth areas to accommodate any of these growth scenarios.

Unlike maps of natural features, maps of future land use are inherently dynamic. They reflect the collective desire of the residents living in each community at the time the maps are made. However, not only can such desires and the political will to implement them change, but the boundaries of jurisdictions can also change. Currently in Arizona, any areas not within the limits of a city or town are planned by the county. But as cities annex new land, they take over the planning of those areas. Map 2 shows the extent of city and town boundaries today. A common pattern is that, at the edge, the city limits feather out, because as cities and towns annex neighboring lands, they often do not do so in a solid pattern. Some areas at the edge remain in the county jurisdiction, but they, too, will be annexed by a city eventually. Thus, county planning tends to focus more on rural rather than urban development. Some of the areas that are single-family residential and are not currently in city corporate limits (Map 6) likely will be included within the boundaries of a city or town in the future, and the desired use may change. ■

Regional Transportation

Light Rail and Density

The Arizona Republic **Editorial Board**

The Valley's car-oriented culture has shaped the urban area, encouraging low-density, low-rise development. Residents love the vistas and elbow room. But with shopping, homes and workplaces widely separated, every errand means a trip in the car.

Critics have long argued that such low-density development is incompatible with rail service. Light rail generally makes sense with at least 15,000 people per square mile. In Phoenix, the average is 2,500. But averages are deceptive.

The Valley includes some highly populated spots where rail service would be a natural. Around Arizona State University, for instance, densities run as high as 20,000 people per square mile.

In new developments, densities are rising as builders profit from cramming in more homes per acre. Developers are also backtracking to older neighborhoods, filling in vacant lots or replacing single-family houses with multi-family housing. Even downtown Phoenix is gaining residents as people reject long commutes.

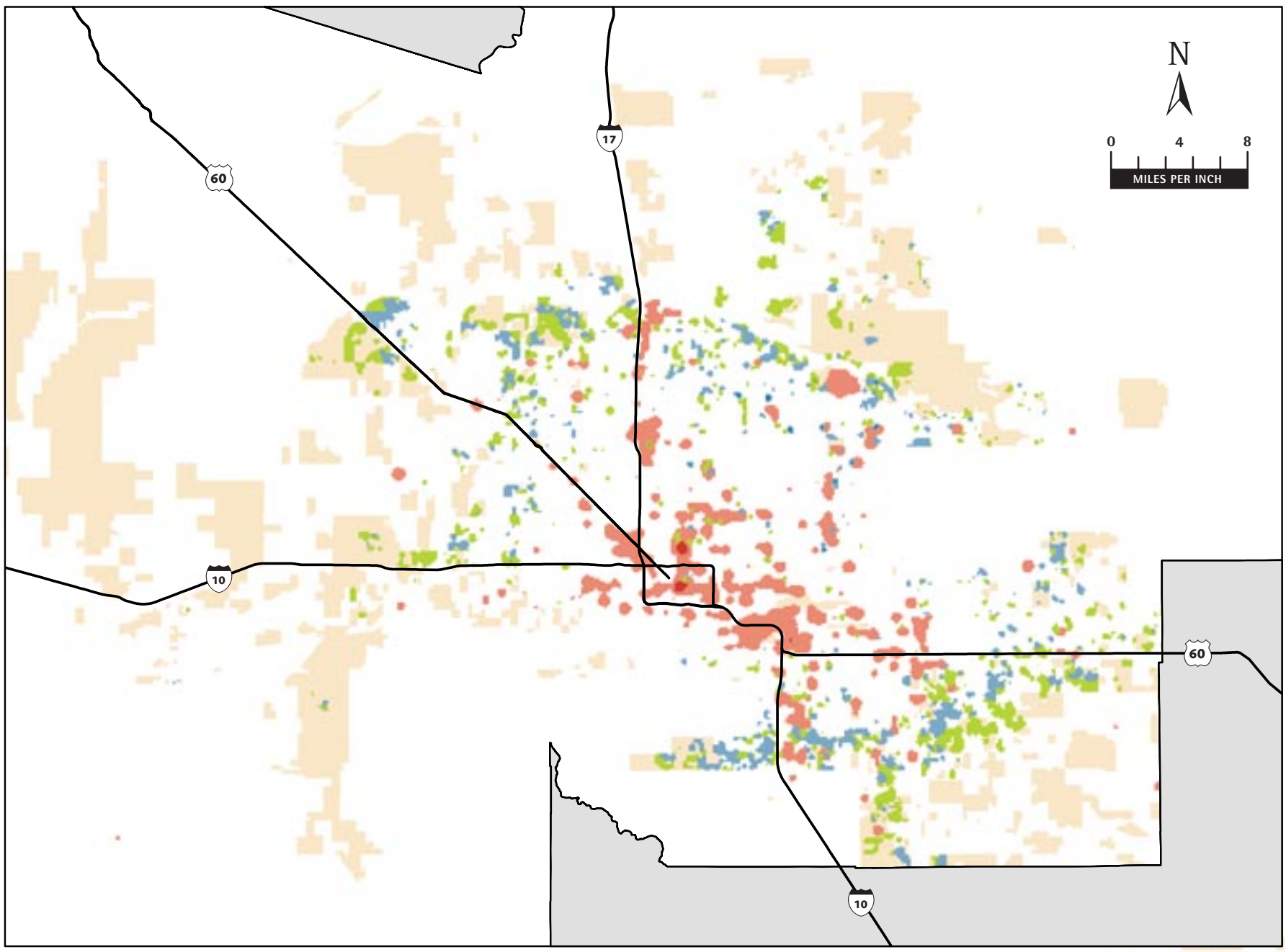
Other cities with similar development patterns, including Denver, Houston and Salt Lake City, have jumped aboard the rail bandwagon.

Their experience shows that rail itself encourages the higher densities that make it truly efficient. Shopping and everyday services, such as childcare and dry cleaners, cluster around stops. With groundbreaking a year away, there are already signs of that along Phoenix's planned light-rail route. The latest residential projects along Central Avenue anticipate using nearby rail stops as a selling point.

The density question hasn't stopped voters from understanding that rail is an essential part of the transportation mix. They see that freeways can't carry the whole load, an aging population will need alternatives to driving, and exhaust is smudging our desert skies. While regional plans for rail have failed, voters in Phoenix and Glendale have approved funding for a light rail project. So has the Tempe City Council.

A look at Los Angeles shows that it doesn't take traditional high-density development for rail to flourish. The five-county metro area has 556 miles of commuter, light rail and subway. Twelve years ago, it had zero.

Map 7: New Residential Density, 1990–1999, and Employment Density, 2002



Residential Completions Density, 1990–1994
- 1 to 5 Units per Acre
- Over 5 Units per Acre

Residential Completions Density, 1995–1999
- 1 to 10 Units per Acre
- Over 10 Units per Acre

Employee Density
- 5 to 50 Employees per Acre
- 50 to 150 Employees per Acre

- Planned and Existing Master-Planned Developments
- No Data
- U.S. Highways and Interstates

MARICOPA ASSOCIATION of GOVERNMENTS

Data: Maricopa Association of Governments

Source: Greater Phoenix 2100, Arizona State University

The backbone of any urban region is its transportation system. The ability to efficiently transport people and goods from one place to another is critical to a region's health and sustainability.

An inefficient system can have a variety of negative impacts. The more miles that have to be traveled or minutes vehicles have to idle in traffic, the more carbon monoxide (CO), carbon dioxide (CO_2), hydrocarbons and particulates are added to the air. The personal cost of transportation goes up as trips get longer. The regional cost goes up as governments must provide more and more transportation facilities. All these factors have a negative impact on a region's economy and quality of life.

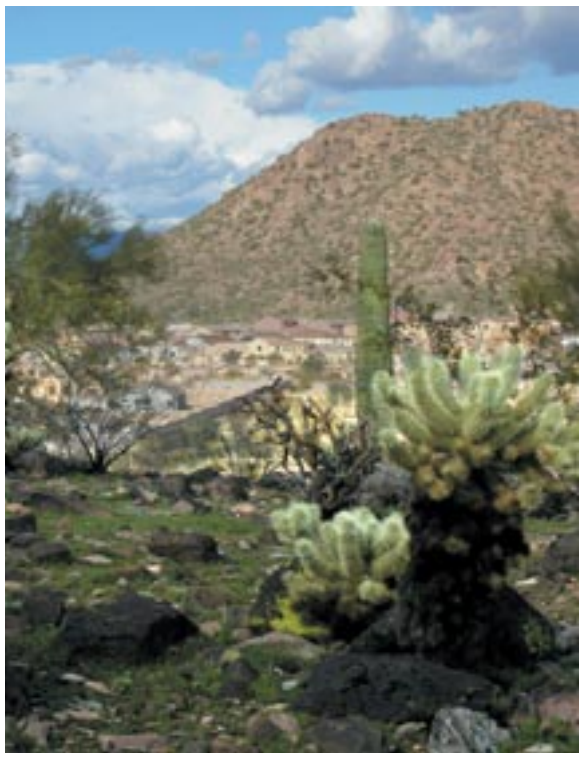
There are two factors that determine the efficiency of a region's transportation system: land use, which defines the "to" and "from" of travel, and, the physical facilities of streets, highways, and mass transit.

Land Use and Trip Length

Land use affects the length of trips, which in turn affects the time spent traveling, the fuel consumed, the air pollution generated and the number of miles of road needed.

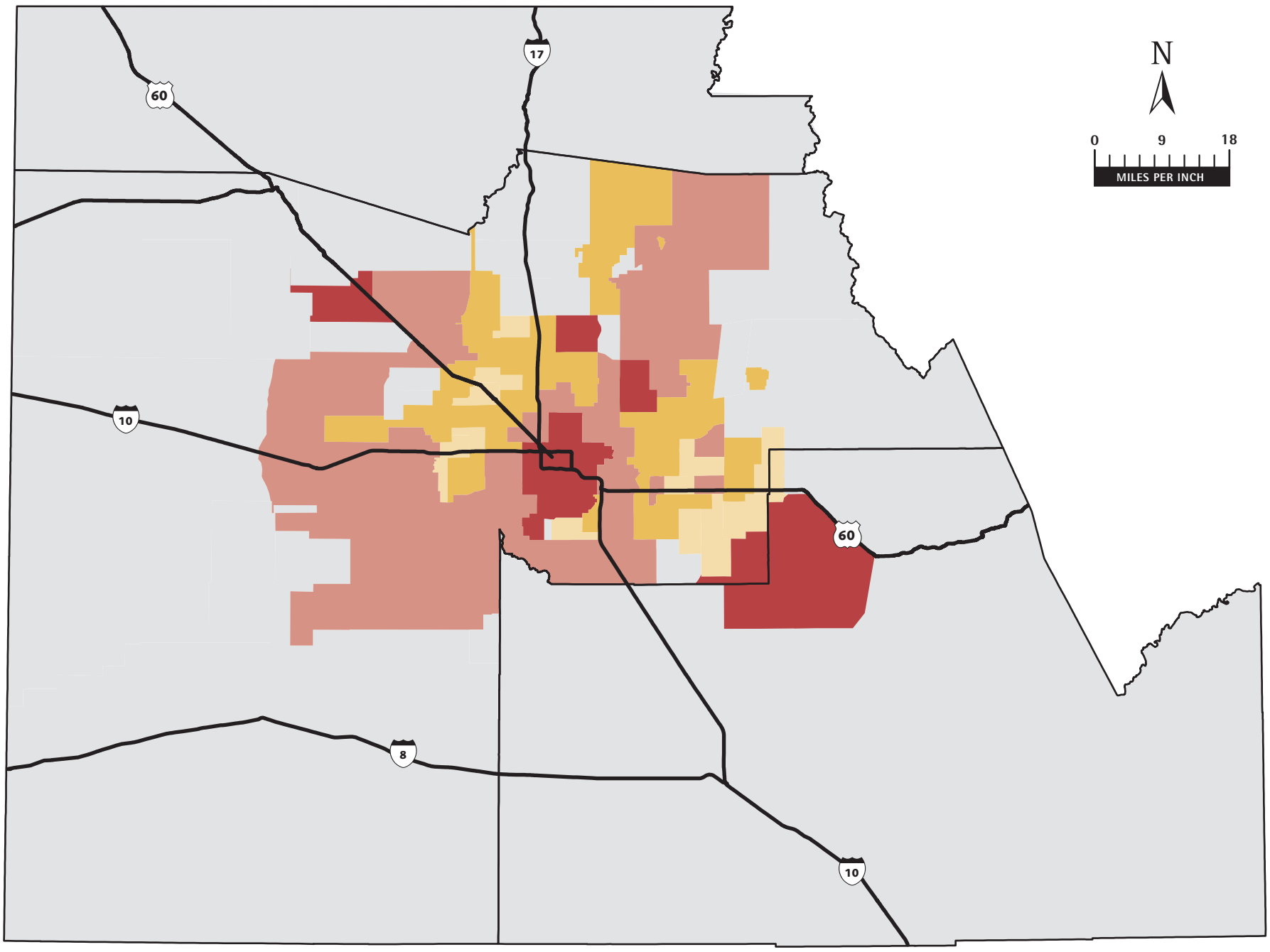
Map 7 shows the location of new residential building permits for Maricopa County from 1990 to 1994 in blue and from 1995 to 1999 in green. Most of these are located at the fringe of the region's existing urban areas. Map 7 also shows as tan areas the location of currently planned major residential projects that have been approved by the local municipality or county.

New residential building permits, the blue and green areas, represent the starting points of future morning commutes and reflect increases in trip demand. The non-retail employment concentrations, shown in red, represent the end points. Most of the new starting points will generate commutes to the same areas where employment is



Tramonto, North Gateway Village, Phoenix

Map 8: Commute Time and Place of Work, 2000

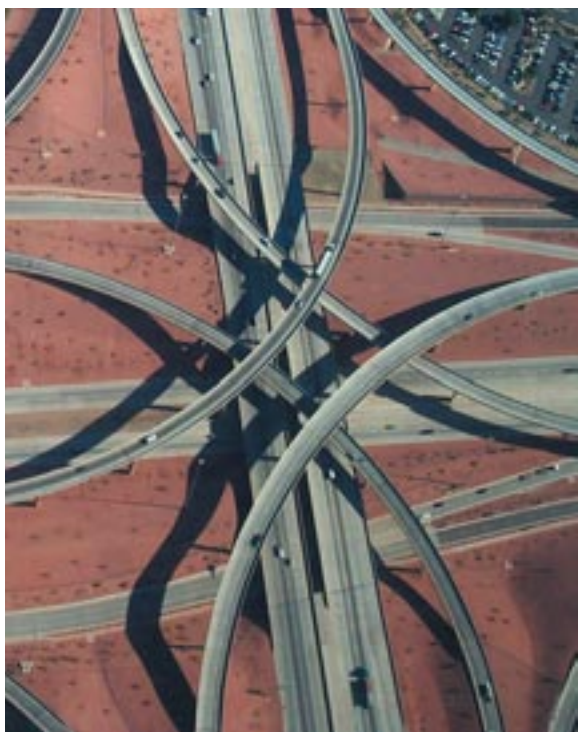


MORNING COMMUTE TIME IN MINUTES

- 1 to 15 Minutes
- 15 to 20 Minutes
- 20 to 25 Minutes
- Greater Than 25 Minutes
- No Data
- U.S. Highways and Interstates

Data: Trip Reduction Program, Maricopa County

Source: Greater Phoenix 2100, Arizona State University



Interchange of Interstate 17 and Loop 101, Phoenix

already concentrated, which, with only a few exceptions, are located near the region's center. As new residential growth locates farther from the regional center, the average distance people commute to work will become longer. Longer trip lengths mean a less efficient transportation system. Future employment growth in fringe areas may change this trend.

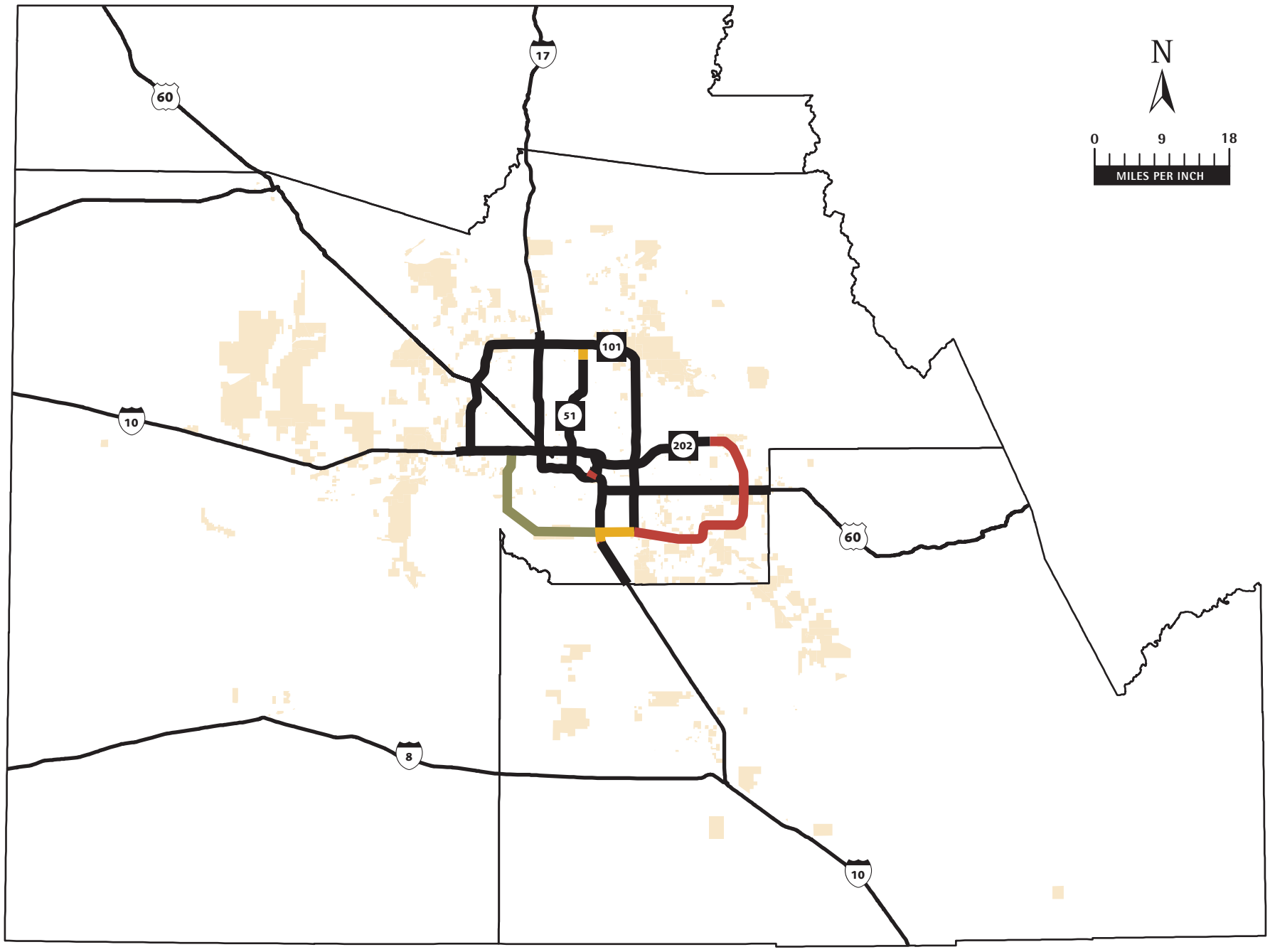
Map 8 shows the time people spend in their commute based on their place of employment. For example, most of the people working in downtown Phoenix travel from all parts of the region, resulting in high commute times, as shown in dark red on the map. People working in businesses located farther out are more likely to live closer to work, and thus their commute times are lower. There are, however, several exceptions to this, including the areas in and around Deer Valley Airport and Scottsdale Airpark. These areas have commute times similar to downtown, which means people working there live in a dispersed pattern around the region, similar to those working in central Phoenix. These areas have fewer employees than more central areas, so their impact on the average trip length is low. However, they do show a trend in the development of fringe employment centers to the north and south.

The two areas on Map 8 to the southeast and northwest with high commute times do not have high employment concentrations. Rather, they have a few businesses of moderate size whose employees commute from other parts of the region. Because there are so few businesses in these areas, their results can obscure the overall picture.

Freeway Facilities and Transportation Demand

Transportation efficiency requires facilities adequate to meet travel demand. Greater Phoenix

Map 9: Regional Transportation Plan and Future Potential Development



CURRENT AND PLANNED REGIONAL FREEWAY SYSTEM

- Existing U.S. and State Highways and Interstates
- Under Construction
- Funded
- Under Study
- Planned and Existing Master-Planned Developments

Data: Arizona Department of Transportation; Maricopa Association of Governments

Source: Greater Phoenix 2100, Arizona State University

is nearing completion of a 50-year freeway expansion. This plan, which was initially developed in the early 1960s, is paid for by state fuel taxes, federal funds and dedicated local sales tax. Map 9 shows the facilities included in this regional plan and their status as of 2003. Nearly all parts of this system are either open, under construction or about to be built. The only exception is the southwest loop around South Mountain, which is under study.

However, this freeway system, planned in 1960, was only intended to meet the transportation needs of 50 years, and there has been a great deal of growth in areas not covered by that plan. Map 9 shows planned residential development. For the most part, the newer freeways are located near the new residential development built between 1990 and 1999 (Map 7), but lie just inside of the planned developments.

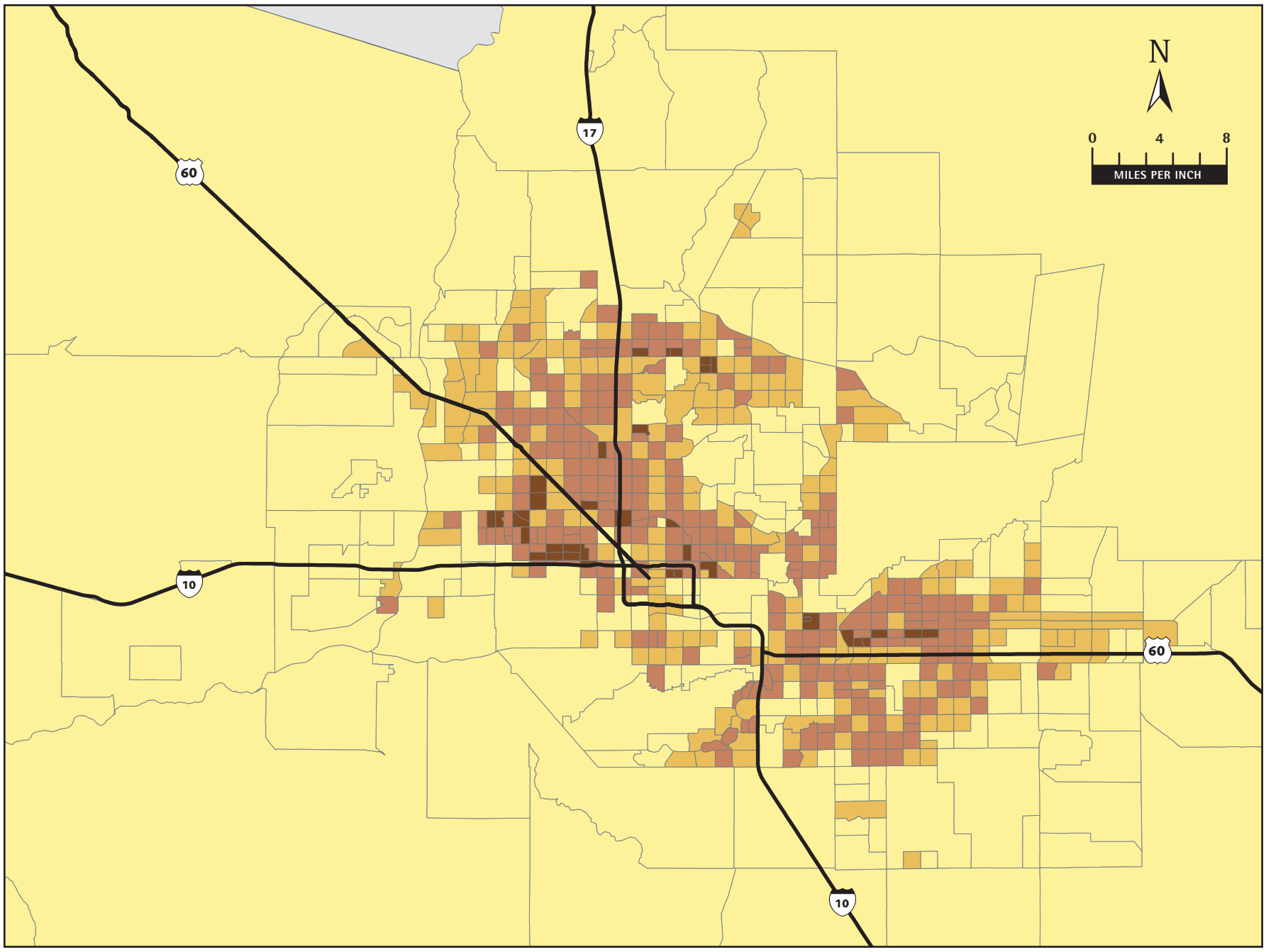
Transit and Population Density

One of the key factors in the success of a transit system is the density of population and employment in the areas the system serves. The higher population densities in cities such as New York, Washington, D.C. and Chicago are commonly cited to explain the success of their transit systems. Studies of urban areas have shown that as population density increases, so does the percentage of mass transit trips. As the number of transit trips increases in a defined area, the type of transit that can be economically provided changes. Busses can serve areas with densities as low as three households per acre or 5,700 people per square mile. Light rail can usually serve areas with densities in the range of eight households per acre or 15,000 persons per square mile. Although densities in the Phoenix region are much lower than in New York, they can support various forms of mass transit.

Phoenix Bus Service

Comparing densities between cities is not easy. Population density is the number of people that live within a prescribed area, usually one square mile. However, the area selected for this calculation can affect the result. Geographies used to calculate density are typically based on geopolitical boundaries such as counties or U.S. Census

Map 10: Population Density, 2000



POPULATION DENSITY (PER SQUARE MILE)

- 0-2,500
- 2,500-5,000
- 5,000-10,000
- 10,000-21,000
- No Data
- U.S. Highways and Interstates

Data: 2000 U.S. Census

Source: Greater Phoenix 2100, Arizona State University

Metropolitan Statistical Areas (MSA). However, comparing counties from different regions is not always appropriate. Some regions have smaller counties that closely match the boundaries of the region's urban areas. Other regions, central Arizona for example, have counties that are often much larger than the urban area. For example, the population density of Maricopa County is about 330 persons per square mile, but only about 12 percent of the county can be considered urban. The population density of just the urban portion of the county is around 2,500 persons per square mile. This density is comparable to other major growth cities in the United States.

Map 10 shows population densities of the urban areas of Greater Phoenix. This map reveals the urban portion of the region's figure-eight pattern, with population densities generally higher in the center. But this pattern is not uniform. Densities in the range of 10,000 to 21,000 people per square mile (dark brown on the map) can be found in the northeast, west and southeast as well as the central areas. These densities are associated with major activity centers such as Arizona State University or with high concentrations of multi-family housing. Areas with a density of 5,000 to

Table 6: Density by Distance from Center of Region

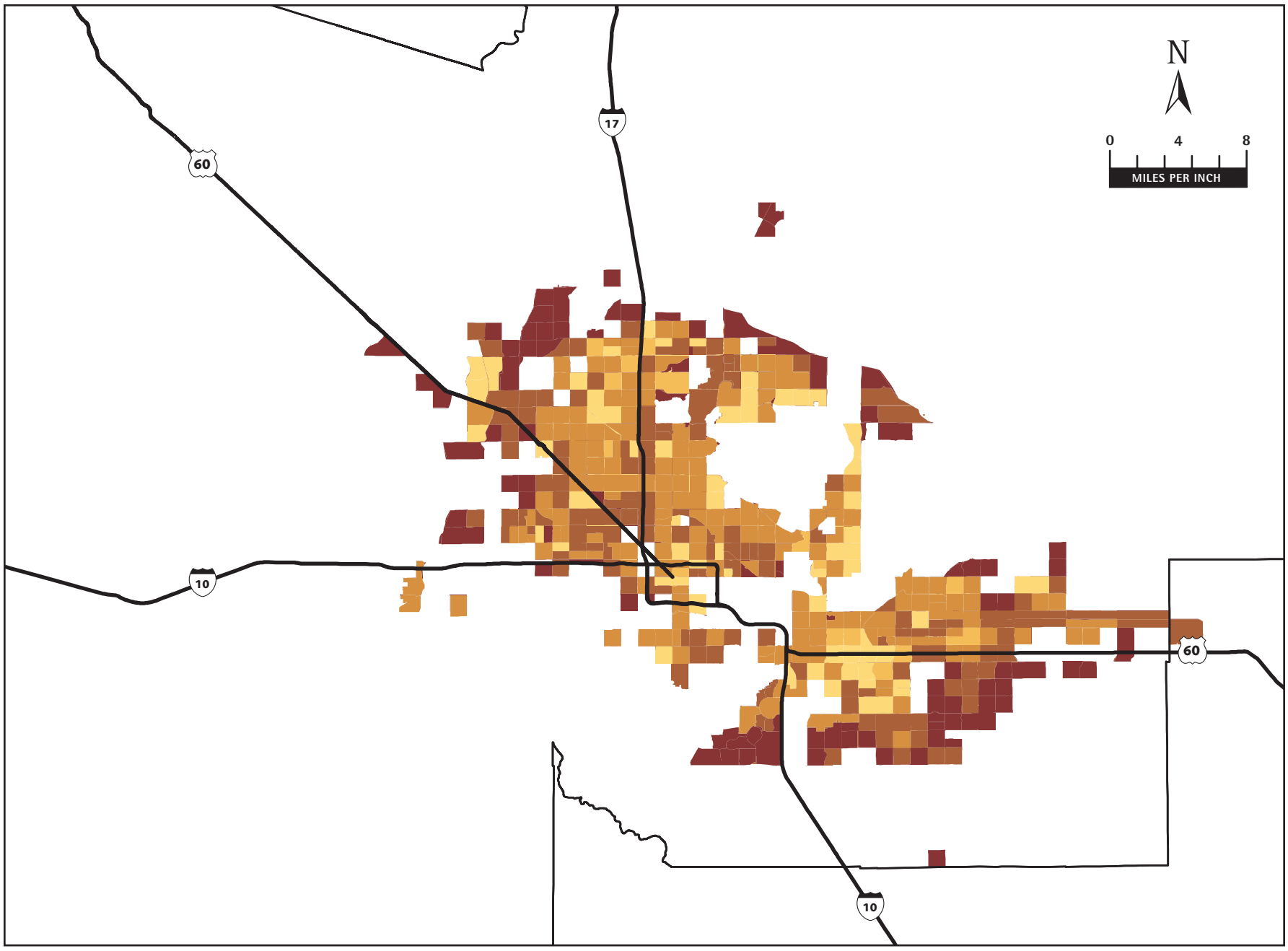
CENSUS TRACTS WITH 1,000 PERSONS PER SQUARE MILE OR GREATER

Distance in Miles from Region Center*	Persons per Square Mile
2	3,920
4	5,417
6	5,408
8	5,260
10	5,087
12	4,886
14	4,800
16	4,593
18	4,367
20	4,302

* Intersection of Washington Street and Central Avenue was used as region center.

Source: 2000 U.S. Census

Map 11: Change in Population Density, 1990–2000



DENSITY CHANGE, 1990–2000 (PERSONS PER SQUARE MILE)

- Density <2,500 per Square Mile, Year 2000
- Decline
- No Change
- Increase 1 to 25%
- Increase 25 to 100%
- Increase Greater Than 100%
- U.S. Highways and Interstates

Data: 1990, 2000 U.S. Census

Source: Greater Phoenix 2100, Arizona State University

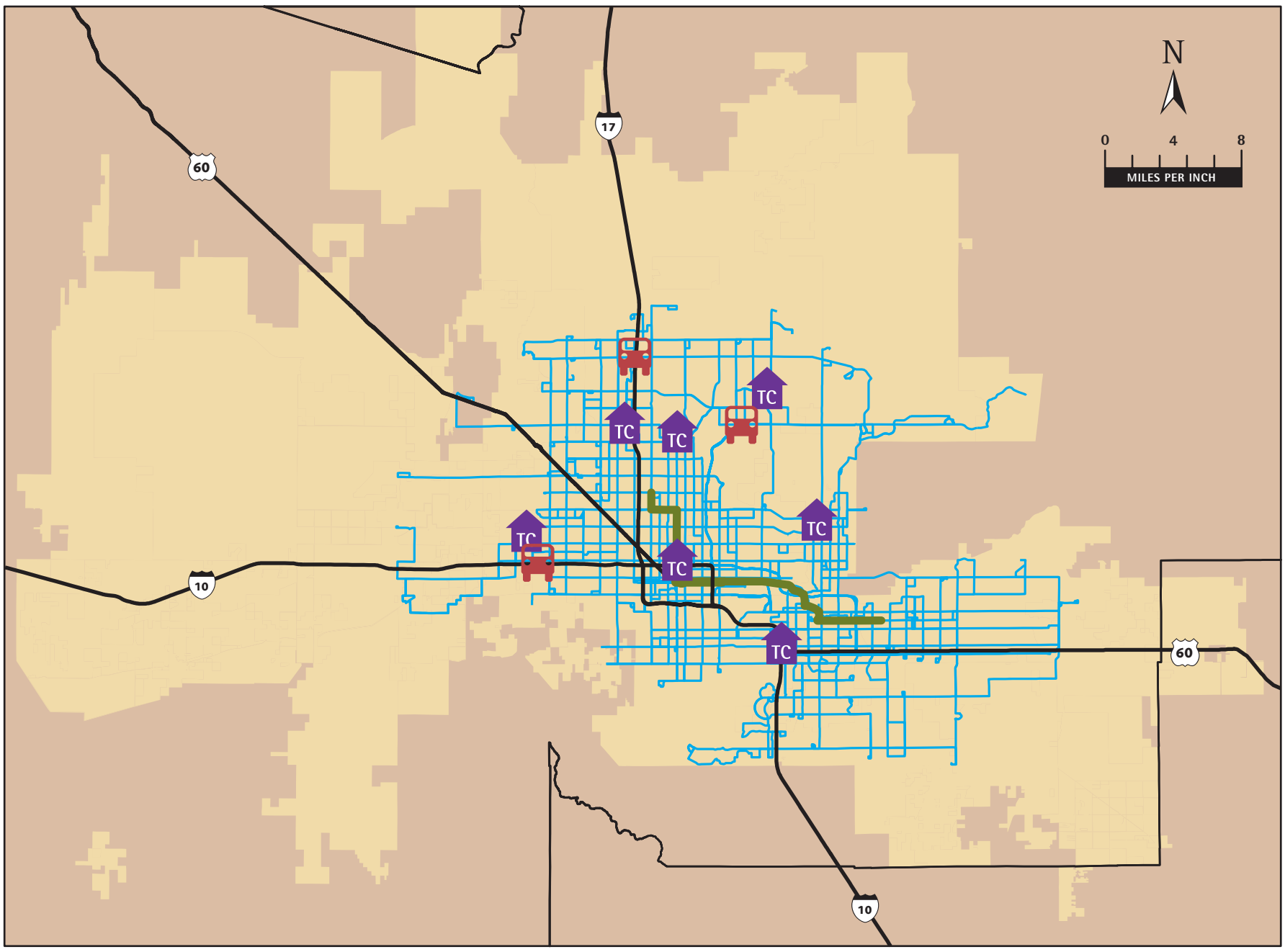
10,000 persons per square mile (medium brown on the map) can be found across the entire urban portion of the region.

The population density of the region, particularly the urbanized portions of the region, has been steadily increasing since 1960, a time when it was lower than that of many other major urban areas. Between 1960 and 2000, Greater Phoenix was consistently among the urbanized areas in the United States showing the greatest increase in population density. This can be attributed to three major trends: (1) an increase in the number and concentration of occupied multifamily dwelling units, (2) a decrease in the average lot size of single-family houses, and (3) an increase in residential infill development on parcels of land that had initially been skipped over.

The average density of Greater Phoenix increased by 45 percent between 1990 and 2000, from 153 to 222 persons per square mile. Much of this increase was a result of open desert land being converted to urban development, but even the higher density areas had significant increases. Between 1990 and 2000, the number of square miles with a density above 2,500 persons per square mile increased from 339 to 455. Not only did these high-density areas increase in number, they also become more dense. During this decade, the average density of these high-density areas increased 11 percent, from 4,750 to 5,264 persons per square mile. Map 11 shows areas in the urban portions of Greater Phoenix that increased or decreased in population density between 1990 and 2000. The areas with the highest change of over 100 percent increase (dark brown on the map) are at the urban fringe. These are areas that started out with a small population in 1990. Though they have experienced a decade's worth of growth, it will take some time before they reach a density sufficient to support transit. But there are some central areas (medium brown on the map) that experienced density increases from 25 percent to 100 percent. As these central areas increase in density, particularly along a common corridor, the efficiency of transit will increase and modes such as light rail will become practical.

Patriots Square Park, Phoenix

Map 12: Valley Metro Bus System and Future Light Rail System



Future Light Rail Line

Valley Metro Bus Routes

TC Transit Centers

Park and Ride

U.S. Highways and Interstates

Data: Valley Metro

Source: Greater Phoenix 2100, Arizona State University

Map 12 shows the extent of existing transit service, primarily the Valley Metro bus routes, in the urban portions of Greater Phoenix. Though several bus routes extend out to the urban fringe in some areas, the routes are at their densest in areas of high population density. Map 12 also shows the proposed light rail line, which will connect some of the denser areas of the urbanized region with some of the region's major employment areas, including downtown Phoenix, Sky Harbor Airport, downtown Tempe and Arizona State University.

Regional Transportation Planning

The Greater Phoenix region does not have a plan for the next 50 years of freeway construction. Several efforts are underway, including a plan called Vision 21 initiated by the Governor's office and a new regional transportation plan initiated by the Maricopa Association of Governments (MAG). One difficulty both of these efforts face is the extent of the region's boundaries as develop-

Proposed light rail near Bank One Ballpark, Phoenix

IN 2002, 87% OF COMMUTERS DROVE ALONE TO WORK AT LEAST ONE DAY A WEEK.

Source: TDM Annual Survey 2002

ment occurs. MAG is the metropolitan planning agency for Maricopa County and all its member agencies are within the county, with the exception of Apache Junction, Queen Creek and Peoria, which extend into Pinal and Yavapai counties. MAG is not authorized to plan facilities within Pinal or Yavapai counties, nor does it have any member agencies wholly within these counties. Yet, the development of Greater Phoenix in the next 50 years will almost certainly include large areas of these two adjacent counties.

Currently, there is no regional or state agency that provides coordination of transportation planning among the three counties. Recognizing the need to integrate transportation planning, MAG, in partnership with the Central Arizona Association of Governments (CAAG), has extended its data collection and planning efforts to include parts of Pinal County, even though it will not be able to adopt a plan for the area.

Information About Changing Trends

Changes in land use and demographics will be very important when planning for the next 50 years of transportation needs. Within the region, fringe cities are beginning to emerge, complicating work travel patterns. As baby boomers continue to age, the older portion of the region's population will become a larger percent of the total, and changes in its travel behavior will affect transportation needs. A larger percentage of the younger generation will be Hispanics, and their travel behavior is also likely to change. As the region grows, activities such as large venue entertainment will draw larger audiences to the city center. Furthermore, the Internet is changing how people shop, work and play. The impact of these technologies on travel is unclear.

The demand for information needed to understand these changes is high, but availability is low. The 2000 census results are providing some insight, but a more detailed analysis of the relationships between demographic trends and travel behavior is needed. ■

Water: Supply, Use and Quality

Our Water Legacy

Grady Gammage, Jr., *Author,* Phoenix in Perspective
Board Member, Central Arizona Project

For the last 50 years, water has been the thing we do best. In 2003 we are in the fifth year of record drought, but our lawns, swimming pools, and clean cars are largely unaffected. Since the Groundwater Management Act of 1980, groundwater pumping has been curtailed, and municipal and agricultural use has moved toward renewable supplies. Arizona's Colorado River allocation is now being fully utilized, thanks to creative "banking" of more than two million acre-feet for future use.

The maps show a progressive conversion of agricultural to urban use. Unlike California, we build new subdivisions where we used to farm. The interests of cities and farmers, therefore, have generally been in concert. But subdivisions and farms are fundamentally different. The water supply to people's houses cannot be easily curtailed. The long-held assumption that by converting to crops of houses instead of cotton we will have enough water for nearly endless growth will be severely tested if the drought continues.

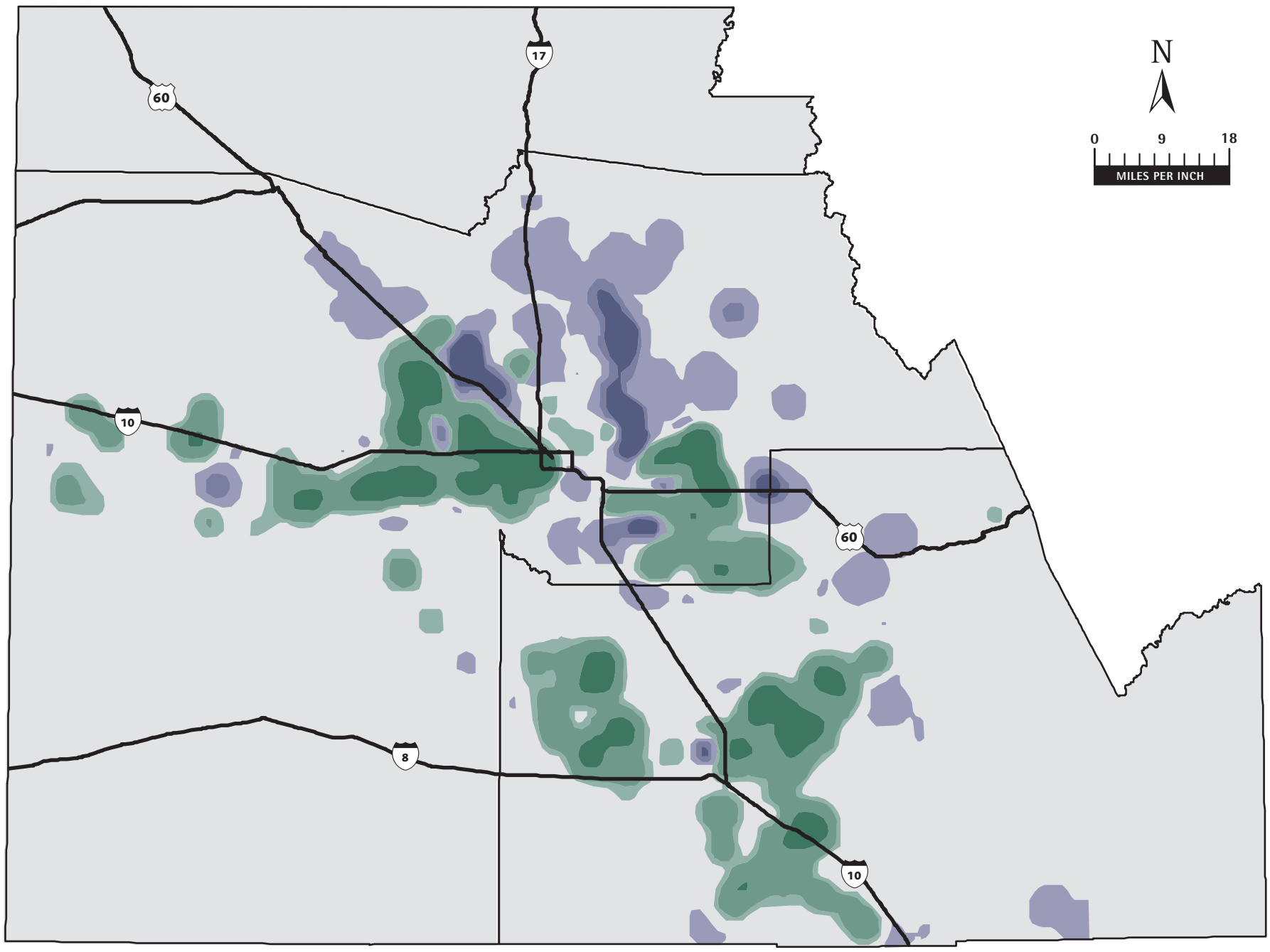
Pressures on groundwater are building. Future growth on the west side of Greater Phoenix will again require pumping. An imaginative mechanism called the Groundwater Replenishment District permits pumping for subdivisions if surface water is stored elsewhere. Nearly 100,000 lots have been laid out already using the replenishment district for "assurance," and at least 100,000 in the West Valley are in the pipeline.

Water has provided our clearest consensus: we need more than we have, and we will use all we can get. We do not want outsiders to think lack of water might stop our growth, and we do not want to debate future water resources too openly, for fear of being overheard. But the link is undeniable. We can only support a population for which we have an adequate water supply.

There is the challenge: in the next 50 years can water remain "the thing we do best"?

Above: Roosevelt Dam overflow, 1916, Gila County

Map 13: Predominant Use of Well Water (Groundwater), Agricultural and Residential, 1996–2000



USE OF WELL WATER FOR 1996–2000 (ACRE-FEET PER SQUARE MILE)

Residential
- 1–500
- 500–1,000
- 1,000–3,200
- 3,200–15,000
- No Data

Agricultural
- 1–500
- 500–1,000
- 1,000–3,200
- 3,200–15,000
- U.S. Highways and Interstates

ARIZONA DEPARTMENT OF WATER RESOURCES

Data: Arizona Department of Water Resources

Source: Greater Phoenix 2100, Arizona State University

Halfway between Phoenix and San Diego along Interstate 8, among the fields of hay and lettuce, is a sign that says, "Where water flows, food grows." If you added "and people go," the sign would tell the story of Greater Phoenix. In the 900 years between the Hohokam Indian culture and today's urban metropolis, man's management of water has been the key to survival in the Sonoran desert. Books like Marc Reisner's *Cadillac Desert* have chronicled the modern history of water supply development, which has been characterized with stories of vision, perseverance and massive construction projects – not to mention backroom politics, midnight raids and raging floods. The result for Greater Phoenix has been an abundant supply of water to meet the needs of both current residents and those who will inhabit the area in the coming decades. Yet, while supplies are abundant, they are not unlimited. During the next 50 years, it is possible that growth and increased demand for water will reach the limit of these resources. How water is managed will determine when the region reaches this point and what impact it will have on the region's economy and culture.

The Three Water Spigots

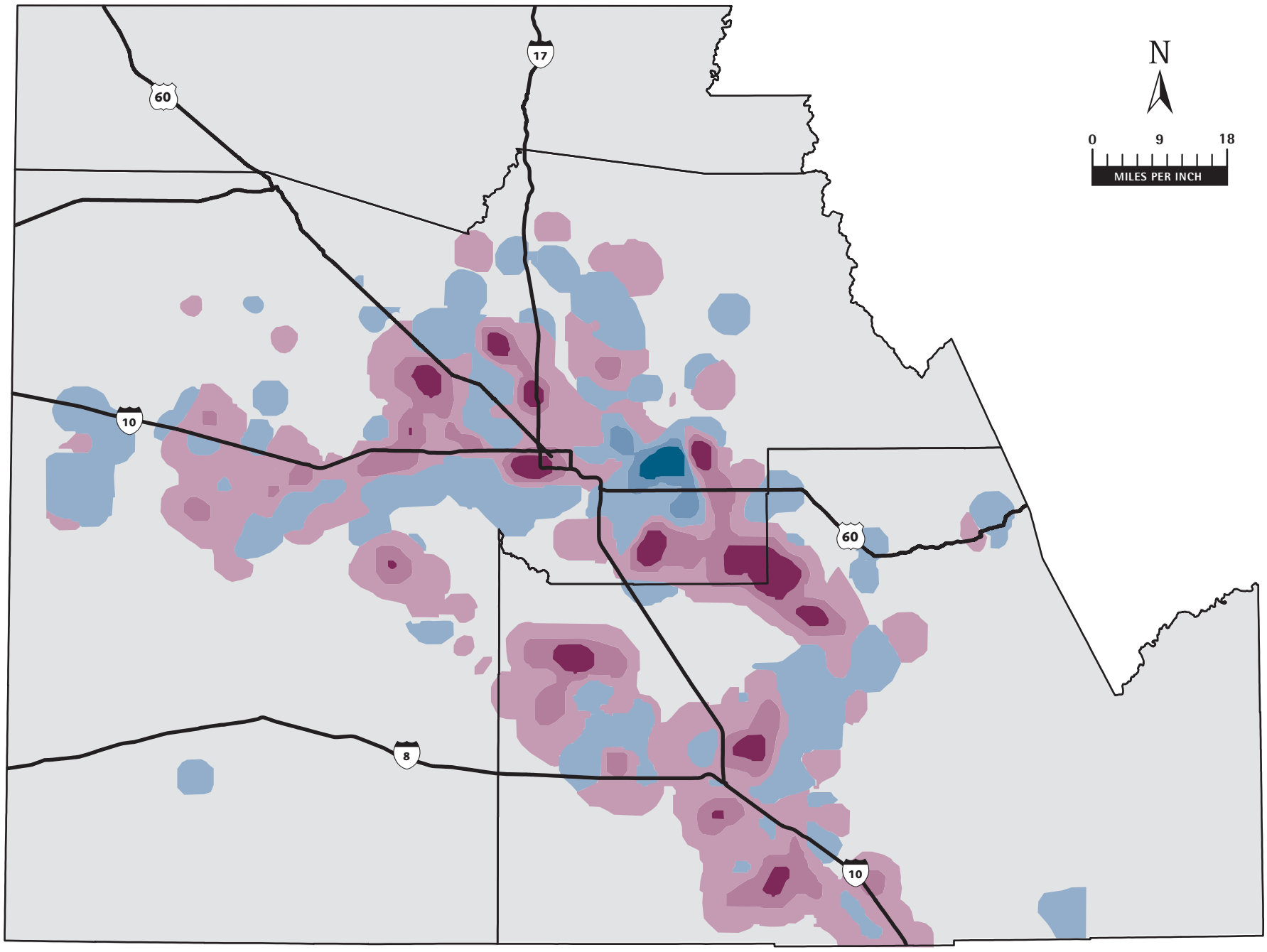
Today three major sources of water serve Greater Phoenix:

- Surface water from Arizona's Salt and Verde river systems, distributed by the Salt River Project (SRP)
- Local groundwater pumped using wells from the area's deep aquifer systems, and
- Colorado River water, delivered by the Central Arizona Project (CAP).

The oldest in use, regional surface water, was originally diverted from local rivers by the Hohokam Indians to irrigate their fields in the desert. Between 1902 and 1945, the surface water was contained by a massive federal government reclamation effort that constructed six dams along the two largest rivers, the Salt and Verde, which flow from the mountains to the north and northeast. Funding for construction came in the form of a loan, made possible by the National Reclamation Act of 1902. The loan was backed by collateral in the form of 200,000 acres of land pledged by local landowners. Today, SRP manages this system, but landowners within the SRP boundaries hold the rights to these surface waters.

Also in early use was the groundwater in the aquifers located beneath the region, which are replenished by rain and by the infiltration of surface water from irrigation and local rivers and washes. Substantial development of groundwater supplies began in the 1940s, with the emergence of efficient technology for drilling and pumping deep wells.

Map 14: Change in Volume of Well Water (Groundwater) Use, 1985–2000



CHANGE IN TOTAL 5-YEAR VOLUME BETWEEN 1985–1989 AND 1996–2000
(ACRE-FEET PER SQUARE MILE)

Increase
- 4,500 to 2,100
- 2,100 to 900
- 900 to 10
- No Data

Decrease
- -10 to -900
- -900 to -2,100
- -2,100 to -4,500
- U.S. Highways and Interstates

ARIZONA DEPARTMENT OF WATER RESOURCES

Data: Arizona Department of Water Resources

Source: Greater Phoenix 2100, Arizona State University

The most recent source is the Colorado River, the Southwest's largest watershed, which conveys water from the mountainous areas in northern Arizona, Nevada, Utah, Wyoming, New Mexico and Colorado. This water is transported over 160 miles from Lake Havasu to Greater Phoenix via the CAP canal. The 1.5 million acre-feet delivered annually by the CAP is a part of the 2.8 million acre-foot entitlement of Colorado River water. The canal, which first began carrying water in 1985, serves municipalities, agricultural users and Indian communities.

During the last decade, a new source has emerged: effluent from wastewater reclamation plants. Advancements in converting wastewater to high-quality water have created a new supply of "reclaimed" water that is beginning to be used for agriculture, cooling of power plants, irrigation of golf courses and parks, artificial lakes and as a primary source for restoring riparian habit along the region's river systems.

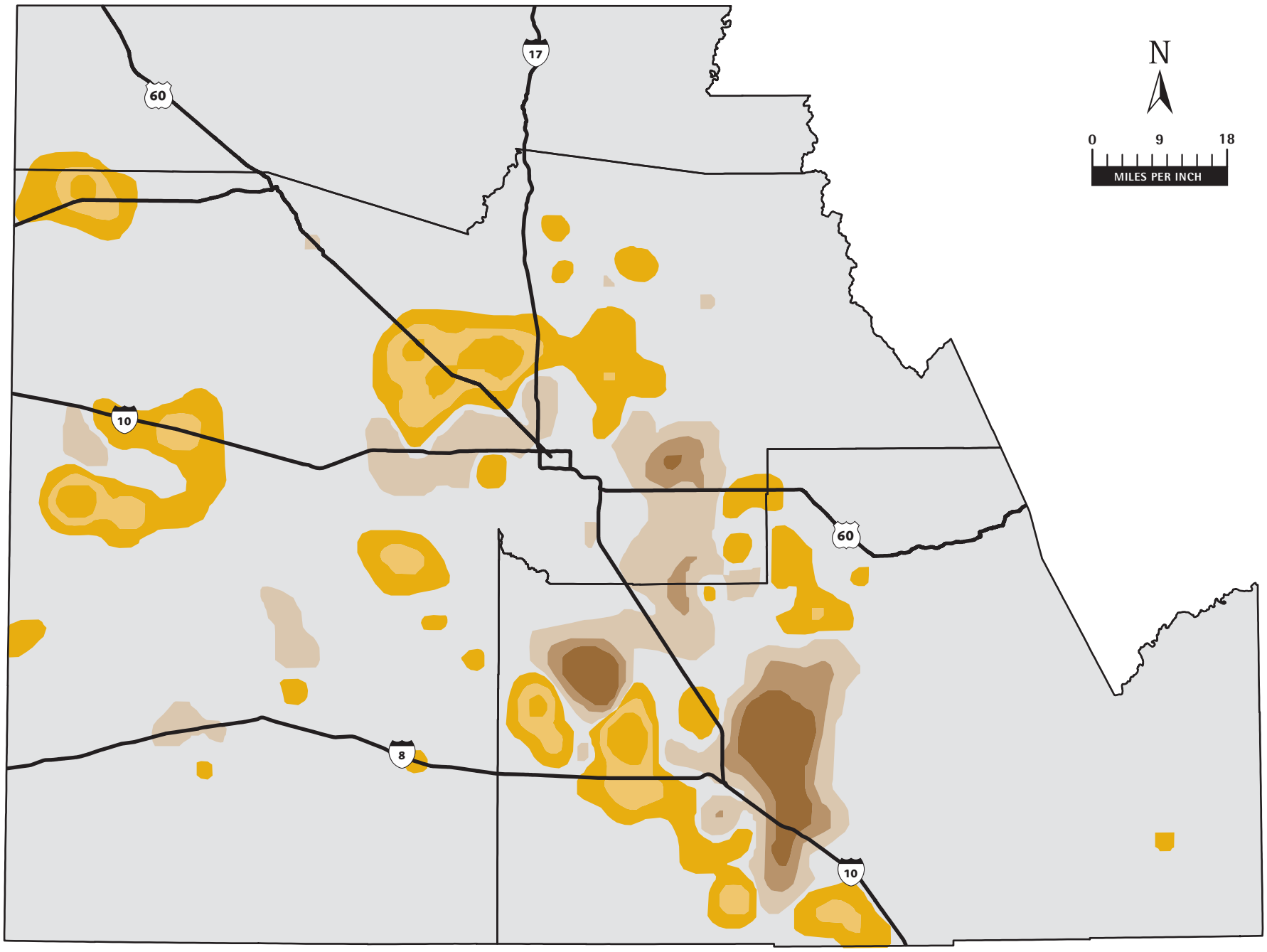
The communities in Greater Phoenix use these sources of water in varying amounts, with some dependent more on one than another. But in many parts of the region the current rate of use of groundwater may have serious implications for the future.

Will We Pump the Well Dry?

Over the past 50 years, groundwater in Greater Phoenix has been pumped out more rapidly than it is being replenished, creating a condition called "overdraft," characterized by declines in aquifer water levels. The right to use groundwater belongs to whomever owns the overlying land. Because wells often draw water from beneath neighboring lands and can pump aquifers dry, other users' access to groundwater can be affected, property damage can result from subsidence and riparian areas can suffer from a lowering of the water table. In 1980, the Groundwater Management Act established the Arizona Department of Water Resources, which regulates the groundwater used in five Active Management Areas (AMA) of the state where, historically, water levels had been dropping. Two of these, the Phoenix and Pinal AMAs, are in the greater Phoenix region. The new regulations allow existing wells to continue pumping, but severe restrictions have been placed on new large-capacity wells and new groundwater uses. The state closely monitors groundwater levels and maintains several regulatory tools to protect available groundwater supplies.

Map 13 shows significant areas of agricultural and residential groundwater use. Agricultural use of groundwater follows the historical pattern of irrigation in the central west, central east and southeast parts of the region. Residential, or potable, groundwater use varies throughout the region. While residential use does not follow existing urban patterns, parts of Scottsdale, Glendale, Sun City, Chandler and Apache Junction do show high use of groundwater.

Map 15: Change in Level of Groundwater, 1985–2000



CHANGE IN 5-YEAR AVERAGE WATER LEVEL 1985–1989 TO 1996–2000
(ACRE-FEET PER SQUARE MILE)

Decrease
- -230 to -100
- -100 to -50
- -50 to -10
- No Data

Increase
- 10 to 50
- 50 to 100
- 100 to 300
- U.S. Highways and Interstates

ARIZONA DEPARTMENT OF WATER RESOURCES

Data: Arizona Department of Water Resources

Source: Greater Phoenix 2100, Arizona State University

Since the introduction of CAP water into the region in the 1990s, there has been a decline in the use of groundwater. Map 14 shows the changes in patterns of historic use of groundwater for the region for two time periods, 1985–1989 and 1996–2000. Many of the irrigation districts and municipal water systems have begun to replace groundwater allocations with Colorado River water from the CAP and surface water from SRP. Today, areas of highest groundwater municipal use are in communities still relying on groundwater, such as Sun City, Scottsdale and rural communities.

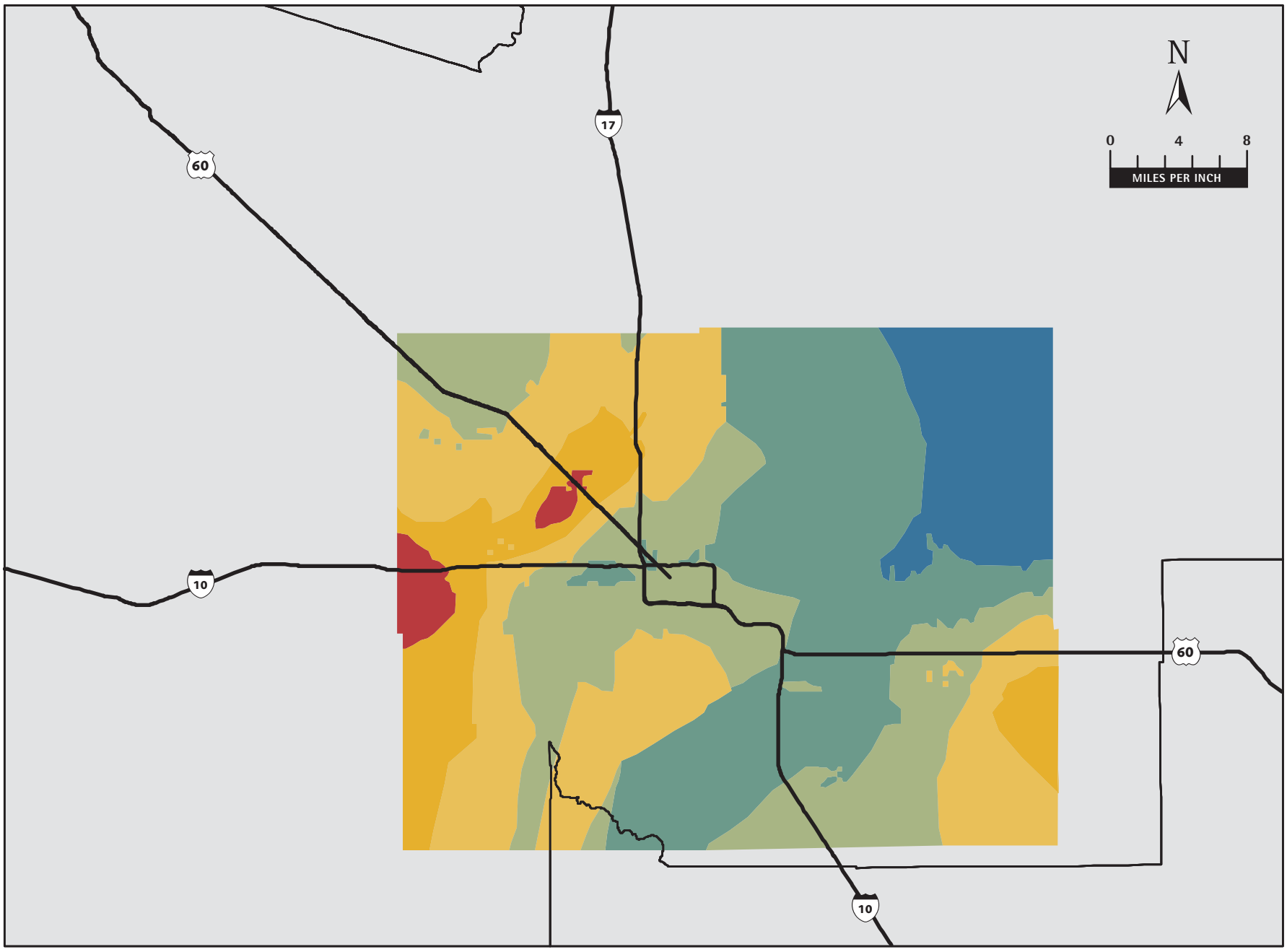
Groundwater will continue to play an important role in meeting future water demands, particularly in times of drought. It should be noted that some of the aquifers in the region are still experiencing water level declines, which may limit the future use of groundwater in these areas. Map 15, which shows changes in groundwater levels for the two time periods of 1985–1989 and 1996–2000, shows that areas near Sun City and Scottsdale are still experiencing declines. Management of surface and groundwater use in these areas will be important to meet existing and future water needs.

Groundwater Quality

Because Greater Phoenix is located in the arid Sonoran Desert, regional issues of water quality are different than in parts of the country where streams and rivers flow year-round. There, water quality issues focus on the contamination of water bodies such as streams, rivers and lakes from pollution sources in urban and agricultural areas. In Greater Phoenix, though, there are few rivers and washes with year-round water flow, and issues of water quality focus more on groundwater than surface water. Most of the surface waters within the region are considered ephemeral and experience flow only during flood events. The significant surface waters in the region – the

Drilling for water circa 1910, near Miami

Map 16: Concentrations of Nitrate in Well Water, 2001



NITRATE IN MG/L

- 1 - 3
- 3 - 6
- 6 - 10
- 10 - 15
- 15 - 20
- 20 - 25
- No Data
- U.S. Highways and Interstates

ARIZONA DEPARTMENT OF WATER RESOURCES

Data: Central Arizona–Phoenix Long-Term Ecological Research; Arizona Department of Water Resources

Source: Greater Phoenix 2100, Arizona State University

Verde, Salt and Gila rivers — are diverted and/or stored in reservoirs and then distributed via canals for agricultural and urban use. The San Pedro River in the eastern part of Pinal County is one exception. Because these waters are captured before they reach urban and agricultural areas, most of the runoff into these rivers is from natural flows. Their water quality is actively monitored and managed by the Salt River Project and other irrigation districts.

Groundwater is surface water that has filtered through the ground into the region's aquifers. Some of this water comes from urban and agricultural areas, where it picks up organic and inorganic materials that constitute many types of contamination. Contaminants can also enter groundwater from landfills, waste storage lagoons, chemical spills, leaking underground storage tanks, improperly managed hazardous waste sites, fertilizers and pesticides, sewage, animal waste and other sources. Serious health effects can result from such contamination, including cancer; liver, kidney, and nerve problems; and birth defects such as methemoglobinemia (an oxygen deficiency condition) in infants.

Nitrate is one such contaminant. Nitrate comes from nitrogen, a plant nutrient supplied by inorganic fertilizer and animal manure. It also can come from airborne nitrogen compounds given off by industry and automobiles and then deposited on the land in precipitation and dry particles. Other nonagricultural sources of nitrate include lawn fertilizers, septic systems and domestic animals in residential areas. Nitrates are soluble in water and can easily pass through soil

Arizona Falls circa 1890 (left) and current dam (right), Indian School Road and 56th Street, Phoenix

to the groundwater table, where they can persist for decades and accumulate to high levels as more nitrogen is applied to the land surface every year. Nitrate is one of the inorganic contaminants regulated by the 1974 federal Safe Drinking Water Act, which allows a maximum standard for nitrates of 10 mg per liter. Map 16, a survey of wells in Greater Phoenix, shows that most of the region complies with the federal standard (areas of green and blue), but in the agricultural areas to the west and southeast, concentrations of nitrate exceed the standard. In these areas, well water will need to be treated before it can be used for domestic consumption.

Water Information for the Region and Beyond

The geography of the region's surface water supplies extends far beyond the region presented in this Atlas. In an area with less than eight inches of annual rain, the watershed required to support an urban population needs to be either vast or in an altogether different climatic location. In the case of Greater Phoenix, both are true. The watershed of the Gila, Salt, and Colorado rivers covers much of the western United States. Maps showing the location of the rivers and reservoirs for this much larger region are necessary for a full understanding of the future water supply of Greater Phoenix.

Most of the surface water in the state today is used for agriculture irrigation, but this has been steadily changing as municipal areas grow and lands used for agricultural decline. Since agricultural land use generally consumes more water per acre than urban land use, the mapping of these trends will also be important in understanding the future of the region's water supplies.

While surface water is the largest supply of water to Greater Phoenix, groundwater is still very important for a variety of reasons. First, parts of the region have limited access to the delivery infrastructure of surface water supplies and therefore continue to rely on groundwater pumping. As these areas accommodate future growth, the hydrology and politics of water supply may become far more important to growth debates. Second, surface water supplies are affected more by drought conditions than groundwater and therefore groundwater can become a critical resource during drought conditions. Predicting when groundwater resources will be critically needed thus becomes important. Finally, there is an undeniable hydrologic link between ground and surface water, though Arizona law has for generations treated the two as unrelated. Water flow within the region's smaller perennial streams and rivers, such as Cave Creek Wash, New River and the Aqua Fria River, are heavily dependent on the level of regional groundwater. Pumping of groundwater, therefore, can have serious environmental impacts on the quality of open space and riparian habitat. ■

Air Quality

Air Quality and the Public's Health

Catherine R. Eden, *Director, Arizona Department of Health Services*

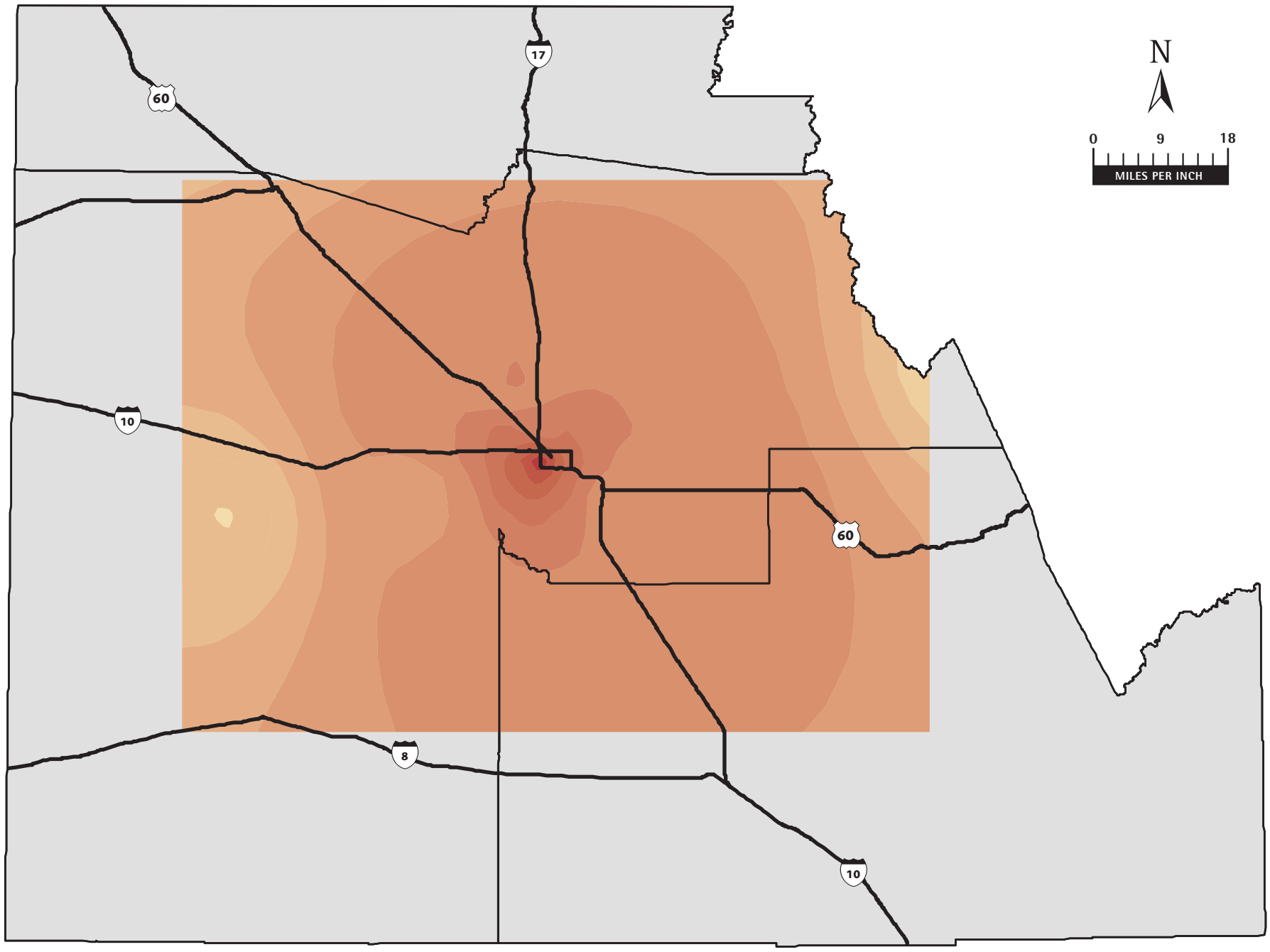
As many as seven out of ten Arizonans right now are breathing air that is unhealthy. Public health scientists consistently have shown that poor air quality causes many respiratory and cardiovascular illnesses. Prolonged exposure to the particulate levels found in Arizona's urban areas aggravates asthma and results in shortness of breath, pulmonary disease, decreases in lung function, increased rates of hospitalization, and premature death.

Considering these sobering facts, improving air quality is not just a good thing to do. It is a matter of life and death. A primary mission of the Arizona Department of Health Services is to provide the leadership to make Arizona a healthy place in which to live and work. Our Healthy Arizona 2010 Project embodies these ideals by identifying key public health issues that must be addressed for Arizonans to live healthier lives. It will come as no surprise that the primary Healthy Arizona 2010 environmental health objective is to improve the air quality in Arizona's urban areas.

Many public and private efforts are currently underway to improve air quality in Arizona, and significant progress has been made in recent years. But we still have a long, long way to go. Additional solutions will require innovative, integrated approaches that include the participation of the entire community. Only then will we be able to breathe easier.

Above: Pinnacle Peak, Scottsdale

Map 17: One-Year Average Concentrations of Fine ($PM_{2.5}$) Particulates, 2000



ONE-YEAR AVERAGE $PM_{2.5}$ CONCENTRATION (UG/M3)

- 5
- 6
- 7
- 8
- 9
- 10
- 11
- 12
- 13
- 14
- 15
- No Data
- U.S. Highways and Interstates

ADEQ Arizona Department of Environmental Quality

Data: Arizona Department of Environmental Quality

Source: Greater Phoenix 2100, Arizona State University

Over the last few years one of the most common complaints surrounding the growth of Greater Phoenix has been a perceived decline in the region's air quality. The air quality of the urbanized areas of Maricopa County is degraded by a variety of pollutants that affect health and visibility. The Environmental Protection Agency (EPA) gave the area a non-attainment rating of "serious" for carbon monoxide (CO) and particulates in 1996, and for ozone in 1997. Since the early 1970s, federal, state and local agencies have implemented a variety of programs to reduce these pollutants and since 1996 the region has not exceeded the national standards for CO or ozone. So why do people think air pollution it is getting worse? Most of these pollutants are actually invisible to the human eye. But an urban haze, commonly called the brown cloud, frequently hinders visibility in the greater Phoenix region. When most people refer to declining air quality, this visible brown cloud is what they mean.

The brown cloud is an elevated concentration of particulates, most of which come from the exhaust of motor vehicles that use fossil fuels. The brown cloud forms from the emission of small particles such as soot and dust, the conversion of gaseous emissions such as nitric oxide into particulate nitrate, and the conversion of gaseous hydrocarbons into particulate organic carbon. The finest of these particulates are known as $PM_{2.5}$, or particulate matter that is 2.5 micrometers and smaller in size. These are considered to be the principal cause of the region's decrease in visibility.

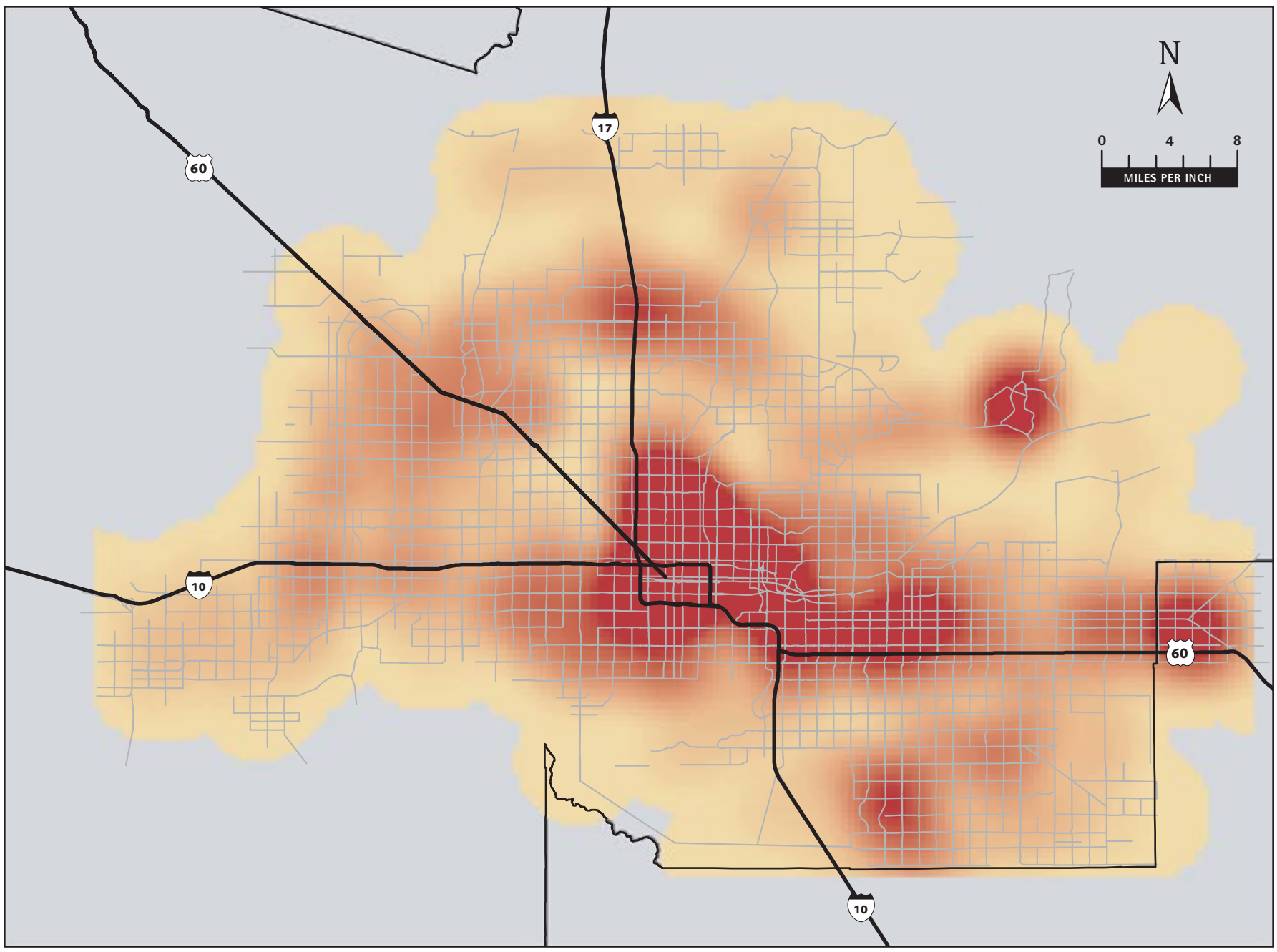
Map 17 depicts the daily average of $PM_{2.5}$ registered at monitoring sites in the year 2000. The contours are a result of sampling from more than 9 ambient air monitoring sites that are managed by state and county agencies. An average of greater than 15 micrograms per cubic meter is in excess of EPA's proposed standards. The map shows that $PM_{2.5}$ particulates are highest near the center of the region but also are measured at high levels in the north, east and south.

Automobiles are the Primary Source

Automobiles contribute to air pollution in two ways. The first is through the emission of gaseous and particulate pollution from the fuel combustion process: exhaust from vehicle engines fueled by gasoline and diesel contribute more than 65 percent of $PM_{2.5}$ in the region. The second is through the act of driving on paved and unpaved roads: as tires move along the roads, materials are broken down into smaller and smaller dust particles that linger in the atmosphere.

More automobiles are traveling the roads every year as a result of the tremendous growth that is occurring in the region. High traffic volumes appear throughout the valley, particularly surrounding employment centers. Map 18 shows the concentration of traffic volume within the urbanized

Map 18: Traffic Volume Concentrations, 2000



VEHICLE TRIPS PER DAY PER SQUARE MILE CONCENTRATION

Low — High

No Data

U.S. Highways and Interstates

MARICOPA ASSOCIATION of GOVERNMENTS

Data: Maricopa Association of Governments

Source: Greater Phoenix 2100, Arizona State University

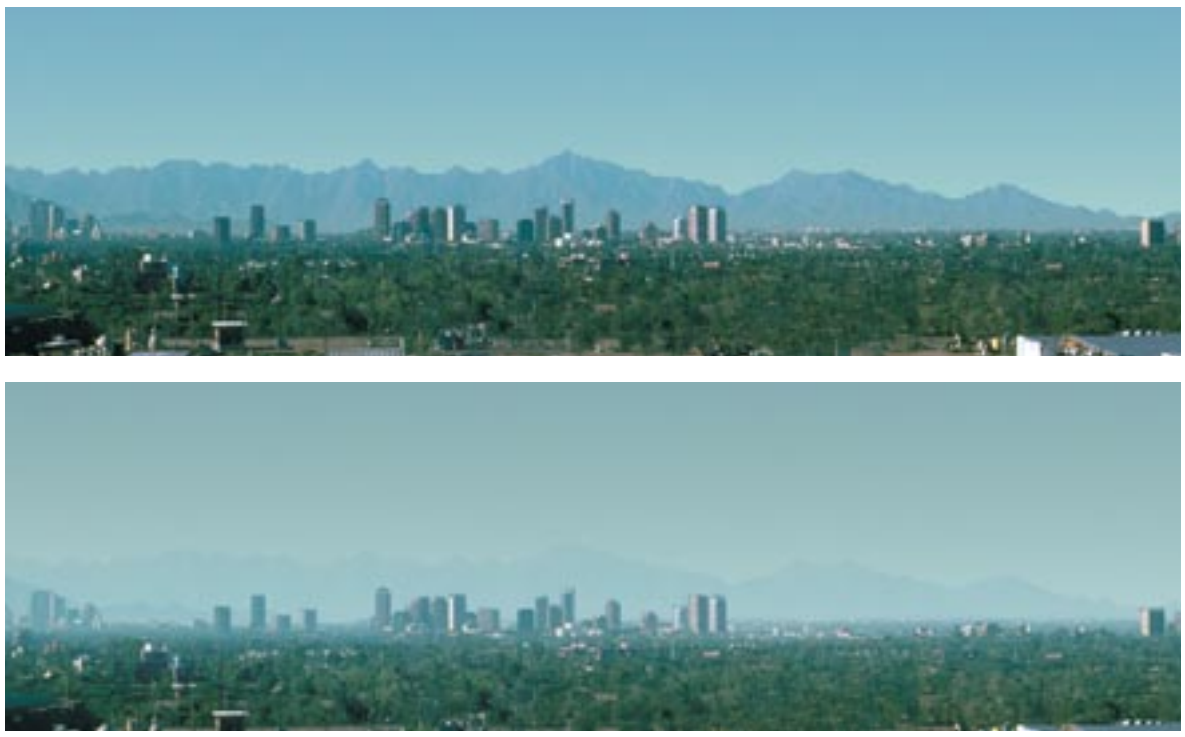
portions of the Phoenix region. Generally, the areas where volumes are the highest are areas around the region's primary employment centers.

On February 10, 2000, the EPA published Tier 2 motor vehicle engine standards and gasoline sulfur controls. On January 18, 2001, the EPA published heavy-duty engine and vehicle standards and highway diesel fuel controls. These new standards will significantly reduce vehicle emissions, including those contributing to the brown cloud.

Policy Response to Brown Cloud

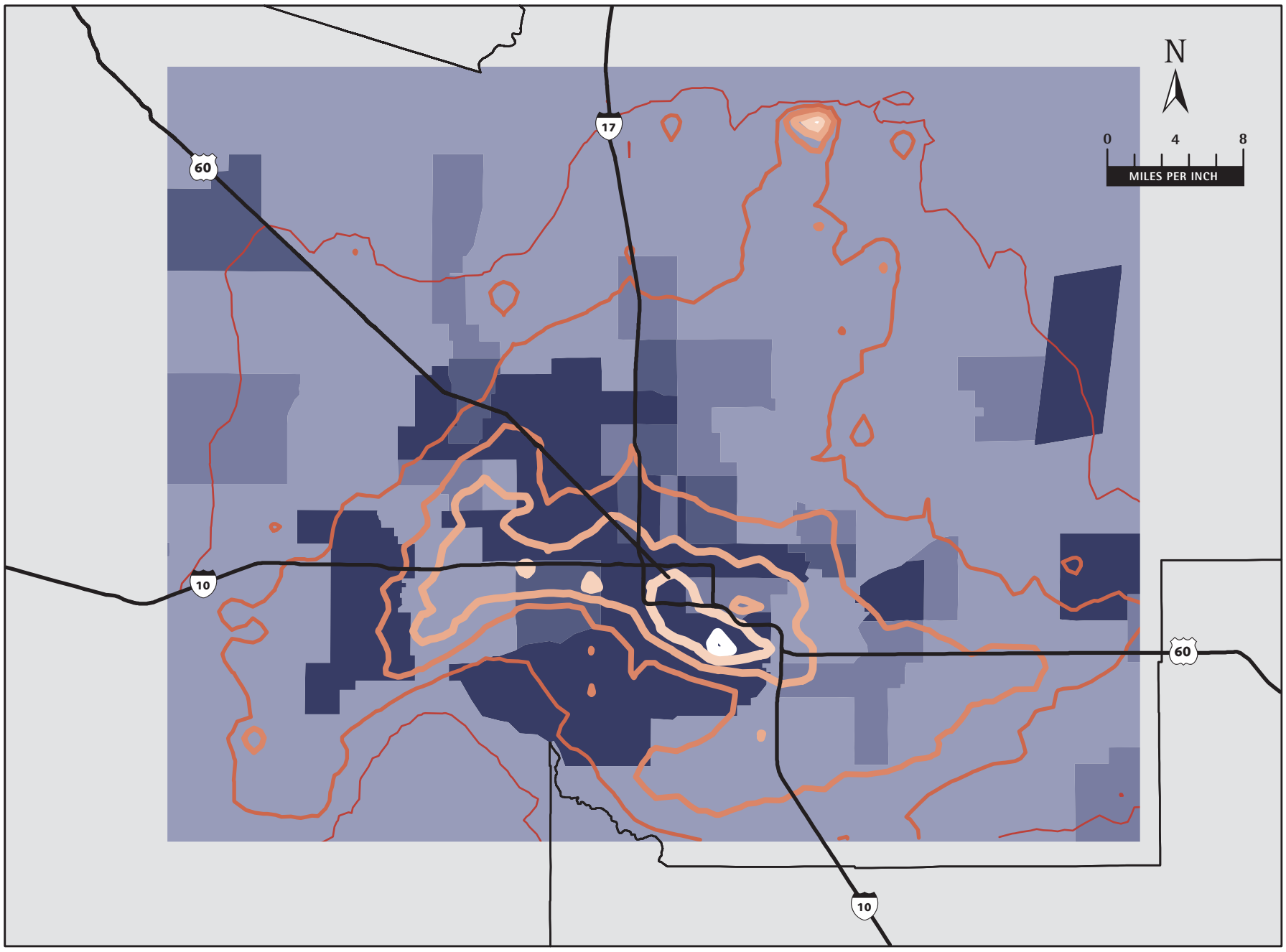
In 2000, Governor Jane Hull signed an executive order to establish the Brown Cloud Summit, recognizing visibility pollution as a major concern for the region. Goals were established to identify and reduce causes for visibility pollution.

In January of 2001, the Summit's final report confirmed that visibility in the region is getting



Average best and worst day visibility, view of downtown Phoenix looking southwest towards Estrella Mountains

Map 19: Hospital Asthma Discharges, 1999, and Concentrations of Coarse (PM_{10}) Particulates, 2000



INDIVIDUALS ADMITTED TO NON-FEDERAL HEALTH FACILITIES AND DISCHARGED WITH PRIMARY DIAGNOSIS OF ASTHMA, AS A PERCENT OF TOTAL POPULATION

(ug/m^3)

Low

High

Maximum 24-hour Average PM_{10} Particulate Concentrations

30 90

50 110

70 130

No Data

U.S. Highways and Interstates

Arizona Department of Health Services

ADEQ Arizona Department of Environmental Quality

Data: Arizona Department of Health Services; Arizona Department of Environmental Quality

Source: Greater Phoenix 2100, Arizona State University

worse. The report cited the results of a four-year study that showed that the days with the best visibility became progressively dirtier, by 64 percent, over the course of that period. The days with the worst visibility increased by 10 percent over the same time period. As a result of these findings, several pollution control measures were implemented, including restrictions on diesel engine idling and accelerated purchases of equipment that is in compliance with federal emissions standards. A Blue Sky Target Days program was instituted that created a visibility index for Greater Phoenix. A Blue Sky Day is one during which visibility averages 25 miles or more.

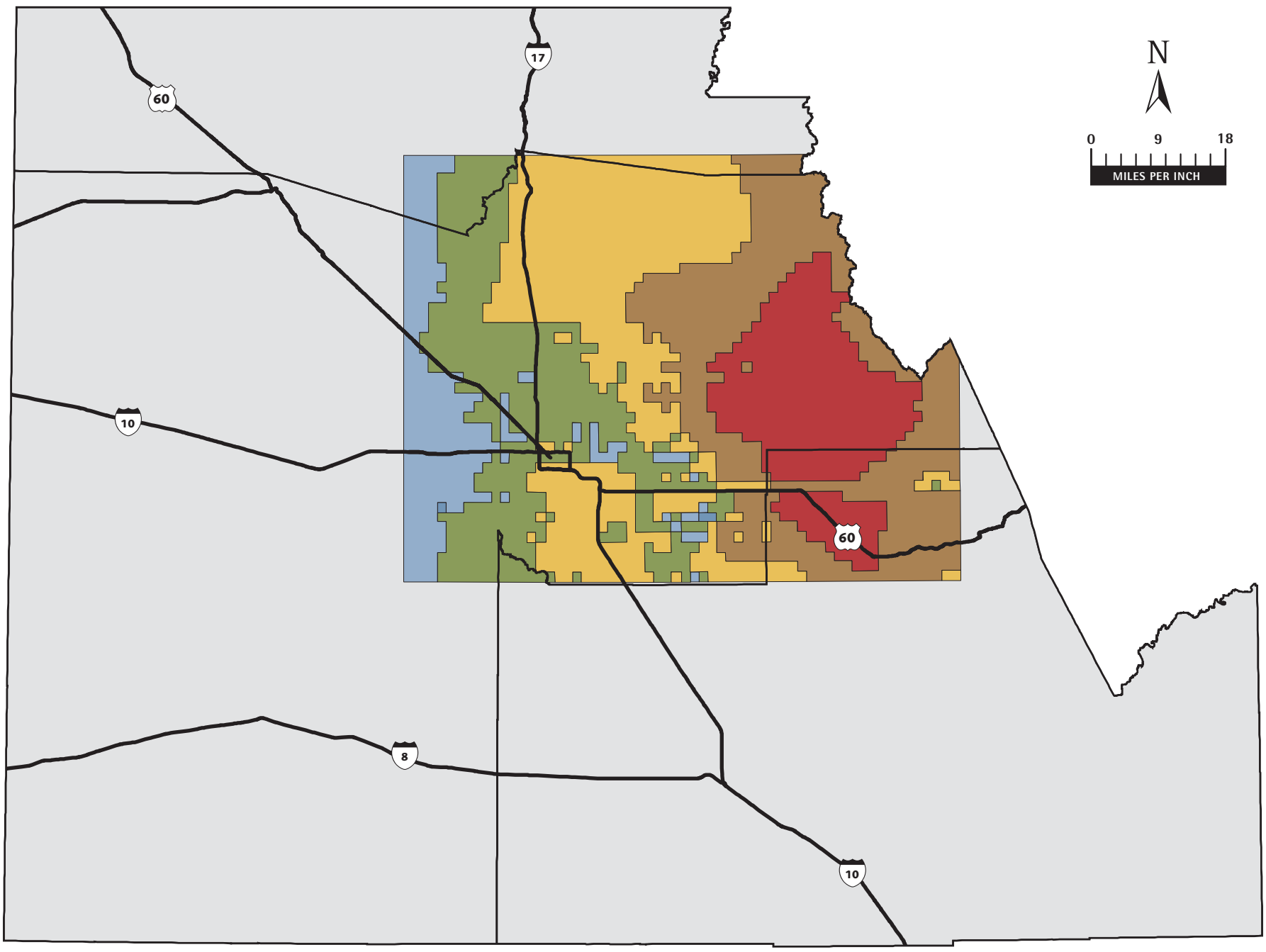
Health Concerns

While efforts have been made to combat air pollutants, they remain a health concern for Greater Phoenix. Pollutants such as sulfur dioxide, lead, ozone, nitrogen dioxide, carbon monoxide and particulate matter have been cited as contributing to decreased lung function, infections and increased mortality rates. In the Greater Phoenix region, particulates and ozone are especially prevalent. The Environmental Protection Agency (EPA) has classified Phoenix as not in attainment of EPA standards for carbon monoxide and particulates (PM_{10}, which are particulates 10 microns in diameter and smaller). The American Lung Association, in its State of the Air 2002 report of the worst 25 metro areas for ozone pollution, ranks the Phoenix/Mesa metropolitan area twelfth.

Particulates come in different sizes. PM_{10}, particulates or coarse particulates less than 10 microns in diameter, affect humans by accumulating in the upper respiratory tract. PM_{10} is thought to contribute to chronic bronchitis, decreased lung function, coughing, painful breathing and premature death. A study completed in 1995 identified more than 650 premature

Desert Samaritan Medical Center, Mesa

Map 20: 24-Hour Worst Case Ozone Saturation



MODELED OZONE CONCENTRATIONS BASED ON CONDITIONS OF JULY 26, 1996, 2:00 pm (PPMV)

- 0.025–0.038 Lowest
- 0.038–0.05
- 0.05–0.063
- 0.063–0.075
- 0.075–0.087
- 0.087–0.10 Highest
- No Data
- U.S. Highways and Interstates

ASU Arizona State University

Data: Environmental Fluid Dynamics, Arizona State University

Source: Greater Phoenix 2100, Arizona State University

deaths in Maricopa County as being the result of exposure to PM_{10}. Direct sources of PM_{10} are smokestacks and automobiles; indirect sources are vehicles traveling on paved and unpaved roads, materials handling, crushing and grinding operations and windblown dust.

Sites throughout the region monitor annual PM_{10} concentrations (Map 19). An average of more than 50 micrograms per cubic meter (ug/m^3) is out of compliance with the air quality standards. According to the mapped readings, south Phoenix and the southeast valley have the highest levels of PM_{10}.

Distributions of PM_{10} concentrations across a large metropolitan area often show small localized areas of elevated concentrations. These areas are indicators of nearby emitting sources that do not generally disperse evenly across a geographic range. Nonetheless, a general gradient of PM_{10} does prevail throughout metropolitan Phoenix, with the highest concentrations in the center of the urban area, tapering off to near background values at the far fringe. Many of the areas with high PM_{10} concentrations also have a high number of asthma patients. 1999 figures show that patients admitted to non-federal health facilities and discharged with a primary diagnosis of asthma are clustered in the central Phoenix region (Map 19).

Ozone is another pollutant that can have adverse health effects. Ozone occurs naturally in the stratosphere and provides a protective layer 10 to 30 miles above the earth. Ozone at ground level, however, is created by a chemical reaction between the oxides of nitrogen and volatile organic compounds that are found in motor vehicle exhaust, industrial emissions, gasoline vapors and chemical solvents. When exposed to sunlight and hot weather, these chemicals cause ground-level ozone to form in harmful concentrations. As

Gambel's Quail (Callipepla gambelii)

Interstate 10 on-ramp at 7th Street, Phoenix

a result, it is known as a summertime air pollutant. Many urban areas tend to have high levels of ozone, but rural areas are also affected because wind carries ozone and the pollutants that form it hundreds of miles away from their original source. Maricopa County, though currently listed as a non-attainment area for ozone, has not had a federal ozone violation since 1997. Ozone concentrations are monitored at various times of day. Data collected at 2:00 pm on July 26, 1996, show estimated concentrations of ozone across the region (Map 20). Areas of red, on the eastern edge of the greater Phoenix area, have higher concentrations than areas in blue, though this snapshot does not tell the whole story. Ozone concentrations in any single place can vary widely during the day according to the time when car emissions reach their peak and wind patterns move the ozone throughout the valley.

Breathing ozone concentrations of 0.12 ppm can irritate the respiratory tract and impair lung function, causing coughing, shortness of breath and chest pain. Heavy exercise can bring on symptoms at lower ozone levels of 0.08 ppm. Evidence also suggests that ozone exposure lowers the body's defenses, increasing susceptibility to respiratory infections.

Though there have been national studies on the impacts of air pollution on health, relating health to air quality in the greater Phoenix region is limited by available data. The Arizona Department of Health Services collects data from various public and private health institutions, but the Department's resources to analyze these data and provide them in a form that can be mapped are limited. Also, though the Arizona Department of Environmental Quality is able to map a variety of air quality parameters in the more urban areas of the region, its monitoring network is limited in the expanding parts of Maricopa and Pinal counties. In the future, as both agencies are able to provide more regional data, further analysis of health and air quality will be possible. ■

Pollen and Allergies

Richer Information for Better Health Decisions

Raymond L. Woosley, *Vice President for Health Sciences, The University of Arizona*

Like nearly everyone in the U.S., Arizonans are concerned about their personal health and healthcare. On the one hand, they are troubled by the possibility of not getting sufficient care to maintain or improve their health. On the other hand, many worry about the potential negative consequences of medical mistakes or poor quality care. Clearly, our finite ability to provide healthcare means that we must find better ways to deal with residents' personal health concerns and the significant economic costs health problems present to our state.

These maps illustrate a promising strategy for solving some healthcare problems and preventing others, namely better information from a richer combination of innovative sources.

Just think:

- What if citizens considered the flow of air pollution when they voted on an air quality initiative?
- What if parents selected a school for an asthmatic child based on where pollen counts are lowest in their community?
- What if environmental changes and the effects of urban development informed our investments in healthcare?

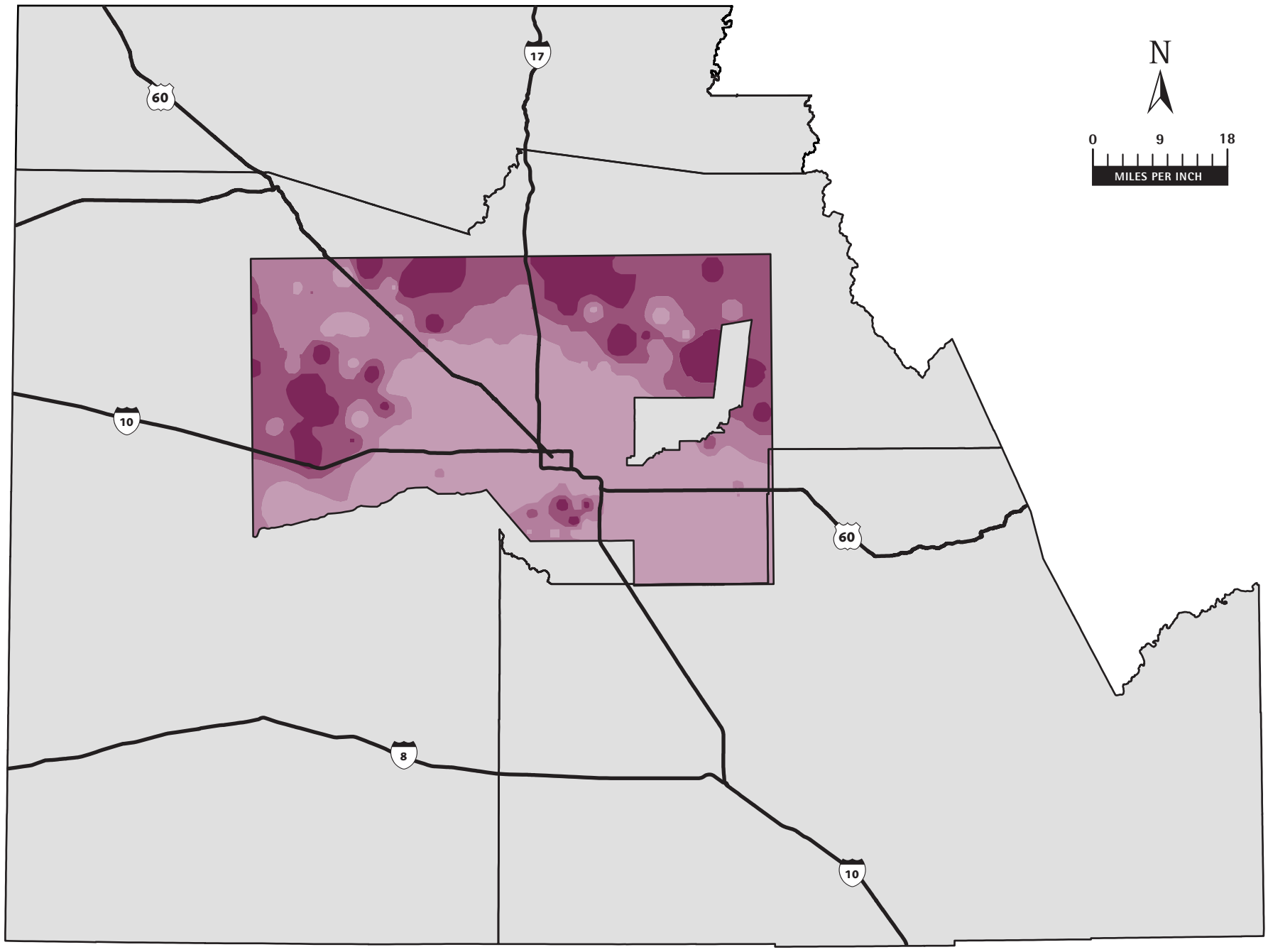
Until recently, we used relatively crude approaches to gathering and interpreting health data. For example, we often assume that all people will respond similarly to air quality changes. We have learned, though, that this ignores the population's genetic diversity. Likewise, we now know that there are differences in air quality that can be characterized on a large scale, but with a great deal of local precision. Combining such air quality measurements with predictions of health outcomes based on genetic biodiversity has the potential to individualize healthcare decisions on a macro scale.

This Atlas clearly shows how much new information could affect individuals' choices on the healthiest places to live, scientists' investigations of the causes and cures of increasingly prevalent diseases such as asthma, and policy makers' decisions on healthcare budgets.

Admittedly healthcare is costly, but illness costs more, and healthcare dollars buy benefits for individuals and the state. Environmental research, protection, and restoration similarly require substantial funds, although they also yield a strong return. To do the most for individuals and Arizona, it makes sense to use modern tools of science to conduct research on health and the environment that will inform healthcare investments and foster healthy lifestyles. If Arizona chooses that path, the future will be different and our lives better for it.

Above: Mexican Gold Poppy (Eschscholtzia mexicana)

Map 21: Frequency of Ambrosia (Ragweed) Pollen, 2002



POLLEN FREQUENCY OF AMBROSIA (RAGWEED) COLLECTED 2002

- 0–15%
- 16–32%
- 33–49%
- 50–92%
- No Data
- U.S. Highways and Interstates

Data: Central Arizona–Phoenix Long-Term Ecological Research, Arizona State University

Source: Greater Phoenix 2100, Arizona State University

Allergic rhinitis, commonly called hay fever, is the body's immune system response to allergens such as pollen or mold. When some people inhale these allergens, their immune system triggers the release of histamines and other chemicals that cause sneezing, fluid in the eyes and nose, congestion and itchiness.

Pollen consists of the microscopic male cells of flowering plants that are necessary for plant fertilization. Pollen from plants with brightly colored flowers usually does not trigger allergies. These plants are dependent on animals and insects, such as bees, for distribution of their pollen, which is large and wet in order to stick to animal hairs and is not easily dispersed by wind. However, many trees, grasses and low-growing weeds have small, light, dry pollen that is well suited for dissemination over long distances by wind currents. These are the pollens that typically trigger allergy symptoms.

One common complaint heard from people new to Arizona is that they did not have allergies or their allergies were not as bad until they moved to the state. Pollen-producing plants that grow in the Sonoran Desert are often different from those in other regions of the country. An allergy can develop for the first time because of contact with pollen unique to the region. Also, the warm climate and absence of a hard freeze extends the allergy season to year-round. The warmer climate means many plants flower for longer periods and there are plants that flower more than once a year.

Some allergies are caused by species of plants introduced to this region from other parts of the country and world, such as Olive (Olea), White Mulberry (Morus), Russian Thistle (Salsola) and Bermuda grass (Cynodon dactylon). But Arizona has a wide variety of native plants that can cause allergies, including: Cottonwood (Populus fremontii), Mesquite (Prosopis), Desert Broom (Baccharis), Wing Scale (Atriplex canescens), Palo Verde (Cercidium) and Ragweed (Ambrosia).

Ragweed is one of the most common allergy-causing plants in the United States. Though ragweed pollen does not reach the same levels in the Sonoran Desert as in other parts of the country, there are over a dozen native species of ragweed in the region. Map 21, the distribution of ragweed pollen sampled in Greater Phoenix, shows that the higher pollen counts are in agricultural and desert areas and lower counts are in the more urban areas. Common Ragweed (Ambrosia artemisiifolia) can be found near ditches and cultivated fields and Canyon Ragweed (Ambrosia ambrosioides) can be found growing along desert washes and canyons. ■

Changing Demographics

Hispanics, Boomers, and Greater Phoenix

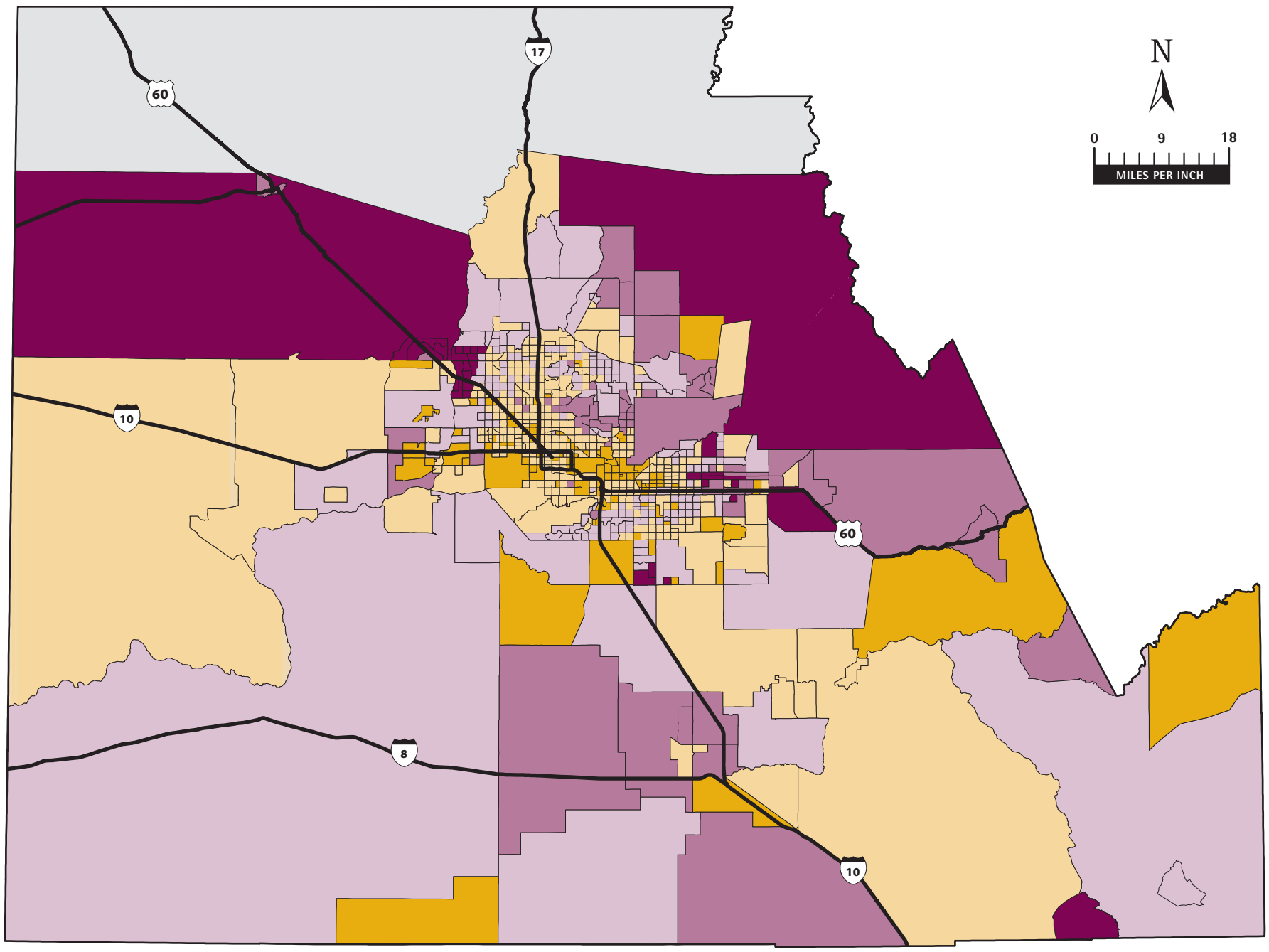
Congressman Ed Pastor, *Fourth Congressional District of Arizona*

Phoenix's human landscape has shifted dramatically over the past two decades. An influx of baby boomers and their families, together with a rapidly expanding Hispanic community, has created a dynamic southwestern metropolis where people want to pursue the American Dream. Together with their children, the boomers make up 57 percent of the Phoenix population and bring valuable skills and ideas to our community. The number of Hispanic residents doubled between 1990 and 2000, contributing a youthful energy that evokes the region's proud heritage.

Phoenix has benefited economically and culturally from the rapid growth in these segments of the population. At the same time, providing quality schools, affordable housing, adequate water, efficient transportation, sufficient health care and high-tech job training to these same segments challenges governments. However, if we want to make the best use of our human resources now and be ready for the changes the future holds for these two dominant groups, we will need to master these and other issues. With the baby boomers moving towards retirement, our communities must be ready to understand and meet new health care and mobility needs. As our immigrant community grows, we must ensure access to the education and health care that help these new Americans to be productive in our economy.

The evolution of Phoenix from a small town to a lively metropolitan region continues step by step. Our commitment to facing the challenges of this change with foresight and flexibility must advance as well. With careful planning and dedication, Phoenix will remain a place where quality of life and opportunity attract people from all walks of life.

Map 22: General Age of Adults, 2000



AGE OF ADULTS

- More Than 50% Over 54 Years Old
- Mixed - Fewer Younger
- More Than 50% Baby Boomers
- Mixed - Fewer Older
- More Than 50% 21 to 34 Years Old
- No Data
- U.S. Highways and Interstates

Data: 2000 U.S. Census

Source: Greater Phoenix 2100, Arizona State University

In addition to experiencing rapid population growth, Greater Phoenix is experiencing rapid changes in the population's age and ethnicity. The changes in demographics will bring changes to the region's need for jobs, education and housing.

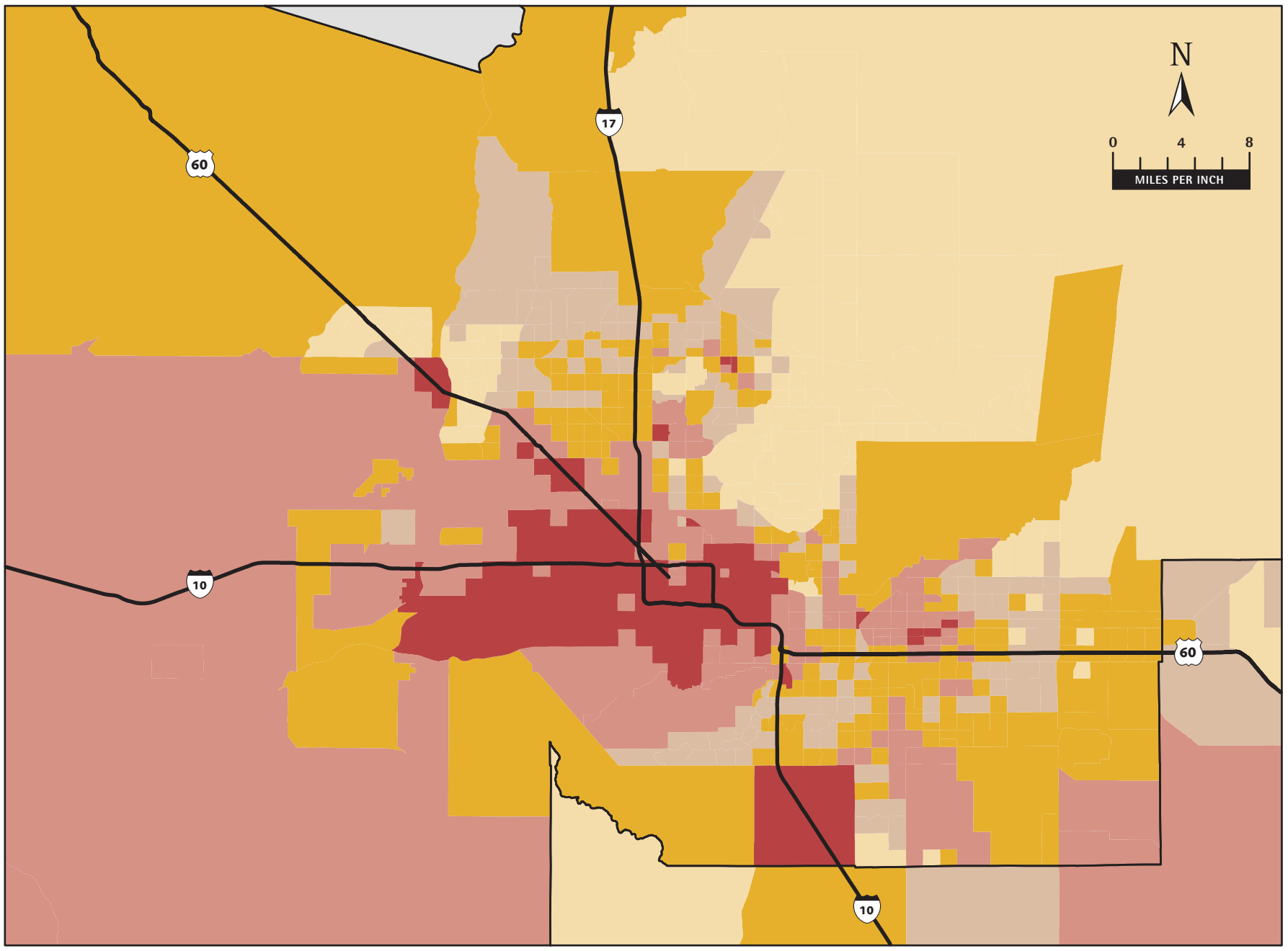
Baby Boomers and Their Shadow

For the past 40 years, baby boomers, born in the postwar expansion between 1945 and 1963, have been the largest age group in the United States. The movement of this group through time has created a bulge that has strained the social and economic institutions of each decade with its needs for hospital maternity wards, schools, colleges, jobs and housing. Representing 27 percent of the population in Greater Phoenix, baby boomers, now in their forties and fifties, are approaching the retirement phase of their lives. Unlike previous retirement generations, Baby Boomers are healthier, more diverse, better educated, more informed, have greater political clout, live longer and have different desires about where they want to live when they retire.

During the 1980s, baby boomers who wanted to become homeowners faced a number of obstacles such as rising home prices and high interest rates. During the last ten years, however, they have been taking advantage of low interest rates and have flooded the homeownership market, making first-time home purchases, moving up to bigger homes and refinancing existing mortgages. According to an April 2002 survey of recent homebuyers by the National Association of Realtors and the National Association of Home Builders, 53 percent of the homebuyers were 45 years old or older. Many baby boomers now hold mortgages with 25 to 30 years remaining. But as baby boomers move towards retirement, and with the current loss of value in retirement investments, increasing bankruptcies and the lack of adequate retirement planning, some will no longer be able to afford their mortgage payments and still retire. Some choosing to retire will be seeking more affordable housing while others may choose to retire later, decisions that may change the demand for affordable housing.

Sun City

Map 23: Hispanic Population as Percent of Total Population, 2000



PERCENT HISPANIC POPULATION

- 0.0–5.0
- 5.1–10.0
- 10.1–20.0
- 20.1–50.0
- 50.1–100.0
- No Data
- U.S. Highways and Interstates

Data: 2000 U.S. Census

Source: Greater Phoenix 2100, Arizona State University

The 2000 census now confirms that baby boomers have a shadow. Another bulge, consisting of those under the age of 21, has appeared in the nation's age structure. In fact, in Greater Phoenix, this group is larger than the baby boomers, representing 30 percent of the region's population. This is a departure from the national trend: the nation's median age is 35, whereas the Phoenix region's is only 33.

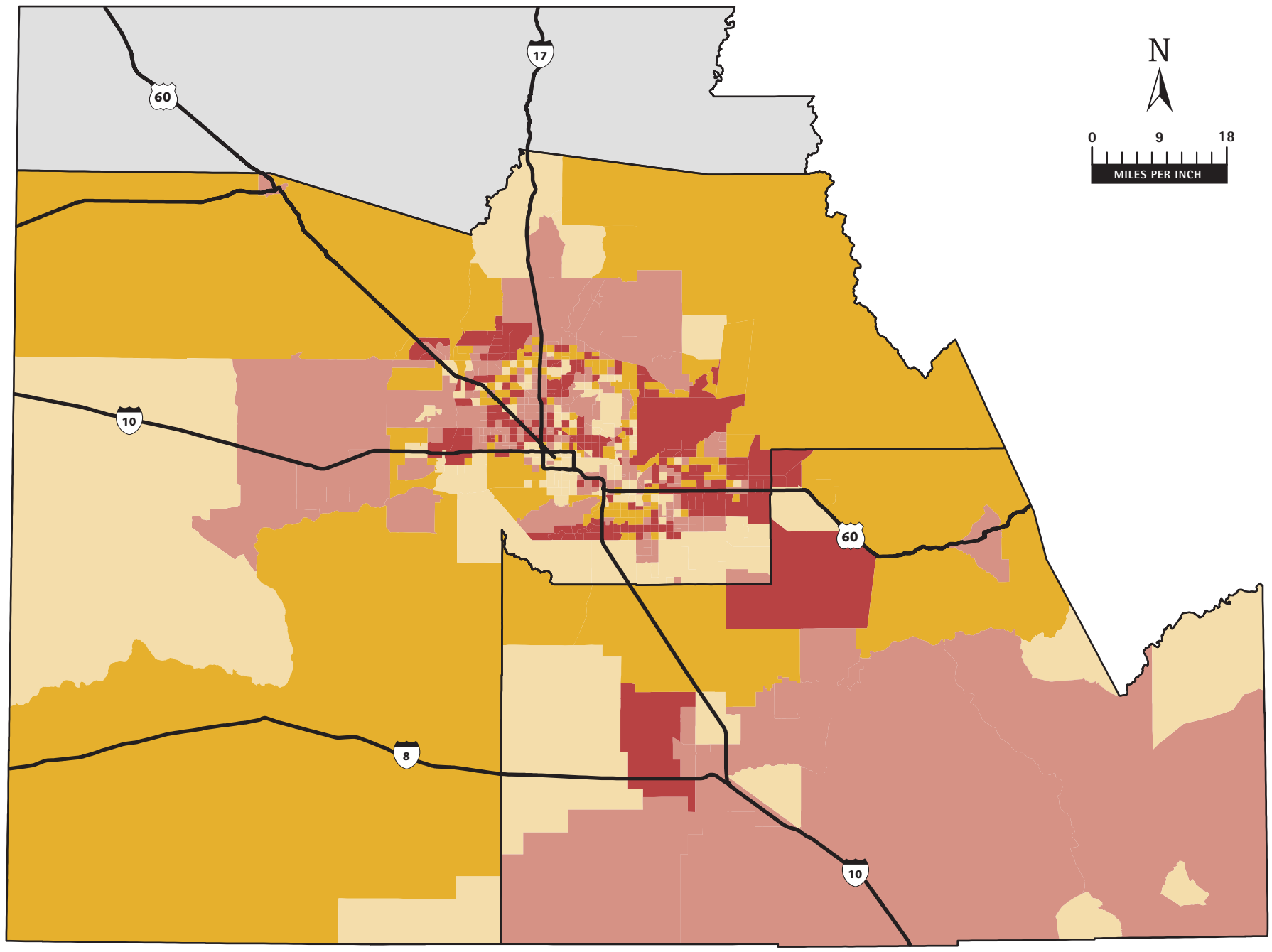
Map 22 characterizes the general age distribution of the population for Greater Phoenix based on the 2000 census. Baby boomers are more likely to be in the suburbs than in urban areas; those over 55 are more likely to be in areas of traditional retirement communities; and Generation X, those between 21 and 34, are more likely to be living in the central city locations. This distribution, however, is likely to change over the next few decades. As baby boomers become empty nesters and/or retire, they will no longer have a need for the good schools, big houses, short commutes and other suburban amenities they sought in their family-building days. Many have indicated in recent surveys that they would leave the Phoenix area if they could. Many baby boomers will seek to regain some of the values and amenities they did not have in the predominately suburban Phoenix region. Experts are predicting a nationwide exodus out of the suburbs. Following a growing national trend, some will seek a more urban lifestyle that includes quality housing within walking distance of a variety of dining, entertainment and retail options. Others will seek to escape declining air quality and increasing congestion and will look to high quality rural communities, larger acreage, fewer people and outdoor recreation opportunities such as golf.

The Growing Hispanic Population

Rapid growth in Hispanic population is a national trend. Between 1990 and 2000, the national Hispanic population increased by 57 percent, while the overall population grew by 13 percent. In Greater Phoenix, the growth in Hispanic population is more than double that of the nation. The Greater Phoenix Hispanic population increased 118 percent between 1990 and 2000, which is an annual growth rate of 8 percent. Considering the overall population of the region grew by 47 percent, the Hispanic population is growing at more than twice the rate of the general population. In fact, as of 1999, 25 percent of the region's population is Hispanic, up from 17 percent in 1990 and 14 percent in 1980. If these trends continue, 50 percent of the region's population will be Hispanic by 2020.

The growth in the Hispanic population has taken place both in the traditionally Hispanic neighborhoods of the region's inner cities and in rural agricultural communities. Map 23 shows the extent of areas that have a majority Hispanic population

Map 24: Change in Percent of Hispanic Population, 1980–2000



CUMULATIVE HISPANIC PERCENT POPULATION CHANGE 1980–1990 AND 1990–2000

- Less Than 100% Change for Both
- Greater Than 100% for 1980–1990
- Greater Than 100% for 1990–2000
- Greater Than 100% for Both
- Partial Tracts–Data Not Mapped
- U.S. Highways and Interstates

Data: 2000 U.S. Census

Source: Greater Phoenix 2100, Arizona State University

IN PHOENIX AND TUCSON MORE THAN HALF THE POPULATION UNDER 18 IS HISPANIC.

The Arizona Republic, 2002

Table 7: National and Regional Hispanic Demographics

	UNITED STATES			GREATER PHOENIX		
	1990	2000	Annual % Change	1990	2000	Annual % Change
Total Population (,000)	248,711	281,422	1.2%	2,200	3,252	4.0%
Hispanic / Latino (,000)	22,354	35,306	4.7%	374	817	8.1%
% Hispanic / Latino	9%	13%		17%	25%	

as based on 2000 census data. These areas are significantly expanded from 1990. In addition, from 1990 to 2000, almost 85 percent of the under-18 population growth was Hispanic.

Rapid growth in the Hispanic population is not confined just to these traditional areas. Map 24 shows the change in Hispanic population as a percent of total population from 1980 to 2000 for different parts of the region. Areas in dark yellow, light red and dark red have experienced a 100 percent or greater increase in their Hispanic population during this time frame. These areas are spread throughout the region, including the suburbs and the fringes of the urban areas.

The rapid growth in Hispanic population will continue to change the character of Greater Phoenix, contributing to a more vibrant cultural mix, but also presenting challenges in housing, transportation, employment and, most importantly, education. ■

Hispanic Education

An Alarm Meant for All of Us

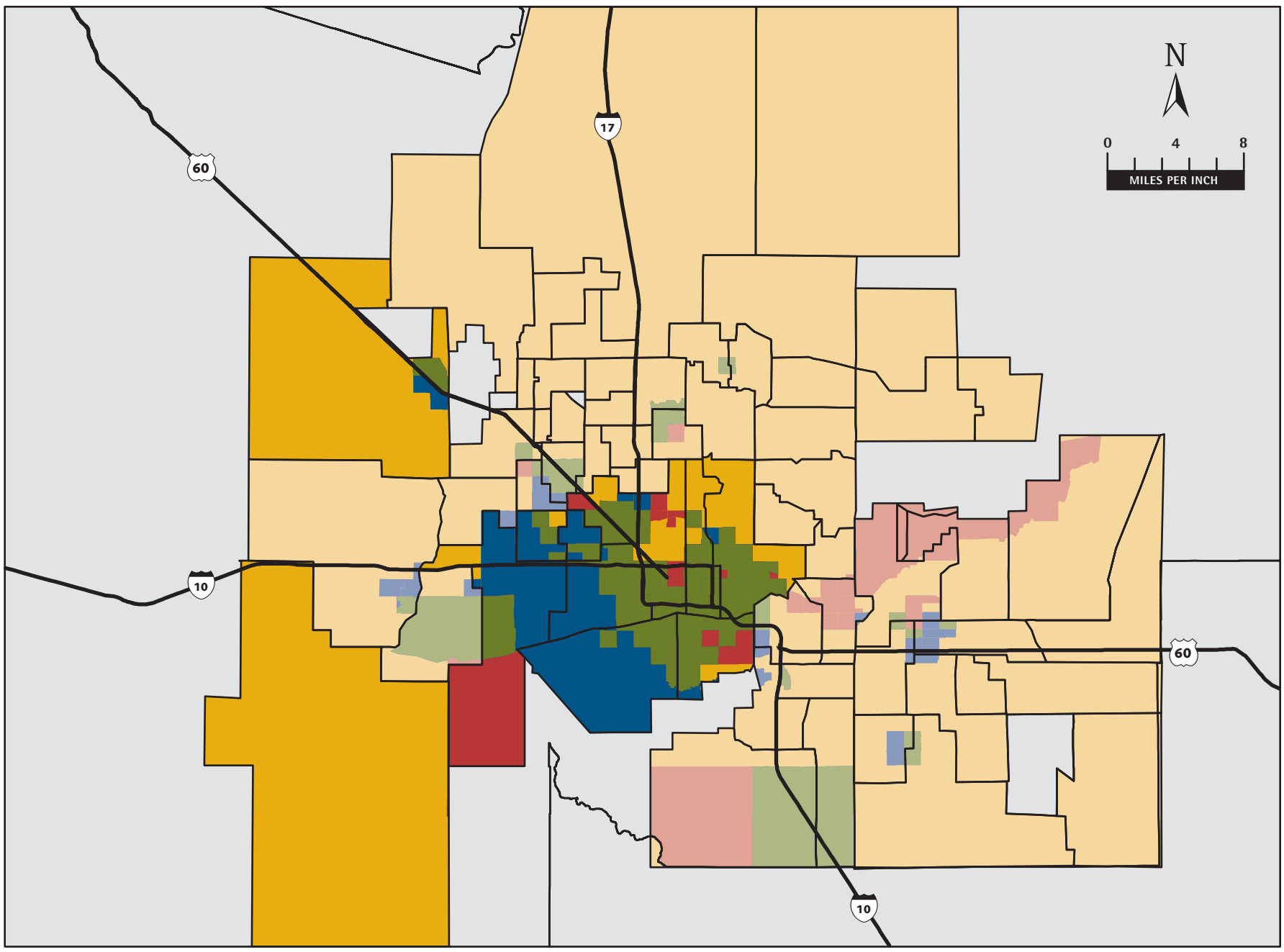
Dr. Carol G. Peck, *President/CEO, The Rodel Charitable Foundation of Arizona*
(Former Superintendent, Alhambra Elementary School District)

These maps sound an alarm that should be heard in every school, every business, every philanthropy, every public agency, and every postsecondary institution in Arizona. If we want to prevent the high costs of low achievement and benefit from all available talent, dramatic actions must be taken now. Throughout my 31 years of working in education, I have seen young people overcome poverty's effects repeatedly, but doing so takes more than wishful thinking. I recommend seven steps:

- Use significant incentives to attract the best and brightest educators to areas with the greatest needs. Implement quality preschool programs and all-day kindergarten (the most cost-effective methods of increasing student achievement) where they are needed most.
- Establish university-based Centers for Raising Achievement in neighborhoods where poverty robs children of opportunity. Publicly recognize and reward these areas' most successful educators and involve them in the Center. Assign interns and student teachers so that our best role models are training tomorrow's educators.
- Ensure that state-mandated curricula are taught in the appropriate grades in poor areas. Provide the extra time, materials, and incentives that will help all students to excel.
- Concentrate on educating highly mobile students. These children are often the lowest achievers because they miss so much and must adjust to a new school over and over.
- Take very young students to visit colleges and universities. Bring college students and recent graduates to schools to inspire everyone from preschoolers to 12th graders to teachers.
- Identify the schools where poor students excel. Ask educators there to share what they are doing and help others to follow their examples.

With Arizona's many needs, some will say we cannot afford to tackle the problems of high dropout rates and poverty. I can only respond that doing nothing will cost far more than making our communities and schools into places where every student can learn and achieve at high levels.

Map 25: AIMS Test Scores and Areas of Hispanic Persons and Poverty Households, 2000



School Attendance Boundaries
No Data
U.S. Highways and Interstates

2001 10TH GRADE AIMS TEST SCORES

	More Than 40% Scored Below the AIMS Standard	More Than 60% Scored At or Above the AIMS Standard
Not High Poverty or Hispanic		
Greater Than 20% Below Poverty		
Greater Than 40% Hispanic		
Greater Than 40% Hispanic and Greater Than 20% Below Poverty		

Maps & Facts℠ Mapping Services

Data: Arizona Department of Education; Maps & Facts Unlimited, Inc; 2000 U.S. Census

Source: Greater Phoenix 2100, Arizona State University

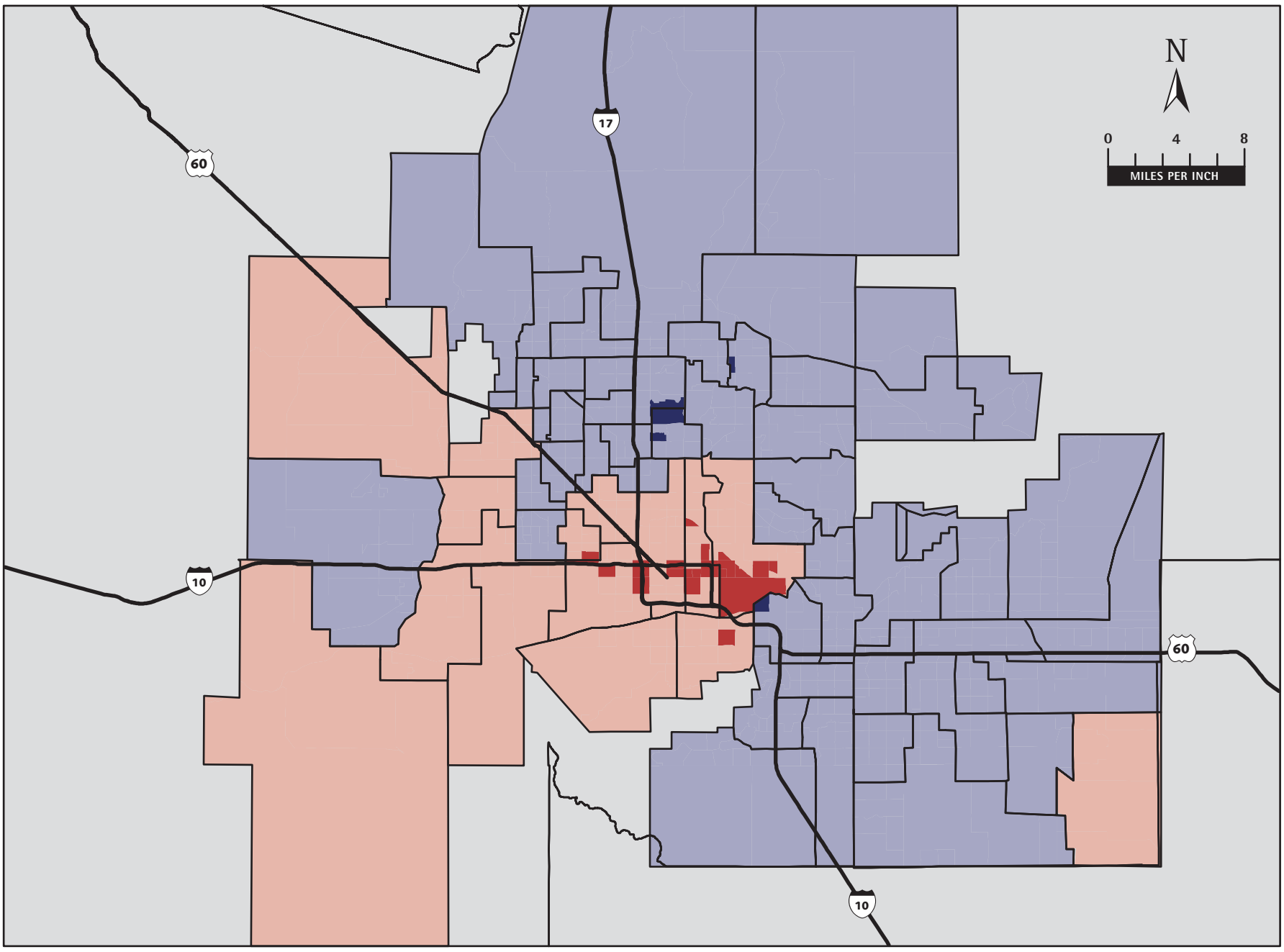
As Arizona moves into the 21st century, there is evidence that the educational achievement of its Hispanic population has not kept pace with that of other groups. A large number of today's Hispanic young people have not achieved success in the state's educational system and are unprepared to take part in the knowledge-based economy of coming decades. In 2000, while Hispanics made up 25 percent of the state's total population, the population of those 18 and under was 36 percent Hispanic. In Greater Phoenix, Hispanics make up half of the K–12 population, yet just 12 percent of the bachelor's degrees awarded from state universities in 2000 went to Hispanics. Lower education levels contribute to lower income: nationally, the income of Hispanic families is 40 percent below that of whites. Barriers created by poverty and language contribute to this imbalance.

Poverty as a Barrier to Educational Achievement

In 2000, 12 percent of the total population of Maricopa County lived in households with incomes below the poverty level. Among Hispanics, this rate was twice as high, with 24 percent of Maricopa County's Hispanic population living in poverty households. Poverty has been cited as one barrier to educational achievement among Hispanics. In order to examine this assertion, Map 25 uses 2000 census data to show the relationships between areas of poverty (defined as areas where the percent of households living in poverty was above 20 percent), areas with a high Hispanic population (defined as areas where the percent of Hispanic population exceeds 40 percent) and high school achievement as determined by the 2001 AIMS test scores of 10th graders. The lighter shade of each set of colors on the map indicates that 60 percent or more of the students in that high school scored at or above the AIMS State standard. The darker colors show high schools where more than 40 percent of the students scored below the state standard (less than 60 percent scored at or above the standard). The blues show areas with greater than 40 percent Hispanic population in 2000, the reds show areas where more than 20 percent of households were living in poverty and the greens show places with both high poverty and a large Hispanic population.

While below-average test scores can certainly be found in areas with less poverty and a lower Hispanic population (yellow), the high poverty and high Hispanic areas are usually associated with schools with below-average test scores. The dark green areas that are concentrated in the

Map 26: Children in Language-Isolated Households, 2000, and High School Dropout Rate, 2001



	Dropout Rate At or Below Average	Dropout Rate Above Average
Age 5–17 in Language-Isolated Households Less Than or Equal to 35%		
Age 5–17 in Language-Isolated Households Greater Than 35%		

High School Attendance Boundaries
No Data
U.S. Highways and Interstates

Maps & Facts℠ Mapping Services

Data: Arizona Department of Education; Maps & Facts Unlimited, Inc; 2000 U.S. Census

Source: Greater Phoenix 2100, Arizona State University

central portions of Phoenix show both high rates of poverty and a high Hispanic population. All of these areas are associated with schools experiencing below-average test scores.

Hispanic Dropout Rates and Language

Hispanics make up about 30 percent of Arizona's high school students but account for 42 percent of the state's dropouts. Mexican-Americans who are second generation, however, are much more likely to finish 12 years of schooling.

Delayed acquisition of English language skills has been suggested as one of the major factors in high dropout rates for Hispanics. Map 26 shows 2000 dropout rates for Greater Phoenix high schools. Red hues represent high dropout rates while the shades of purple indicate low rates. This map also shows areas where a higher number of families are language isolated. Language isolation means that no one over the age of 14 speaks English in the home. The darkest red and purple are areas where, based on the 2000 census, more than 35 percent of the children 5 to 17 years of age live in language-isolated households. The lighter colors are areas where fewer than 35 percent of the children live in language-isolated households. Again the positive correlation between high dropout rate and high percentage of children in language-isolated households shows the greater risk of dropping out for those who are language isolated. This is not to say that language isolation is the only factor related to high dropout rates. This map also shows that high dropout rates occur in areas where language isolation is not a major factor.

More Information About Students and Schools is Needed

In order to address the opportunities and obstacles faced by the region's Hispanics in the 21st century economy, more information is needed. But such information is not readily available. For instance, it is difficult to obtain information on demographics of students by school. This report has used census tract data to represent the demographic characteristics of school populations. It would be more accurate and useful to have that informa-

Yavapai Elementary School, Scottsdale

MORE THAN 4 OUT OF EVERY 10 LATINO STUDENTS WHO ENTER HIGH SCHOOL IN ARIZONA DO NOT GRADUATE, TWICE THE RATE OF ANGLO STUDENTS.

The Arizona Republic, 2002

tion by school population, which is currently not readily available in a database form.

One missing ingredient is a consolidated map of Pinal County's school attendance areas, including high schools, elementary and middle schools and school district boundaries. Because such a map was available for Maricopa but not for Pinal County, the relationship between census demographic data and Arizona Department of Education data could not be established.

A more comprehensive atlas would provide other indicators of success, such as high school graduation rate and continuation of education beyond high school. Additional measures of poverty, such as per capita income and unemployment, also would be included. Various other factors also may be associated with success in school. It may be instructive to consider whether students speak English at home, and, since second-generation Hispanics tend to complete 12 years of schooling, it would be useful to have maps showing how long people have lived in this country, when students started in the Arizona school system and what the student turnover rate is in schools. One complication in tracking students and estimating dropout rates is the high mobility of these at-risk students. These families move frequently and will switch schools, sometimes several times in one year. Tracking these students from school to school is currently not possible. Lastly, while some schools or school districts keep some of this information, there is no comprehensive source for the data for the region's schools as a whole. ■

Housing Affordability

Arizona's Quiet Crisis

Terry Goddard, *Arizona Attorney General*
(Former Director, U.S. Department of Housing and Urban Development, Arizona State Office)

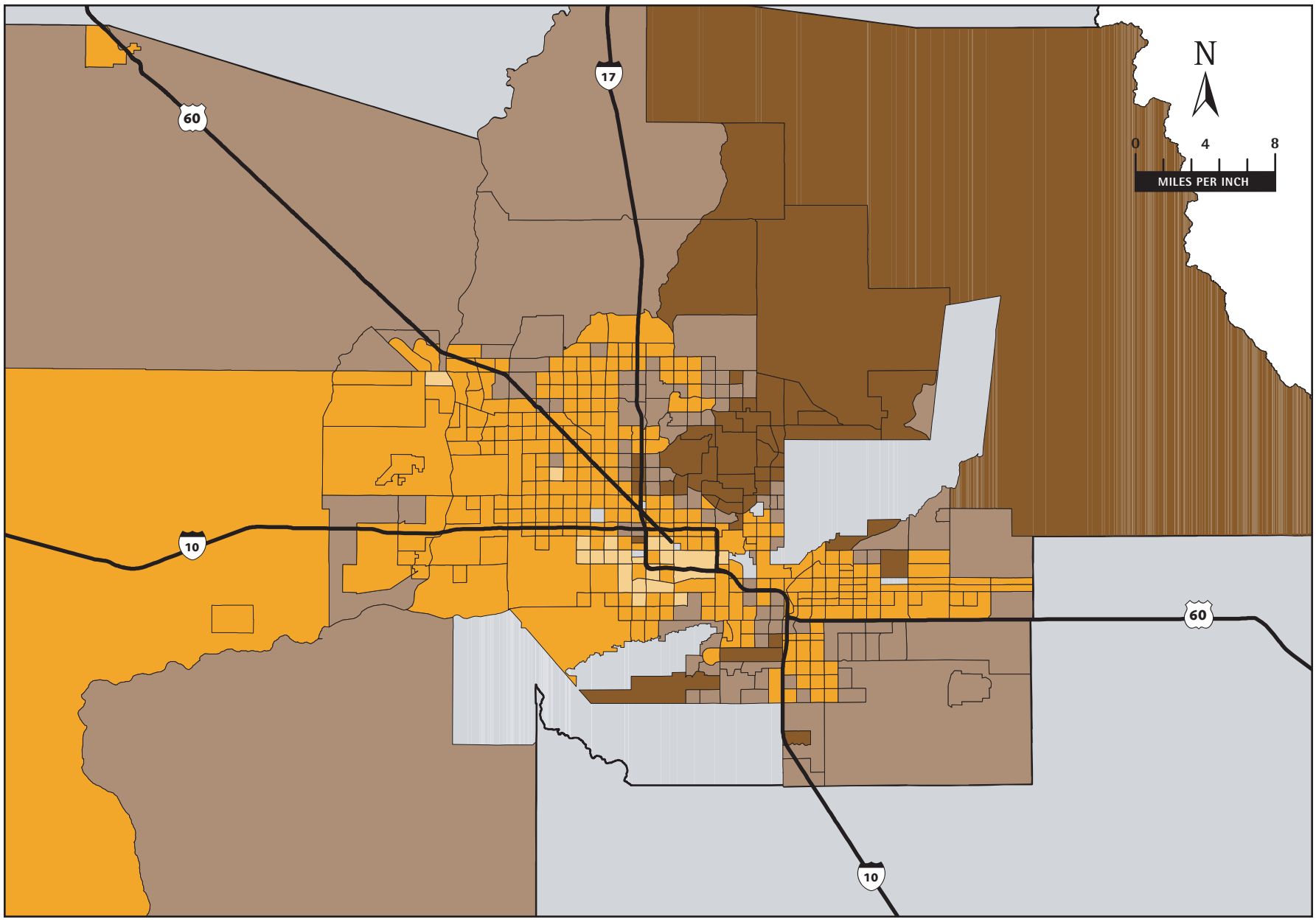
Arizona is facing a quiet crisis of housing affordability. This Atlas makes clear that, for the last decade, the cost of housing has risen while family incomes have fallen. Local restrictions and NIMBY (Not In My Back Yard) reactions have helped to drive up costs and decrease the land available for affordable housing. The crisis is quiet because until very recently, the housing problem has been below the radar screen of public policy attention. Nevertheless, it is serious. Lower-income workers, critical to maintaining Arizona's economy, are finding housing increasingly scarce. When affordable housing does exist, it is usually far from employment opportunities.

Central Arizona does not yet suffer the horrendous housing problems faced by Silicon Valley, where many workers must commute two and three hours each way from the only homes they can afford. But, without aggressive action, central Arizona faces a similar prospect in the future.

A recent study by the Arizona Department of Housing and the U.S. Department of Housing and Urban Development highlights the affordability gap in Arizona. Every city in our state has some lower-income citizens who cannot afford any shelter in that community. As the largest city, Phoenix has the biggest problem with about 32,000 families unable to find a place they can afford. Unfortunately, the study shows that most cities use their limited housing subsidy funds to help families who earn enough to afford housing. Those most in need (making less than 40 percent of the city median income) get little attention. At the same time, cities use zoning and local regulations to make building lower-cost units difficult.

Arizona must provide leadership to support lower-income workers' housing needs, while cities must stop pretending that these workers will somehow find a place to live outside their borders.

Map 27: Median Single-Family Home Sale Price (New and Resale), 2001



MEDIAN SALE PRICE

- $35,000 to $70,000
- $70,000 to $145,000
- $145,000 to $220,000
- $220,000 to $800,000
- No Data
- U.S. Highways and Interstates

ASU Arizona State University

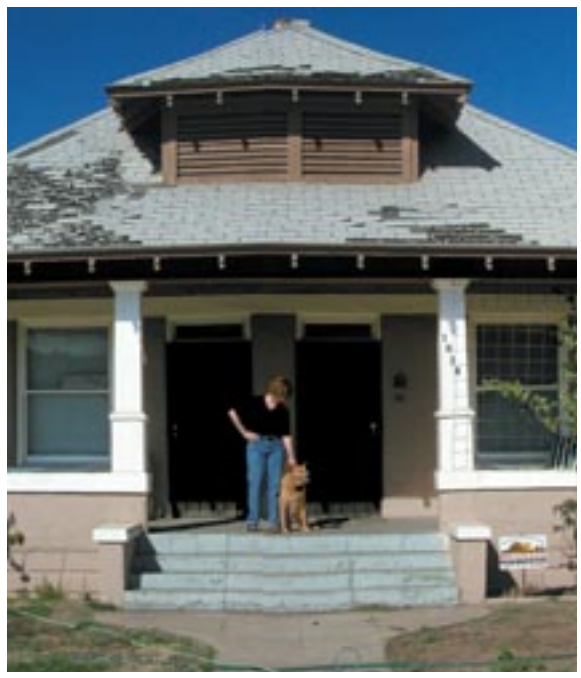
Data: Arizona Real Estate Center, L. William Seidman Research Institute, W.P. Carey School of Business at Arizona State University

Source: Greater Phoenix 2100, Arizona State University

The decades between 1970 and today were dismal for housing affordability in Arizona. The number of households in Maricopa County that could afford a median priced home declined from 64 percent in 1970 to 22 percent in 1980. During the next decade, this number increased to 41 percent, but at the same time home prices increased by 30 percent and middle-income wages experienced a 21 percent decline in buying power, the largest decline in real income of any state in the nation. This has been particularly hard on families with low incomes. Comparing 1980 and 1990 census income data for Maricopa County and local surveys of housing costs, the number of very-low-income households increased more rapidly in the 1980s than did the availability of very-low-cost housing. During the 1990s, affordability remained stable at 1990 levels but the number of people that can afford a median value home remains 21 percent less than it was in 1970.

The Region's Favored Quarter and Its Struggling Core

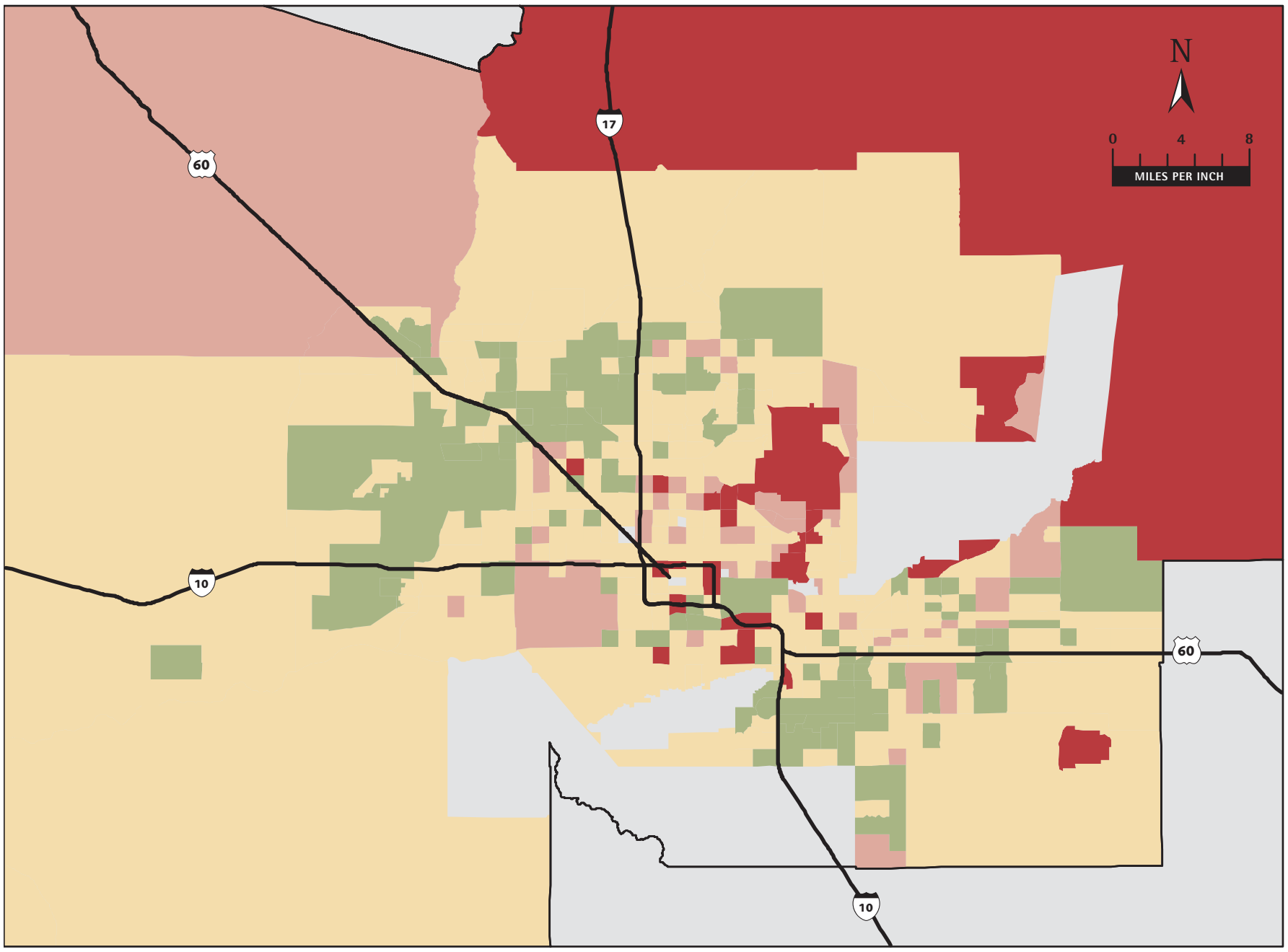
Single-family homes, when plotted by sales price, show a distinctive pattern throughout Greater Phoenix. Map 27 shows how the prices of single-family homes, new and resale, were distributed throughout the region in 2001. Homes selling at or below Maricopa County's median sale price of $142,000 are predominately located in the central and west part of the region. Homes selling for an amount above the median sale price are predominately located in the suburban north, northeast and southeast parts of the region. Most of the homes in the highest range, above $220,000, are located inside a pie wedge that starts just north of downtown Phoenix, extends out to the northeast, and includes areas around North Central Avenue, Squaw Peak and Camelback Mountain, the town of Paradise Valley, and parts of central Phoenix and Scottsdale. This phenomenon is not unusual



Above: Homeowner house renovation, downtown Phoenix

Left: North desert living, Scottsdale

Map 28: Average Home Price Compared to Price of Home Affordable to Median-Income Family



Very Low Affordability – Home Price 100% to 25% Greater Than Can Be Afforded
Low Affordability – Home Price 25% to 10% Greater Than Can Be Afforded
Affordable – Home Price Close, 10% Greater to 25% Less Than Can Be Afforded
Very Affordable – Home Price is 25% to100% Less Than Can Be Afforded
No Data
U.S. Highways and Interstates

ASU Arizona State University

Data: Arizona Real Estate Center, L. William Seidman Research Institute, W.P. Carey School of Business at Arizona State University

Source: Greater Phoenix 2100, Arizona State University

in Southwest growth cities and is sometimes referred to as the "favored quarter."

The majority of homes in the lowest price range, those that are affordable to people earning $20,000 to $25,000 a year, are located near the central core of the city. All of these central area homes are resale; the only new homes in this lowest range are located in the west central part of the region.

Who Can Afford To Live Where They Want?

In the quality-of-life survey conducted by the Morrison Institute for Public Policy in 1999 entitled *What Matters In Greater Phoenix*, 45 percent of those interviewed cited the character of their neighborhood and 40 percent cited closeness to work, schools and/or shopping as the most important factors in their choice of where to live. Only 20 percent cited some type of housing feature, such as size or number of rooms, as the important factor. However, affordability is at least a constraining factor in people's choice. Regardless of what you consider to be a quality neighborhood or where you work, if your family income is only $25,000 a year, the areas where you can buy a single-family home are limited.

Map 28 shows the discrepancies between median income and average home sales. This map shows,

Table 8: Distribution of Median Sale Value of Single-Family Homes, 2001

Value	Percent of Resale	Percent of New	Percent of Total
Up to $75,000	1.4%	<.01%	1.0%
$75,0001 to $100,000	11.8%	0.2%	8.2%
$100,001 to $125,000	25.3%	18.3%	23.1%
$125,001 to $150,000	22.2%	18.4%	23.1%
$150,001 to $175,000	14.1%	33.7%	20.2%
$175,001 to $200,000	8.8%	12.1%	9.8%
$200,001 to $250,000	9.4%	9.1%	9.3%
$250,001 and Greater	7.0%	8.3%	7.4%

Source: Arizona Real Estate Center, L. William Seidman Research Institute, W.P. Carey School of Business at Arizona State University

by 2000 census tract, the percentage difference between the value of a home that could typically be purchased by someone making the median income of the census tract and the cost of the average priced home sold in the same census tract. There are several areas, shown in dark and light reds, where those people earning the median income for that area cannot afford to purchase an average priced home for the same area. The areas shown in green are where people with a median income for that area could afford a more expensive home than one at the average price for the same area. Such differences can have a variety of impacts. In areas where there is a negative gap, many people will have to stretch their budgets in order to purchase a home. This will make it difficult to improve the percentage of home ownership in these neighborhoods, a key factor in neighborhood stability.

Affordability is a Complex Issue

The factors influencing housing affordability are more complex than just housing cost and buying power. Declining inventories of private vacant land, increased reliance on the sale of state land (a difficult and time-consuming process), increasing travel time between low- and medium-cost housing and the location of low- and medium-paying jobs, increased community demand for higher residential design standards, infrastructure costs and impact fees, rising insurance costs and declining mortgage rates all affect housing affordability. And, homeownership is not the only important aspect of housing affordability. Rental rates of apartments and houses are also an important factor, because many people either cannot afford a house or choose not to purchase one for other reasons. In addition, it is just not the lower end of housing affordability that can affect the region as a whole. The location of high-end executive housing can have an impact on the desirability of business locations and thus on economic development.

Unfortunately, information about the factors that affect housing affordability and location decisions is not easily obtained. Many public and private organizations collect data in time frames and geographies that are fragmented and inconsistent. For example, median single-family sales price is often reported inconsistently. Median new home sale price is often compared to a median home sale price that included new and resale houses. The median sales price information used in Map 27 was collected from several local organizations and organized by the Arizona State University Center for Business Research, but the Center's research area does not include Pinal County. This is because the quality of data received from sources in Pinal is not at the same level as data in Maricopa County. In order to better understand the forces affecting housing affordability in Greater Phoenix, it will be necessary in the future to collect data that can be more easily correlated with other factors being studied. ■

The High-Tech New Economy

Riding the "Soft" Technology Wave

Rick Weddle, *President/CEO, Greater Phoenix Economic Council*

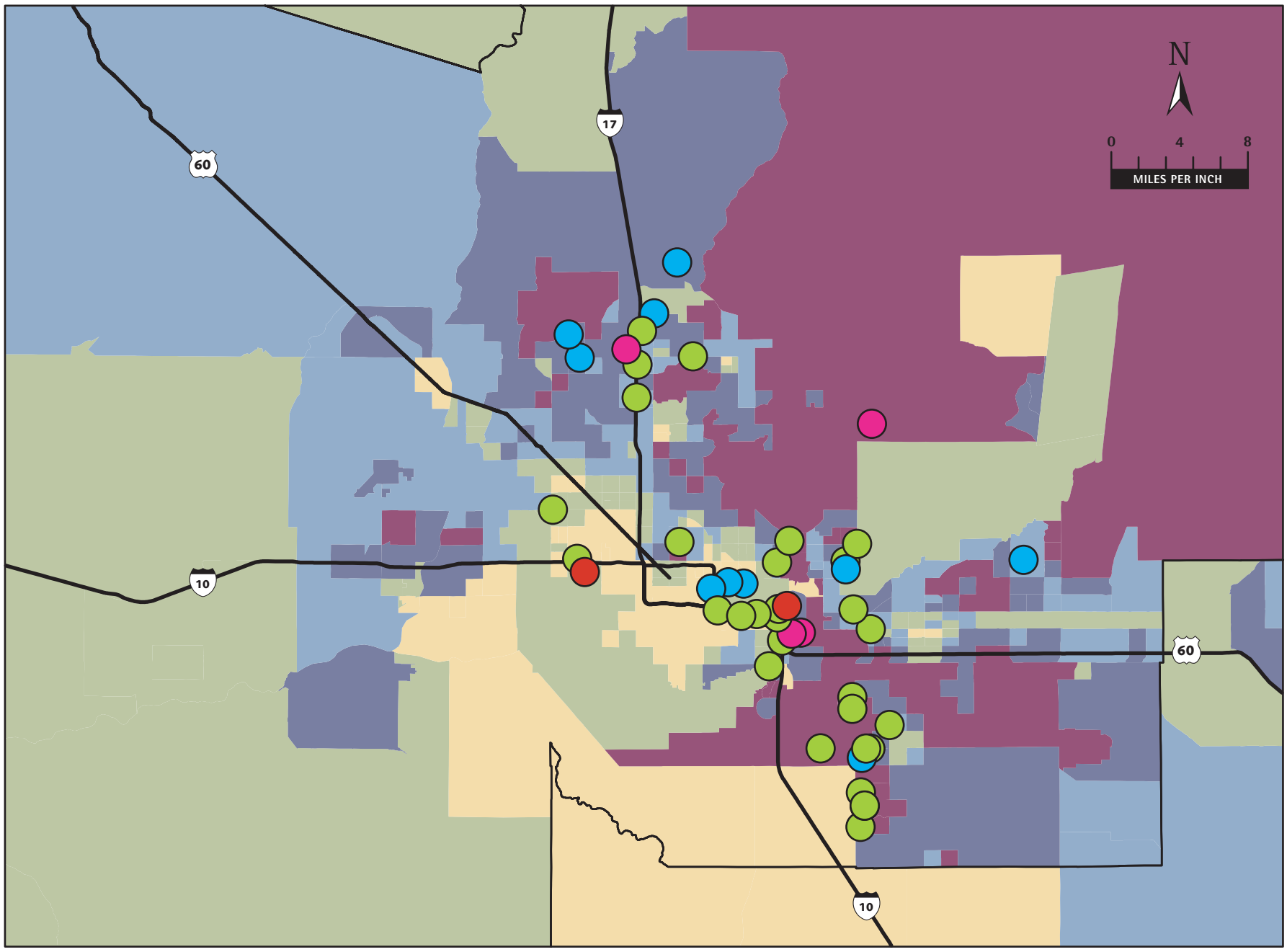
As Greater Phoenix works to transition to a high-tech economy, two tenets for our time should be uppermost in our minds:

1. The criteria for attracting high-tech talent change continually.
2. Talent is swayed by knowledge-generating assets already in place.

In the first tech era, Greater Phoenix was fortunate enough to have what the "hard" technology companies wanted. Our region's ample land and suburban housing appealed to these high-tech manufacturers. As today's "soft" technology wave (dependent on inventive technology uses instead of building better chips) gains momentum, however, different amenities will be sought. As Carnegie Mellon University professor Richard Florida notes, rather than suburban campuses, this imaginative segment prefers hip downtown areas that support their creative tendencies.

If our traditional land-use patterns hold, the region will be ill prepared to meet the needs of this group. Such talent will more likely be attracted by intangible assets such as knowledge-generating centers and a sense of community in neighborhoods rich with arts and culture than to physical infrastructure. Thus, to be successful, our region must look to flexibility in its physical infrastructure and nurture its community and intellectual resources. With this shift, Greater Phoenix will better its chances of attracting the talent that will vault it into the leading ranks of high-technology centers.

Map 29: High-Tech Employment Clusters and Percent of Workforce with Some College Education, 2000



EMPLOYMENT CLUSTERS

- Aerospace
- Bioindustry
- Information
- Software
- No Data
- U.S. Highways and Interstates

PERCENT OF POPULATION 25 YEARS AND OLDER THAT HAS HAD SOME COLLEGE, BASED ON 2000 CENSUS DATA

- 0–28%
- 28.01–45%
- 45.01–58%
- 58.01–70%
- 70.01–87.5%

ASU Arizona State University

Data: Arizona Real Estate Center, L.William Seidman Research Institute, W.P. Carey School of Business at Arizona State University

Source: Greater Phoenix 2100, Arizona State University

Though Greater Phoenix is not ranked among the top technology centers in the country, it is nevertheless recognized as a growing center in the high-tech sector. In the Milken Institute's 1999 study of various measures of technology sector output for the 50 largest regions in the United States, Phoenix consistently ranked among the top 15. But among these high-tech centers, Greater Phoenix ranks lowest in terms of the percent of workers involved in knowledge industries. As a result, recent studies and conferences have examined the question, "How can Greater Phoenix attract more knowledge-based industries and workers?"

During the late 1990s, when the Internet burst on the scene as the new engine of the information economy, urban futurists like William Mitchell of MIT forecast that we would become a placeless society, where cyber-places would be more important than physical places. But the reality has been different. As electronic communications technology shrinks the constraints of place and distance, people have greater opportunities to live where they prefer rather than where they must. Place matters even more now. Where information companies and skilled professionals prefer to locate determines the geography of the new economy.

Today, young knowledge workers in their 20s and 30s are looking for exciting places to live. They prefer places with high environmental quality, compact urban centers, vibrant nightlife, revitalizing neighborhoods and living options that include industrial lofts and eccentric urban apartments. How does Phoenix meet these desires? New-economy futurist Richard Florida found that cities that were ranked high for amenities, such as San Francisco, Austin and San Diego, have high concentrations of knowledge workers. Phoenix, however, still ranks among the lowest in the categories of environmental quality, overall amenities and arts and culture.

There are some emerging urban centers in Greater Phoenix with the amenities that young knowledge workers seek. Downtown Phoenix, the Camelback Road and 24th Street core, northeast Phoenix and Scottsdale and downtown Tempe all are developing sites of urban living and vibrant night life. These areas have yet to attract significant numbers of knowledge workers, but the potential is there. Map 29 shows areas of concentration of major employers considered part of the high technology economy: aerospace, biotechnology, information and software. In general, knowledge workers are located where traditionally there has been growth in office tech space, and not around these emerging urban centers of the high-tech economy. Map 29 also shows the distribution of people in the work force who have some college education. Except for the area just north of downtown Phoenix, this distribution corresponds more to recent residential growth at the fringe than to urban centers. However, this may begin to change. With the introduction of the new Translational Genomics Research Institute in downtown Phoenix, a major concentration of knowledge workers will be created within one of the region's major urban centers. ■

Open Space Preservation

The Great Gift of Metro Phoenix

Ed Fox, *Vice President, Communications, Environment & Safety, Pinnacle West*

For the past 50 years, through economic booms and busts, "growth" has been the Phoenix mantra. Considering the region's wealth of land, the absence of conservation planning early on is hardly surprising. Moreover, residents could easily reach the vast desert spaces surrounding the emerging metropolis. Later on, however, as the city expanded rapidly, development began to compromise the mountain vistas and people's access to open desert. In turn, residents and governments moved to protect the special places that defined their communities.

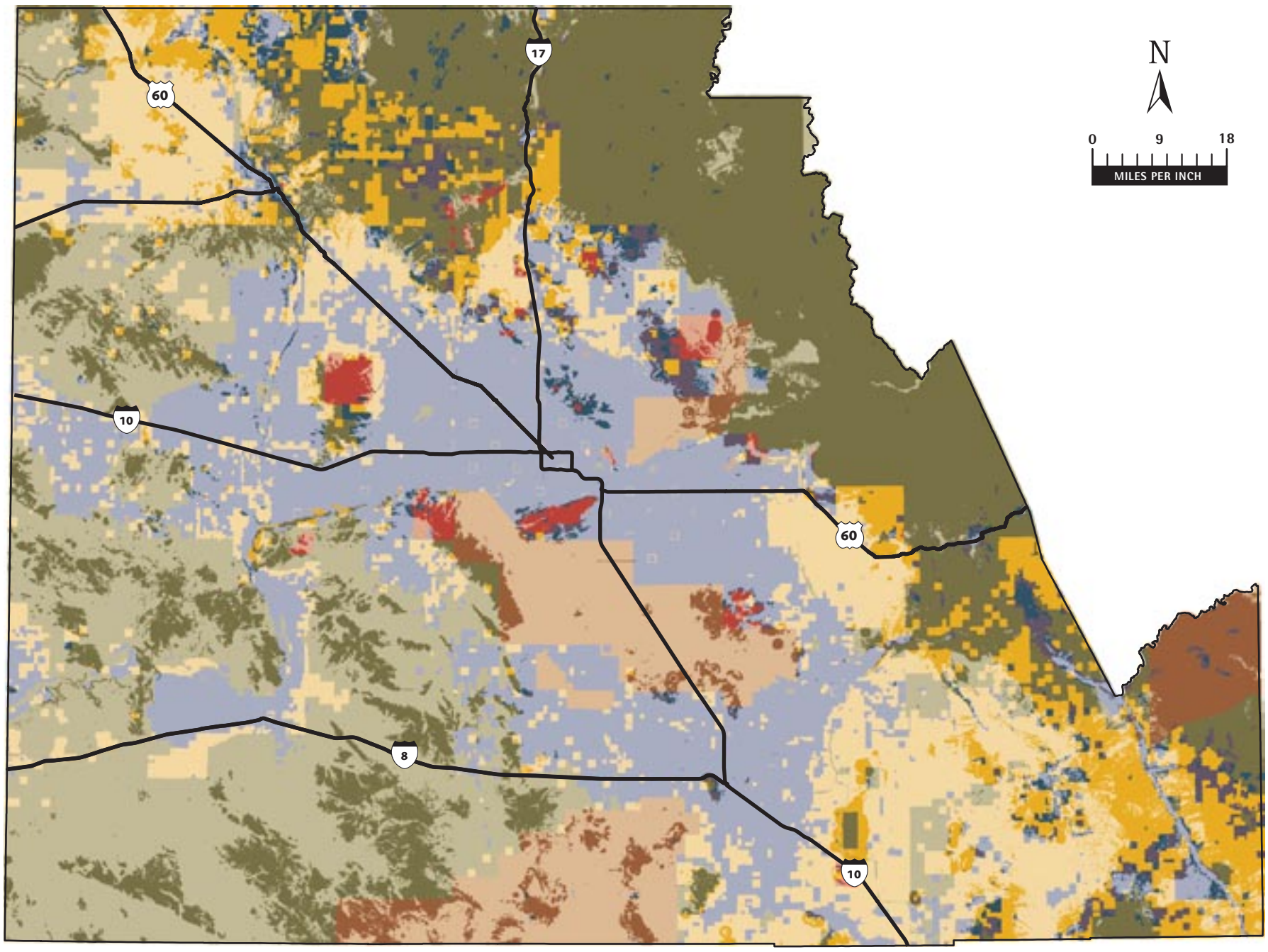
This tension between development and conservation has yielded some remarkable results. Parks and preserves — South Mountain, Estrella Mountain, McDowell Mountain, Squaw Peak, North Mountain, the White Tanks, the San Tans, North Sonoran Preserve, Superstition Wilderness, Lake Pleasant Regional Park and Cave Creek — are jewels in our urban fabric. No place in our region is more than an hour's drive from unspoiled desert. This is not to say that we are done with preservation; rather we need to take pride in our accomplishments. This is especially true since, for many large cities, open space means only a riverfront park or a place with ball fields and picnic tables. In Phoenix, the undeveloped open spaces within the urban core are unique.

In the future, as this Atlas shows, protecting open spaces from development will be harder to do, especially since so many desirable acres are State Trust lands. These lands, according to the Arizona Constitution, must be managed to benefit schools and other designated beneficiaries. Conservation is not recognized as a benefit. Under current law, our past practice of preserving large tracts is unlikely to continue, except in cities wealthy enough to purchase trust lands.

Growth may still be the economic mantra for many in our community, but most Arizonans now realize that conservation must be part of our future. Whether through concepts of "sustainability" or "smart growth," we must establish a strategic plan for economic vitality that also protects our quality of life including the desert in and around our urban centers.

Above: Ahwatukee Village from South Mountain, Phoenix

Map 30: Land Ownership and High Natural Resource Areas



LAND OWNERSHIP — High Natural Resource Areas — Other Areas

- Private
- Public
  - State
  - Local
  - Native American
  - Federal
- No Data
- U.S. Highways and Interstates

Data: USGS Western Ecological Research Center Sonoran Desert Field Station; Arizona State Land Department; Maricopa County

Source: Greater Phoenix 2100, Arizona State University

The beauty of Arizona's landscape has attracted tourists from around the world and millions of new residents. This influx of people has come at a cost. As more visitors and residents come to Arizona to enjoy the natural beauty, the demands made on the natural resources become greater and greater. In the last decade, the region's residents have spoken out to support the preservation of open space and natural resources. Open space preservation consistently receives high ratings on community and regional surveys and has strong support through local initiatives that have been passed to fund open space acquisition. Finding ways to allow urban and rural development to continue while preserving open space and natural resources is now a major regional issue.

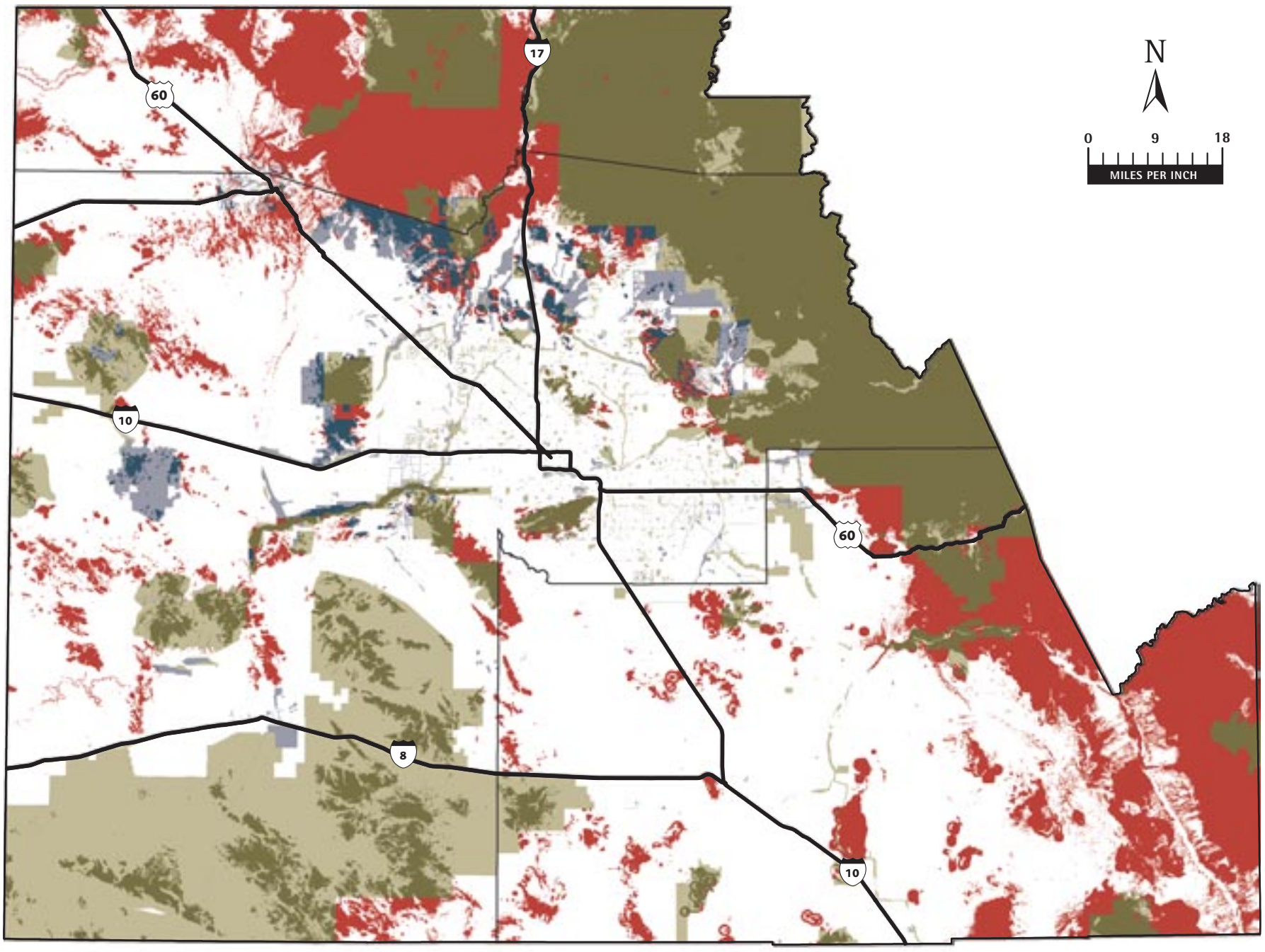
Table 9: Ownership of High Natural Resource (HNR) Areas

Land Ownership	Acres	Percent of Total	Acres of HNR Areas	Percent of HNR Owned	Percent of Total HNR
Private	2,746,429	25%	423,927	15%	9%
Public					
State	2,265,761	21%	795,478	35%	18%
Local	123,241	1%	88,339	72%	2%
Native American	971,080	9%	334,658	34%	7%
Federal	4,716,041	44%	2,872,513	61%	64%
Total Public	**8,076,123**	**75%**	**4,090,988**	**85%**	**91%**
TOTAL	**10,822,552**		**4,514,915**	**42%**	

The Diversity of the Desert

Greater Phoenix is located in the northern part of the Sonoran Desert, one of the largest arid ecosystems in the world, spanning two states in Mexico (Baja California and Sonora) and two states in the United States (California and Arizona). Unlike other deserts of the world, the Sonoran Desert's biological diversity is vast, supporting thousands of plant and animal species within 80 diverse plant communities such as ironwood-paloverde woodlands, saguaro cactus–mesquite scrublands, and cottonwood-willow riparian forests. Much of this diversity is focused around the wash and mountain areas of the region. Map 30 shows areas of high natural resource value (areas of darker color). These are areas of

Map 31: Existing and Planned Open Space and High Natural Resource Areas



OPEN SPACE	High Natural Resource Areas	Other Areas
Planned		
Existing		
Not Planned for Open Space		

No Data

U.S. Highways and Interstates

Data: USGS Western Ecological Research Center Sonoran Desert Field Station; Arizona State Land Department; Maricopa County; Pinal County; Yavapai County; Flood Control District of Maricopa County; Maricopa Association of Governments; Nathan & Associates

Source: Greater Phoenix 2100, Arizona State University

high slope and visual value, riparian areas along the region's rivers and washes, and areas estimated to have a high diversity of mammal, reptile, amphibian and bird species.

Efforts to Preserve Open Space

The process of open space preservation in the greater Phoenix region is complicated by land ownership. Public agencies own 75 percent of the land in the region (Table 9). Generally, land in federal ownership (44 percent of the region) can be considered permanently preserved as open space with some level of natural resource management. However, this is not true of State Trust land, which is constitutionally dedicated to raising funds for education through the lease and sale of the land for rural and urban uses. The areas of dark yellow and dark blue on Map 30 – state and private lands that together represent 27 percent of the high natural resource areas – are areas that could potentially be lost to urban and rural development.

Desert near Town of Florence

A variety of local, state, and federal agencies either currently manage or have plans to manage 6 million acres, or 53 percent, of land within Greater Phoenix for recreation and open space purposes. This includes various local cities, Maricopa County, the Arizona State Land Department, the USDA Forest Service, the Bureau of Land Management, and the Bureau of Reclamation. Map 31 shows the location of these lands (greens and blues). These areas include about 54 percent of the high natural resource lands. This leaves about 2 million acres of high natural resource lands currently not managed or planned as open space (shown in red).

Sunset behind Union Hills, Phoenix

There are a number of efforts underway to expand lands dedicated to desert open space. Currently, there are several nonprofit groups actively involved in acquiring land for preservation, including the Nature Conservancy, the Desert Foothills Land Trust, and the McDowell Sonoran Land Trust. Recent state legislation and initiatives have created programs to preserve open space. The Arizona Preserve Initiative (1996/1997) defines a process to designate and sell or lease State Trust land for conservation purposes. Applications have been filed for land in Phoenix, Scottsdale, Cave Creek, Fountain Hills, and the Superstition Mountains. Proposition 303, approved by voters in 1998, sets aside $220 million in state matching funds over 11 years for the purchase of State Trust lands for open space preservation. The cities of Scottsdale and Phoenix have approved dedicated sales taxes for purchase of desert open space – two-tenths of a cent in 1995 and one-tenth of a cent in 1999 respectively. A variety of groups and government agencies are actively pursuing the acquisition of dedicated open space. The Maricopa Association of Governments adopted a regional open space plan in 1995 to try to coordinate the open space plans of various governments. Most recently a coalition of rural, development, education and environmental interests are trying to forge a consensus plan on reserving state lands as open space.

Though the two maps in this chapter provide one representation of lands valued for open space preservation, there are other factors not represented by these maps. Information on natural resource value, that is, information needed for detailed land use planning and regulation, is lacking. Also lacking is a consensus on what factors should be considered in deciding which lands to preserve. Continued data collection, research, and public discussion are needed to further the issues of open space preservation. ■

Urban Heat Island

The Public and Climate Change

Sheila Grinell, *President/CEO, Arizona Science Center*

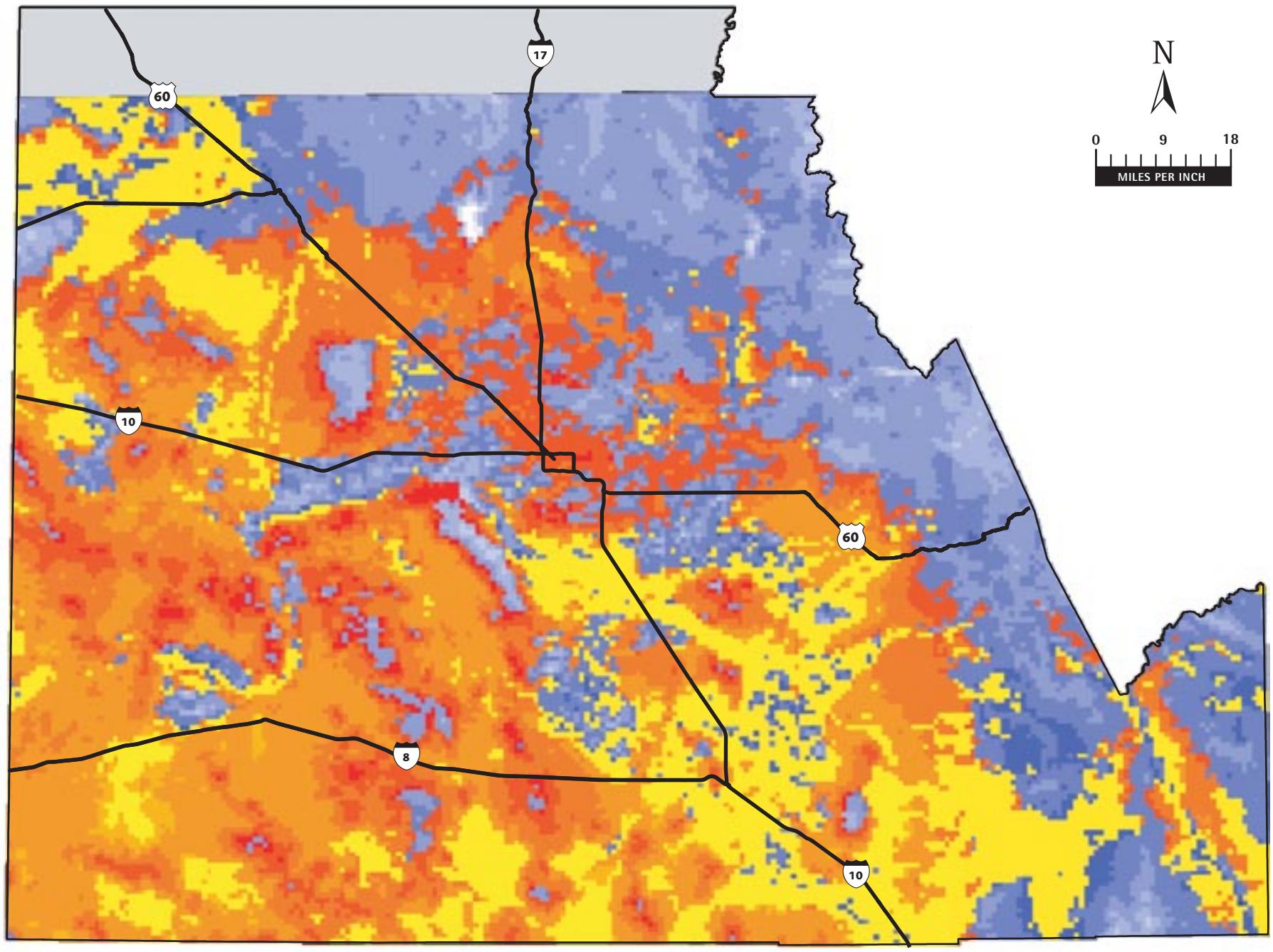
Climate change is one of the most significant and heavily debated subjects in contemporary society. Scientists in many disciplines are gradually unmasking the multiple dimensions of the topic, including natural variations over time, changes due to geological forces and the effects of human activity, and their possible physical and economic impacts. Yet, science only defines climate change's boundaries. The public, through its policy leaders, must decide what to do about the many possible worrisome consequences. To make informed decisions about options, citizens need reliable information presented succinctly without jargon or bias. In short, they need to be educated.

Our media, however, rarely do justice to the complexities of climate change and its specific instances, such as the heat island effect. Local TV news (the information source most used by adult Americans), newspapers and magazines, and Internet web sites cover seemingly contradictory scientific studies, which ideologues cite as support for particular positions. But science, by definition, welcomes contradictions, as researchers seek to verify and understand different aspects of an idea.

Today, there is scientific consensus about most features of climate change. There is no policy or political consensus. Our communicators and educators should help the public see the difference between scientific conclusions and policy recommendations. Fortunately, evidence shows that the public welcomes this information when it is provided consistently and respectfully by a trusted source.

Above: Clark Spiny Lizard (Sceloporus clarkii)

Map 32: Change in Surface Temperature from Day to Night, June 2001



Temperature Change (Degrees C) from Day to Night in Areas with "Above Regional Average" Temperatures During Day

Hotter — Cooler

29.3-26.1 | 39.2-36.0 | 49.2-45.9 | 58.9-55.9

Temperature Change (Degrees C) from Day to Night in Other Areas

Hotter — Cooler

7.96-3.94 | 20.8-16.8 | 33.7-29.7 | 46.3-42.5

No Data

U.S. Highways and Interstates

NASA

ASU Arizona State University

Data: National Aeronautics and Space Administration; Geological Remote Sensing Laboratory, Arizona State University

Source: Greater Phoenix 2100, Arizona State University

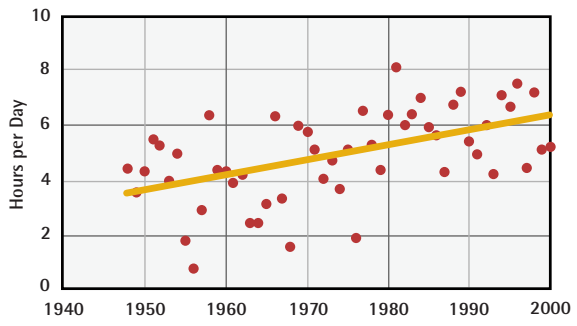
Greater Phoenix is getting hotter and staying hotter for longer periods of time. Since 1949, the average low temperature at Phoenix Sky Harbor International Airport has risen more than 10 degrees Fahrenheit, and urban areas get hotter and stay hotter than rural areas. Greater Phoenix is not unique in this experience. The urban heat island effect has been measured in urban areas around the world.

During the day in moist rural areas, the solar energy absorbed by the ground evaporates water from the vegetation and soil. This evaporation results in a cooling effect that compensates for some of the solar gain. In cities, the buildings, streets and sidewalks absorb solar energy, which, due to the thermal properties of asphalt, brick and concrete, then warms the surrounding air. Waste heat from city buildings and cars also contributes to urban heat by adding as much as one-third of that received from solar energy. Work done at Arizona State University analyzing long-term temperature records in Phoenix shows that the urban heat island effect can add from 4 to 8 degrees Fahrenheit to the temperature of the urban areas of the region.

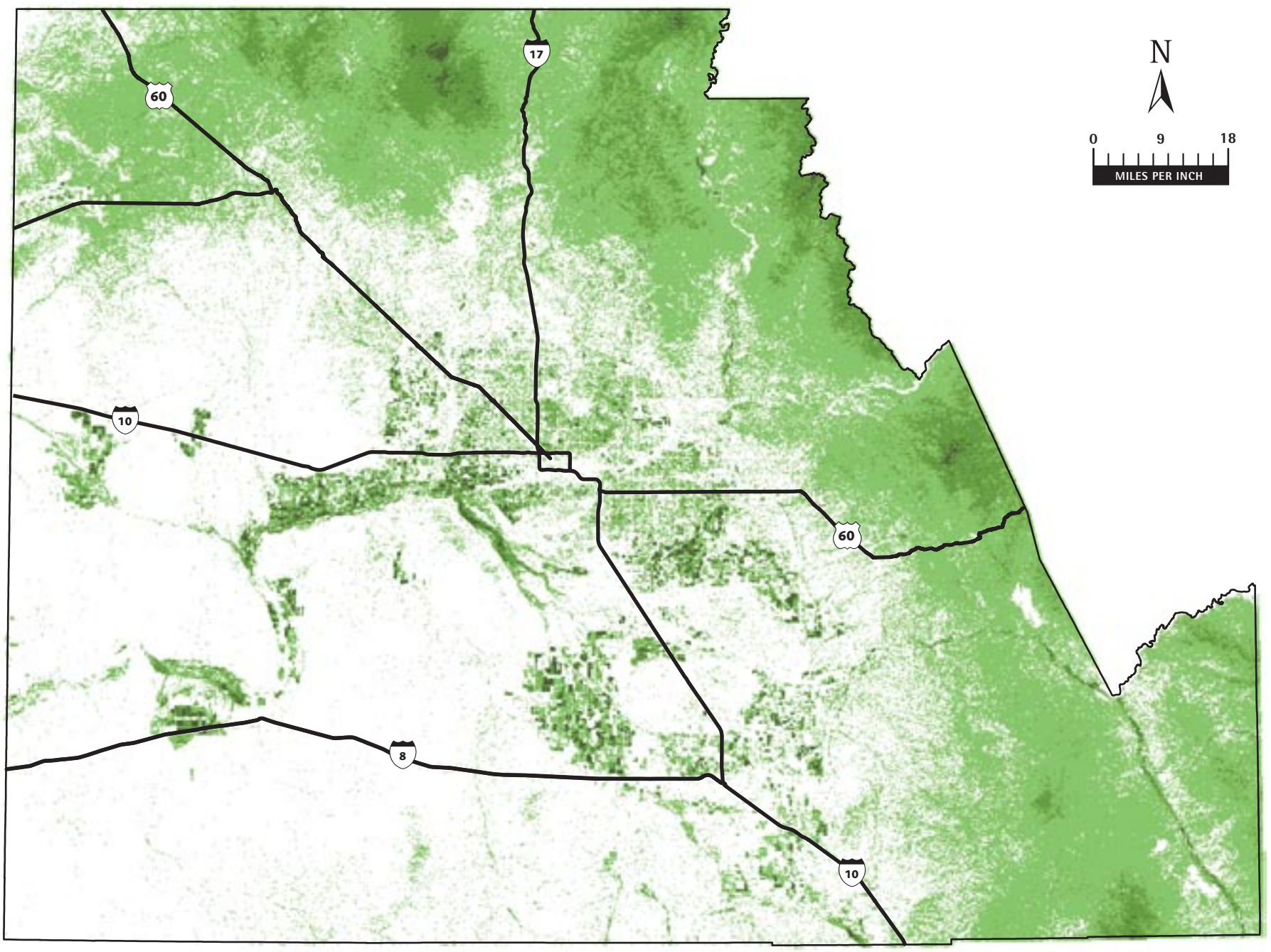
Urban heat islands can affect both human health and the urban environment. Health can be affected when heat islands cause an increase in ground-level ozone pollution (See: "Air Quality"). The urban environment is affected when the rise in temperature brings an increase in energy demand to cool homes, offices, and other buildings. Salt River Project estimates that for every degree of increase in temperature, its residential customers use $5 to $7 more of electricity per month.

The heat island effect is not equal in all parts of the urban area. Using data from daytime and nighttime thermal satellite images of the earth surface temperature, Map 32 shows areas of the region that have a tendency to get hot and stay hot. Dark red areas on the map get hotter than the regional geographic average during the day and do not cool off at night. Yellow areas on the map

Chart 2: Hours per Day with Effective Temperature >100 Degrees F at Sky Harbor Airport, 1948–2000



Map 33: Density of Vegetation, June 2001



DENSITY OF ACTIVELY PHOTOSYNTHESIZING VEGETATION, JUNE 2001

- Lowest
- Highest
- No Data
- U.S. Highways and Interstates

NASA

ASU Arizona State University

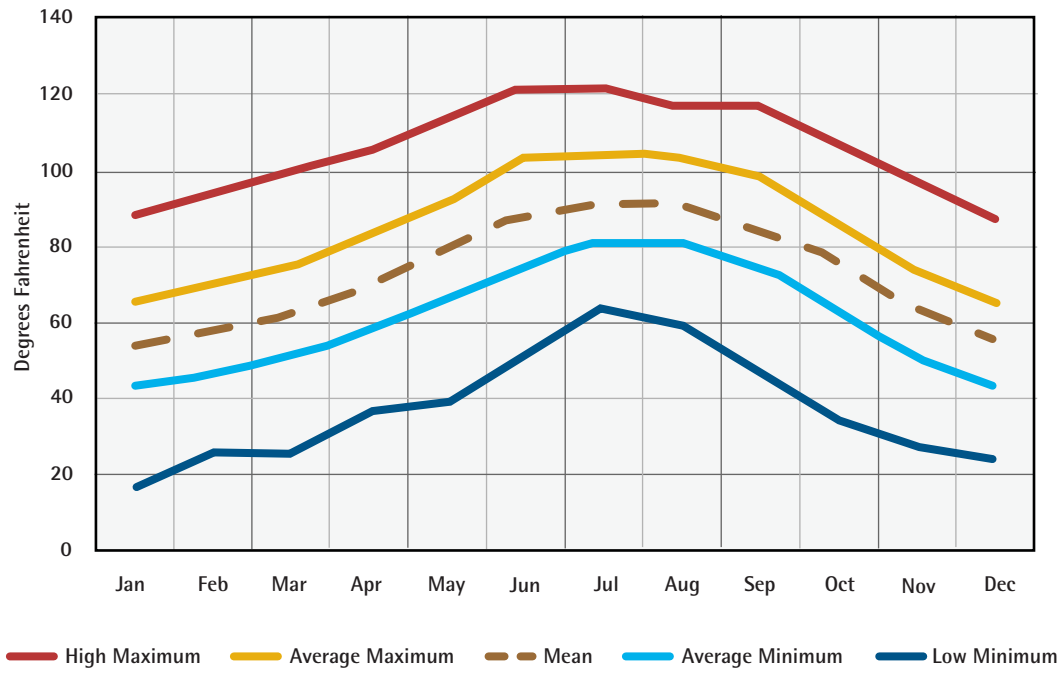
Data: National Aeronautics and Space Administration; Geological Remote Sensing Laboratory, Arizona State University

Source: Greater Phoenix 2100, Arizona State University

get hotter than average during the day but cool off at night. Blue areas on the map remain below average in temperature during the day, with darker blue areas getting cooler at night. Pockets of cool temperatures can be seen in areas such as Phoenix's Arcadia neighborhood, where preserved orchard trees and expansive grassy lots keep the area cooler during the day and retain less heat to be given off at night. East of Phoenix, the Salt River Pima Indian Community cools more rapidly than neighboring Scottsdale because of its agricultural uses and lack of pavement and rooftops.

Map 33 shows areas of the region where large amounts of dense vegetation can be found, with darker greens indicating more dense vegetation. Comparing this map of vegetation with the areas of cooler temperature (blue color) on Map 32 shows a close relationship between vegetation and temperature.

Chart 3: Temperatures in the Phoenix Metro Area



ASPHALT USED TO PAVE STREETS IS ONE OF THE LARGEST CONTRIBUTORS TO THE HEAT ISLAND EFFECT IN URBAN AREAS.

Unlike other parts of the country, Greater Phoenix's heat island is not primarily a result of urban growth that has replaced the natural landscape. High summer daytime and nighttime temperatures have always been a natural occurrence in the Sonoran Desert. Map 32 shows that temperatures are cooler in the northern and eastern parts of the region, but much hotter in the southern and western parts of the region. This pattern of regional temperature corresponds to areas of vegetation, shown on Map 33, and the general elevation rise that increases from southwest to northeast. In the region's central and southwest desert areas, exposed rock gets very hot during the day and retains heat that is then released at night. This phenomenon can be seen on Map 32 as red rings around the blue mountains of the southwest and central part of the region. The lower rocky slopes of these mountains absorb and retain heat during the day and radiate it at night, while the higher parts of the mountains stay below average during the day and cool off at night. As agricultural uses were introduced to the region, the solar absorption characteristics of vegetation and the evaporation of irrigation water created zones of cooler temperatures. Now as urban development replaces agricultural uses, temperatures have increased, and are in some cases higher than the original desert temperatures.

In 1997, the Environmental Protection Agency (EPA) launched the Heat Island Reduction Initiative to work with communities and public officials to reduce the impact of urban heat islands. In 1998, the EPA and the National Aeronautics and Space Administration (NASA) began an effort to study the urban heat island in ten U.S. cities, including Phoenix and Tucson. Phoenix and Scottsdale have discussed what measures might be taken to reduce the region's urban heat island as part of city planning efforts. Other states and cities have initiated programs that target urban heat islands. California has implemented a cool roof rebate program to provide an incentive for construction projects with reflective roofing. Los Angeles is replacing nearly 53 acres of paved schoolyards with green space. Salt Lake City in Utah and the California cities of Sacramento and Davis have established parking lot shading regulations and guidelines. In Arizona, programs to add more plants and trees in the urban landscape will have to be balanced with water use considerations. ■

Greater Phoenix 2100: What Comes Next?

Where Will the Ideas Come From?

Jon Talton, *Columnist,* The Arizona Republic

High-quality universities form the core of America's economy in the 21st century. Where steel mills and railroads once determined a nation's strength, today a modern nation depends on the engines of its knowledge industries. The tie between a strong economy and higher education is seen most dramatically now in Silicon Valley. But I've watched this transformation across the country in my 20 years of reporting on regional economies in the United States. Strong universities attract and develop talent, the great prize of today's economy. They produce the ideas and technologies that seed entire industries.

A regional economy based on university-driven industries creates high-paying jobs, and better living standards for everyone. It also fuels culture, amenities, and the tax base to address urban problems. This is a key lesson and compelling opportunity for Greater Phoenix. Except for semiconductor manufacturing, Phoenix is an underachiever in knowledge jobs, and our chip jobs are in danger of moving overseas. Only by using universities as economic engines can the region avoid becoming a low-wage colony, with severe social and economic consequences. So far, Phoenix has not realized the potential of its major university. Indeed, competing cities usually have two or more such institutions.

Reversing this trend will require significant increases in state funding, especially for attracting and retaining talented professors and researchers. State inhibitions against technology transfer should be removed. Administrators must have more flexibility in deciding how building projects are funded, and tuition is assessed. We have a host of best practices from around the nation that can help. The next few years will be critical in determining whether Greater Phoenix can position itself to join the quality knowledge economy. Failing to do so is the most costly option of all.

One of the major challenges of the Greater Phoenix 2100 (GP2100) project is to help people stretch their normal sense of time. In our daily lives we fret about the number of minutes in a daily commute, count the hours until the end of a workday, and endure the months before the next holiday. Politicians measure time in election cycles of two to six years, and plan their policy initiatives accordingly. Rarely, a public priority like the Central Arizona Project takes one or more decades to complete.

This temporal myopia doesn't insulate us from the influences of longer timelines. Certain scientific perspectives help reveal the patterns that normally escape our view. Climatologists uncover decadal cycles of drought and flood and century-long trends of global warming, both of which define the carrying capacity of our desert environment. Archeologists, comfortable with a millennial perspective, describe how the rise and fall of civilizations reflect their ecological contexts. Geologists see these same landscapes through the lens of continental movements that take hundreds of millions to billions of years.

Think of this Atlas as the appetizer on a menu of Greater Phoenix 2100 products designed to collectively show the residents of Arizona the future they are creating. Understanding what this relatively long-term – 50- to 100-year – future may be can help us make decisions today that will move our region in a desirable direction toward tomorrow. Incorporating the latest in information and telecommunications technology, GP2100 will provide tools that attempt to make sophisticated scientific results more accessible to policy makers and the public. In coming months and years, the project will convene university, government and community partnerships to build:

- an electronic version of the E-Atlas, including real-time access to data collected, maintained, and hosted by federal, state, and local agencies;
- a simulation capability, tentatively referred to as Sim Phoenix, which will combine numerical modeling with the data in the Atlas to allow different future scenarios to be explored;
- a Decision Theater immersive environment, in which the results of Sim Phoenix and other models can be experienced with state-of-the-art, high-definition computer graphics and SenseSurround audio; and
- a series of symposia and workshops, Greater Phoenix Conversations, in which the public and policy makers can discuss key environmental issues with academic and agency scientists and engineers.

Like a diamondback shedding its skin, Greater Phoenix will continue to outgrow its political boundaries as it matures. The maps in this Atlas point toward a future that is two generations away, requiring expansion of our concepts of place as well as time. To begin this psychological adjustment, the Atlas intentionally depicts a region that extends well beyond any present jurisdiction. Satellite imagery is the best and perhaps only way to reveal how dramatically the definition of neighborhood will need to change, both here and in cities around the globe. To attempt to capture this extra-terrestrial perspective, we include an ambitious "dessert" in the Greater Phoenix 2100 menu: the design, construction, launching and control of Urban Sat, a new remote sensing satellite whose instrument package will be optimized for measurement of variables of critical importance to urban resource monitoring and modeling, both here and in other rapidly growing urban centers around the world.

We hope that readers will find the maps and commentaries in this Atlas to be of practical value. However, their most important purpose is to serve as an invitation to engagement. We want people to use this and the other parts of the forthcoming Greater Phoenix 2100 toolkit to explore and actively design their own futures. You can find directions for contacting us at www.gp2100.org. We look forward to the participation of you and your neighbors, as well as that of representatives from other universities and from local, state and federal government agencies. By broadly and aggressively pursuing these intellectual challenges, we expect to gain many new insights that will be relevant to other urbanizing portions of North America and the rest of the world. Ultimately, the lessons learned in Greater Phoenix will help residents, political leaders, and agency heads in cities across the globe to recognize the need for long-term solutions to the common problems we all confront.

Jonathan Fink
Vice President for Research
& Economic Affairs
Arizona State University

Above: Chenille Prickly Pear (Opuntia aciculata)

Left: Arizona State University campus

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Above: Ocotillo (Fouquiera sp.) and Saguaro (Cereus giganteus)

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