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Greater Phoenix 2100: Building a National Urban Environmental Research Agenda

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INTRODUCTION

At the start of the twenty-first century, scientists of all types are becoming increasingly bold in their willingness to examine complex systems. Multidisciplinary teams using the latest information technology are now attacking problems of societal relevance that had, until recently, been considered too difficult for the available tools. Nowhere is this transformation better illustrated than in the growing attention ecologists, geologists, and other natural scientists are paying to the study of cities and their metropolitan regions. The multidimensional challenge of addressing science problems in urban settings is compounded by intense interest from policy makers and the general public in their solutions, especially in cities that are experiencing the pressures associated with rapid growth.

One of the places where this new kind of exploration is being most aggressively carried out is metropolitan Phoenix, Arizona, which has been among the fastest-growing urban areas in the United States over the past decade. A confluence of federally funded scientific research, public interest in quality-of-life issues, and academic aspiration of the region's only research university have positioned Greater Phoenix to be an ideal national laboratory for interdisciplinary study of the complex interactions between an urban population and its physical, biological, and social environment. A project called Greater Phoenix 2100 was launched in April 2001 by Arizona State University (ASU), in conjunction with various state and federal agencies, to capitalize on these research opportunities, and to use them to better inform public policy debates about regional

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growth. This chapter describes the background, goals, and proposed implementation strategy for the Greater Phoenix 2100 project.

BACKGROUND: DRIVERS OF CHANGE

Cities present important challenges for scientific inquiry. Rapidly growing urban regions pose especially complex issues for science, policy, and our futures. Most natural scientists in the United States have eschewed the study of such human-dominated ecosystems as cities in favor of learning about the interactions of more purportedly pristine environments. American geophysical and biological scientists have discovered urban places only relatively recently as field laboratories for their work [e.g., Botkin and Beveridge, 1997; Pickett et al., 1997; Collins et al., 2000; Grimm et al., 2000; Valentine and Heiken, 2000; Fagan et al., 2001; Fernando et al., 2001]. The consequences of this discovery are potentially wide ranging. If we can better understand urban processes, then we might be able to create healthier metropolitan regions, or "city-regions" [e.g., Calthorpe and Fulton, 2001].

Perhaps because of the change in the millennium, several scholars and writers have urged society to look ahead more critically. Jonathan Weiner [1990] speculates about planet Earth over the next one hundred years. Stewart Brand [1999] takes an even longer view—10,000 years. Robert Costanza [2000] advocates envisioning as a tool for policy analysis. Such queries into the future help us begin to identify drivers of change that are likely to influence the fate of the planet in this new century and millennium. The U.S. Environmental Protection Agency's Science Advisory Board defines such drivers as "the large social, economic, and technological forces that [are] likely to drive future changes in environmental conditions" [1995, p. 4]. Further, they observe that such drivers "can generate environmental stressors…that cause adverse effects on specific human health and ecological endpoints" [1995, p. 4]. Some possible drivers of change that might affect metropolitan regions include: (1) population dynamics and consumption; (2) urbanization; (3) connectivity and networks; (4) technology, economics, and politics; (5) culture and the arts; (6) education and human services; and (7) global and regional environmental processes. In addition, metropolitan regions themselves contribute substantially to all types of global environmental change; thus, we must look to cities and their social and ecological dynamics to understand the origin and possible solution to global environmental change.

Population growth and migration include those factors that will change the global demographic structure. The Earth currently has about six billion inhabitants. The United Nations projects the world's population to plateau at 9.4 billion by the year 2050 and then slowly rise to 10.4 billion by 2100 [Barrett and Odum, 2000]. This translates into some 12.6 billion additional individuals appearing on the planet over the next century [Brand, 1999]. Half of the world's population will soon live in cities, and the number of these urban inhabitants is expected to double by 2030 [United Nations Development Programme et al., 2000]. By 2050, two-thirds of the people in the world will be living in urban regions.

Population growth drives change because everyone requires water, food, shelter, clothing, and energy. However, the levels of consumption vary widely. The United Nations notes that globalization tends to separate the costs from the benefits because “consumers derive goods and services from ecosystems around the world…This [appropriation] tends to hide the environmental costs of increased consumption from those doing the consuming” [United Nations Development Programme et al., 2000, p. 23]. Society’s desires to consume the basics and the amenities of life affect the level of resources necessary to fulfill those demands.

Human populations consume natural resources but also produce wastes as byproducts of this consumption. These wastes, such as excess CO_2 from fossil-fuel burning, NO_x from automobile exhaust and nitrogenous solutes from fertilizer, must be assimilated by natural or designed ecosystems or they will accumulate in the environment. That accumulation does occur is obvious from the alteration of biogeochemical cycles and the CO_2-induced warming that is already well documented [e.g., Vitousek, 1994]; what is perhaps less well known is generation of much of this waste can be traced directly to cities.

Population changes caused by growth and migration, and the associated consumption, are closely linked to urbanization. The movement of people to cities and metropolitan regions involves the transformation of land use from rural and natural to urban and suburban, the urbanization of the wild, the abandonment of the rural, and the recovery of the core city and older suburban neighborhoods. Some key questions related to both population growth and urbanization are: (1) Why do people choose to live where they do? (2) What policies direct/affect growth and development? (3) What are the long-term impacts of these policies, both for ecological systems and for further development?

Connectivity involves the ways that new networks and information systems will alter communities, knowledge transfer, time, social relationships, and education. Connecting technologies such as the automobile and the Internet may also divide. While we can assume that connectivity will continue to transform human society, the details remain obscure. Uncertainties surround such questions as: (1) What will communities look like when people no longer need to be next to each other for commercial reasons? (2) How will business, educational, and public institutions be affected? (3) How will connectivity affect use, knowledge, experience, and perception of place? (4) What will be the ecological consequences of a reduced need for transportation?

Connectivity and networks from new technologies are likely to drive global changes. Technological change is often linked to politics. Examples of technological and political linkages include: war, energy policy, and scientific advances, such as, space exploration and biotechnology. Changes in the gross national and domestic products, extractive enterprises, industry and manufacturing, food and fiber, tourism, and transportation drive economics too.

The culture and the arts also drive change. Recreation and entertainment affect our aspirations and expectations. The Beatles, for example, helped define the youth culture of the late twentieth century. The past also helps shape the future. As a result, understanding the history and prehistory of nations, regions, and communities can help society anticipate possible changes.

Historic innovations in education such as universal public, primary and secondary schools and the GI Bill in the United States have resulted in dramatic transformations. Future alterations in education and other human services are likely to have similar impacts. For example, how health care is delivered to an aging population will no doubt drive major changes.

The global environment is also likely to see major changes in the future [Harrison and Pearce, 2000]. Global warming trends are well documented. Species are becoming extinct at a dramatically accelerating rate, from rain forests to coral atolls to deserts. Meanwhile, local climate changes as a result of urban heat island (or heat archipelago) effects are becoming better known. For example, summer nighttime average temperatures in the Phoenix metropolitan region increased by 2.2°C between 1970 and 1990 [Brazel et al., 2000]. Additional environmental drivers of change influencing the global commons and, to varying degrees, specific regions and landscapes, include: natural disasters, the nitrogen cycle, energy uses and greenhouse effects.

GREATER PHOENIX 2100

Against this global backdrop, ASU launched a new research initiative called Greater Phoenix 2100. It will combine a regional perspective with the latest scientific information to address several socially-relevant questions, including: (1) What are the desirable characteristics of Greater Phoenix that today's citizens want to preserve or create for their great-great-grandchildren? (2) How do we best describe the metropolitan Phoenix region as it exists today? (3) How do we characterize explosive urban growth? (4) What tools can help citizens and policy-makers make educated forecasts about the region's future? (5) How will trends in science and technology affect the development of metropolitan regions like Greater Phoenix? (6) How will social and economic changes drive metropolitan policies during the next 100 years? The project also will serve as a focal point for coordinating federal, state, academic information programs relating to the environment of the region, and will be linked with similar studies in other metropolitan areas. Greater Phoenix 2100 will build state-of-the-art forecasting and decision tools and theories. Coupled with the National Science Foundation-supported Central Arizona-Phoenix Long-Term Ecological Research Project (CAP LTER) Greater Phoenix 2100 has the potential to launch a network of similar undertakings nationally and internationally.

Greater Phoenix 2100 has been influenced by several other national efforts, such as the Los Alamos National Laboratory's Urban Security and Sustainability

Project, the U.S. Geological Survey's (USGS) Urban Dynamics Project, the National Science Foundation's (NSF) Urban Research Initiative, various university institutes, and state "smart growth" initiatives. In the mid-1990s, Los Alamos Laboratory developed a multidisciplinary urban modeling approach [Heiken et al., 2000]. Their team used their modeling capabilities to develop urban security and sustainability scenarios, focused on a few cities, including Los Angeles, Dallas, Portland (Oregon), and Albuquerque. In 2000, Phoenix was added to the list of cities to be modeled. However, that year the budget for the program was greatly reduced.

The USGS Urban Dynamics Research program supports studies of the landscape transformations that result from the growth of metropolitan regions over time. By combining a variety of data sources including historic maps, Landsat satellite data, and aerial photography, the project's scientists document past effects of urbanization on landscapes, and model land-use changes under alternative growth scenarios. Among the metropolitan regions that have been analyzed are Portland (Oregon), Chicago, Baltimore–Washington, San Francisco, and New York. The program is a partnership among the USGS, University of California at Santa Barbara, NASA, and others.

The Urban Research Initiative (URI) was an interdisciplinary program coordinated by the National Science Foundation's Social, Behavioral, and Economic Sciences Directorate (http://www.nsf.gov/pubs/1998/nsf9898/nsf9898.txt). Its goal was to support projects studying processes that determine or constrain the nature and direction of change in urban environments. This research was intended to facilitate development of a predictive understanding of the complex interactions among people, the natural environment, and the physical settings of urban environments. Originally launched as a multi-year program in 1998, the URI became incorporated into NSF's "Biocomplexity" initiative in 1999.

Several universities have projects with goals similar to those of Greater Phoenix 2100. For example, the University of Texas at Austin's Urban Issues Program focuses research on topics like the built environment and housing, community development, demographic change, economics, the natural environment, planning, urban form, and design. Portland State University has established an Institute of Portland Metropolitan Studies. This institute serves the Portland, Oregon region by providing new access to its higher education resources. The institute is attempting to create a shared understanding of the region, its issues and prospects by providing a neutral forum for the study of metropolitan policy issues. The University of Texas at Austin and Portland State University exemplify the trend among urban universities to contribute to the knowledge base of their region.

In concert with the American Planning Association's Growing Smarter Project, several states have adopted new statutes to modernize their approach to growth management [Meck et al., 1999]. For example, Maryland enacted a Smart Growth program in 1997. By revamping Maryland's laws, the state's leaders expressed their conviction that improved growth management laws would be one of the most important ways to reduce pollution and to stimulate economic development. In 1998, Arizona adopted a Growing Smarter law, followed in 2000 by Growing Smarter Plus. The Arizona law requires counties and cities to adopt comprehensive plans to guide their growth. Maryland and Arizona typify numerous examples of the growing nationwide interest in the nature of urban growth.

In spite of these notable beginnings by governments and universities, few activities are systematically coordinated over long periods of time or across complex bureaucratic divides. Several conditions discourage the needed cooperation. Federal/state/private/academic collaborations are fragmented. The social, biological, and physical sciences are disconnected from one another as well as from the humanities, law, engineering, public policy, and the environmental design arts. Growth debates lack a scientific foundation and tools for forecasting the environmental and social consequences of growth are limited. With the framework provided by Greater Phoenix 2100, we believe that the Phoenix metropolitan region can address and move beyond these current constraints.

WHY STUDY METROPOLITAN PHOENIX?

The Phoenix region possesses three characteristics that make it an ideal urban laboratory: it is geographically delimited; it is a national leader in growth; and it typifies the arid urban west. Water and energy availability impose sharp resource constraints that define the physical boundaries of the metropolitan region. From both a modeling and a political perspective, the boundary conditions of the region are relatively simple: it is encircled by public land and most of the urban, built up area is contained in a single county with 27 jurisdictions (fewer than most other large U.S. regions). As a result, until relatively recently, few "leap-frog" developments have occurred beyond a well-proscribed, contiguous metroplex.

Throughout the twentieth century, the Phoenix region grew consistently and rapidly, especially after the second world war (Figures 1 to 5). The population of the Phoenix metropolitan region has been growing at some of the most rapid rates in the U.S. Maricopa County grew 44.8 percent between 1990 and 2000, increasing from 2,122,101 to 3,072,149 people. This made it the fastest growing and fourth most populous county in the country. During the 1990s, the City of Phoenix topped a million people and became the sixth largest city in the nation. Its spatial expanse has eclipsed that of the city of Los Angeles. According to City of Phoenix Planning Department data, the region is growing by about 63,000 residents per year (more than 2000 per week), who require about 23,000 new housing units. The number of people in Arizona is expected to double in the next 20 years [Gammage, 1999; Morrison Institute, 2000].

Much of the expansion has been in the form of suburban sprawl. Recently, 9,000 acres of land per year (one acre per hour) have been developed, resulting in loss of both natural desert environments and productive irrigated farmlands

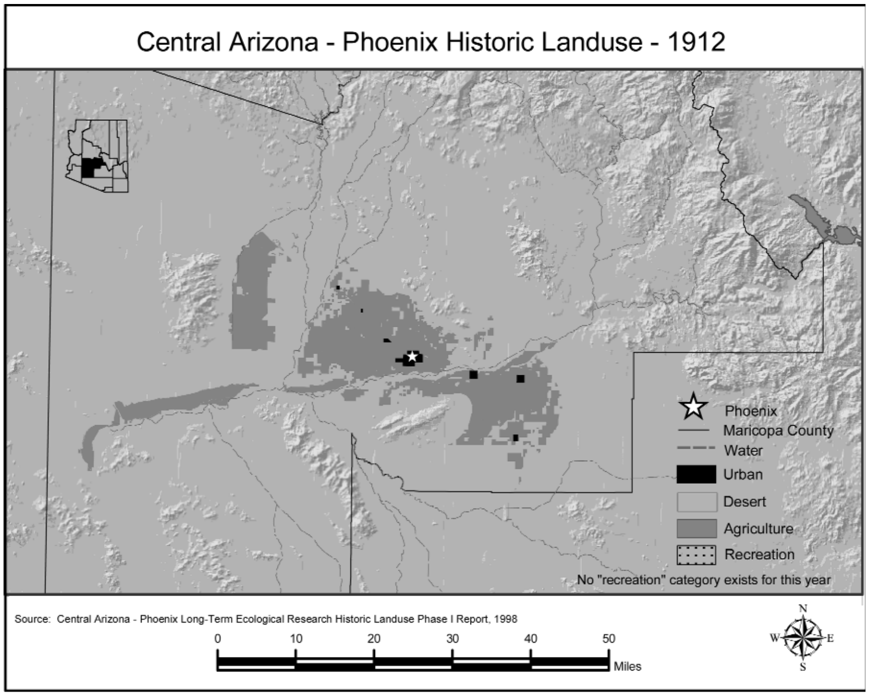

Figure 1. Central Arizona Phoenix Historic Landuse – 1912.

[Gammage, 1999; Morrison Institute, 2000]. Air pollution has increased to alarming levels, with Maricopa County failing to meet federal standards for two air pollutants (particulates and ozone) at various times in the past decade. Other signs of environmental degradation abound, ranging from visual clutter to water diversion from natural stream courses, to contaminated ground water plumes, to noise and traffic problems [Gammage, 1999; Morrison Institute, 2000]. As these trends continue, an area once well known for its scenic beauty and health benefits is developing a more negative image and reality. This transformation has serious implications for the state's important tourism, retirement, and film industries.

Phoenix also typifies other rapidly growing cities in the arid and semi-arid American West. The economy has a strong and growing high tech sector, spurred by business-friendly tax policies and an abundance of relatively cheap land. However, mass transit options are limited, social welfare needs are underfunded, and the continuing influx of new residents is nearly balanced by a relatively large exodus of existing citizens. From a global perspective, Phoenix shares environmental similarities with many of the most rapidly urbanizing regions around the world, adding to the relevance of projects like Greater Phoenix 2100.

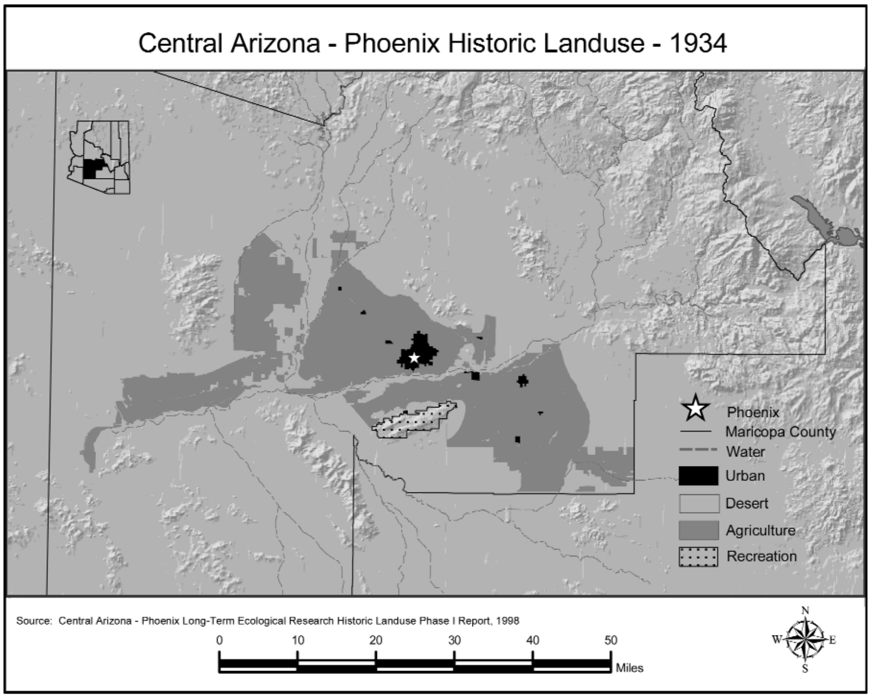

Figure 2. Central Arizona Phoenix Historic Landuse – 1934.

WHY HAVE A UNIVERSITY-LED PROJECT?

Besides the above advantages that metropolitan Phoenix offers for an urban environmental science and policy initiative, the region's one major university (ASU) is well-positioned to play a leadership role. ASU contains several high-profile environmental research projects and teams, it has the institutional persistence to engage in a long-term project of this type, and it is largely detached from the economic and political interests with a stake in possible conclusions reached by studies of growth impacts on the urban and surrounding environment.

The flagship of ASU's environmental research portfolio is the Central Arizona–Phoenix Long-Term Ecological Research (CAP LTER) project, which was selected in 1997 by the National Science Foundation to be one of two urban sites in the LTER network [Grimm et al., 2000]. The aim of CAP LTER is to understand the changing urban fabric of the Phoenix region's arid ecosystem, through an understanding of how land-use change and other human activities alter ecological conditions in and around the metropolis, and, conversely, how these ecological changes feed back to affect further human decisions, behavior and activity. CAP LTER is a multidecade-scale monitoring project, involving 48

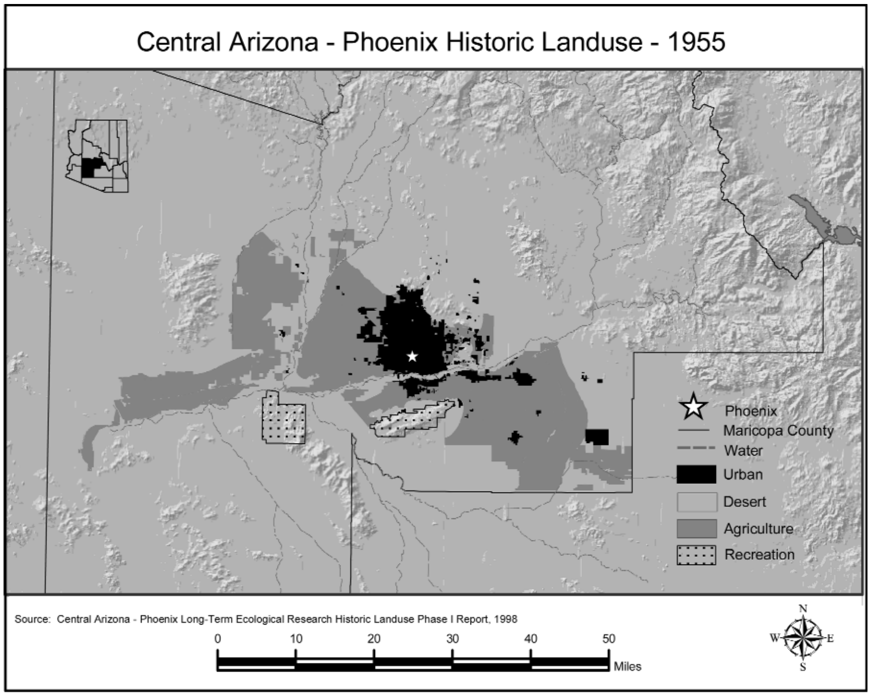

Figure 3. Central Arizona Phoenix Historic Landuse – 1955.

co-investigators from 14 ASU departments, and partnerships with numerous state, federal, and city agencies. The other urban LTER project is in Baltimore, which differs from Phoenix in age, growth rate, environmental setting, and politics [Grimm et al., 2000].

In addition to CAP LTER, ASU houses several other relevant research projects funded by federal, state, and local agencies. As part of NSF's Urban Research Initiative, ASU researchers have been studying the growth and distribution of a carbon dioxide "dome" within the metropolitan region. NSF also recently awarded ASU one of their prestigious IGERT (Integrated Graduate Education and Research Training) grants, for urban ecology. NASA has supported a collaborative study between ASU planetary scientists and the City of Scottsdale to develop terrestrial remote sensing tools for urban resource management. A spin-off of this project, funded by NASA's Mission to Planet Earth, is a comparative remote sensing study of 100 rapidly growing cities around the globe, using ASTER (Advanced Spaceborne Thermal Emission and Reflection Radiometer) and other remote sensing instruments on the Terra platform. ASU's Environmental Fluid Dynamics Program has extensive research partnerships with the EPA's Office of Atmospheric Research and with the Arizona Department of Environmental Quality for modeling airflow within the Phoenix metropolitan area.

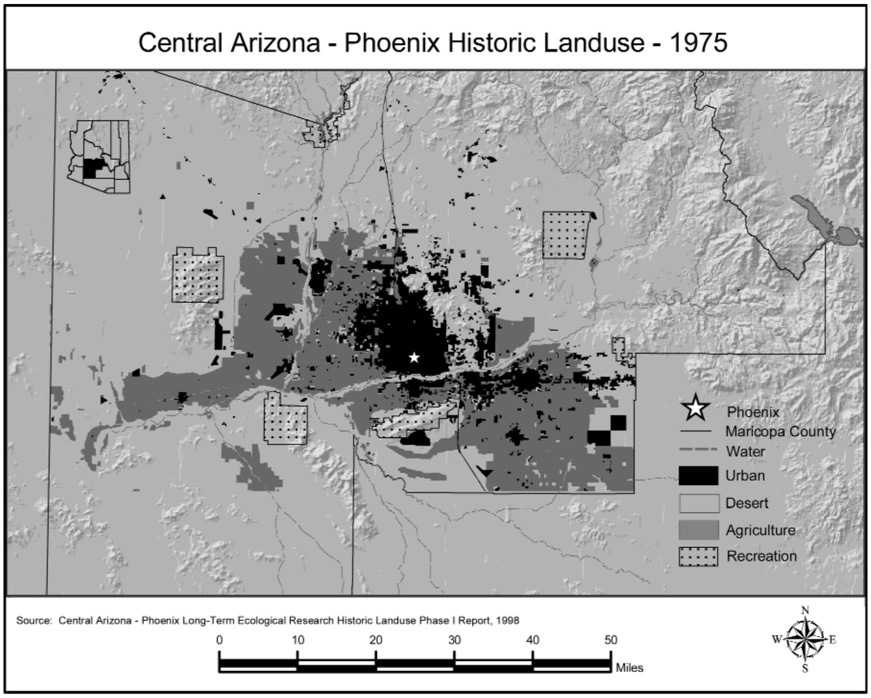

Figure 4. Central Arizona Phoenix Historic Landuse – 1975.

Besides the above federally funded projects, ASU has also worked with planners in the City of Phoenix to develop a GIS database for the city's 134-square-mile, largely undeveloped, North Area. Multiple data layers including geology, soils, drainage, vegetation, land ownership, and land use were developed for this parcel, which constitutes approximately 20 percent of the city's area. In addition, ASU researchers conducted original research of specific geological features using NASA data and specific vegetation and wildlife patterns based on field research. The GIS maps and other studies were used to conduct land suitability analyses, the identification of environmentally sensitive areas, as well as forecasts of potential environmental consequences of possible future developments. The ASU work led to approximately one third of the area being set aside by the city and state as a Sonoran Preserve. The city also changed its planning and development requirements for the area [Steiner, 2000].

PLOTTING POSSIBLE FUTURES FOR METROPOLITAN PHOENIX

In concert with the above university-based activities, Greater Phoenix 2100 represents a focal point to coordinate a variety of federal, state, municipal and academic research efforts, ultimately linking with similar studies in other cities.

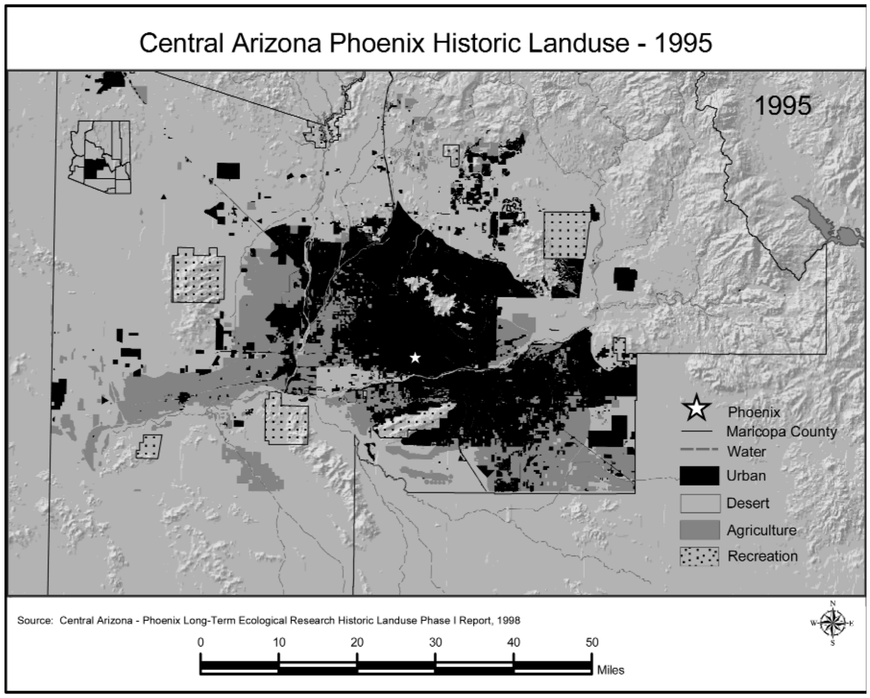

Figure 5. Central Arizona Phoenix Historic Landuse – 1995.

However, the first goal of Greater Phoenix 2100 is to answer environmental policy questions that people in the region care about by providing objective, scientifically based information. To present these results most effectively, Greater Phoenix 2100 will build state-of-the-art forecasting and decision tools and theories.

ASU and various government entities possess a significant storehouse of information about greater Phoenix. ASU faculty and students study and analyze practically every important aspect of central Arizona from its underlying geological structure to daily real estate transactions. Significant data exist concerning climatic variations, the flora and fauna of the Sonoran Desert biome, regional history and economic trends, and health and education of the population. An important goal of Greater Phoenix 2100 is to make this information available in ways that will enable wise, knowledge-based decision-making that can shape the region during the next 100 years.

The 100-year timeframe presents a purposefully longer-term view of the metropolitan region than has previously been developed. While short-term visioning is limited by immediate considerations, a century-long perspective requires the incorporation of multigenerational concerns and changes in technology. A 100-year timeframe also allows for evaluation of impacts of such geologically common but societal rare events as droughts, major floods, and gradual climate changes. In short, Greater Phoenix 2100 will provide a strong, scientifically based resource for considering the region's long-term prospects and for creating the kind of future its residents want.

Several linked products are envisioned to flow from Greater Phoenix 2100. First, existing data can be coalesced into a dynamic warehouse of continuously updated regional information. Such a data repository can be presented to the public through an Urban eAtlas, which will be made available in electronic and more conventional forms. The Urban eAtlas will provide an important resource for the documentation of existing conditions and will be designed to enable the construction of future scenarios. The digital version will be available on-line so that it may be continuously accessed and updated. The data warehouse and Urban eAtlas will contribute to a third major product: a Decision Theater where local leaders, citizens, students, and researchers can explore future options for the region. The Decision Theater will be an immersive physical space, in which scientific data, group dynamics, and interactive computer technology can be used to develop simulations of the region's futures and considerations of their consequences. The simulations and their representations will evolve with new computational and representational technologies as well as with new scientific information.

Greater Phoenix 2100 will complement and augment existing long-term monitoring activities being conducted at ASU, such as those of the CAP LTER project. A long-term goal of Greater Phoenix 2100 might be to launch a satellite in cooperation with NASA to regularly take the pulse of the metropolitan Phoenix area (as well as other cities, depending on orbital characteristics). One option would be for this "Phoenix-Sat" to have a highly elliptical orbit, passing low over the region twice daily, enabling diurnal measurements of such dynamic parameters as traffic, air quality, soil moisture, and construction activity. Tools such as the Urban eAtlas, the Decision Theater, and Phoenix-Sat will enable scholars and decision-makers alike to probe the major issues that metropolitan areas like Phoenix will face in the coming 100 years. As a result, problems may be anticipated and avoided while societally desirable opportunities may be pursued with vigor.

SUMMARY

With the launching of Greater Phoenix 2100, a community of scientists and public stakeholders seeks to tackle some of the most complex scientific and policy issues of the twenty-first century. Through a combination of advanced visualization tools and robust community involvement, Greater Phoenix 2100 will be a clearinghouse for fundamental questions about the impacts of urbanization on natural environments and social function. Results will be provided to inform debates among policy makers and citizens about future options. The hundred year time frame allows unique exploration of issues that might not otherwise be possible. Because the problems and opportunities faced by Phoenix typify those of many of the most rapidly growing urban areas in the United States and the world, the results of Greater Phoenix 2100 can potentially be relevant to hundreds of millions of people.

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