Urban Head Island
Background Information

Living in the desert has always been a challenge for people and other living organisms. There is too little water and, in most cases, too much heat. Some of the highest temperatures on earth have been recorded in deserts, yet we also know that people have lived in deserts for thousands of years. Certainly the more than three million people who make metropolitan Phoenix in Arizona their home are evidence of our ability to create livable places in harsh environments.

As Phoenix has grown, the natural environment has been transformed from the native desert vegetation into a diverse assemblage of built materials, from buildings, to parking lots, to roadways. Concrete and asphalt increase mass density and heat-storage capacity. This in turn means that heat collected during the day is slowly radiated back into the environment at night. While both the city and the Sonoran Desert are hot during the day, the desert cools down much more quickly at night than the city. Figure 1 shows the average minimum temperature in the Phoenix metropolitan area has increased (along with its population) since 1945, as compared to a nearby rural location.

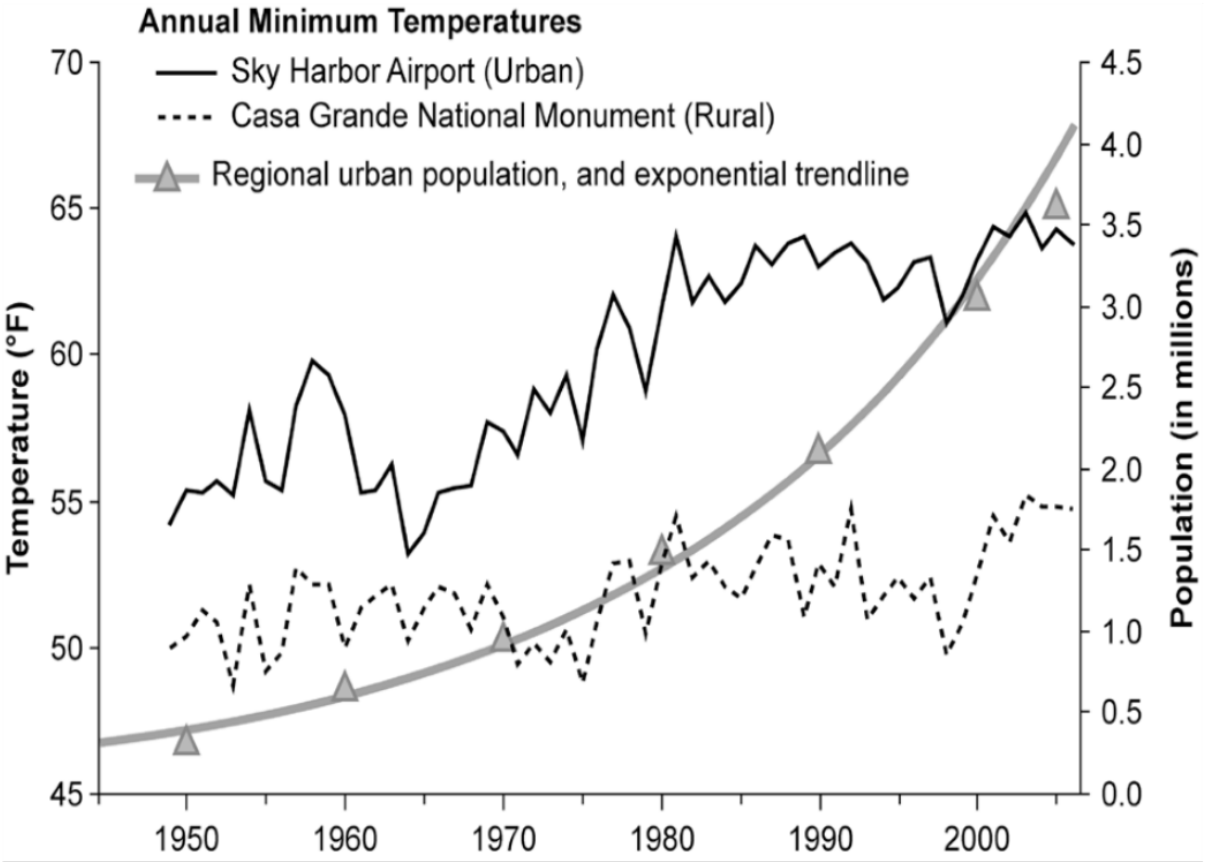

Figure 1. Annual Minimum Temperatures and Population Growth in the Phoenix Metropolitan Area. Source: A. Brazel, 2004

Temperature changes impact urban dwellers in many ways, influencing their health, comfort, energy costs, air quality, visibility levels, water availability and quality of life (Karl et al., 2009). Over the 20th century, average annual temperatures have increased 3.1°F in Maricopa and Pinal counties. In urban areas of the counties, however, temperatures rose over three times higher than in rural areas (increases of 7.6°F vs. 2.3° F). A high growth rate combined with clear, calm weather, low altitude with intense sun, and heat-absorbing surfaces explain our greater than normal urban warming (Brazel 2000). Scientists call this phenomenon the Urban Heat Island. While other cities also experience this type of heat, the Phoenix-area Urban Heat Island is a nighttime phenomenon in which the average low temperatures have increased over time. Because minimum daily temperatures have increased in the Phoenix area, it takes less time to reach uncomfortable temperatures during the day and longer to cool off during the night. The average number of hours per day with temperatures greater than 100°F between May and September has doubled since 1948 from 1.8 to 3.4 hours per day. During July and August, the two warmest months of the year, the average number of hours per day with temperatures greater than 100°F has also doubled from 3.6 to 6.4 hours per day. Thus, the number of "misery hours" per day has nearly doubled as the result of urbanization (Baker et al., 2002).

So what does this mean for living sustainably in desert environments? Some researchers have found that the pattern of the Phoenix Urban Heat Island is more complex than just a hot urban center surrounded by cooler rural locations. Researchers have found that temperatures are moderated by the density and diversity of plants in neighborhoods (Stabler, et al., 2005). Thus, even in the urban core, some neighborhoods with lush landscapes are much cooler than adjoining neighborhoods with barren landscapes. These differences are due in large part to the distinct preferences for certain landscape-design features and plant combinations (Larsen & Harlan, 2006; Martin & Stabler 2004). What this means in Phoenix is that climatically stressed neighborhoods tend to have fewer resources to cope with extreme temperatures (Harlan et al., 2008).

Landscaping appears to be one way to mitigate the impact of the Urban Heat Island phenomenon. Designing the built environment with different materials is another approach. Cool roofs and cool pavements use alternative materials and designs that absorb and retain less thermal energy than conventional materials under identical environmental conditions (Carlson & Golden 2008). Individuals and city planners can play a role in making our urban environment more sustainable by employing new design and construction techniques.

The Urban Heat Island is an important topic of research at Arizona State University. In particular the following research projects and groups have contributed to our understanding of this phenomenon in Phoenix.

Central Arizona Phoenix Long-Term Ecological Research Project (caplter.asu.edu)

Decision Center for a Desert City (dcdc.asu.edu)

Sustainable Materials & Renewable Technologies Solutions for Energy and Climate (asusmart.com)

Neighborhood Ecosystems: Human-Climate Interactions in a Desert Metropolis (shesc.asu.edu/node/297)

Urban Vulnerability to Climate Change: A System Dynamics Analysis (shesc.asu.edu/node/552)

References

Baker, L.A., A.J. Brazel, N. Selover, C. Martin, N. McIntyre, F.R. Steiner, A. Nelson, & L. Musacchio. (2002). Urbanization and warming of Phoenix (Arizona, USA): Impacts, feedbacks, and mitigation. *Urban Ecosystems* 6: 183-203.

Brazel, A. J., N. Selover, R. Vose, & G. Heisler. (2000). The tale of two climates: Baltimore and Phoenix urban LTER sites. *Climate Research* 15(2): 123-135.

Carlson, J. & Golden, J. (2008). Climate, Energy, and Urbanization. *A Guide on Strategies, Materials and Technologies for Sustainable Development in the Desert*. Prepared for the City of Phoenix by the National Center of Excellence on Sustainable Material and Renewable Technology (SMART) Innovations, Global Institute of Sustainability, Ira. A. Fulton School of Engineering, College of Design, Arizona State University. 379pp.

Harlan, S. L., Brazel, A. J., Jenerette, G. D., Jones,

N. S., Larsen, L., Prashad, L. & Stefanov, W. L. (2008). In the shade of affluence: The inequitable distribution of the urban heat island. *Research in Social Problems and Public Policy, 15*, 173-202.

Karl, T. R., Melillo, J.M., & Peterson, T.C. (eds.). (2009). *Global Climate Change Impacts in the United States*. Cambridge University Press. 334pp.

Larsen, L. & Harlan, S. L. (2006). Desert dreamscapes: Residential landscape preference and behavior. *Landscape and Urban Planning, 78*, 85-100.

Martin, C.A. & L.B. Stabler. (2004). Urban horticultural ecology: Interactions between plants, people and the physical environment. *Acta Horticulturae,* 639: 97-101.

Stabler, L.B., C.A. Martin & A.J. Brazel. (2005). Microclimates in a desert city were related to land use and vegetation index. *Urban Forestry & Urban Greening* 3: 137-147.