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Articles

Ecosystem services and urban heat riskscape moderation: water, green spaces, and social inequality in Phoenix, USA

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Urban ecosystems are subjected to high temperatures—extreme heat events, chronically hot weather, or both—through interactions between local and global climate processes. Urban vegetation may provide a cooling ecosystem service, although many knowledge gaps exist in the biophysical and social dynamics of using this service to reduce climate extremes. To better understand patterns of urban vegetated cooling, the potential water requirements to supply these services, and differential access to these services between residential neighborhoods, we evaluated three decades (1970–2000) of land surface characteristics and residential segregation by income in the Phoenix, Arizona, USA metropolitan region. We developed an ecosystem service trade-offs approach to assess the urban heat riskscape, defined as the spatial variation in risk exposure and potential human vulnerability to extreme heat. In this region, vegetation provided nearly a 25°C surface cooling compared to bare soil on low-humidity summer days; the magnitude of this service was strongly coupled to air temperature and vapor pressure deficits. To estimate the water loss associated with land-surface cooling, we applied a surface energy balance model. Our initial estimates suggest 2.7 mm/d of water may be used in supplying cooling ecosystem services in the Phoenix region on a summer day. The availability and corresponding resource use requirements of these ecosystem services had a strongly positive relationship with neighborhood income in the year 2000. However, economic stratification in access to services is a recent development: no vegetation–income relationship was observed in 1970, and a clear trend of increasing correlation was evident through 2000. To alleviate neighborhood inequality in risks from extreme heat through increased vegetation and evaporative cooling, large increases in regional water use would be required. Together, these results suggest the need for a systems evaluation of the benefits, costs, spatial structure, and temporal trajectory for the use of ecosystem services to moderate climate extremes. Increasing vegetation is one strategy for moderating regional climate changes in urban areas and simultaneously providing multiple ecosystem services. However, vegetation has economic, water, and social equity implications that vary dramatically across neighborhoods and need to be managed through informed environmental policies.

Key words: climate change, economic stratification, ecosystem services, extreme heat events, urban heat riskscape, vegetated cooling

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