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Integrating Ecosystem Services Into Urban Park Planning & Design

Dorothy C. Ibes
College of William and Mary, dcibes@wm.edu

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Urban parks, which include a variety of green, brown, and gray infrastructure (e.g. greenways, native desert parks, plazas), are key providers of ecosystem services within cities. Given the importance of urban ecosystem services to the social and ecological health of urban ecosystems, there is a growing consensus that ecosystem service considerations should be integrated into urban park planning, policy, and design. Yet this integration is limited by a lack of relevant, accessible tools and standards for implementation. To address these deficiencies the present study developed the Urban Park Ecosystem Services (UPES) tool. UPES an open-source, geographically contextualized planning tool and site design guidelines for systematically integrating multiple ecosystem service considerations into urban park planning. To maximize relevancy and accessibility to practitioners, the tool was based on an existing planning ordinance, already in use by planners. UPES was customized to an arid city using Phoenix, Arizona as a case study, but can be modified for use in other cities based on their specific geographic conditions and policy goals. UPES provides a starting point and foundation for the integration of ecosystem service considerations into urban park planning and design to maximize their benefits across an urbanized region.

Keywords

Urban parks, ecosystem services, public space, urban sustainability, public policy, urban planning

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INTRODUCTION

The UK National Ecosystem Assessment (2012: 1) defines ecosystem services as "the benefits provided by ecosystems that contribute to making human life both possible and worth living." These benefits are both tangible—such as the provisioning of food and water, climate regulation, economic stimulation, and educational opportunities—and intangible, such as the generation of social capital, cultural meaning, and spiritual enjoyment (MA 2005; deGroot et al. 2009; Ibes 2011).

Urban parks and civic spaces—outdoor, public land uses in a city—are key providers of a diverse range of ecosystem services in cities, and so contribute to urban resilience and sustainability (Bolund and Hunhammer 1999; Tratalos et al. 2007). Vegetation in parks has been linked to enhanced air and water quality, microclimate cooling, flood mitigation, and reduced energy consumption. Trees remove carbon dioxide from the air, release oxygen, and filter suspended particles and storm water (Woudstra and Fieldhouse 2000; Sherer 2003). Civic spaces also provide economic benefits to communities by increasing nearby property values and attracting tourism (Lutzenhiser and Netusil 2001; Nicholls and Crompton 2005; Harnik and Welle 2009). Access to parks has been shown to enhance the physical, mental, and spiritual health and well-being of urban residents, while reducing rates of depression, obesity, and attention disorders (Sherer 2003; Chiesura 2004; Bedimo-Rung et al. 2005; Louv 2005).

Given the important role parks play in the provisioning of urban ecosystem services (Bolund and Hunhammer 1999; Chiesura 2004; Andersson 2006; Nowak et al. 2008) and evidence that urban form significantly impacts service provisioning (Tratalos et al. 2007), there is growing consensus that ecosystem service considerations should be integrated into park planning, policy, management, and design (Cadenasso and Pickett 2008; Lovell and Johnson 2009; Sander 2009; Schilling 2010; Ibes 2011). Effectively providing and managing ecosystem services in desert cities is particularly beneficial, as this can be a means of promoting social, economic, and environmental sustainability in these landscapes, considered some of the most unsustainable on Earth (Ross 2011). Although other urban open spaces, such as native residential landscaping and private parks, also deliver ecosystem services, public spaces have the advantage of being publically owned and managed. This allows for the coordination of design and management on vast spatial and temporal scales and does not require navigating the complex realm of private property ownership and rights.

Yet, despite widespread agreement of its importance, the formal and systematic integration of ecosystem services into planning and design, is limited for a number of reasons that must be resolved before it can be effectively incorporated. These limitations stem from the natural science genesis of the ecosystem services model, disregard of geographic context and service tradeoffs (particularly in arid regions), ideological tensions between urban planning and ecological discourses, and the absence of accessible, balanced tools and standards for implementation.

With the aim of advancing ecosystem service applications in cities, the present research updates and improves an existing, popular, open source planning tool for civic space design by augmenting it with multiple ecosystem service considerations and tailoring it to desert cities. The resultant open-source Urban Park Ecosystem Services planning tool, and its accompanying standards, provides a civic space typology for arid cities, complete with context-appropriate design guidelines for enhancing four key ecosystem services—recreation, social/civic benefits, cooling, and biodiversity—in various civic space types across the urban-to-rural gradient of an urbanized region. Guidelines detail the proper size, service area, primary landscaping type and orientation, and spatial context of each park type, as well as the appropriate and expected magnitude of provisioning for each service. Development of the tool and standards is informed by an extensive review of existing tools for assessing and managing ecosystem services, and interdisciplinary literature from the fields of geography, public health, environmental justice, leisure science, urban and ecosystem ecology, landscape architecture, and climatology. Although designed specifically for a desert city, Phoenix, Arizona, UPES can be customized to other cities, reflecting their unique geographic conditions and preferences.

Obstacles to Integration

The integration of ecosystem services into planning and design is limited first, because the model was originally designed for non-urban landscapes, principally by natural scientists, and as such is not well-suited to the built environment. Research that has explicitly studied ecosystem services in cities, focus on ecological processes *in* the city, rather than *of* the city (Collins et al. 2000; e.g. Bolund and Hunhammer 1999). These perspectives do not fully integrate human and built elements into urban ecosystem models, presumably because they fail to recognize the city as an ecosystem in its own right, composed of interacting ecological, social, and built systems (e.g. MA 2005). Proper assimilation of the built environment, as well as cultural and economic services, which represent key anthropocentric values in cities, is therefore required to make the model relevant to urbanized regions (Kinzig 2009; Ibes 2011).

A second issue is that the ecosystem services framework, as applied to urban parks in particular, lacks balanced geographic, contextual, and spatial considerations. No distinction is made between the appropriateness and potential benefits of a square versus a nature preserve in the city center versus on the urban fringe. Certainly not all civic spaces in a city can, or should, be expected to provide all possible ecosystem services (e.g. wildlife preservation, social benefit, and storm water mitigation); in most cases, tradeoffs must be made. Failure to consider the place-specific tradeoffs, impacts on urban form (e.g. contribution to sprawl), potential disservices, and overall effectiveness of urban park ecosystem service provisioning may result in detrimental, rather than favorable, outcomes. In an assessment of the sustainability of a greenway system, Lindsey (2003) focused on six principles: harmony with nature, livable built environments, place-based economy, equity, polluters pay, and responsible regionalism. Findings revealed that some principles were prioritized over others and that enhancement of one principle often degraded another. Likewise, research on two parks in Barcelona revealed that one of the parks successfully contributed to the social, political, and environmental dimensions of sustainability, while the other ignored all but the environmental dimension (Saurí et al. 2009). Parés and Saurí (2007) argue that urban open spaces with negative environmental impact can still be considered valuable and appropriate if they fulfill social or political sustainability goals; meanwhile other parks may emphasize environmental objectives. Campbell (1996) attacks this quandary from the planning perspective, recognizing that it is not only unnecessary, but also impossible to give equal balance to all the dimensions of sustainability in every situation.

Urbanists warn that expansive greenway and park systems may disrupt the urban fabric, exacerbating sprawling development and reducing overall access to civic spaces (Kunstler 1996; Talen 2010a). Other scholars question the validity of emphasizing ecological functioning in every area of a city (or in every park), suggesting it is appropriate to have some places where social services take center stage (Parés and Saurí 2007; Saurí et al. 2009)[1]. Such perspectives suggest that balanced approaches to urban planning that consider what ecosystem services should be emphasized, and *where*, are necessary for the maintenance of coherent, sustainable urban form.

Management of ecosystem service tradeoffs in arid urban regions is particularly challenging, understudied, and misunderstood. For example, recent studies of arid city urban tree programs concluded that some expected results (e.g. carbon sequestration, air quality) were at best relatively insignificant and, at worst, negative due to the high water demand of trees and negative feedback from residents (Pincetl 2010; Pataki et al. 2011). Further, urban park and civic space research tends to focus only on the benefits of *green* space (e.g. Maas et al. 2006; CABE Space 2010; Schilling 2010). Such terminology may be figurative, essentially referring to natural, undeveloped lands, but distinctions should be made for the sake of public understanding and to promote appreciation for (and highlight the ecosystem services provided by) both native desert landscapes and grey infrastructure (e.g. playgrounds, plazas). This is particularly crucial in arid cities where water requirements for widespread urban greening is environmentally and economically impractical and counterproductive (Parés and Saurí 2007; Pataki et al. 2011). Jenerette et al. (2011: 2637) warns that,

> "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."

Further, civic space research frequently ignores native desert urban parks. As such, the potential benefits of such *brown infrastructure* is grossly underappreciated and misunderstood, and there exists few design standards for protecting and enhancing its value. Surely, the 16,000-acre native desert landscape at South Mountain Preserve in Phoenix has ecological value, and a hike to Dobbins Lookout at 2300 feet can be physically and spiritually exhilarating.

A third limitation to successful integration of ecosystem services into urban planning stems from the ideological tensions between and within urban planning and ecological discourses. This strain is clearly played out in the debate over the ecological value of novel ecosystems, or landscapes that have been "heavily influenced by humans" (Marris 2009: 450), including urban parks. Some scholars tout the ecological potential and importance of these landscapes, while others consider them "ecological disasters, where biodiversity has been decimated and ecosystem functions are in tatters" (Marris 2009: 452). These ideological tensions are also entertainingly played out in the ongoing "street fight" between two influential sets of urbanists (Steuteville 2011: 1). Landscape urbanists criticize New Urbanism for clinging to outdated neoclassical designs, paying only lip service to ecological considerations, and

[1] For more comprehensive discussions of managing ecosystem service tradeoffs in landuse planning and decision-making see UNEP 2011; Goldstein et al. 2012; Howe et al. 2014; and others.

promoting environmentally degrading compact urban form (Munson 2011; Steuteville 2011). From the other side, New Urbanist Emily Talen (2010b: 2) critiques landscape urbanist rhetoric by writing,

> "Beyond the jargon and the wasting of everyone's time, by far the most serious problem with landscape urbanism is that it completely leaves out of the discussion something many of us consider to be pretty essential: humans… they seem not to understand, nor care about, people going to work, looking for jobs, riding the bus, raising families, buying groceries."

These heated debates reflect age-old disputes about what constitutes "nature," what kind of nature is valuable and why, and if humans (and their settlements) are part of, or outside of, the natural world.

The final major limitation to the successful integration of ecosystem service considerations into civic space planning and design is the absence of accessible, balanced tools and standards for implementation (Tzoulas 2007; Sander 2009; Schilling 2010). Urban scholars have highlighted the need for a planning approach that synthesizes and balances the tradeoffs of multiple biophysical and socio-economic perspectives across multiple spatial scales (Sander 2009; Schilling 2010), and also details, "how different land uses can be configured for greater support of biodiversity and ecosystem services" (Colding 2007: 46). Further, scholars argue, such a tool can only be effectively and efficiently mobilized by urban planners and designers (Gutman 2007). Duany and Talen (2002: 244) assert that what is needed to balance environmental goals and coherent, sustainable urban form is a complete "reworking of the tools of planning implementation" and new "regulatory devices" that integrate the goals of multiple stakeholders, including conservationists, architects, designers, landscape architects, and transportation planners.

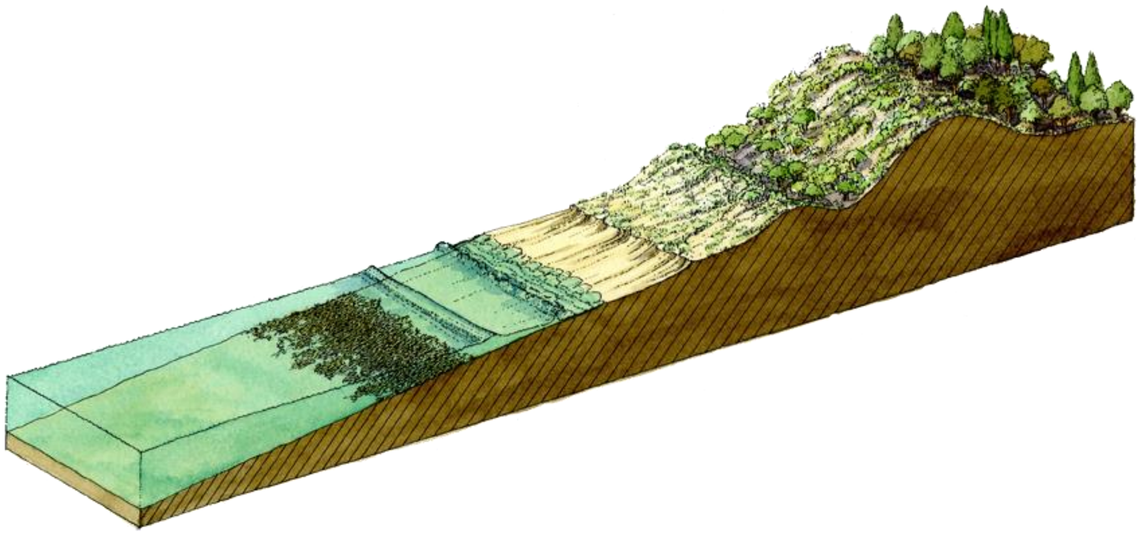
Seeking to resolve the current limitations and provide an integrated regulatory planning device, the present study adapts the ecosystem services model to an urban context, integrates it into an existing planning tool, and balances multiple services across an urbanize region. The Urban Park Ecosystem Services planning tool and standards (UPES) also draws from transect planning theory to overcome the historic, geographic, and ideological limitations to integrating ecosystem services into urban park planning and design.

Transect Planning

Conventional urban planning in the United States follows the Euclidean model of zoning, which emphasizes low-density, sprawling, auto-centric development and the separation of land uses. This approach has been blamed for a host of social, economic, and ecological problems both within and beyond urban boundaries, including increased land and resource consumption, pollution, traffic congestion, impeded access to social services, degraded human health and quality of life, economic inequality, and ecological decline (Hall 2007; Gonzalez 2009; Barnett 2011). An alternative to Euclidean zoning, Transect Planning is a context-sensitive, form-based approach to zoning reform that promotes the evolution of compact, sustainable urban forms that support a diversity of habitats for human and natural systems (Duany 2002; Duany and Talen

2002; Bess 2006). The transect model has its roots in ecology. At a local scale, a waterfront region exemplifies an ecological transect wherein a perpetually wet zone (e.g. lake) transitions into to a wet/dry zone (e.g. beach), and eventually to dry land (e.g. scrubland to forest). Each zone contains a unique mix of plant, animal, and insect species specially adapted to the conditions of that location (Figure 4.1).

Figure 4.1 Example of an ecological transect (CATS 2013)



In the context of human settlements, transect planning seeks "the proper balance between human-made and natural environments" (Duany and Talen 2002: 247), by defining habitat types (i.e. transect zones) across a range of urban intensities from undisturbed wild lands to formally designed, dense urban centers. Each zone maintains a character of place by organizing specific urban elements in a way that is "true to locational character" (Duany and Talen 2002: 146). Transect planning is codified in the SmartCode manual, a multi-scalar planning and regulatory tool designed to guide the development (and redevelopment) of more sustainable, context-sensitive human settlements (CATS 2013, *Codes*). The approach can be calibrated to local social and ecological conditions and preferences at multiple scales (e.g. block, neighborhood, city, region).

In the SmartCode manual, the built environment is organized into a typology of six transect zones: Preserve (T1), Reserve (T2), Sub-urban (T3), General Urban (T4), Urban Center (T5), and Urban Core (T6) (see Figure 4.2). The distinctive characteristics of these zones, referred to as T-zones, are outlined in Table 4.1. *Special Districts* (SD) are an exception to the standard SmartCode zone guidelines. These zones consist of "areas with buildings that by their function, disposition, or configuration cannot, or should not, conform to one or more of the six normative Transect Zones" (SmartCode 2009: xi). Examples include university campuses, historic sites, and other places of natural and/or cultural significance. This exception would also apply to parks of particular social, natural, cultural, or historic significance—such as Central Park in New York City or the National Memorial Parks in Washington, D.C. As such, new or existing parks that fall outside of these guidelines are permitted, given sufficient justification of their significance.

Figure 4.2 Transect zones in SmartCode (2009)

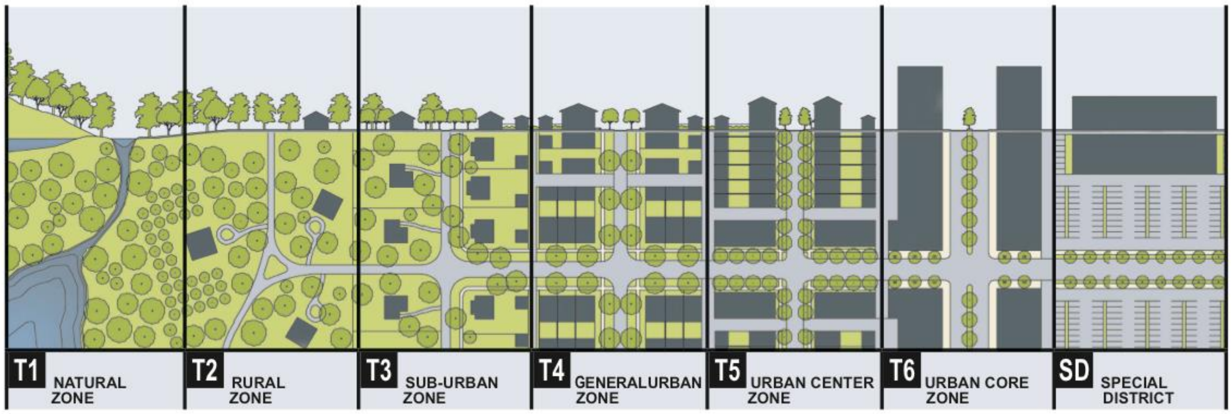


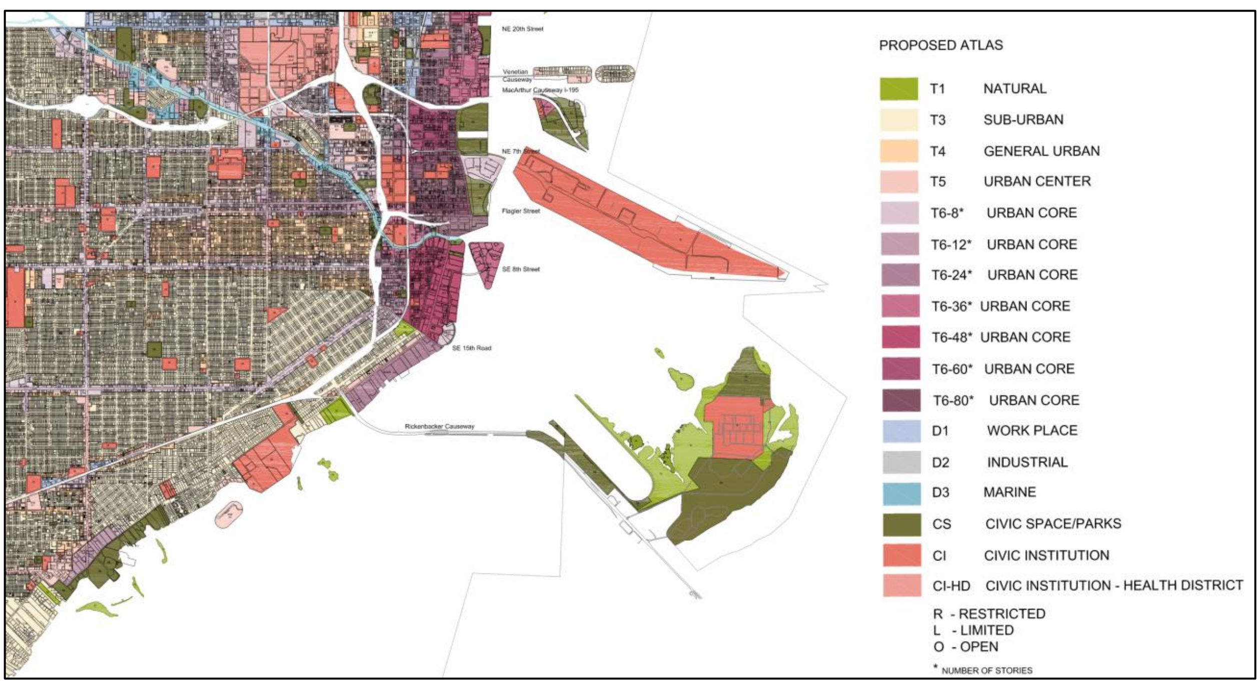
Table 4.1 Primary characteristics of each transect zone as outlined in SmartCode (2009)

	Overview	General Character
T1-Natural (or preserve)	Consists of lands approximating or reverting to a wilderness condition, including lands unsuitable for settlement due to topography, hydrology, or vegetation.	Natural landscape with some agricultural use
T2- Rural (or reserve)	Consists of sparsely settled lands in open or cultivated states. These include woodland, agricultural land, grassland, and irrigable desert. Typical buildings are farmhouses, agricultural buildings, cabins, and villas.	Primarily agricultural with woodlands, wetlands, and scattered buildings
T3- Sub-urban	Consists of low-density residential areas, adjacent to higher zones with some mixed use. Home occupations and outbuildings are allowed. Planting is naturalistic and setbacks are relatively deep. Blocks may be large and the roads irregular to accommodate natural conditions.	Lawns, and landscaped yards surrounding detached single-family houses; occasional pedestrians
T4- General Urban	Consists of a mixed use but primarily residential urban fabric. It may have a wide range of building types: single, side yard, and row houses. Setbacks and landscaping are variable. Streets with curbs and sidewalks define medium-sized blocks.	Mix of houses, townhouses & small apartment buildings, with scattered commercial activity; balance between landscape and buildings; presence of pedestrians

T5- Urban Center	Consists of higher density mixed-use buildings that accommodate retail, offices, row houses and apartments. It has a tight network of streets, with wide sidewalks, steady street tree planting and buildings set close to the sidewalks.	Shops mixed with townhouses, larger apartment houses, offices, and civic buildings; predominantly attached buildings; trees within the public right-of-way; substantial pedestrian activity
T6- Urban Core	Consists of the highest density and height, with the greatest variety of uses, and civic buildings of regional importance. It may have larger blocks; streets have steady street tree planting and buildings are set close to wide sidewalks. Typically only large towns and cities have an urban core zone.	Medium to high-density mixed-use buildings, entertainment, civic, and cultural uses. Attached buildings form a continuous street wall; trees within the public right-of-way; highest pedestrian and transit activity

In practice, T-zones rarely (if ever) follow a perfect urban-to-rural continuum or concentric circle pattern of dense urban core to natural zones, but are instead arranged in relation to existing urban form and planned, desired patterns of growth (or restricted development) (See Figure 4.3). For example, a university campus may abut a wildlife refuge on one side and a planned dense, mixed-use development on another. In this way, the transect supports a spectrum of anthropocentric to eco-centric habitats, including areas of human and wildlife co-habitation (e.g. farms in rural areas and wildlife habitats in city parks).

Figure 4.3 In practice, T-zones rarely follow a strict urban to rural continuum, as demonstrated by this excerpt from the City of Miami's transect form-based zoning code (City of Miami Planning Department 2008)



As applied to the planning of urban parks, transect theory would assert that, in general, a 300-acre nature preserve is most appropriately located in or near a natural or rural zone, while a half-acre plaza is best situated in a dense, built up urban core bustling with retail and high-density residential dwellings. By extension, such an approach allows for certain goals (or ecosystem services) to be prioritized in certain civic spaces, balancing out the multiple goals across a city where they are most appropriate. Social and civic ecosystem services would be most aptly emphasized in more developed (i.e. urban) transect zones, while native biodiversity protection (which requires minimally-disturbed, native landscapes) would be emphasized in less developed rural areas and wild lands.

The transect approach, as operationalized in SmartCode, reconciles many of the limitations that have hampered the successful integration of ecosystem services into urban park planning, particularly in arid cities. As the approach recognizes the place-specific conditions and qualities of heterogeneous urban landscapes, it provides an integrative model of human and natural systems that allows for the incorporation of an array of ecosystem services across a region. Since SmartCode is open-source and already in use by planners, it is also accessible and familiar. In addition, the Code provides an organized but integrative structure for uniting both human and natural considerations as it is aligned with core ecological principles of diversity, evolution, adaptation, and habitat gradients (Talen 2002, 2009). Finally, because the Code is customizable, the approach can easily be adapted to address the particular characteristics and needs of a diverse range of cities.

Incorporating the ecosystem service framework into the SmartCode protocol also presents an opportunity to improve the Code itself. A common critique of SmartCode, and New Urbanist practice more broadly, is that such approaches are “too narrowly aligned with architectural sensibilities” and lack rigorous, scientifically-based “ecological considerations” (Krieger 2010: 1). With respect to civic space design, the Code is both simplistic and lacking clear ecological and environmental standards from scientific, empirical research. The current typology dedicates a single page to civic space design, outlining five categories—parks, greens, squares, plazas, and playgrounds—accompanied by rudimentary guidelines specifying the size, use, and landscape type appropriate for each. Considering the increasingly widespread use of this document to guide planning and design—most recently the complete rezoning of Miami, Florida (City of Miami Planning Department 2008)—the scant attention paid to the ecological characteristics of civic spaces highlights a critical gap, but also a unique opportunity to incorporate the ecosystem services concept into a popular urban planning tool.

UPES DEVELOPMENT

In the development of the Urban Park Ecosystem Services planning tool and standards (UPES), this study progressed through three principal phases. The first step involved creating landscape design guidelines for a suite of key arid region urban park ecosystem services across a gradient of urban-to-natural landscapes. This phase was informed by a review of existing ecosystem service management tools as well as literature from a number of relevant fields. The four services included in the new tool include recreation, social/civic benefits, microclimate cooling, and biodiversity protection. These services were chosen for the study as they represent fundamental characteristics of successful civic spaces, are well-researched, engage both social and natural science ideologies, and are amenable to transformation into design guidelines (Jacobs 1961; Whyte 1980; Mitchell 2003; Sherer 2003; Forsyth and Musacchio 2005; Giles-Corti et al. 2005; Low et al. 2005; Talen 2010a; Faeth et al. 2011; Nowak and Heisler 2011; NRPA 2012). These are not the only important benefits of civic spaces; however, it is beyond the scope of this article to incorporate all possible services. Instead, UPES represents a starting point and model for integrating ecosystem services into urban park planning and design, encouraging the integration of additional benefits, as deemed appropriate and desired by communities and decision-makers.

In the second phase, SmartCode civic space typologies and the existing park classification system in the case study site are analyzed, critiqued, and compared. The strengths and weaknesses of each system as applied to civic space planning across an urbanized region are identified, informed by the aforementioned review of literature. The documents referenced in this phase include the two most recent City of Phoenix General Plans (2002 and 2015) and the most current SmartCode (2009) manual. SmartCode represents an organized, cost-effective, and flexible planning code that can be easily adapted to local conditions and allows for the integration of multiple social and ecological (i.e. ecosystem service) considerations in park planning and design. Further, SmartCode, which is already in use and continuing to gain favor among urban planners and designers, will facilitate the adoption of this new tool.

Based on the findings of the previous phases and associated literature, the final step of the study involved augmenting SmartCode with ecosystem service considerations tailored specifically to arid urban ecosystems. Here, design guidelines for the four ecosystem services considered in this study were attached to appropriate civic space types, emphasizing a range of eco-centric to anthropocentric values as appropriate to their context. Specific determinations were based on which type of landscape could most effectively and efficiently provide each service, as well as where (across the urban-to-natural gradient) each service was most essential. Given the range of possible interpretations and geographic variations, the final design specifications are not meant to be rigidly followed, but should be informed by site-specific natural, social science, planning, and design expertise. As such, this research does not represent an end, but a start to the systematic integration of multidisciplinary science into the SmartCode, park planning, design, and management.

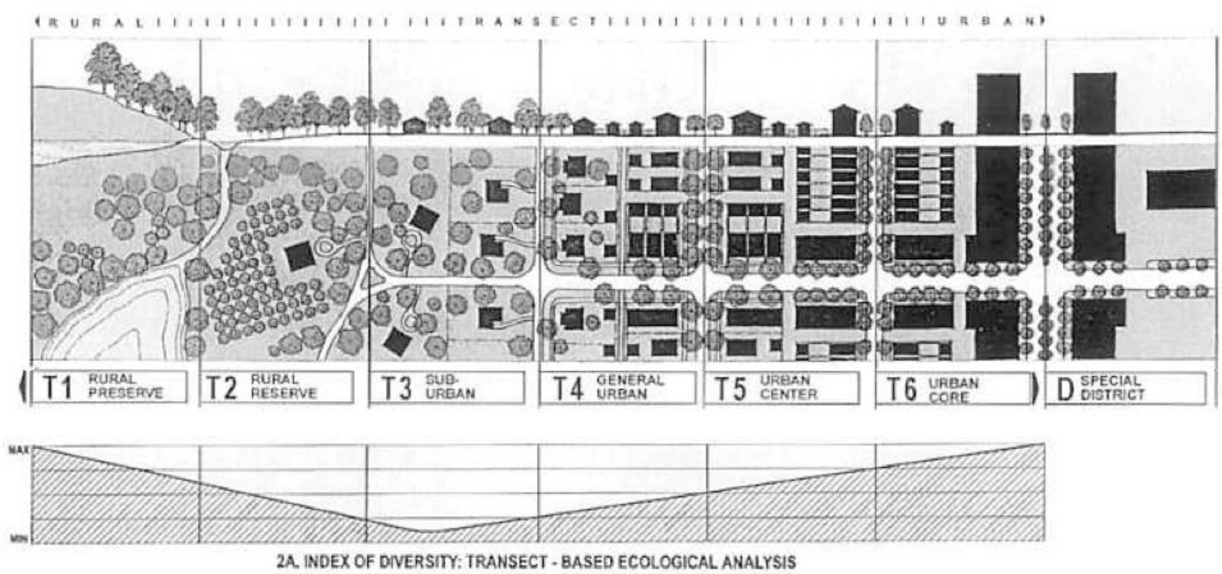
RESULTS & DISCUSSION

Design for Enhanced Urban Park Ecosystem Services across the Transect

The first component of this study involved an assessment of existing tools for managing ecosystem services, an extensive review of literature related to ecosystem service provisioning in urban landscapes, and the development of criteria for enhancing a range of ecosystem services in different civic space types. While there are a number of other critical urban park ecosystem services that could be integrated into these standards, this study focused on a suite of four direct benefits that are particularly critical to human and biological health and well-being in hot, arid urban park spaces: recreation, social/civic benefits, microclimate cooling, and biodiversity protection. The review drew primarily from the fields of urban planning, public health, geography, environmental justice, leisure science, urban and ecosystem ecology, landscape architecture, and climatology.

Tailored to arid cities, the following section outlines the review findings and resultant guidelines for civic space design in the most urban to most natural zones, and the transitional spaces between them. A central tenet of these guidelines is that the benefits of the entire park system should be maximized while fostering the growth and development of a coherent urban form including one or more compact, walkable urban nodes (where feasible and appropriate), as well as a diversity of human and non-human habitat types, from suburban to natural zones. Also in alignment with transect theory, these guidelines emphasize native biodiversity in the natural and rural zones, and social benefits in the urban core, assuming the lowest of each in the suburban zones as illustrated by Figure 4.4.

Figure 4.4 Excerpt taken from Duany (2002: 257). The bottom figure shows a "hypothetical level of diversity for each transect zone."



Existing Tools

Various tools have been developed to assess and manage ecosystem services in diverse landscapes. These tools are valuable in the quest to integrate ecosystem services into urban planning and design, yet their widespread use by planners is hampered by one or more limitations. Specifically, several tools require a high degree of expertise to translate their recommendations into user-friendly, standardized planning guidelines, while others outline theoretical frameworks rather than providing clear steps to implementation. Some tools do not allow for the prioritization of multiple ecosystem service services across an urbanized region and/or are not conducive to application at various scales and in different urban contexts (e.g. small towns versus large metropolitan areas).

InVEST (Integrated Valuation of Ecosystem Services and Tradeoffs; Natural Capital Project 2015) is open-source software that "provides information about how changes in ecosystems are likely to lead to changes in the flows of benefits to people." InVEST is a sophisticated and valuable tool for decision-making, but the time and level of expertise required to set up, analyze, and implement the recommendations limit its widespread usability by city planners and park managers.

The software suite iTree was developed by the USDA Forest Service to analyze and assess urban forestry. Its potential for managing tress in civic spaces is substantial, but the use of software by park planners is limited by its exclusive focus on trees.

The Federal Resources Management and Ecosystem Services (FRMES) guidebook outlines "common methods for incorporating ecosystem services considerations into decision making" that can be integrated into other decision-making frameworks (Duke Nicholas Institute 2015). The concepts, processes, and methods outlined in the book are a valuable reference for cities looking to integrate ecosystem services into planning, design, and management, but as it is specifically tailored to use by U.S. federal agencies, its application in other contexts proves a barrier to widespread adoption.

The Economics of Ecosystems and Biodiversity (TEEB) manual details "a structured approach to valuation that helps decision-makers recognize the wide range of benefits provided by ecosystems and biodiversity, demonstrate their values in economic terms and, where appropriate, capture those values in decision-making" (TEEB 2015). TEED reports and case studies provide a wealth of guidance for managing services, but require a high level of expertise and time, that many park planners and designers may not possess, in order to integrate the guidance into park planning.

Recreation

The ability to support physical activity represents a fundamental role of urban parks. Access to parks is correlated with increased levels of physical activity (Bedimo-Rung et al. 2005; Giles-Corti et al. 2005), which in turn promotes a physically and mentally healthy urban population (Orsega-Smith et al. 2004; Bedimo-Rung et al. 2005; Maller et al. 2005). Access to parks has repeatedly been linked to decreased rates of obesity (Kaczynski and Henderson 2007), a growing epidemic in the United States particularly among minority and low-income populations (Ogden et al. 2006).

The provisioning of recreation in urban parks is related to park size, accessibility, physical condition, safety, aesthetics, facilities, and the built environment. Larger parks have been linked to increased rates of physical activity in communities and proximity to parks has been shown to increase park use, as well as the frequency and level of physical exercise by urban residents (NRPA 2012). Giles-Corti et al. (2005) correlate access to public open spaces with increased physical activity, especially at more proximate, large, scenic parks. The level of physical activity engaged in by urban residents is highly influenced by their ability to walk to a civic space (NRPA 2012). Studies show that adults and youth who live within a half mile of a park exercise two to five times more per week than other urban residents (Frank et al. 2007;

Kaczynski and Henderson 2007). A commonly cited distance threshold for regular use is a quarter mile, meaning that ideally all city residents would be within a five-minute walk of some type of park (Thwaites et al. 2005; Boone et al. 2009). This is not to say that parks beyond walking distance are not valuable urban amenities, but only that their accessibility may be limited, particularly by low-income and limited-mobility populations (e.g. elderly, disabled, those without cars).

The condition, safety, and aesthetics of park grounds and facilities also impact park use for recreational purposes. The frequency of park use and overall activity levels are higher in safe, scenic parks with well-maintained facilities (Coen and Ross 2006; Cohen et al. 2006; NRPA 2012). Park safety can be said to encompass both perceived and actual safety. The condition of parks and surrounding areas, including the presence of graffiti, refuse, or other signs of vandalism, can impair perceived safety (Quebec en Forme 2011). Objective personal safety in parks is related to actual crime rates in parks and surrounding areas, which often leads to reduced park use, which can subsequently attract more criminal activity (Crompton 2001; Bedimo-Rung et al. 2005). Park aesthetics are the "perceived attractiveness and appeal of the various design elements of a park" (Bedimo-Rung et al. 2005: 165). Certain aesthetic features are extremely influential in park use, including landscaping, topography, and the presence of art and water features. Some important design issues include the size of a park, its layout, landscaping, the balance between sun and shade, topography, ease of access, visual appeal, and other features such as ponds or sculptures (Bedimo-Rung et al. 2005; Giles-Corti et al. 2005).

The specific amenities, facilities, and features of a park also play an important role in the use of parks for recreational purposes. Generally, more recreational facilities lead to increased levels of physical activity (Li et al. 2005; Rosenberger et al. 2005). The quality and condition of facilities are also a factor, wherein newer and/or better-maintained features often increase activity (Bedimo-Rung et al. 2005). Specific types of amenities are particularly influential in spurring physical activity, including trails, playgrounds, and sports complexes (Kaczynski et al. 2008; Floyd et al. 2008; NRPA 2012). In fact, parks with trails (paved or unpaved) and forested areas were found to increase physical activity levels sevenfold by Kaczynski et al. (2008). Features that support physical activity and prolong park visits, such as bicycle racks and restrooms, further extend use (Kaczynski et al. 2008). Vigorous levels of physical activity are encouraged by the presence of playgrounds, ball courts, and fields (Floyd et al. 2008).

The built environment surrounding urban parks is a final key determinant of park use for recreational purposes. Use is limited by the presence of low-density housing, single land uses, or poor access. Particularly in zones of high urban intensity, access to parks and related recreational benefits can be amplified by boosting housing density around parks and increasing the diversity of surrounding land uses, particularly active uses (e.g. hotels, bars, restaurants). Other methods include creating a sense of enclosure around parks with landscaping and building frontages to make the space a "positive feature" of the landscape, creating a central focal point or feature, and constructing permeable perimeters that are pedestrian and bike friendly (Jacobs 1961; Talen 2010a).

Recreation Across the Transect

The UPES prioritizes recreational provisioning along the transect where there is a higher density of people, while the specific types of facilities are related to the given social and environmental context. For example, areas of higher population density are targeted because they have more people overall but also because these neighborhoods tend to have more lower-income populations, higher rates of obesity, and less access to private outdoor lawns (Mokdad et al. 2003; Papas et al. 2007). The appropriateness of specific recreational facilities is related to the built context, wherein extensive hiking trails are best supported by large nature preserves and playgrounds more suited to small neighborhood parks.

Civic spaces in the most urban transect zones of desert cities such as Phoenix can best support recreation by being within close proximity to residents, particularly in areas with high density housing and mixed land uses. These parks should be accessible by sidewalks, bicycle paths (with racks for parking), and public transportation. Such parks may support recreation by integrating playgrounds, ball courts, and other exercise equipment suitable to smaller spaces (e.g. exercise stations). The presence of small water features (e.g. fountains, splash pads), drinking fountains, movable seating, shaded areas, food kiosks, and art can also aid in their utilization (Whyte 1980). The landscaping in the parks and the surrounding buildings should create a sense of enclosure and safety.

Civic spaces in the transitional zones between suburban and densely urban areas can encourage recreational use by including larger water features such as ponds and lakes. These parks may include large athletic complexes, swimming pools, playgrounds, paths, trails, picnic tables, and artificial water bodies. Accessibility can be enhanced by extending bus routes to these areas and integrating bike trails (and racks), sidewalks, and walking paths, when possible.

Sparsely developed areas are best suited to larger, more scenic parks, although *Special District* parks supersede this rule. Landscaping in these parks should be naturally disposed. Such areas may support low-impact outdoor recreational activities such as hiking, biking, and horseback riding via trails. Portable restrooms, water pumps or fountains, and shaded picnic areas should be provided whenever possible.

Social/Civic Benefits

Jane Jacobs (1961) recounted some of the numerous non-consumptive reasons people visit parks beyond active recreational use: to relax, read, work, show off, find love, meet other people intentionally or spontaneously, retreat from the busyness of the city, connect with nature, entertain children, people watch, or just see what happens. Public parks represent areas where residents can commune, socialize, and form social ties (Coley et al. 1997; Kuo et al. 1998). Parks are also “places were interpersonal and intergroup cooperation and conflict can be worked out in a safe and public forum” (Low et al. 2005: 3). While somewhat intangible, such social and civic uses are of tremendous importance (Boyd and Banzhaf 2006). In this way, public spaces facilitate and support the development of social capital, cultural diversity, equity, justice, and representative political participation (Ferris et al. 2001; Mitchell 2003; Sherer 2003; Parés and Saurí 2007; Seeland et al. 2009).

The ability of civic spaces to successfully deliver social and civic benefits is largely a product of their accessibility, comfort, aesthetics, spatial distribution, and surrounding built environment. First, parks must be where people are; therefore surrounding areas should support high density housing, active and mixed land uses, and infrastructure for public transportation, biking, and walking. Also, particularly in urban centers, there should not be too many parks or too much park acreage, as excessive competition has a way of saturating the market, often resulting in underutilized and degraded public spaces (Jacobs 1961; Harnik 2010; Talen 2010a). Low et al. (2005) present six guidelines for management and promotion of cultural diversity in urban parks. The authors claim parks should represent the history of the local people, create access through proper transportation, be safe, facilitate a variety of uses for a variety of preferences, maintain facilities as well as scenic features, and communicate cultural meaning. Youth development can be facilitated in parks by offering activities and programs that encourage social, intellectual, physical, and emotional health. Such activities could include gardening programs, environmental education tours, and community sporting events (NRPA 2012).

Civic spaces are made comfortable and welcoming by providing seating (preferably movable) in both shaded and open areas, water (e.g. drinking fountains), and food (via farmers markets, food trucks, kiosks, or nearby restaurants). Parents with children, in particular, need these amenities as well as safe places for their children to play. Facilities should therefore be well-maintained, clean, and lit at night. Hardscapes, including paved areas, paths, benches, gazebos, and private nooks also enable park use for social purposes such as children's games, private conversations, and wheelchair access (Jacobs 1961; Harnik 2010).

After years of study, William Whyte (1980) and his team discovered seven key features that enable the use of small urban parks and plazas for social and civic purposes. First, locating a site near a busy street corner can immediately enliven a space. Also important was providing a diversity of seating options including chairs, ledges, and steps in a variety of environmental contexts (i.e. shade, sun, wind). Whyte's research also revealed that trees, places to eat, and accessible water features both attracted people to parks and made them stay longer. Finally, to facilitate engagement between diverse park visitors, the element of *triangulation* was deemed essential. A piece of art, pleasant view, or unusual event could serve this function if it prompted two (or more) strangers to engage in conversation.

Social/Civic Benefits Across the Transect

Overall, the guidelines developed by this study concentrate social and civic park values in areas of high urban intensity. These areas should support a sufficient (though not excessive) number of squares, plazas, and neighborhood parks that contain elements known to facilitate social interaction and civic engagement, including community gatherings, personal expression, and political demonstrations. Where appropriate, these sites should include a variety of seating options in sun and shade, public art, drinking fountains, food vendors, paved areas, gardens, paths, gazebos, and private corners. Further, such parks are best located at busy intersections that already support a vibrant street life. Suitable surrounding land uses include civic buildings (e.g. city hall, libraries, schools, government offices), and mixed commercial and residential land uses. The need for proper infrastructure for public transportation, biking, and walking must also be underscored. Events that promote conservation, education, arts, and culture should be encouraged in small to moderately sized parks (i.e. squares, neighborhood and community parks, rather than preserves). To foster social interaction and inclusion, public art, performances, and other efforts that communicate cultural meaning and history should be integrated into all urban parks, big or small.

Microclimate Cooling

Particularly in arid cities, the cooling benefits of parks and open spaces represent one of the most valuable ecosystem services. Ecosystem services related to urban cooling also have a global impact, reducing global greenhouse gas emissions and regional energy use (Akbari 2002; Baker et al. 2002; Nowak and Heisler 2011). Studies of the Phoenix urban heat island (UHI) have determined that temperature difference between the most intensively built up areas can be up to 13°C higher than surrounding rural lands (Hawkins et al. 2004; Brazel et al. 2007). This heat island effect exacerbates already extreme risks to human health and comfort in hot, arid cities like Phoenix. Park landscapes with open areas, trees, and other vegetation contribute to human health and comfort by providing protection from the sun's heat and ultraviolet rays. These areas also mitigate the heat risks posed by high temperatures and the urban heat island effect via evapotranspiration and the release of radiant heat (Yu and Hien 2006; Jenerette et al. 2011).

The magnitude of cooling provided by various park landscapes is primarily a product of patch size, landscaping, density and extent of vegetation, irrigation practices, and the availability of water. Park size is positively correlated with lower air temperatures relative to surrounding urbanized landscapes (Barradas 1991; Jauregui 1991). Spaces in the middle of large parks can be up to 13°F (7°C) cooler than adjacent areas. Larger parks also have a more significant impact on cooling outside their boundaries than smaller civic spaces, particularly if they contain green vegetation (Nowak and Heisler 2011). The presence of trees and other vegetation considerably increases the cooling benefits of parks (Kalnay and Cai 2003; Jenerette et al. 2007). Urban landscapes with a high percentage of tree coverage (via larger and or more trees), and trees that are tightly planted, have a more significant cooling benefit than areas with few, sparsely planted trees. This effect is especially pronounced during the hot afternoon hours (Spronken-Smith and Oke 1998; Nowak and Heisler 2011). Open grassy areas also contribute to cooler air temperatures both inside and around parks, especially in the morning hours around sunrise (Spronken-Smith and Oke 1998). Irrigation of urban vegetation, xeric or green, greatly enhances the cooling effects of park landscapes in arid cities via evapotranspiration (Brazel et al. 2007; Pearlmutter et al. 2009; Shashua-Bar et al. 2009; Chow et al. 2010).

The cooling influence of parks is most significant during nighttime hours, and the level of cooling provided by different park landscapes (trees vs. open grass) varies by time of day (Nowak and Heisler 2011). Daytime cooling is most dependent on shade and evapotranspiration, while nighttime temperatures are most impacted by the release of heat from impervious surfaces (e.g. pavement and buildings) (Oke et al. 1991; Spronken-Smith and Oke 1998; Nowak and Heisler 2011). As such, parks with trees and irrigated vegetation provide the most intense cooling benefit during the afternoon hours, while grassy parks cool surrounding landscapes most efficiently in the morning and at night (Spronken-Smith and Oke 1998; Pearlmutter et al. 2009; Shashua-Bar et al. 2009). The integration of diverse landscape types in parks, including shaded areas with trees and open turf areas, results in the most beneficial configuration for 24-hour cooling. Finally, the presence of water features in parks, including fountains, ponds, lakes, pools, and splash pads, can enhance heat relief by cooling the human body directly (via evaporation of water from the skin) and cooling the surrounding air (via evapotranspiration of plants) (Nowak and Heisler 2011).

Microclimate Cooling Across the Transect

The need for microclimate cooling aimed at increased human health and comfort is most critical in neighborhoods with high population density and areas with copious impervious cover as they are at the highest risk of heat stress due to the UHI effect. Larger parks in less developed areas can also be managed to provide cooling, but this should be accomplished with minimal disturbance. For example, although the planting of grass over the 16,000-acre South Mountain Park would enhance urban cooling, such practices are in conflict with water and biodiversity conservation practices.

In an effort to balance the cooling benefits of urban parks without contributing to urban sprawl or high water consumption, this study suggests several methods for enhancing microclimate cooling in different civic space types. First, smaller parks in highly urban areas can effectively provide cooling benefits with water features (e.g. ponds, pools, splash pads, fountains), irrigated vegetation, and large, tightly planted trees. Integrating a patch of open lawn in these smaller parks can slightly extend the cooling effects, particularly during the night. Parks in transitional zones may best provide cooling benefits by integrating ponds and lakes and landscaping that includes a mix of trees and large open grassy areas. Larger parks in more rural zones can provide cooling via open space, but should also provide strategically placed, shaded areas for relief during hot days.

Biodiversity

The role of urban landscapes in the protection of biodiversity and conservation efforts overall is a controversial subject, and as such represents the most complex ecosystem service addressed in this study. To begin, there is no consensus among scholars, practitioners, and lay people regarding what type of outcome is desirable and what *kind* of biodiversity is valuable (Marris 2009). Traditionally, the relationship between cities and wildlife protection has been antagonistic. Prompted by the industrial revolution, cities were considered a disturbance to, not protector of, biodiversity; and if there were any benefit of cities it was to keep people and development out of wild lands (Grimm et al. 2008). However this perspective negates the possibility that biodiversity can and should be protected in cities (Ibes 2011).

Yet another perspective on the urban biodiversity debate advocates that cities can play a role in biodiversity protection, but that only native species are valuable. From this angle, non-native flora and fauna are undesirable, and as such, not worthy of protection (Marris 2009). From still another viewpoint, it is not the particular biological composition of a landscape that matters, but rather how that ecosystem is functioning or what services it provides. Some urban scholars argue that there is value in *novel* ecosystems, which contain unique biological communities (i.e. with respect to composition and abundances) due to human alteration and management (Hobbs et al. 2005; Marris 2009). From this perspective, the ecosystems of managed urban landscapes, including urban parks, have been irrevocably changed but efforts to restore these to their previous state may be both impractical and unachievable. Hobbs et al. (2006: 5) suggest human and financial resources should rather be directed to the preservation of existing natural areas, while accepting altered landscapes for "what they are and what benefits they provide." In fact, the benefits, or ecosystem services, provided by novel ecosystems are extensive and include providing habitat for native and non-native species, as well as water filtration, erosion control, and recreation and aesthetic values. Further, there is evidence that such novel landscapes are becoming more the norm than the exception, and for this reason alone should not be disregarded (Marris 2009).

A final matter is that biodiversity is an often oversimplified and misunderstood concept. Species richness refers to the variety of species, while species abundance relates to the number of plant and animal species in a given area. Species evenness is a measure of the distribution of different species in an area. If there were, for example, 250 species of birds in a park but only three types of insects, this would constitute poor evenness. When one speaks of biodiversity or species diversity, this is a measure of both richness and abundance (Tuomisto 2010).

Despite these tensions and complications, there is evidence that urban parks can and do play a role in protecting biodiversity and ecological processes, functioning, and services (Forsyth and Musacchio 2005), even non-native landscapes transformed by human activity (Rosenzweig 2003; Marris 2009). In a survey of research on novel ecosystems, Marris (2009) reported that exotic forest systems may, in fact, contain *more* biodiversity than native forests and support higher rates of nutrient cycling and biomass. This new focus on ecosystem services has thereby transformed perspectives on the biodiversity value and potential of urban landscapes. "Ecosystem-service arguments are powerful enough to get some ecologists to abandon, or at least put to one side, their deep distrust of novel ecosystems," notes Marris (2009: 452).

Biodiversity in cities is controlled directly by humans through the planting of vegetation, and indirectly through the creation of habitat types (e.g. size, landscaping, vegetation) that attract particular biological communities (Faeth et al. 2011). An urban park habitat is a product of the community and structure of plants at the scale of the entire park, or a subsection. Park habitats and the biodiversity they support are related to their size, how fragmented or connected they are, the types and abundance of vegetation, irrigation practices, and the presence of water. Larger parks connected by greenways or other biological corridors support more plant and animal life than small fragmented, isolated landscapes, because smaller parks generally provide fewer resources (i.e. food, water, and shelter) and isolated patches present a barrier to migration (Faeth et al. 2011). In particular, bird and arthropod abundances are lower in smaller patches, while a set of many small parks with diverse landscape types can actually increase bird diversity in cities (Faeth and Kane 1978; Donnelly and Marzluff 2006). In general, minimally developed, larger landscapes and connected urban patches tend to better support biodiversity in cities, particularly native plant and animal life (Faeth et al. 2011).

The local biological community in parks is also influenced by the composition and abundance of vegetation and presence of water features; therefore, the protection of biodiversity in arid city parks requires consideration of both green and *brown* infrastructure. Managed and irrigated green parks in desert cities generally have higher productivity than the surrounding native desert (Imhoff et al. 2000; Kaye et al. 2005). Because of the increased availability of water, food, and habitat, the abundance and richness of animal and insect species are often higher in green parks relative to native and rural desert landscapes (Faeth et al. 2011). Increased vegetation in desert cities, particularly irrigated vegetation, also supports biodiversity year-round by buffering seasonal variations in food and water supplies (Pierotti and Annett 2001; Reichard et al. 2001), and by stabilizing the microclimate (Imhoff et al. 2000; Kaye et al. 2005). Increasing vegetation in parks can therefore serve to increase (primarily non-native) biodiversity in cities (McKinney 2008; Shochat et al. 2010). If the goal is to attract native species, then planting and protecting native plants is the preferred approach (Faeth et al. 2005; Tallamy 2010). Also, existing, undisturbed native desert landscapes should be protected from alterations (e.g. planting trees, grass) to maintain their integrity and the native biological communities they support. Conversion of native desert landscapes significantly alters the composition and functioning of these ecosystems (Marzluff et al. 2001; Chace and Walsh 2006), including productivity and carbon, water, and nitrogen balances (Kaye et al. 2005; Pataki et al. 2006; Gaston et al. 2010). Integrating water features in parks can also enhance patch biodiversity as it both provides a consistent water source and facilitates adaptation of certain species to arid urban ecosystems (Faeth et al. 2005; Shochat et al. 2006). Such water sources could include fountains, ponds, and lakes that are present water year-round.

Biodiversity Across the Transect

As discussed previously, there is no consensus regarding what kind of biodiversity can or should be provided by urban landscapes. Though an impediment to most urban ecological research, this controversy is, in fact, perfectly suited to the transect approach to civic space planning. By design, the transect approach integrates multiple eco-centric and anthropocentric benefits in their proper context. Faeth et al. (2011: 77) note that,

> "The goal of conserving and reconstructing habitats within cities is often to minimize loss of species; however, for this to work, environments must be preserved and created where wildlife and humans can coexist. In urban environments, this usually involves the coexistence of native and nonnative species in the same environment."

Reflecting this sentiment, this study emphasizes the promotion of both native and non-native biodiversity, but prioritizes native biodiversity where feasible, and considers tradeoffs across other ecosystem services. For example, the large minimally-developed mountain preserves in Phoenix are best suited to native biodiversity protection, while smaller neighborhood parks may be less focused on biodiversity protection overall, but may still support non-native biodiversity via green vegetation planted primarily for cooling and social benefits.

The number, composition, and variety of species varies across the gradient of intensely urban to undeveloped wild lands. Understanding of these variations is informed largely by island biogeography theory (MacArthur and Wilson 1967) and the intermediate disturbance hypothesis (Connell 1978; Faeth et al. 2011). Generally, the diversity of species is lowest in built up, paved urban centers and areas that experience frequent or severe disturbances (Marzluff et al. 2001; McKinney 2008). Native biodiversity is generally highest in wild lands outside of the city, though oftentimes the highest biodiversity in urbanized regions occurs in the intermediate or *transitional* zones (McKinney 2008). While in temperate cities the opposite is often the case, frequently in desert cities there is lower richness but greater abundance of bird species (predominately non-native) in non-native green spaces (Germaine et al. 1998; Green and Baker 2003). Broadly, the guidelines in this research emphasize the protection of native biodiversity in preserves and other larger parks in the more rural and natural transect zones. Enhancement of non-native biodiversity is not a priority but may be a secondary benefit of smaller parks in areas of higher urban intensity. The planting of native trees and other vegetation is encouraged in all civic spaces when possible, provided reasonable human and financial resource requirements.

Comparison of SmartCode & City of Phoenix Park Classification Systems

In the next phase of the study, SmartCode and the City of Phoenix park typologies were assessed and compared to direct the modification of SmartCode for arid cities by highlighting the strengths and weakness of each system and revealing opportunities for improvements (Table 4.2).

SmartCode

SmartCode defines urban civic spaces as "outdoor areas dedicated for public use," and outlines five categories: parks, greens, squares, plazas, and playgrounds. A normative and prescriptive document, the SmartCode Manual devotes one of its 58 pages to guidelines for these spaces. On this page each civic space is accompanied by a four to six-sentence description outlining the appropriate use, spatial context, landscaping type, size, and transect zone for each civic space type (Appendix I).

The SmartCode civic space typology has the advantage of being well-organized and easily integrated into urban planning and design across a range of urban-to-natural landscape types. However, the Code's descriptions for the different civic spaces are too vague, generic, and simplistic to guide the meaningful design of diverse park types in a large urban area, particularly in an arid ecosystem. The Code also does not address the intended ecological benefits of these spaces but rather focuses narrowly on civic and recreational benefits, hampering the possibility of creating multi-functional civic spaces that support a range of ecosystem services.

City of Phoenix

In its most recent General Plan, the City of Phoenix (2015) classifies its parks into the following categories: urban parks, neighborhood parks, community parks, district parks, and special facilities. The previous plan, from 2002, included a category of desert parks and mountain preserves (City of Phoenix 2002). The General Plan is descriptive and regulatory, providing descriptions of 64- to 127-words for each park type, outlining their primary purpose, urban context, service area, and examples (Appendix II).

The benefit of the City's park typology is that it represents a variety of park types in an arid urban ecosystem and more explicitly outlines the benefits of these spaces as compared to the SmartCode system. However, the system does have a number of shortcomings. First, it lacks landscaping and other design guidelines for parks. Also, some of the categories overlap and are not mutually exclusive. For example an urban park may also be considered a neighborhood park or special facility. With regard to size, there are gaps in the classification system such that there is no classification for parks that are not urban parks but are less than 15 acres (such as numerous mini parks of under a half acre) or between 15 and 40 acres. Overall, the size specifications are simultaneously ambiguous and unnecessarily limiting. These issues signal areas for improvement of the classification system.

Taken together, the Phoenix and SmartCode park classification systems both lack sufficient guidelines for enhancing microclimate cooling, biodiversity, social and civic benefits, and the recreational value of urban parks. Also, neither system explicitly communicates the significance of native or brown infrastructure in arid regions, with the exception of the 2002 Phoenix General Plan, which includes a classification for Mountain Preserves and Desert Parks. However this category of brown spaces is missing from the 2015 update. More explicit guidelines for enhancing ecosystem services across a gradient of park types would benefit both classification systems.

Table 4.2 Comparison of City of Phoenix and SmartCode park classification systems, including park type characteristics, ecosystem services emphasized, and recommended improvements (SmartCode 2009; City of Phoenix 2002, 2015)

City of Phoenix Park Classifications

Park Type	Size	Primary Purpose	Location	Service Area	Other Details	Ecosystem Service(s) Emphasized	Examples	Needed Improvements
Urban Park	Small	Daytime use, pedestrian respite, beautification	Densely developed urban areas	Not specified	Pedestrian-oriented and feature green open spaces	Passive recreation, aesthetic benefit	Caesar Chavez Plaza, Heritage Square	Needs additional purpose and design guidelines
Neighborhood Park	~15 acres	Active and passive recreation	Within walking or bicycling distance of residences. Often bordered by local or collector streets.	½ mile or 4,000 to 7,000 people	Most include children's playground and picnic areas, open play turf areas, parking, lighted volleyball and basketball courts, and restroom facilities.	Active and passive recreation for general pop & children	Moon Valley, Verde, and Desert Star	Define biking/ walking distance. Does this consider presence of paths/ safety of transportation?
Community Park	~40+ acres	Active recreation	Located on collector or arterial streets	1 ½ mile radius or 20,000-50,000 people	Most include lighted basketball, volleyball, soccer and softball facilities; playgrounds; picnic areas; restrooms, pools, lighted tennis courts, and/or ramadas.	Heavy focus on active recreation	Roadrunner, Circle K, and Falcon Parks	Size guidelines are limiting. Needs additional design guidelines for natural environment.
District Park	200+ acres	Active and passive recreation	On arterial streets, or where size/function will have minimum impact, i.e., commercial/ industrial areas.	5-mile radius; 100,000-200,000 people	May include golf courses, festival area, amphitheater, playgrounds, picnic areas, lighted basketball/ volleyball courts, lighted racquetball/ softball/ soccer/ tennis facilities, restrooms, and ramadas.	Passive/active recreation, entertainment, economic activity, children's recreation	Encanto, Paradise Valley Park, Desert West, and Cave Creek Rec Area	Large parks should include native landscapes to expand ecosystem service provisioning. District/community parks are similar, may be combined.
Desert Parks & Mountain Preserve	7,000 + acres	Ecological preservation* and recreation	Not specified	City-wide	Hiking, mountain bicycling, horseback riding, picnicking, outdoor education, bird watching, and biological field studies.	Recreation, habitat, water quality and provisioning, biodiversity, natural heritage protection	Phoenix Mtn Preserve, Camelback Mtn, South & North Mtns, North, Papago Park.	Should address level of disturbance more specifically and distinguish between desert & mountain parks. Also not all parks should strive to maximize all benefits-prioritize.
Special Facilities	Any size	Are unique in purpose & design	N/A	N/A	Range from historical sites to sites providing very specialized services.	N/A	Cancer Survivors' Park, Rio Salado, Tres Rios, Cactus Gardens.	N/A

* Specifically to maintain hydrologic processes, desert patch and corridor connectivity; avoid land fragmentation, preserve unique and interesting landform mosaics and vegetation types and integrate these into the built environment; preserve lands above 10% slope in undisturbed state (including transition lands and washes) (City of Phoenix 2002).

(**Table 4.2**, *continued*)

SmartCode Civic Space Classifications

Park Type	Size	Description	Primary Purpose	Location	Service Area	Ecosystem Service(s) Emphasized	Examples	Needed Improvements
Playground	Any size	Should be fenced.	Children's recreation	In residential areas or in parks or greens.	Not specified	Recreation for children	N/A	More detail regarding design and landscaping.
Plaza	½ - 2 acres	Open space consisting primarily of pavement; trees optional.	Civic and commercial purposes	Spatially defined by buildings and located at major intersections	Not specified	Civic and economic	N/A	Vague description, too generic to be useful in guiding park design
Square	½ - 5 acres	Open space consisting of paths, lawns, trees. Formally disposed.	Unstructured recreation and civic purposes	Spatially defined by buildings and located at major intersections.	Not specified	Recreation	N/A	Difference between plaza and square is negligible, should be combined.
Green	½ - 8 acres	Open space consisting of lawn and trees. Naturalistically disposed.	Unstructured recreation	Need not be spatially defined by building frontages, may be spatially defined by landscaping	Not specified	Recreation	N/A	Does not consider benefit of 'brown'/ native open space
Park	8+ acres	Natural preserve consisting of paths, tails, meadows, water bodies, woodlands, open shelters. Naturalistically disposed.	Unstructured recreation	May or may not be spatially defined by building frontages, may line natural corridors	Not specified	Recreation	N/A	Overly generic definition of a varied open space type, should be further developed

UPES

Stemming from the findings of the literature review and analysis of park classification systems, the final step in this research was the development of an open source, integrated tool and standards for civic space planning and design, augmented with ecosystem service considerations (Table 4.3). Although the model is customized for Phoenix's park system, slight modifications and local calibration can expand its applicability to other city park systems.

UPES integrated and reconfigured the civic space types from both systems. The new typology includes nine categories, four that are not in the original SmartCode: *desert preserves, desert community parks, desert neighborhood parks,* and *greenways*. *Squares* and *plazas* are combined into a single category (*Square/Plaza*), as they were deemed sufficiently similar. SmartCode's *green* classification is now a *green neighborhood park*, and *park* is a *green community park*. With respect to the City of Phoenix parks classification system, *community* and *district* park categories are now *green community parks* and *desert community parks*, emphasizing the nature of their landscaping and allowing for wider variations in size. *Urban parks* are *squares/plazas* (or designated special facilities) and *neighborhoods parks* are separated into *desert* and *green neighborhood parks*.

The UPES includes specific guidelines for enhancing recreation, social/civic benefits, cooling, and biodiversity in various civic spaces across the urban-to-natural gradient. The appropriate and expected magnitude (level) of provisioning for each service is also noted. Also included are general guidelines with respect to the proper size, service area, primary landscaping type and orientation, and spatial context of each park type. These guidelines signify recommendations, not hard and fast rules.

Reflecting its foundation in SmartCode, UPES is designed to be applied at a variety of scales and contexts by developers, architects, planners, park professionals, community groups, and other decision-makers. UPES can also be used by developers and architects to appropriately situate and design park spaces. For example, a square may be placed at the center of commerce, small pocket parks with playgrounds dispersed among residential developments, and a larger open space located on the fringes of the development. This configuration provides a variety of park types without compromising walkability. City and regional planners can use UPES to assess the current distribution of urban park ecosystem services then apply the tool to prioritize new parks and park updates, highlighting which services to enhance, in which parks, and how. The tool can be used by park "friend groups" and not-for-profit organizations to guide redevelopment of existing parks in a manner that maximizes and balances desired ecosystem services, such as nature appreciation, community health, and biodiversity protection. UPES is not intended to radically alter existing park spaces, but rather guide new development and urban renewal efforts. Using UPES, existing park spaces can be evaluated in terms of their appropriateness to their contexts, and new parks can be designed with a clear sense of purpose and place.

Table 4.3 Urban Park Ecosystem Service (UPES) planning tool and standards

Civic Space Type	Size (approx.)	Service Area	Primary Landscaping & Orientation	Spatial Context
Desert Preserve	1000+ acres	City-wide	Native xeric, natural water bodies	Independent of building frontages or formal landscaping. Surrounding areas mainly low-density residential, farms, & natural areas
Desert Community Park	20+ acres	1-5 miles radius; 20,000-200,000 people	Native xeric, naturally disposed, natural water bodies	Located in low to moderate density residential and/or commercial areas. May be spatially defined by landscaping.
Green Community Park	20+ acres	1-5 miles radius; 20,000-200,000 people	Mix of native vegetation and non-native, irrigated, naturally disposed green grass and trees.	Located in low to moderate density residential and/or commercial areas. May be spatially defined by landscaping.
Desert Neighborhood Park	1-20 acres	1/2 mile; 4000-7000 people	Native xeric	In densely populated areas easily accessible by walking/biking and public transportation.
Green Neighborhood Park	1-20 acres	1/2 mile; 4000-7000 people	Non-native, irrigated naturally disposed green grass and trees.	In densely populated areas easily accessible by walking/biking and public transportation.
Square/Plaza	Up to five acres	1/4 mile	May be primarily pavement. Formally disposed mix of native xeric and non-native, irrigated green vegetation.	At the intersection of important thoroughfares with sidewalks, bike/walking paths, surrounded by civic buildings and mixed commercial and residential land uses. Spatially defined by building frontages.
Playground	Any size	1/4 mile	Primarily pavement or sand, little to no vegetation. Should be fenced and contain shaded areas and shelters.	In residential areas or inside other park types.
Greenways & Basins	Any size	City-wide	Linear green space with native vegetation in riparian zones.	Along natural water bodies and corridors.
Special Districts	Any size	City-wide	Varied.	Varied.

(**Table 4.3**, *continued*)

Civic Space Type	Ecosystem Service Prioritization and Design Guidelines			
	Recreation	**Social/Civic**	**Cooling**	**Biodiversity**
Desert Preserve	Low to moderate. May support low-impact outdoor recreational activities such as hiking, biking, and horseback riding via trails/paths. Portable restrooms, water plumps or fountains, and shaded picnic and seating areas should be provided.	Low to moderate. Provisioning of social/civic benefits in these parks may be limited as the priority is on biodiversity protection with some secondary recreation and cooling benefits.	Moderate to high. Cooling provided by maintaining minimally-developed open spaces largely free of impervious surfaces and buildings. Shade should be provided via artificial structures and/or native vegetation. Drinking water should be provided.	High (native). Preservation of intact, minimally-developed native desert patches will contribute most to native biodiversity protection.
Desert Community Park	Moderate to high. Structured & unstructured recreation. May include athletic complexes, pools, playgrounds, paths/trails, picnic facilities, and artificial water bodies. Accessibility facilitated via bike paths, racks, and sidewalks.	Moderate. Events that promote conservation, environmental education, public art, youth development, and culture should be encouraged.	Moderate. Cooling provided by maintaining minimally-developed open spaces largely free of impervious surfaces and buildings. Shade should be provided via artificial structure and/or native vegetation. Drinking water should be provided.	Moderate to high (native). Preservation of intact, minimally-developed native desert patches will contribute most to native biodiversity protection. Native landscaping should be prioritize whenever possible.
Green Community Park	Moderate to high. Structured & unstructured recreation. May include athletic complexes, pools, playgrounds, paths/trails, picnic facilities, and artificial water bodies. Accessibility facilitated via bike paths, racks, and sidewalks.	Moderate. Events that promote conservation, environmental education, public art, youth development, and culture should be encouraged.	High. Cooling benefit can be enhanced by providing a mix of irrigated open grassy areas as well as trees, flowers, and other green vegetation. May include larger water bodies (e.g. ponds and lakes). Drinking water should be provided.	Moderate to high (mixed native and non-native). Irrigated green vegetation, including grass and trees, and year-round water features will enhance primarily exotic biodiversity. Xeric landscaping can be integrated to provide low to moderate biodiversity protection.
Desert Neighborhood Park	Moderate to high. Structured & unstructured recreation. May include public art, playgrounds, ball fields/courts, skate areas, and water features (e.g. swimming/wading pools). Should provide picnic areas, drinking water, restrooms, seating, shaded areas, food (e.g. kiosks, trucks)	Moderate to high. May include a variety of seating options in sun and shade, public art, drinking fountains, food vendors, paved areas, gardens, paths, gazebos, and private corners. Events the promote conservation, education, arts, youth development, and culture should be encouraged.	Low to moderate. Cooling benefits should be enhanced by providing drinking water and shade structures. Drinking water should be provided.	Low to moderate (native). Xeric landscaping can provide moderate biodiversity protection.

(**Table 4.3**, *continued*)

Civic Space Type	**Ecosystem Service Prioritization and Design Guidelines**			
	Recreation	**Social/Civic**	**Cooling**	**Biodiversity**
Green Neighborhood Park	Moderate to high. Structured & unstructured recreation. May include public art, playgrounds, ball fields/courts, skate areas, and water features (e.g. swimming/wading pools). Should provide picnic areas, drinking water, restrooms, seating, shaded areas, food (e.g. kiosks, trucks)	Moderate to high. May include a variety of seating options in sun and shade, public art, drinking fountains, food vendors, paved areas, gardens, paths, gazebos, and private corners. Events the promote conservation, education, arts, youth development, and culture should be encouraged.	Low to moderate. Cooling benefits should be enhanced by providing drinking water and shade structures. Drinking water should be provided.	Low to moderate (mixed native and non-native). Irrigated green vegetation, including grass and trees, and year-round water features will enhance primarily exotic biodiversity. Xeric landscaping can be integrated to provide low to moderate biodiversity protection.
Square/Plaza	Low. Unstructured recreation, civic, and commercial. May include public art, playgrounds, exercise equipment, and wear features suitable to smaller spaces (e.g. exercise stations, fountains, splash pads, fountains). Should provide picnic areas, drinking water, seating, shade, food (e.g. kiosks, trucks).	High. May include a variety of seating options in sun and shade, public art, drinking fountains, food vendors, paved areas, gardens, paths, gazebos, and private nooks.	Low. Limited cooing benefit can be provided via irrigated green vegetation, small water features, and/or tightly planted trees with a dense canopy. Drinking water should be provided.	Low. Limited biodiversity benefits can be gained via year-round water sources, irrigated green vegetation and trees. Native planting may attract native fauna.
Playground	High. Unstructured children's recreation. Should contain children's play equipment. May include public art and water features.	High. To encourage socialization, playground should contain play structures, seating in sun and shade, and drinking water. Restrooms when possible.	Low. Limited cooing benefit can be provided via irrigated green vegetation, small water features, and/or tightly planted trees with a dense canopy. Drinking water should be provided.	Low. Limited biodiversity benefits can be gained via year-round water sources, irrigated green vegetation and trees. Native planting may attract native fauna.
Greenways & Basins	High. Paths/trails along corridors may be integrated to encourage physical activity.	Varied. May include elements of other park types that facilitate social/civic uses as appropriate.	Moderate to high. Cooling benefit via evapotranspiration, will vary based on consistency of water supply and vegetative abundance.	Moderate to high (native and non-native). Vegetation along banks may provide native and exotic habitat.
Special Districts	Low to high, depending on specific site purposes and features. May integrate elements and features of other park types that facilitate recreational uses as appropriate.	Varied. May include elements of other park types that facilitate social/civic uses as appropriate.	Varied. May include elements of other park types that provide cooling benefits as appropriate.	Varied. May include elements of other park types that facilitate biodiversity protection as appropriate.

CONCLUSION

Synthesizing theory and practice from a range of disciplines including urban planning, public health, geography, urban ecology, climatology, and landscape architecture, the product of this research is an accessible tool for logically and systematically integrating multiple ecosystem service considerations into urban park planning practice.

UPES, like InVEST, iTREE, FRMES, TEEB—represents one approach to managing and maximizing ecosystem services. Each tool has its strengths as well as its ideal geographic, spatial, and temporal context. UPES has several strengths in its specific application to civic space planning. One of its strengths is its simplicity. Once it is customized to a particular urban context, it can be understood and applied by planners and developers with limited ecological expertise. UPES is also the first attempt to integrate the ecosystem service framework into SmartCode, a planning protocol already in use by urban planners and developers.

By integrating ecosystem service considerations into SmartCode, UPES synthesizes two powerful and complementary, but individually incomplete approaches to achieving a more sustainable urbanism and capitalizes upon the strengths of each approach, while minimizing their shortcomings. In this way, ecosystem service planning is injected with balanced contextual, spatial considerations necessary for the maintenance of coherent, sustainable urban form. Additionally, by explicitly integrating *brown* spaces, UPES advances an appreciation for, and appropriate design of native desert parks including the consideration of tradeoffs between urban greening and water use. As it is based on existing (and currently used) models and typologies, UPES is familiar and therefore instantly accessible to designers, planners, and decision-makers looking to maximize park ecosystem services across an urbanized region. In addition, UPES improves the popular planning model, SmartCode, by integrating detailed, scientifically-based ecological considerations, as well as considerations of the tradeoffs, feedbacks, and potential synergies between the multiple benefits of urban civic spaces. For this study, the tool and standards were customized for the study area and so represent an arid region model of SmartCode; however, UPES is flexible enough to allow for geographic customization to other cities looking to enhance urban sustainability by integrating ecosystem service consideration into their planning and design.

UPES is not static but represents a dynamic model in the quest to integrate ecosystem service considerations into civic space planning and design. The incorporation of additional services into the model, as well as the potential for calibration to additional city types, embodies a prolific area for future research. Given the dynamic nature of cities, the innumerable potential park ecosystem services, and shifting place-specific tradeoffs and preferences, UPES requires customization. An advanced version of UPES may integrate dozens of ecosystem services—water supply, carbon sequestration, economic stimulation, nature appreciation, environmental educational, health promotion, and others. With the help of natural and social scientists, practitioners, and the wider public, UPES can be continuously refined and augmented to reflect dynamic local geographies, including needs, priorities, and place-specific goals and limitations, advancing sustainable urbanism in cities across the globe.

APPENDIX I

Descriptions from the SmartCode (2009: SC41) manual are as follows:

- *Park*: A natural preserve available for unstructured recreation. A park may be independent of surrounding building frontages. Its landscape shall consist of paths and trails, meadows, woodland and open shelters, all naturalistically disposed. Parks may be lineal, following the trajectories of natural corridors. The minimum size shall be 15 acres. Larger parks may be approved by warrant as districts in all zones.
- *Green*: An open space, available for unstructured recreation. A green may be spatially defined by landscaping rather than building frontages. Its landscape shall consist of lawn and trees, naturalistically disposed. The minimum size shall be 2 acres and the maximum shall be 15 acres.
- *Square*: An open space available for unstructured recreation and civic purposes. A square is spatially defined by building frontages. Its landscape shall consist of paths, lawns and trees, formally disposed. Squares shall be located at the intersection of important thoroughfares. The minimum size shall be 1 acre and the maximum shall be 5 acres.
- *Plaza*: An open space, available for civic purposes and commercial activities. A plaza shall be spatially defined by building frontages. Its landscape shall consist primarily of pavement. Trees are optional. Plazas shall be located at the intersection of important streets. The minimum size shall be 1 acre and the maximum shall be 2 acres.
- *Playground*: An open space designed and equipped for the recreation of children. A playground shall be fenced and may include an open shelter. Playgrounds shall be interspersed within residential areas and may be placed within a block. Playgrounds may be included within parks and greens. There shall be no minimum or maximum size.

APPENDIX II

Extracted from the Phoenix's 2015 General Plan Facility Standards (City of Phoenix 2015: 1-3), with the exception of the description of Mountain Parks and Desert Preserves, which comes from the previous General Plan (2002), as this was not included in the 2015 update.

- *Urban Parks:* Special parks that are small, pedestrian-oriented and feature green open spaces in the midst of the more densely-developed urban areas. They serve the distinct purpose of providing, for daytime use and pedestrian respite, small areas that beautify the streetscapes of buildings and concrete with trees, plants, seating and art. Existing urban park areas are Cancer Survivors, Caesar Chavez Plaza, Heritage Square, and Patriots Square
- *Neighborhood Parks*: Neighborhood parks are designed to serve an area within a radius of one-half mile or a population from 4,000 to 7,000 people; examples include Moon Valley, Verde, and Desert Star. These parks are within walking or bicycling distance of residences and are typically 15 acres in size. Local or collector streets typically border them. Most neighborhood parks include children's playground and picnic areas, open play turf areas, parking, lighted volleyball and basketball courts, and restroom facilities. Planned community developments may also provide neighborhood recreational facilities and open space. However, these areas tend to be small, private, and limited in

recreational opportunities. They are not sufficient to meet a wide range of recreational and public open space needs.

- *Community Parks*: Community parks such as Roadrunner, Circle K, and Falcon serve an area of one and one-half miles and a population of 20,000 to 50,000 people. These parks are typically 40 acres or larger, with active recreation improvements, and are located on collector or arterial streets. Organized team sports, leagues, and large-activity facilities are located in these parks. Most existing community parks include lighted basketball, volleyball, soccer and softball facilities; playgrounds; picnic areas; and restroom facilities. Pools, lighted tennis courts, and ramadas also may be included. Community parks have turf areas that are unprogrammed open spaces, which can be used for a variety of activities and events.
- *District Parks*: District parks draw from several communities and are 200 acres or larger, serving 100,000 to 200,000 people. They provide for active and passive recreation and serve a five-mile service radius. They may include specialized activities such as a golf course, festival area, or an amphitheater. In general, district parks are located on arterial streets, or in areas where the size and function will have minimum impact, i.e., commercial or industrial areas. They also serve the immediate local communities as neighborhood parks or community parks and contain these features: playgrounds and picnic areas, lighted basketball and volleyball courts, lighted racquetball courts, lighted softball and soccer facilities, restroom facilities, lighted tennis courts, and picnic ramadas. District parks include Encanto, Paradise Valley Park, Desert West, and Cave Creek Recreation Area.
- *Mountain Preserves and Desert Parks*: These areas accommodate various recreational and outdoor activities - hiking, mountain bicycling, horseback riding, picnicking, outdoor education, bird watching, and biological field studies. Ecological principles included are: (1) hydrologic processes should be maintained, (2) connectivity of desert patches and corridors should be maintained, (3) patches should be as large as possible, (4) unique and interesting mosaics of landforms and vegetation types should be included in the preserve, (5) diverse mosaics should be integrated into the developed human environment, and (6) a preserve should be considered at multiple scales. Another preserve plan recommendation is to preserve lands above the 10 percent slope, including transition lands and washes in their undisturbed state (City of Phoenix General Plan 2002: 283, 287).
- *Special Facilities*: Special facilities fill an important role with the city's park system as amenities that are unique in their purpose, design, and the needs they fulfill. Such sites/amenities range from historical sites to those providing very specialized services. Some of the facilities in this category include Pueblo Grande Museum, Patriots Park, Maryvale Stadium, Phoenix Municipal Stadium, Oakland Athletics' Training Complex, Heritage and Science Park, Shemer Art Center, Cancer Survivors' Park, Rio Salado and Tres Rios, Tovrea Castle with Carraro Cactus Gardens, the Irish Cultural Center, and the Japanese Teahouse Garden.

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