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Sustainable Urban Park Systems

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Lack of multi-dimensional, substantive research on city park systems has undermined the potential role of these public amenities in advancing urban sustainability goals. This study informs holistic policy, planning, and management of parks to balance the multiple goals of sustainability region-wide. A vision for a sustainable urban park system is introduced, informed by multidisciplinary thought and theory. This vision is then operationalized in the development of a quantitative method that examines four key dimensions of sustainability—physical, environmental, socio-economic, and built—across a citywide urban park system. The approach can be customized for use in other cities, but is here applied to Phoenix, Arizona as a proof of concept. Findings demonstrate how a multi-dimensional analysis of an urban park system can provide a more nuanced understanding of these complex human-environment systems, and provide a point of departure for sustainable urban park management and policy as well as future research concerned with balancing multiple sustainability goals in park planning and design.

Keywords
Urban parks, public space, green space, sustainability, sustainable urbanism, policy

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INTRODUCTION

Sustainability is fundamentally concerned with the long-term maximization, balance, and maintenance of social, financial, and natural capital (Goodland 1995). Likewise, sustainable urbanism and sustainable development seek to enhance the health of social, economic, and environmental systems in cities and other developed regions (Campbell 1996; Roseland 2000; IUCN 2006; Adhya et al. 2010). Copious research demonstrates that healthy urban parks provide a host of ecosystem services in cities, contributing to the multiple dimensions of sustainability. These benefits include opportunities for recreation and social integration (Bedimo-Rung et al. 2005; Low et al. 2005), microclimate cooling (McPherson 1994; Bolund and Hunhammar 1999; Jenerette et al. 2011), economic stimulation (Lutzenhiser and Netusil 2001; Irwin 2002), and biodiversity protection (Andersson et al. 2007; Faeth et al. 2011), among others. However, degraded, inequitable, and undesirable urban parks can contradict sustainability efforts (Massey 1994; Madanipour 1999; Marne 2001; Boone et al. 2009). Evaluating the sustainability of urban parks and their ability to contribute to sustainable urbanism more broadly, requires an understanding of their geographic, built, social, and historic context (Jacobs 1961; Low et al. 2005; Parés et al. 2006; Byrne and Wolch 2009; Harnik and Welle 2009), as well as how these diverse and complex human-environment systems function cooperatively across an urbanized region (Duany and Talen 2002). However, the bulk of urban park studies disregard their context and hone in on individual or a small subset of sites, rather than assessing the entire city park system, as a whole. Not all urban parks in all geographic contexts can, or *should*, be designed and managed to provide all possible ecosystem services and benefits (Campbell 1996; Lindsey 2003; Parés and Saurí 2007). More appropriately, the distribution of parks and their associated benefits and services should be sensitive to their geographic context and logically distributed across an urbanized region (Duany 2002; Talen 2010).

This study proposes a vision for a sustainable urban park *system* to guide holistic management, planning, and evaluation. This definition is operationalized by quantitatively examining four key dimensions of sustainability across a citywide urban park system. The paper has five main sections. The first section reviews scholarly literature on the physical, environmental, socioeconomic, and built characteristics of sustainable urban parks, then examines approaches to balancing tradeoffs and enhancing beneficial synergies between the multiple goals of sustainability across a network of parks. As urban park research evokes diverse disciplinary perspectives, this article integrates thought and theory from urban planning and design, geography, architecture, landscape architecture, urban ecology, natural resource management, and leisure science. Informed by this review, the second section introduces a vision of a sustainable urban park system. This segment imagines a park system that balances and maximizes multiple social and environmental goals while contributing to the overall sustainability of an urbanized region over time. This vision guides the development of a method for evaluating citywide park systems that balances the multiple dimensions of sustainability and informs holistic planning, design, and management. The third section describes the study area, data used, and evaluation steps, as applied to the case study site. The steps include: 1) identifying a suite of indicator variables for each of the four dimensions of sustainability, 2) calculating these variables for the case study site using spatial and archival data collection methods, and 3) running descriptive and inferential statistics on the dataset. The final two sections detail the study results and discuss the implications for sustainable urban park planning, design, management, and evaluation.

BACKGROUND

Sustainable Urban Parks

The social and environmental health and sustainability of urban parks, as well as the specific ecosystem services they provide, is heavily dependent on their physical, environmental, socioeconomic, and built conditions and context.

Physical Characteristics

Parks of various sizes maintain distinct, but complementary ecosystem services that contribute to sustainable urbanism. Generally, larger parks support more plant and animal life than smaller, isolated parks (Faeth et al. 2011). Larger parks are also correlated with increased rates of visitation and physical activity (Giles-Corti et al. 2005; NRPA 2012), particularly if they are scenic (Giles-Corti et al. 2005). In hot arid regions, larger parks are cooler than surrounding areas, facilitating use on hot days (Barradas 1991; Jauregui 1991; Nowak and Heisler 2011). Yet, park use is heavily mitigated by distance, wherein more distal parks—even large, scenic parks—are used less by local residents than more proximate, smaller parks (Cohen et al. 2006). Small neighborhood parks also serve critical social and civic functions by providing spaces close to home in which people can commune with nature, relax, socialize, form social ties, play with children, and participate in civic life (Jacobs 1961; Coley et al. 1997; Kuo et al. 1998; Forsyth and Musacchio 2005; Low et al. 2005). An ideal urban park system therefore includes a variety of smaller, proximate neighborhood parks as well as larger destination parks, to deliver a range of social and ecological benefits and services across an urbanized region.

Available amenities and facilities influence a park's social and environmental sustainability (Low et al. 2005; Byrne and Wolch 2009). More recreational facilities and amenities generally lead to more physical activity in parks (Li et al. 2005; Rosenberger et al. 2005), as long as the sites are well maintained (NRPA 2012). Certain features are particularly effective at supporting more frequent and vigorous physical activity and longer park visits, such as trails, playgrounds, sport complexes, ball courts and fields, water features, drinking fountains, and restrooms (Whyte 1980; Floyd et al. 2008; Kaczynski et al. 2008; NRPA 2012). Parks with a diversity of amenities support social and cultural sustainability by supporting a variety of uses for a variety of users and preferences (Low et al. 2005). In hot arid regions, the presence of drinking fountains, swimming pools, water features (e.g., ponds, splash pads, pools, fountains), and shade structures in parks is particularly essential for extending and increasing park use, particularly during the hot summer months (Nowak and Heisler 2011). These same features buffer seasonal variations in food and water supply, serving to support and boost both native and non-native species biodiversity (Faeth et al. 2005; Shochat et al. 2006).

Landuse and Land Cover

Landuse and land cover influence the use, enjoyment, ecological functioning, and biodiversity potential of park spaces (Byrne and Wolch 2009). The presence of trees (Whyte 1980) and forested areas (Kaczynski et al. 2008) encourage park use. Of particular importance in hot, arid cities, open grassy areas and green vegetation increase human health and comfort, and therefore promote park use and enjoyment via microclimate cooling and protection from the sun's heat and ultraviolet rays (Spronken-Smith and Oke 1998; Yu and Hien 2006; Jenerette et al. 2007, 2011). By extension, the lack of these features—i.e., sparsely vegetated parks with extensive impervious cover—may reduce park use, particularly in the summer. Larger, undisturbed native park landscapes are best suited to support native biodiversity in cities (Faeth et al. 2011). The alteration of native desert patches (e.g., into irrigated green spaces) radically disrupts their species composition and ecosystem function (McKinney 2008; Shochat et al. 2010). However, especially in arid regions, non-native landscapes often maintain more biodiversity and higher productivity than surrounding native landscapes (Imhoff et al. 2000; Kaye et al. 2005; Marris 2009). As such, the type of landscape that is appropriate in a particularly park setting is dependent on the specific benefits desired (e.g., civic use, microclimate cooling, non-native biodiversity, native biodiversity).

Green, gray, and brown infrastructure in parks promote different, but complementary sustainability goals. Green vegetation in parks provides relief from stress and depression (Davis 2004; Mind 2007), induces intellectual development in children (Heerwagen and Orians 2002; Isenberg and Quisenberry 2002), and promotes physical activity (Pretty et al. 2006). Gray hardscapes (e.g., paths, plazas, and benches) facilitate the use of parks for walking, particularly among low-mobility visitors (Carstens 1993), children's games, relaxation, people watching, and other social activities (Jacobs 1961; Low et al. 2005). Brown, native desert landscapes are largely ignored in the urban park literature, but there is evidence that these areas are highly valued by urban dwellers. For example, South Mountain Park, a 6600-hectare native desert park in Phoenix, attracts over three million visitors a year (City of Phoenix 2012).

Socioeconomic Context

Given the importance of quality, proximate parks to the health and well-being of vulnerable populations, the socioeconomic makeup of neighborhoods is another crucial consideration when assessing the sustainability of an urban park system (Byrne and Wolch 2009; Cutts et al. 2009). Densely populated neighborhoods are in greatest need of public outdoor spaces not only because these areas contain more people than low-density neighborhoods, but also because these areas tend to be home to more lower-income populations with higher rates of obesity, less access to private outdoor spaces, and lower rates of automobile ownership (Mokdad et al. 2003; Papas et al. 2007). Proximity to parks by these high need populations is another equity concern as living within walking distance of a park has been shown to increase levels of physical activity three-fold (Giles-Corti et al. 2005). While several studies note higher access to urban parks by minority, low-income, and vulnerable populations (Nicholls 2001; Wolch et al. 2005; Timperio et al. 2007), these sites have been found to be smaller (Wolch et al. 2005; Boone et al. 2009), more congested (Sister et al. 2010), of lower quality, and with fewer recreational facilities (Gordon-Larsen et al. 2006; Moore et al. 2008). Revealing the historic, social, and institutional forces that shape cities and the distribution of parks and other urban amenities, Boone et al. (2009) found that high access to parks by minorities in Baltimore, Maryland was a 'hand-me-down' from the white residents that once inhabited those neighborhoods.

Built Environment

The built environment around parks greatly influences their social health (Byrne and Wolch 2009). Jane Jacobs (1961:101) argues that "the main problem of neighborhood park planning boils down to the problem of nurturing diversified neighborhoods capable of using and supporting parks." Parks surrounded by single use, low-density, residential neighborhoods are frequently underutilized, whereas dense, mixed-use neighborhoods with active land uses (e.g., hotels, restaurants, and shops) support lively, vibrant public space (Jacobs 1961; Talen 2010). These well-used parks promote safety by attracting more "eyes on the street" (Jacobs 1961:35). Further, safety, both actual and perceived, supports cultural diversity in parks (Low et al. 2005) and spurs increased park use (Crompton 2001; Bedimo-Rung et al. 2005). Busy street corners with street-level activity and food options, such as restaurants and shops, automatically enliven nearby park spaces (Jacobs 1961; Whyte 1980; Flint 2012).

Balancing Multiple Sustainability Goals in Urban Parks

The quest for sustainability in cities activates a key tension in the urban sustainability and urban park discourse—namely how (or if) to go about balancing the multiple goals of sustainability in park planning, design, and management. Some scholars argue that park planning must strive to balance all the dimensions of sustainability, while others claim that this aim is not only unattainable, but undesirable and unnecessary. Campbell (1996) asserts there are always tradeoffs between the social, economic, and environmental dimensions of sustainability in planning, therefore it is impossible to give equal balance to all dimensions in every situation. Lindsey (2003) note that the enhancement of one dimension often degrades another, while Parés and Saurí (2007) argue that parks with negative environmental impacts are still valuable if they fulfill social or political sustainability goals, as long as other parks emphasize more ecological objectives. Working within these constraints, the notion that not all parks can nor *should* provide all possible benefits is the most reasonable and robust viewpoint.

With the goal of balancing the social and ecological benefits of urban parks, Forsyth and Musacchio (2005) develop detailed park design guidelines. Their guidelines emphasize the importance of connectivity, diversity, and access for both human and non-human life. Balancing social and ecological goals in this way necessitates trade-offs, but Forsyth and Musacchio (2005:6) acknowledged that not all parks can be all things to all species (humans or wildlife); in the end, the values that are emphasized "will depend on the park's context and in many cases will be highly contested, not only between social and ecological values, but within them." Nonetheless, synergistic relationships between social and ecological benefits can be fostered by way of simple additions such as a bench in a nature preserve, or a birdhouse in a city square (Rosenzweig 2003). Such synergies are also the foundation of Cranz and Boland's (2004) new urban park model, the "Sustainable Park," which the authors claim emerged in American cities in the 1990s. The Sustainable Park is different from previous park models (which focused predominantly on the social benefits of parks), in that it integrates both social and ecological values, merging the ideals of sustainable development with human health and well-being. These spaces emphasize landscape restoration and support human well-being by providing access to nature, opportunities for social integration, environmental education, and a sense-of-place, while facilitating community stewardship, public-private partnerships, and the development of community and regional pride (ibid).

Urban revitalization efforts implemented in the City of Curitiba, Brazil provide an example of such integrated sustainability in urban park planning and design. In the 1960s, an urban renovation project was initiated to improve the quality of life in Curitiba (Rabinovitch 1992). The plan expanded city parks and green areas from 0.5 to 52 square meters per resident, one of the highest averages in the world. Given the city's location on a large natural floodplain prone to frequent flooding (Tucci 2004), the new parkland also provided flood protection, negating the need for costly flood infrastructure and ultimately saving the city millions of dollars. A "green guard," composed of trained municipal employees, was deployed to maintain the parks and provide environmental education to visitors, and interpretive centers were located throughout the park system to teach visitors about local ecology. Programs were initiated to encourage the formation of citizen groups—such as Friends of the Park and the Boy Scout Bicycle Watch—to foster community responsibility and participation in park maintenance and safety. On the weekends, green buses transport people to the various parks and the 17-hectare botanical garden, free of charge (Rabinovitch 1992).

To balance and coordinate multiple planning goals and advance coherent, functional, and sustainable urban form, a new generation of urban planners has resurrected a geographically-contextualized planning model—Transect Planning—grounded in Transect Theory (Duany 2002, Duany and Talen 2002; Low 2008; CATS 2009; Sorlien and Talen 2012). Transect Theory, derived from ecological and geographic principles, was first adopted into city planning by Patrick Geddes's (1915, Valley Section), Ian McHarg (1965, Design with Nature), and Christopher Alexander (1977, A Pattern Language). Advocating the notion that "certain forms and elements belong in certain environments" (Low 2008: I30), Transect Theory strategically organizes the elements of the built and natural environment (e.g., different types of parks) along a gradient of varying urban intensity, and provides a means of discerning which elements are most appropriate, where. Each 'zone' maintains a distinct habitat type (e.g., dense urban core, suburban, natural preserves), thereby supporting and satisfying diverse human preferences and ecological requirements across an urbanized region (Duany and Talen 2002; CATS 2009; Sorlien and Talen 2012). As applied to an urban park system, Transect Theory would situate large, naturally landscaped parks outside the city center, emphasizing biodiversity protection in these sites, while locating smaller plazas and community gardens in bustling, mixed-use urban neighborhoods, to maximize access and thereby social and civic benefits (Jacobs 1961; CATS 2009).

Defining a Sustainable Urban Park System

This article introduces a vision of an urban park system, which is evolving towards a more sustainable state while contributing to the overall sustainability of an urbanized region over time. Synthesizing the attributes of sustainable urban parks outlined in the literature and integrating the principles of Transect Theory, we introduce an ideal of a sustainable urban park system to guide the planning, design, management, and assessment of city parks. Recognizing that the move to sustainability is a dynamic, ongoing process of improvement as opposed to a static, measureable end goal or state (Bagheri and Hjorth 2007; Adhya et al. 2010), the vision reflects the notion that not all parks in a system can, or should, support all possible social, ecological, and economic goals and activities across all temporal and spatial scales (Campbell 1996; Lindsey 2003; Forsyth and Musacchio 2005; Parés and Saurí 2007). Instead, a *sustainable urban park system* provides a variety of ecosystem services across an urbanized region, emphasizing particular benefits in the most appropriate park sites and locations (Low 2008) and satisfying the various and shifting needs and preferences of diverse human and non-human life (Gobster 2001, 2002; Gobster and Westphal 2004; Forsyth and Musacchio 2005). Despite the dynamic, flexible nature of a sustainable urban park system, there are some universal standards. All parks are clean, safe, aesthetically pleasing, well-maintained, and culturally sensitive (Gobster and Westphal 2004; Low et al. 2005; Harnik 2010). Each park is welcoming and accessible to a diversity of ages, genders, sexual orientations, and ethnic/cultural groups (Mitchell 1995; Talen 1998; Talen and Anselin 1998; Wolch et al. 2005; Talen 2006), via various modes of transportation, including walking, biking, and public transportation (Talen 2002; Harnik 2010). Taken as a whole, a sustainable park system fosters social interaction, cohesion, and the generation of social capital (Jacobs 1961; Mitchell 1995; Chiesura and De Groot 2003; Chiesura 2004; Low et al. 2005), while supporting biological diversity and ecological functioning where possible and geographically appropriate (Forsyth and Musacchio 2005; Tzoulas et al. 2007; Schilling 2010; Talen 2010). Parks prioritizing social use (e.g., over native biodiversity)— in arid urban regions, in particular —provide drinking water, restrooms, and shade structures, while balancing water use with microclimate cooling benefits (via urban greening); these features provide relief from the local climate and urban heat island effect, improving human health and comfort and extending the usability of these areas year-round (Forsyth and Musacchio 2005; Jenerette et al. 2011). Native biodiversity is supported where feasible and appropriate by protecting, creating, and supporting native habitat (Forsyth and Musacchio 2005). The urban form around parks is appropriate to their location along the urban-to-natural transect. More dense settlements and active uses (i.e., land uses that generate foot traffic on the street, e.g., hotels, restaurants, and retail shops) surround smaller parks in the most populated urban areas to enliven the spaces and expand park uses and benefits (Jacobs 1961), whiles more diffuse developments encircle larger, less disturbed park landscapes in suburban and rural areas to help promote biodiversity and ecological health (Duany 2002; Duany and Talen 2002; Duany and Brain 2005; Talen 2010; Faeth et al. 2011). Ultimately, a sustainable park system supports both human and biological health in cities, contributing to broader sustainability goals beyond the park boundaries by aiding in the advancement of cities and their neighborhoods towards an increasingly sustainable state (Cranz and Boland 2004).

Guided by this vision, this study evaluates the diverse and extensive urban park system of Phoenix, AZ, modeling a holistic approach to urban park assessment that can be customized to other cities. The results of the analysis demonstrate what can be gained by a multi-dimensional analysis of a park system and provide a point of departure for policy development and further research concerned with balancing multiple sustainability goals in park planning and design.

DATA AND METHODS

Study Area

Phoenix is located in the Northern Sonoran Desert of Central Arizona, a hot, arid desert ecosystem with low ecological resilience (Walker et al. 2006; Liu et al. 2007). The urban landscape is comprised primarily of non-native plant taxa (Martin et al. 2003) that are heavily irrigated, resulting in a landscape that is more lush and biologically diverse than the surrounding native desert (Hope et al. 2003; Walker et al. 2009). The region receives some 280 days of sunshine and eight inches of precipitation annually (NOAA 2004; 2010). Daytime temperatures are some of the hottest in the United States, with daytime high temperatures exceeding 31 degrees Celsius nearly half the year (Schmidli 1996; Climatezone.com 2003). The first known inhabitants of this region arrived over 2000 years ago, attracted to the region for its abundance of flat, arable land and ample surface water resources. The Hohokam abandoned the area around A.D. 1450 for yet unknown reasons, but Euro-American colonists resettled the valley in the 1860s. Despite the extreme, dry climate, both groups of settlers enjoyed ample water resources via the local Salt, Verde, and Gila Rivers (fed by mountains to the north), which they used to maintain a lush green oasis in the Arizona desert. The water demands of such water-intensive non-native landscaping has not been a major concern until recent decades due to rapidly rising populations, increased agricultural production, and a continued legacy of the ‘oasis’ mentality (Larson et al. 2009). Now, extending over 800 kilometers, with a population of over 1.4 million (U.S. Census Bureau 2010), the City of Phoenix faces numerous environmental and social challenges, including high water use paired with a strained water supply, economic inequality, social injustice, and sprawling urban development (Bolin et al. 2005; Gober 2006; Ross 2011). The low-income, minority neighborhood of South Phoenix has been described as “a stigmatized zone of racial exclusion and economic marginality” located in a “contaminated zone of mixed land uses which currently hosts an assemblage of industrial and waste sites, crisscrossed by freeways and railroads” (Bolin et al. 2005: 156-7).

Despite the substantial obstacles to sustainability in the City, Phoenix does boast an invaluable asset in the quest for a more sustainable urbanism—an extensive and diverse urban park system including nearly 200 sites (TPL 2011). However, optimization of this formidable park network is limited by the absence of an integrated, multi-dimensional, large-scale appraisal. This study operationalizes our vision of a sustainable park system to evaluate the extent to which Phoenix’s park system is contributing to the multiple goals of sustainability, and to provide a point of departure for future park planning and design decision-making in the region.

Data

The social, environmental, physical, built, and spatial data for this study were obtained through a number of public and private sources, including the City of Phoenix Parks and Recreation and Planning Departments, Arizona State University (ASU) GIS data repository, Central Arizona-Phoenix Long Term Ecological Research project (CAP-LTER), United States Census Bureau, and Phoenix Urban Research Lab (PURL). Additional details on the datasets, sources, and temporal scales are outlined in Table 1. The specific parks included in the study were selected by referencing a GIS shapefile of park boundaries provided by the City of Phoenix Parks

Department. The shapefile included 205 parks, 29 of which were not yet developed, and so were removed from the analysis. Fourteen additional sites with incomplete information were also removed from the final analysis. The final sample included 162 parks, representing 92 percent of all the developed parks in Phoenix.

Table 1. Datasets used in the analysis, source, and temporal scale.

Dataset	Source and Temporal Scale
Park Boundaries	Phoenix Parks & Rec. (2012)
Parks database	Phoenix Parks & Rec. website parks database (2010)
Quickbird, classified (2.4 meter spatial res.); SAVI index.	CAP-LTER (2005)
Census blocks and block groups	U.S. Census Bureau (2010)
Parcels	PURL (2010)
City center shapefile and Phoenix boundary	ASU GIS data repository (2010)

Methods

Informed by the multidisciplinary review of literature, the first step in the analysis involved selecting and computing a suite of quantitative variables that reflect the physical, environmental, socioeconomic, and built characteristics of sustainable parks. The selected variables are not a comprehensive representation of *all* the nearly limitless components of a sustainable park system, yet facilitate a substantial improvement to routine, oversimplified assessments.
One benefit of this approach is that similar data can be quickly and easily collected and analyzed for other large cities, providing a rapid, cost-effective, and revealing evaluation of a citywide park system.

The key variables are size (Jacobs 1961; Barradas 1991; Jauregui 1991; Coley et al. 1997; Kuo et al. 1998; Forsyth and Musacchio 2005; Giles-Corti et al. 2005; Low et al. 2005; Cohen et al. 2006; Faeth et al. 2011; Nowak and Heisler 2011; NRPA 2012), the presence of particular facilities and amenities (Whyte 1980; Faeth et al. 2005; Li et al. 2005; Low et al. 2005; Rosenberger et al. 2005; Shochat et al. 2006; Floyd et al. 2008; Kaczynski et al. 2008; Nowak and Heisler 2011; NRPA 2012), microclimate cooling (Spronken-Smith and Oke 1998; Yu and Hien 2006; Jenerette et al. 2007; Jenerette et al. 2011), and land cover (Whyte 1980; Imhoff et al. 2000; Heerwagen and Orians 2002; Isenberg and Quisenberry 2002; Davis 2004; Kaye et al. 2005; Pretty et al. 2006; Mind 2007; Kaczynski et al. 2008; McKinney 2008; Marris 2009; Shochat et al. 2010; Faeth et al. 2011). Also critical is the mix of land uses surrounding parks (Jacobs 1961; Whyte 1980; Talen 2010; Flint 2012) as well as neighborhood population density (Coley et al. 1997; Kuo et al. 1998; Forsyth and Musacchio 2005; Low et al. 2005), income, and ethnic mix (Mokdad et al. 2003; Papas et al. 2007) (Table 2).

Table 2. Park measures used in the analysis

Physical characteristics	Landuse and land cover	Socioeconomics of park neighborhoods	Surrounding built environment
Size (area)	Percent grass, trees, soil, buildings, impervious	Mean median household income	Percent single-family and multi-family parcels
Presence of facility/ amenity: Community center, path/trail, ball court/field, playground, pool, water feature, shade area, drinking fountain, restroom, picnic area	Percent green vegetation (grass + trees)	Mean population density	Percent retail or commercial/industrial parcels
Percent of all amenities/facilities (n=10)	Average SAVI (soil-adjusted vegetation index)	Percent Hispanic, black, white, other ethnicity	Distance from city center
	Percent developed (impervious + buildings)		Landuse mix (mix of single, multi, mixed parcels)

Physical measures include the area of each park and the presence or absence (not count) of ten different facilities and amenities— community center, path/trail, ball court/field, playground, pool, water feature, shade area, drinking fountain, restroom, picnic area. Park area was calculated in ArcGIS using boundary shapefiles. A database of amenities and facilities at each site was compiled by referencing detailed park descriptions from the City of Phoenix Parks and Recreation website (City of Phoenix 2010).

Land cover measures reflect the amount of grass, trees, buildings, impervious cover, soil, and average greenness of each park landscape. The ratio of different land covers in each park was computed in ArcGIS by applying zonal statistics to the classified Quickbird LULC raster, specifying park boundaries as the zones to be calculated. The Quickbird Classified raster (CAP-LTER 2005) included the following categories: grass, trees, buildings, impervious cover, water, and soil. Average greenness of parks, which also relates to microclimate cooling potential (Hedquist and Brazel 2006; Jenerette et al. 2007), was calculated by running zonal statistics on a SAVI (Soil-Adjusted Vegetation Index) raster dataset in ArcGIS. Although it is more commonplace to use NDVI (Normalized Difference Vegetation Index) to measure a landscape's greenness, SAVI is best suited to desert regions where there is substantial soil exposure coupled with sparse vegetative cover, as the reflectivity of the soil can alter NDVI values (Huete 1998). SAVI is also used in arid cities as a proxy for temperature and to model the cooling effects of parks in mitigating the Urban Heat Island effect. In Phoenix, climatologists correlate higher SAVI values with lower air temperatures (Hedquist and Brazel 2006) and cooler surface temperatures (Jenerette et al. 2007).

The socioeconomic measures in this analysis classify the mean income, population density, and ethnic mix of each park's neighborhood. Park neighborhoods are defined as areas within a five-minute walk (or 400 meters) of each site, as this is considered a threshold for regular park visitation (Boone et al. 2009). Using the finest scale census data available for each measure, median household income and population density around parks was computed by intersecting 400-meter park buffers with census block groups and census blocks, respectively.

The mix of ethnic groups in each park neighborhood was calculated by intersecting park buffers with block group data, summarizing values for black, white, Hispanic, and other ethnicities.

Built measures reflect the urban morphology of park neighborhoods, including the percent of various landuse types and the mix of land uses, as well as the distance of each park from the city center. The distance of each park (using nearest park edges) from the downtown area was calculated in ArcGIS using city center and park boundary shapefiles. Using parcel data for the City of Phoenix, the percent of the following land uses within 400 meters of each site was calculated: single-family homes, multi-family dwellings, commercial and industrial uses, and retail parcels (i.e., convenience stores, strip malls, restaurants, bars, car dealers, banks, motels, hotels, and store/office combos). Five levels of landuse mix were then developed along a gradient of urban intensity following Talen (2010), wherein areas are classified as 'more urban' if they contain more retail, commercial/industrial, and high density residential land uses, and 'less urban' if there are more low-density residential land uses (i.e., single-family homes) and fewer retail and commercial/industrial parcels. Criteria for each level are outlined in Table 3.[1]

Table 3. Landuse mix levels and criteria

Level	Criteria
Level 1	>50 percent single-family homes
Level 2	>50 percent single-family homes & >30 percent commercial/industrial mix
Level 3	>50 percent multi-family homes
Level 4	>50 percent multi-family homes & >30 percent commercial/industrial mix
Level 5	>50 percent commercial/industrial mix

After computing each measure, values for the 162 parks were entered into a SPSS database. Descriptive statistics and correlations were then computed and analyzed. Results reveal a multi-faceted picture of individual parks and the park system as a whole, as well as the relationships between the different measures and park sites.

RESULTS

The following section describes the statistical results displayed in Table 4 and Appendix I. All correlations discussed in the following section are statistically significant at either the 0.01 or 0.05 level based on a two-tailed Pearson's Correlation test.

Descriptives

The 162 parks in this study (Figure 1) range in size from 0.07 to 6592.04 hectares, with a mean size of 72.71, and a standard deviation of 534.39 hectares. The total area of the study parks is 11,779.38 hectares, and nine sites exceed 100 hectares. The majority of the parks (53.70 percent)

[1] The eight park neighborhoods that did not fit these levels were classified as follows: Level 1: 40-50 percent single-family homes; Level 3: 40-50 percent multi-family or >30 percent single-family + >40 percent commercial/industrial; Level 4: >40 percent commercial/industrial & >30 percent multi-family.

are ten or more kilometers from the city center, while a fifth of the sites (21.60 percent, *n*=35) are located within a five-km radius.

Table 4. Descriptive statistics for variables

Variable	Mean	Median	Std. Dev.	Min	Max
Area (ha)	72.71	4.13	534.39	0.07	6592.04
Distance to center (km)	12.23	10.83	8.27	0.87	39.97
Community Centers	0.12	0	0.33	0	1
Paths Trails	0.14	0	0.35	0	1
Ball Court	0.8	1	0.4	0	1
Playground	0.83	1	0.37	0	1
Pool	0.27	0	0.44	0	1
Water	0.1	0	0.3	0	1
Shade	0.66	1	0.48	0	1
Drinking Fount	0.11	0	0.32	0	1
Restroom	0.5	0.5	0.5	0	1
Picnic	0.76	1	0.43	0	1
% 10 Amenities	0.43	0.45	0.19	0	0.8
Grass	0.36	0.36	0.24	0	0.93
Trees	0.16	0.12	0.13	0	0.62
Trees & Grass	0.52	0.55	0.26	0	0.97
Soil	0.33	0.28	0.24	0	0.97
Impervious	0.07	0.05	0.08	0	0.58
Buildings	0.07	0.04	0.1	0	0.61
Developed	0.14	0.12	0.14	0	0.79
SAVI	0.48	0.47	0.19	0.07	0.95
Nbhd Income	52037	41988	27821	9277	154548
Nbhd Pop Den	7.17	7.06	4.09	0.24	23.2
% Hispanic	0.44	0.41	0.29	0.04	0.93
% White	0.43	0.41	0.3	0.03	0.92
% Black	0.07	0.04	0.08	0	0.47
% Other Ethnicity	0.04	0.04	0.03	0	0.14
% Single family	0.79	0.86	0.24	0.04	1
% Multi family	0.1	0.03	0.16	0	0.84
% Retail	0.02	0.01	0.03	0	0.13
% CI	0.09	0.03	0.14	0	0.7
CI and Retail	0.11	0.04	0.16	0	0.73
Landuse Mix	1.37	1	1	1	5

With respect to facilities and amenities, 76 percent or more of the parks are equipped with playgrounds (*n*=135), ball courts or fields (*n*=130), and picnic areas/grilling facilities (*n*=123) (Figure 2). About two-thirds of the sites have some type of shaded structure and half the parks contain restrooms. More than a quarter of the spaces include pools (*n*=43). Relatively few sites contain paths or trails (14 percent, *n*=23), community centers (12 percent, *n*=20), drinking fountains (11 percent, *n*=18), or water features such as a lake or lagoon (10 percent, *n*=16). Of the ten amenities documented, there is an average of 4.3 present in each park; some sites have none and others contain as many as eight of the ten different amenity/facility types.

The land cover evaluation revealed highly variable ratios of soil, grass, and trees across the study sites, but a predominance of 'brown' (i.e., unvegetated, soil) space (Table 4). In total, the study parks contain just under 10,000 ha of brown land cover (84.62 percent of total park area), 1500.52 ha of grass and trees (12.74 percent), and 281.16 ha of impervious cover and buildings (2.39 percent). The nine largest parks (each over 100 hectares) are principally brown and un-vegetated, comprised of 81 percent soil and 14 percent green vegetation (i.e., combined grass and tree coverage). The high ratio of soil versus green cover may indicate an abundance of native, xeric landscaping, though field research is necessary to verify this assumption. Some parks contain no grass while other landscapes contain up to 93 percent grass. Total tree land cover in a site ranges from zero to 62 percent. Combining grass and tree percentages (total vegetated area), values range from zero to 97 percent, with an average of just over 50 percent. Average soil land cover in the parks is 33 percent, ranging from 0-97 percent. With respect to building area and other impervious cover, parks are on average 14 percent developed, with a range of 0-79 percent. Mean SAVI (based on a scale of 0-1) for the parks range from 0.07 to 0.95, with a mean of 0.48 and standard deviation of 0.19.

Analysis of the social and built characteristics of neighborhoods around parks revealed the following results. The median annual household income of neighborhoods surrounding the sites range from \$9277-\$154,548, with a mean of \$52,036. In comparison, the median household income for the entire city is \$56,186, or \$4150 greater than in park neighborhoods. The average population density of neighborhoods surrounding parks is 2.91 people per hectare, with a maximum density of 9.39 and minimum of 0.10 people per ha. By comparison, the mean population density for all census blocks in the city (n=10,684) is 3.72 people per ha. The largest proportional ethnic group is white (47 percent), followed by Hispanic (41 percent). All other ethnicities combined represent the remaining 12 percent of the population. Some 43 percent of study parks are located in Hispanic-dominated neighborhoods, while 44 percent are situated in predominantly white neighborhoods. The dwelling-type in park neighborhoods is overwhelmingly single-family. Of the 120,128 parcels within 400 meters of the parks, approximately 81 percent are zoned single-family, 12 percent are multi-family, six percent are commercial/industrial, and two percent are retail.

Correlations

Physical Characteristics

Larger parks are statistically more likely to have ball courts/fields, playgrounds, pools, water features, restrooms, picnic areas, and an overall larger percentage and diversity of total amenities (Appendix I). Larger parks are less developed, greener (i.e., higher average SAVI values), and surrounded by fewer retail, commercial, and industrial land uses. The neighborhoods around larger parks are significantly higher income, less Hispanic, and more white and other ethnicity. Larger parks are located farther from the city center. Parks with a large diversity of amenities have higher SAVI values, and are generally larger and less developed.

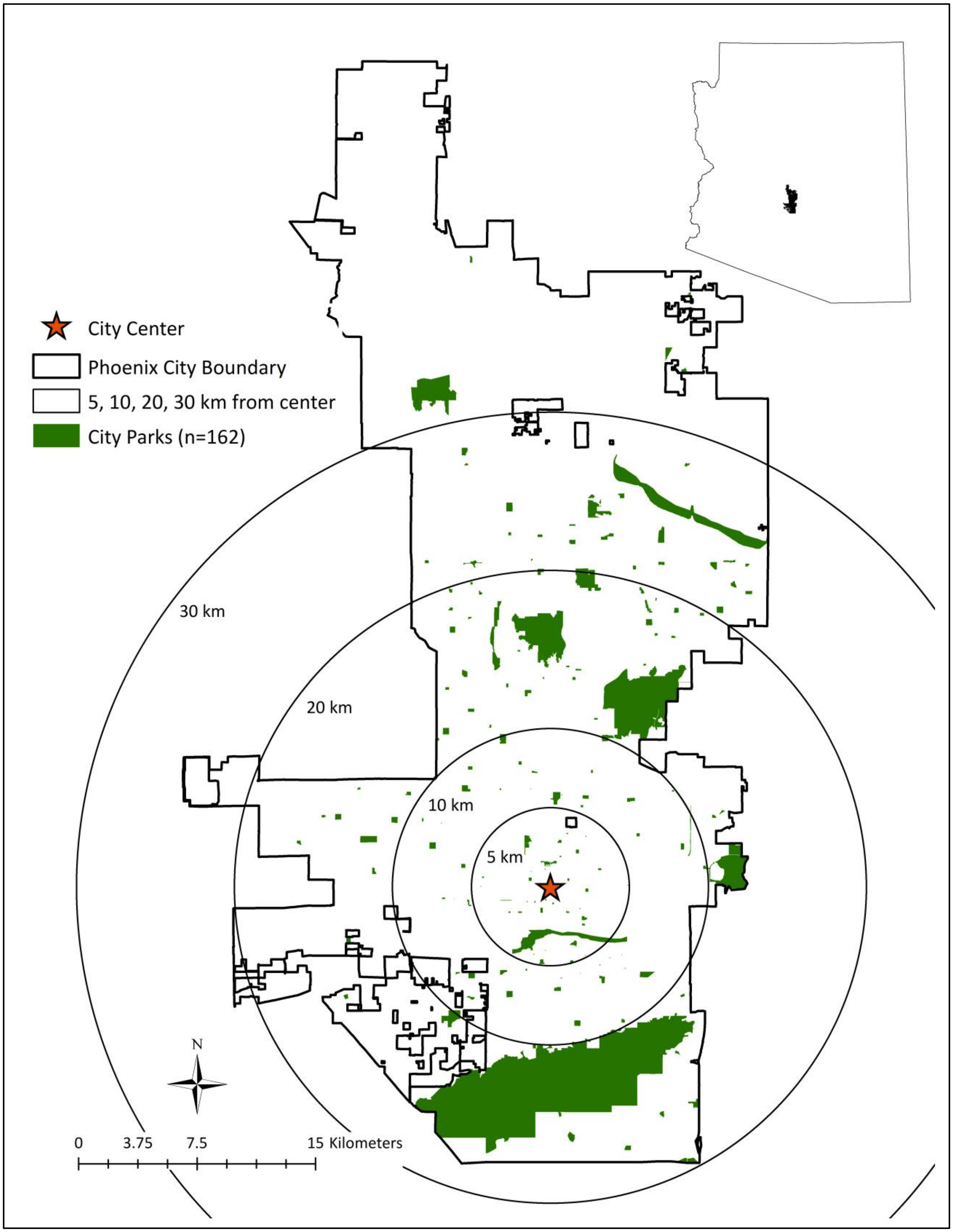

Figure 1. Map of parks in the study area (n=162), including their distance from Phoenix's city center (5, 10, 20, 30 km buffers). Inset map in the upper right corner indicates the location of Phoenix within the state of Arizona.

Landuse and Land Cover

As expected, parks with more grass and trees have significantly higher SAVI values. More highly vegetated parks also have relatively fewer paths/trails, more ball courts/fields, and more picnic facilities. These parks are generally in higher density neighborhoods with less commercial and industrial parcels. Parks with more soil land cover have more paths/trails, less impervious cover, and tend to be located in low-density, higher income neighborhoods on the urban fringes. Parks with higher average SAVI values tend to be larger and are more likely to have restrooms, picnic areas, and a higher diversity of amenities overall. Higher SAVI values are correlated with less impervious and building cover and more vegetation (i.e., grass and trees). Parks with high average SAVI values tend to be farther from the city center and surrounded by fewer commercial/industrial and retail parcels. More developed parks (i.e., those with more impervious cover and larger building footprints) are less likely to have restrooms or picnic areas and have fewer amenities overall. Predictably, they have lower SAVI values and less vegetation. These parks are located closer to the urban center, mostly in lower-income neighborhoods with higher Hispanic and black and fewer white residents, as well as more commercial/industrial and retail parcels.

Socioeconomic Context

Parks in high-income neighborhoods are significantly larger, farther from the city center, and in less "urban" (i.e., high density, mixed-use) neighborhoods. These parks are dominated by soil coverage and are less developed overall. High-income neighborhoods with parks have significantly higher proportions of whites than Hispanics and contain more single-family and fewer commercial/industrial and retail parcels. Parks in high-density neighborhoods are more vegetated, particularly containing more grass. These neighborhoods are lower income, more Hispanic, less white, and contain fewer commercial/industrial and retail parcels. Parks in neighborhoods with larger Hispanic populations are smaller and more developed, with fewer paths/trails, drinking fountains, and trees. These parks are located closer to the urban core and are generally surrounded by fewer single- and multi-family parcels, and more commercial/industrial and retail parcels.

Built Environment

Parks in neighborhoods comprised of predominantly single-family parcels tend to be far from the urban center, with higher SAVI values and higher income, white residents. Parks in neighborhoods with more multi-family homes have fewer playgrounds and more retail and commercial/industrial land uses. Parks surrounded by more commercial/industrial land uses are closer to the urban center, less developed, and display lower SAVI values. These neighborhoods have fewer single-family parcels, are of higher urban intensity, and support higher Hispanic and black populations, as compared to white. Parks surrounded by retail development are often in lower-income neighborhoods with more Hispanic and fewer white residents, as well as fewer single-family and more multi-family parcels.

Parks located in areas of high urban intensity are negatively correlated with SAVI, income, population density, percentage of white residents, and distance to the city center. These neighborhoods tend to have more commercial/industrial, multi-family, and retail parcels. Parks closer to the city center are generally smaller and in lower income neighborhoods with fewer paths/trails and less soil land cover. Smaller parks are commonly more developed and located in neighborhoods with proportionately higher Hispanic populations and comprised of more commercial/industrial and retail land uses.

DISCUSSION AND CONCLUSION

This research has moved beyond the singular focus of many park assessments to generate a nuanced, multi-dimensional understanding of the physical, environmental, social, built, and spatial characteristics of a park system. This assessment provides a point of departure for the development, realization, and evaluation of public policy aimed at advancing a region's sustainability through civic space planning and design. First, a vision of a sustainable urban park system, guided by multidisciplinary thought and theory, is proposed. The paper then identifies relevant measures and a place-specific method for quantitatively assessing a complex suite of parks and park characteristics that can be adapted for use in other cities based on local social, economic, environmental, and climatic conditions, urban form, and public policy goals. By modeling the application of the quantitative assessment in the case study area, this paper also provides a proof of concept that demonstrates the feasibility, value, and operationalization of the method, while enhancing understanding of the multiple physical, ecological, social, and built characteristics of Phoenix's park system. The results offer a rich assessment of the individual sites and the system as a whole, identifying numerous points of departure for advancing the social and ecological sustainability of the city's park system, and by extension, the city itself. The policy implications of the key findings and recommendations for improvements are discussed below.

First of all, we must begin with an understanding that the results of this assessment do not point to simplistic black and white conclusions, but instead highlight the complexities of a sizeable and diverse urban park system, while sorting out a more nuanced and multi-dimensional understanding of these intricate human-environment structures. Referring back to our definition of a sustainable urban park system—and the elements of that system that can be assessed with this quantitative, citywide assessment—several important themes emerge that highlight the strengths and weaknesses of the Phoenix parks system with regards to sustainability measures.

First, several findings hint that Phoenix's park system is providing several key social and ecological benefits, contributing to the sustainability of the city and in some cases synergistically amplifying both social and ecological health. The presence of several very large, brown, undeveloped parks with paths and trails, may suggest that these expansive landscapes harbor native biodiversity and ecological functioning (Esbah et al. 2009), while providing recreational benefits for urban residents. The presence of playgrounds, ball courts/fields, and picnic areas in over three-quarters of the city parks indicates that existing parks may be successfully providing important recreational services shown to reduce rates of obesity and incite social interaction in public space (Bauman et al. 1999; Giles-Corti and Donovan 2002; Low et al. 2005; Gordon-Larsen et al. 2006). Other key findings suggest a potentially equitable distribution of parks and green space in Phoenix. First, the fact that neighborhoods around parks are, on average, lower-income than the city as a whole implies that parks are not disproportionately located in affluent neighborhoods. Second, the number of parks in Hispanic and white-dominated neighborhoods are nearly equal, indicating that proportionally Hispanics have higher access (based on proximity) to parks overall, given the Hispanic population of the city is slightly smaller than the white population. Finally, parks in higher density, low-income, Hispanic neighborhoods are more vegetated (i.e., contain more grass and trees coverage), which is an attribute linked to increased human health and well-being in the parks literature (Loukaitou-Sideris 1995; Chiesura 2004; Wolch et al. 2005; Walljasper 2012). However, the reason for this equitable pattern of distribution may not be intentional, but rather a reflection of historical patterns of racism and 'white flight.' High access to parks and other favorable urban amenities may be a legacy of 'white privilege' (Pulido 2000: 15) from a time when urban core neighborhoods were dominated by white residents, who later fled to suburbs to escape low-income minorities (Pulido 2000; Boone et al. 2009). Such patterns highlight the importance of considering the often inconspicuous social, political, and historical drivers of urban park location, design, quality, and equity (Gandy 2002; Bolin et al. 2005; Byrne and Wolch 2009).

Further, our promising findings are offset by a number of equity concerns that pose substantial social sustainability challenges with respect to Phoenix's park system. For example, compared to wealthy, white residents, low-income and minority populations have less access (via proximity) to *large* parks, particularly native desert landscapes that may foster proportionally more native flora and fauna than smaller sites. Conversely, parks in Hispanic neighborhoods were found to be statistically smaller, more vegetated, and contain fewer paths/trails, drinking, fountains, and trees. A similar result was found in a Baltimore, Maryland study, wherein black residents had higher access to parks within walking distance, but white residents had access to more park acreage (Boone et al. 2009). This finding also echoes Kinzig et al. (2005) who discover that neighborhoods of lower socioeconomic status in Phoenix contain less diverse plant and bird communities. These findings have environmental justice implications with respect to access to parks and other natural features given that affluent populations are overall more mobile (via higher car ownership) and more likely than poorer residents to maintain large *private* yards. Larger parks also provide higher rates of microclimate cooling, contain more of certain amenities (e.g., ball courts/fields, playgrounds, pools, water features, restrooms, picnic areas), and represent unique biological and cultural features of high scenic and recreational value in Phoenix (City of Phoenix 2012; 2014).

Limited access to large, amenity rich parks with cooling benefits and playgrounds by high-density and minority neighborhoods is another finding of paramount concern given the mental and physical health benefits of access to open space with diverse amenities (Li et al. 2005; Low et al. 2005; Rosenberger et al. 2005; Byrne and Wolch 2009) and microclimate cooling effects (Spronken-Smith and Oke 1998; Yu and Hien 2006; Jenerette et al. 2007; Jenerette et al. 2011). Efforts aimed at achieving more equitable access to large, native desert parks in Phoenix are recommended, yet care should be taken to avoid habitat disruption to achieve this goal. Enhanced public transportation to these sites from low-income regions is one possible solution. However, evaluations of proximity and access do not necessarily constitute comprehensive measures of park equity and access. A particular park may be close but undesirable if it is neglected, unwelcoming, or simply not preferred (Jacobs 1961; Gobster 1998; Brownlow 2006). This lack of quantitative and observational field data is a limitation of this research. A valuable and logical complement and extension of this work would therefore integrate additional methods of data collection and field evaluation. For example, Gobster (1998) proposes that studies of parks in diverse neighborhoods should evaluate (via surveys and other qualitative means) resident perceptions of safety, belonging, and comfort to reveal the more intricate and often hidden reasons for particular patterns of use or disuse.

A final concern with respect to environmental justice in this study is that parks in neighborhoods with more multi-family parcels are correlated with fewer playgrounds. These areas are more likely to be lower-income and less likely to have private outdoor space, and therefore have a higher need for playgrounds and public space in general (Loukaitou-Sideris 1995; Wolch et al. 2005; Walljasper 2012). In response to these findings, increased access for children may be increased—not necessarily by creating new parks—but by incorporating playgrounds into existing parks and encouraging higher density housing and mixed use development around smaller park spaces (Jacobs 1961; Talen 2010).

This analysis also revealed potential barriers to park use and human health and comfort in Phoenix parks. Only half the parks have restrooms, which are critical for encouraging park use (Molotch and Noren 2010), particularly among the elderly (Carstens 1993). Most, but not all parks, include some form of shade structure, but very few have drinking fountains. These amenities are particularly essential in hot arid cities where dehydration and heat exhaustion deter park visitation and threaten human health—a hazard to which low-income residents in Phoenix are already disproportionately exposed (Jenerette et al. 2011). Very few parks have paths or trails, though these constitute important recreational amenities for encouraging exercise and reducing rates of neighborhood obesity (Kaczynski et al. 2008). Overall, the city parks contain an average of four of the ten amenities measured, but this varies greatly across parks, wherein some sites have no amenities and some include up to 80 percent. Depending on their purpose and the needs and preferences of proximate populations, some of these low-amenity sites should be prioritized for park improvement. Evidence that population density around parks is lower than for the city overall, and that park neighborhoods are dominated by single-family residential land uses and few active uses (i.e., retail), suggests that accessibility to parks by the broader population, and therefore the realization of the mental and physical benefits of spending time in parks, is limited. Increasing the density of developments around parks and integrating more active uses is recommended to expand the use and vitality of these spaces (Talen 2010). This study also found an abundance of soil land cover in area parks. Increasing grass cover in certain areas may promote human health and well-being by mitigating the urban heat island effect, reducing related energy use, and providing aesthetic benefits, but such decisions must also consider the water use tradeoffs of such efforts in a water-scarce region (Jenerette et al. 2011).

Study results also expose numerous characteristics of the biological health and sustainability of Phoenix parks. First, there are a number of very large, minimally developed parks dominated by soil land cover (presumably native). Given that extensive grass and tree cover is not native to Phoenix (Martin et al. 2003) and agreement that large parks generally support more biodiversity (Faeth et al. 2011), this finding suggests that Phoenix parks are protecting extensive native landscapes (and ostensibly native biodiversity and ecosystem functioning). Gober (2006) states that these large native parks exist because mountainous topography historically limited development on these landscapes. Phoenix parks also appear to be supporting substantial non-native biodiversity. Some 59 percent of study parks (n=96) contain more than 50 percent grass and tree land cover, suggesting the dominance of non-native, irrigated habitat for both native and non-native flora and fauna (Hope et al. 2003; Faeth et al. 2005, 2011; Shochat et al. 2006; Walker et al. 2009). A unique insight from this study is evidence that native desert landscapes are highly valued by residents, as they are correlated with high-income populations. This finding warns against a common assumption that people prefer urban 'green' spaces to 'brown' spaces, and that only green parks provide social, cultural, and public health benefits. This apparent preference for and value of native desert parks offers a means of synergistically balancing and enhancing the benefits of park spaces in arid cities—wherein native landscapes are left undisturbed and low-impact trails are created to protect native biodiversity, avoid maintenance and high water inputs needed for green landscapes, and deliver valued aesthetic (e.g., scenic) and recreational ecosystem services.

To maximize success, the development of specific policies related to park development, management, and design in Phoenix should be preceded by in-depth field assessments at individual sites to assess their social and ecological functionality, coupled with qualitative interviews with residents about their use of and satisfaction with local parks. Throughout the process, planners and decision-makers should strive to engage the community. Over time, targeted improvements—sensitive to the social, ecological, built, and geographic context of the city—will serve to continually enhance the contribution of urban parks to the sustainability of this unique desert city, potentially making it a model for other large arid urban regions. If repeated, the vision and analysis presented herein may reveal similar opportunities to maximize, balance, and maintain social and natural capital in other cities, thereby expanding the role and potential of urban park systems to advance sustainable urbanism worldwide.

Appendix I

Pearson's Correlations

Variable	Area	Com. Center	Paths/ Trails	Ball Court	Play-ground	Pool	Water	Shade
Area	1	0.125	0.117	0.291**	0.176*	0.299**	0.360**	0.157
Community Centers	0.125	1	-0.045	0.092	0.067	0.199*	0.064	0.071
Paths Trails	0.117	-0.045	1	-0.198*	-0.245**	0.116	0.043	0.03
Ball Court	0.291**	0.092	-0.198*	1	0.319**	0.088	0.06	0.234**
Playground	0.176*	0.067	-0.245**	0.319**	1	0.119	-0.019	0.379**
Pool	0.299**	0.199*	0.116	0.088	0.119	1	0.129	0.077
Water	0.360**	0.064	0.043	0.06	-0.019	0.129	1	0.106
Shade	0.157	0.071	0.03	0.234**	0.379**	0.077	0.106	1
Drinking Fount	0.087	0.046	0.138	-0.022	0	0.099	-0.051	0.005
Restroom	0.419**	0.263**	-0.053	0.372**	0.315**	0.210**	0.207**	0.352**
Picnic	0.220**	0.036	-0.185*	0.228**	0.484**	0.175*	0.138	0.511**
% Amenities	0.475**	0.360**	0.096	0.491**	0.547**	0.486**	0.322**	0.640**
Grass	0.05	-0.004	-0.302**	0.219**	0.161*	0.008	-0.133	0.155*
Trees	0.064	-0.148	-0.079	-0.03	-0.115	0.002	0.111	-0.044
Trees Grass	0.081	-0.08	-0.313**	0.183*	0.085	0.009	-0.063	0.117
Soil	0.06	-0.009	0.391**	-0.113	-0.029	-0.031	-0.007	-0.002
% Impervious	-0.017	0.167*	0.062	-0.14	-0.063	0.116	0.204**	-0.108
Buildings	-0.332**	0.108	-0.143	-0.115	-0.124	-0.075	-0.134	-0.229**
Developed	-0.258**	0.177*	-0.07	-0.167*	-0.129	0.012	0.019	-0.232**
SAVI	0.277**	-0.013	0.046	0.137	0.071	0.077	-0.004	0.153
Nbhd Income	0.250**	-0.164*	0.193*	-0.007	-0.041	-0.03	0.041	0.068
Nbhd PopDen	-0.152	0.085	-0.202**	0.017	0.029	0.073	-0.14	0.061
% Hispanic	-0.282**	0.121	-0.279**	0.131	0.108	-0.055	-0.089	0.049
% White	0.257**	-0.103	0.282**	-0.132	-0.074	0.07	0.075	-0.05
% Black	-0.096	-0.061	-0.141	0.014	-0.068	-0.097	-0.02	-0.048
% Other Ethnicity	0.290**	0.051	0.190*	0.043	-0.097	0.065	0.121	0.168*
% Single family	0.124	-0.073	-0.009	0.053	0.178*	0.121	-0.071	0.082
% Multi family	0.006	-0.009	0.081	-0.128	-0.213**	-0.006	0.038	-0.031
% Retail	-0.183*	0.183*	-0.026	-0.001	-0.023	-0.061	0.101	-0.087
% CI	-0.189*	0.098	-0.071	0.055	-0.06	-0.188*	0.058	-0.087
CI and Retail	-0.199*	0.118	-0.067	0.048	-0.057	-0.176*	0.068	-0.091
Landuse Mix	-0.096	0.049	0.062	0.045	-0.067	-0.182*	0.043	-0.074
Distance to center	0.266**	0.01	0.296**	0.059	0.063	0.126	-0.074	0.063

** Correlation is significant at the 0.01 level (2-tailed); *Correlation is significant at the 0.05 level (2-tailed).

Appendix I: Person's Correlations (continued)

Variable	Drink Fount	Rest-room	Picnic	Amen-ities	Grass	Trees	Trees Grass	Soil	Imperv.
Area	0.087	0.419**	0.220**	0.475**	0.05	0.064	0.081	0.06	-0.017
Community Centers	0.046	0.263**	0.036	0.360**	-0.004	-0.148	-0.08	-0.009	0.167*
Paths Trails	0.138	-0.053	-0.185*	0.096	-0.302**	-0.079	-0.313**	0.391**	0.062
Ball Court	-0.022	0.372**	0.228**	0.491**	0.219**	-0.03	0.183*	-0.113	-0.14
Playground	0	0.315**	0.484**	0.547**	0.161*	-0.115	0.085	-0.029	-0.063
Pool	0.099	0.210**	0.175*	0.486**	0.008	0.002	0.009	-0.031	0.116
Water	-0.051	0.207**	0.138	0.322**	-0.133	0.111	-0.063	-0.007	0.204**
Shade	0.005	0.352**	0.511**	0.640**	0.155*	-0.044	0.117	-0.002	-0.108
Drinking Fount	1	0	0.015	0.216**	-0.005	0.024	0.007	0.008	0.023
Restroom	0	1	0.476**	0.723**	0.104	-0.071	0.058	0.033	-0.055
Picnic	0.015	0.476**	1	0.665**	0.268**	0.071	0.278**	-0.151	-0.03
% Amenities	0.216**	0.723**	0.665**	1	0.129	-0.061	0.085	0.008	0.014
Grass	-0.005	0.104	0.268**	0.129	1	-0.087	0.858**	-0.714**	-0.267**
Trees	0.024	-0.071	0.071	-0.061	-0.087	1	0.437**	-0.394**	0.064
Trees Grass	0.007	0.058	0.278**	0.085	0.858**	0.437**	1	-0.848**	-0.209**
Soil	0.008	0.033	-0.151	0.008	-0.714**	-0.394**	-0.848**	1	-0.180*
% Impervious	0.023	-0.055	-0.03	0.014	-0.267**	0.064	-0.209**	-0.180*	1
Buildings	-0.039	-0.215**	-0.372**	-0.302**	-0.317**	-0.265**	-0.422**	0.005	0.129
Developed	-0.015	-0.191*	-0.293**	-0.216**	-0.390**	-0.159*	-0.435**	-0.101	0.678**
SAVI	-0.056	0.167*	0.183*	0.183*	0.219**	0.133	0.266**	-0.108	-0.251**
Nbhd Income	0.094	0.002	0.056	0.043	-0.043	0.116	0.021	0.159*	-0.139
Nbhd PopDen	-0.081	-0.141	0.077	-0.037	0.313**	0.047	0.307**	-0.371**	0.106
% Hispanic	-0.216**	0.11	0.047	0.008	-0.008	-0.207**	-0.114	-0.052	0.11
% White	0.207**	-0.129	0.011	0.01	0.023	0.243**	0.146	0.036	-0.086
% Black	-0.072	0.03	-0.231**	-0.142	-0.109	-0.191*	-0.197*	0.054	-0.074
% Other Ethn.	0.15	0.185*	0.046	0.196*	0.102	0.019	0.102	0.003	0.019
% Single fam	-0.007	0.063	0.12	0.113	0.077	0.058	0.099	-0.044	-0.053
% Multi fam	0.061	-0.11	-0.096	-0.1	0.013	0.051	0.038	-0.017	-0.032
% Retail	-0.022	-0.058	-0.13	-0.046	-0.268**	-0.046	-0.266**	0.117	0.220**
% CI	-0.052	0.029	-0.07	-0.07	-0.092	-0.147	-0.159*	0.071	0.082
CI and Retail	-0.049	0.015	-0.085	-0.07	-0.128	-0.137	-0.186*	0.083	0.111
Landuse Mix	-0.013	0.012	-0.095	-0.059	-0.056	-0.033	-0.068	0.071	-0.041
Distance to center	0.165*	-0.131	-0.003	0.107	0.035	-0.022	0.021	0.176*	-0.183*

** Correlation is significant at the 0.01 level (2-tailed); *Correlation is significant at the 0.05 level (2-tailed).

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