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PERSPECTIVES

Emerging issues in urban ecology: implications for research, social justice, human health, and well-being

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Abstract Urbanization affects landscape structure and the overall human condition in numerous ways. Green spaces include vegetated land cover (e.g., urban forests, trees, riparian zones, parks) which play a distinctive role in urban ecology. This article reviews emergent literature on the linkages between urban green spaces, social justice, and human health. We explore this subject in the context of landscape structure, ecosystem services, and distributional equity as it relates to various health outcomes. Finally, we conclude by identifying gaps in the scholarship and potential areas of future research.

Keywords Green space · Urban ecology · Public health · Nature · Well-being

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Introduction

Currently, over 50% of the world's population lives in urban areas and there are over 20 megacities with populations exceeding 10 million people (United Nations 2014; Pickett et al. 2011). As populations continue to gravitate toward urban areas, it is vital to strategically conserve and manage our natural resources. Landscapes play a pivotal role in the collective vision of sustainability science which explores the complex interactions between environmental and human systems (Wu 2013). Wu (2013) describes landscape sustainability as the long-term capacity of landscapes to provide benefits that support and enhance human well-being. Vegetation is a key component of the landscape that can be used to characterize ecological biomes, ecosystems, and other natural spaces. Research continues to reveal how vegetated (e.g., managed or unmanaged) areas such as urban green spaces (e.g., parks, forests, riparian buffers, and gardens) can positively influence human well-being (Hartig et al. 2014; Jackson et al. 2013; Kuo 2015; Wolf and Robbins 2015), regardless of sociodemographic boundaries. However, the interdependence between ecosystems and their respective benefits are often overlooked (Perrings et al. 2010). Examining the dual benefits of resilient ecosystems for both nature and humans is a complex endeavor that will require broader frameworks (Bull et al. 2016; Cumming 2011) that capture how vegetation supports ecological integrity and leads to socio-ecological benefits. Thus, understanding the link between urbanization and landscape structure represents an emerging research area that can transform our perspective on the ways that urban vegetation (e.g., green space) contribute to health and well-being (Tsai et al. 2015).

Urban vegetation can provide a number of benefits and hazards to health and well-being. For example, trees with a high leaf area index can have a greater capacity to remove atmospheric pollution; however, its species should have low emissions of biogenic hydrocarbons to minimize ozone formation (Taha et al. 1997). Major global organizations and initiatives such as the Millennium Ecosystem Assessment (MEA 2005) and The Economics of Ecosystems and Biodiversity (TEEB 2008) have recognized the importance of ecosystem integrity to human well-being. The demands placed on increasingly diminished green space are only expected to increase as over 60% of land expected to become urban by 2030 has yet to be built (Secretarist of the Convention of Biological Diversity 2012). Characteristics of urban form (e.g., complexity, centrality, compactness, porosity, and density) can relate to variables such as patch shape, extent of fragmentation, and proportion of open space which influence the delivery of ecosystem services (Huang et al. 2007). For instance, Huang et al. (2007) used satellite imagery for 77 cities across the globe to spatially analyze different patterns of urban form. They observed that countries with higher levels of average income and built infrastructure showed a higher proportion of urban open space. Specifically, some ecological indicators exhibited a strong inverse correlation with factors related to socioeconomic status (Huang et al. 2007). Globally, studies on disparate coverage or access to vegetation by socioeconomic status have taken place in locations such as Bolivia (Wright Wendel et al. 2011), Colombia (Scopelliti et al. 2016), Canada (Pham et al. 2012), South Africa (McConnachie et al. 2008), China (Wolch et al. 2014), various parts of Europe (Mitchell et al. 2015), and the USA (Bruton and Floyd 2014; Heynen et al. 2006; Landry and Chakraborty 2009; Schwarz et al. 2015).

Limited access to urban green spaces and their respective health benefits involve issues of environmental and social justice (Jennings et al. 2012). Specifically, social justice perspectives seek to illuminate limited access to urban green space that arises from historical discrimination and/or exclusionary policy or management regimes and the absence of policy to rectify unjust conditions. The spatial distribution of green spaces affects the extent that people from all socioeconomic groups can access these environments. Studies highlight inequalities in access to urban nature, and disadvantaged neighborhoods have often been found to have less public green space (Boone et al. 2009; Wen et al. 2013), lower levels of vegetation cover (Pham et al. 2012; Tooke et al. 2010), and fewer street trees (Landry and Chakraborty 2009). As urban ecosystems are a key variable at the nexus of environmental and sociological change, gaining additional insight about this relationship and approaches to address practical concerns can take the emerging field of urban ecology "to the next level" (Tanner et al. 2014). Concerns related to social justice are one of the pressing issues in urban ecology that can have implications on human health and well-being. Since urban ecology involves the study of different infrastructure, social processes, and ecological feedbacks within the larger dynamic of cities, science on the health implications of urban nature is a key component of urban ecology (Tanner et al. 2014; Coutts 2010). In this article, we synthesize recent literature to discuss this topic in the context of urban green spaces, ecosystem services, and how the inequitable distribution of vegetation may result in differences in health by socioeconomic status.

Green spaces and the encompassed ecosystem services

Parks, forests, community gardens, and the myriad other forms of private and public green spaces collectively make up our local and global system of green infrastructure (GI). GI has been defined as "an interconnected network of green space that conserves natural ecosystem values and functions and provides associated benefits to human populations" (Benedict and McMahon 2006). The definitions of other forms of vegetated land cover discussed in the literature are presented in Table 1.

Table 1 Description of terms for vegetated areas

Term	Description
Green space	"Open, undeveloped land with vegetation" (CDC 2008) which can include areas such as parks, woodlands, gardens (Lachowcyz and Jones)
Green infrastructure (GI)	Interconnected network of green spaces (Benedict and McMahon 2006) which involves the natural, seminatural, and artificial networks of ecological systems at different spatial scales (Tzoulas et al. 2007)
Parks	A type of green space which is usually owned by and accessible to the general public (Hunter et al. 2015). Parks may include playgrounds, recreational facilities, and other features that promote outdoor recreation
Canopy cover	Incorporates the role of trees to shade the ground which is influenced by factors such as canopy height, shape, and leaf area (Shanahan et al. 2015b)
Nature	Includes physical features that are not of human origin; often overlaps terms such as the natural environment (Hartig et al. 2014)

As a number of these terms overlap, Table 1 provides a general context of terminology used in this article. The explicit inclusion of the human benefits of GI makes this definition somewhat distinct from some landscape ecology approaches which focus on the environmental benefits of GI as a landscape design strategy (Wright 2011). The anthropocentric, human, benefits of GI are discussed in subsequent sections of this paper and include, for example, ambient temperature regulation and opportunities for physical activity and improved mental health. Landscape ecology and design commonly focus on how GI supports environmental systems without an examination of how doing so can result in subsequent human health benefits. A socio-ecological definition that includes human benefits recognizes that human and environmental benefits are intimately intertwined. Insights from urban ecology can inform our understanding about environmental challenges confronted by cities and solutions to mitigate their impact (Grimm et al. 2008). This is particularly important since some argue that the success of urban ecology will be measured not only by how it advances the science but also the extent to which it relays tangible benefits to society at large (Tanner et al. 2014).

Frameworks used to understand landscape sustainability may include key components such as ecological processes, structural features, ecosystem services, and landscape configuration (Wu 2013). It is also important to consider such ecological factors since the type, quality, and location of green space can affect the magnitude of its influence on health and well-being (Wheeler et al. 2015). For example, biodiversity is another ecological factor that can moderate the health benefits of green spaces, but biodiversity varies across different human communities. Even though aspects of biodiversity may be positively linked to the provision of ecosystem services (Harrison et al. 2014), disadvantaged communities tend to have a lower richness of plant species and vegetation abundance in green spaces (Clarke et al. 2013; van Heezik et al. 2013). While there is some indication that higher levels of actual or perceived biological diversity (e.g., higher numbers of plant species) can enhance the psychological restoration value of green spaces (Dallimer et al. 2012; Fuller et al. 2007), there may be an inherent conflict in which green spaces are most attractive to people, versus which might deliver the greatest benefits. On the other hand, several studies demonstrate how fragmentation can damage ecosystems and reduce their encompassing structure and functions (Haddad et al. 2015), yet others suggest that fragmentation of urban vegetation can increase access to green spaces and enhance the opportunity for them to be utilized (Tsai et al. 2015). Both of these areas represent timely topics for consideration in well-being research.

Categories of ecosystem services

Ecosystem services (ES) is a concept often used to describe the direct and indirect benefits that humans receive from nature (WHO 2005). The litany of ecosystem services can be categorized into provisioning, regulating, cultural, and supporting services (MEA 2005; Mellilo and Sala 2008). The *provisioning* services include water produced as a service of the hydrological cycle but also the plant and animal materials used as food and to make clothing and the natural resources used to produce energy (WHO 2005). *Regulating* services include processes such as water purification, climate regulation, carbon sequestration, flood control, and the pollination necessary for food production. *Cultural* services include non-material benefits from nature such as recreation on green spaces, the economic benefits generated from people visiting green spaces, along with the aesthetic and spiritual experiences felt when observing or being immersed in the natural environment. *Supporting* services (e.g., soil formation, nutrient/water cycling) serve as a backbone necessary for other ecosystem services. Some scholars classify supporting services as *habitat services*, which emphasize the overarching role of the landscape to the life cycles of species and the biodiversity necessary to maintain resilient ecosystems (De Groot et al. 2010; TEEB 2008). The Common International Classification of Ecosystem Services (CICES) does not include supporting services among its classification of ecosystem services. Instead, CICES treats supporting services "as part of the underlying structures, process and functions that characterize ecosystems" (CICES 2015).

The next horizon for urban ecology requires an understanding of the interrelated elements of cities including green and gray infrastructure, society, human behavior, and the array of stakeholders that would collaborate in this effort (Grimm et al. 2008; Tanner et al. 2014). Some argue that using the ES framework to understand the linkages may limit strategic goal setting since the extent of benefits depends on the outcome of interest, temporal and spatial variation, interagency implementation, and restrictive targets that influence how services are regarded (Perrings et al. 2010). Nonetheless, ecosystem services still provide a nexus between ecology and broader sustainability outcomes (Wu 2013), and despite these aforementioned limitations, effective implementation of this insight on ecosystem services is still in its infancy (Guerry et al. 2015). Others acknowledge that relaying the benefits of ecosystem services to multiple sectors is an area in need of improvement (Bull et al. 2016; Larson et al. 2016b).

Human health and well-being outcomes related to ES from green space

Many studies illustrate linkages between urban ecosystems and public health through a range of benefits such as heat hazard mitigation (Jesdale et al. 2013), aesthetics and engagement with nature, storm water management (Kondo et al. 2015a), along with outdoor recreation, and physical activity (West et al. 2012). Previous research from multiple disciplines indicates that urban green space can be beneficial to health as it can result in opportunities for physical activity (Hartig et al. 2014; West et al. 2012), improved mental restoration and cognitive abilities (Dallimer et al. 2012; Wolf and Housley 2013) and positive social outcomes such as reduced crime (Harris et al. 2017; Kondo et al. 2017; Kondo et al. 2015a; Kuo and Sullivan 2001; Troy et al. 2012). Even though less exposure to green space may be linked to a greater risk of morbidity and mortality for some health concerns (Donovan et al. 2013; Kuo 2015), the results have nonetheless been mixed. For example, results have been inconsistent when examining the role of green spaces on physical activity (Hartig et al. 2014), decreased body weight (James et al. 2015), and the occurrence of local crime levels (Locke et al. 2017; Wolf and Robbins 2015). However, different types of urban vegetative cover (e.g., herbaceous, shrub land, and forest) can also have significant and positive relationships with health-related variables like physical activity and body mass index (Tsai et al. 2015). While the potential scale of these benefits in relation to the risks associated with green spaces remains unclear, preventive strategies in public health have increasingly embraced the role that green spaces could play in shaping healthy communities (Jennings et al. 2016a) and public policy is beginning to follow suit (National Park Service 2011; UK Department of Health 2010). For example, Larson et al. (2016a) explored the role of public parks on multiple domains of subjective well-being (social, financial, community, and physical) in cities across the USA. They found that variables such as park quantity, quality, and access displayed a positive association with well-being. Kuo (2015) recently identified 21 potential pathways to describe how nature influences human health and well-being with immune functioning emerging as a promising central pathway in the nature and health relationship. Applying the criteria used by Kuo to assess pathways can aid in addressing critical questions in nature and health research by unraveling existing and emerging pathways. These criteria include the following steps: (1) examine the mechanism's effect size upon the nature-health link, (2) identify its role in determining a specific health outcome tied to nature, and (3) determine whether it incorporates other pathways between nature and health.

Given that direct interactions with green spaces can promote multiple benefits to health and well-being (Shanahan et al. 2015a), their design and structure are critically important for ensuring they both attract users and deliver the greatest benefits. For instance, a higher density of vegetation along the forest edge and larger patches of herbaceous cover were linked to higher levels of physical activity across parts of the USA (Tsai et al. 2015). While some suggest that western cultures prefer "open savannah" landscapes with few trees, studies show that parks with 30–40% tree cover (Shanahan et al. 2015a) and manicured green spaces tend to attract the most visitors (Coombes et al. 2010). Studies that examine the ecosystem services received from GI can also be influenced by the scale at which the services are analyzed (Richardson et al. 2012). The scale at which GI is assessed can either mask or reveal the potential health benefits derived from the *presence* of, *access* and *exposure* to, GI (Coutts and Horner 2015). Some services come simply from the presence of GI (e.g., water, air, heat reduction) in one's environment, and these benefits are often best analyzed at large spatial scales. For example, in a study of forest cover in the Pacific Northwest, it was observed that heterogeneity at a large spatial scale was crucial to sustain forest regeneration and a range of ecosystem services such as primary production, natural hazard regulation, and timber production (Turner et al. 2013). Others services are obtained from access (e.g., physical activity) or mere exposure to GI (e.g., stress reduction) (Hartig et al. 2014). Careful distribution of green space in one's local environment may increase levels of recreational walking by providing more direct paths to a range of locations and enhancing perceived attractiveness (Giles-Corti et al. 2013). Access can denote use, and accessing GI is much more likely if it is close to where humans live, work, and play (Astell-Burt et al. 2014). Even though access, by default, provides exposure, it is not a prerequisite for it. Everyday exposure can occur within one's home, workplace, neighborhood or even on the commute to work. However, many health benefits derived from *access* to green spaces are generally more localized, and a finer scale of analysis, at times even smaller than the city scale, is appropriate (Richardson et al. 2012).

Vegetation can also reduce impacts of the urban heat island due to the cooling effect of shading and evapotranspiration (Jesdale et al. 2013). For instance, a comparison of the normalized differentiated vegetation index (NDVI) and sensible heat flux in Indianapolis showed an inverse relationship between the presence of vegetation and impervious surfaces (Wilson et al. 2003). Also, other characteristics of vegetation (e.g., leaf area, biomass, species, and shape) relate to ecological functions that are a direct pathway to various health benefits (Shanahan et al. 2015a). For instance, a study in Germany noted how specific species of street trees have features (e.g., leaf area density and transpiration rates) that support ecosystem services such as heat and drought mitigation (Gillner et al. 2015). An inverse association was observed between structural features of tree cover and some health ailments (Kardan et al. 2015; Wheeler et al. 2015). Likewise, a recent study in Toronto found that areas with higher tree density exhibited significantly fewer cases of cardiometabolic conditions (Kardan et al. 2015). Since ecosystem degradation will not have the same health implications and threats to all segments of society (Myers et al. 2013), the question of who is benefitting and whether anyone is being disproportionately and adversely affected by landscape alterations that reduce ecosystem services raises critical questions of social justice.

Social inequalities and access to different types of green space

The distribution of green space can vary by socioeconomic groups and the actual type of green space. This notion is further discussed in this section.

Parks and public green space

Studies in metropolitan areas tend to show that racial or income disparities in access to green space exist, but these patterns are not always consistent (Zhou and Kim 2013). A national study in the USA showed consistent findings of lower availability of parks and public green space in lower socioeconomic status and non-White neighborhoods (Gordon-Larsen et al. 2006). At a finer spatial scale, research in Boston (Duncan et al. 2012) and Atlanta (Dai 2011) observed that census tracts with a greater proportion of racial/ethnic minorities had less density and access to open space. Using street-level measures of residential greenness, Li et al. (2015) found that greenness was positively associated with per capita income, education attainment, and proportion of owner occupied housing (for block groups). Conversely, two studies in Maryland observed that blacks and low-income persons did not have lower access to parks (Abercrombie et al. 2008; Boone et al. 2009) yet the size of the parks varied with larger parks located in mostly White block groups (Boone et al. 2009). Exploration on particular drivers of these disparities is limited. For example, what could be driving the disparity in access to parks of higher quality (i.e., larger parks) is that those with higher incomes and non-minorities may have a greater ability to pay a premium to live near higher quality parks and public green space that can support a greater array of health-supporting ecosystem services (e.g., physical activity, social capital) (Jennings and Johnson Gaither 2015).

Tree and canopy cover

Along with disparities in GI distribution as it relates to parks, other studies have made similar observations more broadly by tree and canopy cover. One study on tree and canopy cover (Landry and Chakraborty 2009) found that residential tree cover in census block groups was negatively associated with the proportion of African American and Hispanic residents and positively associated with the proportion of owner occupied housing and median household income. During a comparison of tree coverage across race/ethnicity in Miami-Dade County, FL, areas with predominately White residents had greater tree density, diversity of trees, coverage as well as energy savings from canopy cover (Flocks et al. 2011). Heynen et al. (2006) examined the distribution of urban forests in Milwaukee, WI and concluded that census tracts with higher median income, greater percentage of non-Hispanic Whites, and lower percentage of vacant housing also had greater residential canopy cover. They also observed that census tracts with more Hispanic residents had significantly less residential tree cover; however, no significant patterns were associated with African Americans. Zhou and Kim (2013) found distinct patterns of disparity in the distribution of tree canopy in six US mid-western cities. In their study, less canopy coverage was observed in block groups with more African American residents (i.e., for four of the six study areas) and median house age was a consistently significant control variable across the study areas (Zhou and Kim 2013). Bruton and Floyd (2014) compared the amount of wooded areas and tree canopy between minority and non-minority areas in Greensboro, NC and also found differences by income but not by race/ethnicity; however, they did not control for potential confounding factors (e.g., home ownership). However, observations can also be mixed as it related to studies on tree and canopy coverage. For instance, Duncan et al. (2014) examined the association between spatial distribution of trees (tree density) and socio-economic characteristics across Boston census tracts and did not find significant associations between tree density and race/ethnic composition or a measure of poverty. While this finding reveals that there are not always social inequalities associated with tree density, the literature appears to be more consistent in observations of social inequality in canopy cover. Future studies can explore the role of both tree density and canopy cover on various health outcomes to account for different structural characteristics of vegetation.

Underlying drivers to inequitable distribution and limited ES from green space

While studies exploring the socioeconomic disparities in access to green space are increasing, only a few address the historical and contemporary social–political processes underlying the observed patterns (e.g., Boone et al. 2009; Heynen et al. 2006). Moreover, greater attention should be given to understanding barriers to the decision-making processes experienced by disadvantaged communities. Differential access to and availability of quality green spaces can also be driven by a range of factors. Some of these factors include the following: land can be less affordable in greener suburbs (Pham et al. 2012), varying preferences can influence community engagement in greening activities (Conway et al. 2011; Troy et al. 2007), and removing trees may ease some concerns related to public safety (Forsyth et al. 2005) or storm damage (Landry and Chakraborty 2009) that might be considered more important in disadvantaged communities. However, given the range of potential benefits that green spaces can provide, these inequalities have the potential to drive or at least worsen social disadvantage (Heynen et al. 2006; Jennings and Johnson Gaither 2015).

Many of the underlying drivers that lead to inequitable distribution of green space mirror the factors that result in unequal exposure to environmental burdens in communities. This is important to note as historical policies related to urban planning can vary by location and influence the availability of green space across socioeconomic groups (Astell-Burt et al. 2014). Following the Hastings et al. (2006) discussion, limited access to and availability of green space become an injustice when public policies failed to address underlying historical discrimination, exclusionary policies, and management practices. The interaction between social processes such as residential segregation, community stressors (e.g., income inequality), and structural factors (e.g., zoning policies and governance structure) can affect the presence of amenities and hazards in the physical environment (Payne-Sturges and Gee 2006). As an illustration, Jesdale et al. (2013) explored the extent of canopy cover with degrees of residential segregation across the USA and found that the lack of canopy cover was associated with segregation, especially for locations dominated by racial and ethnic minorities. Specifically, Blacks, Asians, and Hispanics were significantly more likely to live in areas with no tree canopy and more impervious surface (Jesdale et al. 2013). Others note how financial constraints on local governments and low awareness of the benefits from green space can restrict their development (Kabisch 2015). Similar financial restraints of low-income residents can limit their purchasing power to live in desirable communities that are often characterized by quality green spaces (Astell-Burt et al. 2014; Landry and Chakraborty 2009). Also, the availability of neighborhood resources such as parks and greenways can be influenced by residential location and the extent of pollution sources (Payne-Sturges and Gee 2006). A study in Hall County, Georgia found that communities with a large proportion of racial/ethnic minorities and low-income persons often live in close proximity to industrial facilities yet they also reside farther from parks (Johnson Gaither 2015). As a result, inequitable distribution of green space can limit the extent of ecosystem services received by disadvantaged communities which can have multiple health implications (Astell-Burt et al. 2014; Jennings and Johnson Gaither 2015). Other scholars discuss how urban greening efforts are a strategy to reclaim vacant lots and positively influence health and safety (Kondo et al. 2015b; South et al. 2015). Future research tying inequities in the distribution of GI to inequities in health may aid in remedying inactions in alleviating GI disparities. For example, a cost/benefit analysis weighing the costs to incorporate GI solely against, for example, aesthetic benefits may be less persuasive compared to adding health benefits to the equation which may make the benefits outweigh costs. This may be especially pertinent in neighborhoods disadvantaged in many ways, including in their access to GI.

Differential health outcomes linked to inequitable access to green space

A number of studies document how inequitable access to green space and their respective ecosystem services relate to differences in health across sociodemographic groups (Jennings and Johnson Gaither 2015; Roe et al. 2013; Ward Thompson et al. 2016). Uneven distribution of green space constrains opportunities for everyday exposure to green space, active and passive forms of outdoor recreation, and utilitarian uses of public parks and trails (e.g., walking and cycling). For example, since green spaces can deliver ecosystem services such as climate regulation, psychological renewal, and outdoor recreation which promotes physical activity, inequitable access may relate to health disparities in heat-related illness, obesity, cardiovascular issues, and psychological concerns (Jennings and Johnson Gaither 2015). In their population health study in England, Mitchell and Popham (2008) found that areas with the most coverage of green space displayed lower health inequalities related to income for deaths from circulatory disease and all-cause mortality. Moreover, the incidence rate for all-cause mortality in low-income areas declined by 50% between areas with the lowest exposure to green space and areas with greatest space exposure (Mitchell and Popham 2008). Astell-Burt et al. (2014) reported similar results from a study in Australian cities where populations at a higher risk of chronic diseases such as cardiovascular disease and type 2 diabetes often lived in areas with the lowest amount of green space. Health inequalities related to varying access to green space can be related to other health outcomes. After examining the effect of maternal education on birth weight, Dadvand et al. (2012) observed that greater coverage of vegetation corresponded with an increase in birth weight among women with a lower level of education in Barcelona, Spain. Even though this study did not find strong evidence that linked exposure to green space and healthy pregnancy, it demonstrates the value of exploring such research questions across different socioeconomic groups (Dadvand et al. 2012). While the provision of green spaces is inevitably important to help relieve inequalities in access, programs that enhance exposure to these locations are critically important to encouraging their use (Cohen et al. 2013). Though it is difficult to establish conclusively whether healthy people seek out better neighborhood conditions or if health improves after exposure to environmental amenities.

Policies and practices to redress social and health inequalities related to green space

Due to the potential health benefits from green space, interest in whether parks and green space are equally available in poor and minority communities has stimulated a second wave (Taylor et al. 2007) and an expansion of the urban environmental justice agenda (Anguelovski 2015; Jennings et al. 2012). The first wave of environmental justice studies focused on environmental hazards and locally unwanted land uses, particularly in racial/ethnic minority and low-income communities (Bullard 2000). However, in order to practice sustainable development principles, it is essential to incorporate considerations of nature's benefits (i.e., ecosystem services) and natural capital in decision-making processes (Guerry et al. 2015). Practices that can be helpful from a planning perspective include empirically evaluating growth management policies and streamlining multiple policy strategies to improve effectiveness (Bengston et al. 2004). Some policies to manage green space often focus on both real and perceived disservices that natural spaces can provide for people. For example, these risks can be related to transmission of insect-borne diseases such as malaria (Quiroga et al. 2013), falling branches or trees (Vision 2015), and a negative perception of safety in some neighborhoods (Lachowycz and Jones 2013). For example, some qualitative studies note that crime, poorly maintained recreational areas, or few organized activities can limit physical activity in low-income areas (Jarrett et al. 2013; Jarrett et al. 2012).

Through better practices, the structure and configuration of vegetation can be managed in the urban environment in order to sustain and account for ecosystem services in multiple settings. Some recommend that affirmative actions to increase green space availability in low-income communities are a strategy to redress such inequalities (Astell-Burt et al. 2014). However, this approach can have its limitations since concerns related to storm damage and the watering requirement of new trees may burden low-income residents (Landry and Chakraborty 2009). Watkins et al. (2016) analyzed four nonprofit tree planting programs in the USA and found that they are less likely to happen in areas with more racial/ethnics minorities in general and low-income levels in particular. With this in mind, tree planting initiatives should not only expand in disadvantaged communities (Watkins et al. 2016) but also incorporate strategies to support long-term maintenance in such initiatives.

Other factors influence the effectiveness and longevity of green space initiatives in minority and low-income communities. For example, scholars are careful to note that increasing access to green space does not necessarily guarantee that they will be utilized in a way that is conducive to public health (Astell-Burt et al. 2014; Floyd et al. 2008), especially for individuals who are not physically active or have other concerns related to the outdoor activity (e.g., severe allergies) (Jennings and Johnson Gaither 2015). Although green space initiatives can enhance neighborhoods and increase local property values (Wolch et al. 2014), many low-income residents are concerned about gentrification which can cause them to be displaced to other locations (Watkins et al. 2016; Wolch et al. 2014). Since different communities can vary in their needs and overall context, a one-size-fit all approach may not be favorable for green space projects. For example, temperature regulation may be less important in wealthier neighborhoods where people can access services such as air conditioning. As a result, it is important to engage local residents in the design and programming related to green space initiatives (Smiley et al. 2016), for them to be fully embraced and beneficial at the local level. Consequently, planting programs that have a social mission, community oriented, and support local capacity to maintain trees can help address inequities more effectively (Watkins et al. 2016).

Conclusion and future research directions

Acknowledging that all green spaces are not created equally (Jennings and Johnson Gaither 2015; Kondo et al. 2015b; Tanner et al. 2014) is important since green spaces present trade-offs that should be considered in the context of ecosystem management (Escobedo et al. 2011; Pataki et al. 2011) as well as health and well-being (Jennings and Johnson Gaither 2015; Lovasi et al. 2013). For instance, increased stem density in tree cover removes more water out of ecosystems, yet this feature is important for other services such as landscape aesthetics and pollution regulation (Harrison et al. 2014). In this article, a primary question has centered on how ecological aspects of urban green spaces relate to health but also how inequitable distribution of green space (and their respective benefits) overlaps with social justice and differences in health outcomes. These patterns can arise even when the area designated as “public green space” is not equal across socioeconomic gradients (Shanahan et al. 2015b). Dobbs et al. (2014) expressed how ecological factors can influence landscape structure and relate to inequalities in the social and environmental arenas. More recently, an increasing number of investigations have focused on racial and income disparities in access green spaces (e.g., parks), healthy food options (e.g., supermarkets, fresh fruits, and vegetables), and safe walkable communities (Anguelovski 2015). Future research can continue to explore the connection between ecosystem services and social determinants of health through factors such as neighborhood and built environment as well as social context (Jennings et al. 2016b). This can be particularly relevant to social justice as it may provide an avenue to explore broader variables that relate to differences in health by income and race/ethnicity (Jennings and Johnson Gaither 2015; Jennings et al. 2016b). This will necessarily require interdisciplinary approaches to the study of ecosystem services that transcend the boundaries of environmentally focused disciplines.

Some strides have been made in extending the benefits of ecosystem services beyond the environmental and economic fields to the medical community (Jennings et al. 2016a) and other sectors (Bull et al. 2016; Jennings et al. 2016c). However, research taking into account the full role of sociodemographic variation and environmental factors is lacking. It is critical that future research is more representative of such racial/ethnic diversity. Research can also continue to be improved by testing the effects of policy and management changes to green space (e.g., long-term benefits of tree planting initiatives), with perspectives and holistic needs of disadvantaged communities taken into account. With the availability of multiple datasets that could be used to characterize green space (e.g., NDVI, LIDAR, NLCD, and other remotely sensed data), acknowledging the preferences of different groups may inform the strategies that are most effective. Research is now needed to more closely examine different trade-offs and to what extent do the most preferred and most visited green spaces deliver health and well-being benefits. Further insight can be developed about how the quality of green space influences human health and the role of tree species, air quality, and exposure to pollen at different geographic levels (Lovasi et al. 2013).

Successfully integrating ecosystem services into the decision-making process necessitates strong evidence illustrating the benefits to human well-being at multiple points in time (Guerry et al. 2015). Longitudinal study designs can help control for self-selection and socioeconomic variables that influence residential choices. For example, Crowder and Downey (2010) used longitudinal analyses to demonstrate that compared to Whites, Blacks and Latino householders were less able to avoid neighborhoods with environmental hazards. They noted that even Black and Latino householders with high incomes were less able to avoid such hazards than low-income Whites. More longitudinal studies on the change of green space across different socioeconomic groups can also enhance our understanding on this topic (Astell-Burt et al. 2014). On the other hand, qualitative methods can also contribute insight on the historical, political, and socioeconomic processes that give rise to disparities in availability of parks and public greenspace.

Though the benefits of urbanization for human society are unequivocal, there are also a range of negative impacts. For example, urbanization can lead to lower levels of physical activity (Oyebode et al. 2015) and is tied to an increase in many chronic and non-communicable conditions such as obesity, high blood pressure, and diabetes (Dye 2008). Green space can play an important role in maintaining and enhancing physical health of city residents, and indeed, there is evidence that people who live in greener environments are less likely to suffer from cardiovascular disease (Donovan et al. 2013; Mitchell and Popham 2008). Given the mixed results regarding the role of green space on physical activity (Hartig et al. 2014), improved air quality, and biodiversity and microbiota, these topics warrant further study (Kuo 2015). Also, relatively few studies have examined exactly how far people are willing to travel to get to green spaces. Since this may vary for different community groups (for example, disadvantaged groups may have poorer access to private vehicle transport), it remains an important knowledge gap that may inform provision policies. It is also incumbent on policy makers to involve the public, especially disadvantaged communities, in the development of green space provision policies.

Critical measures of biophysical and socioeconomic status should also be monitored to explore the complexity within social-ecological systems (Guerry et al. 2015). Such knowledge can inform our perspective of landscape resources and how they relate to the collective trajectory of human existence. As contemporary challenges to sustainable development cannot afford to perceive environmental health and human well-being as separate agendas (Wu 2013), it is important for urban ecologists to be more receptive to insight from other disciplines (Tanner et al. 2014). This collective insight can support partnerships across multiple sectors (e.g., transportation, public health, planning, recreation, etc.) and disciplines to translate scientific knowledge into action. Given increasing urbanization and encroachment on green spaces, merging insights from diverse fields can enhance our knowledge of how urban ecosystems (McDonnell and MacGregor-Fors 2016) support human health and inform the development of equitable policies that position society for a more sustainable future.

Compliance with ethical standards

Conflict of interest The content in this article are those of the authors and do not necessarily reflect the views of the federal government.

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