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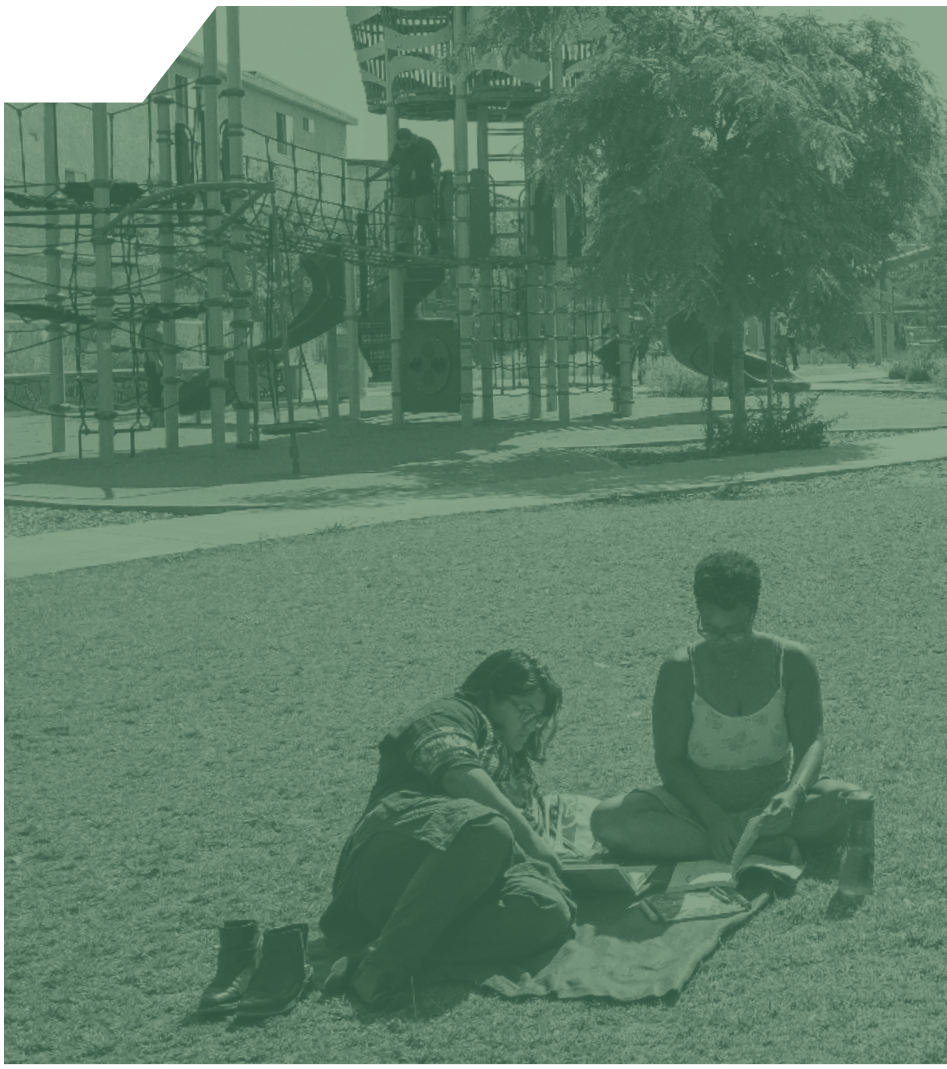

THE BENEFITS AND COSTS OF URBAN PUBLIC SPACES

ACKNOWLEDGEMENTS

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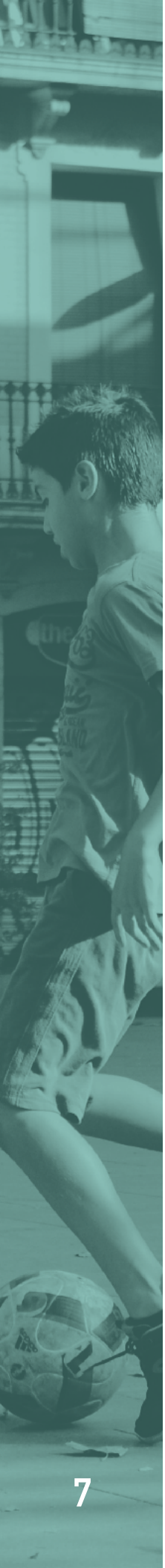


INTRODUCTION

Urban public spaces impact communities' quality of life. New parents seek the company of others at the park. Basketball players drop by a recreation center to see if there's a pick-up game they can join. Children race to the playground after school to release pent-up energy with their neighborhood friends or join a community-provided after school program. A worker takes a quiet lunch break on a bench under the shade of a street tree. Neighbors convene in the community room of the local library for their monthly reading group, just after a nutrition class ends. These activities build community and sense of place within a city, catalyzing economic development and providing benefits for both the environments and their residents.

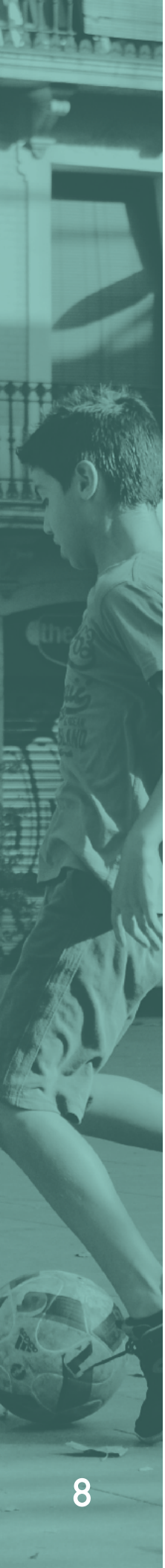
The nature of public space is changing. New models of public space provision and management shape the distribution, accessibility, and use of public spaces. Some cities seek to expand public space through new models of publicly accessible private space. In other cities, individuals and communities create their own types of public spaces by reclaiming underutilized public right-of-way land, including parking lots and vacant land. Cities aspire to energize mundane public spaces, such as bus stops and transit hubs, through public art and literacy interventions.

We expect many things from our public spaces. We ask them to revitalize neighborhoods, reduce crime, redress longstanding socio-economic and racial inequalities, and catalyze economic development. We want parks and trails to address urban environmental issues such as stormwater runoff as well as public health concerns such as obesity. Urban public spaces cannot serve as a solution for a city's problems, but they hold promise for transforming communities. San Antonio, Texas' Downtown Riverwalk is often credited with revitalizing the city's downtown area. Yet, questions remain: what frameworks do we have for evaluating the economic, environmental, equity, health, and social impacts of such an investment? How far throughout the city are the impacts felt, and how long will they last? Could a similar project be successful in another city?

Our report, a renewed inquiry into urban public spaces, synthesizes research to guide decision making and shape future investments in, and maintenance of, our urban public spaces. We summarize existing knowns and unknowns about public spaces across six themes:

1. Social capital and community development benefits of public spaces for individuals. *E.g. How can public spaces build community networks and trust? Do public spaces encourage civic engagement?*

2. Social costs and inequitable benefits. *E.g. Do major investments in urban public spaces displace certain individuals from those spaces? Do poorly maintained public spaces lead to crime?*



3. Economic benefits and costs. *E.g. Do well-maintained spaces improve nearby property values? To what extent do urban public spaces, like libraries, contribute to workforce development?*

4. Environmental benefits and costs. *E.g. Do parks help cool the surrounding neighborhood? To what extent do paved urban public spaces diminish water quality?*

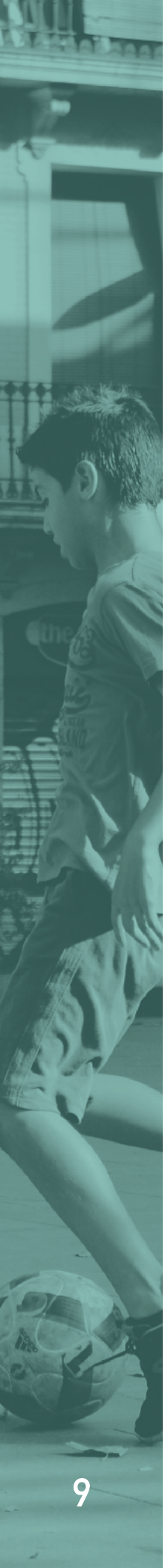
5. Health benefits and costs. *E.g. Do urban public spaces improve mental health and wellbeing? Which features of parks are associated with more physical activity happening in the space?*

6. Barriers to developing, managing, and maintaining urban public spaces. *E.g. What are the top priorities for improving public accessibility of public spaces?*

Our report reflects an interdisciplinary synthesis of prominent research on urban public spaces in American cities from 1990 to the present[1]. Our research team included five co-investigators and twelve research assistants from three universities and one federal agency[2]. Our interdisciplinary approach reflects our diverse expertise in the social sciences, and health and environmental sciences. We also worked with urban public space practitioners from the Schuylkill Center for Environmental Education and an advisory board with extensive expertise in urban public spaces with regard to policy, practitioner, and scholarly perspectives[3].

The Schuylkill Center for Environmental Education participated in the cross-sector NaturePHL program designed to connect physicians, educators, public health advocates and park and recreation agencies to offer outdoor activity opportunities to families in Philadelphia. Their green space mapping effort provides an online platform at NaturePHL.org that allows users to search for outdoor activities in 400 parks and green spaces in Philadelphia.

Public spaces are essential to urban life. They benefit and shape residential development, economic development, environmental quality, and physical and mental health. Yet there are major disparities in public space access that limit the equitable distribution of those benefits. Our report uncovers sources



of these disparities and points toward opportunities for improving public space access and the associated benefits.

WHAT DO WE MEAN WHEN WE SAY PUBLIC SPACES?

Public spaces are spaces that are open and accessible to the public. Examples are neighborhood parks, local libraries, trails, and playgrounds. These spaces are usually government owned and managed, and open for use by anyone (Kohn, 2004). However, there are few places that meet this definition in most cities today. Instead, there are many different types of spaces used by the public, such as privately owned public spaces, government-owned vacant lots that are managed by the community as gardens, publicly owned parking lots that serve as market spaces on the weekends, and privately owned arts institutions that function as public community spaces. There are also spaces, such as unused areas in and around transportation corridors, that are accessed primarily by individuals with marginalized social statuses. These populations may include youth and those experiencing homelessness.

We developed an alternative framework that reflects how the public views and uses these spaces, rather than using legal ownership definition (e.g., publicly owned vs. privately owned). We consider spaces to be public if social groups view the place as public; if the place serves a function for public use; or if it is managed for a range of uses and activities by different social groups (De Magalhães, 2010; Varna & Tiesdell, 2010). The following exemplifies our typologies of urban public spaces.

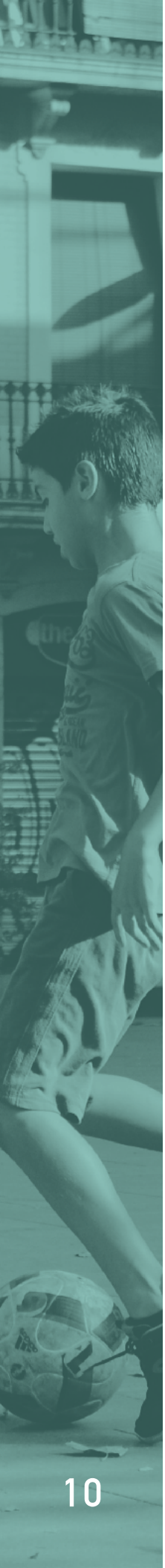
Quintessential public spaces (spaces designed to be used by the public): Parks, trails, libraries, plazas, playgrounds

Natural public spaces (natural spaces that are accessed by the public): Beaches, rivers, forests

Public right-of-way (portions of public spaces that are accessed by the public as a part of their daily transportation): sidewalks, streets, parking lots, transit stops

Privately owned but publicly accessible: privately owned parks, malls, schools/universities with public space, arts and cultural institutions and spaces

Undefined space (spaces that are not intentionally designed for the activities that take place there): vacant land (e.g. community garden in an abandoned lot), parking lots (e.g. weekend food or flea markets)



We searched for each of these types of public spaces to reflect our expansive framework. Some types of public spaces have been the subject of more research than others. For instance, there is considerable research on quintessential public spaces, and far less research on undefined spaces, like parking lots or vacant land. We hope that this report expands the way funders, policymakers, and practitioners think about what functions as a public space in our cities today.

GUIDE TO READING THE REPORT

The report is designed to be read as a complete manuscript or in sections, depending on the reader's interests. It is organized based on a series of guiding questions across the six themes. These questions capture key debates in urban public spaces and synthesize the most prominent literature in the field. Each guiding question can be directly accessed using the Table of Contents.

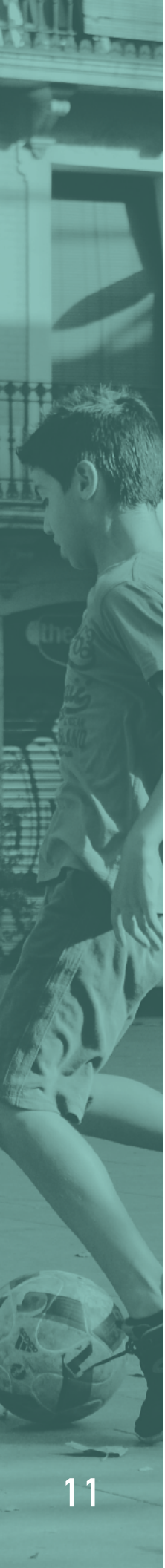
Each guiding question is followed by a detailed synthesis of the knowledge to answer the question, as well as a summary of the weight of evidence to support an answer to the question. The following terminology summarizes the evidence:

Sufficient: Sufficient implies good consistency among studies. If there are inconsistencies, there are multiple high-quality studies that show the association, and there are biases that would account for any disagreement by lower-quality studies.

Limited: This implies fair consistency as well, but chance or bias cannot be ruled out due to the design or quality of the studies, based on the three following scenarios:

1. All the studies have weaknesses that inhibit causal interpretation;
2. There are several good quality studies that show the association but may have residual biases, or the studies are limited in number or scope (e.g., multiple studies conducted in one location);
3. Several studies show an association, but a higher-quality study does not show the association, casting some doubt.

Inadequate: This implies that there is enough inconsistency to cast doubt on any positive results, or the studies are so poorly designed that we can't expect them to adequately address the hypothesis. Alternately, there may be too few studies to determine consistent findings.



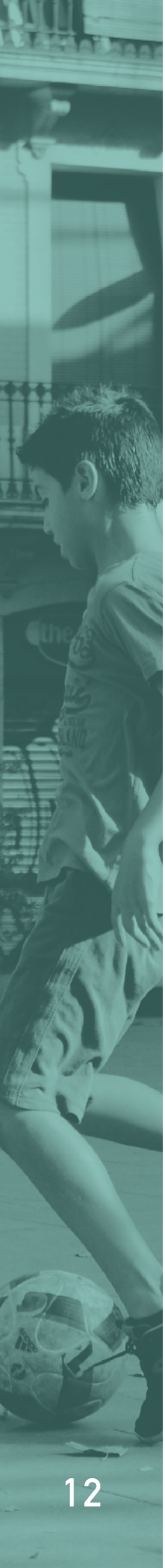
WHAT ARE THE KEY TAKEAWAYS ABOUT URBAN PUBLIC SPACES?

Key Finding #1:

STUDY AFTER STUDY FINDS THAT INEQUITIES IN URBAN PUBLIC SPACES BENEFIT CERTAIN COMMUNITIES AND FAIL OTHERS.

Research shows that public spaces provide a wealth of benefits for cities:

- Create opportunities for social contacts and connections
- Provide places for expressing free speech
- Increase economic activity and property values
- Lower temperatures, reduce stormwater runoff, and promote biodiversity



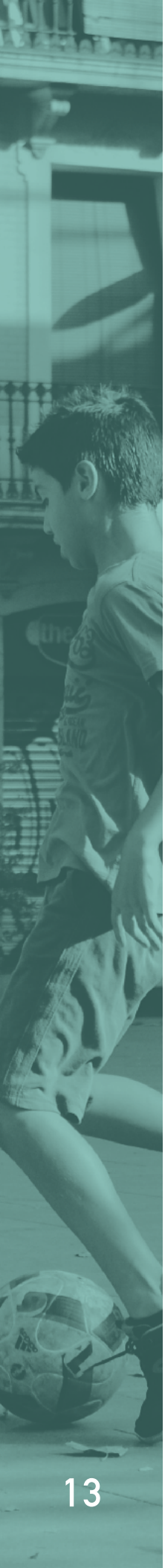
- Improve mental health
- Provide spaces for physical activity
- Offer health-related information, as well as health programming
- Serve as refuge sites during extreme weather events

However, studies reveal substantial inequities associated with the distribution of these benefits. Public spaces are unevenly distributed across neighborhoods and cities, and the quality of these spaces also varies. Low-income communities and communities of color have less access to high-quality public spaces than whiter and wealthier neighborhoods, and the quality of public spaces has important implications for the health of communities and their environment. Poorly maintained public spaces depress property values, attract litter, and incite fear of crime. High-quality public spaces supported through public and non-profit funding are concentrated in whiter and wealthier communities. Local stewardship addresses some inequities in park maintenance, however, reliance on community groups to maintain public spaces can justify budget cuts, reinforce inequities, and place more burden on those tasked with regular stewardship activities. Further, poor neighborhoods face challenges in creating and retaining civic groups. In these poor neighborhoods, informal and grassroots groups may struggle to make political connections and remain stable over time. These inequities in our public spaces are persistent and pervasive in urban neighborhoods across the country.

Key Finding #2:

PUBLIC SPACE INVESTMENT THAT CATALYZES ECONOMIC DEVELOPMENT IS OFTEN ASSOCIATED WITH DISPLACEMENT.

Major investments in public spaces that are guided by pro-business interests and focus on economic development (e.g. flagship arts institutions and urban parks) may risk contributing to user, residential, and commercial displacement, exclusion from the planning process, and a change in the social and cultural tone of the local community. Several studies suggest that pro-business investments often exclude or only superficially include residents and community members in the planning process, which limits the ability of community members to shape the investment and temper negative impacts. Evidence indicates that private ownership of public spaces, which is usually fiscally driven or incentivized, also tends to limit the political, social, and democratic functions of public space and puts constraints on who can actually use the space. While investments driven by business interests have the potential to displace existing residents, targeted investments that create a range of



benefits other than business activity may actually restore access to public spaces for local residents who feel that these areas have become inhospitable for them. Further, the social returns on investment in public spaces, such as decreases in crime, have been estimated to be highest in low-income neighborhoods and on vacant and rundown lots. There is little research on the types or characteristics of investment in public spaces that mitigate displacement risk.

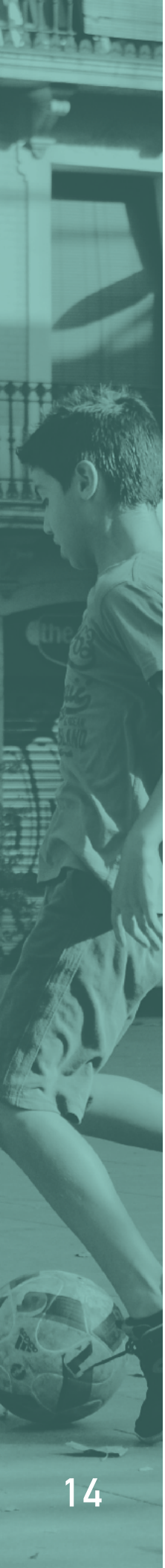
Key Finding #3:

THERE IS SUFFICIENT EVIDENCE THAT THE SPATIAL AND PHYSICAL DESIGN OF PUBLIC SPACES MATTERS FOR CERTAIN ENVIRONMENTAL OUTCOMES, BUT LIMITED EVIDENCE THAT DESIGN IMPACTS SOCIAL OUTCOMES.

Design decisions have critical implications for environmental outcomes. Decisions about landscaping directly impacts water quality, air quality, and temperature. On a hot day public spaces with **impervious surfaces** are hotter than parks with large shade trees. However, the spatial arrangements and species of trees are also important for air quality. **Coniferous trees** remove more air pollution than deciduous ones. Sparse vegetation doesn't allow for enough wind speed reduction to allow the vegetation to reduce air pollution, but dense vegetation may prevent contaminated air from reaching the forest interiors. In short, planting trees without sufficient attention to environmental outcomes may limit the environmental benefits of our public spaces.

However, evidence is limited that public spaces designed to encourage social encounters foster long-term, deep relationships across social groups. There are disagreements over the extent to which design and aesthetics may encourage or discourage uses of a particular space. This disagreement stems, in part, from the contextual specificity of how the design is implemented or perceived. Studies show sufficient evidence that spaces that are designed or intended for social interactions, such as recreational parks and athletic areas, allow users to form social ties and foster a sense of community based on their racial and class identities, as well as their common interests. However, evidence is limited that these features build social capital across different social groups. Social factors, such as the enforcement of particular rules by community members or authority figures, are shown to have a greater impact on guiding or regulating interactions across social groups than specific design features.

There is evidence that design can foster temporary civility across social groups to coexist and share the space. However, this civility may not translate into

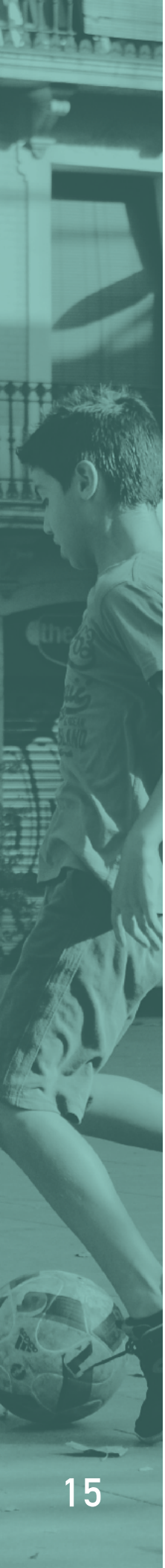


meaningful relationships beyond the specific locale of interactions and in some cases can even fall apart during conflicts over the use of public space. Design can also negatively impact social interactions. Different groups may have varying needs and interests in a space, limiting the potential for interactions across social groups. For example, single-use spaces such as dog parks can exclude people who are uninterested or do not need to partake in the designated activity.

Key Finding #4:

GENERALIZING ABOUT URBAN PUBLIC SPACES AND THEIR IMPACTS IS DIFFICULT BECAUSE CONTEXT IS IMPORTANT.

The local context is important: what might be successful in one city may have a different outcome in a different city or neighborhood, given the social, political, and economic circumstances. In some contexts, dense vegetation intimidates park users and creates a feeling of isolation, yet in others, users are drawn to it. In some neighborhoods, researchers have found that community stewardship of public spaces has exacerbated inequities as wealthier communities have greater capacity for stewardship. In other neighborhoods, community stewardship has called attention to these inequities, leading to broader engagement in political processes. Programming may lead to increased physical activity in parks, but only under certain conditions. Evidence on the inter-group interactions in public spaces developing into a broader, long-term social cohesion across social groups is supported in certain contexts. The impact of public space design on who actually uses the public space and how is context dependent.



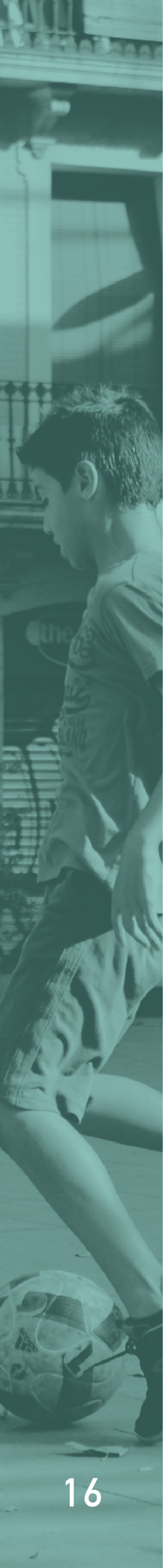
WHAT ARE THE KEY KNOWLEDGE GAPS THAT LIMIT THE POTENTIAL OF URBAN PUBLIC SPACES?

Knowledge Gap #1:

THERE IS A NEED FOR RESEARCH ON PUBLIC SPACES BEYOND THE QUINTESSENTIAL PARKS, LIBRARIES, PLAZAS, AND PLAYGROUNDS.

There is a critical need for research on more diverse types of public spaces, as well as studies comparing results across these nontraditional public spaces to understand if the findings from quintessential public spaces are true for other types of public spaces. For instance, do informal dog parks on vacant lots provide the same types of social benefits as formalized neighborhood parks? Many studies focused on particular types of public spaces. For instance, public health research focused on parks and trails, while sociological studies examined the impacts of parks, libraries, and plazas on **social capital**. Studies from geography and urban planning included a focus on informal green spaces, particularly community gardens, but rarely considered libraries or recreation centers. Little environmental research examined public spaces specifically, with the exception of studies that focused on the potential for green space to mitigate temperatures (e.g. “park cool islands”), which suggests a need to more systematically assess the role that public spaces actually play in shaping urban environments.

What is a park cool island? A city sidewalk is often a few degrees warmer than a trail in a shady park. This phenomenon is called a “park cool island” and it is created by the presence of grass and trees, as well as the absence of cement and blacktop.

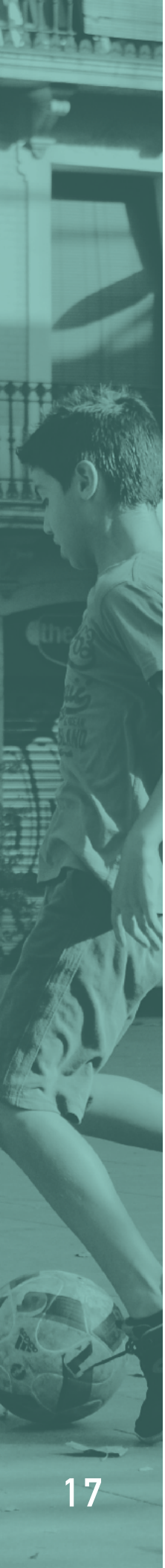


Certain types of public spaces were less researched overall, including natural spaces such as beaches, or arts and cultural and/or religious institutions that functioned as public spaces. Future studies should include a broader framework for urban public spaces that reflects how spaces are currently used by the public. This would foster understanding of how public spaces can be created, designed, and managed to optimize opportunities for social connections, community development, crime reduction, environmental quality, and physical and mental health.

Knowledge Gap #2:

THERE IS A NEED FOR MORE RESEARCH ON THE CONTEXTUAL FACTORS THAT SHAPE OUTCOMES.

We need to better understand the contextual factors that lead to different outcomes. Exploring the question "under what circumstances" would allow practitioners and policymakers to tailor different public space interventions for different neighborhoods and contexts. For instance, the large-scale gentrification impacts associated with the opening of The High Line in New York City, as well as other **signature parks** across the country, suggest that high-profile parks have considerable potential to gentrify neighborhoods. But less is known about whether smaller public space investments in neighborhoods with different socio-demographics would successfully avoid gentrification, or would simply take longer for gentrification to take hold. In the context of optimizing public spaces for heat mitigation, there will clearly be different approaches for different climatic regions and even for different geographic factors within the same region. The question about whether tree plantings are an appropriate strategy to reduce surface and air temperatures also depends upon the local climate and water availability. Much of the research on urban public spaces has been conducted in large coastal cities with diverse populations, most notably Los Angeles and New York City. There is a need for research that directly engages with contextual differences: across cities, by size of cities, by different socio-demographic profiles, by environmental characteristics, by quality of public space, and over time. This would allow fuller exploration of "under what circumstances" certain public space interventions lead to different outcomes and would allow practitioners and policymakers to design public space interventions that optimize benefits and minimize costs in their local geographies.



Knowledge Gap #3:

THERE IS A NEED FOR MORE INTER- AND CROSS-DISCIPLINARY RESEARCH AND GREATER COLLABORATIONS AMONG RESEARCHERS, PRACTITIONERS, AND POLICYMAKERS.

There is a need for more inter- and cross-disciplinary research and greater collaboration among researchers, practitioners, and policymakers to address complex questions about our urban public spaces. When, how and why do certain public spaces enable cross-social interactions while others do not? Is there a certain threshold of investment or type of investment that minimizes the likelihood of displacement and marginalization? How to invest in public spaces to improve civic culture, health, local environments, and sense of pride in a place without creating economic displacement is a pressing question for many urban areas. Answering these questions requires incorporating diverse methodological approaches and theoretical perspectives to evaluate the tradeoffs and unintended consequences of investments in urban public spaces. Further, closer collaboration with practitioners that create and manage our public spaces in cities across the country could provide insights into issues that have great context specificity (e.g. conditions where features of urban public spaces facilitate meaningful connections across social divisions).

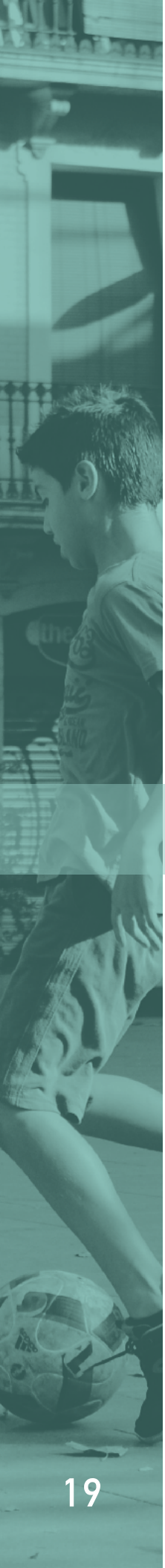
Knowledge Gap #4:

THERE IS A NEED FOR MORE ROBUST STUDY DESIGNS.

Research on urban public spaces has uncovered many associations, such as the correlation between proximity to green space and improved mental health. However, many studies are limited in their ability to infer causation or reveal the mechanisms that lead to these correlations. For instance, is green space correlated with mental health because of improved air quality, reduced noise, or the types of social interactions that happen in green spaces? Many studies describe associations between parks and physical activity, but it is unclear whether living near a park leads to (causes) greater physical activity or whether people who already engage in more physical activity choose to live close to parks. Why do some spatial designs foster social capital and cohesion while others do not? There is a need for more robust study designs to examine whether relationships between public spaces and social outcomes are causal, rather than simply correlated, and there is a need for additional studies to reveal the mechanisms underlying the association.

There is a need for stronger evidence, including **experimental designs** and **longitudinal studies**, to better understand the long-term impacts of public spaces on **social capital**, economic activity, and health, among other outcomes. By taking advantage of initiatives to install new public space or for public space improvements, research can directly track outcomes following the changes in public space. Even more robust are designs involving randomization of sites to receive the public space improvements, allowing **control** for extraneous factors that might also cause changes during the study period. **Randomized trials** have been used to study the effects of vacant lot greening on mental health and crime (Branas et al., 2018; South, Hohl, Kondo, MacDonald, & Branas, 2018). Other studies have utilized a **quasi-experimental** or **natural experiment** approach, by measuring social/economic/health indicators before and after public space improvements; such as in studies of physical activity in neighborhood residents after installation of new walking and cycling routes (Macmillan et al., 2018), injuries occurring in retrofitted playgrounds (Howard et al., 2005), and crime around new green stormwater infrastructure (Kondo, Hohl, Han, & Branas, 2016).

There are many untapped data sources from various technologies, such as web applications or wearable health devices that could be better utilized in the study of urban public spaces. Big data analytics have advanced rapidly in multiple fields, yet haven't been fully explored in the context of public

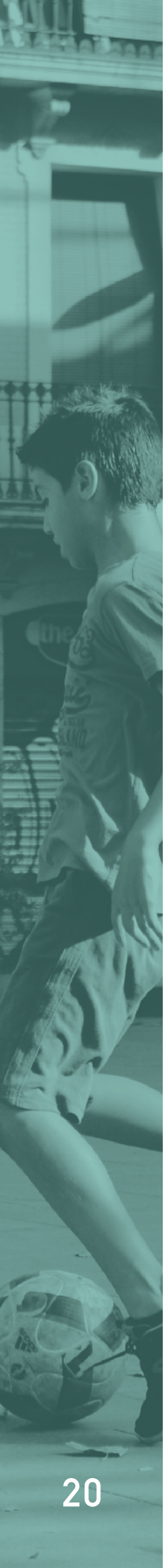


space. Some exceptions are in the field of evaluation, where researchers have attempted to replicate paper and pencil park audits that require hours of on site observations by drawing on social media data or remotely sensed data, such as Google Earth imagery. These efforts promise to make evaluation more efficient and less costly, but the tradeoffs and limitations of big data approaches should be further explored. For instance, whose opinions are overlooked if social media data are used to survey opinions of a local park? Or, what features along a trail are not visible from satellite imagery? With data from locational tracking by smartphones (e.g., Google Location History), it would be possible to gain valuable information about how far people are willing to travel to visit a public space, either for repeated or infrequent visits. Other valuable data would include the routes taken to travel to a public space and how long visits last. Connecting locational data with social network data would allow insight into the use of public spaces for socializing. Furthermore, locational tracking may help address gaps in existing research. For example, if living near a park is associated with improved mental health or increased physical activity, is there any evidence that those outcomes occur because of actual visits to the park, or is living nearby enough? Despite the promise of locational data, privacy concerns will make access to and use of this data challenging.

SOCIAL BENEFITS

1) DO PUBLIC SPACES BUILD SOCIAL CAPITAL AND COHESION WITHIN SOCIAL GROUPS?

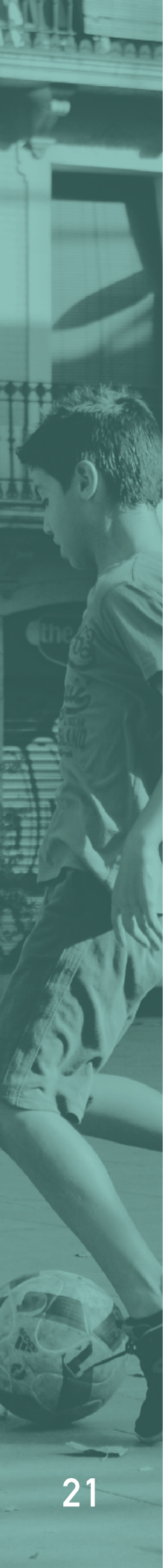
There is sufficient evidence that active "**place-making**"(Gieryn, 2000) practices by public space users are associated with **social cohesion**, or a sense of shared identity, among individuals with shared social traits. Shared social traits can include race, ethnicity, age, immigration status, and people's life stage (e.g., married, parenting, retired). The "public-ness" of public space is defined by ownership, level of control, civility among users, physical configuration, and how much people actually use the space (Varna & Tiesdell, 2010). Users attribute a unique set of meanings to public spaces and claim symbolic ownership by taking care of the space, using the space regularly for organized or informal social interactions, and by altering the space aesthetically (e.g., moving tables for a picnic or installing murals). Use of public spaces collectively is associated with "bonding" **social capital** (Lukasiewicz et al., 2019), which are social ties among people of the same social background, especially for marginalized individuals such as teenagers or recently arrived immigrants.



Social capital refers to our connections to others, and how these connections give us access to information and resources. For example, you may learn about a new bike path from a coworker, or about an interesting summer camp option by hanging out with other parents at a park.

Studies indicate that public spaces with lower levels of surveillance and social control (e.g. rules enforced by security guards or scrutiny for "proper" behaviors by other users) foster social interactions and collective ownership of these spaces by social groups (Kallman, 2015; Main & Sandoval, 2015). Whites and middle-class users are more likely to expect the use of public space to be individual or private experiences, for exercise or moments of reflection. Alternatively, racial and ethnic minorities, immigrants, and teenagers primarily use public spaces for socializing with each other (Trouille, 2013; Vieyra, 2016) (Vieyra, 2016; Trouille, 2012).

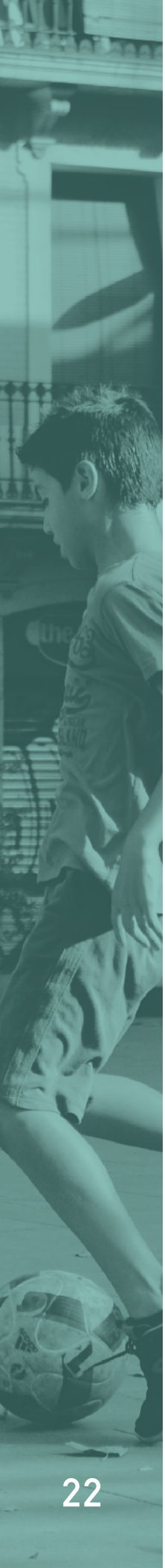
Studies show sufficient evidence that spaces that are designed or intended for social interactions, such as recreational parks and athletic areas, have the strongest positive impact on the users. This allows users to form social ties and foster a sense of community based on their racial and class identities, as well as their common interests. For example, routine use of basketball courts by Black residents (Vieyra, 2016) or soccer fields by Latinx residents (Trouille, 2013) transforms these areas into spaces that are associated with a particular racial or ethnic subculture. The users interact with each other to give social and material support, while also expressing collective identity and informal ownership of a public space by delineating the *us* versus *them* along racial and class lines (Kallman, 2015). These users enforce the rules of conduct and minimize conflicts with *others* (white, middle-class users) for fear of the others calling law enforcement (McNamarah, 2018). Larger stadiums or arenas create a space for socializing among residents that share interests in sports and commitment to the local team (Borer, 2008). This is one of the ways in which public spaces serve as what Ray Oldenburg (1989) called "the third place," casual dining spaces such as cafes and pubs as a place where the regulars and drop-in customers can experience the sense of community in a carefree, festive atmosphere. When it is tolerated, even if not officially permitted, users may symbolically claim collective ownership of the public spaces through aesthetic modification or intentional use of the space for rituals and social gatherings (Main & Sandoval, 2015).



Main and Sandoval's (2015) study of MacArthur Park in Los Angeles, California shows Latinx park users describing a feeling of comfort in seeing the park reminding them of their home countries, based on the presence of primarily Latinx users and street vendors. It also mentioned the significance of unique cultural events taking place in the park, such as the annual El Salvadoran Feria Agostina and the Central American Independence Day celebration and parade.

Notably, even when a diverse population is sharing a space, users tend to congregate along existing social lines, such as race, ethnicity, class, and common interests (Low, Taplin, & Scheld, 2009).

Public space users who view their use of public space as social experiences, rather than than those who view their public space use as private experiences, are more likely to develop a sense of collective identity or togetherness among people who share similar demographic traits. These traits can include race/ethnicity, class, educational backgrounds, and immigration status; also known as in-group **social cohesion**. White, middle-class visitors to public green spaces tend to view them as places of peaceful respite where they can appreciate nature in ways that are more consistent with the Western, romantic notion of nature and wilderness (Low et al., 2005). Public space uses also tend to differ along with gender identities. For example, while both men and women value social activities in the park, women are much more likely to use public parks with others and consider playgrounds as their favorite park amenity. Men are more willing to come to the park alone and are drawn more to the sports facilities (Loukaitou-Sideris, 1995). Immigrant women with children find connections to other mothers through their uses of public libraries (Branyon, 2017), indicating that gender combined with life stage shape users' expectation for using public space to socialize with their in-group (Audunson, Essmat, & Aabø, 2011). Studies did not distinguish across types of public spaces in discussing their **significance** on **social cohesion** or **social capital** beyond describing the specific space that was the focus of the case study. More studies are needed to understand why some urban public spaces create **social cohesion** among immigrants and others don't. Moreover, Barrett (2011) points out that museums' studies of their visitors often lack critical consideration of a self-selection among the types of individuals that visit museums. She argues

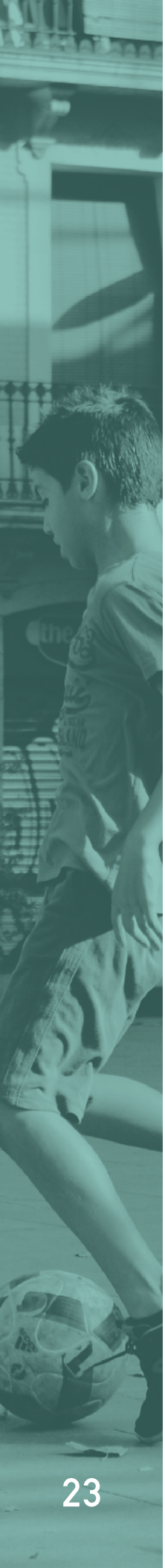


that these studies risk conflating the existing users with the public at large or the community when discussing the role of the museums as public places.

But some social groups are marginalized from these public spaces. Most notably, the use of public space by people experiencing homelessness does not appear to result in closer social connections with each other (Reitzes, Crimmins, Yarbrough, & Parker, 2015). Unhoused individuals traverse between the "marginal spaces" (e.g. back alleys, under freeway overpasses) and the "prime spaces" (e.g. plazas, sidewalks) as they attempt to maximize their access to resources and safety (Snow & Mulcahy, 2001). Their occupancy of the space for living rather than leisure fundamentally increases the risks of scrutiny over their use of public space. Homelessness has become increasingly criminalized (Stuart, 2016). As a result, homeless individuals tend to minimize their spatial occupation and their interaction with each other. When the homeless population congregates in public spaces, they find a level of safety associated with their concentration but their relationship to each other tends to be instrumental for survival. These associations occur along racial lines, age of individuals, and the length of being homeless (Addo, 2018).

Teenagers and racial minorities are also aware of the social scrutiny they face while using public space, due to the conflicting sentiments that children must be protected but not heard (Valentine, 1996). Young people's use of public spaces to socialize often violates the intended uses because they are rarely intended users of the public space (Childress, 2004; Lieberg, 1995) and activities such as loitering or skateboarding are prohibited (Borden, 2019; Thomas, 2005). Some teens congregate in public spaces with less explicit surveillance, such as parking lots or green spaces, or hang out in privately owned and managed quasi-public spaces such as shopping malls while minimizing their presence or resisting adults' gaze in protest (Kato, 2009; Pyyry & Tani, 2016). The youth engage in these practices because most public spaces are not designed with this age group in mind, or are implicitly or explicitly hostile toward their presence, regardless of their race, class, or gender. Young people find that navigating public spaces with others like themselves reduces the anxiety of social scrutiny, and makes their use of public space, such as riding the subway, more enjoyable (Ocejo & Tonnelat, 2014). Among **LGBTQIA+** youth, socializing in public spaces tends to occur along racial and class lines (Greene, 2019; Reck, 2009; R. Rosenberg, 2017).

The evidence is limited on the extent to which the **social capital** being fostered in public spaces extends into long-term relationships, or has broader significance in strengthening social cohesion within social groups. There is sufficient evidence that repeated, routine use of public spaces by immigrants or ethnic minorities (Langegger, 2013a; Trouille, 2013), the youth (McCray & Mora, 2011; Skelton & Valentine, 2005), or the regular visitors at quasi-public retail spaces like shopping malls (Duneier, 1992; Oldenburg, 1989) fosters



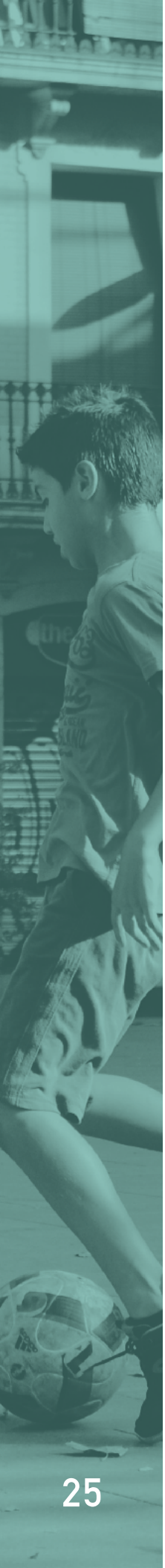
stronger bonds and collective identity among the users. But often these individuals already know each other before arriving to the public space, and there is inadequate evidence showing that new relationships are being forged and retained within members of shared social identities through their shared use of public space. The significance of public spaces for collective identity formation may not be static, as evidenced by the declining significance or changing configurations of "gayborhoods" for the **LGBTQIA+** communities (Ghaziani, 2014; Greene, 2019). As social acceptance and recognition of heterogeneity within social groups expands for marginalized communities, their needs to carve out distinct identity-based social space within public space may decline for the relatively privileged members within that group. These privileged members can include middle-class, white, gay men, when compared to low-income, Black, transsexual women. Additionally, the availability of online applications, such as Grindr, that enable social connections have expanded opportunities for **LGBTQIA+** individuals to find others with shared identities or interests (Blackwell, Birnholtz, & Abbott, 2015). Among the unhoused population, the newly dislocated initially resist socializing with others on the street—at the cost of being excluded from resources and information—yet they eventually begin to identify with other homeless individuals, even if the relationships remain instrumental and ephemeral (Snow & Anderson, 1993).

Overall, studies on this topic tend to focus on large coastal cities with diverse populations, most notably New York City, New York and Los Angeles, California; and less on smaller cities with more homogeneous populations. Methodologically, the studies of **social capital** and cohesion tend to rely on qualitative data and analysis, most commonly **ethnography** and interviews (see Khoo et al. (2012) for the review of the library research). But few studies use different methods such as surveys, individual diaries, or **GIS**. It is common for studies to combine multiple data collection methods. This also means that the measurement of **social capital** tends to be qualitative (e.g., perceived and expressed sense of trust or distrust) rather than quantitative (e.g., number of links, or relationships among people in the same network). The complexities of findings regarding how **social capital** and cohesion are fostered in public spaces illuminate the importance of taking intersectional approaches in studying public spaces to understand how the spaces reflect, reinforce, or challenge intersections of identities and social boundaries. Recent reports on the potential of museums and libraries as community catalysts list social connections as one of the key social wellbeing dimensions to be emphasized in reimagining the role of these public institutions (Norton & Dowdall, 2016). The report emphasizes the need to identify specific needs of community members, especially in low-income communities of color, while also connecting organizational and cultural resources at an institutional level. More research is needed to continue delineating and comparing within a social group. Examples include individuals experiencing long-term homelessness and street youth; both recently-arrived immigrants and multi-generation

immigrants; Latinx communities across generations or across ethnic groups; or middle-class Black families that are long-term residents and middle-class white families that are newcomers. It is also important to keep in mind that these differences are contextually and relationally understood, meaning that not everyone in each social group shares the same needs and desires in their use of public space. Furthermore, studies have not engaged in longitudinal approaches to examine whether bonding **social capital** being cultivated in public spaces develops into long-term relationships or fosters **social cohesion**.

2) DO PUBLIC SPACES FOSTER SOCIAL CAPITAL OR COHESION ACROSS EXISTING SOCIAL DIVISION LINES (E.G., RACE, CLASS, AGE)?

Common theories frame public spaces as democratic places of coexistence and collective mobilization across demographic and status lines. But findings from the current scholarship provide limited evidence that public spaces create actual opportunities for diverse groups of people to interact and forge "bridging" **social capital**; relationships across social boundaries (Lukasiewicz et al., 2019). There is some consensus in the scholarship on the general attempt to peacefully coexist between social groups, but the interactions can



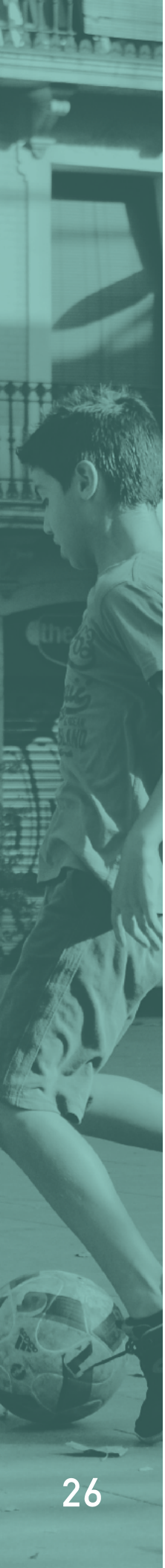
remain superficial (Lofland, 1971; Simões Aelbrecht, 2016) or even become hostile when there is a competition over access to the same public space (Aptekar, 2015; Trouille, 2013).

Trouille (2012) studied a public soccer field in a predominantly white, middle-class Los Angeles, California neighborhood. Latinx soccer players who did not live nearby but worked in the area had been playing the pick-up game mid-day for a long time before the park was renovated. In order to retain their control over the field, the players engaged in a variety of tactics to discourage newcomers, especially whites, from joining the game. For example, the leader kept a limited number of jerseys for the player that he distributes at his discretion. There were also other informal rules that the newcomers were called out to have violated, a reminder of their outsider status.

Some studies highlight public space's potential for bringing people of diverse backgrounds together to perform civility, while others point to the limitations of such potential, especially in terms of producing lasting connections. The latter set of studies attribute these limitations to several factors:

- The changing role of public spaces, decreased opportunities for the diverse population to share public spaces (de Souza Briggs, 2007; Low, 2009),
- Increased privatization and surveillance of public spaces (Davis, 2006; Shepard & Smithsimon, 2011), and
- Conflicting visions on the expected uses of the space (Aptekar, 2015; Loukaitou-Sideris, 1995; Sendra, 2015).

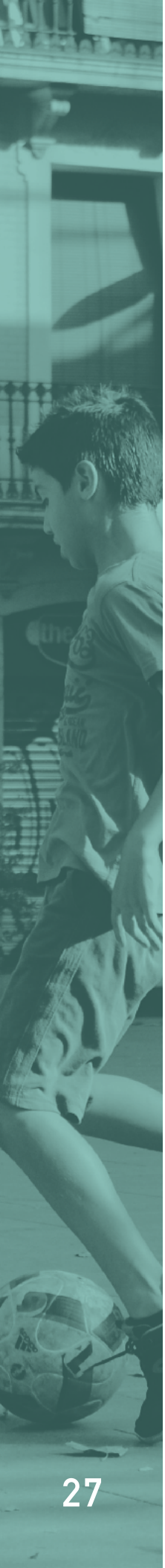
There is limited evidence that monitoring can improve urban public space accessibility for marginalized populations. There are conflicting findings among studies, in part due to the historical practices associated with monitoring as a form of "cleaning up" public spaces and removing certain park users. However, several studies indicate that monitoring practices, when applied with



the explicit intent to improve accessibility, can have benefits for marginalized populations. Studies used various methods to examine the potential of public spaces to foster cross-social group interactions, including ethnographic observations, interviews, surveys, and Public Participation Geographic Information Systems (PPGIS). PPGIS brings **GIS** mapping technology to empower the public in producing data and knowledge for their community.

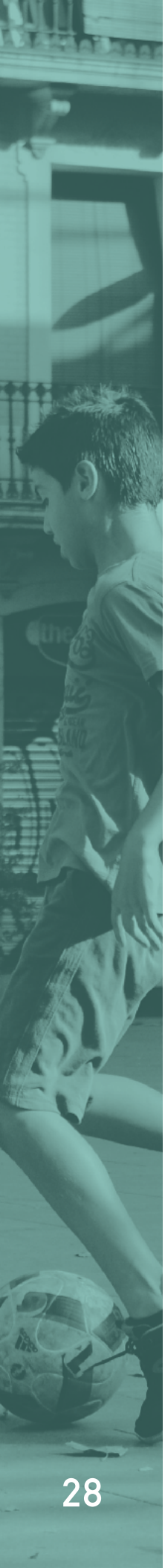
Public space has long been seen as imperative for democracy and civility in urban studies scholarship. Jane Jacobs (1992) argued that public space is crucial for creating opportunity for routine, mundane interactions among strangers, thus creating a sense of trust and collective identity. Contemporary research partially supports this theory. Ray Oldenburg's (1989) "the third place" concept refers to a neutral place that is neither home nor work, where strangers and regulars can gather to experience a sense of community. Anderson's (2011) "cosmopolitan canopy" concept, developed as a result of ethnographic observation of Philadelphia's Reading Terminal Market, describes a type of public place where visitors develop civility and tolerance toward others while coexisting in diverse public space. The space Anderson describes attracts a diverse population engaging that population in activities that create "symmetrical relations" among users, resulting in civil interactions that overcome existing preconceptions toward strangers. Overall, social scientific research on this topic tends to focus on the negative aspects of the public space's impact on social cohesion and diverse **social capital**, particularly focusing on the experiences of socially-marginalized populations' challenges or disinterest in forging these ties. While implied, studies have not extensively explored how the dominant groups value and practice inter-group experiences in public spaces while they share spaces with others.

Among the studies that do find evidence of interactions and relationships across social boundaries being forged in public spaces, **social capital** development was identified in both spaces that were intended for diverse, interactive uses and those that are not intentionally designed for social interactions. When the public space offers amenities that encourage interactions of strangers; such as libraries, parks, or youth centers; these spaces can foster bridging capital across social groups through repetitive, mundane activities. These activities can include volunteering, playing sports, or visiting libraries with children (Amin, 2002; Lukasiewicz et al., 2019; Melike Peterson, 2017). Social mediation—individuals actively engaging to initiate contacts or facilitate interactions—seems to encourage interactions among strangers of different social backgrounds sharing public spaces. For example, at public markets where the merchants model civil interactions amongst themselves and with the customers, visitors engage in friendly interactions with strangers (Kallman, 2015). Librarians can also facilitate and model inter-group encounters through formal programming such as language acquisition and public information seminars for recently arrived immigrants (Vårheim, 2011).



An opportunity for the public space to foster social capital across racial and class lines seems to be on a decline in many American cities (Chaskin & Joseph, 2013; Curley, 2010; de Souza Briggs, 2007). This is partially owed to residential segregation but also due to the increased surveillance of public spaces that often results from privatization of ownership or management. Direct and indirect surveillance of public space limits access to resources and threatens the potential to foster encounters across social division lines including between whites and racial minorities (Davis, 2006; Low, 2009 Shepard & Smithsimon, 2011). There is sufficient evidence that formal monitoring of public spaces by the police implicitly or explicitly targets marginalized populations—such as people experiencing homelessness and people of color—reinforcing a sense of intimidation and marginalization among these population (Sampson & Raudenbush, 1999). There is an increasing awareness of instances where white individuals call law enforcement on black individuals picknicking or socializing in public spaces (Kahn, 2019; McNamarah, 2018). These instances serve as anecdotal but instructive examples of the competing evidence of public spaces becoming a place of contention rather than comradery and reconciliation (Mann, 2018). These instances may occur in the context of people of color generally perceiving public spaces as "white space," where their presence is at risk of scrutiny regardless of their socioeconomic status. Additionally, whites may attribute negative perceptions to spaces occupied by people of color regardless of the socioeconomic status (Anderson, 2015). When the monitoring is conducted by the citizens, the process similarly reproduces the status hierarchy. Newman's (2013) case study in Paris found that privileged members of the community took on the leadership of monitoring a public park, while leaving racial minorities and immigrants in the position of being monitored.

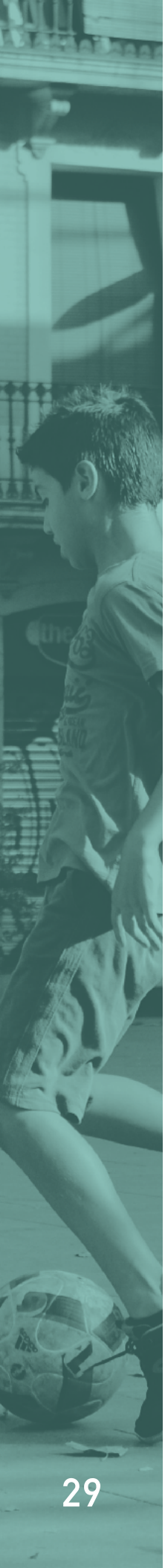
Newman (2013) argues that the wealthier, white Paris residents who engage in "vigilant citizenship" to monitor and regulate public space have assumed the authority over the space from the state. These residents advocated for "open space" physical design without fencing or walls, arguing that they will keep an eye on the space to ensure it will remain safe and civil. Nevertheless, Newman finds that "civility" is defined in close association with citizenship, and this private, citizen-driven surveillance of



public spaces contributes to the fear and vilification of Maghrebi and West African youth as "others" threatening the civility of the public space.

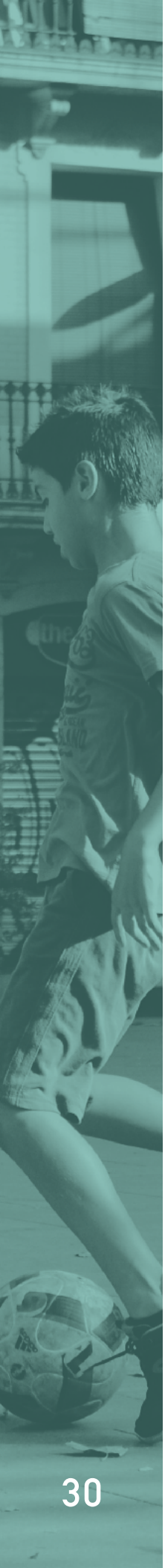
Public green spaces may enhance opportunities for diverse users to share and coexist in the space, but conflicts over the informal ownership and the purposes of a given space could create disputes and social distancing (Burrage, 2011). Studies indicate that conflict arises when the availability of space is limited or certain activities—such as playing soccer or holding a party—are deemed inappropriate or an inconvenience to other groups (Loukaitou-Sideris, 1995; Trouille, 2013). Aptekar's (2015) study of community gardens in a gentrifying neighborhood showed a sense of collective identity among the growers, while also illuminating how competing visions for the garden's aesthetic and management style across ethnic and class groups produce tension. Further studies should explore the specific needs and expectations among the marginalized populations toward the public space. How would these populations wish to use the space if they could design and maintain it, rather than being under surveillance by the police or other users? Place-managing institutions, such as museums, could engage the public in its depiction of certain cultural identities and history, thus actively enhancing their role as public space (Barrett, 2011).

Current scholarship indicates competing evidence of public space creating and impeding cross-social interactions and cohesion. For example, Watson (2013) finds that "mundane" public spaces, such as sidewalks or public markets, can produce "magical urban encounters" among strangers, who may engage in conversations, help each other, and comfortably pass by each other at a proximity that is more intimate than they would in other space. She qualifies that these spaces also become places where whiteness, heteronormativity, and patriarchy are questioned and challenged as diverse groups of users (especially marginalized populations) occupy and socialize in these spaces. Dog owners may develop relationships with other dog owners of different social backgrounds at dog parks, facilitated by their shared interest in dog ownership (Graham & Glover, 2014). However, the owners' preferences for certain breeds or personalities of dogs could guide interactions. When dog parks are implemented as a part of public space redevelopment, white and middle-class owners begin to dominate the space (Tissot, 2011), thus not all dog parks foster bridging **social capital**. A closer contextual examination of when, how and why certain public spaces could enable cross-social interactions is needed to further clarify the relationship between the space and the social relationships. Studies on this topic primarily focus on parks (including recreational parks, dog parks, community gardens), public markets, and public facilities (e.g., libraries): all places that are intentionally designed for



social interactions. More studies could focus on less intentional or monitored spaces—such as abandoned lots or transit spaces—shedding light on the contextual specificity of when and how inter-group bridging capital gets developed to incorporate these elements into public space design and management.

The evidence on the inter-group interactions in public spaces developing into a broader, long-term **social cohesion** across social groups is limited or only supported in certain contexts. Strangers sharing public spaces generally act in ways that are civil and cooperative (Lofland, 1971), but these interactions tend to remain instrumental for facilitating mobility and temporarily creating a sense of shared interests (Simões Aelbrecht, 2016). Formal programming at public libraries has been found to foster the users' trust of the space, the organization, and other users (Vårheim, 2011), though these connections tend to be more ephemeral when compared to the in-group social connections that develop among the program participants (Hodgetts et al., 2008). In some cases, individuals avoid developing bridging capital even when they acknowledge that social ties expand opportunities to access resources, preferring to stay within their ethnic groups (Manton, Pennay, & Savic, 2014). There is sufficient evidence that cross-group civility and interactions fail to reduce or eliminate the impact of the structural or individual prejudice and discrimination. In some cases these result in superficial civility, which could still be beneficial in cities undergoing demographic transitions, but in other cases it creates tension among users sharing the space. For example, studies of farmers markets find persistent racial and class divisions at public markets based on the dominance of white bodies, the types of produce being sold, and the goods' higher average price point (Aptekar, 2015; Oths, Manzella, Sheldon, & Groves, 2016; Slocum, 2008). Even though majority of the shoppers at these markets may find the space inviting and inclusive, low-income minority shoppers read the space and understand that they are not the target users of the market. Tolerance and civility toward social others in public settings must be cautiously examined, rather than being deduced as the signs of true acceptance or progressive, inclusive values. For example, heterosexual individuals of faith may express acknowledgment and acceptance of LBGTQIA+ individuals in public; but in-depth qualitative data reveal that such performance of civility did not change their fundamental religious, conservative beliefs about sexuality. Thus the opportunities and the challenges of the extent to which the bridging social capital extends to broader, long-term **social cohesion** of heterogeneous population should be examined and understood contextually. More research is needed to further delineate under which circumstances bridging capital fostered in public spaces has potential for creating ties that are long-term and expansive, and under which circumstances they remain ephemeral or even create more intergroup tensions.

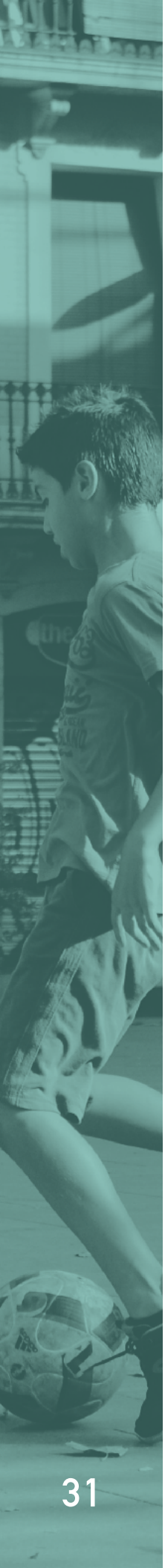


3) DOES PUBLIC SPACE DESIGN ENCOURAGE OR DISCOURAGE DEVELOPMENT OF SOCIAL CAPITAL AND SOCIAL COHESION?

There is limited evidence that the design of the space impacts **social capital** or cohesion development among users. Currently, there are disagreements in scholarship over the extent to which the design and aesthetics of the space encourage or discourage uses of a particular space. This is partly due to the contextual specificity in when and how the design encourages or discourages public space use. Thus, the evidence is inadequate for drawing a firm conclusion on the causal relationship between a particular spatial design of a public space and diversity and civility of its use. However, there is sufficient evidence that white, affluent users are most likely to find public spaces welcoming, especially when they easily find the types of amenities they expect in public spaces. These expected amenities include trails, green spaces, and open-use design spaces that allow users to utilize the space for a wider range of activities to fit their needs. People of color, youth, and housing-insecure individuals are more likely to find public space designs to be exclusionary toward them, due to explicit forms of surveillance or restrictive entry (e.g. gates and fences). These marginalized populations also feel excluded when the types of amenities they expect, such as picnic tables or athletic fields, are not present.

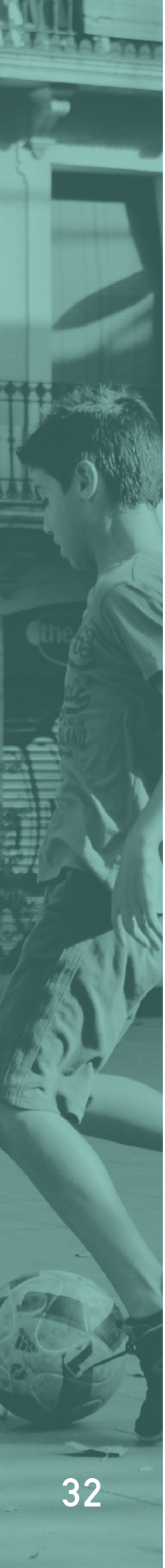
Environmental psychology scholarship points to the physical designs of a space having direct or indirect impacts on who would use a particular public space and how they use it. These studies primarily focus on how users interpret and give meaning to the physical appearances and the social atmosphere of public spaces. Kevin Lynch's (1960) seminal work in Spatial Imageability (SI) highlighted elements of a physical environment that guide our understanding of the meanings being embedded in space and how to navigate it. There is sufficient evidence that the five elements he identified (paths, edges, districts, nodes, and landmarks) do guide how public space users attribute meaning to the space. The way people interpret the intended users and uses of a public space might not match the actual intentions of the planners or architects. These design or aesthetic features may be explicit or implicit, and not all users may be aware of why some spaces appear inviting to them and not to others.

There are urban public space designs that intentionally aim to encourage social inclusion and diversity. New Urbanism design's central feature is mixed-use, pedestrian-friendly public spaces that create opportunity for the residents to interact on a regular basis (Duany, Plater-Zyberk, & Speck, 2001). However, New Urbanism's design effectiveness in creating social inclusivity has been contested. There is limited evidence that the design features such as communal mailboxes or public plazas actually correlate with the community diversity or resident interactions (Cabrera & Najarian, 2015). Social science scholarship has critiqued positive assessment of this design theory based on implicit bias (Day, 2003; Marcuse, 2000); however, the empirical basis of such



critique has also been questioned (Ellis, 2002). Public spaces with an open design, rather than specific intended uses, encourage diverse users to coexist and interact in the space. Each group is able to then engage in the use that meets their needs (Sendra, 2015). Sendra argues that "assemblage thinking," which anticipates dynamic interactions between planned and unplanned aspects of the space in envisioning its potential uses, enhances opportunities for unexpected interactions and improvisational behaviors in public spaces. This can, in turn, prepare the users for encounters with strangers elsewhere. Spatial design that encourages social encounters may not foster both social capital and **social cohesion**. For example, Roberts' (2007) study found that owner-renter division was not overcome by the design of public spaces in mixed-income communities in the United Kingdom—despite creating opportunities for regular cross-class interactions—indicating that tolerance and civility among a diverse population's co-presence must be distinguished from social cohesion. Certain places—such as museums—are expected to be accessible only to those with **cultural capital** to appreciate art, regardless of the admission costs or transportation access (Barrett, 2011), thus discouraging those who do not consider themselves to be the eligible users.

Explicit forms of exclusionary designs, known in the scholarship as *defensive* (Newman, 1973) or *hostile architecture* (Mitchell, 2003), intentionally aim to reduce undesirable uses of the public space. These uses include loitering, sleeping, or skateboarding; and the design implements barriers, fences, or bumps to discourage these activities. Yet there is sufficient evidence that these exclusionary designs are not directly effective in preventing unwanted users or uses of the space, unless mediated by social factors such as class, homogeneity, or social surveillance (Merry, 1981). Use of surveillance cameras and security guards can create an exclusionary atmosphere, which is increasingly common in privately owned and managed publicly accessible spaces (Davis, 2006; Németh & Schmidt, 2011). Urban public space could feature designs that are less intentional but still have impacts on the user demographics and types of uses in the space. There is sufficient evidence that there is an implicit bias in the way the spaces are designed for the uses that meet the needs of dominant social groups; whites, the middle-class, males, and adults (Brodin, 2007; Day, 2003). Aesthetics of public markets, such as farmers markets, could signal exclusion without intention or explicit designs, when the dominant bodies present are white (Slocum, 2008) or their general atmosphere is coded as "young" or "middle-class" based on what is being sold at what prices (Oths et al., 2016). Examples of implicit and somewhat unintentional ways in which the public space reflect the tastes and lifestyles of the dominant social groups, while making the space less desirable to others, includes emphasis on trails for leisurely strolls over sidewalks for commuting by foot; homogeneity and uniformity in architectural styles; or lack of tables and grills for social gatherings (Low et al., 2009). Limited public transit for

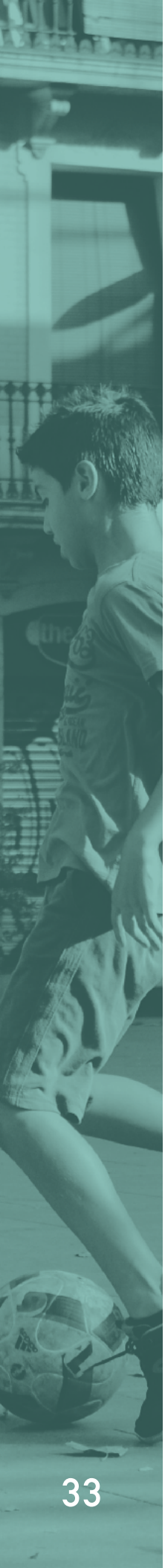


accessing the public space implicitly makes public space less accessible to low-income residents and teenagers (McCray & Mora, 2011).

Current scholarship finds limited evidence that urban designs or aesthetics directly make the space truly accessible and meaningful to everyone. Additionally, there is a substantial set of social science scholarship finding consistent evidence that the social outcomes of urban designs are mediated by social factors, such as demographic homogeneity (Talen, 1999) or social surveillance (Merry, 1981). The planning scholarship's reliance on objective interpretation of physical space's characteristics fails to effectively take into consideration the users' subjective understanding of public space (Lotfi & Koohsari, 2009). Park use among low-income residents results in positive social interactions when the park is well-maintained (to encourage long duration of stay) and when the user already has a relatively expansive social ties with in the community (Kaźmierczak, 2013). These findings indicate that the impact of public space design on who actually uses the public space and how they use it should be contextually examined, rather than as a static and objective quality of a design. Compared to the studies of **social capital** and cohesion, scholarship on this topic uses a more diverse set of methodologies (cognitive mapping, quantitative social network analysis, and statistical analysis) combined with qualitative data such as interviews, surveys, and direct observations. Researchers tend to deduce what the physical design and aesthetic of a space must mean to these individuals from the users' actions; yet in order to fully take into consideration subjective and dynamic reading of these spaces by the users, these methods could be complemented with qualitative data or more experimental methods. This would foster better understanding of users' perception as they see and enter specific public spaces.

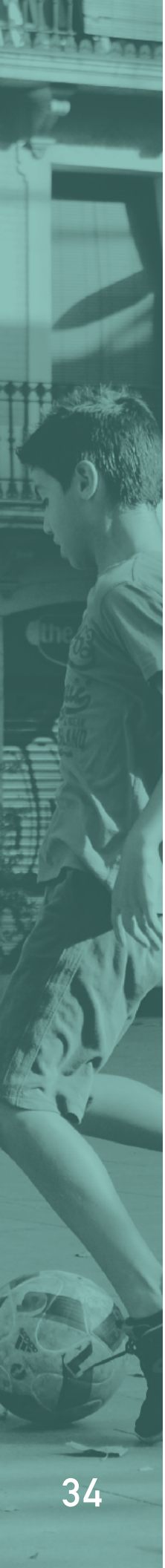
4) DOES DIGITAL TECHNOLOGY/SOCIAL MEDIA MEDIATE SOCIAL INTERACTIONS IN PUBLIC SPACES?

Social media have created new opportunities for strangers to gather in physical public spaces. Academic research focuses on two ways in which digital technology has fostered interactions and a sense of collective identities among strangers in public spaces: leisure and activism. Despite the perception that mobile digital technology has liberated personal relationships from spatial constraints, physical space continues to play a vital role as hybrid space (of digital/physical nature, of public/private nature) for social interactions (Freeman & Sheller, 2015; Wilken, 2008). For example, teens' interactions with others in public space is inherently connected to their social media interactions (Lane, 2016; Patton, Lane, Leonard, Macbeth, & Smith Lee, 2017). Nevertheless, current scholarship only presents limited and somewhat conflicting evidence on the link between individuals' social media use and the development of social capital and cohesion in public space among these individuals. Some case studies find evidence of the uses of specific apps or



games to interact with strangers in public spaces (e.g. Humphreys, 2010, 2017), but these interactions seem to remain ephemeral and superficial, rather than resulting in long-term, collective identities (Crawford, 2008; Vella et al., 2017). Similarly, studies of social movements caution against overemphasizing the role of the digital media in mobilizing the activists into the public space (Milan, 2015; Sassen, 2014). Studies on this topic are overly optimistic of the potential of the digital technology to connect strangers; yet there is a dearth of empirical studies to test these hypotheses, especially with a focus on how the technology can (or cannot) forge connections across existing social status divisions (e.g., class, race, age, disability). To this effect, studies of long-term impact of these public space interactions are needed.

There has been increasing advancement in games that aim to bring people out of their homes and help them interact with each other in public spaces. There is limited evidence that games and apps such as Foursquare (Humphreys & Liao, 2013) or Pokémon GO (Humphreys, 2017) create a shared sense of place among strangers through parochialization of public space (Humphreys, 2010), whereby people sharing the space experience a sense of familiarity or commonality with others. Flash mobs, or planned collective amateur choreographed performances in public spaces, are often organized online and become an opportunity for the participants to temporarily experience the collective effervescence of connectivity and a sense of self-efficacy (Seo, et al. 2014). Vella et al. (2017) cautions that this sense of **social cohesion** among strangers may not be necessarily a direct result of the shared use of physical public space. Some Pokémon GO players in the study expressed hesitation at accessing public spaces that they perceived to be unsafe, and those reporting the most positive outcomes were people who were otherwise experiencing social isolation. Similarly, flash mobs serve varying purposes for participants

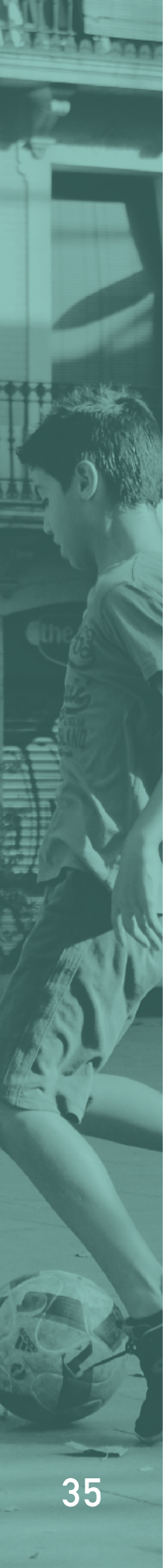


ranging from artistic expression to political statements and commercial advertisement (Molnár, 2014). Thus, whether or not participation in flash mobs creates meaningful, long-term connections among strangers must be contextually analyzed and empirically tested.

The apps that connect strangers only connect the users of the same app, while the users' preoccupation with their mobile devices would take away opportunities of serendipitous face-to-face interactions in public (Crawford, 2008). Moreover, the typical users of these digital technologies are homogeneous in terms of class, status, and age; this limits who might develop social connections using these devices and apps (Thom-Santelli, 2007) or through participation in flash mobs. Social media applications that allow people to meet strangers in public spaces, such as Grindr, simultaneously expand and limit the potential for who meets whom through these apps. The apps enable individuals to find others to connect in ways that are not possible without the technology, but the ability of the users to screen others using the application's profiles could reinforce stereotypes and social boundaries rather than overcoming the barriers (Blackwell et al., 2015). These findings exemplify collective occupation of space does produce space- and time-specific sense of social cohesion.

There is sufficient evidence that contemporary social movements are inherently connected to the advancement of digital technology, particularly mobile communication devices and software such as Facebook and Twitter. The conclusions on the extent to which technology is essential for mobilization in public spaces varies across the studies. Some studies highlight how media facilitates and shapes the social protest and democratic political expression in public spaces (Arora, 2015), especially for the #Occupy movements (Juris, 2012; Lubin, 2012). But there are also studies that caution against overstating the impact of information technology in organizing public protest. In some Occupy locations, factors such as existing social networks and major media platforms played more substantial roles than social media (Sassen, 2014). Social media-led activism creates "individuals-in-group" experiences rather than actual social coherence through "crowd protesting" (Milan, 2015).

Milan's (2015) study of the social media's impact on social movement found that the new technology has shaped how people come together around shared grievances or concerns. The way the activists use social media to engage in the movement, according to Milan, is distinct because for these activists groups it becomes a

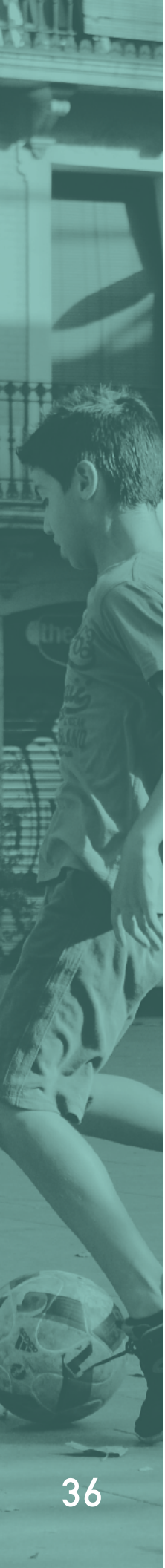


tool for activism rather than an end unto itself. For example, individuals use social media to directly call other individuals into action, but these connections remain between two actors. Individuals within the crowd protesting method, therefore, continue to operate as individual actors working "with" many others rather than working as a collective.

Based on these current understandings of the significance of social media/ digital technology in public space use, more studies are needed to unpack when, how, and among whom the technological advancement guides the public use by engaging in comparative, experimental and/or **longitudinal studies** of the relationship.

5) DO CHANGES IN PUBLIC SPACE ACCESSIBILITY ENHANCE SOCIAL CAPITAL OR SOCIAL COHESION?

There is sufficient evidence showing that when the members of public learn about the pending or actual loss of public spaces, it can lead to the development of **social cohesion** over a collective sense of loss and urge to take action. A sense of loss can be articulated in terms of direct and immediate loss of public spaces through demolition and redevelopment, through loss of access to public spaces, or through restrictive ordinance and surveillance. Privatization of public spaces, either through private management of publicly owned spaces or through public access to privately owned spaces, results in explicit and implicit exclusionary practices. Studies find that individuals and communities respond to their exclusion through mobilization and collective action, with mixed outcomes. There is also limited evidence that when a new public space is planned or built, this mobilizes the communities either in opposition or support. Compared to the studies of the loss of public space, the studies on the residents' reactions to the gaining of new public spaces focuses on limited types of public spaces, such as **LULUs** (locally unwanted land use) or dog parks. It remains unclear when and why certain public space development catalyzes **social capital** and cohesion cultivation among the residents, and which are the most effective in building community around these issues.



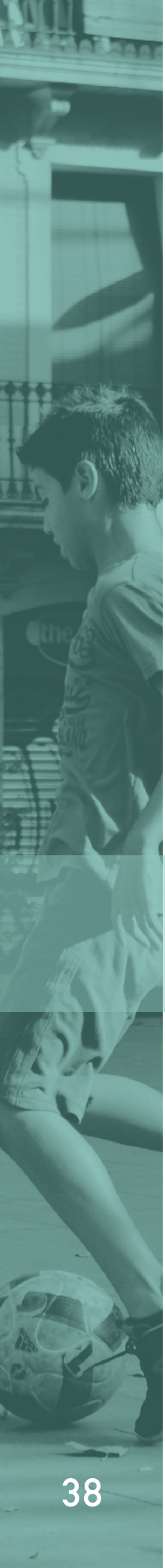
Removal of a public pool that was popular among Latinx immigrants in North Denver resulted in community mobilization to formally rename the park as La Raza Park (Langegger, 2013b). Threat of land tenure for community gardens galvanized not only gardeners but nearby residents and community activists in an effort to preserve the lots in New York City and Los Angeles, California (Irazábal & Punja, 2009; Saldivar-Tanaka & Krasny, 2004). When budget cuts for public libraries were announced in Toronto, Canada, community reactions led to broader conversations about the role that public libraries play in the community, especially for marginalized populations such as the homeless, immigrants, and women with children (Frederiksen, 2015). Studies find that collective action, in an attempt to reclaim the public space that is perceived to be exclusionary, often take place as direct action *in* these spaces. Organizing unpermitted street parties, Critical Mass bike rides' traffic disruption, or performance arts (Shepard & Smithsimon, 2011; Shepard, 2014) encourage activists and supporters to occupy the spaces in festive or interactive ways thus protesting the regulatory ordinances that limit the permitted uses of the space. Some skateboarders view their use of public or quasi-public space as a form of political statement, and their collective efforts to identify and redefine the space's ownership are at the center of the skaters' subcultural practice and identity (Borden, 2019).

A number of studies on the Occupy movements across North America articulate how the unpermitted encampment of public spaces as a part of the activism became another manifestation of the movement's claim that privatization of public goods has undermined democracy and equity. This was emphasized when it came to light that many of these parks were privately managed public spaces or privately owned, publicly accessible spaces (Kohn, 2013; Marcuse, 2012). Guerilla gardens (Adams & Hardman, 2014) or Food not Bombs (Sbicca & Perdue, 2014) also exemplify collective actions to use public spaces for addressing social issues to seek broader, long-term solutions. These actions echo Holston's (1998) conceptualization of spaces of insurgent citizenship, where actions are taken to counter the urban planning practices' utopian visions that are not ethnographically grounded in the lived experiences of diverse urban populations (Hou, 2010; Low et al., 2009).

Communities also mobilize when new public spaces are planned or actually developed, especially when the development is seen as **LULUs** that would cause disruption or harm to nearby residents or marginalized populations. There is sufficient evidence that the proposal of **LULUs** can catalyze community organizing around the shared grievance, though the evidence is limited on the extent to which such organizing can effectively intervene or affect the outcomes of the development. Toxic waste or landfill establishment in low-income communities of color has spurred environmental justice activism in protest (Bullard, 2008; Pellow & Brulle, 2005). More recently, green development has come to face similar resistance from local residents who fear that it

spurs **green gentrification** (Anguelovski, 2016). McClymont and O'Hare (2008) caution that urban planners must distinguish this local resistance against proposed development in marginalized communities from the NIMBYism (Not In My Back Yard). NIMBYism has become associated with white, middle-class suburban residents' mobilization against public amenities that they deem socially undesirable or economically risky, such as mental health facilities or affordable housing (DeVerteuil, 2013). The residents' ability to mobilize themselves around shared grievances over **LULUs** in their community is associated with economic and **social capital** of the community (Buckman, 2011; Schively, 2007). However, studies have not examined whether or not residents coming together to protest actually fosters long-term, expansive **social capital** and cohesion that extends to the realms beyond the specific concern.

The evidence is limited on the extent to which urban design and planning could effectively address the collective grievances expressed by the community against proposed developments. Middle-class communities can successfully organize themselves against proposed development when they perceive the project as threatening toward their health, environment, economic assets, or a particular way of life (Schively, 2007). In some cases the well-intended redesigning of public space could have adverse effects. For example,



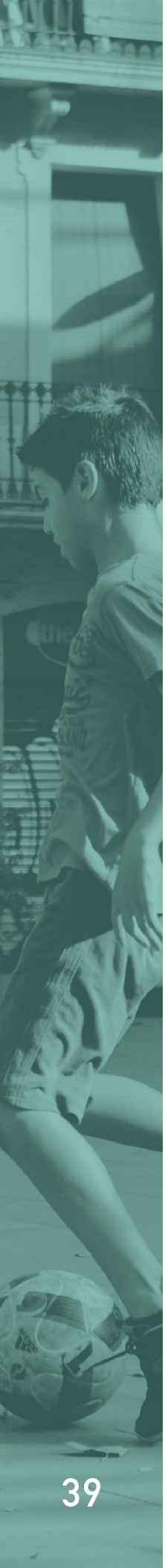
a proposed demolition of the Claiborne freeway overpass in New Orleans, Louisiana, which had once bisected the historic Black neighborhood of Treme, was intended as a form of reconciliation for the negative impact that past urban planning had caused in the community (Castillo, 2011). However, the idea to remove the overpass and redevelop the street as a cultural corridor has met with resistance and critique. The community had since developed a tradition of using the space under the overpass as a central gathering space for second line parades and Mardi Gras Indian processions (Zewde, 2010). Studies of mobilization for and against development of public spaces primarily focus on more controversial spaces, but there is limited research on smaller amenities that could signify signs of neighborhood transition or enhanced sense of exclusion such as sidewalks, playgrounds, small green spaces, or dog parks.

Studies of loss and gain of public space facilitating social ties and cohesion are typically case studies of specific events or spaces in larger coastal cities in the U.S. The movement scholarship tends to focus on the formal organizing among activists, with less focus on how everyday citizens are impacted directly by the changes in public spaces, or indirectly through social activism around the loss or the development of public spaces. Studies of these social reactions to the changes in public space are most commonly published in critical geography, sociology, and urban studies literature; the search for the scholarship did not identify collaborations between these disciplines and urban design and planning scholarship on this topic.

SOCIAL COSTS AND INEQUITABLE BENEFITS

6) DO MAJOR INVESTMENTS IN PUBLIC SPACES DISPLACE CERTAIN POPULATIONS?

There is sufficient evidence to suggest that major investments in public spaces guided by pro-business interests and focused on economic development (e.g. flagship arts institutions and urban parks) contribute to user, residential, and commercial displacement; exclusion from the planning process; and a change in the social and cultural tone of the neighborhood. Investments in waterfronts (Bryson, 2013), parks (Brownlow, 2006; Dooling, 2009; Pincetl, 2003; Rigolon & Németh, 2018b; Wolch, Byrne, & Newell, 2014), and public gardens (Eizenberg, 2012) have negatively impacted certain populations that utilize those spaces, such as low-income people or people of color. Additionally, pro-business investments tend to exclude or only superficially include residents and community members in the planning process, which limits the



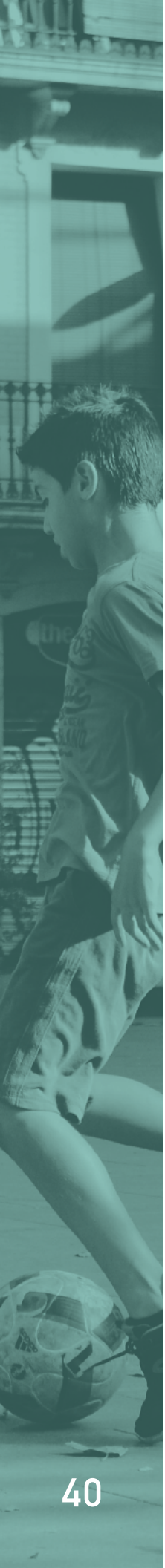
ability of community members to shape the investment and temper negative impacts (Checker, 2011). There is little research on the types of investment that mitigate displacement potential.

Most often, the populations displaced or marginalized from urban public spaces are those who are broadly considered vulnerable based on their socioeconomic status or race. This includes black women (Brownlow, 2006), low-income populations (Bryson, 2013; Dooling, 2009; Eizenberg, 2012; Lang & Rothenberg, 2017; Loughran, 2014; Pincetl, 2003; Rigolon & Németh, 2018b), and populations experiencing homelessness (Stuart, 2014; Toolis & Hammack, 2015). Low-income populations are often displaced from public spaces and the surrounding neighborhood because they are priced out of their neighborhoods, either through increasingly high property taxes or increased rents. In other cases, low-income or racial and ethnic minority residents feel that they do not belong in the renovated or newly-created urban public spaces (Checker, 2011; Lang & Rothenberg, 2017). Populations experiencing homelessness are frequently evicted through police action and have their spaces destroyed or renovated.

There are two aspects of urban public space investments that contribute to residential displacement. First, investments in large-scale greening projects (such as New York City's High Line) tend to increase property values and displace the neighborhood's lower-income residents, who may no longer be able to afford rents or property taxes. This process is known as **green gentrification** or the green space paradox (Wolch et al., 2014).

Many cities strive to improve green space accessibility in underserved neighborhoods by creating new parks or renovating existing parks. However, such improvements can raise property values and create residential displacement in the short- or long-term. Wolch et al. (2014) label this process the green space paradox.

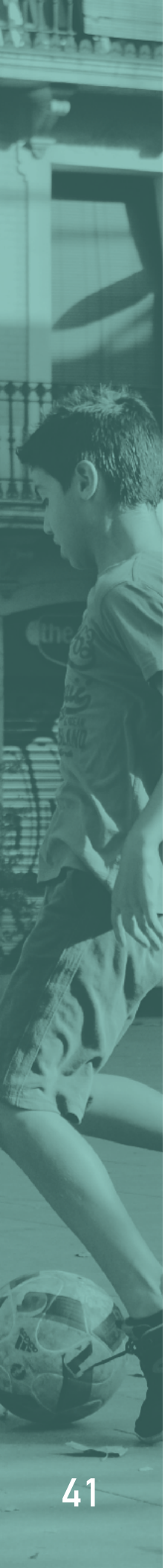
Second, financial support from nonprofits that have a singular focus (e.g. environmental issues but not housing) contribute to residential displacement because they fail to preserve or create affordable housing in neighborhoods that are experiencing rapid economic redevelopment associated with the new green space (Rigolon & Németh, 2018b). Additionally, lack of investment may also displace populations. Brownlow (2006) discusses how Philadelphia's lack of maintenance investment of Cobbs Creek Park created a fear of crime and violence in the space, particularly for Black women. While it did not displace



them from the surrounding neighborhoods, this lack of investment made the park inhospitable for Black women.

Although not all studies address the nature of investments in detail, many studies highlight how public-private partnership investment is often associated with displacement and marginalization, since a key goal of public space investment is to catalyze economic development (e.g. The High Line in New York City, Atlanta Beltline in Atlanta, Spokane waterfront in Spokane, Washington). Matthew's (2010) review of the role of public art in gentrification describes how flagship arts institutions and arts districts, as well as smaller-scale and temporary art such as festivals and public art displays, attract the middle and upper class. This influx of middle- and upper-class residents can contribute to residential and commercial displacement over the short- or long-term. However, there is variation in the way that the studies characterize public-private investments: some projects are described as public investment designed to attract private development (e.g. Anguelovski, Connolly, Masip, & Pearsall, 2018) or as a state-sponsored park expansion guided by a neighborhood community development corporation motivated by gentrifiers (e.g. Checker, 2011). They provide different levels of detail on the nature of the investment, and the majority of the studies focus on landmark urban public spaces, with little attention given to smaller neighborhood spaces. There is little research on the potential for small-scale urban public spaces to create (or mitigate) residential displacement following a major investment (e.g. renovation, new construction). Future research needs to address whether there is a certain threshold of investment or type of investment that minimizes the likelihood of displacement and marginalization.

We uncovered studies on only two types of public spaces discussed: parks and the arts, with different areas of emphasis within the arts (presence of artists, different types of art professionals, different types of arts organizations, and different types of arts activities). The majority of this research is based on case studies and uses qualitative methods (archival research, ethnographic research, interviews, and content analysis of official materials and journalistic accounts). Much of the literature that focuses on case studies includes a detailed account of the planning process, and has a common theme: the planning process was driven by pro-business interests and community members were either excluded (Dooling, 2009) or only nominally included (Checker, 2011; Lang & Rothenberg, 2017; Patrick, 2014). About a quarter of the studies address citywide processes and use regression analysis to explore changes in demographics and property values in several neighborhoods (Anguelovski et al., 2018; Immergluck & Balan, 2018). With the exception of one study in Spokane, Washington and another in Barcelona, Spain, all of the studies were conducted in large American cities or metropolitan areas, such as New York City; Atlanta, Georgia; and Seattle, Washington. There is a disproportionate number of studies of the High Line and other flagship parks in New York City.



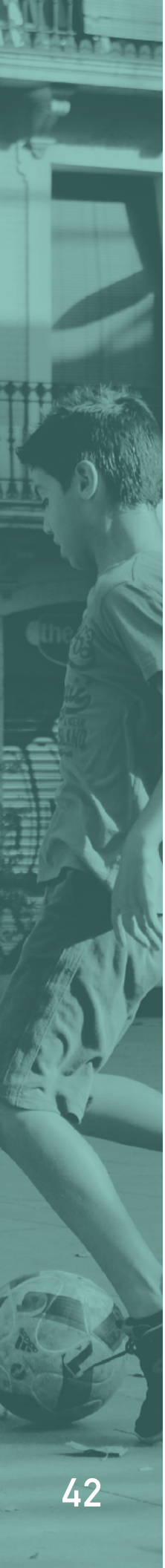
7) DO POORLY MAINTAINED OR STEWARDED SPACES NEGATIVELY IMPACT THE USE OF PUBLIC SPACES?

There is sufficient evidence to suggest that poorly maintained or poorly stewarded spaces have negative impacts on surrounding neighborhoods. In particular, poorly maintained public spaces attract civil disorder, and additional research suggests that civil disorder spreads across neighborhoods (Keizer, Lindenberg, & Steg, 2008). Although there is little agreement on the connections between civil disorder and crime, civil disorder influences perceptions of safety and increases fear among park users.

There is limited research on the association between poorly-maintained parks and sense of pride in community; however a study by Manduca and Sampson (2019) suggests that neighborhoods characterized by high levels of violence, incarceration, and lead exposure reduce social mobility. Some neighborhoods are especially harsh on children's development.

Two studies show that poorly maintained parks are more likely to have community participation in maintenance initiatives, which may imply that there is still a sense of ownership in the community despite poor maintenance.

Most studies that look directly at the relationship between park maintenance and civil disorder find signs of civil disorder in poorly-maintained parks (Brownlow, 2006; Loukaitou-Sideris, 1995; McCord & Houser, 2017; Sampson & Raudenbush, 1999; Troy & Grove, 2008). Further, Keizer et al.'s (2008) study supported "The Broken Windows Theory;" the theory that signs of crime can lead to increased crime and disorder. Their study in Chicago found that existing litter can double the number of people who litter and steal. Different studies examine different aspects of civil disorder; some look at physical elements, such as graffiti, litter, and abandoned cars and facilities which can be attributed to poor maintenance itself (Brownlow, 2006; Cutts & Minn, 2018; Kuo, Bacaicoa, & Sullivan, 1998). Others focus on social disorder as defined by activities and social trends; including vagrancy, public drunkenness, squeegeeing (the unsolicited act of cleaning cars stuck in traffic and then asking for pay), panhandling, and loitering (Troy & Grove, 2008, Ranasinghe, 2011, McCord & Houser, 2017).

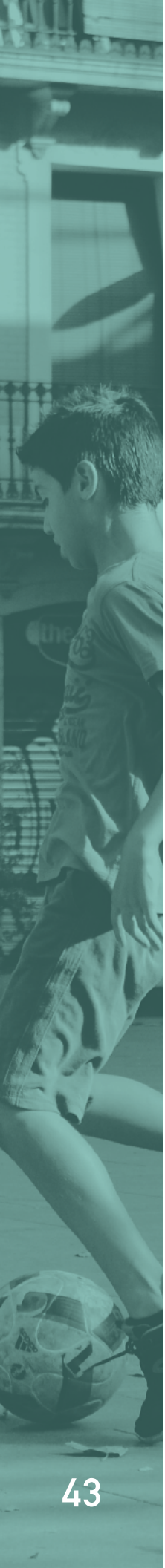


Two studies (Ranasinghe, 2011, Sampson & Raudenbush, 1999) highlight that civil disorder is not associated with violent crime. Ranasinghe (2011) argues that squeegeeing and other forms of civil disorder are not dangerous, but can make people uncomfortable. Laws against forms of civil disorder build upon this fear of discomfort, and conflate criminal activities with civil disorder. Sampson and Raudenbush's (1999) study challenges the Broken Windows Theory mentioned in other studies, such as Keizer (2008). Sampson and Raudenbush (1999) state that civil disorder does not create an environment that encourages crime, but that it aesthetically displeases policymakers and potential investors, who are then more likely to disregard the surrounding neighborhood.

Crime and perceptions of safety are recurring themes. Many studies suggest that poor maintenance creates a feeling of distrust towards the public space, which leads to a fear of danger that permeates the surrounding neighborhood (McCord, 2017; Troy, 2008; Brownlow, 2006). Conversely, caring for blighted properties, such as vacant land, can reduce multiple forms of violence (Branas et al., 2018; Moyer et al., 2018). McCord (2017) examined different environmental factors to see what made participants feel safer using a public park; features such as benches, sports facilities, water fountains, and parking lots were found to have a positive relationship with feelings of safety and comfort. There are mixed findings on the role that dense vegetation plays in one's perception of safety. Sreethan (2014) argues that dense vegetation intimidates park users and creates a feeling of isolation, while Kuo (1998) counters with findings that show participants are more drawn to dense vegetation and would choose to incorporate dense vegetation if given the chance to design a green space.

Kuo (1998), Kinder (2016), and Cutts and Minn (2018) found that community participation may actually be higher in poorly maintained public spaces. Cutts and Minn (2018) addressed sense of pride in the community and maintenance on publicly accessible vacant private property. Specifically, in the Arizona suburbs, where unattended houses led to neglected and dying yards, members of the community were willing to rally together and tend to these properties. Cutts argued that this is in part because poorly maintained private property lowered the value of the entire neighborhood, having real financial impacts on the community. Kinder's (2016) research in Detroit found similar examples of public space stewardship, particularly on vacant residential land, for economic and social reasons.

The studies we reviewed for this question covered a wide range of public spaces, including streets, beaches, rivers, and publicly accessible private property; though the majority centered around parks, and most studies did not focus specifically on public space maintenance. There are several public space evaluation tools that assess park quality and maintenance of site conditions (see Kaczynski et al.'s (2012) Community Park Audit Tool (CPAT) and Rigolon

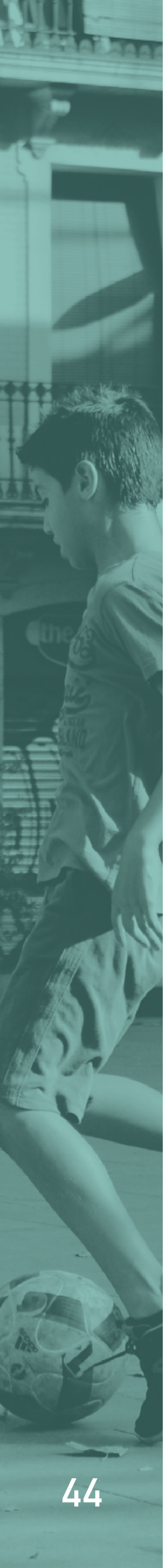


and Nemeth's (2018a) QUality INdex of Parks for Youth (QUINPY) tool). A little over half of the articles included used qualitative data and methods, such as interviews, surveys, and focus groups in order to obtain their results. The remaining articles focused on quantitative data such as environmental inventories, demographics, and crime rates, which were then broken down through statistical analysis. There is a lack of experimental work in this area, and there is limited research on public space maintenance in relation to sense of pride in community, although other measures of public engagement with public spaces are explored in greater detail (fear, comfort).

8) HOW DO DISPARITIES IN URBAN PUBLIC SPACE MAINTENANCE MANIFEST BY DEMOGRAPHICS?

There is sufficient evidence that well-maintained parks are concentrated in whiter and wealthier cities and neighborhoods, while poorly maintained public spaces are located in lower-income minority cities and neighborhoods. Neighborhood environments have important implications for the health and wellbeing of children, as evidenced by Manduca and Sampson's (2019) research on harsh environments and intergenerational social mobility for Black and white children. Most studies address race and class as predictors of poor maintenance but don't examine other dimensions of social difference. Additionally, the majority of this research focuses on parks and recreational spaces, with well-maintained spaces characterized as those with more acreage, facilities, and funding. Additional research addresses street trees and streams, with a focus on planting and restoration, respectively. With the exception of one study in London, Ontario (Gilliland, Holmes, Irwin, & Tucker, 2006), the eleven studies reviewed for this question provide evidence of systematic inequity by race and/or income.

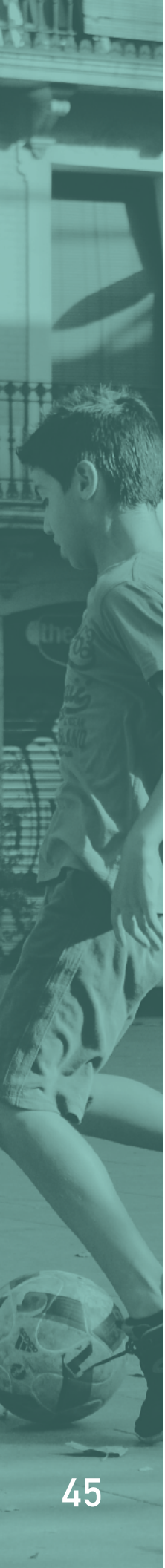
Most studies show that higher-quality urban public spaces—including parks, high **tree canopy** cover, and stream restoration efforts—are located in neighborhoods with white populations and middle- and upper-income populations (Watkins, Mincey, Vogt, & Sweeney, 2017). One study also found that Asian populations have access to well-maintained parks in Southern California (Dahmann, Wolch, Joassart-Marcelli, Reynolds, & Jerrett, 2010). Conversely, poor-quality parks are concentrated in neighborhoods with low-income residents and people of color, particularly Black and Latinx populations, both at the neighborhood scale (Boone, Buckley, Grove, & Sister, 2009; Wolch, Wilson, & Fehrenbach, 2005) and the municipal scale (Rigolon, Browning, & Jennings, 2018). Interestingly, Loughran's (2014) study of the High Line in New York City suggests that even though the well-maintained park is located near low-income neighborhoods, these residents do not use the space because they feel it is not designed for them.



Rigolon et al.'s (2018) cross-city study of park inequalities in the 99 largest cities in the U.S. found that whiter and wealthier cities have higher-quality park systems compared to cities with higher populations of low-income ethnic minorities. This study, conducted at the municipal level, reflects the findings of studies conducted at the neighborhood scale. In St. Louis, Missouri, Arroyo-Johnson (2016) found discrepancies between playground safety and physical proximity based on neighborhood racial composition. In Los Angeles, California, Joassart-Marcelli (2010) found discrepancies in funding for parks across the city, noting that state and non-profit funds favor middle-income communities and that inner ring suburbs with large minority communities suffer from less funding. Dahmann et al. (2010) also noted that the availability of recreation courses varied by neighborhood affluence across Southern California.

These neighborhood-scale studies provide detailed accounts of the factors driving park inequities and the resulting consequences. Historical processes—such as redlining, racial segregation and declining populations—continue to impact park provision today in cities like Baltimore, Maryland (Boone et al., 2009). Residents in neighborhoods with declining populations tend to suffer from poor park maintenance. Conversely, wealthier neighborhoods often have better recreational opportunities due to the presence of infrastructure supporting the programs (Dahmann et al. 2010) and well-established funding streams to maintain them (Joassart-Marcelli, 2010). Research on tree planting and stream restoration initiatives also suggests that such initiatives primarily occur in wealthy and white neighborhoods (Watkins et al., 2017). Perkins (2013) argues that one way to account for disparities in maintenance of public spaces is to have the local government take full responsibility for maintenance instead of relying on a patchwork of community groups and nonprofits.

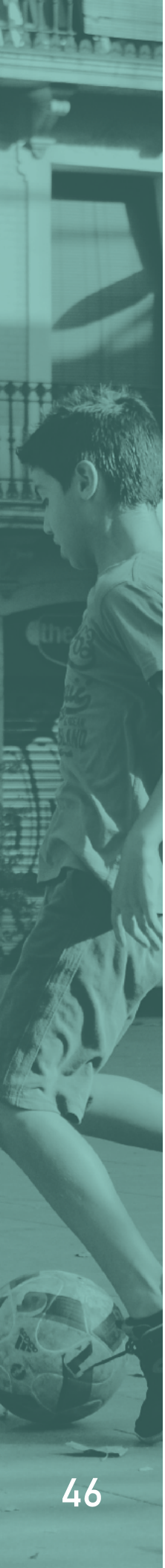
These studies draw on very diverse data sources, as well as qualitative and quantitative data analysis approaches, illustrating the different ways to examine park maintenance. Arroyo-Johnson conducted playground assessments based on Google Earth and site visits, while Rigolon et al. (2018) used the Trust for Public Land Park Score data to explore the relationship between municipal demographics and park quality. Boone et al. (2009) conducted a historical analysis, spatial analysis, and qualitative analysis of the factors shaping park accessibility in Baltimore, Maryland. Three studies conducted in Los Angeles, California examined fiscal capacity, based on bonds data and recreational programs, relying on statistical analysis and spatial analysis to trace flows of funding across park systems. A handful of other studies (e.g. Brownlow, 2006; Loughran, 2014) used qualitative approaches, including content analysis and interviews, to examine the political actors and institutions driving decisions within the park system as well as the experiences of community members.



9) DO CIVIC GROUPS AND NONPROFITS IMPROVE THE MAINTENANCE OF PUBLIC SPACES?

There is sufficient evidence that the involvement of civic groups and nonprofits in urban public space stewardship can improve maintenance. This is a particularly relevant topic in the context of declining public funding and cuts to parks and recreation budgets, which may lead to diminished public space maintenance. In this regard, nonprofits and civic engagement may act as an intervention strategy (Mathers, Dempsey, & Molin, 2015; Wolf, Blahna, Brinkley, & Romolini, 2013). However, research has also shown that reliance on these groups can create and reinforce inequitable patterns of maintenance across neighborhoods and place a disproportionate burden on the groups responsible for maintenance. Studies primarily address “natural areas” and green spaces/green infrastructure projects, using qualitative research methods such as interviews, participant observation, planning document analysis, surveys, database analysis, comparative case studies, and historical analysis. There is little research on what kinds of partnerships or how differing nonprofit/civic group structures shape urban public space maintenance outcomes.

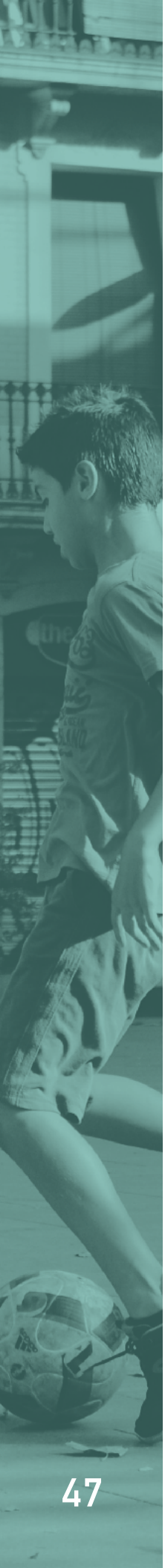
The activities and structure of civic groups and nonprofits take many different forms and operate on different levels of formality. Responsibilities include tasks such as: physical labor/maintenance (both paid and unpaid), bureaucratic management and ownership responsibilities, planning, advocacy,



community outreach, and resource-providing partnerships (resources including money, supplies, volunteers, technical expertise). At times, the distinctions between civic groups and nonprofits are very clear. In other cases, the two entities are intertwined, with civic groups being organized by a larger nonprofit, or eventually becoming formalized as their own nonprofit (Brownlow, 2011; Connolly, Svendsen, Fisher, & Campbell, 2013; Ghose & Pettygrove, 2014; Mattijssen et al., 2017).

Civil society organizations, such as nonprofits, have recently become significant urban governance actors that play a large role in land use decision-making and the distribution of public goods and services (Pincetl, 2003). About a third of the articles reviewed outline the positive outcomes of nonprofit involvement in the urban public space sphere. In researching a rails-to-trails endeavor in Chicago, Illinois, Rigolon and Németh (2018) found that a reliance on park nonprofits for project management and maintenance was beneficial since they focus on one (or a few) parks, unlike government agencies that must focus on the city's park system. Because parks and recreation departments need to develop plans to maintain every park in the city simultaneously, some receive less maintenance than others. Murray (2010) makes a similar point: private nonprofits have the ability to enact centralized responsibility over a space in a way that makes performance easier to monitor, whereas the diffuse responsibilities of government entities may falter in this arena. In certain instances, nonprofits may also actively work to improve equitable maintenance patterns across a city. In an analysis of the spatial distribution of tree-planting projects led by nonprofits, Watkins et al. (2017) found that such projects were less likely to be implemented in higher-income neighborhoods due to the fact that a large portion of nonprofits have the explicit goal of targeting and assisting low-income neighborhoods.

While the involvement of nonprofits and civic groups in the management and maintenance of urban public spaces can improve efficiency, there are also notable downsides to their governance. For example, Eizenberg (2012) outlined a case study in which The Trust for Public Land (TPL) gave a community legal ownership over a public community garden and helped to implement a maintenance regimen led by a board of active garden managers. She found that the responsibilities placed on the garden managers by TPL required them to learn new organizational and bureaucratic skills in order to fulfill their responsibilities. Members took on larger amounts of work and volunteered much more time than was previously required. This burden on the grassroots volunteers impeded rather than encouraged ongoing participation in the collective. Additionally, in an analysis of Los Angeles, California's nonprofit-implemented "Million Tree Program," Pincetl et al. (2013) found that after trees were planted in a neighborhood, local residents were largely expected to take on the responsibility of irrigating and maintaining the trees in the public right of way. Campbell (2017) made a similar observation about tree planting and

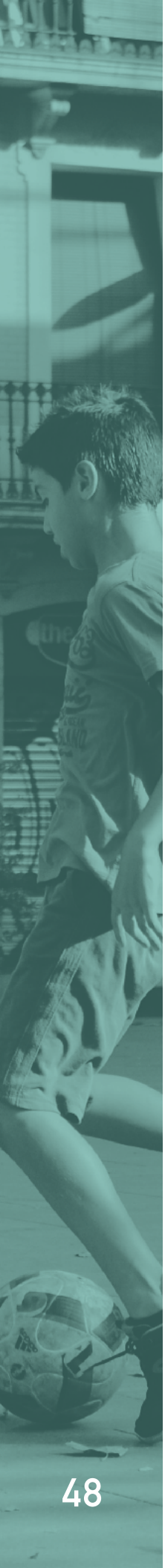


maintenance in New York City. While this responsibility was not burdensome for wealthy neighborhoods with gardeners, the garden maintenance, tree debris, and water costs were seen as a nuisance in other lower-income neighborhoods (Pincetl et al., 2013).

Furthermore, civic engagement is not always a grassroots or bottom-up endeavor. In Milwaukee, Wisconsin, the parks director encouraged the formation of civic groups in order to make up for the lack of paid park maintenance employees after park budgets were cut (Perkins, 2013). Perkins (2013) suggested that the residents were mainly motivated to participate in the civic groups out of fear that the parks would be lost or end up degraded if they did not volunteer. Rather than being voluntary, the civic participation was more of a coercive act spurred by the need to justify park budget cuts. This strategy resulted in some well-maintained sites and some deteriorated sites, depending on the participation of volunteers. Overall, volunteer coalitions were not robust enough to substitute for a paid maintenance workforce.

Finally, in an analysis of neighborhood-level capacity for community garden maintenance in Milwaukee, Wisconsin, Ghose and Pettygrove (2014) found that groups who lack access to the resources necessary for grassroots organizing—such as social and political capital, free time, and financial resources—are likely to face significant barriers to becoming involved in civic group activities. Resource-poor individuals tend to be geographically concentrated, and civic group activities also tend to be very localized in nature. Therefore, poorer neighborhoods face serious disadvantages in formulating and retaining civic groups that could improve their surrounding public spaces. Landry and Chakraborty (2009) found a significant proportion of tree cover on public right-of-way neighborhoods in Tampa, Florida, with a higher proportion of Black residents, low-income residents, and renters. Additionally, Joassart-Marcelli et al. (2011) found that nonprofits involved in urban park activities in Southern California tended to be more active in affluent, fiscally stronger, suburban, conservative, and white municipalities.

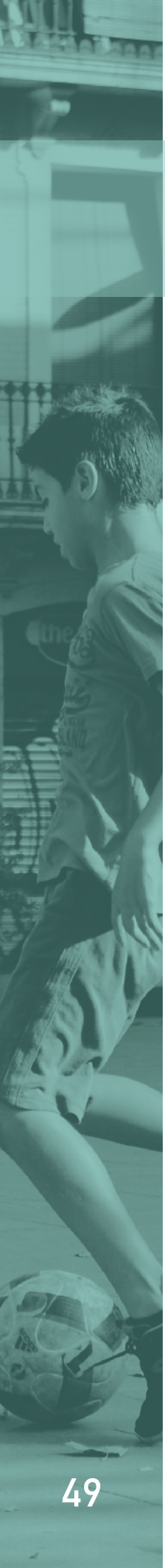
Mattijssen et al. (2017) define formalized citizen groups as those that have established rules and procedures that govern their activities and behaviors. Those that are not formalized lack the institutionalized procedures that formalized citizen groups have.



Similarly, Mattijssen et al. (2017) found that citizen groups who were formalized or institutionalized tended to have more social capital and were more likely to be recognized by the state as legitimate actors, which allowed the groups to qualify for greater subsidies and grants and allowed them to survive longer. Small, grassroots, or informal volunteer groups with few political connections struggle to achieve longevity and the financial resources necessary to operate on a large scale, further contributing to inconsistent patterns of maintenance (Mathers, 2015). Additionally, localized groups that are able to efficiently manage their own public spaces may be less likely to support citywide services or taxes that distribute those same amenities to other communities, which also contributes to long-term inequities (Foster, 2011).

On the other hand, several studies find that voluntarism among marginalized groups calls attention to persistent inequities, resulting in positive changes in community urban spaces (Brownlow, 2011; Connolly 2013, 2014; Mathers et al., 2015). Civic volunteers may implement more motivated and fruitful maintenance regimens than government entities because of their personal connections to the space (Mathers et al., 2015). In Philadelphia, Pennsylvania's Cobbs Creek Park, Brownlow (2011) highlighted a case in which voluntarism in a marginalized Black community encouraged participants to reclaim public space and expose racialized injustices in urban public space maintenance trends. The community members inserted themselves into the park's restoration plan, which originally offered few opportunities for community insight, by volunteering their time and labor. They used their role and newfound political power as much-needed volunteers to draw attention to the fact that park funds were disproportionately being directed towards wealthier and whiter parts of the city. Furthermore, participants were highly invested in the rejuvenation of the long-neglected local park because they would personally benefit from access to it. In New York City, Connolly et al. (2013; 2014) found that environmental stewardship organizations acted as both partners and critics of public agencies, at times encouraging the city government to devote more funds and attention to equitable provisioning of parks and recreation resources.

The structure, extent of involvement, and activities of the maintenance entity have an important impact on maintenance outcomes. For example, Eizenberg (2012) found that when a nonprofit, The New York Restoration Project, was brought in to revitalize neglected public spaces in New York City, the organization failed to integrate the needs, concerns, and input of local community members in their maintenance regimes. On the other hand, Eizenberg observed community autonomy being highly valued in the Trust For Public Land's nonprofit maintenance style.

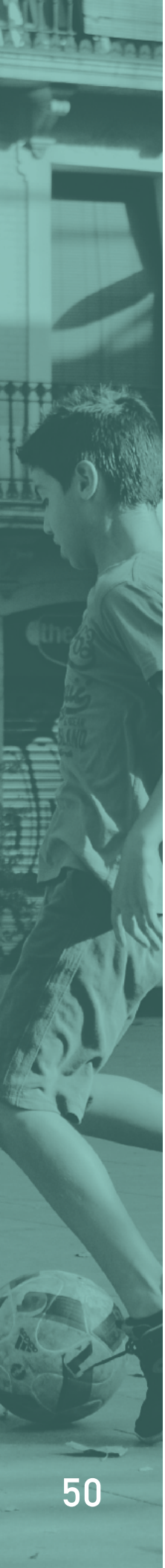


ECONOMIC BENEFITS AND COSTS[4]

10) HOW DO PUBLIC SPACES INFLUENCE THE VALUE OF NEARBY PRIVATE PROPERTY?

There is sufficient evidence to conclude that urban public spaces influence the value of nearby private property. Public spaces in good condition are associated with increased property values, while public spaces in poor condition are associated with decreased property values. Many different factors affect the value of the private property: type of public space (park, river, sidewalk, etc.), size of public space, crime rate, ease of access, pollution of soil and water, condition, and maintenance. Characteristics such as increased access to facilities, improved sense of community, attractive scenery, and level of maintenance have a positive effect on private property values. Public spaces that are an eyesore; are abandoned; or are sites for loitering, congestion, and increased crime have a negative effect. These conclusions are based on a vast amount of literature on green spaces, parks, trees, and improvements to public space and how these factors affect private property value. Much of this literature consists of strong cross-sectional studies as well as a few strong review papers looking at how the value of properties varies with proximity to public space. While most of the literature focuses on positive effects correlated with proximity to attractive public spaces, some studies point out important concerns with social equity. Homeowners and landlords can see increased property values due to improvements in public spaces. This can be considered an unearned benefit to those who—by chance or political favoritism—own property near areas where public space investments are being made. This can create a burden for renters, who may not be able to afford the increased rent and/or who do not personally value the new or improved public space concomitant with its market valuation.

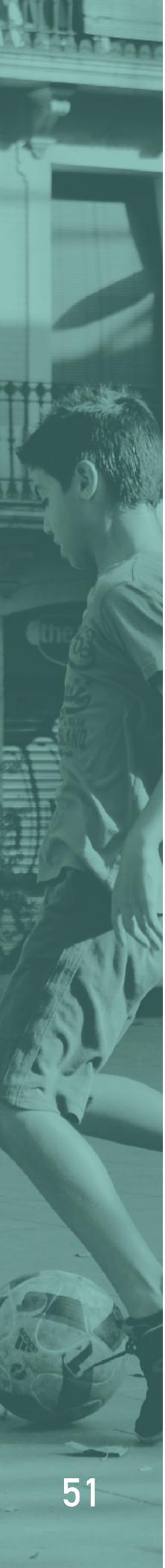
Many studies show that the closer private property is to a public park, the greater the property value. Other studies look at the effects of different types of public spaces, such as vacant lots, gardens, stadiums, and sidewalks. In particular, the attractiveness of the public space is important for property value. Public spaces that are classified as attractive (assuming they are well-kept) are beaches, rivers, parks, lakes, and areas with trees. People will often pay substantially more for proximity to a beach: $1119 for a one meter decrease in distance to shoreline or about a 0.5% increase in value per meter (Hamilton & Morgan, 2010). As a reference, the homes with low access to the beach had median house prices of ~$450,000 while the houses with high access had median house prices of ~$1,000,000 in this study. Proximity to parkland with



recreation opportunities increased the property value of homes 5 to 10 miles away by 0.04 to 0.06% (Kovacs, 2012). Houses across from or adjacent to parks, public squares, rivers, and lakes had 14% higher prices compared to otherwise similar properties (Cebula, 2009). Adding trees to neighborhoods, especially wealthy neighborhoods, increases property values as much as 10-15% (Wolf, 2007). Community gardens increase the value of nearby properties by as much as 9.4% (Voicu & Been, 2008). Green infrastructure can have a positive effect on property values as well. A **cross-sectional study** found that participants had a **willingness-to-pay** of 2% more in monthly rent or additional mortgage payments to live in locations that have a high-quality green infrastructure environment (Mell, Henneberry, Hehl-Lange, & Keskin, 2016). These effects vary greatly in size from study to study, with Kovacs reporting an increase of 0.04 to 0.06%, while Cebula (2009) reports and increase of 14%. The small effects reported by Kovacs are for properties quite distant (5 to 10 miles) from public spaces, while studies looking at the impacts of public spaces in the immediate neighborhood of a property find much higher impacts.

Some public spaces are viewed as a disadvantage to live near and every foot closer to the space decreases the value of private property. Many reasons contribute to these situations; mainly crime, pollution, abandonment, lack of lighting, and the space's status as a general eyesore. Vacant lots may create opportunities for violence and illegal activities (see section on social costs and benefits). The blighting effect of vacant lots on nearby property has reduced household values by as much as 20% in some neighborhoods in Philadelphia, Pennsylvania (Slabinski, 2012). In areas with high crime, properties have lower values when located next to parks where robbery and rape rates are higher (Troy & Grove, 2008). With vacant and rundown lots, there is substantial room for improvement, leading to high returns on investment in these areas; Branas et al. (2016) reported societal returns of $333 per dollar invested through lower costs incurred by victims (medical expenses and property damage), the criminal justice system (police and court costs), and society at large (productivity losses due to those engaging in illegal activities). While increases in property values would have the potential to contribute to gentrification, these returns include other factors that may be less linked to displacement. Exactly which types of investments are associated with gentrification and displacement of existing residents is not well understood. While it is clear that public spaces in good condition increase property values and those in poor condition decrease property values, the impact of public spaces falling on the continuum between the best-maintained and worst-maintained is not well understood. There is some optimal point where investments in park conditions would yield the best returns, but this point is yet to be investigated in depth (Wolch et al., 2010a).

Loughran (2014) argues that contemporary parks and public spaces are best analyzed on a continuum of privilege. He details the existence of a growing inequality in urban public spaces due to economic resources being spread

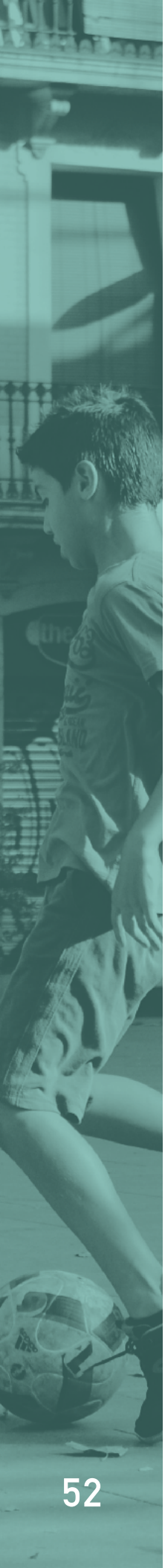


unevenly, resulting in highly-developed public spaces in wealthy areas (these parks are associated with higher property values) and neglected parks in poor neighborhoods (where the parks are associated with lower property values). When investments are made, there are increases in property value no matter the location, but the magnitude of the benefit varies by location and over time; with strikingly high returns found for investments in distressed public areas. The impacts of such investments on existing residents are not clear. While investments driven by business interests have the potential to displace existing residents, targeted investments that create a range of benefits other than business activity, might actually restore access to public spaces for local residents who feel that these areas have become inhospitable for them (for example, see Brownlow's (2006) study of how Cobbs Creek Park became inhospitable for local residents due to a lack of investment).

Type and size of the public space also influence property values. Researchers compared the price premiums in Portland, Oregon associated with property values within 1500 feet of parks of varying sizes. The study examined the mean size of public parks (20 acres) and found that being within 1500 feet of such an area increased property values with the effect varying from $1360 to $2780 depending on the modeling assumptions used. To assess golf courses, they looked at the mean size (116 acres) and found that being within 1500 feet of such an area increased property values with the effect varying from $6408 to $6942 depending on the modeling assumptions used (Bolitzer & Netusil, 2000). The extent to which these differences are due to size versus type of public space is not clear. Further investigations should be carried out to disentangle these effects. Understanding the role of size would clarify whether investments in numerous, small, and dispersed public spaces would create more value than concentrated investments in a single or few, centralized, and large public spaces. At present, the optimal size of parks and the nature and extent of investments that maximize welfare for community members remain important research questions.

11) CAN BUSINESSES TAKE ADVANTAGE OF THE OPPORTUNITY TO EARN/CHARGE/SELL MORE NEAR PUBLIC SPACES?

There is sufficient evidence that investments in public space enhance business activity based on multiple review articles and longitudinal studies. Businesses can take advantage of the opportunities to gain more revenue when located close to an attractive public space or when improvements are made to the space. The extent to which specific businesses benefit from this additional activity and revenue is less clear; as increases in rents were also documented, thus transferring the benefit from businesses that rent to the property owner. Such rent increases may displace existing businesses and residents. Future studies should focus on the manner and extent to which businesses gain revenue from increases in foot traffic or local events. Additionally,

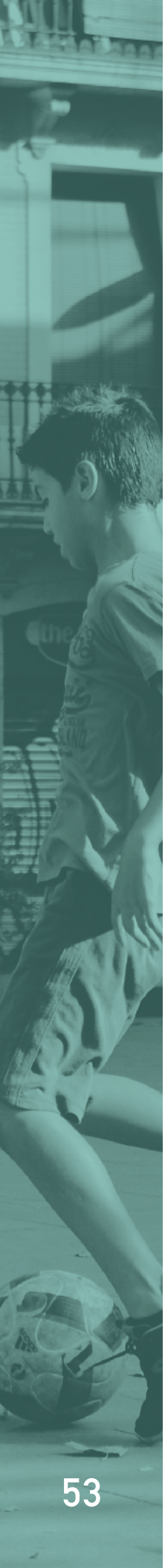


more research is needed on how improvements from outside organizations impact the local businesses and how business activity is affected by renovations to public spaces.

A business must be visible and accessible to the public, and a location near a public space offers this type of essential visibility and accessibility. When public spaces are improved or new public spaces are created, businesses see direct positive effects. Improvements to Fort Greene Park in Brooklyn, New York, led to an increase in foot traffic that drew businesses to the area (Sutton, 2010). Additionally, renovations to Manhattan's Bryant Park have attracted thousands of visitors each day. Within two years, leasing activity on neighboring Sixth Avenue increased 60% over the previous year due to the park (Garvin & Berens, 1997). Between 1990 and 2000, rents for commercial office space near Bryant Park increased between 115% and 225% compared with increases of between 41% and 73% in the surrounding submarkets (New Yorkers for, Ernst, & Young, 2003).

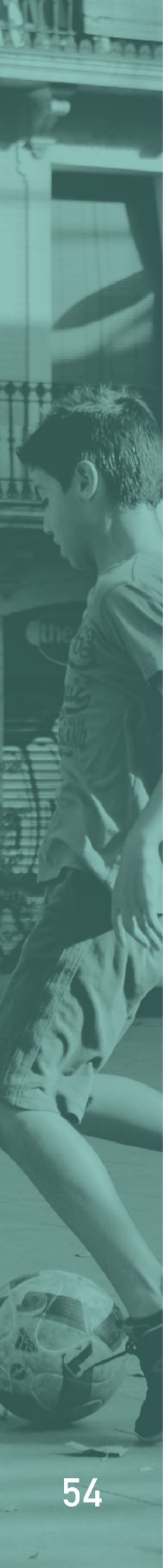
A commonly neglected area of study is the physical street as a public space. San Diego, California has undertaken the installation of roundabouts, bike lanes, and other improvements designed to enhance safety. The installation of these features in the business district increased sales by 20%, according to a study of the tax receipts from 95 businesses (McCann, Meyer, Woods, & Morfas, 2012). In Lancaster, California, a public investment of $10 million in landscaping, lighting, and trees led to 40 new businesses opening, 800 new jobs, $125 million in private investment, and growth of sales **tax revenue** by 26% (McCann et al., 2012). These studies suggest that improvement in street quality benefits businesses, but these studies do not report comparisons to areas not receiving these upgrades. The lack of comparison areas means that other areas that did not undertake these improvements to public spaces may also have experienced similar economic growth, in which case the economic growth would be typical of that region and not caused by the improvements in public space. The increases reported by these studies are large, suggesting that growth was to some extent above baseline expectations, but not all of the reported growth is necessarily due to improvements in public spaces.

Increased foot traffic does not benefit all businesses equally. Businesses that own land near public spaces would benefit from increased property values, but businesses that rent property may find that the increased visibility and sales opportunities eventually become incorporated in their rent, as prospective renters become willing to bid more for properties offering enhanced sales opportunities. It is likely that businesses for which convenience of location is key—such as coffee shops, restaurants, and shopping areas—will benefit the most.



12) WHAT ARE THE ECONOMIC IMPACTS OF PUBLIC SPACES THAT SERVE AS SIGNATURE ATTRACTIONS?

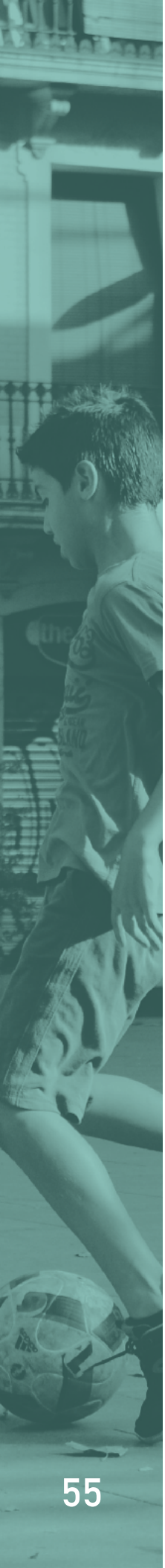
Some public spaces have high visibility and become associated with the character of a particular area, drawing visitors to that area. These are termed "signature public spaces" and include stadiums, large parks, waterfront areas, plazas, and other places people can gather. There is sufficient evidence that such signature attractions enhance economic activity. In addition to the signature attraction itself, high-visibility events using the public space, termed "signature events," have the potential to draw people to the area, thus providing additional economic activity. Fewer studies are available on such signature events. While these events generate economic activity, the extent to which this economic activity is simply displaced from other locations is not always clear. Therefore, the value of signature events for local economies is variable, but positive impacts are supported with limited evidence based on cross-sectional and before-and-after studies. Because the impacts of signature public spaces are large, these investments may be influenced by political considerations and may have the most potential to displace existing residents.



Public spaces are key areas where tourism generates economic activity, especially when these spaces become a signature attraction and host signature events. Improvements to urban public spaces, as well as more marketing and increased accessibility, will likely have measurable effects on tourism revenue. Many large U.S. cities dedicate significant funds towards developing and redeveloping infrastructure to attract tourists. Judd (1995) states that development of multiple signature attractions in cities is key to improving tourism and developing economic areas throughout the city. This leads to the decentralization of economic processes, effectively allowing more people to benefit from improvement.

Multiple studies indicate that parks attract tourists, leading to a positive economic impact. Economic impact can be defined as the net economic change in the income of host residents that results from tourist spending (Crompton, 2000). With 835,000 overnight visitors and 522,000 day visitors in 2007, 5% of San Diego, California's tourism was due to the city parks, and 20% of tourists visited a park when they came to the city. The daily spending of these tourists was $107 per overnight visitor and $48 per day visitor, resulting in total spending of $114.3 million (Harnik & Crompton, 2014). This comprehensive study of park tourism in San Diego concluded that 35% of every tourist dollar spent went directly to benefit the local economy. The High Line redevelopment in New York City produced $2 billion in new construction and $900 million in new **tax revenues** (Loughran, 2014). The park had over 7.6 million visitors in 2015, of whom came from outside of New York (Evans, 2017); this increase in tourists had direct impacts on the local economy. The River Walk in San Antonio, Texas was begun in 1939 at a cost of $400,000 and has become the city's signature attraction and center of its $4.5 billion tourism industry (Imam, 2006). The River Walk features walkways, greenery, restaurants, hotels, shops, and a ferry route. The economic impact of non-resident visitors to the River Walk is about $3.1 billion per year (Nivin, 2014), although the direct benefit of the River Walk on the whole city is not clear. In Chicago, Illinois, Millennium Park was officially opened in 2004, transforming 24.5 acres of commuter rail lines, poorly maintained park land, and parking lots into a **signature park**. In the first six months, more than 2 million people visited; international visitors spent $300 per day for and overnight domestic visitors spent $150 per day (Uhlir, 2005). In Seoul, South Korea, the Cheonggyecheon Restoration Project renovated an urban area to create green space along the Cheonggyecheon Stream through the heart of the city. The renovation has since led to 33% of the visitors being out-of-town tourists, as well as an increase in land prices in Seoul by 2.5% over 10 years and 50% to 200% in the nearby area (Ryu & Kwon, 2016).

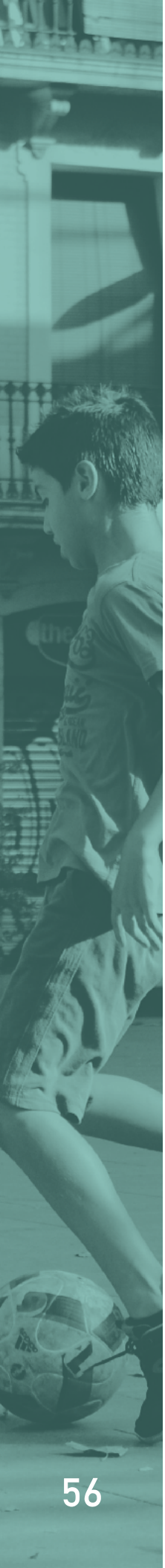
While studies suggest that the creation of signature attractions in public space can have direct economic benefits to the city through increases in tourism, they also indicate that increases in land value may be a burden on renters. When stadiums are developed, specifically large-scale projects like the



Olympic Park in Atlanta, Georgia, property values dramatically increased, but not without gentrification (Harnik, 2000).

Event tourism is key when creating an image for a city and marketing that image to attract tourism and generate economic activity. A review paper (Getz & Page, 2016) describes organizational setup of event tourism and suggests that large-scale events have the greatest impact, both immediate and long-term. Many cities are known for tourism events conducted in public spaces, including Mardi Gras in New Orleans, Louisiana, the New Year's Eve ball drop in Times Square, New York City, and the Olympic Games. The economic impact on New Orleans from Mardi Gras increased steadily from 1986 to 2000; spending in the metropolitan area increased almost 300% over these 14 years (Gotham, 2002). In Charleston, South Carolina, the local Wine and Food Festival generated $2 million in revenue (Kim, Duncan, & Chung, 2015). Businesses can take advantage of event and festival tourism through increased exposure regionally, nationally, or internationally and make gains in economic activity even outside of the scheduled festival. In 2015, the World Expo took place in Milan, Italy; this event can last up to six months. A study was conducted to look at the effects of the Milan Expo 2015 on local hotels and their operating performance and seasonality. The absolute value of real revenue per available room was €154, while the mean registered in the 11 years before was €97 (Sainaghi & Mauri, 2018). This corresponds to a roughly 159% increase during the event. In addition to these results, the event caused seasonal differences to be reduced. Another category worth consideration is sports tourism. Events such as the NCAA Men's Basketball Final Four, the Super Bowl, the World Series, and large-scale race events have extraordinary economic impact due to the robust number of out-of-town visitors. Such events take place in private venues and are open to only those who can pay the substantial ticket prices. However, in some cases public funds are expended for the construction of venues in support of the events, which have citywide impacts. In 2002, the NCAA Men's Basketball Final Four generated an economic impact of $59.6 million in Atlanta, Georgia, mostly from the 37,000 out-of-town visitors (Mondello & Rishe, 2004). These events may displace tourism from other locations, and so these figures should not be viewed as overall increases in net economic activity or as social benefits.

More studies of "**natural experiments**" where new parks or events are created in one area but not in otherwise comparable areas are needed, as these studies provide controls that help identify the incremental effect of the intervention. In addition, continued investigations should be carried out on long-term effects of signature events and improvements of public space specifically to attract tourism. There is a lack of investigation into how long the duration the economic impact from an event lasts, and the overall effect it has on a community. In the future, when renovations to public space are made for tourism reasons, the economic impacts should be studied closely over time to identify the true effect of the renovation or creation.

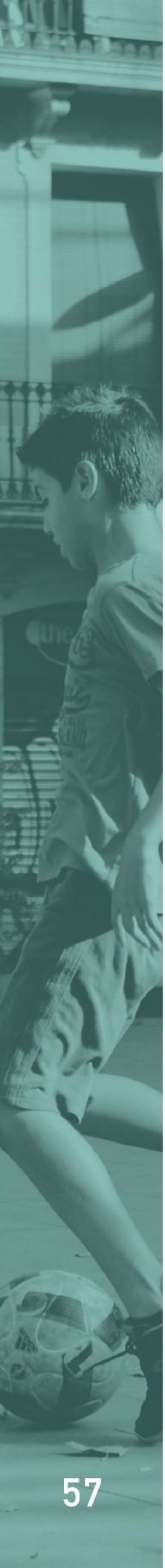


13) ARE INVESTMENTS IN LIBRARIES JUSTIFIED BY THE IMPROVEMENTS IN SOCIAL AND HUMAN CAPITAL THEY PROVIDE?

Sometimes, investments in public spaces are made with goals of quality-of-life and social and human capital improvements. Libraries are a key public space in this regard, as they can help train patrons and can assist them in searching for jobs. There is limited evidence correlating investments in libraries with social and human capital improvements from an economic standpoint, specifically with regard to job-seeking activity. Many studies have demonstrated substantial **returns on investment (ROI)** for investments in libraries. However, it is challenging to attribute ROI definitively to a library, since improvements in social and human capital are hard to quantify.

Libraries serve as an important resource for individuals seeking jobs and technology education. Library employees have described the increasing pressure to provide access to computers and instruct patrons on how to use them (Julien & Hoffman, 2008). Because of the increasing amount of job applications and job postings on the internet, and fewer on paper or in person, people increasingly need to be trained to use computers. According to the 2007 Libraries and the Internet Study, the second most prevalent use of the internet at libraries was for job seeking, reported by 44% of the visitors (Bertot, McClure, & Jaeger, 2008). These studies are important to note because they demonstrate that investments in programs at local libraries, specifically in technology education, will provide the necessary resources for job-seeking patrons to understand how to search for jobs, apply for jobs, and be successful in landing those jobs.

The total direct and indirect return on investment for every $1 expended on South Carolina's public libraries by state and local governments is $4.48 (Barron, Williams, Bajjaly, Arns, & Wilson, 2005). A 2004 study of public libraries in Florida found that for every $1 invested, the public libraries returned $6.54 in economic benefits (Griffiths, King, Tomer, Lynch, & Harrington, 2004). The measurement ROI has been applied to many different types of organizations and community resources. While common in the for-profit sector, the application of ROI measures to libraries, museums, educational institutions, and parks has lagged considerably behind. Part of the difficulty has been in quantifying benefits from non-priced goods and services that can differ from use to use, user to user, as well as from library to library (since their services vary). With today's climate of strained budgets and pressures for increased accountability and transparency, the need for clear and accurate statements of how public monies are used and, the resulting benefits, can help ensure continued investment.



Future studies should focus directly on how people use libraries to get jobs or improve their businesses. Interventional studies in which the impact of libraries and library programs on the ability of job applicants to get and keep jobs would further strengthen the knowledge base on this topic.

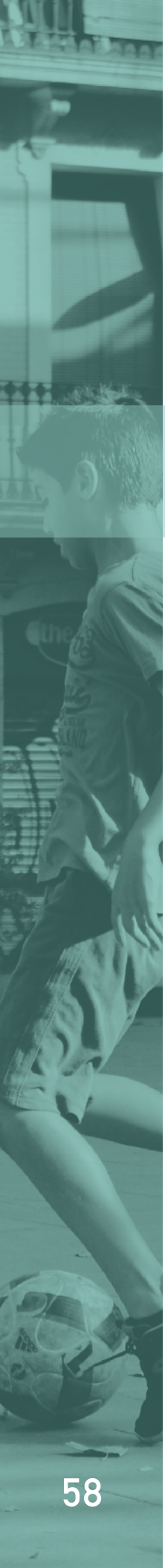
14) CAN BUSINESS IMPROVEMENT DISTRICTS (BIDS) BE USED AS AN EFFECTIVE FINANCING MECHANISM FOR THE UPKEEP OF PUBLIC SPACES?

There is limited evidence that **business improvement districts (BIDs)** can influence property values and business revenue when used as a financing mechanism for the upkeep of urban public space. BIDs are defined areas within which businesses are required to pay an additional tax in order to fund projects within the district's boundary. BIDs are often used to promote pedestrianization, beautification, and quality of life specifically through job creation, increases in business density, and increases in sales volume for neighborhood small businesses. BID organizations help local economic development by providing street sweeps, safety ambassadors, and streetscape improvements to reduce fear and crime (Hoyt, 2005). As seen in the section describing how public space affects property value, decreases in crime have associated economic benefits.

In New York City, a before-and-after study looked at the implementation of BIDs on commercial properties. They compared prices of properties inside BIDs to those outside the BID and its immediate vicinity (still in the same zip code) throughout the process to assure the increase in commercial property value could be attributed to the BID designation. Price per square foot of commercial properties sold within the 5-year period immediately following BID designation was 30.2% higher than before BID designation, while properties outside the BID appreciated 15.5% (Ellen, Schwartz, & Voicu, 2007).

A **cross-sectional study** was conducted to predict the economic benefits of the implementation of a BID in downtown Asheville, North Carolina. The study forecasted a positive economic impact on property values and retail sales within the district lines (Ha & Grunwell, 2014). Researchers focused on surveys from business owners about their total sales from year to year and what they expected to increase or decrease. With the implementation of the BID in the central business district, it was estimated that the average growth in retail sales would be 5.3% annually, in addition to normal growth rates without a BID. Additionally, the property values in the district were estimated to increase 2% annually.

The implementation of BIDs is controversial, as BIDs allow more affluent neighborhoods to keep **tax revenues** in their area rather than benefiting less affluent areas. However, the economic benefits from the associated



improvements have been demonstrated to be significant in some studies. There is limited research on the associations of BIDs with property values and business revenues with only two review papers and three cross-sectional studies found. Many of the studies focused on community benefits, reduction in crime, and cleaning the streets; fewer focused on the economic benefits. Future work should assess the direct economic benefits of implementing a BID.

ENVIRONMENTAL BENEFITS AND COSTS

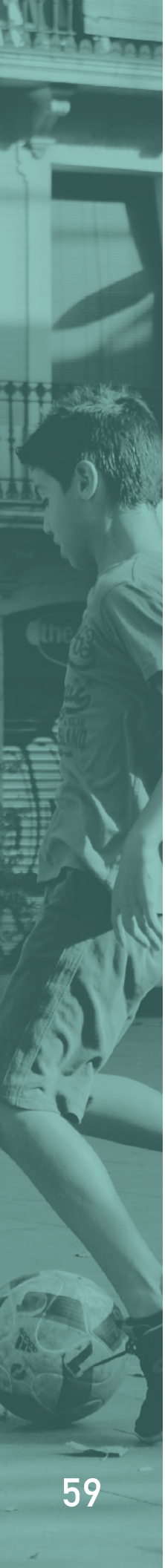
This section of the report describes how the characteristics of public spaces, such as the presence or lack of natural vegetation, determines the environmental benefits and costs of public space. A condensed list of the air, water, and biodiversity-related impacts associated with each of these characteristics is given in Table 1, and is described in depth in the text below.

15) DOES VEGETATION IN PUBLIC SPACES IMPACT AIR POLLUTION?

While there is extensive research on whether urban vegetation and green infrastructure can effectively reduce air pollution, evidence of their effects depends on many factors and therefore evidence is limited. These factors include plant or tree species, micro-scale conditions, spatial arrangement or placement, and climatic conditions. Although extensive research on the effects of urban vegetation and trees on air pollution exists, there have been few studies on public spaces specifically.

Important factors involved in air quality include **deposition, dispersion, volatile organic compounds (VOCs)**, coniferous versus **deciduous trees,** and **engineered green infrastructure**. **Deposition** is the settling of particles on to vegetative surfaces. **Dispersion** is the spread of gaseous or suspended particles or compounds throughout an air volume. **VOCs** are common naturally-occurring and synthetic chemicals that easily evaporate, react with other compounds, and often contribute to smog and human health problems. **Coniferous trees** are those that bear cones and needles or scaled leaves throughout the year; **deciduous trees** shed broader, flatter and hairy or waxy leaves annually. Engineered green infrastructure is the category of built or preserved structures that encourage urban runoff infiltration or detention; for example parks, rain gardens, bump-out planters, and green roofs.

The quantity of air pollution that can be removed depends on the plant or tree species. Certain tree and shrub species are more effective at removing ozone

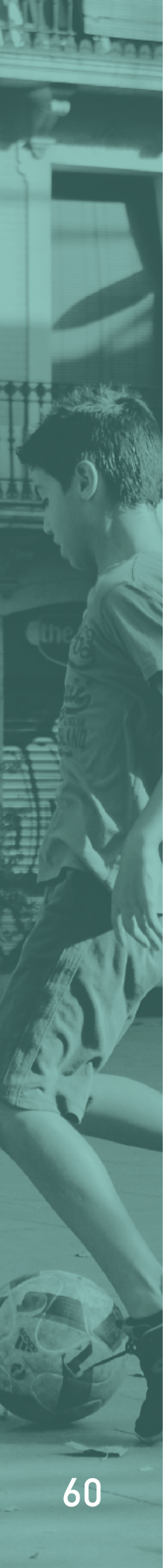


and allergens (Sicard et al., 2018). Trees bearing leaves with larger surface areas, longer lifespans, and rougher leaf textures have higher pollutant uptake capacity (Beckett, Freer Smith, & Taylor, 2000; Moreno, Sagnotti, Dinarès-Turell, Winkler, & Cascella, 2003).

While coniferous trees are better at removing particles, deciduous trees are better at absorbing gases from the air (Beckett et al., 2000; Bolund & Hunhammar, 1999; Currie & Bass, 2008; Sæbø et al., 2012). One study estimated that pine trees in Los Angeles, California remove almost half of ambient concentrations in nearby air pockets, thereby reducing 10% of regional atmospheric ozone (Dwyer, McPherson, Schroeder, & Rowntree, 1992).

Currie and Bass (2008) concluded that in most cases shrubs, grasses, and **engineered green spaces** also act as sinks for pollution, albeit not as effectively as trees. Carbon-containing gases, such as carbon dioxide and monoxide, are also captured differently by different plants. Besir and Cuce (2018) studied the retained carbon content of various vegetation types and found trees and shrubs to contain the highest level of carbon at around 50%, carbon levels in grass to be around 45%, and herbaceous perennials to be around 43%.

Tree or vegetation placement and air movement is another key factor in the removal of pollutants from air. **Coniferous trees** are better suited to capture and retain **particulate matter** (PM) from the air, especially in high windspeed (turbulent) conditions. In contrast, turbulent air can flow easily past smooth-leaved trees, reducing or preventing particulate **deposition** altogether (Beckett et al., 2000). There are mixed findings on whether near-roadway vegetation barriers, green walls, greenbelts, and a single row of trees can remove urban air particulate and **gaseous pollutants** (Setälä, Viippola, Rantalainen, Pennanen, & Yli-Pelkonen, 2013). Near-roadway vegetation's influence on **dispersion** and airflow also impacts the location and life of pollutants. Trees in an urban **street canyon**, or a street lined on both sides with buildings, can either increase or decrease air pollution concentrations, depending on spatial positioning (Amorim, Rodrigues, Tavares, Valente, & Borrego, 2013). Abhijith et al. (2017) likewise found that trees in urban **street canyons** retain gaseous pollutants and therefore allowed concentrations to remain constant or build around sidewalks. One study found that ozone concentrations were higher



under **tree canopies** than in less-vegetated open areas and those located alongside roads. In contrast, low-level hedges and shrubs enabled more airflow above green infrastructure and footpaths, therefore enabling concentrations to decrease (Fantozzi, Monaci, Blanusa, & Bargagli, 2015).

The size of parks or urban forests plays a role in pollution removal. Parks that are less than 100 meters in length or width may not make any significant reduction to pollutants within the park (Xing & Brimblecombe, 2019). In larger parks or urban forests, dense vegetation can reduce wind speeds, which can prevent the penetration of air with high PM concentrations to reach forest interiors (Setälä et al., 2013). In addition, **engineered green spaces** or green stormwater infrastructure (GSI) can reduce air pollution by influencing local **dispersion** patterns.

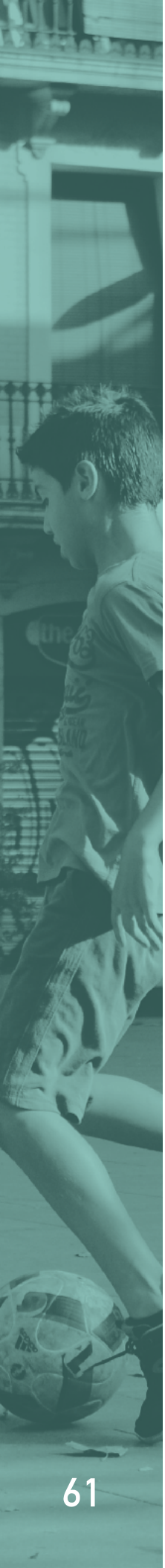
16) DOES VEGETATION IN PUBLIC SPACES EMIT POLLUTANTS OR ALLERGENS?

The evidence on whether trees and vegetation in public spaces emit pollutants or allergens is limited because very little research on emissions from vegetation has been conducted specifically in public spaces. In addition, there is insufficient research in some areas, and conflicting findings in other areas. There is a higher quantity of literature on emissions of **VOCs**, with fewer focusing on emitted pollen and other allergens.

Biogenic emissions—or the ejection of pollen, allergens, carbon dioxide, and **VOCs** by plants—can vary by plant or tree species. Many of these emissions are considered undesirable due to their immediate or secondary impacts on air quality. For example, some of the most common biogenic compounds released by trees, specifically conifers, are terpene chemicals. Terpenes are deemed harmful to air quality, since they often serve as precursors to ozone and other reactive products involved in atmospheric chemical reactions. Such reactions include the formation of other greenhouse gases such as carbon monoxide and methane, as well as aerosols (Amorim et al., 2013; Kesselmeier & Staudt, 1999; Sun, Niinemets, Hüve, Rasulov, & Noe, 2013; Taha, 1996). Biogenic emissions are also influenced directly by temperature, sun exposure, and humidity.

Greenhouse gases, including nitrous oxide, can be produced in significant quantities by certain urban vegetation. Lawns, turfgrass, and other common urban plant types can produce relatively more of these gases than natural ecosystems (Pataki et al., 2011). Additionally, changing climate and other disturbances can encourage higher emission rates and decreasing air pollutant uptake and **deposition** capacity (Pataki et al., 2011).

The impacts of biogenically-emitting vegetation can be offset by certain species that release little to no VOCs or greenhouse gases. Incorporating



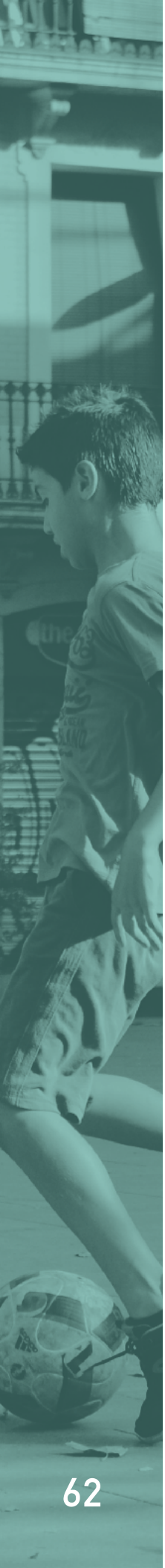
low-emission trees in sites can cool air temperatures (Taha, 1996), thereby reducing **photochemical** reaction rates and the production of associated pollutants. These trees would also remove air pollutants already present. Examples of low-emitting tree species include crape myrtle, judas, elm and cedar trees (Taha, 1996).

17) DOES LAND COVER IN PUBLIC SPACES AFFECT URBAN TEMPERATURES?

There is sufficient evidence that **impervious surfaces** increase surface and air temperature, contributing to **urban heat island** (UHI) effects. UHI is a term for the higher atmospheric and surface temperatures that occur in urban areas compared to rural areas due to urbanization/human activity. However, there have been few studies conducted specifically in public spaces other than streets and highways. On the other hand, there is sufficient evidence that public spaces including parks and **engineered green spaces** have cooling effects. Green spaces offer shade and cooling that lower surface temperatures and reduce cooling costs in nearby or attached buildings. The benefits derived from these spaces depend on the vegetative species, vegetative placement, underlying **land cover**, and size. Developing, improving, and maintaining these green spaces has been shown to reduce the intensity of thermal effects in urban environments.

Many public spaces have **impervious surfaces** that include buildings, side-walks, parking lots, roofs, and streets; all of these increase surface and air temperatures and contribute to UHI effects. UHI is caused by processes where heat in the form of light energy comes into cities and gets trapped and retained over long periods of time. The effects are increased with heat caused by traffic, industry, buildings, pavement, and other **impervious surfaces**. UHI is of concern because it can increase pollution levels, increase heat-related mortality, and change precipitation patterns. In the summer and winter when the temperatures are at their extremes, the effects of UHI are more severe (Arnfield, 2003).

Public spaces with a large percentage of **impervious surfaces** such as side-walks, parking lots, pavements, and rooftops have heating effects on **urban microclimates**. A common measure of heat storage of materials is **irradiance** (W/m2), which quantifies the release of energy once it has been absorbed. In Tokyo, research looked at the heat storage and subsequent **irradiance** of various materials including asphalt, blacktop concrete, soil, and sand. Asphalt heats considerably more than the other materials (Asaeda, Ca, & Wake, 1996). More empirical research is needed to test whether decreasing **impervious surface** coverage specifically in public spaces can change temperatures in and around the space.

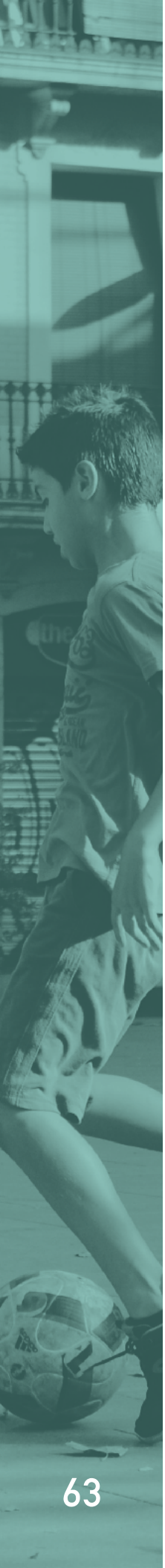


Parks can have the most profound effect on air and land surface temperatures in cities, depending on the park's size, and on the vegetation and **biodiversity** supported within them. Parks have cooling effects that are enhanced by the extent of vegetative cover, number of trees, larger size, and improved irrigation. Park Cool Islands (PCIs) can be created and quantified by looking at the thermal effects of parks. PCIs are formed by the combined effect of evapotranspiration and shading, causing a decrease in temperature (Shashua-Bar & Hoffman, 2000). Park size is correlated with the associated cooling effect, although the effect is non-linear (larger park size indicates increasing returns). PCI intensity is mainly determined by the area of trees and shrubs in the park, the size of the park, and the shape of the park; with grass generally having a relatively lower effect (compared to trees and low vegetation) on the cooling (Cao, Onishi, Chen, & Imura, 2010).

Parks with substantial trees, waterbodies, and grass reduce air temperature and increase humidity. Tree clusters in parks with short ground vegetation have higher cooling effects than single trees, grass, and water bodies. Irrigation provides greater cooling effect in these settings but involves greater maintenance costs (Amani-Beni, Zhang, Xie, & Xu, 2018) and improved irrigation systems help with cooling effects, specifically with grasses (Amani-Beni et. al. 2018). Parks offer clear benefits not only within their boundaries, but in the surrounding areas as well. One study investigated the cooling effects downwind from a PCI and found that at noon, the park could cool areas 1 kilometer downwind by up to 1.5°C or 34.7°F (Ca, Asaeda, & Abu, 1998). These studies suggest that parks' cooling effects depend on park size, geometry, type of vegetation, and upkeep; and that parks have cooling effects beyond their boundaries.

The extent of **tree canopy** cover in parks moderates air and surface temperatures. Greater canopy cover is associated with lower temperatures, up to 22.8°C or 73°F on asphalt (Napoli, Massetti, Brandani, Petralli, & Orlandini, 2016). This suggests that many smaller trees will not have as great of a cooling effect as larger trees that provide more shading. Air cooling by the tree's leaf color, foliage density, leaf thickness, and leaf texture have effects on air cooling in decreasing order.

Street trees reduce daytime indoor and outdoor temperatures in **street canyons,** but since they can reduce air circulation, can also cause an increase in nighttime indoor and outdoor temperatures (Morakinyo & Lam, 2016). Targeted tree placement to provide shade over walkways and other pedestrian spaces can improve outdoor comfort the most by reducing air temperatures (Johansson & Emmanuel, 2006).



18) DO PUBLIC SPACES AFFECT ENERGY USE?

There is limited evidence that public spaces affect energy use, due to the many characteristics that can affect energy use. Many studies compare energy costs associated with different building materials, roofing types, or building characteristics, while a smaller number of studies evaluate how improvements to public space can lower energy costs. However, there have been few studies conducted specifically on how public spaces affect energy use.

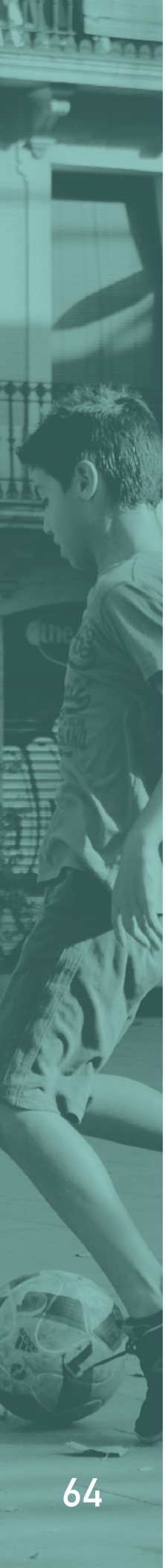
First, **impervious surfaces** in public spaces can increase surface and air temperatures and thereby increase the costs of cooling. On a summer day, the air temperature in a city is about 2.5°C or 36.5°F warmer than in the surrounding areas, which translates to an increase of 5 to 10% of urban peak electric demand (e.g. due to air-conditioning) (Rosenfeld et al., 1995).

Effective mitigations include increasing the **albedo** of the surfaces, green roofing, and planting of vegetation. When these **impervious surfaces** are engineered to reduce surface and air temperature, research has shown that it can reduce cooling costs of nearby buildings over time. Rooftops and pavements can be mitigated with light and reflective surfaces or coatings. One study documented that when roofs were painted white and coated, the reflectivities increased, and electrical savings resulted in about $0.86/m2 per year (Akbari, 2003). This suggests that there is not much incentive to replace or recoat roofs due to project costs, but if changes were made to the roofing material in the production step it could reduce cooling costs.

Public spaces that contain water bodies, or that use direct shading from trees and **engineered green spaces,** can lower energy costs for nearby buildings. When a green space is significant in size, it can reduce the air temperature by up to 2°C or 35.6°F in the nearby area, creating an energy savings of up to 4.5% (Wong et al., 2011). The presence of ponds and trees cool the air and shade the urban surface.

Green roofing can be a key component in Leadership in Energy and Environmental Design (LEED) certification. LEED certification comes with many benefits to the building owners, mostly more efficient buildings and higher rental costs. Green roofing has the potential to earn LEED points through a design that mitigates UHIs. Green roofing can replace reflective roofing (which also can result in LEED points) due to their evaporative cooling from the plants and soil chosen. A combination of green roofing and shading has been shown to reduce indoor air temperature by 5.1°C or 41.2°F, decreasing the effective cooling costs significantly per household (Kumar & Kaushik, 2005).

A recent review found that in residential areas, buildings with trees used 2.3% to 90% less cooling energy because of shading effects, and up to 20% less heating energy through windbreak effects compared to buildings without



trees (Ko, 2018). While trees effectively reduce temperatures, the impact on energy use in buildings can vary depending on type of material, architecture, design, geometry, tree species, aspect, and season (Salmond et al., 2016). Depending on the species, trees may reduce nighttime cooling, but have higher temperatures underneath their canopies than the street in early mornings (Sanusi, Johnstone, May, & Livesley, 2017).

However, tree-planting or greening initiatives can also have negative effects on energy consumption depending on climate. While tree planting can decrease cooling costs in warmer climates, it can increase wintertime heating costs in colder climates by reducing air temperatures locally (e.g. Miami vs. Madison) (McPherson, Herrington, & Heisler, 1988).

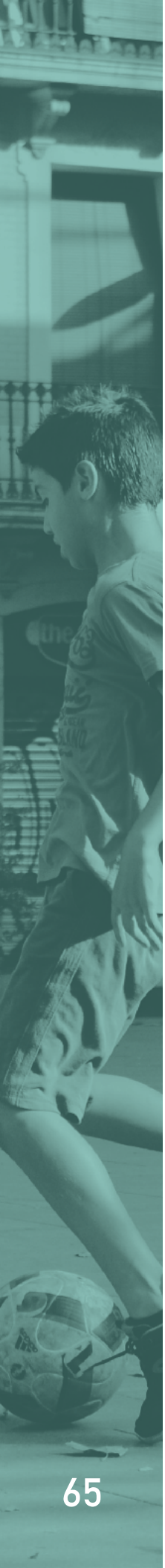
More investigation is needed into whether and how street trees and engineered green spaces affect indoor temperature, and thereby energy consumption. This research is made difficult by the large variability in building design, materials, and size. In addition, there is increasing concern about climate change and its impacts, especially on urban environments in warmer climates. Therefore, most studies focus on interventions to reduce UHI and cooling energy costs in warmer climates. More research is needed about interventions in cooler cities.

19) DO PUBLIC SPACES AFFECT STORMWATER RUNOFF AND FLOODING?

There is limited evidence that public spaces positively impact stormwater runoff, because the impacts are highly dependent on the characteristics of the public space. Public space with extensive **impervious surfaces**, rooftops, or turfgrass exacerbate stormwater runoff; while public spaces with trees, shrubs, and green spaces mitigate stormwater runoff and flooding. The shape, size, and other features of public spaces can also either contribute to or mitigate stormwater runoff issues. In addition, there have been few studies on the impacts to stormwater runoff and flooding of public spaces in particular.

Research on the impacts of **impervious surfaces** has been steady since the 1950s, and has produced consistent findings. Stormwater flows in watersheds comprised primarily of **impervious surfaces** (at a minimum 10% of coverage) are subject to higher volume and frequency of flooding events. Road networks in particular have been shown to increase **peak discharges** (Wemple et al., 2017). Rooftops and public spaces such as streets, roads, parking lots, and transportation networks—have been shown to contribute substantially to urban stormwater runoff.

With heavy rainfall in areas with a high percent of **impervious surface** coverage, streams may widen, causing streambank erosion and higher **suspended**



solids loads which are detrimental to aquatic life. Construction of **impervious surfaces** especially contributes to sedimentation (Wheeler, Angermeier, & Rosenberger, 2005).

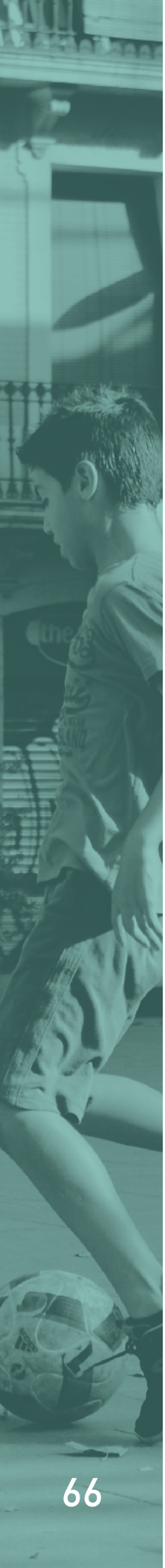
Turfgrass, which is a common form of vegetation found in parks and public spaces, acts similarly to an impervious (e.g. paved) surface. Soil or surface compaction is high, which reduces infiltration capacity. In addition, shallow or thin turf (resulting from poor management) can result in sediment erosion. Proper maintenance can improve infiltration capacity and reduce erosion from turfgrass, including aeration, adjusted mowing height, and fertilization (Freeborn, Sample, & Fox, 2012).

Public spaces, parks, and open spaces host trees, shrubs, and **engineered green spaces**, which are beneficial to reducing stormwater flows and improving surfacewater quality. A small number of studies have evaluated the stormwater benefits of urban parks. However, they are mostly modeling exercises, not empirical studies. By applying stormwater runoff models to urban park spaces, studies have found beneficial impact of parks on stormwater management, primarily via higher **stormwater infiltration** rates compared to other urban spaces (Gill, Handley, Ennos, & Pauleit, 2007; Konijnendijk van den Bosch, van den Bosch, Nielsen, & Maruthaveeran, 2013; Zhang, Xie, Zhang, & Zhang, 2012).

Trees impact surface waters and aquatic ecosystems primarily by reducing stormwater flows from **impervious surfaces.** Green, vegetated spaces in urban areas have been found to reduce flooding (Kaźmierczak & Cavan, 2011). By extension, urban green spaces are important for cities' adaptation to climate change (Gill et al., 2007).

Trees also store and intercept rainwater, primarily via their crowns and canopy. However, there are many factors that influence interception, including duration and frequency of rainfall; rainfall intensity; leaf area and surface characteristics; meteorological factors; and season or time of year. Rates of storage vary by tree species; **coniferous trees** tend to intercept rainwater at higher rates than **deciduous trees.** Xiao and McPherson (2016) found that the needle leaf evergreen Picea pungens (blue spruce) could store three times the amount of rainwater than could deciduous Lagerstroemia indica (crape myrtle).

In addition, trees absorb water through their root systems, promote **stormwater infiltration** to the groundwater table, and release water to the atmosphere through transpiration (Cappiella et al., 2016). Mature trees with large crowns or canopies play an important role in reducing stormwater flows, primarily via evapotranspiration (Gill et al., 2007). Trees are very efficient compared to other forms of vegetation at reducing stormwater.



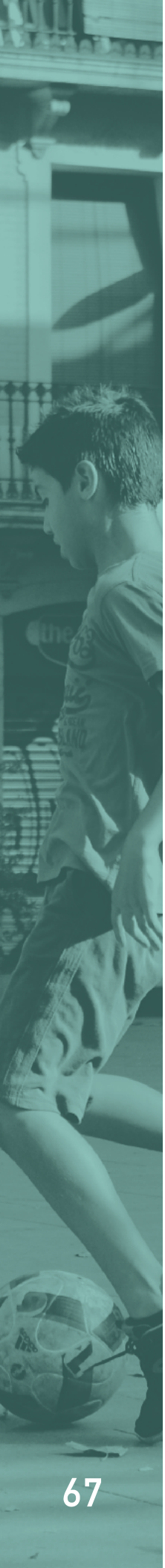
A bioswale is a depressed or channeled drainage area that receives rainwater runoff (often from an impervious surface like a parking lot) that is vegetated. One study found that trees installed in engineered bioswales can absorb 46 to 72% of total water within the system (Scharenbroch, Morgenroth, & Maule, 2016).

Cities therefore widely use trees as best management practices (BMPs) to reduce water quality impacts of urban impervious surfaces and urban development. Urban trees can be used to comply with stormwater management regulations, and requirements associated with the Clean Water Act, such as total maximum daily loads (TMDLs).

However, many factors affect urban tree mortality or survival, tree condition, and growth. These factors are important considerations for site design and when assigning water quality credits (Center for Watershed Protection, 2017).

There are also a limited number of studies that directly address the water quality impacts of urban trees. Findings from individual studies are often not directly comparable due to different scales or methods used.

Cities are installing green stormwater infrastructure throughout public spaces including streets, sidewalks, parks, recreation centers, schools, institutional space, and rooftops. Common **engineered green space** project types include stormwater tree trenches, bioswales, rain gardens, curb bumpouts, green roofs,



planters, and wetlands (for examples, refer to https://www.epa.gov/green-infrastructure/what-green-infrastructure). Empirical studies on the effects of **engineered green spaces** on stormwater flows is limited (Liu et al., 2017).

Basic research has found that **engineered green spaces**—also known as green stormwater infrastructure—store, detain, and infiltrate rainwater; thereby delaying and reducing stormwater runoff (Chui, Liu, & Zhan, 2016; Rizzo et al., 2018; Roy-Poirier, Champagne, & Filion, 2010), and recharging groundwater (Newcomer, Gurdak, Sklar, & Nanus, 2014; R. D. Stewart, Lee, Shuster, & Darner, 2017; K. Zhang & Chui, 2018).

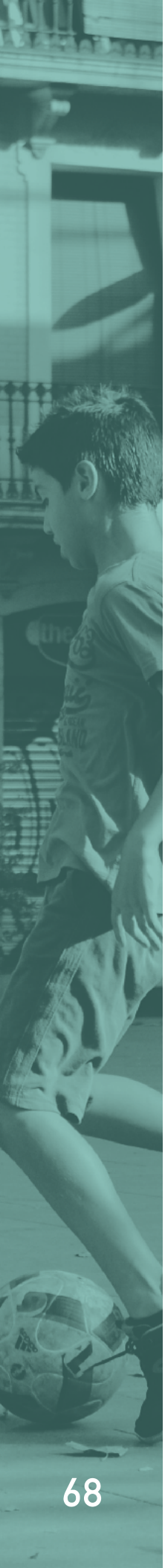
Green roofs provide stormwater volume reduction, primarily via evaporation and transpiration. A series of studies in Germany found that green roofs could reduce annual stormwater runoff by 65 to 85% of annual precipitation (Mentens, Raes, & Hermy, 2006). The **rainfall-runoff relationship** for green roofs is strongly influenced by the depth of substrate (materials beneath vegetation), the season, climate, amount of rainfall, vegetation species, and roof depth, among other factors (Mentens et al., 2006). One study estimated that green roofs covering 10% of buildings across a city would reduce runoff by 2.7% (Mentens et al., 2006).

However, the long-term performance of **engineered green spaces** is not often monitored or studied, and empirical studies of urban BMP performance are often limited by data that are incomplete or of poor quality (Liu et al., 2017). Most modeling efforts assume constant performance, while it is known that BMP performance and efficiencies vary over time (Liu et al., 2017), and can be affected by maintenance, structure **degradation**, or pollutant accumulation.

In addition, while it is known that **engineered green spaces** can effectively manage routine storms, there is no consensus in the literature on the extent to which they can manage large storms or control flooding. The spatial placement of these **engineered projects** within and throughout a city may affect the extent to which they control flooding (Zellner, Massey, Minor, & Gonzalez-Meler, 2016). Aging infrastructure may lack capacity to manage stormwater flows under future precipitation patterns influenced by climate change (Rosenberg et al., 2010).

20) DO PUBLIC SPACES AFFECT SURFACE WATER QUALITY?

There is limited evidence that public spaces positively impact water quality, because the impacts are highly dependent on the characteristics of the public space, and little research directly evaluates public spaces in cities. Stormwater runoff from **impervious surfaces** can have relatively high pollutant loads (Zhao, Li, & Wang, 2011). Soils in close proximity to roadway environments tend to be high in copper, chromium, lead, nickel, and zinc as a result of tire and brake pad wear, vehicle emissions, road surface wear, and **atmospheric**

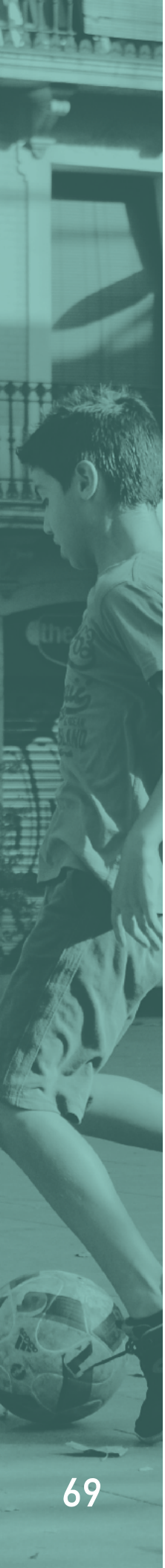


deposition from other sources (Duong & Lee, 2009; Eriksson et al., 2007; Sutherland, Tack, & Ziegler, 2012; Zhao et al., 2011). Other pollutants commonly found in stormwater runoff include nutrients (e.g. nitrogen and phosphorus from fertilizer application), oils, sediments, and bacteria.

Impervious surfaces also contribute to warming of stormwater runoff, which can increase temperatures of surface waterbodies. High concentrations of **impervious surfaces,** including roads and buildings, contribute to thermal pollution, especially in spring and summer months. This is especially true in watersheds with a high percentage of impervious, paved, surface cover (Herb, Janke, Mohseni, & Stefan, 2008). One study of surface runoff from an asphalt parking lot in Minnesota found that the parking lot contributed to increased stream temperatures only during large rainfall events when temperatures were high (Herb et al., 2008). Additional research is needed on the influence of climate change on these relationships.

Public spaces, parks, and open spaces host trees and shrubs, which are beneficial to water quality. Urban trees are effective at removing nutrients from stormwater and soils (Livesley, McPherson, & Calfapietra, 2016). Trees are also able to remove some heavy metals from stormwater and soils (Livesley et al., 2016). However, trees are not commonly used as phytoremediation measures because of their long growth-time (Pulford & Watson, 2003).

Vegetation within **engineered green spaces** can reduce pollutant loads in stormwater runoff either directly by removing the pollutants (e.g. via sorption or filtration), or indirectly by reducing the flow of polluted stormwater. These projects directly remove pollutants primarily by enhancing plant uptake and by promoting growth of microbes in the root zone of plants (K. Zhang & Chui, 2018). One study examined project capacity to remove pollutants in park spaces, and found that the allocation of 10% of the land area within parks



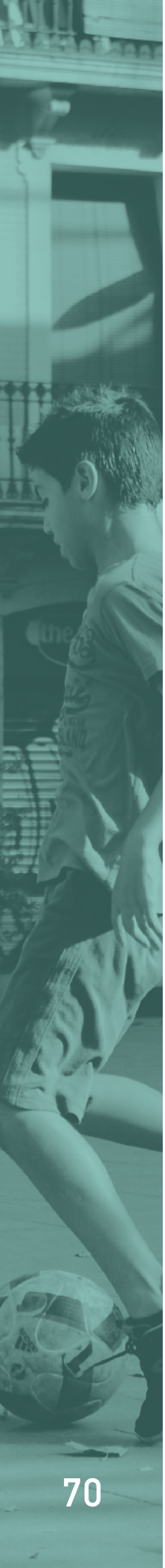
for stormwater management would result in a 62% reduction of nitrogen (Segaran, Lewis, & Ostendorf, 2014).

David et al. (2014) examined the efficiency of engineered green spaces (combination of rain gardens and a bioswale) at removing a wide variety of water pollutants. They found between 18 and 100% reduction in mercury, polychlorinated biphenols (PCBs) and dioxins, and between 20 and 90% reduction in cadmium, copper, nickel, lead zinc and polycyclic aromatic hydrocarbons (PAHs).

Many research questions remain surrounding the design and implementation of **engineered green spaces**. These questions include considerations regarding design for different (changing) climates and geographic setting characteristics, design targets (runoff reduction versus pollutant load reduction), filtration versus detention, the targeting of specific pollutants, and design goals for the entire life-cycle of the project (including ease of maintenance) (Vogel et al., 2015).

Permeable pavements are another engineered mitigation measure to reduce pollutant loadings in stormwater (Bean, Hunt, & Bidelspach, 2007; Chandrappa & Biligiri, 2016). These permeable pavements are part of a suite of strategies, called Low Impact Development (LID), aimed at both reducing stormwater runoff volume and pollutant loads (Battiata, Collins, Hirschman, & Hoffmann, 2010). Other LID strategies include downspout disconnection and rainwater harvesting. Permeable pavements are an LID strategy that can reduce pollutant loadings via physical processes (pollutants are filtered by the pavement), chemical processes (chemical reactions with pavement material will precipitate out pollutants), and biological processes (microbes in pervious pavements can consume and dissolve pollutants) (Chandrappa & Biligiri, 2016).

On the other hand, public spaces with lawns and ornamental vegetation may be fertilized, which can contribute to nutrient problems in waterbodies (Livesley et al., 2016). Urban turfgrass is the largest crop to be irrigated and fertilized in North America (Milesi et al., 2005). Large inputs of nutrients (fertilizers) are often applied to turfgrass throughout urban areas. Thin stands of highly compacted turfgrass provide little opportunity for **stormwater infiltration**, and therefore pass excess nutrients into the soil and stormwater runoff to nearby surface waters. One potential mitigation measure is to border turfgrass



areas with trees and other vegetation; these species increase the ability of soil to buffer nutrients, thereby reducing impacts to surface waters (Livesley et al., 2016). Green roofs have also been shown to export or release nutrients (e.g. nitrogen and phosphorus). This phenomenon has been linked to application of fertilizers (conventional more so than controlled release fertilizers) on green roof vegetation (Emilsson, Berndtsson, Mattsson, & Rolf, 2007).

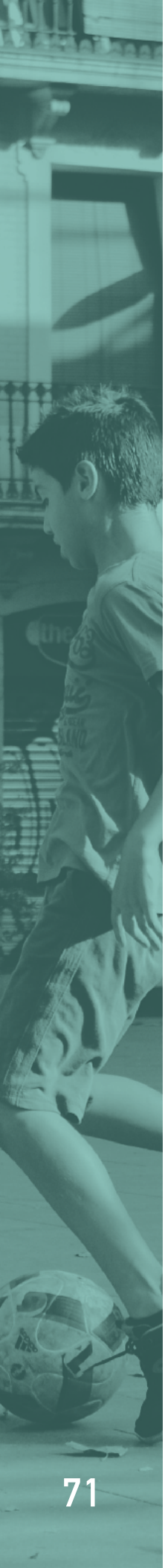
21) DO PUBLIC SPACES IMPACT BIODIVERSITY?

Evidence on the role of urban public space in urban ecosystems is limited due to lack of studies and mixed findings depending on circumstances. Parks serve as **biodiversity** hot spots in some cities, but unless parks are well-connected across cities, these small hot spots are limited in their ability to contribute to **species richness**. Also, the presence of **non-native species** can limit or shape **species richness**.

Existing evidence shows that urban public space can play a vital role in urban ecosystems. This is particularly true for biodiversity, ranging from soil microbes to macroinvertebrates and insects, fish, reptiles and birds. Urban parks are often more species-rich than other urban green spaces (Nielsen, Van Den Bosch, Maruthaveeran, & van den Bosch, 2014). One review of 14 studies found that urban parks were the most species-rich of any other forms of urban green spaces, including urban forests, gardens, vacant land, seminatural grasslands, nature reserves, roadside plantings, and green roofs (Konijnendijk, Annerstedt, Nielsen, & Maruthaveeran, 2013). This review found strong evidence that parks are **biodiversity** hotspots in urban areas.

However, spatial isolation of parks and green spaces impacts habitat and biodiversity. More fragmented habitat negatively impacts **species richness**, so that small parks often serve as habitat patches or islands. Networked, connected parks and green spaces can support more species diversity and abundance than small isolated parks (Garden, McAlpine, & Possingham, 2010; McKinney, 2002). For example, one study found that isolation of urban parks and green space negatively impacts both invertebrate and bird **species richness.** On the other hand, increasing the size of parks can override the negative influence of isolation on **biodiversity** (Konijnendijk et al., 2013).

Ornamental plants, mostly **non-native species,** constitute a large percentage of plant species in urban parks (Nielsen et al., 2014). The presence of **non-native species** tends to increase along an urban to rural gradient (Aronson, Handel, La Puma, & Clemants, 2015). In the New York City region, native plant **species richness** decreased and **non-native species richness** increased with increasing urban **land cover** (Aronson et al., 2015). A report sanctioned by the International Federation of Parks and Recreation Administration (IFPRA), Benefits of Urban Parks, reviewed 15 studies of both flora and fauna

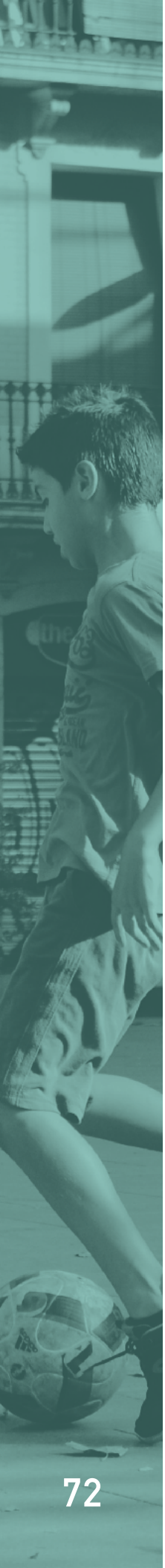


in urbanized areas and found high percentages of exotic species of flora compared to **native species** (Konijnendijk et al., 2013). A similar pattern was found when examining fauna such as birds, invertebrates, and soil macrofauna, but a lesser percentage of non-native to native than flora. They found evidence that urbanized areas harbor more generalist species of birds, bees, ants, beetles, butterflies, and vascular plants compared to rural areas (Konijnendijk et al., 2013).

Non-native species pose some possible negative impacts to biodiversity. Ornamental plants are often selected for their pest resistance, which can negatively impact urban **arthropod** food webs and **herbivore biomass** (Raupp, Shrewsbury, & Herms, 2010; Tallamy, 2004). Studies have shown that landscaping with native plants can support greater diversity and abundance of arthropods, including honeybees and native bees in urban areas (Burghardt, Tallamy, Philips, & Shropshire, 2010; Frankie et al., 2005). Insects and spiders are closely linked with global functioning and play an important role in maintaining ecosystem health, thus arthropods can be used as indicators of environmental change. More research is needed to assess the effects of spatial isolation and plant species mix on a more diverse array of flora and fauna (Nielsen et al., 2014).

However, the prevalence of non-native vegetation in parks and throughout cities may not be detrimental to **biodiversity** and other ecosystem functions. Some ecologists argue that native plants should be favored in urban ecosystems because these ecosystems may function better with communities of species that have co-evolved in a geographic area. On the other hand, **non-native species** are, for example, more capable than **native species** of growing in and remediating contaminated urban soils. If ecosystem function goals include improving water infiltration and reducing runoff, preventing flooding and erosion, reducing pollution, and restoring soil microbial communities, non-native species are important to meeting those goals (Anderson & Minor, 2017).

Engineered green spaces can also play a role in **biodiversity** of cities. For example, research suggests that green roofs, as a form of **engineered green space,** can provide valuable habitat, foraging and nesting sites for multiple species. One study in Toronto, Canada, found that native bee species that used ground-level habitat also used green roof habitat (Colla, Willis, & Packer, 2009). A study conducted in London, England found that green roofs, compared to brownfields, support many similar invertebrate species (Kadas, 2006). A more comprehensive study found no significant differences between ground-level habitat patches and green roofs in terms of species richness and abundance (MacIvor & Lundholm, 2011b). Research (using a systems approach) on the connection and relationship between habitats in urban areas can inform best practices for management of parks and engineered green spaces.



22) DOES VACANT LAND PROVIDE ECOLOGICAL VALUE?

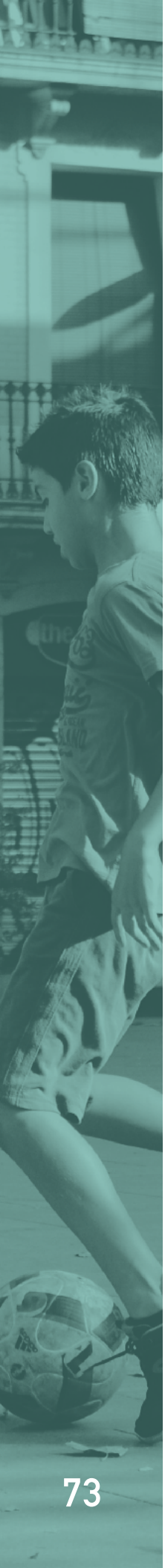
While there is consistent evidence that unmaintained vacant land provides ecological value, the depth and breadth of such studies is limited. Numerous cities across the US are dealing with the results of decades of decline in population and resources. Many of these cities have an oversupply of vacant land, including brownfields on former industrial sites, greenfields, and wasteland as well as abandoned, derelict, and uncultivated land (Anderson & Minor, 2017). Unmaintained vacant land may have ecological value in providing suitable habitat for insects (Gardiner, Burkman, & Prajzner, 2013; Uno, Cotton, & Philpott, 2010), species of small mammals (Magle, Reyes, Zhu, & Crooks, 2010), and birds (Ortega-Álvarez & MacGregor-Fors, 2009). Vacant lands may even contribute to conservation of rare and endangered species (Harrison & Davies, 2002), and have been shown to provide refuge for endangered plants (Vessel & Wong, 1987). More research is needed to assess the potential of vacant lands of various shapes and typologies, with attention to the multiple functions of vacant land before or after restoration (e.g. habitat connectivity, water retention).

Vacant lands throughout Europe have been found to support a diversity of rare species (Gardiner et al., 2013). For example, in the United Kingdom, studies have found more than 100 species of hoverflies, 57 species of bees, rare beetle and moth species in postindustrial vacant land sites (Eyre, Luff, & Woodward, 2003; Jacob-Remacle, 1984; Wright, 1988). A species of beetle thought to be extinct was found in a brownfield site in the UK, and rare species of spiders were found in an abandoned urban quarry in the Czech Republic. Another study found more butterfly species living in previously industrial lands, compared to grasslands such as meadows or pastures (Öckinger, Dannestam, & Smith, 2009).

In addition, a diverse below-ground community has been shown to thrive in vacant lots in Cleveland and Akron, Ohio (Grewal et al., 2011). This study compared soils in vacant lots to soils in newly-established gardens and found that while soils in vacant lots had less soil moisture, nutrients, and organic matter (due to lack of gardening practices); they had an equivalent **nematode** population; maturity and structure indices; and genus diversity.

Investigating whether unrestored vacant lots harbor rare or endangered plants or animals, and which site characteristics contribute to this phenomenon, would be an important future step in this work (Bonthoux, Brun, Di Pietro, Greulich, & Bouché-Pillon, 2014). The changes in ecological value of vacant lots over time and the processes that maintain existing levels of diversity are another area for future research (Johnson, Borowy, & Swan, 2018).

Creation of green space in vacant land could offer opportunity to preserve declining species, restore ecosystem function, and support diverse ecosystem services (Gardiner et al., 2013). Much of the ecological potential of vacant land



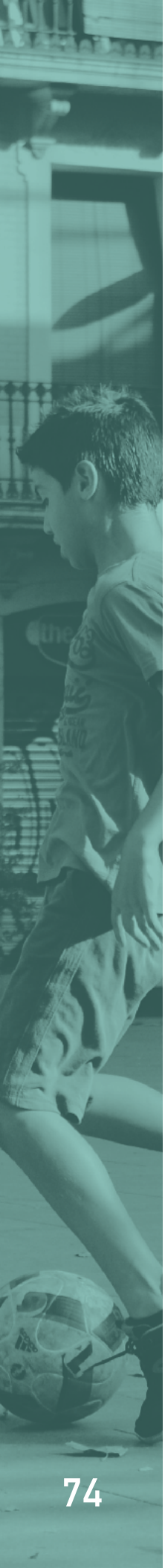
lies in the extent to which it is connected. While individual lots or clusters of lots serve as habitat patches (Anderson & Minor, 2017), higher densities of vacant land could act to increase connectivity of urban ecosystems (Herbst & Herbst, 2006). This could create an extensive network of habitat and provide stepping stones for species such as migratory birds or butterflies travelling between larger habitat preserves (Angold et al., 2006). De Sousa (2004) focused some case studies on the conversion of brownfields to parks or open spaces. The author found examples of brownfields used for habitat/wetland rehabilitation, public access to water, historic preservation, trail provision, property linkages, health **risk** reduction, infrastructure improvement, education, tourism, and public safety. Human-centered goals (e.g. provision of recreation) helped to persuade or justify public spending.

While maintenance of restored vacant land might be necessary for social or economic purposes (e.g. to reduce appearance of blight or to provide public recreation use), maintenance can negatively impact **biodiversity** (MacIvor & Lundholm, 2011a). Further, vacant lands are often ignored in conservation planning.

23) DO PUBLIC BEACHES OR INFRASTRUCTURE SYSTEMS (E.G. LEVEES) REDUCE RESILIENCE TO CLIMATE EVENTS?

Evidence on whether installation of gray infrastructure in coastal wetlands or other natural coastal ecosystems changes resilience to climate change is limited. This is due to lack of long-term controlled studies, and changing understandings and projections of climate change.

Natural coastal ecosystems such as salt marshes, coral reefs, mangroves, oyster reefs, seagrasses, dunes, and barrier islands serve as a natural infrastructure that can be resilient to climate change (e.g. hurricane protection). Common forms of infrastructure that are built in and through natural coastal ecosystems include sea walls, levees, dikes, bulkheads, breakwaters, jetties, and riprap. In general, these infrastructures are designed to prevent sea-water intrusion or flooding in built or urban areas. While this infrastructure is often able to (at least temporarily) protect urban communities, human-made infrastructure is constructed to specific parameters and has a finite lifetime. Its effectiveness declines over time, and it lacks the capacity to adapt to changing coastal conditions, such as rising sea levels. Traditional engineered structures can also have negative impacts on coastal shorelines by altering the transportation of sediment and the ability of the shoreline to respond naturally to changing conditions and forcing factors. This can result in habitat loss and loss of species diversity (Bilkovic & Mitchell, 2013; Govarets & Lauwerts, 2009; Seitz, Lipcius, Olmstead, Seebo, & Lambert, 2006).



Natural coastal ecosystems themselves provide a natural infrastructure that can be resilient to climate change (Costanza et al., 2008). Two comprehensive reviews on natural infrastructure determined that coastal salt marsh vegetation plays a critical role in attenuating waves, providing storm protection, and stabilizing shorelines by reducing erosion (Gedan, Kirwan, Wolanski, Barbier, & Silliman, 2011; Shepard et al., 2012). Salt marsh and other forms of coastal ecosystem are self-maintaining (Gedan et al., 2011); they are able to self-repair after major storm events (Ferrario et al., 2014) and are able to grow and adjust to sea level rise.

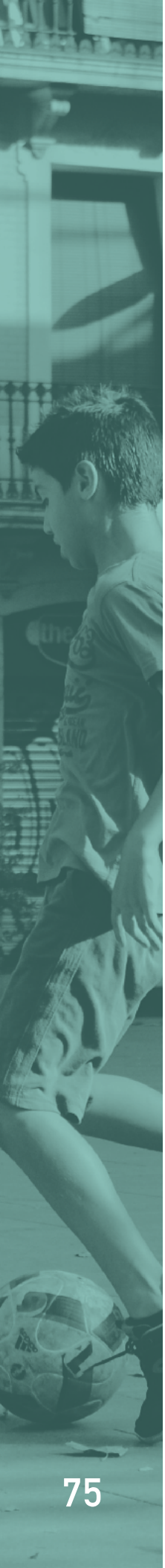
Coastal ecosystems can be viewed as self-maintaining natural levees to protect coastal areas and communities from storms. These self-maintaining natural levees are usually cheaper to build and maintain than engineered infrastructure. They do require more space than engineered systems; however, restoring and preserving them has been shown to be a cost-effective strategy. For example, according to one estimate based on a regression model of 34 major hurricanes to hit the US since 1980, coastal wetlands have provided $23.2 billion per year in storm protection services (Costanza et al., 2008). The study found that a loss of one hectare of wetland corresponded with increased average storm damages of $33,000 from some storms.

As a review by Sutton-Grier et al. (2015) points out, gaps in research on natural infrastructure include understanding how natural infrastructure handles extreme events, how these benefits vary with different types of storms, and how biomass changes temporally (Sutton-Grier, Wowk, & Bamford, 2015). Studies that directly compare built versus natural infrastructure for climate resilience in public spaces are lacking.

Some have argued that hybrid systems—engineered and natural infrastructure—could enhance resilience to climate change as well as reduce the risk of coastal flooding and erosion. This approach might incorporate natural ecosystem preservation or restoration with built infrastructure such as openable flood gates, removable sea walls, and dwellings on stilts or elevated platforms (Sutton-Grier, Wowk, & Bamford, 2015). However, few studies have investigated this approach.

24) DO PUBLIC SPACES THAT INCLUDE INDOOR OR OUTDOOR LIGHTING IMPACT SPECIES?

There is sufficient evidence supporting the guiding question that indoor or outdoor lighting in public spaces impacts species, specifically their natural timing patterns. The biological world is greatly controlled by light; species are nocturnal and diurnal and seasonal reproduction cycles, large-scale migrations, and many other timing patterns are directly correlated with lighting. Natural lighting, on both the large and small scale, has a direct correlation to

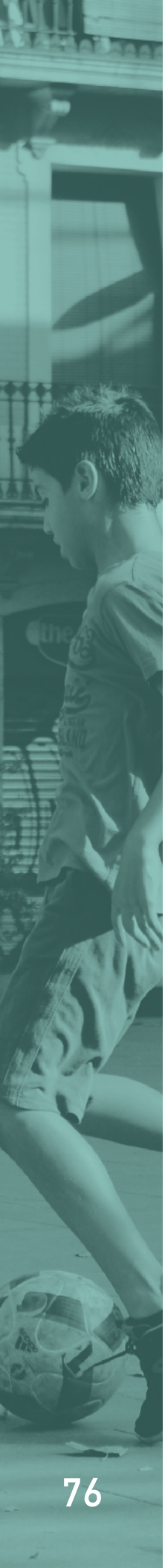


these species' timing patterns; any changes (such as installation of artificial lighting) can have profound effects.

Artificial lighting can occur on a large scale (urban cities as a whole) and on a small scale (parks, parking lots, and green spaces). Existing literature focuses on the effects of artificial lighting on different species, but also considers impacts of different types of lighting. Artificial nighttime lighting mainly impacts biological timings (Gaston, Davies, Nedelec, & Holt, 2017). A relatively new field of research, supported by a deep evidence base, examines the impacts of artificial lighting in urban environments on species' natural patterns. In 2008, a **cross-sectional study** investigated the effect of light pollution

in urban public spaces on amphibians and reptiles and saw positive, negative, and neutral effects. Ultimately, the study deemed it too early to gauge the effects on other taxa in light-polluted environments (Perry, Buchanan, Fisher, Salmon, & Wise, 2008). There has been substantial research done since this time, focused mostly on insects, birds, and bats.

Light can be viewed both as a resource and as an information source (Gaston, Bennie, Davies, & Hopkins, 2013). Light as a resource affects photosynthesis, partitioning of activity between day and night, and dark repair and recovery. Light as an information source affects **circadian clocks**, visual perception, spatial orientation, and light environment. The wavelength of the light emitted can have great effects on species' behavior, but this relationship varies greatly between species.



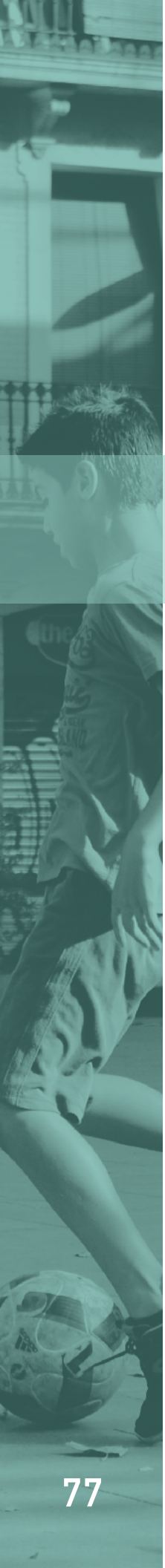
In a field experiment, Lewanzik & Voigt (2017) recorded bat activity at 46 street lights for 12 nights. Half of the street lights had conventional mercury vapour (MV) lightbulbs, and half had light-emitting diodes (LED) lightbulbs. They found that a transition from conventional to LED streetlamps could lead to a more natural level of competition between light-tolerant and light-averse bats in urban settings.

Research gaps remain regarding impacts of different lighting characteristics, such as wavelength range, dimming during low human activity times, and motion sensors.

Species movement throughout urban ecological areas can be affected by artificial lighting. A study in the United Kingdom found that a certain bat species' movement throughout the city was reduced depending on the intensity of lighting (Hale, Fairbrass, Matthews, Davies, & Sadler, 2015). Bats would travel through multiple common gaps to reach other ecological spaces, avoiding those with more lighting. Research on whether narrowing of the gaps and dimming of lighting can promote species movement is lacking.

Investigations of other species, such as insects, have found similar impacts from artificial lighting. A **cross-sectional study** focused on how insect populations and dispersal were affected by artificial light (Perkin, Holker, & Tockner, 2014). The study examined insect behavior under two conditions: lights on or off. Adult aquatic insects were negatively affected by artificial light, an important consideration when planning lighting along rivers in urban spaces. Another study investigated how insects, specifically moths, were affected by artificial light and found that street lights limit moth dispersal and could divide a suitable landscape into many small habitats (Degen et al., 2016).

Artificial lighting impacts avian species as well. A **cross-sectional study** examined the effect of light pollution on dawn song and mating patterns in five common forest-breeding songbirds (Kempenaers, Borgström, Löes, Schlicht, & Valcu, 2010). The study found that light pollution had substantial effects on the timing of reproductive behavior and on individual mating patterns, with the potential for important evolutionary consequences. Under the influence of street lights, females started egg laying an average of 1.5 days earlier; in four of the five species, the males started singing significantly earlier at dawn than males in different parts of the forest.



Some urban planners have developed part-night lighting schemes to try to mitigate issues with natural timing patterns in urban public spaces. A **cross-sectional study** found that when comparing unlit, part-night, and full-night lighting treatments on different bat species, there was no significant difference in activity between part- and full-night lighting sites in five of the eight species. This suggests that current strategies fail to encompass the full range of most bat species (Azam et al., 2015). More research is needed to explore whether and how mitigation strategies can benefit all species and maintain biodiversity in urban landscapes.

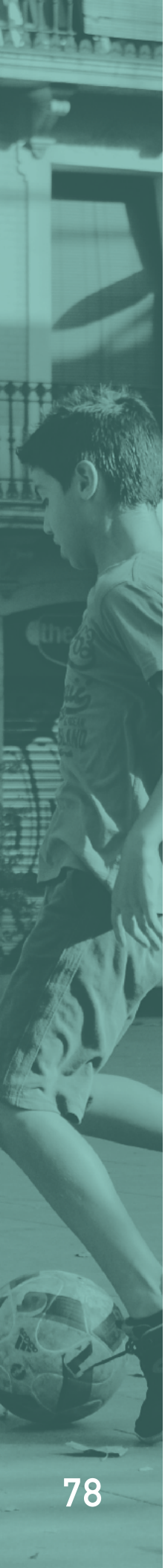
HEALTH BENEFITS AND COSTS

25) IS LIVING NEAR GREEN PUBLIC SPACES ASSOCIATED WITH IMPROVED MENTAL HEALTH?

The evidence is sufficient for an association between living near green open space and improved mental health. Various study designs in different locations, including large **longitudinal studies** and one randomized trial, have consistently observed this association. The plausibility of the association is supported by short-term experiments demonstrating measurable improvements in mental health following participants' exposure to green space. The most consistent observations appear to be regarding improvements in general wellbeing and depression- and stress-related measures, with fewer reports and less consistent findings for anxiety.

Studies on this topic did not usually assess public green spaces specifically; they instead assessed urban parks, other open green areas, or the density of vegetation in a neighborhood ("greenness"). Proximity to green space was often characterized as the total amount of parkland within a certain distance from a person's house, or by overall greenness in an area surrounding the home. Mental health was considered quite broadly across the body of research, and included measures of depression, anxiety, general stress, and overall well-being; measured using self-report, **validated scales,** and medical diagnoses.

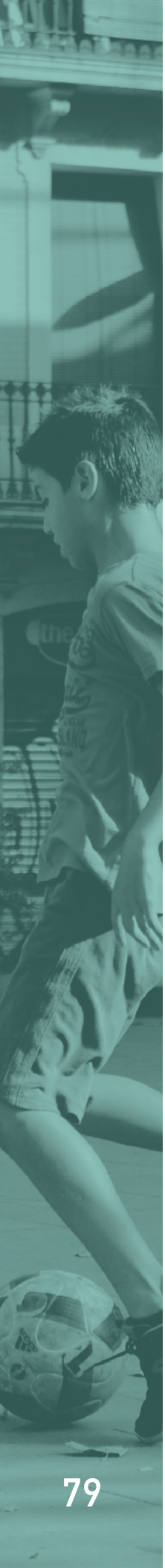
Well-being basically means feeling well. It's an experience that includes good mental health, but also involves life satisfaction and a sense of meaning or purpose.



Some studies focused on aspects of attention, learning, and cognitive function, but we did not include this research in our review. For a simplified terminology, we refer in this discussion to studies of "mental health" in relation to "green space."

Numerous cross-sectional studies have been conducted on this topic, and most have observed an association between living near green space and better mental health in adults (as reviewed by Gascon et al. (2015) and Houlden et al. (2018)). For example, in a study of same-sex identical twins, raised in the same households in the U.S., the adult twin living with more healthy vegetation in a 1-kilometer radius around their home had better mental health, on average, than their twin living in a less green location (Cohen-Cline, Turkheimer, & Duncan, 2015); this association was observed for the measures of depression and stress, but not anxiety. Inference from the cross-sectional studies on this topic is limited by an inability to establish temporality of the relationship (i.e., which came first, good mental health status or living near green space?).

Strong evidence comes from a large **longitudinal study** in which participants of the British Household Panel Survey were evaluated before and after a move to neighborhoods with more or less green space (Alcock, White, Wheeler, Fleming, & Depledge, 2014). A measure of psychological distress improved in the first year after moving to more green space, and the improvement was sustained over the three years of follow-up. In contrast, participants who moved to neighborhoods with less green space experienced a worsening of psychological distress in the year before the move, with improvements resulting in a return to their baseline status following the move (Alcock et al., 2014). Additional **longitudinal studies** also found positive associations between living near green space and improved mental health during study followup (Astell-Burt, Mitchell, & Hartig, 2014; Engemann et al., 2019; Feng & Astell-Burt, 2018). A concern with non-randomized studies is that the observed improvements in mental health status in these studies may be attributed not to greenspace, but instead to other, related variables such as socioeconomic factors (i.e., persons who live near green space tend to have higher incomes, and their secure socioeconomic position may be the cause of their good mental health). However, the vast majority of studies adjusted for related variables such as age, gender, race, and education to account for these extraneous factors; many with extensive adjustment. Engemann et al. (2019) found in Denmark that the vegetation density within a 201-meter by 201-meter square around a child's home(s) until age 10 was associated with diagnosis of psychiatric disorders after age 10. Greater greenness was associated with reduced **risk** of psychiatric illness, overall, and for many individual diagnoses. They found that **adjustment** for urbanization, parents' socioeconomic status, family history of psychiatric disorders, parental age, and municipal socioeconomic factors only slightly changed the association between neighborhood



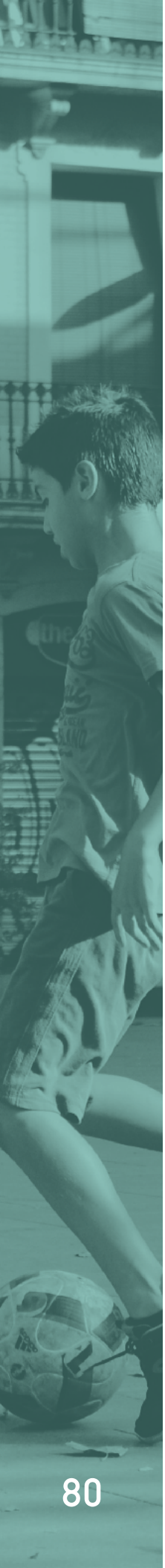
greenness and diagnosis with psychiatric disorders. The strongest associations with green space were seen with diagnosis of psychiatric disorders during adolescence, and also within a primarily a suburban or city center setting, as compared with a rural setting (Engemann et al., 2019).

The plausibility of a causal association between living near green space and improvements in mental health is supported by observations from short-term **experimental studies** of activity within green space. Bratman et al. (2015a) and Bratman et al. (2015b) compared urban residents who participated in a walk through a natural, urban area to those randomized to an urban neighborhood walk, and observed the nature walk to be associated with decreases in self-reported rumination (a pattern of thought associated with depression), anxiety, negative affect, and decreases in neural activity of a brain region associated with sadness and behavioral withdrawal. These differences could not be attributed to the length of the walk, heart rate, or respiration rate. Levels of the stress hormone cortisol were decreased with exposure to nature among urban dwellers directed to have a nature experience of at least 10 minutes, three times a week, over an 8-week period (Hunter, Gillespie, & Chen, 2019). A 'nature experience' in this study was defined as "anywhere outside that, in the opinion of the participant, included a sufficiency of natural elements to feel like a nature interaction." Study participants had the flexibility to pick when they wanted to go for their nature experience, what they wanted to do, and for how long. The only restrictions were that the nature experience had to take place in daylight and could not include aerobic exercise.

Participants served as their own control, with repeated within-person comparisons of cortisol levels before and after the nature experience. Limitations of these short-term studies for addressing our guiding question are conceptual differences in the green space exposure (living near vs. activity within green space), as well as limited follow-up in the **experimental studies** precluding evaluation of a lasting impact. Nevertheless, the studies do demonstrate measurable improvements in mental health indicators following green space exposure.

We found only one study using a randomized, **experimental design** to evaluate the mental health effects of neighborhood green space on nearby residents. The study was conducted in Philadelphia, Pennsylvania, in which more than 500 vacant lots were randomized for "greening and cleaning," cleaning only, or no treatment (South et al., 2018). The cleaning and greening intervention included removing trash and debris, planting new grass and trees, installing an open fence around the perimeter of the lot, and regular maintenance.

The treatments were carried out over a 2-month period, followed by monthly maintenance. Neighborhood residents (342 participants) were interviewed before and after the vacant lot interventions using a validated scale to assess psychological distress. The cleaning and greening intervention was associated

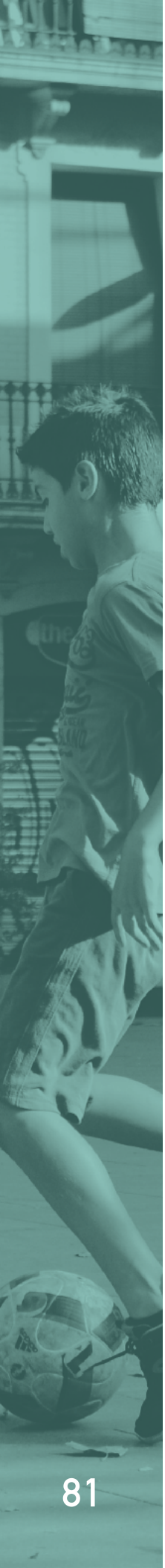


with improved scores for depressed mood and feelings of worthlessness (when compared to no intervention), whereas no significant mental health improvements were related to the cleaning intervention alone. The improvement in depressed mood was particularly pronounced in neighborhoods below the poverty line. No changes in other measures, such as nervousness or restlessness, were observed.

Mental health improvements from living near green space could plausibly occur through a number of pathways. These could include relief from noise, heat, and air pollution offered by green space; through increased physical activity and social contact when using green space; or from psychological restoration associated with experiencing green landscapes (Kaplan, 1995). Few studies specifically addressed these varying mechanisms to attempt to distinguish the characteristics of landscapes or the uses of nearby green space associated with improved mental health. An association between neighborhood green space and lower odds of psychological distress was observed only among physically active participants in a large survey of Australians (Astell-Burt, Feng, & Kolt, 2013), suggesting a pathway through exercise. The short-term experimental studies of Bratman et al. (2015a, 2015b) suggest a **mechanistic pathway** involving exposure to nature above any exercise benefit, as both the nature group and the **control** group experienced a walk as part of the intervention.

The available literature offers limited information on types of green space associated with mental health improvements. One study found that small parks ≤4 hectares and larger parks >5 hectares within the immediate neighborhood were associated with lower psychological distress, whereas medium-sized parks were not (Wood, Hooper, Foster, & Bull, 2017). In a **meta-analysis** of short-term "green exercise" intervention studies, short-term improvements in mood were seen with all types of green spaces, such as urban green space, countryside/farmland, forest and woodland, and wild habitats, although the greatest improvements were seen with waterside green spaces (Barton & Pretty, 2010). Only higher-quality neighborhood green space was associated with improved mental health in several studies—specifically among public open spaces (Francis, Wood, Knuiman, & Giles-Corti, 2012), parks (Feng & Astell-Burt, 2018), and streetscapes (van Dillen, de Vries, Groenewegen, & Spreeuwenberg, 2012)—regardless of the quantity. Quality was summarized in these studies using a variety of measures such as structured inventory of amenities/characteristics and participants' perception of "good" quality.

The body of literature on this topic is compelling and provides sufficient evidence for a causal effect of living near green public space on improvements in mental health. Nevertheless, there are data gaps worthy of addressing to further the field of knowledge. At the core of this guiding question is a desire



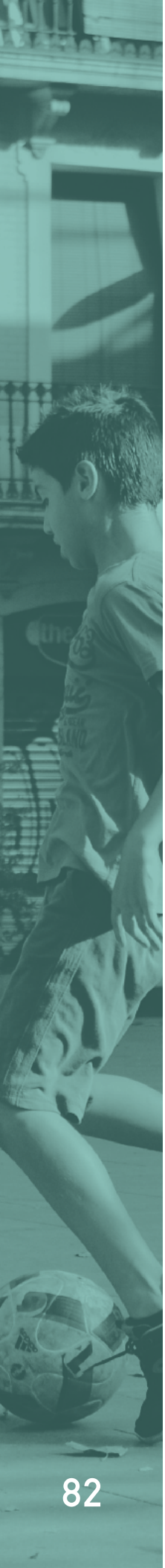
to understand the optimal amount and placement of open public spaces within a neighborhood for the mental health of residents. Researchers should seek opportunities for further **randomized studies** of changes to neighborhoods, as well as continued improvement of longitudinal study designs comparing within-person changes over time. The length of time it takes to observe an effect after new green space installation is of interest, as well as the types of green space and the amenities and characteristics of the space that may influence mental health improvements (e.g., size of the green space, type and quality of vegetation, other features of the landscape like water, and built environment features like walking loops, picnic areas, etc.). Resident experiences in green space which are associated with mental health (e.g., exercising, socializing, relaxing, viewing arts in the space, etc.) are also important. More studies to distinguish effects from streetscape greenery would also be beneficial in order to understand the importance of immediate proximity/views. Finally, there is virtually no research on population mental health in relation to non-green space public spaces such as public plazas, community centers, and libraries.

26) DOES INSTALLATION OF NEW PUBLIC SPACES LEAD TO DECREASES IN CRIME WITHIN THE NEIGHBORHOODS SURROUNDING THE SPACE?

Evidence for this question is limited. Changes to neighborhood environments—such as installation of new public space—have the potential to change patterns and rates of crime and violence, but a limited number of studies have been conducted to date. An increasing number of studies are evaluating the impacts of neighborhood changes on violence, especially in high-risk environments (Branas & Macdonald, 2014). Study outcomes include domestic violence, property crimes, violence crimes, drug crimes, and nuisance or misdemeanor crimes; all studies have used either **quasi-experimental** or **experimental research designs.** Interventions evaluated have involved greening or trees, often occurring on vacant land.

Kuo & Sullivan (2001) conducted a **natural experiment** of 145 women assigned to live in 1 of 18 architecturally-identical public housing blocks. The outdoor common spaces surrounding each block varied in terms of the presence of trees and other vegetation. The study found that women living in the greener housing blocks experienced less self-reported intimate partner violence and aggression.

A study of a new trail in Chicago, Illinois examined crime rates surrounding the trail after installation, compared to crime rates in similar city neighborhoods away from the trail as well as to crime rates before installation (Harris, Larson, & Ogletree, 2018). Crime rates (disorderly, violent, and property crimes) significantly improved around the trail, compared to pre-intervention and compared

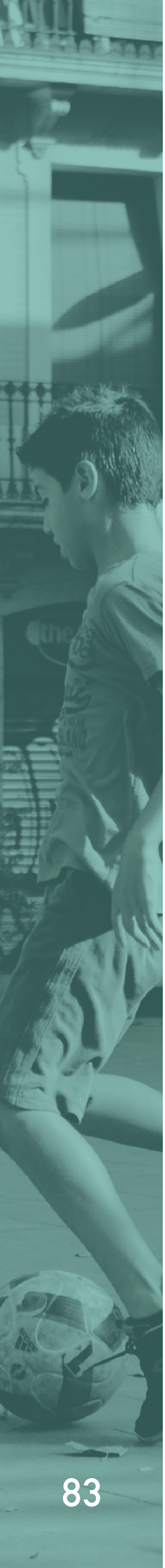


to **control** neighborhoods. Reductions in crime were also observed in a study of new green stormwater infrastructure in Philadelphia, Pennsylvania (Kondo et al., 2016). Fewer crimes involving burglaries, narcotics possession, and narcotics manufacturing were seen near the green stormwater infrastructure sites after installation when compared with changes that occurred at **matched control** sites.

Vacant land is a major part of the landscape of postindustrial cities such as Philadelphia, Pennsylvania. These vacant spaces often have a negative influence on neighborhoods in terms of nearby residents' health and feelings of safety (Garvin, Branas, Keddem, Sellman, & Cannuscio, 2013). Vacant lots in some Philadelphia neighborhoods have been found to play a role in the drug trade, as well as in the storage of and access to weapons (Branas et al., 2018). A number of communities are taking measures to mitigate these negative impacts. Researchers, municipalities, and their constituents have embraced the cleaning and greening of vacant spaces, and a growing number of **observational studies** have investigated the relationship between vacant lot greening and crime. Branas et al. (2011) conducted an early **quasi-experimental** study of the association between vacant lot greening and violence outcomes in Philadelphia. This study evaluated changes in crime and health outcomes near 4,436 vacant lots that had been cleaned and greened between 1999 and 2008, compared with 13,308 **control** lots. They found an 8% reduction in gun violence near greened vacant land. Cleaning and greening may decrease opportunities for illegal activity, such as hiding guns, by removing uncontrolled growth of weeds and buildup of large trash items on vacant land.

A second **quasi-experimental** study of a vacant-lot greening program in Youngstown, Ohio examined the association between changes in crime around both 166 contractor-greened lots and 78 community reuse lots (primarily community gardens), compared with 959 control lots (Kondo, Low, Henning, & Branas, 2015). The study found a significant reduction in property crimes around contractor-greened lots and a decrease in violent crimes around community reuse lots with felony assaults down by as much as 27%.

Evidence from these studies led to a citywide experimental study of vacant lot greening in Philadelphia, Pennsylvania (Branas et al., 2018). A total of 541 randomly sampled vacant lots were randomly assigned to one of three groups: a **control** group that received no treatment and remained vacant; a partial-treatment group where contractors picked up trash and mowed; and a full-treatment group that received the clean-and-green intervention. There were significant reductions around the intervention lots in crime overall (−13%), gun violence (−29%), burglary (−22%), and nuisances (−30%) in neighborhoods below the poverty line. Based on results from pre- and post- intervention surveys of nearby residents, researchers also found significantly reduced perceptions of crime, vandalism, and safety concerns.



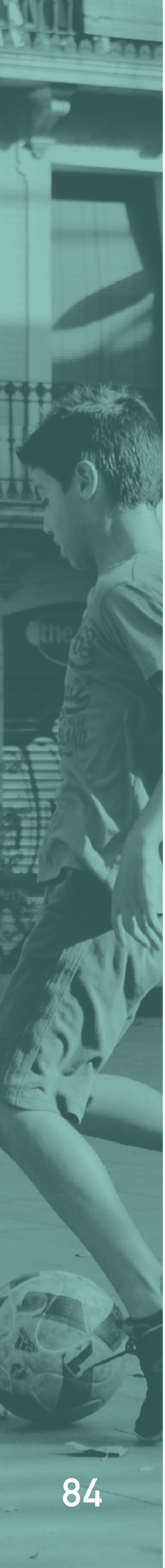
Questions remain about whether observed reductions in crime with installation of new public space can be generalized outside of study locations; for example in smaller cities or in other types of public spaces. It is not known whether these interventions could apply to non-green space public spaces such as public plazas, community centers, and libraries. More work is also needed to understand whether and if these findings hold across social groups, such as those defined by age, gender, or race. Finally, research to elucidate the specific mechanisms between installation of new public space and changes in crime and violence could inform the potential utility of these interventions for protecting public health.

27) IS LIVING NEAR A PARK OR TRAIL ASSOCIATED WITH INCREASED PHYSICAL ACTIVITY?

We found limited evidence for a relationship between living near a park or trail and increased physical activity (PA). The most consistent relationships were found with the closest distances, typically defined as living within ½ mile or within a 10-minute walk from a park. There were less consistent relationships with longer distances and with proximity measured as **park density**. Perceived proximity to parks appears to be importantly associated with PA, and may account for the relationship between objectively measured distance and PA. The studies conducted cannot conclude that parks lead to (i.e. cause) increases in PA in the (nearby) general population, due to design limitations.

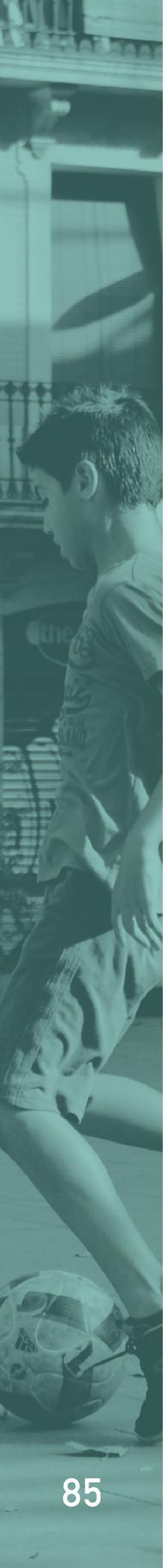
This review focuses on parks and physical activity as there is limited research on other public spaces and physical activity. Parks are routinely identified as an important resource for improving health through physical activity. Features of a park, such as playgrounds, trails, recreation centers, and sports fields enable recreational PA within the park, while active travel (such as walking or bicycling) to or through a park contribute to transit-related PA.

In this review, living near a park (i.e., proximity) was generally characterized as the distance from residence to a park, the length of travel time to a park, or the density of parkland in the neighborhood. Studies defined proximity using objective tools (e.g. **GIS,** GPS) and/or perceived distances or travel time. PA measurements often included recreation and transit activities; measurements were collected with objective tools such as accelerometers or pedometers, or were self-reported in diaries or questionnaires. Living within a ½-mile radius or within a 10-minute walk from a park was positively associated with PA in the majority of studies that examined the relationship, with some exceptions (Bancroft et al., 2015; Kaczynski & Henderson, 2007). Living within 1 mile of a park was positively associated with PA, but with less consistency (Bancroft et al., 2015; Macmillan et al., 2018; Stappers, Van Kann, Ettema, De Vries, & Kremers, 2018). **Park density** was not associated with objectively measured PA (e.g., accelerometer/pedometer) in a review of six studies (Bancroft et



al., 2015). Reviews that did not present the exact proximity measurements concluded that proximity to parks or recreation centers was positively associated with PA (Barnett et al., 2017; Davison & Lawson, 2006; McCormack, Rock, Toohey, & Hignell, 2010; McGrath, Hopkins, & Hinckson, 2015; Sallis et al., 2015), but with some mixed and negative conclusions (Ding, Sallis, Kerr, Lee, & Rosenberg, 2011; Lachowycz & Jones, 2011; Sugiyama, Koohsari, Mavoa, & Owen, 2014). A review of trails (Starnes, Troped, Klenosky, & Doehring, 2011) found that proximity was positively associated with use. Several **natural experiments** were conducted in which neighborhood residents were surveyed following installation of a trail, path, or greenway. A majority of these studies found increases in PA, with some showing a dose-response relationship, such that increases in PA were progressively greater with closer residential proximity to the trail (Goodman, Sahlqvist, Ogilvie, & iConnect, 2014; Macmillan et al., 2018). The magnitude of impact of living near parks/trails on PA appears to be small; reported increases of 14 to 45 minutes per week represent between 3% and 30% of recommend weekly moderate-to-vigorous physical activity (MVPA[5]) (Goodman et al., 2014; Macmillan et al., 2018; McGrath et al., 2015).

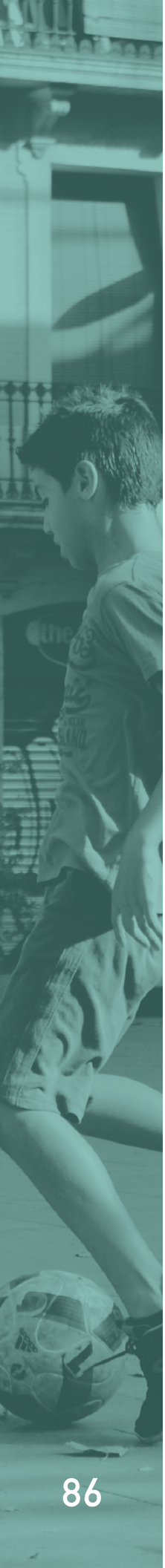
Perceived proximity to parks appears to be important for PA. A review (Bancroft et al., 2015) and a **meta-analysis** of older adults (Barnett et al., 2017) which included perceived and **objective measures** of proximity found **perceived measures** of proximity to be more often associated with PA. Notably, RESIDE, an 8-year **longitudinal study** of >1,800 individuals who moved to newly built homes in metropolitan Perth, Australia, concluded that **perceived measures** of the environment (street connectivity, neighborhood aesthetics, park proximity, proximity to beach access) fully explained the relationship between objectively measured proximity to parks/beaches and



local recreational walking (Christian et al., 2017). The relationship between park proximity and PA also differs by PA measurement; self-reported PA is more often positively associated than **objective measurements** (Barnett et al., 2017; Davison & Lawson, 2006; Ding et al., 2011; Ferdinand, Sen, Rahurkar, Engler, & Menachemi, 2012). These associations may differ by age; Ding et al.'s (2011) review, which compared all combinations of environmental assessment (objective and perceived) and PA (objective and self-reported) for children and adolescents found that the most consistent association for this particular age group was between objectively measured environmental features and self-reported PA.

In our review, we found many recent systematic and non-systematic literature reviews that explored neighborhood environment, including proximity to parks and recreation facilities (inclusive of recreation centers, trails, and playgrounds) in relation to PA, mostly in the U.S. Most studies on this topic used a cross-sectional design, which limits inference related to a cause-and-effect relationship. Another common study concern is incomplete **adjustment** for confounding, given that active people may be more likely to live near a park for reasons unrelated to physical activity. Reviews of **natural experiments** highlighted significant risk of **bias** due to study design; commonly identified flaws point to lack of a comparison group, selection of participants, use of self-reported outcomes, no quantification of exposure, and lack of **power** (Macmillan et al., 2018; Mayne, Auchincloss, & Michael, 2015; Stappers et al., 2018). Furthermore, the studies with short follow-up time may not have found effects due to the time it takes for impact to happen. Moderating factors, such as ethnicity and income, were usually not considered.

Conducting studies in multiple settings with consistent, **objective measurements** of both distance and PA would be of particular importance in establishing a relationship between living near a park and PA. Further **longitudinal studies** (observational and/or **natural experiment**) are needed to help establish causality; however, these studies should pay particular attention to establishing representative participation and unbiased comparison groups. If an increase in PA is observed with proximity, additional details on the types of PA contributing to the increase (i.e., commuting vs. activity within park) would be informative. Given observations throughout this report—that people who are low-income and non-white tend to live in areas that lack well-maintained and safe green open space—studies are needed to examine how socioeconomic factors interact with park/trail proximity in its relationship to PA.



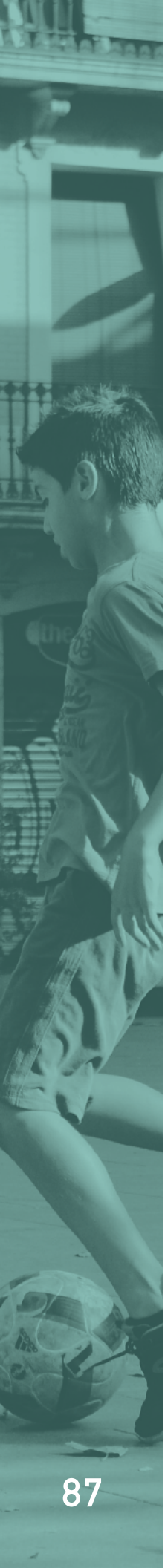
28) WHAT TYPES OF AMENITIES AND CHARACTERISTICS OF PARK/TRAILS ARE ASSOCIATED WITH INCREASED PHYSICAL ACTIVITY?

We found sufficient evidence that certain park amenities are associated with higher levels of PA than others, including walking loops or trails, playgrounds, fitness zones, pools, and sports fields or courts. The total number of different amenities in a park also appears important for PA. Other characteristics of parks associated with PA in some studies include large park size, trail length, and parking. These observations are at the park level, and cannot speak to general population impacts of parks on physical activity.

We sought research comparing PA in parks with and without certain types of amenities and characteristics, as well as studies documenting the use of particular amenities and features within a park for PA. Several studies reviewed moderate-to-vigorous physical activity (MVPA) and total PA to determine if PA levels increase or shift from one activity to another. Jogging, bicycling, swimming laps, and heavy gardening are examples of moderate-to-vigorous physical activity.

Direct observation of parks indicates that certain amenities are frequently used for PA and are associated with more PA occurring in the park. In a large study of 174 neighborhood parks in 25 major U.S. cities, the SOPARC tool (System of Observing Play and Recreation in Communities) was applied to systematically document activity in parks (Cohen, et al., 2017).

The SOPARC tool provides a framework for researchers to collect data about physical activity in parks. The park is split into target areas, locations where physical activity is likely to happen, such as a ball field or trail. The researcher observes each target area for a specified length of time, documenting the number of people using the space, their age and ethnicity, their activities in the space and their level of physical activity (sedentary, walking, or vigorous). With this information, researchers can learn about the amount of physical activity

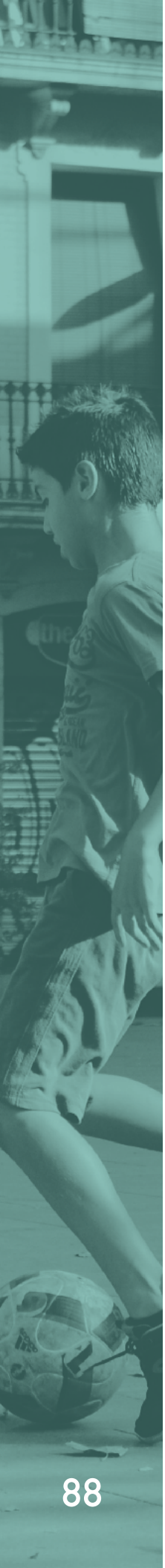


happening in a park, the features being used for physical activity, and the demographics of people exercising there.

Greater MVPA (total time) was observed with walking loops, gymnasiums, fitness zones, pools, sports fields, basketball courts, and baseball fields. Certain features were important for MVPA specifically among children (such as playgrounds) or older adults (such as dog parks, exercise areas, and tennis courts). A walking loop was the feature associated with the most MVPA among seniors; there was over threefold more MVPA among seniors using parks with a walking loop compared to those using parks without a walking loop (Cohen, et al., 2017). Walking paths also appear important; a study of 33 parks in Ontario, Canada (Kaczynski, Potwarka, & Saelens, 2008) found that parks with paved trails were 26 times more likely to be used than parks without them.

There is a positive association between the number of amenities in a park and PA (Christian et al., 2017; Kaczynski et al., 2008; Stewart, Moudon, Littman, Seto, & Saelens, 2018). In a study of >1553 visits to parks in King County, Washington (O. T. Stewart et al., 2018), each additional type of PA-related amenity was associated with an additional 1.3 minutes of PA during the average active visit. Qualitative studies found that a diversity of features within a park is important for park users (McCormack et al., 2010; Van Hecke et al., 2018), though Van Hecke et al. (2018) did not find that all of the quantitative studies of park use validated these statements. In the nationwide assessment of 174 neighborhood parks (Cohen, Han, Evenson, et al., 2017), various characteristics of parks were associated with greater MVPA. These characteristics include the total number of accessible target areas (e.g., playground, lawn, tennis court), the number of areas with supervised activities, onsite marketing for park activities (e.g., signage, posters), and vendors in the park (Cohen, Han, Evenson, et al., 2017). The same park characteristics were also associated with overall park use, which included activities ranging from sedentary to vigorous (Cohen et al., 2016). A **systematic review** of "risky outdoor play" found that play in which children could "disappear/get lost" was positively associated with physical activity by several metrics including frequency and total MVPA in different studies (Brussoni et al., 2015). While these results for "risky play" speak to the impact of supervision rather than the design of public spaces, there may be implications for offering unstructured play areas that differ from traditional playgrounds.

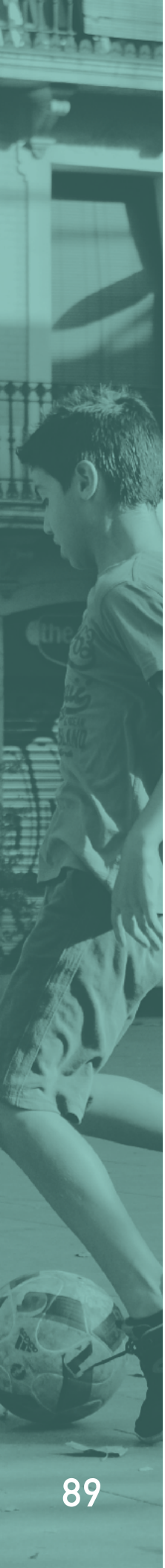
Some studies examined characteristics of size and distance. Park size was associated with use for PA in some studies (Cohen et al., 2010), but others found that the significance of park size diminished after **adjustment** for park amenities and features (Cohen, Han, Evenson, et al., 2017; A. T. Kaczynski et



al., 2008). Furthermore, the use of any particular park for PA was not related to the distance from the park to the user's home in a Canadian study (A. T. Kaczynski et al., 2008). A review of trails (Starnes et al., 2011) reported trail use to be positively associated with longer trail length (one study) and a larger parking lot area (two studies).

Two **randomized trials** tested whether changes in park programming and outreach affected park-level PA (Cohen et al., 2013; 2017). In these trials, parks in Los Angeles, California were randomized to either receive the intervention or to a **control** arm, and PA as well as overall park use were compared before and after the intervention. Results of the two trials differed. In the first trial, conducted in 50 neighborhood parks, interventions involving park director and/or park advisory board training on outreach and marketing in addition to modest funds for park improvements were associated with statistically significant increases in total PA and MVPA (compared to a decrease in **control** parks during the study) (Cohen et al., 2013). The second trial, conducted in high-poverty neighborhoods in Los Angeles, found no effect on park-based PA from interventions of free exercise classes and/or an incentive-based frequent user program (Cohen, et al., 2017). These disparate results seem to indicate that programming may matter, but only under certain conditions, which remain unclarified.

Several quasi-experimental studies assessed PA following installation or improvement of park amenities in order to estimate the change in PA resulting from the improvement. In a review of studies of improvements to playgrounds and parks (Audrey & Batista-Ferrer, 2015), all considered at risk of serious bias, there was no apparent increase in the level of PA among children using the renovated spaces (three studies). Similarly, results were mixed for children's overall use of renovated parks (five studies) (Audrey & Batista-Ferrer, 2015). In contrast, installation of fitness or playground equipment was associated with increased PA for adults, and park renovations with two or more components (new equipment, fencing, lighting, walking tracks) were associated with increased visits and PA for all ages (Smith et al., 2017). The time it takes for any impact is not clear, but may be longer than the duration of the studies (typically shorter than 12 months) (Macmillan et al., 2018; Mayne et al., 2015). The average amount of time that people are active in parks is 19 minutes, as reported in McGrath et al.'s (2015) **meta-analysis** of children's and adolescents' objectively measured daily MVPA and Stewart et al.'s King County study (2018) of adults' PA in parks. Studies have reported percentages of park users engaging in MVPA ranging from 31% to 85% (median=55%) (Joseph & Maddock, 2016). More males than females typically engage in MVPA in parks (Joseph & Maddock, 2016). Seniors have been noted as under-represented users of parks (Cohen, et al., 2017; Joseph & Maddock, 2016). Children are also underrepresented, although they perform a disproportionate amount of the MVPA occurring in parks (Joseph & Maddock, 2016). Demographics of park use



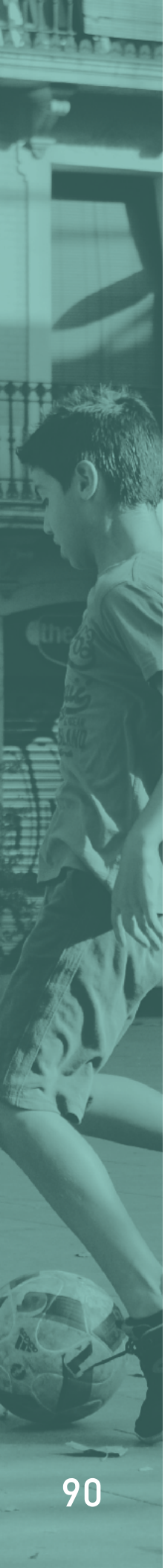
for PA may reflect different preferences in children and seniors; structured and unstructured play for children's PA (McCormack et al., 2010) and walking for older adults (Barnett et al., 2017; Cohen, et al., 2017; Levy-Storms, Chen, & Loukaitou-Sideris, 2018).

While there is a sufficient relationship between the number of park amenities and the amount of PA occurring in park, as well as with a few specific types of amenities, more research is needed to discern the importance of specific park amenities and characteristics on PA. There is a dearth of research on non-physical factors (cultural, educational, experiences, maintenance) that may contribute to individuals' use of public space for PA. Direct observation of park users indicates there are age and gender differences among general users, as well as among those engaged in MVPA, meriting more focused analysis by population subgroup.

29) ARE LIBRARIES AN IMPORTANT SOURCE OF HEALTH-RELATED INFORMATION FOR THE GENERAL PUBLIC?

We found limited evidence that libraries are an important source of health-related information for the general public. Libraries provide health-related information through the availability of online and offline information resources and by individual assistance from library staff. In addition, many libraries go beyond mere access to health information. They also offer health-related programming and direct service, such as exercise classes and health screening events. Libraries also appear to play a prominent role in informing the public about the public health dangers from extreme weather, primarily through designation of their facilities as cooling centers. Despite the many types of health-related information and services offered by public libraries, there has been very little evaluation of the actual impact of such offerings.

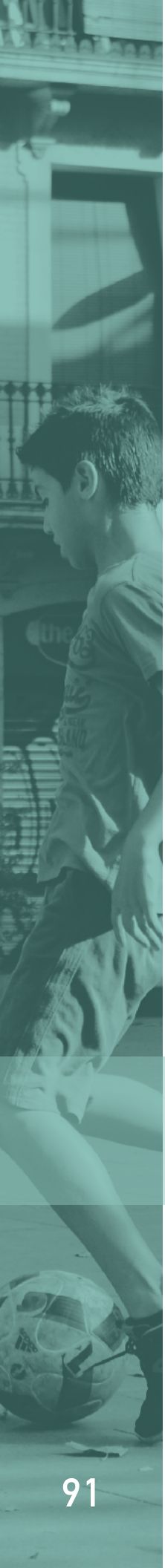
Use of online resources may play an important role in locating health information for library patrons, although the evidence is mixed. In a survey conducted by the Information Policy & Access Center, 71% of city libraries offered assistance locating free health information online, using resources such as MayoClinic or Medline (Bertot, Real, B., Lee, McDermott, & Jaeger, 2015). In addition, 74.5% of U.S. city libraries offered access to subscription health and wellness databases, such as EBSCO Consumer Health Complete (Bertot, Rea Lee, McDermott, & Jaeger, 2015). A Pew Research study found that 38% of local library patrons who use the technological resources do so to look for health information online, although this was not the most common use (the majority used these resources to do research for school or work or to check email) (Horrigan, 2016). In a study of internet access in public libraries, health information was not identified as one of the major content areas critical to the role of public libraries, although assistance in applying for government benefits—including Medicare and Medicaid—was highlighted (Bertot et al.,



2008). These surveys indicate that while many library patrons utilize library resources to access health information online, there are more common reasons for internet usage in libraries and/or these online resources might not be a primary source of such information for the public. A study of internet access in a **medically underserved** population found that healthcare providers were the primary source of health information for a majority of study participants (Zach, Dalrymple, Rogers, & Williver-Farr, 2012).

Library staff may be able to serve as an important resource in locating health information, as long as they have adequate knowledge and training. A 2004 study of librarians in North Carolina found that librarians respond to an average of 10 health-related reference requests per week, and 64% of librarians reported desire for more training in health information and resources (Linnan et al., 2004). The need for greater knowledge and training in health topics was also highlighted in a study of libraries in Oklahoma, in which many library staff surveyed were unclear on the health needs of their constituents and voiced discomfort in addressing health-related reference requests (Rubenstein, 2016; 2017). Some libraries are beginning to address health-related patron needs through training and staffing; a **scoping study** of the role of libraries in population health found public libraries that employ health-specific librarians and train staff were better able to assist patrons with health-related requests (Philbin, Parker, Flaherty, & Hirsch, 2019).

The role of libraries in public health may go beyond the mere provision of health information, into health-related programming and direct service. Reviews of academic literature and the websites of major urban libraries in the U.S. identified numerous health-related library services. Health programming at libraries frequently relies on partnerships with local health clinics, medical schools, or other community partners (PEW Charitable Trust, n.d.). Many urban libraries connect patrons to preventive care services, such as hosting limited health screenings or immunization clinics in partnership with healthcare providers (Bertot, Real, Lee, McDermott, & Jaeger, 2015). Some even provide materials for self-screening, such as the Free Library of Philadelphia's "health backpacks"—containing items such as blood pressure cuffs and scales—available to rent with a library card (Free Library of Philadelphia, 2018a). Assistance with accessing health insurance was also a notable service; the Information Policy & Access Center found that more than 75% of city libraries offer insurance assistance, while numerous library websites we reviewed offered programs for navigating Affordable Care Act plans, Medicare, or Medicaid (Bertot, Real, Lee, McDermott, & Jaeger, 2015; Chicago Public Library, 2019; Free Library of Philadelphia, n.d.a; Los Angeles Public Library, n.d.a; New York Public Library, n.d.a, n.d.b; San Diego Public Library, 2019). Libraries also address physical activity and nutrition, with 75% of city libraries offering fitness classes for patrons, and library websites consistently highlighting exercise classes, cooking and nutrition classes, or offering free meals or snacks for children



(Bertot, Real, Lee, McDermott, & Jaeger, 2015; Chicago Public Library, 2019; City of San Diego, 2019; Dallas Public Library, n.d.b; Free Library of Philadelphia, 2019; Houston Public Library, 2019; Los Angeles Public Library, 2019a; New York Public Library, 2019; Phoenix Public Library, 2019; San Antonio Public Library, 2019; San José Public Libary, 2019). Free health programming at libraries can help particularly vulnerable populations, such as the homeless. Some libraries offer mental health counselling for those experiencing homelessness, while others have begun to stock naloxone—a drug that reverses overdoses—in response to the opioid crisis (City of San Diego, n.d.; Philbin et al., 2019; San Diego Public Library, 2019; San José Public Libary, n.d.).

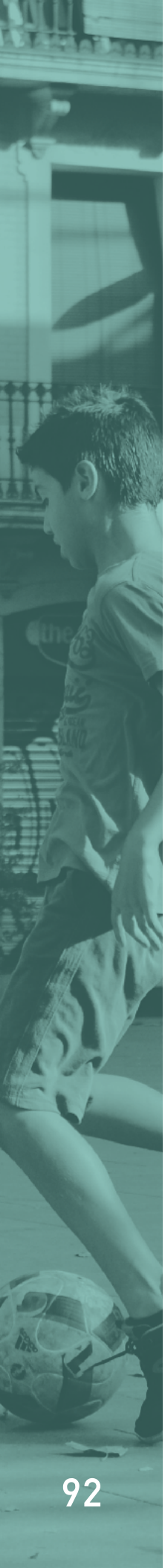
Libraries have been identified as a key resource in public health responses to extreme weather. The city or county government websites of several urban areas mention extreme heat as a health issue in their areas, and many cities—such as New York City; Philadelphia, Pennsylvania; Houston, Texas; and Los Angeles, California—have designated libraries as publicly accessible places with air conditioning for those who need to cool down (City of Chicago, n.d.; City of Dallas, 2018; City of Houston, n.d.; City of Los Angeles, 2018; City of New York, n.d.; City of Philadelphia, n.d.a; City of San Diego, 2006; City of San Jose, 2017). Libraries have similarly been available for warming during extreme cold, such as in Chicago, Illinois (City of Chicago, n.d.). Libraries have also served as important spaces for emergency response to natural disasters such as hurricanes; as evacuation centers or supply distribution hubs; and as places to host programs related to post-disaster recovery (Featherstone, Lyon, & Ruffin, 2008; Hagar, 2014; Rose, 2013).

Libraries provide health-related information to the public through traditional informational resources, as well as through programming and direct service. Research is needed to evaluate the impact of these offerings on library patrons.

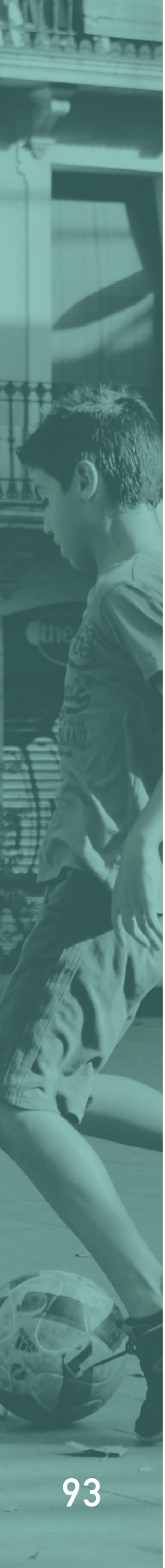
BARRIERS TO PUBLIC SPACE ACCESSIBILITY

30) HOW DO DISPARITIES IN PUBLIC SPACE ACCESS MANIFEST THEMSELVES BY DEMOGRAPHICS?

There is sufficient evidence to suggest that low-income neighborhoods and communities of color have less access to public spaces than wealthier and/or whiter communities based on a multi-dimensional definition of access. This definition takes into account proximity to the public space, quality of the public space, an individual's ability to utilize resources within the space, and an



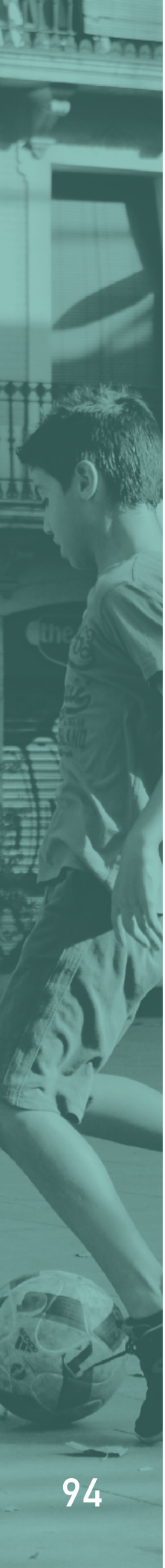
individual's sense of belonging. Regardless of the geographic locations of cities, methods, or dimensions of accessibility employed, the results were similar. Whiter and wealthier neighborhoods had the best access to public parks, with only one study in London, Ontario, Canada finding no evidence of inequities in playground distribution or quality (Gilliland et al., 2006). Studies that based access on proximity alone found mixed results, including the equitable distribution of green spaces across cities (Boone et al., 2009; Hughey et al., 2016). However, studies that incorporated additional dimensions—such as quality, ability to utilize resources, or sense of belonging—consistently found that predominantly Black and Latinx communities, as well as low-income communities, suffer from less access. Further, there is evidence of this inequity in many different types of cities across the U.S., including large cities (e.g. Los Angeles, California and New York City), as well as smaller cities in the southeastern and midwestern U.S. The majority of these studies focus on parks and other recreational spaces, pointing to a knowledge gap regarding public accessibility on different types of public spaces.



Traditionally, access to public spaces by residents has been determined by how close a resident lives to the space (i.e. proximity). However, additional research suggests that simply living near a public space does not make it accessible to all residents. For instance, a park that is congested with many users may not be able to adequately serve all local residents, or a playground with broken equipment may not be safe for children to use. Research on accessibility highlights its multiple dimensions: proximity to public space, ability to use resources within a space, ability to access public spaces that contain high-quality resources, and sense of belonging. Proximity does remain an important component of accessibility to public space (Bryson, 2013; Koohsari, Kaczynski, Giles-Corti, & Karakiewicz, 2013); however, additional dimensions of accessibility provide us with a more complete picture of the disparities communities face when it comes to accessing public space.

An individual's ability to utilize resources in the public space is an important aspect of accessibility. A park that lacks wheelchair ramps will not allow an individual in a wheelchair to access the space (Lara-Valencia & Garcia-Perez, 2018). Additionally, fear of crime may also limit residents' ability to utilize resources within a space (Carro, Valera, & Vidal, 2010), an effect that is especially felt for very marginalized groups such as Black women (Brownlow, 2006). The quality and conditions of the resources provided within public spaces can also shape who uses the space. Quality of resources refers to the acreage of public spaces, how the facilities are maintained, and programming opportunities that activate the public space; thus allowing for the purported benefits to be accessed by all visitors (Dahmann et al., 2010; Rigolon, 2016). Maintenance of public spaces is often uneven due to limited resources available at the city level, and there is an increasingly heavy reliance on community members to maintain their public spaces (Dempsey & Burton, 2012; Perkins, 2013). This reliance on community members contributes to uneven public space quality, since some communities may have resources—such as time or money—in greater supply than others. Finally, sense of belonging impacts who may be able to access public space. Feeling free from surveillance and state violence is important to ensure that users feel welcome in a space. Certain groups feel state violence pressures more than others, limiting the ability for all to use the same spaces equally (Egerer & Fairbairn, 2018). Language of posted signage is a more subtle form of communication that someone is not welcome in a space; this signals to non-native speakers that their language needs are not accommodated (Byrne, Wolch, & Zhang, 2009).

Studies that based access on proximity and quality found two populations with the most limited access to public space: people of color, often Black and Latino residents (Arroyo-Johnson et al., 2016; Boone et al., 2009; Hughey et al., 2016; Rigolon, 2016; Rigolon et al., 2018; Sister, Wolch, & Wilson, 2010; Wen, Zhang, Harris, Holt, & Croft, 2013; Wolch et al., 2005); and low-income residents (Hughey et al., 2016; Jenkins et al., 2015; Rigolon, 2016; Rigolon et al., 2018; Sister

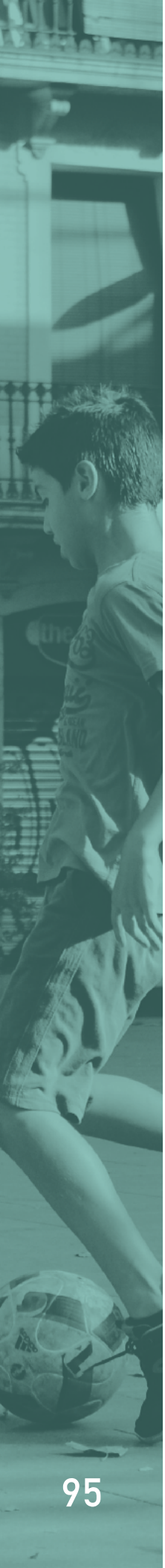


et al., 2010; Smoyer-Tomic, Hewko, & Hodgson, 2004; Wen et al., 2013; Wolch et al., 2005).

Studies that looked at dimensions of public accessibility beyond proximity and quality uncovered additional marginalized populations. Toolis and Hammack et al. (2015) investigated sense of belonging among unhoused populations in public spaces in Santa Cruz, California, and found that they were marginalized in many public spaces because public officials and the broader public treated them as unclean and as criminals. Roca and Villares' (2008) study of public beaches in Spain suggests that beaches with boardwalks and landscaping are more accessible to the elderly and disabled than beaches without these features. However, while these beaches were more accessible, they were also more congested, which further limited use.

Several studies highlight the importance of treating public accessibility as a multi-dimensional construct. Research in multiple cities shows little agreement in accessibility outcomes across studies on park proximity and low-income or racial and ethnic minorities. For instance, Arroyo-Johnson et al.'s (2016) study of playground equity in St. Louis, Missouri indicated that Black residents were furthest from playgrounds, but in Baltimore, Maryland, Boone et al. (2009) found that Black residents and other high-need residents—defined as children, the elderly, the carless, and low-income—had better walking access to parks than white residents. However, in both St. Louis and Baltimore, racial minorities had access to parks of lower quality, characterized by fewer acres per person. Hughey et al.'s (2016) study of parks in a southeastern U.S. county found an equitable distribution of parks, but that park amenities decreased as minority populations increased. Lara-Valencia and Garcia-Perez (2018) found no statistically significant difference in proximity to parks between Latino and non-Latino neighborhoods; however, the quality and the resources found in each of the parks were dramatically different. Rigolon's (2016) extensive literature review on urban park accessibility found that low-income residents and ethnic minorities had access to fewer acres of parks, fewer acres of park per person and to parks with lower quality, maintenance, and safety. Sister et al.'s (2010) study in Los Angeles, California, also found that parks that served communities of color and low-income communities tended to have higher park congestion and poor infrastructure. That said, few studies explicitly mention how these issues of accessibility can be remedied, only that these problems exist.

The studies evaluated for this question draw on diverse disciplinary perspectives, including urban health, geography, urban planning, youth studies, and coastal management. Additionally, the studies employed different methodological approaches, including qualitative (e.g. interviews, archival research, and focus groups) and quantitative methods (e.g. statistical analysis, spatial analysis). While the qualitative approaches provided in-depth accounts of



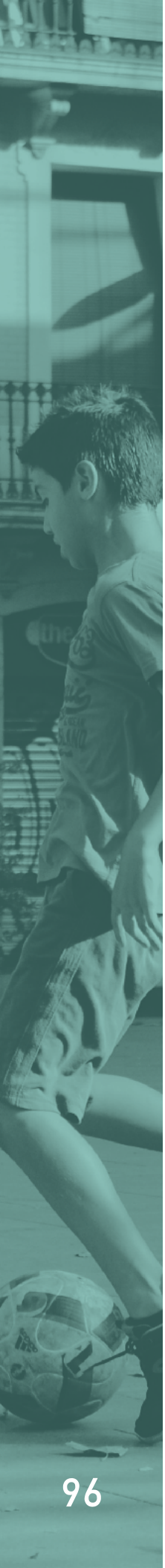
public accessibility at the city or neighborhood scale, the quantitative studies addressed spatial inequities across cities. One study addressed disparities in park distribution in cities across the U.S. Additionally, Rigolon's (2016) and Rigolon et al.'s (2018) **meta-analysis** of inequities in urban park access and quality provides a useful review of existing literature on the topic.

31) ARE PRIVATELY OWNED AND/OR PRIVATELY MANAGED PUBLIC SPACES LESS PUBLICLY ACCESSIBLE THAN PUBLICLY OWNED AND MANAGED SPACES?

There is sufficient evidence that privately owned or privately managed public spaces are less publicly accessible than publicly owned and publicly managed spaces. Public accessibility is a function of proximity to space, an individual or community's ability to utilize the resources in the space, the quality and conditions of the resources in the space, and each individual's sense of belonging in the space. Privately owned and managed public spaces, such as corporate-owned and -managed gardens, are characterized by the partial or complete transfer of state or local rights to private or commercial actors, as well as the reduction or loss of public control (Nissen, 2008; Stein & Mironova, 2018). Driving factors of public space privatization include reduction of public debt, security concerns, cuts to parks and recreation budgets, and devolution of federal responsibility to disparate actors (De Magalhaes & Trigo, 2017; Lindholst, 2017; Nissen, 2008). Private ownership or management of a public space tends to negatively impact at least one or more of these aforementioned facets of accessibility. These patterns are mostly described in larger cities in the U.S., with little research on the effects of privatization of public spaces in smaller cities.

The vast majority of the study found that private ownership of public spaces (parks were used as the example in most of the literature)—which is usually fiscally driven or incentivized—tends to limit the political, social, and democratic functions of public space and puts constraints on who can actually use the space (Németh, 2009). Use of the private sector to provide publicly accessible space concentrates control over the space and limits access to it and behavior in it (Schmidt, Németh & Botsford, 2011).

These limitations and constraints are usually implemented through intentional behavioral control techniques. Spatial control and exclusion in public space is done through the use of surveillance, policing, design measures, fees for use, and techniques that code spaces as privately owned, such as corporate imagery (Schmidt et al., 2011). For example, the privately owned public space Sony Plaza in New York City is decorated with signs of the Sony brand name and a large replica of Spiderman, one of their franchises. Anti-homeless furnishing is another common design measure that makes space less publicly accessible by preventing structures from being used for sleeping; this includes



benches with dividers (Marina Peterson, 2006). Furthermore, a current trend in private-public space is the construction of single-purpose sites such as dog parks, oversized chess boards, or petanque courts (Németh & Schmidt, 2011). Populations that are either uninterested or unable to partake in this specific use are informally excluded from the space. Additionally, the use is usually culturally geared towards the interests of affluent populations (Sager, 2011). This design measure can also act as a way to exclude loiterers or people that use public spaces as a place of respite, rather than as a place for planned activities (Schmidt and Nemeth, 2011). Park fees may also be used to control who has access to parks. There is extensive literature on the use of park usage fees in national parks or preservation areas (Buckley, 2003; Dikgang & Muchapondwa, 2017), but less research on the use of park fees in privatized city parks and other green spaces.

The types of people excluded from public spaces is determined primarily by bodily appearance and secondarily by assumptions about an individual's consumption patterns or ability to spend (Marina Peterson, 2006; Sager, 2011). Populations deemed undesirable by affluent consumers—such as young people, minorities, and those experiencing homelessness—are also frequently excluded (Sager, 2011). Exclusion from public space can amplify larger issues of social stratification and segregation, as well as negatively impacting citizenship rights such as the right to assembly (Peterson, 2006; Sager, 2011).

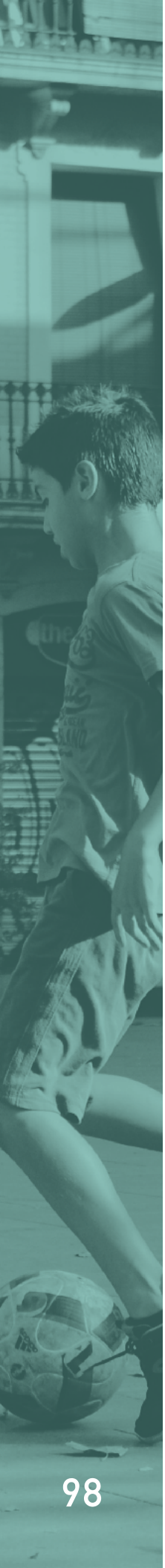
Few articles provided evidence that privately owned or managed public spaces improve public accessibility. Yoon and Srinivasan (2015) found through geospatial and statistical methods that inclusion of privately owned public space in a city reduces overall average distance to the nearest public space. They argued that privately owned public space helps to balance the distribution of public spaces throughout the city by filling in for locations where publicly owned public space is sparse. Therefore, privately owned public space assists in spatial equity. However, distance alone is not an accurate measure of public accessibility, and their study did not address on-the-ground exclusion techniques or the experiences of certain individuals within these privately owned public spaces. Murray (2010) argues that the market forces and financial incentives inherent in private ownership of public space will tend to make private owners more responsible and efficient stewards. However, the study fails to address how fiscal incentives can actually drive cost-cutting, exclusion, and limited use of a space; as public goods are typically not profitable endeavors and should not be treated as typical market goods.

The studies evaluated for this section draw on different disciplinary perspectives, including Urban Planning/Design, Forestry, Urban Studies, Environmental Law, and Sociology. Most of these articles utilized qualitative data and methods including historical analysis, comparative case studies, application of economic theory, literature reviews, typologies, interviews, and

participant observation. Multiple articles also developed indexes that quantified degrees of publicness or accessibility to compare accessibility in different spaces across cities (Németh 2009; Schmidt and Németh 2011; Schmidt et al., 2011). This included the index developed by Schmidt and Németh (2007) that identifies and quantifies publicness as an interaction between ownership, management, and the users and uses of a space by examining the degree to which behavioral control is exerted over the users and uses.

32) WHAT ARE THE KEY PRIORITIES TO IMPROVE PUBLIC SPACE ACCESSIBILITY?

There is sufficient evidence to suggest that increasing available land for public space will be a key priority to improve public space accessibility in cities. Limited land availability is a key barrier to public space provision in underserved communities. In an examination of land consumption and open space loss for all 274 metropolitan areas across the U.S., McDonald et al. (2010) found that 1.4 million hectares of open space were lost between 1990 and 2000. Furthermore, the amount of space lost in a given city was closely correlated with that city's population growth over the same period, making limited open space a particularly relevant issue for cities with a growing number of residents, such as Philadelphia, Pennsylvania. More broadly, the number of people living in urban areas globally grows by 1.96% every year (World Health Organization, 2012). This means a growing number of people will require access to urban public spaces, while land available for public space



development is largely on the decline. There are a number of creative strategies detailed below to make up for the lack of land available for public space development, but it is unclear whether such alternative public spaces provide an adequate replacement or a realistic option for communities in need of more land.

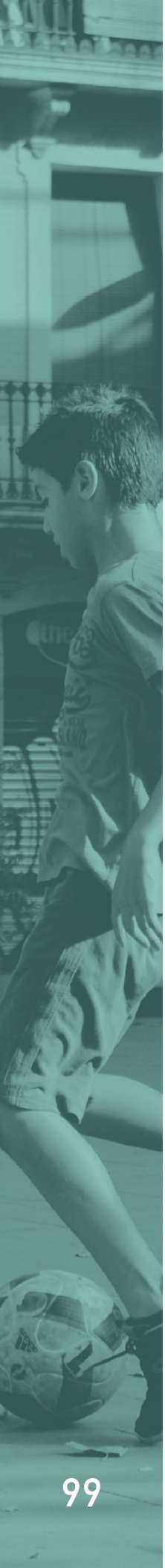
Jim (2004) found that compact city design may reduce available land for green space. Haaland and van den Bosch (2015) also found that dense urban development can limit green space provision.

Densification measures and popular compact city design applications may also threaten land availability in urban areas. This popular compact city technique accommodates a growing urban population and counteracts the repercussions of land-use inefficiencies, such as urban sprawl (Haaland & van den Bosch, 2015). However, in their 2015 literature review, Haaland and van den Bosch found that densification processes, such as consolidation and the redevelopment of previously used land, can reduce urban green space and pose challenges to its provisioning. Similarly, Jim (2004) argued that green space is far less likely to be present in cities implementing compact design measures. While green space, open space, and public space are not necessarily equal, there is much overlap in their uses, and a shortage of any one of them has similar repercussions to a shortage of another.

In light of the lack of large parcels available for park development in many urban areas, scholars such as Wolch et al. (2013) have suggested that creative strategies be implemented in order to provide urban residents with access to open recreational space. Such strategies could include repurposing “vacant lots, alleys, underutilized school sites, public or utility-owned property, unnecessarily wide streets, and abandoned riverbeds” (Wolch et al., 2005, p. 32).

Pop-up parks have also been presented as a possible solution to urban residents’ limited access to traditional public recreation spaces (Salvo et al., 2017). Their attractiveness lies in their inexpensiveness and ability to be easily and quickly implemented in comparison to larger, permanent facilities which are costly and may take multiple years to fully construct (Salvo et al., 2017). Salvo et al. found in their 2017 study of a pop-up park in Los Altos, California, that 85% of surveyed users would not be spending time at any park at all if the pop-up park was not there. Furthermore, park use was found to be greater in this pop-up park than in larger, traditional parks.

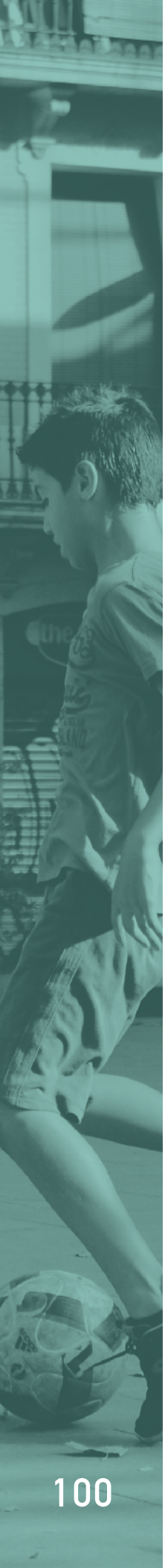
However, unlike permanent parks, pop-ups parks tend to be transient,



seasonal, and only offer precarious access. While they may temporarily afford populations greater access to recreational public space, that access is again reduced once the pop-up closes or moves elsewhere. Further, Harris (2015) claimed that the implementation of pop-ups in otherwise disused or vacant spaces may act as a way for cities to "cheer up" blighted neighborhoods and cover up the "flight of capital" (Harris, 2015 p.598). By implementing pop-ups with short-term leases, landowners can ensure a temporary income stream while marketing the space as attractive for future, more-profitable business endeavors (Andres, 2013). Additionally, pop-ups may act as a way to regulate the uses of otherwise vacant space and discourage squatting or other illicit activities (Harris, 2015). Because pop-up parks tend to host retail or other consumption-oriented activities, they may act as a way to exclude marginalized populations, such as those experiencing homelessness, that may have used the open space as a place of respite (Harris, 2015). Further, it is unclear whether pop-up parks are supplementing for residents' lack of spatial access to other public spaces.

Similar to pop-up parks, San Francisco, California's "Pavement to Parks" program seeks to reclaim parts of overly wide, unused road space in order to construct "parklets," or permanent miniature parks (Birdsall, 2013; Wilson, Tierney, Kim, & Zieff, 2012). After their conception in San Francisco, these "Pavement to Parks" programs have since been implemented by many city planning agencies across the U.S. and have been praised for their ability to aesthetically enhance streets while providing public microspaces for pedestrians. However, the public-private nature of parklet implementation has also caused scholars to question the extent to which they are actually publicly accessible (Littke, 2016).

Another proposed short-term fix to limited public space access involves permanently or intermittently closing streets in order to open them up to public recreation uses. These types of initiatives have been enacted in many cities across the U.S., including "Free Streets" in Philadelphia, Pennsylvania. Wilson et al. (2012) found that with the "Sunday Streets" initiative in San Francisco, California, that participants who were closer to the street involved in the opening were more likely to participate, as well as those with less spatial access to traditional parks. This study suggests that street opening initiatives may be a way to supplement the recreational needs of urban residents who have insufficient access to parks via traditional means. However, these types of programs, as currently implemented, are infrequent and brief, typically only lasting a few hours once or twice a month. In European urban centers, as well as some cities in North America such as Burlington, Vermont and Seattle, Washington, the long-term closure of streets to create public space is a more common occurrence. For example, in the "living streets" of Belgium, residents submit non-car related design ideas to their local government in order to implement alternative uses of their street; design installations typically last 1 to 3 months (von Schönfeld & Bertolini, 2017).



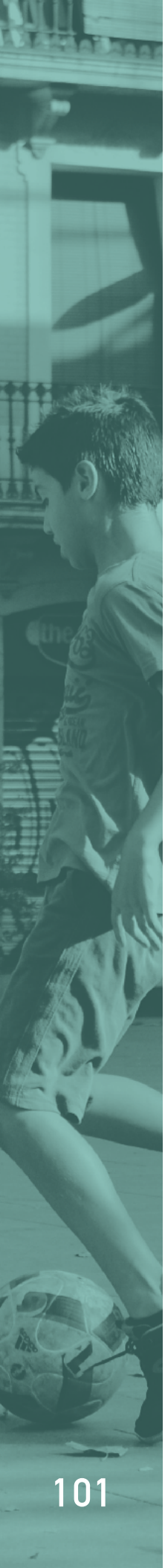
The studies we reviewed for this question incorporated diverse approaches including quantitative techniques (e.g. geospatial analysis, statistical analysis) and qualitative approaches (e.g. surveys, historical analysis, comparative case studies). Studies that analyzed land loss in urban areas tended to utilize quantitative statistical and geospatial methods. Additionally, the studies that used quantitative methods to analyze temporary parks tended to arrive to more positive outcomes. Those critiquing temporary parks tended to use more qualitative methods founded in historical and economic urban trends and the degree to which individuals belonged in a space.

33) CAN INFORMAL GREEN SPACES IMPROVE PUBLIC SPACE ACCESSIBILITY?

There is limited evidence to suggest that informal green spaces can be used as public space by individuals and residents to build community. Informal green spaces (IGS) are those spaces that are outside of the formalized ownership and maintenance practices of other urban green spaces, such as public plazas or privately-owned parks. IGS include street verges, vacant and abandoned lots, gaps between walls or fences, railway infrastructure, brownfields, waterside spaces, structural spaces (walls, fences, roofs), cracks or holes in other infrastructure, and power line rights of ways (Rupprecht & Byrne, 2014). The majority of studies examined how IGS that are claimed by community members resulted in some opportunity for the community to come together. However, there were cautionary tales in which some community members felt unwelcome in their IGS.

There is an abundance of IGS throughout cities, and different people and communities have a variety of reasons for wanting to use these spaces. Residents may see value in land that is not currently occupied because IGS can provide resources to community members that they need and want, not those that are imposed on them by top-down management approaches. IGS can fulfill needs that help to reproduce social identity (Langegger, 2013a). Additionally, these underutilized spaces may be less-surveilled or patrolled by police, since IGS lack formalized use in the eyes of the state. City alleyways are one case of this type of use. Most cities have extensive alleyway networks that are underutilized, other than for dumpster storage. However, these spaces have the potential to become small-scale, hyper-localized green spaces or community spaces, leveraged by neighbors directly proximate to them. This use can maximize green space access for the whole neighborhood. Additionally, greening of these spaces would provide an increase in green infrastructure throughout the city (Wolch et al., 2010b).

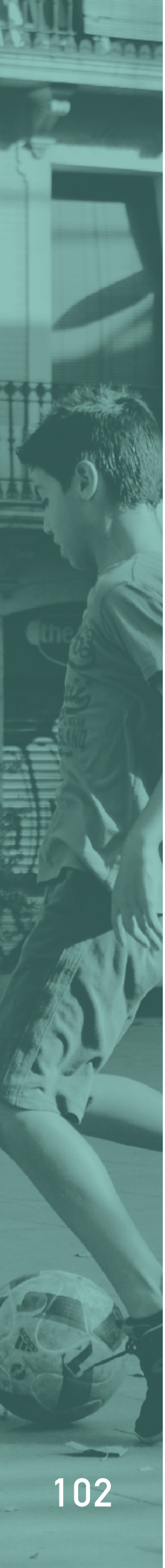
The use of IGS comes with several benefits. Historically, IGS have provided a space for those who are unemployed to do something productive while making sure that those spaces do not fall into complete disrepair before new



development can begin (Drake & Lawson, 2014). Additionally, IGS can serve as a catalyst for social change and cohesion, bringing conflicting groups together. These spaces can be used as extensions of the home; especially if home is not large, safe, or welcoming (Branas et al., 2018). In one randomized controlled trial of cleaning and greening vacant lots, people surveyed reported less fear of going out and increased use of outdoor space for socializing after the intervention (Branas et al., 2018).

There are also several limitations to using IGS as public spaces. To begin, IGS are often viewed by city officials as being unruly, unsanctioned, and requiring control and patrol (Spataro, 2016). For example, the abandoned railway system that surrounds Paris is still owned by the French national rail system. The city has surrounded this rail yard with fencing and patrols it utilizing the police to ensure that the unhoused population remains outside of the space. Further, management of IGS through community gardens is often treated by politicians and the media as a relatively new phenomenon brought on by newer white residents, discounting the long history of urban farmers of color (Reynolds, 2015). Finally, because IGS are not formally managed by the state, the maintenance of these spaces often falls on the volunteer hours and efforts of the communities that surround them, resulting in an uneven maintenance of these spaces. This can burden communities that are often limited in resources (Ghose & Pettygrove, 2014).

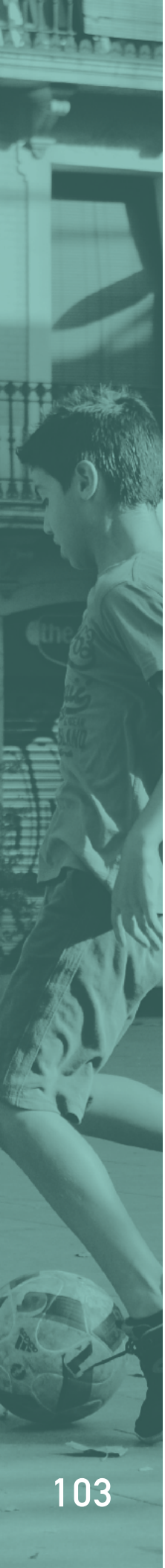
The articles we reviewed for this section used qualitative methods including focus groups, historical analysis, interviews, and participant observation; with some studies using GIS spatial analysis and mixed methods approaches. In the majority of these studies, the research focused on single case studies in specific geographical contexts, demonstrating that there may be some difficulty in drawing generalizations from their findings. There were two studies that focused on historical analyses, providing a clue as to how current informal green space management processes have roots in historical values. Community gardens are a very common form of IGS production. These spaces were most often utilized by those who lived nearby, as well as community organizers and non-profits that were invited into the spaces (Foo, Martin, Wool, & Polsky, 2014; Ghose & Pettygrove, 2014; Langegger, 2013a). Community gardens often served a dual purpose of food production as well as functioning as organizing and meeting spaces. In one case, the garden was constructed as a memorial for children killed by gun violence; the space is now used for community meetings and organizing around issues of gun violence (Langegger, 2013a). While community gardens were the most commonly discussed form of green space, abandoned rail yards (Foo et al., 2014), alleyways (Newell et al., 2013; Wolch et al., 2010a), and waterfront spaces (Rupprecht & Byrne, 2014) were also discussed.



CONCLUSIONS

We sought to uncover the knowns and unknowns of urban public space in North America to guide future decisions, investments, and research about our parks, libraries, trails, and other spaces. Although our research revealed some unexpected findings, our synthesis reinforces what is well-known by public space stewards: public spaces are important and valuable to cities and the people who live in them. This report expands on these findings by providing a more detailed and complex understanding of when and how public space matters to whom. Not all public spaces have the same impact on our social lives, economy, or environment, and not everyone in a city benefits equally from the public space. By doing so, we have identified the aspects of public space that call for future research.

Public spaces bring people together. Multiple studies found that parks and libraries serve as important places for social groups—such as first-generation immigrants and youth—to provide support, share resources, and cultivate a collective identity. Public spaces draw people from different backgrounds; promoting civility across different social groups, creating opportunities for social contacts and connections, and providing places for expressing free speech and engaging in social activism. Even informal green spaces, such as community gardens on vacant land, provide a space for community members, often from similar social and cultural groups, to convene. But there is a limit to the public spaces' potential to bring people together across social groups, especially to build long-term, deeply personal relationships. It is much easier for people with similar backgrounds to develop connections in public spaces, while existing social tension and hierarchy could manifest in how we share the space. Spatial design that incorporates the diverse needs of space users can foster positive and meaningful interactions across users, since our uses of and expectations for the public space vary across our life cycle, social statuses, and personal interests. Even in the era of digitally-connected lives, physical public space continues to play a meaningful role in cities. Community members



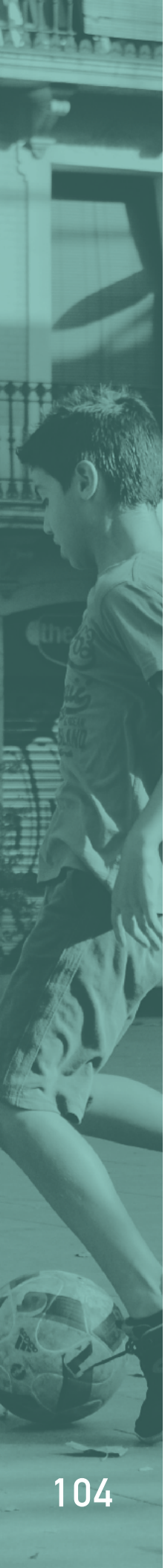
mobilize over the proposed loss or establishment of a public space, underscoring the value placed on these spaces.

Public spaces of all types play a critical role in shaping residential and economic development and valuation. Proximity to parks is associated with elevated economic activity, higher land values, and increased personal wellbeing. **Signature parks**, such as New York City's High Line, create substantial economic benefits. Smaller neighborhood-scale public spaces also increase residential property values and positively impact businesses by increasing local foot traffic. The quality and maintenance of public spaces shape the benefits that communities receive. Poor-quality public spaces are less attractive for people to use; they also depress nearby property values, attract litter, and create opportunities for crime. There is an inequitable distribution of high-quality public spaces across most cities. Whiter and wealthier neighborhoods tend to have the best access to high-quality public spaces, while low-income communities and communities of color have less access.

Public spaces present an opportunity to preserve and improve the environment in cities by lowering local temperatures, reducing stormwater runoff, and creating habitats to promote biodiversity. It is well-documented that green public spaces, especially those that offer shade, have cooling effects on surface and air temperatures. Also known as "park cool islands," these green spaces cool within their boundaries and the nearby surrounding areas. For public spaces with buildings or **impervious surfaces**, increased reflectivity, green roofing, and inclusion of vegetation can lower energy use. Reducing air temperatures is important, particularly with climate change and predicted increases to the number and duration of extreme heat events in many cities in North America. These extreme heat events could exacerbate pollution levels, precipitation patterns, and heat-related deaths.

Public spaces continue to pose challenges to certain environmental concerns, such as stormwater runoff and biodiversity. **Impervious surfaces** negatively impact aquatic and coastal ecosystems primarily via stormwater runoff, which causes increased sediment as well as chemical, bacteria, nutrient, and thermal loads. Streets, parking lots, rooftops, and transportation networks are the primary **impervious surfaces** that negatively impact habitats and biodiversity. Cities are pursuing various forms of green infrastructure on public land to mitigate stormwater runoff; this is another way in which public space can improve local environments.

Public spaces are also good for our health. Living near green open space is associated with improved mental health, with lower rates of depression, and a greater sense of overall wellbeing found among nearby residents. Many different types of park amenities—such as walking paths, playgrounds, and pools—are associated with greater amounts of physical activity happening in the space. Living near a park or trail has also been associated with increased

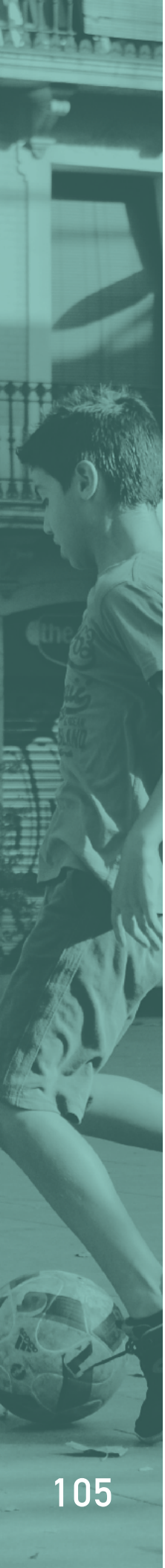


physical activity, but a person's perception of being close to a park may matter more than the actual distance in influencing their physical activity. The public uses libraries as a source of health-related information, and libraries have in turn diversified their programming to reflect health interests. Offerings can include fitness, nutrition, and cooking classes, as well as blood pressure screening. Libraries are also important places for public safety during extreme weather. These public spaces are regularly designated as cooling centers during extreme heat events and are also used as evacuation sites during natural disasters such as hurricanes and wildfires.

Our research also highlighted many unknowns about our urban public spaces. Our section on key knowledge gaps synthesizes critical research needs on urban public spaces across all themes, and we also identified priority knowledge gaps by theme (Table 2).

Social Capital and Social Cohesion Knowledge Gaps: One of the most fundamental aspects of urban public spaces is that they allow for social encounters among strangers. Yet, there is limited evidence that public spaces can successfully foster long-term **social capital** among strangers, and particularly among strangers from different social backgrounds. This limited evidence is in part due to limitations of research design. For instance, existing studies don't adequately distinguish whether people who go to public spaces already have high **social capital** or if people able to build their **social capital** by going to public spaces. In other cases, there simply hasn't been research that fully addresses this question across different types of public spaces or over time. For instance, do certain types of public spaces allow people to build **social capital** across groups, and if so, what are those high opportunity public spaces? In what ways do encounters with strangers in one place impact our relationship to others in the city beyond that particular interaction? Finally, if public space stewards hope that public spaces will build **social capital**, people from different social groups—especially those with marginalized social statuses—must feel comfortable entering and sharing the public space. There is a need for more research on how different perceptions of public spaces encourage or discourage the use of these spaces and the types of **social capital** and **social cohesion** that can be developed.

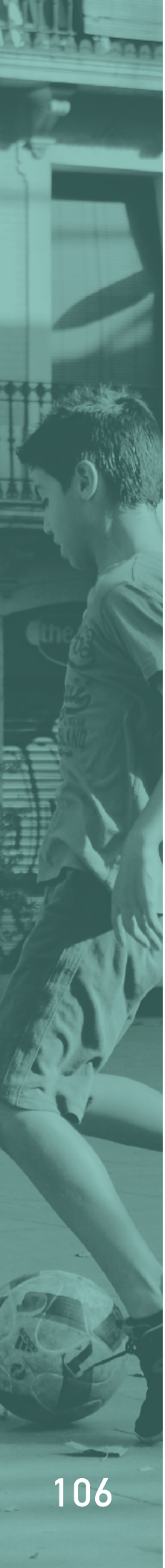
Social costs and equitable distribution of benefits: The inequities associated with the distribution and quality of urban public spaces have social, health, and environmental impacts in nearby communities. Yet there is also evidence that investing in those neighborhoods with inadequate access can lead to multiple forms of displacement and gentrification. A critical question for dealing with inequities in our public spaces is determining what kinds of investments in public spaces mitigate displacement and lead to inclusive and equitable outcomes. Is there a tipping point at which an investment of a particular size will trigger gentrification, or does the nature of the investment



(e.g. private-public partnerships, community partnerships, etc.) matter more than the size? Additionally, given that the maintenance (or lack thereof) of urban public spaces can exacerbate existing inequities, what kinds of partnerships among community members, government agencies, and non-profits provide equitable long-term maintenance outcomes for cities?

Economic benefits and costs: Urban public spaces have an impact on economic activity by improving pedestrian traffic and generating direct and indirect economic benefits for businesses. However, the quality of the public space is important. Poorly maintained urban public spaces can negatively impact economic activity, while signature public spaces can trigger extensive economic development, which can lead to the displacement of residents and businesses who may not be able to afford the concomitant higher rents. More research is needed to understand the tipping point for urban public spaces; to understand how different sizes and types of public spaces affect property values; and to identify what types of investments in public spaces generate equitable economic benefits for businesses and residents, including understanding the proper balance between centralized and dispersed investments. There is also a need for more intentional research design to examine how the creation of a new public space impacts nearby business activities, both in the short and long term.

Environmental benefits and costs: There is surprisingly little research that directly evaluates the environmental benefits and costs of some types of urban public spaces (e.g. plazas) or systems of urban public spaces (e.g. city parks). While research points to many different aspects of urban public spaces—from **land cover** to species selection—that can provide environmental benefits for temperature, energy use, biodiversity, and water quality; our



understanding of how our public spaces currently shape the local environments in cities is limited. This limitation further complicates our ability to predict how changing environmental conditions (i.e. climate change) will affect the environmental outcomes of public spaces. More research is needed on the environmental aspects of all types of public spaces in cities.

Health benefits and costs: Certain health outcomes associated with parks and green spaces are well-supported by research, though there is a need to better understand the contextual factors and underlying mechanisms that shape the relationships between urban spaces and health. Many studies find that living near green spaces improves mental health, but few studies explore the mechanisms behind this association. Do green spaces provide a buffer for environmental stressors like noise, heat, and air pollution? Or is it because people go to these spaces to relax and socialize? Physical activity is another health factor that has been related to parks. Research shows that features of parks (like walking loops and trails) are important determinants of the amount of physical activity happening there, yet adding a park in a neighborhood may not lead to more physical activity at the population level. Do these findings differ by sociodemographics, by geography, or by different types of programming offered in the space? Finally, there is a need for more research on public spaces other than parks and trails.

Barriers to public accessibility: Our research highlights multiple reasons why people may not be able to use public spaces, but less research illustrates effective ways to improve public space accessibility. For instance, more research is needed to examine how public space stewards can address concerns regarding a "sense of belonging" in both established and new public space for individuals who may feel marginalized in parks, plazas, or libraries. In some neighborhoods where there is a lack of public space, the clear solution is to add more public space. This may be complicated in neighborhoods with limited land availability. One potential solution is to use informal green spaces or temporary public spaces, such as pop-up parks. However, additional research should explore whether such alternative spaces can be integrated into existing city agency practices and whether the formalization of the land impacts an individual's or community's use of the space.


APPENDIX

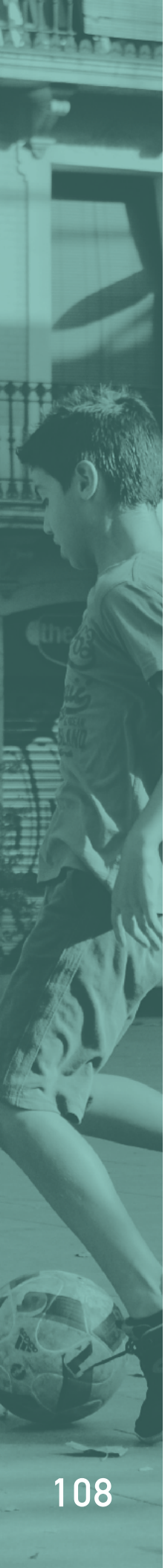
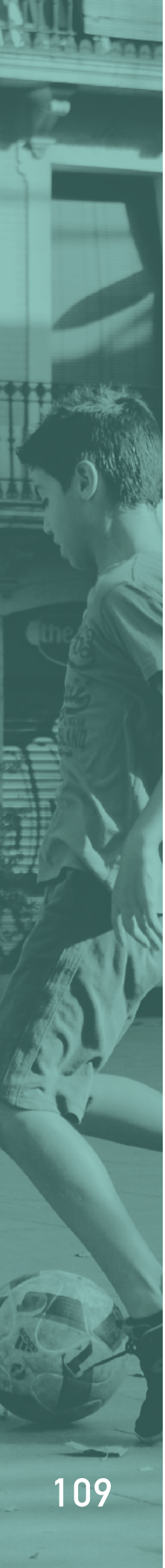


TABLE 1. ENVIRONMENTAL IMPACTS OF URBAN PUBLIC SPACES

	IMPACTS ON AIR QUALITY	IMPACTS ON TEMPERATURE	IMPACTS ON WATER QUALITY	IMPACTS ON BIODIVERSITY
Individual Characteristics				
Trees and Plants	Pollen, allergens, VOCs emission by plants varies by species Carbon dioxide and monoxide captured differently by species		Remove nutrients, sediments and heavy metals from stormwater and soils	
Coniferous Trees	Produce relatively low emissions, reduce production of pollutants and remove present pollutants Better suited to capture and retain particulate matter especially in high wind than deciduous trees	Cool air temperatures	Intercept a substantial amount of rainwater	
Deciduous Trees	Trees bearing leaves with larger surface areas, longer lifespans, and rougher leaf textures have higher pollutant uptake capacity	Ability to cool air temperatures varies by season	Intercept a good amount of rainwater	
Shrubs			Intercept some amount of rainwater	
Lawns and Turfgrass	Can produce more greenhouse gasses than natural ecosystems	Heating effect (mitigated by irrigation)	Fertilization leads to lower quality runoff	Negative impact due to increased runoff and suspended solids
Waterbodies		Cooling effect		
Vacant Lots				Suitable habitat for insects, small mammals and birds Contribute to conservation of rare and endangered species and plants Increase habitat connectivity
Characteristic	Impacts on Air Quality	Impacts on Temperature	Impacts on Water Quality	Impacts on Biodiversity



Urban Public Space Landscapes				
Engineered Green Infrastructure	Removes pollutants	Cooling effect	Encourage urban runoff infiltration or detention	Can harm or help biodiversity
Urban Forests and Large Parks	Effectiveness depends on spatial arrangement, species, and size	Park Cool Islands (PCI) decrease temperature substantially Tree clusters have higher cooling effects than single trees, grass, and water bodies PCI cool areas downwind More canopy cover lowers asphalt temperatures	Reduce stormwater flow and improve surface water quality	Urban forests are often more species-rich than other urban green spaces Connected parks and green spaces can support more species diversity and abundance than small isolated parks Increasing size of parks can override negative influences on invertebrate and bird species richness
Small Parks and Sparse Vegetation (e.g., street trees and shrubs)	Mixed findings whether they can remove urban air particulate and gaseous pollutants Can retain gaseous pollutants and allow concentrations to remain constant or build on paths Ozone concentrations higher under tree canopies Low level hedges enable more airflow improves air pollution on footpaths	PCI decrease temperatures Street trees decrease daytime temperatures but can increase nighttime temperatures due to reduced air circulation Targeted tree placement to provide shade over walkways and pedestrian spaces can improve comfort		Habitat patches can negatively impact species richness
Impervious Surfaces (Streets, roads, parking lots, and transportation networks)		Increases surface and air temperatures	Runoff is increased which leads to higher suspended solids loads Can have relatively high pollutant loads	Hurts aquatic life due to increase suspended solids Can increase surface temperature of waterbodies, affecting ecosystem equilibrium

*blank spaces indicate little to no research has been conducted

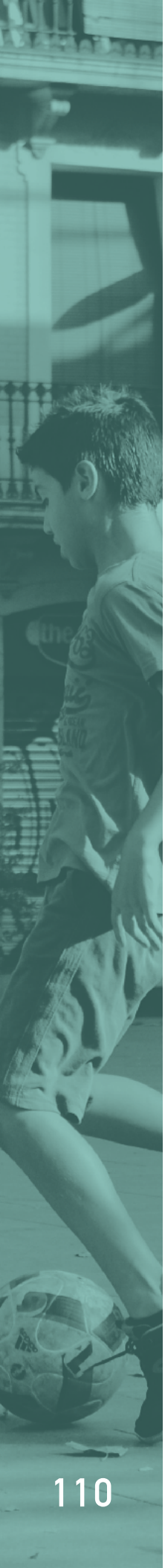
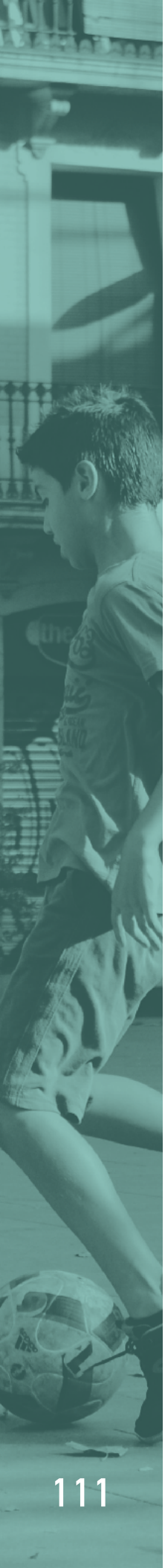


TABLE 2. CRITICAL KNOWLEDGE GAPS BY THEME

THEME	KNOWLEDGE GAPS
Social Capital	Does the use of public space cause interactions and connections, or are people with higher social capital more likely to use public spaces?
	Do the unintended uses of public spaces create social capital and social cohesion?
	Do certain types of public spaces have a greater impact on social capital and social cohesion than others?
	How do perceptions of public spaces encourage/discourage use of public spaces?
	Does sharing of public space enable development of social connections or a sense of community across existing social boundaries?
Social costs	What are alternative approaches to create and/or revitalize urban public spaces that mitigate displacement potential and lead to inclusive and equitable outcomes?
	What types of investments (e.g. small vs. large, corporate vs. community) provide the most benefits to underserved populations?
	What kinds of partnerships (community, government, non-profit) provide medium- to long-term UPS maintenance that provides equitable outcomes that also don't burden certain community members?
Economic	How does the creation of a new urban public space impact nearby business activities?
	How do different sizes and types of public spaces affect property values?
	How do the benefits of investments in centralized vs. dispersed public spaces compare?
	What are the direct benefits for businesses realized from indirect sources like increased foot traffic or events in public spaces?
	What are the direct economic benefits of improvements to public spaces over the long-term?
	When do parks reach the point where they have a negative or positive impact on the property value and businesses? Where is this tipping point?
Environmental	How do impervious surfaces in public spaces contribute to thermal effects?
	Which species are best for urban development and environmental improvements?
	How do public spaces impact energy use in nearby buildings?
	What is the influence of climate change on environmental outcomes in public spaces?
	What are the downstream ecological impacts from single sites, such as buildings or plazas?
Health	What impacts do public spaces other than parks and trails (such as libraries, community centers, recreation centers, or plazas) have on health?
	What are the population-level impacts of public spaces on health, and how long do the effects last?
	What are the contextual factors that shape the relationships between urban public spaces and health? Which qualities of public spaces matter, and do the relationships differ by sociodemographics?
Barriers to public space accessibility	How do different individuals and communities utilize and benefit from alternative UPS (e.g. pop up parks, IGS)? Do these spaces may reliably improve UPS access across cities?
	Can informal green spaces or pop up parks be integrated into existing Parks and Recreation agency practices? How does the formalization of such land into traditional land uses impact an individual's and community's use of the space?
	How can UPS stewards address concerns of "sense of belonging" in new and established UPS?



ENDNOTES

[1]Technical note on the approach to the synthesis

Our synthesis incorporates a wide breadth of scholarship on this topic from multiple disciplines including urban sociology, geography, economics, anthropology, philosophy, landscape architecture, urban planning, public affairs, engineering, environmental health and epidemiology. We focused our review on peer-reviewed academic research, but also included non-peer reviewed literature and policy reports from relevant organizations, such as the National Recreation and Park Association to capture the current dialogues on urban public space in policy and practice.

We targeted studies on public spaces in North American cities from 1990 to the present. This time period marks a trend in urban growth across the country, with many post-industrial cities, such as Philadelphia, gaining population for the first time since the 1950s. This growth has corresponded with a surge of investment in cities and their public spaces, as well as growing attention towards public space in academic literature. In some instances we extended our review to previous decades and large cities in Canada, Western Europe, and Australia to provide the historical and geographic context of how public space and its benefits and costs vary over time or regions.

In Phase One, we developed a typology of urban public spaces. While most definitions of public space indicate that they are spaces that are publicly owned and free for the public to use, this definition of the quintessential public space (e.g. a public library) doesn't adequately reflect contemporary perspectives or use of public space (e.g. community garden on vacant land). We developed a typology of public spaces to reflect the public's point of view to guide the subsequent literature search. The following types of public spaces were included in the literature search: public parks, libraries, recreation centers, playgrounds, community centers/ civic center, gardens, trails, plazas, sports fields (but not if it is part of a school or is gated), schoolyards, public pools, privately owned park that is open to public, rivers, beaches, parking lots, public right of way (e.g., sidewalks, spaces under highways/ bridges), malls, public markets, abandoned urban spaces (e.g., vacant lots, vacant buildings), public transportation (e.g. bus stops, transit station), schools or universities with public spaces, churches/religious institutions if they function as a community center that is free and accessible to the public), arts and cultural institutions spaces if they function as a community center that is free and accessible to the public.

In Phase Two, we developed a series of guiding questions based on the themes of the project. The research team conducted a preliminary review of the literature to identify key debates and questions on public space and developed guiding questions. Our guiding questions directed our literature search. We did not conduct an exhaustive review of all relevant literature, and instead selected the most salient and recent research on the topic and our expert knowledge. We selected studies with strong support for their findings and a high impact in their respective research communities for in-depth review. Due to the interdisciplinary nature of the project, the approach to article selection varied by theme and by best practice of the disciplines most relevant to the theme (e.g. standards in Sociology were prioritized for guiding questions on social capital). Each of the selected studies were evaluated for their relevance, soundness of methods, and importance of their findings. We reviewed over 450 studies. We synthesized our findings based on the guiding questions and developed a detailed assessment of the studies and evaluation of how they respond to the questions. To communicate the overall level of support for each guiding question, we created a classification scheme, as described in the introduction to the report (e.g. sufficient evidence, limited evidence, inadequate evidence). Finally, we synthesized our findings across the themes and identified knowledge gaps to highlight the main takeaways from the research and to prioritize next steps for future efforts.

As part of our process, the research team received feedback from the William Penn Foundation and our advisory board at two critical phases of the project: 1. the development of the guiding questions, and 2. the results of the research synthesis by guiding question. This feedback shaped the direction of the project and provided insights into how to make the project relevant and accessible to policymakers and practitioners.

[2]Research Team

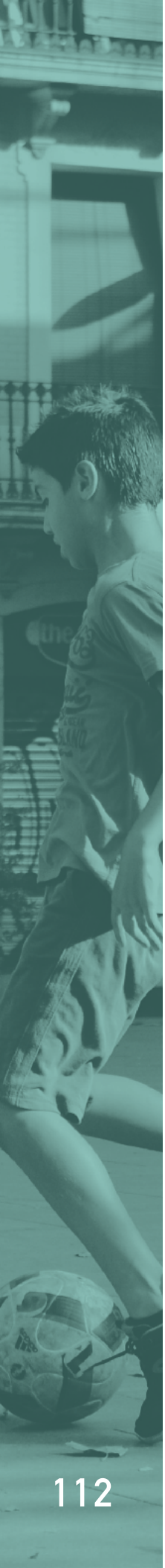
Hamil Pearsall is an associate professor in the Geography and Urban Studies Department at Temple University. She is an urban geographer, and her research addresses the socio-spatial dimensions of environmental justice and urban sustainability in post-industrial cities.

Anneclaire De Roos is an epidemiologist who serves as associate professor in the Department of Environmental and Occupational Health of the Dornsife School of Public Health at Drexel University. Her research focuses on environmental determinants of health in workplaces and the urban environment, and her service activities involve evidence evaluation to inform risk assessment and policy.

Patrick Gurian is an associate professor in the Department of Civil, Architectural, and Environmental Engineering at Drexel University. He has over 20 years of experience evaluating quantitative analysis of environmental policy, generally using benefit cost assessment and decision analytic methods to evaluate options.

Yuki Kato is an assistant professor of Sociology at Georgetown University. She is an urban sociologist whose research examines the dynamic relationship between built environment and social relationships with a particular focus on social inequalities and urban redevelopment.

Michelle Kondo is a research social scientist with the USDA-Forest Service, Philadelphia Field Station. Her research focuses on place-based strategies for disease, violence, and injury prevention, most often in the context of legacy cities and low-resource communities in urban areas.



Research Assistants

Stephen Dickinson is a PhD student at Temple University. His research addresses the impacts of the creation of and improvements to green spaces and parks in cities and the ways in which we can ensure environmental benefits are distributed equitably.

Sarah Ehsan is a graduate student completing her Master of Public Health degree at Drexel University's Dornsife School of Public Health. Her research interests include urban health, sexual health, and health disparities.

Marissa Gabriel is a graduate student at Drexel University. Her research addresses the impacts of public spaces on noise and biodiversity.

Asa Lewis is a PhD student at Drexel University in the college of civil, architectural, and environmental engineering. His research addresses environmental remediation of chemical pollutants in the ecosystem.

Lindsay McCarthy is a graduate student at Drexel University. Her research addresses the impacts of public spaces on air quality.

Radha Pennotti is a Senior Associate at The Food Trust and a research associate at the Dornsife School of Public Health at Drexel University. She has over 15 years of experience working at the intersection of public health, the built environment, and food access.

Kathleen Fenlon and Grace Chung are undergraduate students at Georgetown University.

Theany Su received her BS from Temple University in December 2018. Levi Krum and Casey Mitchell received their BA from Temple University in May 2019. Claire McGinley and Dylan Ponticello are undergraduate students at Temple University.

[3]Advisory Board

1. Dr. Marvin Carr, STEM & Community Engagement, Institute of Museum and Library Services

2. Dr. Richardson Dilworth, Professor, Department of Politics and Director, Center for Public Policy, Drexel University

3. Dr. Genevieve Dunton, Associate Professor of Preventative Medicine and Psychology, Keck School of Medicine of the University of Southern California

4. Dr. Myron Floyd, Professor and Department Head, Department of Parks, Recreation and Tourism, North Carolina State University

5. Ms. Linda Hwang, Research and Innovation, Trust for Public Land

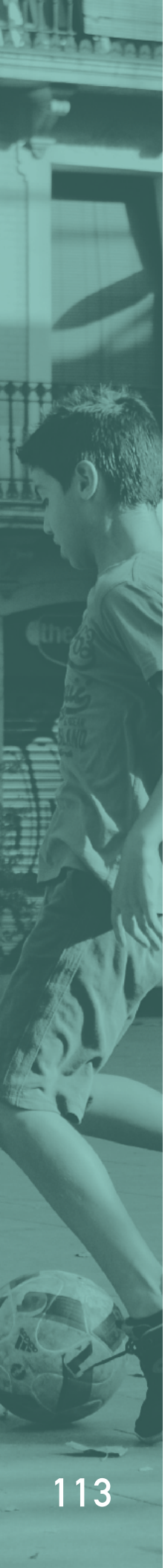
6. Dr. Maria Jackson, Professor, Herberger Institute for Design and the Arts, Arizona State University

7. Ms. Kathryn Ott Lovell, Commissioner of the Philadelphia Parks and Recreation Department

8. Prof. Toni Griffin, Founder, Urban Planning for the American City & Professor in Practice of Urban Planning, Harvard University Graduate School of Design

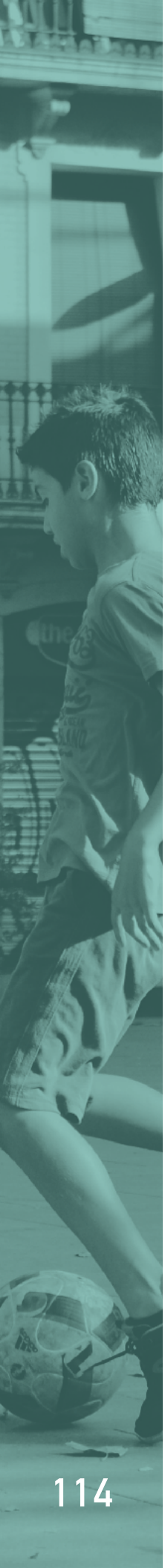
[4] Primer This economic analysis considers literature on market valuation of property near public spaces, enhancement of businesses revenue, and enhancement of human capital due to libraries. Economic benefits would ideally be measured by comparing net social welfare in the world as it is versus net social welfare in a counterfactual world with incrementally more or less public spaces. Given that observing such a counterfactual world is not possible, economic researchers look to opportunities to compare welfare in situations which are comparable except for a differential in access to public spaces. For example, economists compare values of properties that are comparable except for proximity to public spaces; compare business revenue and investments for businesses that are comparable except for proximity to public spaces; and compare measures of human capital (employment) for individuals who are comparable except for access to resources available in public spaces such as libraries. All of these approaches are open to some degree of question. In general, the increases in property values and increases in human capital are consistent with increases in welfare. However, critics of this approach might point out that tendencies to self-segregate by income are significant and growing. As such property premiums might reflect not just the value of the public space but other benefits associated with wealthier areas (status, public services, etc.). To address this, researchers can try to find "**natural experiments**" where public spaces are added to existing neighborhoods or improvements are made to existing public spaces and the impacts on land values in the surrounding area are observed. If an otherwise similar area that does not benefit from public space investments can be used as a comparison, this substantially strengthens the approach. An analogous approach can be undertaken for human capital, in which employment outcomes for individuals who have access to programs provided in public space—generally libraries—are compared to outcomes for those who do not have access to such programs. For both land and human capital improvements, higher market valuations are consistent with the actual creation of wealth.

In contrast, studies of business revenue and investment are less firmly linked to actual social benefit increases, as they likely represent shifts in existing spending and investment, rather than increases in inherent value. Even when additional revenue and investment can be firmly linked to the public space—for example by before and after comparisons—the benefit of the additional economic activity is open to question. This economic activity might simply be displaced from other locations, leading to a concentration of activity around the public space but not a one-to-one net gain in welfare for each dollar of economic activity. In the description below, such studies are cited as evidence of enhanced economic activity, but this should not be confused with increases in net social welfare.



In addition to welfare gains, the social equity impacts of public spaces should be considered. Unfortunately. this aspect of public space is difficult to measure. Increases in rents and displacement of existing residents can be documented and emerge as a concern, particularly for large-scale investment in public spaces. Public spaces that concentrate economic benefits and activity may inherently raise social equity concerns, as the political process may steer such benefits toward favored groups at the expense of marginalized groups. In general, social equity considerations would favor dispersed, small-scale investments in public spaces over concentrated investments in single areas, but the literature identified by this effort did not offer specific guidance on sizing and location of public spaces.

[5]Recommended amount of activity: >=150 to 300 minutes a week of moderate-intensity, or 75 to 150 minutes a week of vigorous-intensity aerobic physical activity, or an equivalent combination for adults; >=60 minutes of moderate-to-vigorous physical activity daily for children and adolescents (ages 6 through 17 years).



GLOSSARY

Adjustment –When studying the relationship between two factors, controlling the effect of a third factor that may be influencing the relationship.

Albedo – The proportion of light from the sun that is reflected by a surface.

Arthropod – An invertebrate animal that has an exoskeleton, a segmented body, and paired jointed appendages; includes insects, arachnids, myriapods, and crustaceans.

Atmospheric deposition – The process in which precipitation such as rain, snow, fog and the particles, aerosols, or gasses included, moves from the atmosphere to the earth's surface

Bias – A systematic error in the design, conduct, or analysis of a research study that can cause an incorrect estimate of the effect an exposure has on a disease or outcome.

Biodiversity – The variety of life , i.e. diversity of species, in the world or in particular habitat or ecosystem.

Biota – An umbrella term for all living organisms within a region, ecosystem or time period, including flora (plant species) and fauna (animal life).

Business Improvement District (BID) – Defined areas within which businesses are required to pay an additional tax in order to fund projects within the district's boundaries.

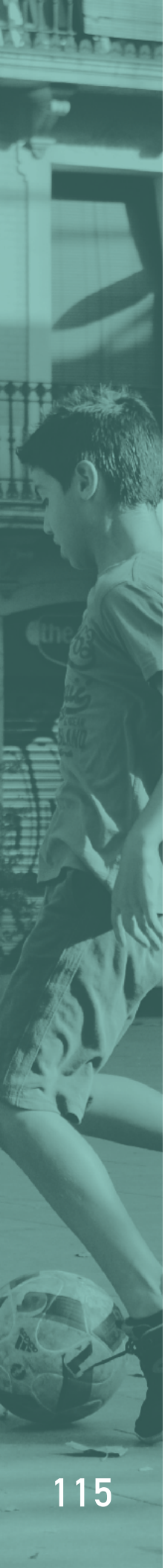
Circadian clock – An internal biochemical oscillator that is synchronized with solar time.

Coniferous trees – Trees that bear cones and needle or scaled leaves throughout the year.

Control – The group of subjects in an experimental research study that does not receive the treatment or intervention; or, in an observational study, the group of subjects that does not have the disease or outcome.

Cross-sectional study – An observational research study in which subjects are observed once at a single point in time.

Cultural capital – One's knowledge and competency in cultural practices that are specific to a particular social group, most notably social class, but also ethnic identities, gender, and subcultural community. Having sufficient cultural capital enables one to navigate social space with confidence, such as knowing how to *appreciate* art or appear as a *legitimate* customer in a commercial space. We acquire cultural capital through socialization throughout our lives, and expansive cultural capital affords access to more social spaces while



limited cultural capital could deter us from entering spaces that implicitly appear intimating or exclusive.

Deciduous trees – Trees that shed broader, flatter and hairy or waxier leaves annually.

Degradation – The process of eroding, weathering or otherwise breaking apart a compound or object into smaller or constituent parts.

Deposition – A movement occurring when gravity and friction act as the primary forces on a particle, allowing the particle to slow in motion and fall, usually resulting in settling onto a surface below.

Dispersion – The spread of gaseous or suspended particles or compounds throughout an air volume.

Gaseous pollution – Gases that lead to air pollution, including nitrogen and sulfur oxides, methane, hydrogen, formaldehyde, ammonia, hydrogen sulfide. Some of these gases occur naturally, while others are products of the burning of fossil fuels including oil, coal, and natural gas.

Engineered green infrastructure or green spaces – The category of built or preserved structures that encourage urban runoff infiltration or detention, for example parks, rain gardens, bump-out planters and green roofs.

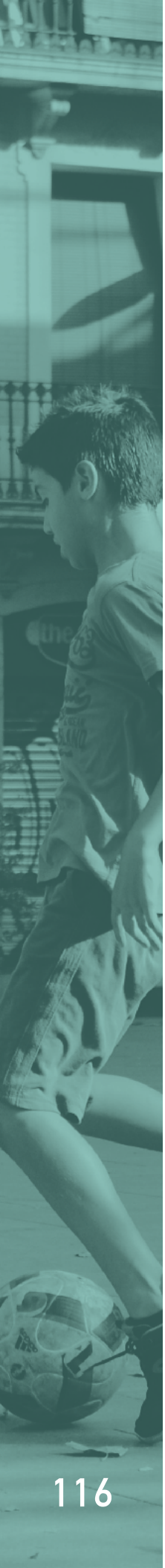
Erosion – The gradual destruction of earth's surface such as soil, rock, or dissolved material.

Ethnography – A sustained observation of social groups, organizations, or communities, over the course of some extended time period, especially by focusing on the interactions among individuals. In some cases observers interact with the study subjects, and in other cases the observations are made unobtrusively. The method is often used in social science research to identify and understand the social norms, the patterns of behaviors, and symbolic meanings of practices, among others.

Experimental study – A research study in which subjects receive a treatment or intervention.

Geographic Information System (GIS) – A system designed to capture, store, manipulate, analyze, and present spatial or geographical information.

Green Gentrification – Theory that posits that greening development in cities contributes to gentrification of previously low-income, minority communities by making the space attractive to the individual and corporate newcomers, who are increasingly invested in the issues of sustainability. In some cases greening may be intentionally deployed as a way to *ready* a community that had historically suffered from divestment and poor infrastructure. In other cases grassroots greening efforts could be inadvertently contribute to the



improved profile of the community to the outsiders, inviting new interests in the community.

Herbivore biomass – The total mass of organisms that consume plants for energy in a given area.

Impervious Surface – Land surfaces, usually artificial, that repel rainwater and do not permit it to infiltrate into the ground.

Irradiance – The flux of radiant energy per unit area.

Land cover – Physical material of the earth including impervious surfaces such as roads and buildings, as well as green spaces such as tree canopy, grass, and herbaceous cover.

LGBTQIA+ – The acronym stands for lesbian, gay, bisexual, transsexual, queer, intersex, asexual and all other sexuality and gender identity categories that do not conform to the heterosexual norm.

Locally-Unwanted Land Use (LULUs) – Land use that are seen as ecologically and economically hazardous to the immediate neighborhoods. Common examples of the LULUs are landfills, prisons, or transportation hubs, which could cause harm to the quality of life in the adjacent communities to these developments and result in economic and health costs.

Longitudinal study – An observational research study in which the same subjects are observed repeatedly of a period of time.

Macroinvertebrates – Organisms that lack a spine (invertebrates) that are large enough to be seen with the naked eye.

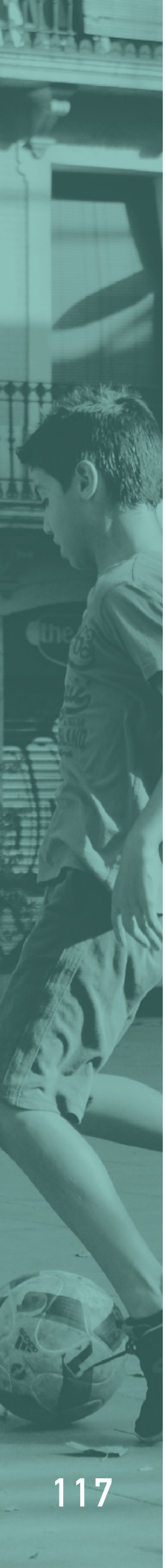
Matched control – In a research study, subjects with a particular outcome may be matched with subjects without that outcome, based on a common characteristic.

Mechanistic pathway – The series of steps that lead to an outcome. For health effects, the mechanistic pathway might include a detailed explanation down to the biochemical level of changes leading to the outcome.

Medically underserved – Describes individuals living in areas with a shortage of primary care health services.

Meta-analysis – A study which combines the statistical results of several independent research studies to draw conclusions about a body of research.

Native / nonnative species – A native species has evolved and adapted within their specific habitat with their neighboring species. A nonnative species evolved and adapted elsewhere and has been introduced into the current location, including but not limited to invasive species.



Natural experiment – A study in which there is a treatment or intervention which cannot be controlled by the investigators, such as a policy or a weather event.

Nematode – Roundworms of the phylum Nematoda that are major component of soil ecosystem and primarily feed on bacteria, fungi, and microorganisms.

Objective measure – A measure that relies on information that is not subject to interpretation based on a person's perception, such as measurement of salivary cortisol levels to indicate a participant's stress.

Observational study – A research study in which subjects do not receive a treatment or intervention.

Particulate matter (PM) – The mixture of liquid droplets and solid particles found in air.

Park density – The number of parks within a specified unit of land.

Peak discharge – Maximum rate of runoff of impervious surfaces during a storm.

Perceived measure – A measure that relies on information that is subject to interpretation based on a person's perception, such as self-reported stress.

Photochemical – Describing a compound that chemically changes due to the absorption of light or solar radiation.

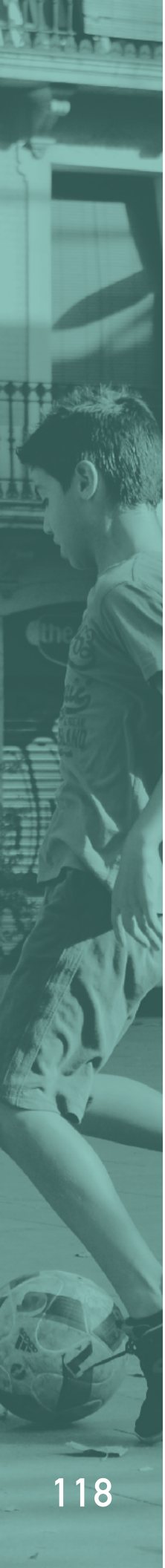
Place-making – Users give meaning to a physical space through their uses and observations of the space. The concept highlights the social meaning of the space as something that is dynamic and socially constructed, rather than an inherent quality in physical designs of the space.

Power – In statistics, the probability of correctly rejecting the null hypothesis; or, the probability of detecting a different result from what is expected when such a difference actually exists.

Quasi-experimental study – A research study in there is a treatment or intervention, but study subjects are not randomly assigned to the treatment or intervention.

Rainfall-runoff relationship – Rainfall is the primary source for runoff of earth's surfaces; inches of rainfall times the area in inches of the surface gives the volume of the runoff.

Randomized trial – An experimental research study in which subjects are assigned at random to receive a treatment or intervention.



Return on Investment (ROI) – A performance measure used to evaluate the efficiency of an investment.

Risk – In epidemiology, the probability of developing a disease or outcome over a certain period of time.

Scoping study – A type of literature review which seeks to assess the size and scope of the available literature on a subject; often more broad and general than a systematic review.

Sedimentation – The process of settling or the deposition of particles out of a fluid such as a lake or river.

Signature Parks – Regional attractions that are landmarks within city limits. Often large scale and a reason the city is known.

Significance – In statistics, when a particular result has a low probability of occurring under the null hypothesis; or, when a result has a low probability of occurring simply due to chance.

Social capital – Connections between more than two people, through which information and resources are shared. Social ties are measured for their quantity (e.g., how many people are you connected?), quality (e.g., how often do you interact with these individuals?), and nature of ties (e.g., is this a workplace acquaintance or neighbor?) in order to assess their significance. Social capital can be measured at an individual level (e.g., why do some people have more ties than others?) or at group level (e.g., why do some organizations foster stronger ties than others?).

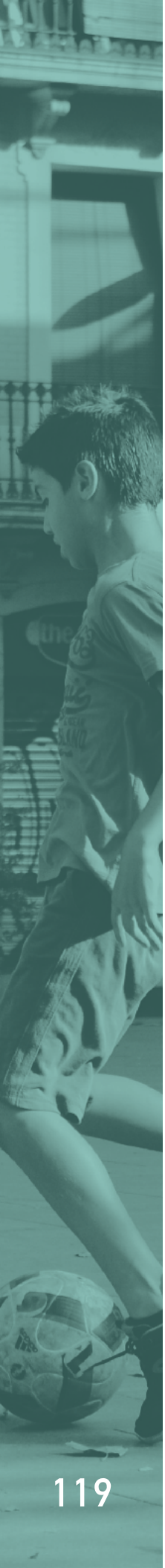
Social cohesion – Collective identities and sense of togetherness experienced among a group of people that are articulated in practice or language. Social cohesion is measured at a collective level, based on subjective assessment (e.g., how closely the members identify with the group?) or objective assessment (e.g., what percent of the residents come out to a neighborhood event?).

Species richness – The count of different species represented in an ecological community, landscape, or region.

Stormwater infiltration – A fundamental component of the water cycle; the process by which water enters the soil and recharges streams, lakes, rivers, and underground aquifers.

Street Canyon – Place where the street is flanked by buildings on both sides.

Suspended solids – Particles that remain in suspension in water such as lakes or rivers due to water's motion.



Systematic review – A type of literature review which selects previously published studies based on a set of systematic criteria and assesses the range and quality of evidence in order to answer a research question.

Tax revenue – The income gained by governments through taxation, the primary source of income for a state.

Tree crown / canopy – The top layer of tree leaves, branches, and stems that provide coverage above the ground.

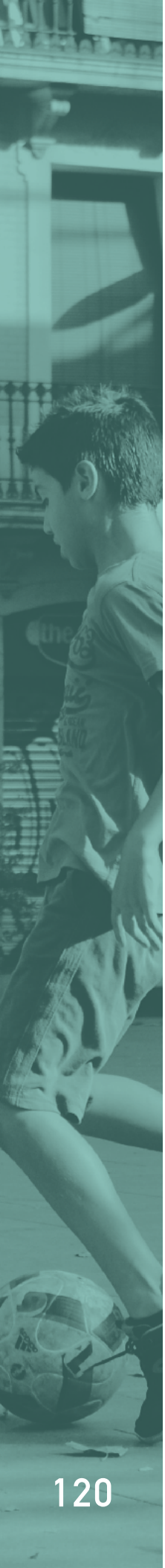
Urban Heat Island – Areas where temperatures are significantly higher than surrounding rural communities, tend to happen in cities.

Urban microclimates – In general, a local set of atmospheric conditions different from adjacent areas, and typically range in size from a few square feet to several square miles; in urban settings, these often take the form of urban heat islands or areas surrounding tall buildings, which cast shadows and absorb heat via brick or concrete surfaces, or reflect light via reflective glass.

Validated scale – A scale used for measuring health that has been tested for its consistency, accuracy, and ability to correctly identify the health condition of interest.

Volatile organic compounds (VOCs) – Naturally-occurring and synthetic chemicals that easily evaporate, react with other compounds and often contribute to human health problems and smog.

Willingness-to-pay – The maximum amount an individual is willing to hand over to procure a product or service.



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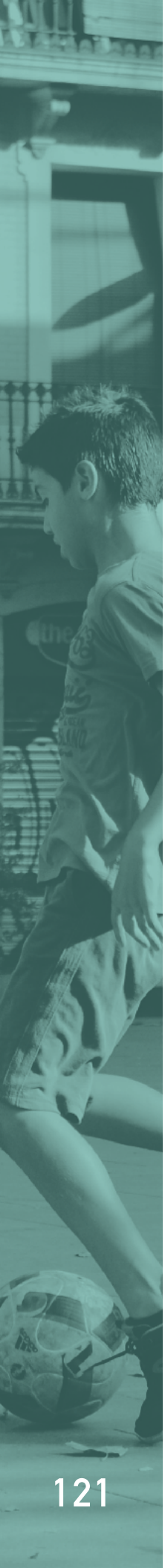

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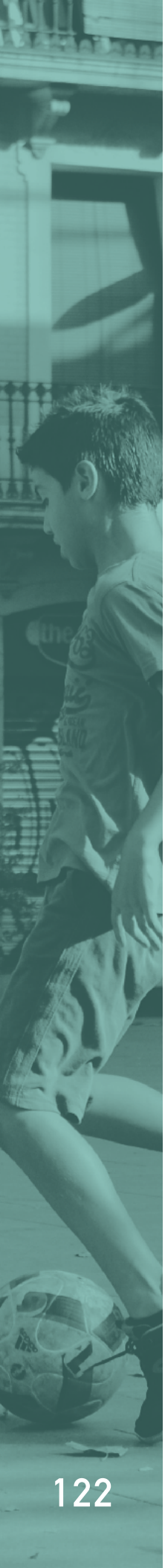

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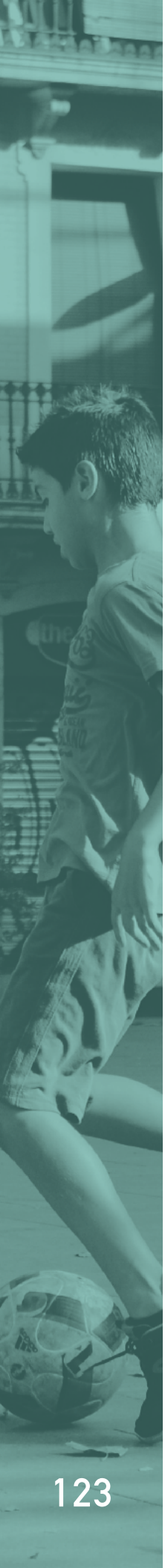

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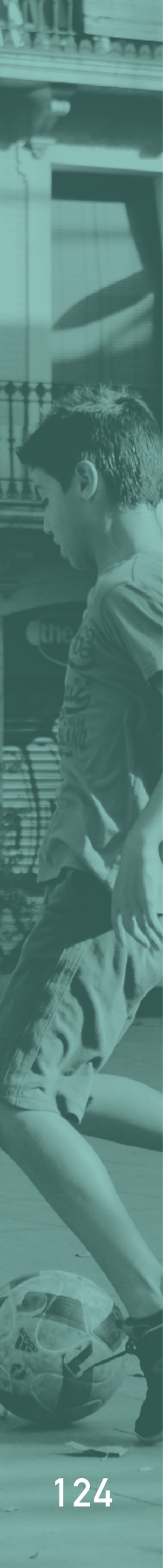

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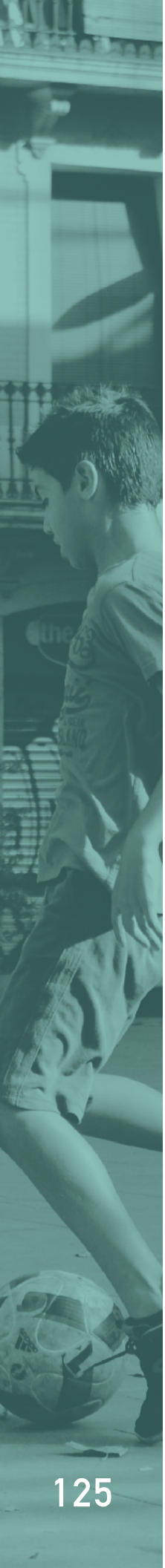

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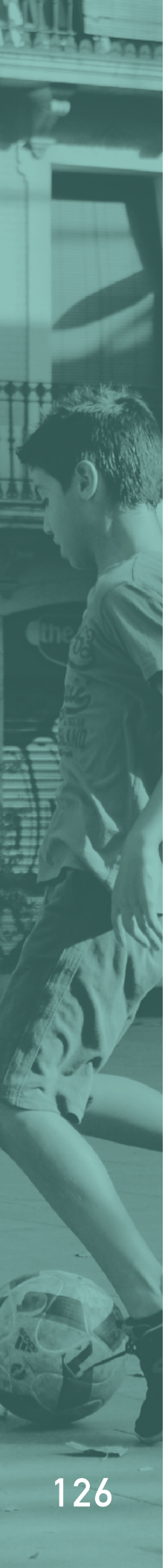

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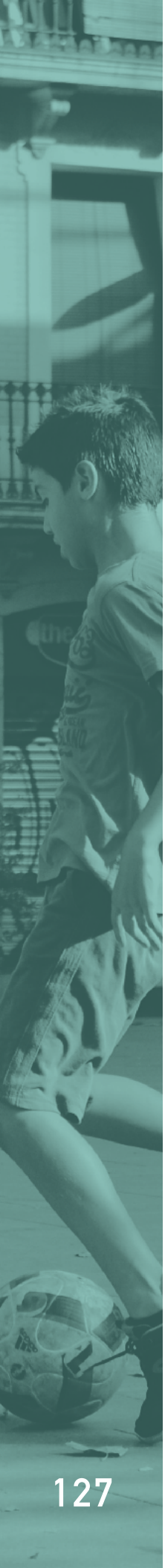

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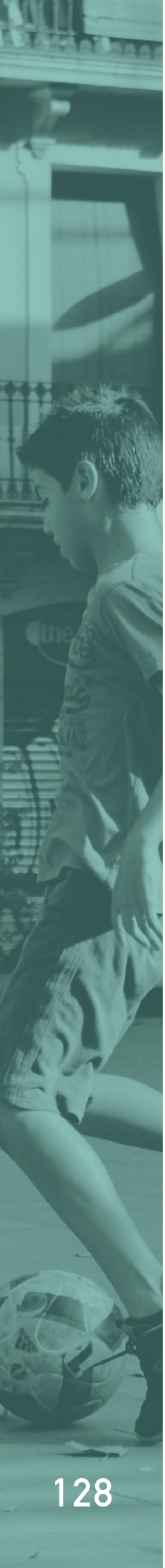

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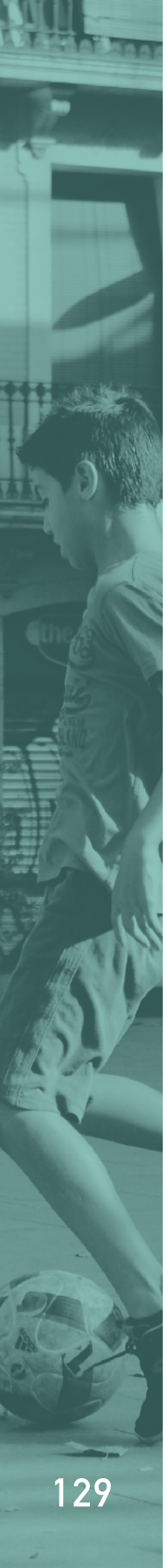

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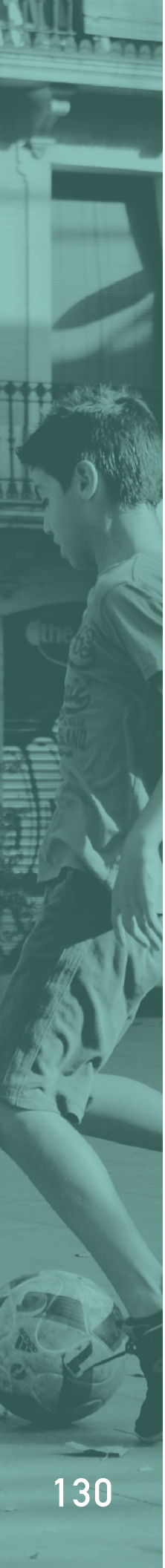

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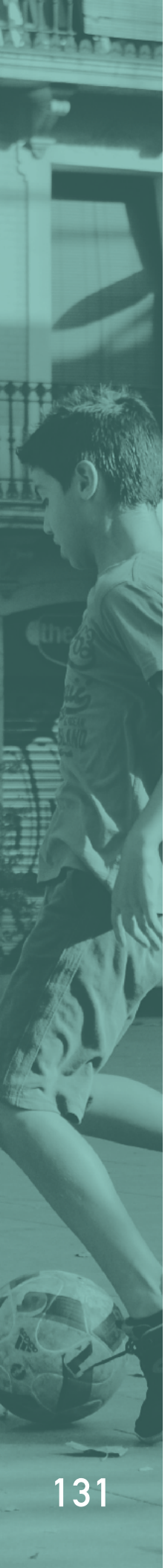

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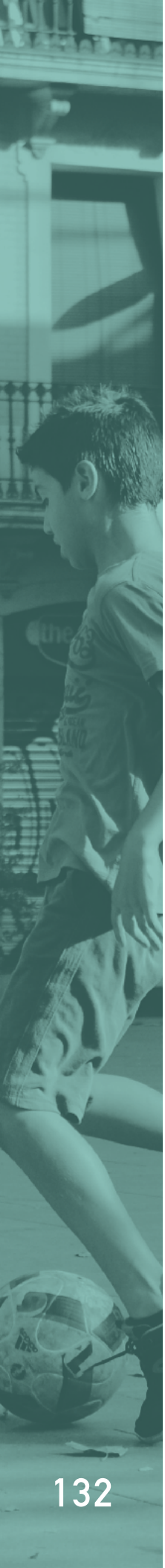

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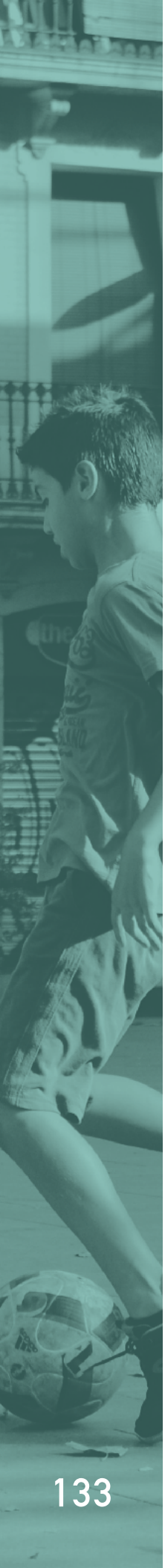

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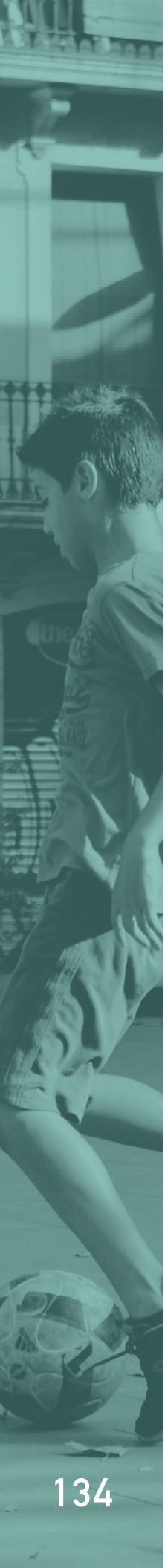

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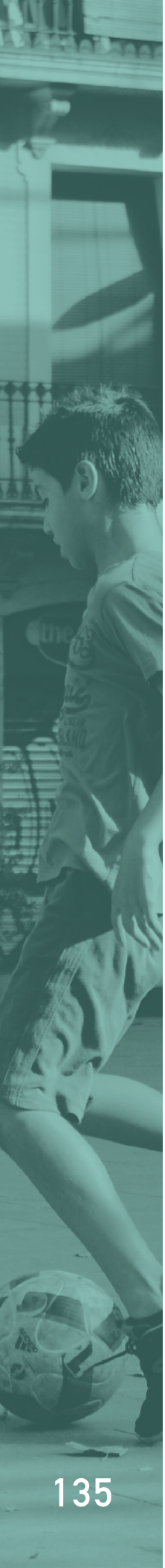

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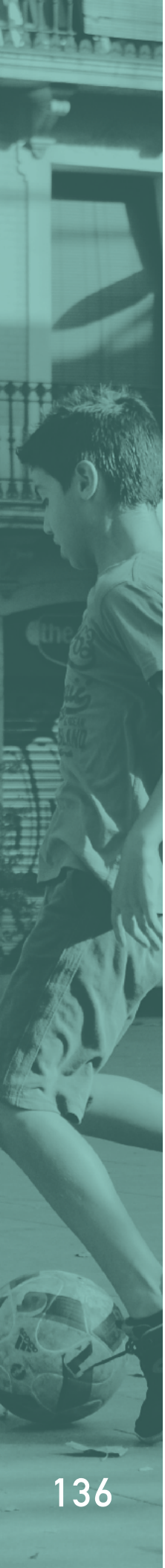

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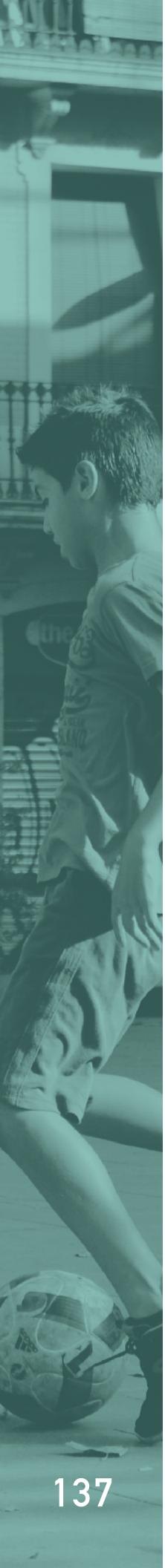

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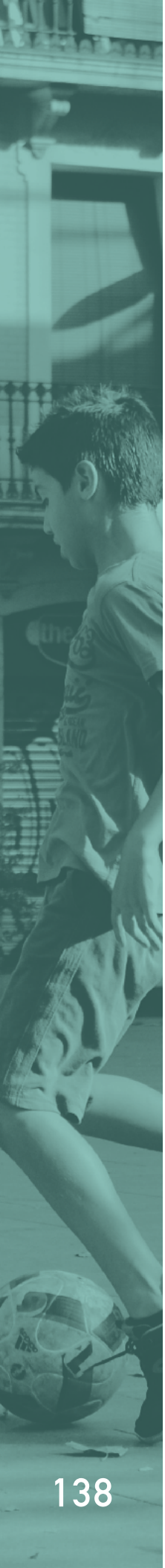

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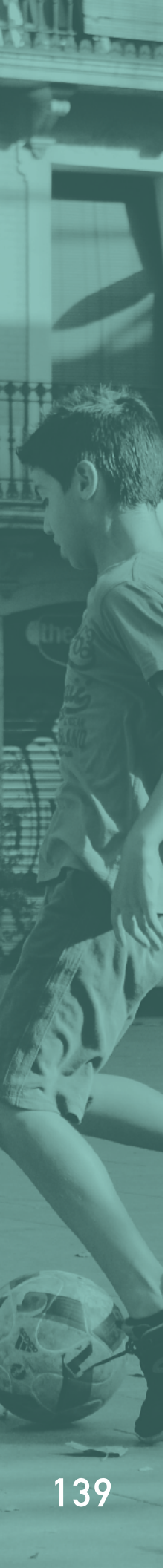

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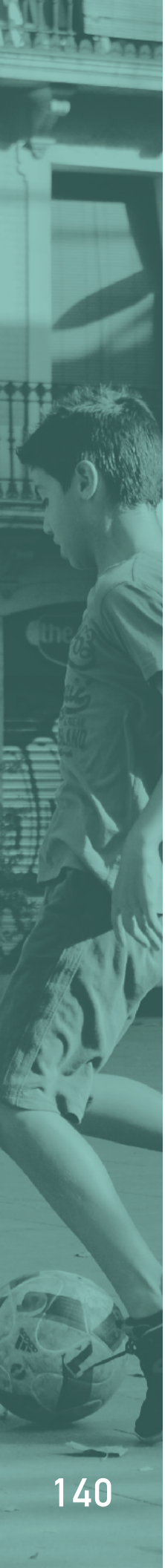

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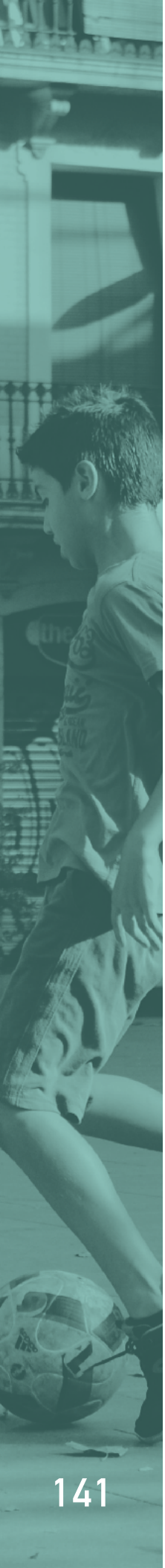

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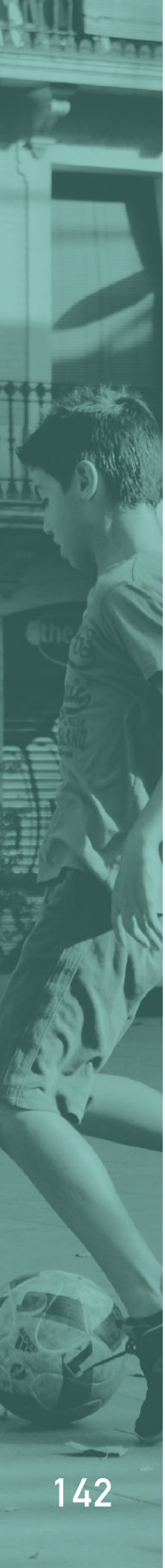

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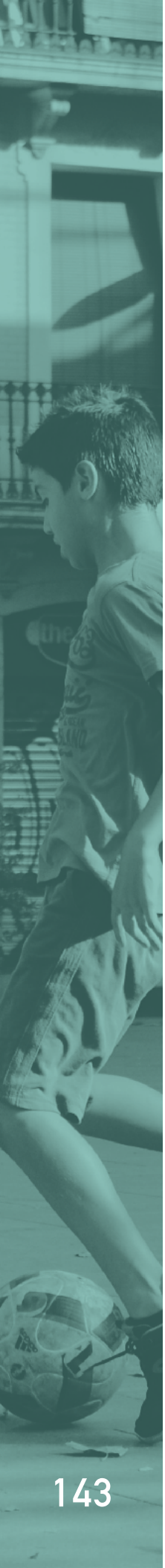

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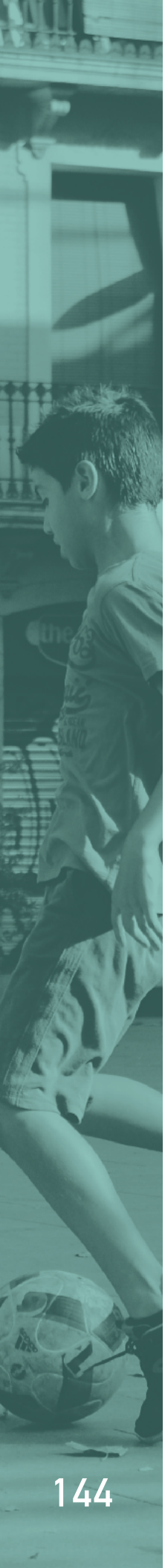

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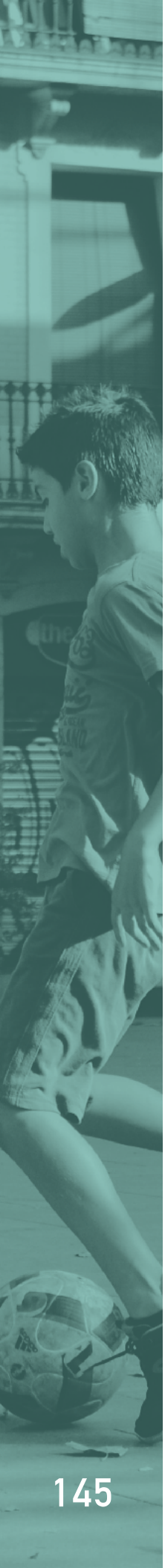

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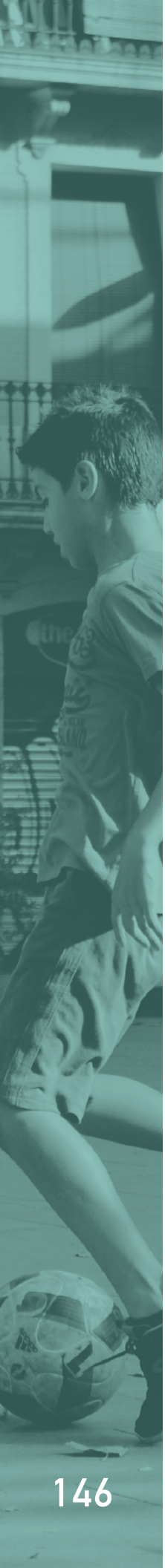

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