

POLICY BRIDGE

A national research agenda supporting green schoolyard development and equitable access to nature

Kathryn T. Stevenson*, Robin Moore†, Nilda Cosco‡, Myron F. Floyd*, William Sullivan‡, Lois Brink§, Dana Gerstein¶, Cathy Jordan**†† and Jaime Zaplatosch††

The diverse benefits of nature are increasingly well-known, but access to nature and its associated benefits are inequitable. In parallel, because school attendance is compulsory, schools are ubiquitous in every community. However, only a small fraction extend classroom settings into outdoor spaces developed as educational resources richly endowed with nature. By greening schoolyards, every community in the United States would provide safe, accessible, natural areas, greatly expanding available educational space and resources benefiting the entire school community. Greening schoolyards offers a promising strategy to ensure all children and communities have access to the health, wellness, learning, and myriad other benefits contact with nature provides. This paper makes the case for green schoolyards as a tool for providing access to nature for all children and sets a research agenda to support that goal.

Keywords: Green schoolyards; Education; Policy; Research agenda; Children & nature; Sustainable communities

Introduction

The benefits of nature are increasingly well-documented and diverse, but they are inequitably distributed. A large and growing body of literature including observational, experimental, and epidemiological studies support a myriad of benefits of access to nature. Exposure to green settings, including urban green spaces, is associated with positive outcomes related to physical health, ranging from cardiovascular health (Duncan et al., 2014) to pregnancy and birth outcomes (Dadvand et al., 2014). Mental health benefits are also diverse, including recovery from stress (Li and Sullivan, 2016), reduced depression (South et al., 2018), restoration of attention (Joye and Dewitte, 2018), and calming our need to scan for threats (Browning and Alvarez, 2019). Community-level benefits of increased exposure to green spaces include increased community cohesion (Peters et al., 2010) and lower crime levels (Wolfe and Mennis, 2012). In addition, green settings are associated with higher academic achievement (e.g., higher scores on standard tests of attention: Kuo, Browning, and Penner, 2018); and pro-environmental behaviors (Stevenson et al.,

2013; Chawla, 2015). However, it is also well documented that access to nature is not equitable. Increasingly, access to nature is a privilege, with low-income communities and communities of color being underrepresented in the use of outdoor spaces (Wen et al., 2013) and having fewer opportunities to engage with nature than their wealthier or white counterparts (Rigolon, 2016). In addition, children in low-income communities may benefit from time in nature to a greater degree than their higher income peers (i.e., the equigenic effect: Mitchell et al., 2015). In short, nature is less accessible to those who would benefit from it most and thus not equitable.

Green schoolyards are “school grounds where natural elements are present and abundant” (Children & Nature Network, 2016a: 4). They may include playground equipment, sports facilities, community gathering spaces, accessible pathways, outdoor classrooms, storage, storm water capture elements, nature play settings, trails, etc. Most critically, they include native vegetation (trees, shrubs, grassland, flowers, etc.), pollinator and/or edible fruit and vegetable gardens, associated animal life, and other natural

* Department of Parks, Recreation and Tourism Management, NC State University, Raleigh, NC, US

† Natural Learning Initiative, Department of Landscape Architecture, NC State University, Raleigh, NC, US

‡ Department of Landscape Architecture, University of Illinois, Champaign, IL, US

§ Department of Landscape Architecture, University of Colorado-Denver, Denver, CO, US

|| The Big SandBox, Philadelphia, PA and Denver, CO, US

¶ Agriculture and Natural Resources Policy Institute, University of California-Berkeley, Berkeley, CA, US

** Institute on the Environment, University of Minnesota, St. Paul, MN, US

†† The Children & Nature Network, Minneapolis, MN, US

Corresponding author: Kathryn T. Stevenson
(kathryn_stevenson@ncsu.edu)

features such as boulders connected to the greater biome surrounding the school (Children & Nature Network, 2016a). Focusing on greening schoolyards improves equitable access to nature on several levels. Because school is compulsory and funded publicly in the United State (U.S.), integrating nature into school grounds would ensure that every child has access to nature in places where they are required to spend a significant portion of their daily lives. Additionally, this benefit would extend to the thousands of adults who work in schools, including teachers, teaching assistants, principals, facility specialists, and volunteers. After hours, benefits would extend to residents of the surrounding neighborhood – especially children and youth. Focusing on schools could increase equitable access to nature in both urban settings, where natural spaces are less common, as well as rural or suburban areas, where natural settings may be ubiquitous, but access is restricted by property lines (Heynen and Robbins, 2005) or access to transportation (Oswald Beiler et al., 2018). Further, across most locales, people of lower income and racial minority status typically live in areas that are less green (Casey et al., 2017; Jennings et al., 2019). As all communities have access to schools, often associated with reliable transportation options, focusing on greening schoolyards is one promising strategy for mitigating these barriers to access to nature.

The green schoolyard or school ground concept has been implemented sporadically for decades but recently, a new wave of interest is rapidly growing internationally (see www.internationalschoolgrounds.org) and nationally. In the U.S., the Children & Nature Network (C&NN) is working with partners toward a goal of establishing a green schoolyard in every community by 2050. Though the focus is on public schools as a mechanism to make equitable change, green schoolyard programs in any sense are congruent with the C&NN goals for healthy children's development, as well as community and environmental benefits (Children & Nature Network, 2017a). Over 120 new and existing partners have signed on to an associated action agenda, which includes goals of 1) a cross-sector national green schoolyards network; 2) communities valuing and promoting green schoolyards; 3) research and metrics to increase the evidence base; 4) sustainable funding; and 5) supportive federal, state, local and school district policies (Children & Nature Network, 2018). The purpose of this paper is to advance goal three, by providing a research agenda for generating, accelerating, and coordinating the research around green schoolyards. We begin by framing the policyscape in which green schoolyards exist and describing how we arrived at this specific research agenda. We then present a research agenda aimed at supporting policy goals to implement green schoolyards across the country. Finally, we propose ways to leverage interdisciplinary research to garner cross-sector support for green schoolyards.

Green schoolyards are impacted by a complex policyscape

Governance and policy structure around public schools varies widely, both within the U.S., and around the world. In the U.S., policy is nested in federal, state, county and

municipal, and local school district levels, with decreasing power of authority. That is, local policy must comply with state and federal policies. However, public schools are funded largely at the state and local levels, and managed most closely by local school districts (Quade, 2018), making it challenging to advocate for policy changes that will promote green schoolyards universally. Accordingly, the work toward affecting change must take into consideration both common challenges and opportunities across school policy contexts as well as acknowledge that specific contexts may demand nuanced approaches.

Acknowledging that specific policy contexts vary widely, we offer a few examples of the types of interests and powers held at each level within the U.S. context. Many federal policies that have the potential to support green schoolyards stem from the Department of Education. For instance, the Department of Education is responsible for ensuring school facilities are safe and education opportunities are equitable. Accordingly, federal education policy could support including green schoolyards in federal assessments of school facilities, adding green schoolyards to assessments of high performing or Green Ribbon schools (Sterrett et al., 2014), or including quality and quantity of green schoolyards in the Office of Civil Rights school report cards (US Department of Education, 2019). Other examples might be encouraging the Environmental Protection Agency to suggest green school yard elements to support municipalities in meeting Clean Water Act standards (US EPA, 2013); the Centers for Disease Control and Prevention (CDC) to integrate green schoolyard elements into the “Whole School, Whole Community, Whole Child” model (Centers for Disease Control and Prevention, 2019); or broadening the definition of the Internal Revenue Service of “community benefit” to include green schoolyards in when completing a Community Health Needs Assessments (Internal Revenue Service, 2019). Encouraging individual state policies commonly include integrating outdoor learning requirements into Environmental Literacy Plans (North American Association of Environmental Education, 2014) or other sustainability initiatives; expanding shared and open land use policies to include green schoolyards (Change Lab Solutions, 2019); or including equity assessments of school ground environments as part of municipal and district planning. These are just a sampling of existing policy levers with potential to support green schoolyards. Given their diversity, overlap, and complexity, it is apparent that the associated work to advance policy must work to identify where there are common barriers and strategies to overcome them.

Several barriers exist to widespread implementation, particularly related to funding and prioritization within increasingly restricted and shrinking school budgets. Benefits such as academic achievement (Tallis et al., 2018), overall student well-being (Chawla, 2015), and teacher retention would be of likely interest to school districts, helping to make the case for green schoolyards even in a complex political environment. However, with persistent testing pressure (Milakovich and Wise, 2019), and mounting demands to attend to basic student needs such as mental health and nutrition (Galindo and Sanders, 2018),

schoolyards fall low on priority funding lists for school systems, arguably because schoolyards are not seen for their potential to address these very needs. In addition, green schoolyards can provide multiple community-level benefits such as increased social cohesion (Peters et al., 2010) and lower crime rates (Wolfe and Mennis, 2012) as well as address storm water quantity and quality (Fitzgerald and Laufer, 2017), which could be of particular interest to municipalities. Yet, with few exceptions such as Chicago, Austin, Denver, and San Francisco, who are using municipal agency funds or voter-approved bonds to help fund schoolyard greening (Children & Nature Network, 2016a), municipalities rarely have the funds or political will to prioritize green schoolyards. A similar challenge is present at the federal level, as large scale initiatives that fall under federal policy often have multiple objectives (e.g., the Every Student Succeeds Act: U.S. Department of Education, 2015), creating a need to generate evidence to advocate for the prioritization of green schoolyards among a long list of objectives.

Development of a research agenda in support of green schoolyards

To fill this need for evidence to support green schoolyards in a complex, diverse, and dynamic polycscape, the Children and Nature Network has supported the generation of a research agenda through a multi-year process with input from a diverse group of experts. The organization itself was formed in 2006 to support a growing

movement around connecting children with the natural world. Through a strategic planning process to maximize access and connection to nature for all children, the organization has supported many initiatives, including Green Schoolyards for Healthy Communities. The Green Schoolyards initiative supported the development of a strategic action agenda, which as stated above, included generating research and metrics to increase the evidence base for the benefits of green schoolyards. To support this specific goal, C&NN conducted an assessment of peer-reviewed research in 2015 and generated a suite of infographics focused on academics, beneficial play, physical activity, and mental health in early 2016 (Children & Nature Network, 2016b). At the beginning of 2017, C&NN also formed a Green Schoolyards Research and Metrics Advisors board (see www.childrenandnature.org/initiatives/schoolyards/advisors/). These Research and Metrics advisors met for a day-long, in-person summit, working to generate an evaluation framework for understanding impacts and opportunities of green schoolyards (Figure 1; Children & Nature Network, 2017b). The framework, and the associated body it draws from, are hence a product of an extensive, iterative process with input from diverse stakeholders, all of whom are experts in their respective fields.

Despite the large amount of research around green schoolyards and the efforts to both document and communicate this evidence, the Research and Metrics Advisors identified a need to further advance research to address the complexity of green schoolyards components and

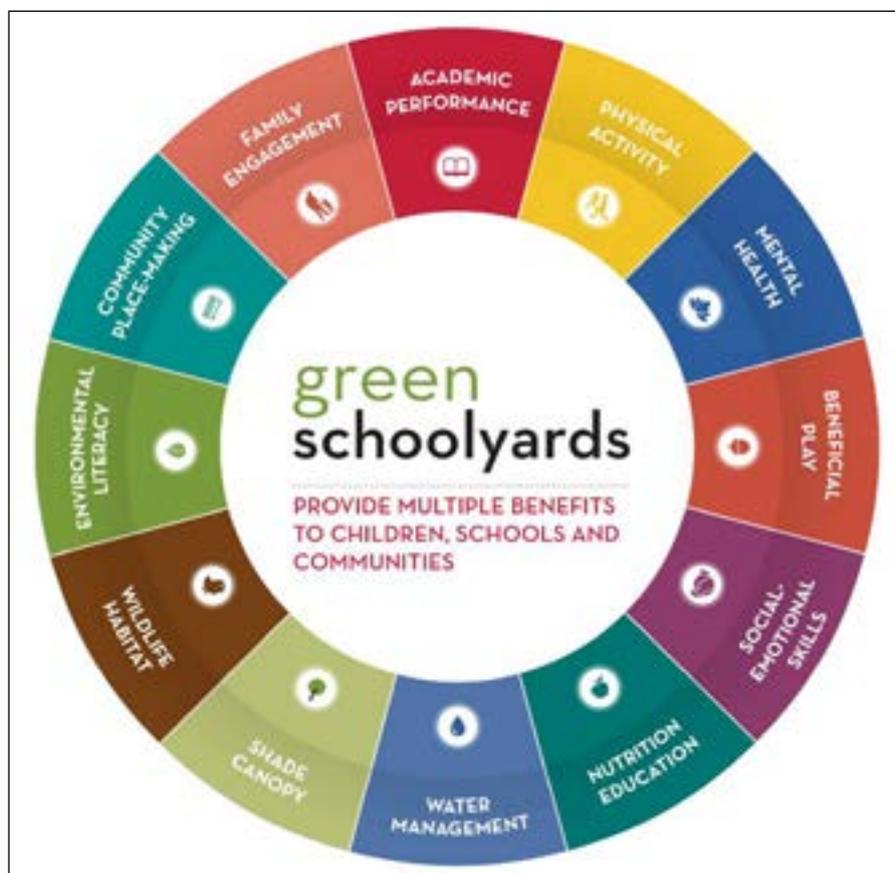


Figure 1: Framework representing the diverse outcomes associated with green schoolyards. Reprinted with permission from Children & Nature Network, 2017b. DOI: <https://doi.org/10.1525/elementa.406.f1>

their supporting programming. These needs were identified as a result of the day-long, in-person summit, as well as nearly a year of conversation and collaboration through conference calls and contributing virtually to a draft of what is now the research agenda we present below. In addition to identifying individual outcomes areas relevant to green schoolyard research and evaluation (**Figure 1**), the Advisors highlighted two additional needs of attending to a) interdisciplinary research and b) strategic research gaps.

Though there is a large and growing body of research around the benefits of green schoolyards (see childrenandnature.org/learn/research; childrenandnature.org/learn/tools-resources; Kuo, Barnes, & Jordan, 2019), by and large, this research does not examine the complexity of green schoolyards or associated programming. Likely because this work is conducted by researchers with specific interests and/or supported by funders with specific priorities, most of the research instead examines isolated benefits in specific cases. These specific cases are encouraging, but more research is needed to make a stronger case for green schoolyards across sectors. A common thread among successful green schoolyard programs in the United States is cross-sector support and cooperation (Children & Nature Network, 2016a). Accordingly, we suggest research that links together complex and interacting benefits of green schoolyards, which can provide insight into key elements that should be coupled for maximum benefit across sectors. For instance, certain design elements can mitigate storm water flooding (Hoang and Fenner, 2016), maximize student engagement (Kuo, Browning, and Penner, 2018), and promote biodiversity (Snäll et al., 2016). Linking such evidence may simultaneously address the funding and prioritization challenges listed above, as it may encourage sectors to find ways to work together to pool resources and political capital.

Secondly, the Metrics and Advisory Board identified several knowledge gaps that may be particularly effective at supporting policies to promote green schoolyards. Here, we refer to strategic research as that with the expressed purpose of accelerating adoption of greening schoolyards, requiring attention to not only what is not known (i.e., research gaps), but what needs to be known (i.e., strategic gaps) to build policy support. These include how green schoolyards impact student, teacher, and community health and well-being; academic achievement; teacher retention and satisfaction; and community cohesion. Additionally, we also see a need for comprehensive cost-benefit analyses of designing and building green schoolyards. To that end, we offer here a research agenda to promote green schoolyards, with the ultimate goal of equitable access to nature for all.

Toward a green schoolyard research agenda

We present the work of the Green Schoolyards Research and Metrics Advisory Board in a suggested research agenda to support adoption of green schoolyard policies across the country, with the goal of providing safe, ubiquitous, and equitable access to nature for all children and communities. The research agenda offers guidance to researchers wishing to contribute to this goal. The agenda

does not represent a coordinated research effort linking together specific researchers or studies, but rather an avenue for researchers from multiple sectors to provide the types of evidence we have identified as most needed to support equitable access to nature through ensuring as many schoolyards as possible are green.

In each section below, we identify outcome areas that we see as potentially convincing to policy makers. In each section, we begin by providing a brief overview of what is already known. Although providing a compendium of this research is beyond the scope of this paper, we offer work done by the Children & Nature Network (noted in links above) as well as a joint research repository reflecting resources from the Children & Nature Network and the North American Association for Environmental Education (naaee.org/our-work/programs/features/eeresearch). Although there are likely other sources, these two are viewed as comprehensive, and represent the only efforts we are aware of to continually gather relevant literature in searchable, accessible formats. We then outline key research questions that we feel would accelerate knowledge growth necessary for ensuring equitable access to nature for all students and communities through green schoolyards.

Academic performance

Although cross sector support is key for successful implementation of green schoolyards (Children & Nature Network, 2016a), schools are certainly part of that equation, and accordingly, we need evidence linking green schoolyards to academic outcomes. Studies have demonstrated that exposure to nature helps individuals recover from the mental fatigue that disrupts attention and concentration that are requisites for academic learning (Kuo, Browning, and Penner, 2018). A quasi-experimental study also found that regular time outdoors during school time was associated with increased reading performance (Otte et al., 2019). Other observational studies also link greenness to academic achievement on several levels. For instance, several spatial analyses have found a positive correlation between greenness and graduation rates (Hodson and Sander, 2019), school greenness and math and English test scores (Tuen Veronica Leung et al., 2019), density of tree cover surrounding schools and various measures of high school academic performance (Li et al., 2019). One study found that test scores were more strongly correlated to the availability of urban trees than poverty (Tallis et al., 2018). Authors offer several explanations for these findings, most linked to decreased stress (Chawla et al., 2014), increased cognitive function (Dadvand et al., 2015), and increased attention (Taylor et al., 2001) associated with exposure to green spaces.

Research in this realm may be difficult (e.g., obtaining student test scores), of tangential interest (e.g., researchers may not put stock in test scores as a legitimate measure of learning), and sometimes even hard to show (Stevenson et al., 2019). However, we suggest that even studies that show that green schoolyards are at least as effective as classroom learning may be beneficial in countering arguments that time outdoors take away from instructional

time (Ernst, 2009; Ernst, 2012; Stevenson et al., 2019). As academic outcomes (i.e., grades, test scores) represent a major policy currency of schools, research in this area is critical to accelerating adoption of green schoolyards so that every child and community has access to nature. Further, as academic achievement gaps tend to parallel gaps in access to nature (Stevenson et al., 2018), we suggest that research in this area could contribute to an argument for how green schoolyards can address both areas of challenge with respect to equity.

In addition to providing evidence linking green schoolyards with student learning, research is also needed to develop best practices for providing curricular activities outdoors, designing schoolyards for diverse learning spaces, and training teachers to use them effectively. Here, we offer several initial research questions:

- Do students who have greater exposure to green schoolyards show the same or even greater academic achievement (e.g., grade, standardized test scores) than their peers who have less exposure?
- What factors encourage teachers to utilize green schoolyards as a teaching tool? For example, what types of professional development, administrative support, and/or attributes of the schoolyard encourage use by teachers?
- Do diverse physical improvements to school grounds (native and pollinator gardens, outdoor classrooms, playground equipment, nature play areas, trees, edible gardens, etc.), make a positive difference to students' perception of school and affective response to being there?
- To what extent are green schoolyards associated with higher levels of student and teacher attendance?

Readers of this paper may already be familiar with, or be interested in, a separate research agenda developed by the Children & Nature Network that focuses solely on nature-based learning (NBL). In 2019, the Oakland Declaration on the vital role of NBL was published, now with almost 130 signatories. These parallel efforts overlap extensively with green schoolyard goals. See Jordan and Chawla (2019) for more suggestions of needed research questions in this area.

Teacher Retention and Satisfaction

In addition to student outcomes, a major concern of schools is teacher retention (Whipp and Geronime, 2017), and linking green schoolyards to teacher-related outcomes may be particularly compelling when making the case for green schoolyards with school districts. Teacher attributes (e.g., high training levels) consistently represent one of the most powerful predictors of student success (Quin, 2017), and schools rightly want to support teachers. We argue that green schoolyards may be part of that equation, and that related evidence may be influential in supporting adoption of green schoolyards by school districts. Forty years of research on how people respond to landscapes shows that urban settings with more nature are more strongly preferred than similar settings without nature (Ordóñez-Barona, 2017). In some of these studies,

the density of neighborhood trees predicts not only satisfaction with one's neighborhood, but also with one's life (Neff et al., 2018). Although few studies have applied these concepts to teachers in school settings, existing evidence suggests that we would find similar trends. High poverty schools are often simultaneously the lowest performing (Reckhow, 2015) as well as the least able to retain teachers (Akiba and Liang, 2014). As with academic achievement, we see research in this area as an opportunity to promote equity in the quality of instruction as well as access to nature. The following research questions are examples of the types of evidence that may be particularly helpful in making the case for green schoolyards as they relate to teacher retention and satisfaction:

- To what extent are teachers who work in schools with green schoolyards more likely to be retained and report higher levels of job satisfaction than their similarly situated peers who do not have green schoolyards?
- What factors related to green schoolyards might influence job satisfaction? Factors might include exposure to the outdoors, opportunities for innovative teaching, or less focus on test preparation.

Social and Emotional Learning

In addition to academic outcomes, recent attention to social and emotional learning (SEL) in education policy (U.S. Department of Education, 2015) signals that evidence linking SEL to green schoolyards may also be compelling to school systems. SEL is the process through which children and adults acquire and effectively apply the knowledge, attitudes, and skills necessary to understand and manage emotions, set and achieve positive goals, feel and show empathy for others, establish and maintain positive relationships, and make responsible decisions (Osher et al., 2016). Bullying and negative social interactions between students are a widespread problem in schools, and evidence suggests that green schoolyards may mitigate these trends by supporting SEL (Bell and Dymont, 2008). Students of color are consistently shown to receive more frequent and severe discipline in schools (Carter et al., 2017), which is linked to several negative outcomes such as lagging academic achievement, failure to graduate high school, and increased likelihood of arrest (Mallett, 2017). We acknowledge the role of factors such as expectation bias in teachers and administrators assigning disciplinary actions disproportionately to students of color in these findings (Gregory and Roberts, 2017). However, we hope that a research focus on green schoolyards and SEL may uncover another area in which green schoolyards and the benefits they provide could help those who need it most. Examples of research questions we identify as needed include:

- What is the relation between built environment and students' positive social interactions?
- To what extent can exposure to green schoolyards decrease negative social interactions?
- To what extent are green schoolyards linked to decreased disciplinary actions in schools? And, if there

is a significant association, are these benefits linked to continued positive outcomes related to academic achievement and school attendance? To what extent may that disproportionately impact students of color?

Individual Health and Wellbeing

Benefits to individual health and well-being appeal across diverse stakeholders, which may make health outcomes one of the most strategic ways to build support for green schoolyards. A focus on health links this work to the healthcare sector, which is one of the only areas that rivals education in public spending (Dutu and Sicari, 2016) and far surpasses it in the private sector (Bauchner and Fontanarosa, 2018). Hence, finding ways to connect green schoolyards to healthcare can couple education and healthcare efforts in terms of communicating benefits and garnering support for both policy and research.

Major health epidemics such as childhood obesity or diabetes will require a multi-pronged approach. Emerging research suggests that access to green spaces can play a promising role. For instance, green schoolyards can increase physical activity and associated health benefits (van Dijk-Wesselius et al., 2018). Natural elements such as trees, logs, and rocks are associated with more active play including running, jumping, and lifting (Bell and Dymont, 2008). Similarly, green schoolyards may provide more appealing opportunities for light to moderate activity than conventional playgrounds for some children (Barton et al., 2008). Research also supports links between green schoolyards and mental health. For instance, exposure to urban spaces with nature helps people recover from stress more quickly than similar spaces with little or no nature (Wells and Evans, 2003; Roe and Aspinall, 2011). Greater exposure to nature is associated with lower levels of the stress hormone cortisol, which may reduce a range of physiological measures of stress (Honold et al., 2016). Both mental and physical health disparities are often coupled with inequities of access to nature and educational achievement, as similar populations often experience disparities in all of these areas (Fiscella and Kitzman, 2009). This is just one example where cross-sector support may be particularly useful in communicating synergistic effects to diverse stakeholders as well as highlighting their benefits.

Although this research area is rapidly expanding, we see opportunities for research to support the case for green schoolyards and draw attention from healthcare sectors. We suggest research on the following:

- To what extent do green schoolyards as a specific space for nature contact increase recovery from the stress students feel?
- When green schoolyards include fruit and vegetable gardens, are they linked to improved nutritional choices made by students?
- Does additional time outdoors for learning beyond recess and physical education increase physical activity and reduce sedentary behavior?
- To what extent do green schoolyards improve physical health of teachers?
- How do the health benefits promoted by green schoolyards fit into the mosaic of other school-based pro-

grams aimed at health outcomes (e.g., school nutrition programs, physical education)? How might green schoolyards integrate with or enhance these programs?

Community Wellbeing

Benefits of green schoolyards to community-level wellbeing may be of particular interest to municipalities. Communities with greater access to nature as measured by tree cover or access to parks have lower theft and violent crime rates (Wolfe and Mennis, 2012) and greater social cohesion (Peters et al., 2010). Note that these studies were conducted in communities where violence and social cohesion were present, highlighting the potential for green schoolyards to contribute to healthy and safe communities. These are accepted by many as basic human rights (BlueSky Funders Forum, 2019; United Nations, 2019) and research supporting how access to green schoolyards may be one of the strongest arguments for how green schoolyards can contribute to an equitable and just society. In many communities, a schoolyard can be a focus of community activity (Valli et al., 2016), providing opportunities to know neighbors and build community ties. This is more likely to be the case if the schoolyard is designed as a shared space for and by the community and is open to the public during non-school hours (Children & Nature Network, 2016a). Although extant research is encouraging and helpful in understanding how to maximize the benefits of green schoolyards to communities, more is needed to strengthen the case. For instance, researchers may ask:

- To what extent do communities around green schoolyards report higher levels of social ties, strength of community, and community efficacy than similar communities that do not have green schoolyards?
- To what extent does physical access to green schoolyards promote these community level benefits?
- What attributes of green schoolyards (e.g., design, design process, associated policies) encourage use by surrounding communities? Which attributes are most associated with community-level outcomes?

Cost-Benefit Analysis

Although all the above would likely be effective in making the case for green schoolyards, economic evidence may be the most powerful. Designing, building, managing, and maintaining green schoolyards requires increased investment. Little published research (if any) addresses the economic impact of green schoolyards. In particular, we underscore the value cost-benefit analyses of green schoolyard projects that recognize the vast amount of resources invested in promoting academic achievement, healthy communities, and their potential benefits outlined above (Kuo, Browning, Sachdeva, et al., 2018; Stevenson et al., 2018). We anticipate such analyses would uncover a favorable return on investment. This gap in the field is impeding the implementation and scaling of green schoolyards because decisions are currently only focused on the front end costs of construction and maintenance of green schoolyards for both new construction and renovation projects, and not the potential economic cost savings

and increased revenues for school districts, municipalities and society. Potential research questions include:

- To what extent are the costs of such investment justified by the benefits to students, teachers, and community members? Do these costs and benefits vary as students age?
- What are the short-term economic savings for green schoolyards? These might include, among others: new parks outside of traditional park district/department boundaries; less vandalism to district property; less maintenance costs due to increased community, school and local business volunteer maintenance; and, decreases in pollutant loading of stormwater in heavy rain events if stormwater is captured on the schoolyard.
- What are the long-term economic cost benefits of green schoolyards, such as lower healthcare costs due to improvements in mental and physical health derived from children, families and community residents using the green space on school grounds?
- What new economic revenue may be generated as a result of green schoolyards in areas such as: increased student enrollment, increased graduation rates, and community organizations' rentals or lease agreements?
- Does the cost-benefit analysis differ for schoolyards in more or less disadvantaged areas?

Moving forward

We hope this short summary will inspire research to support the goal of increasing green schoolyards in every community in the United States and beyond. We invite researchers to join us by contributing to any part of the agenda with which your interests and expertise most align. We imagine scholars from landscape architecture, urban studies, city planning, education (including science education, environmental education, teacher education, education policy and others), economics, conservation biology, nutrition, sociology, parks and recreation, and many others able to provide valuable contributions. Critically, we also request that you report back, early and often, and across disciplines; in journals, but also in popular press articles, at conferences, and through the Children & Nature Network. Although best practices are still emerging for how to maximize implementation and benefits from green schoolyards, it will undoubtedly require cross-sector support and cooperation. This type of communication will be best served by cross-, inter- and trans-disciplinary work, which is best fostered by researchers intentionally sharing their ideas with others outside their normal circles. These activities will be critical to updating the research agenda, including the types of conditions or approaches most needed, the limitations of current work and how to address them, and eventually, moving toward coordinated efforts to investigate collective impact. The Children & Nature Network offers a forum for this through their international conferences and leadership summits, and a growing number of journals (including this one) that prioritize open access and interdisciplinary perspectives. The Children & Nature Network, the North American Association of Environmental Education, and others

also support efforts to communicate research in this area to lay audiences and policy makers as a step in ensuring influences on implementation of green schoolyards. We look forward to your contributions to ensure every child in every community has access to nature and its host of associated benefits.

Funding information

This manuscript was made possible by funding from the W.K. Kellogg Foundation, Kaiser Permanente North California Community Benefits Program and the Pisces Foundation.

Competing interests

The authors have no competing interests to declare.

Author contributions

- Contributed to conception and design: KTS, RM, NC, MFF, WS, LB, DG, CJ, JZ
- Drafted and/or revised the article: KTS, RM, NC, MFF, WS, LB, DG, CJ, JZ
- Approved the submitted version for publication: KTS, RM, NC, MFF, WS, LB, DG, CJ, JZ

References

- Akiba, M** and **Liang, G.** 2014. Teacher Qualification and the Achievement Gap: A Cross-National Analysis of 50 Countries. In: Clark, JV (ed.), *Closing the Achievement Gap from an International Perspective*, 21–40. Dordrecht: Springer Netherlands. DOI: https://doi.org/10.1007/978-94-007-4357-1_3
- Barton, AC, Tan, E** and **Rivet, A.** 2008. Creating Hybrid Spaces for Engaging School Science among Urban Middle School Girls. *Am Educ Res J* **45**(1): 68–103. DOI: <https://doi.org/10.3102/0002831207308641>
- Bauchner, H** and **Fontanarosa, PB.** 2018. Health Care Spending in the United States Compared With 10 Other High-Income Countries: What Uwe Reinhardt Might Have Said. *JAMA* **319**(10): 990. DOI: <https://doi.org/10.1001/jama.2018.1879>
- Bell, AC** and **Dyment, JE.** 2008. Grounds for health: the intersection of green school grounds and health-promoting schools. *Environ Educ Res* **14**(1): 77–90. DOI: <https://doi.org/10.1080/13504620701843426>
- BlueSky Funders Forum.** 2019. Rethink Outside Campaign. Rethink Outside. Available at <https://rethink-outside.org/resources/>. Accessed 2019 Dec 16.
- Browning, MHEM** and **Alvarez, HAO.** 2019 Jul. Editorial commentary: Scanning for threats and natural environments giving our reptilian brains a break. *Trends Cardiovasc Med*: S1050173819300970. DOI: <https://doi.org/10.1016/j.tcm.2019.07.006>
- Carter, PL, Skiba, R, Arredondo, MI** and **Pollock, M.** 2017. You Can't Fix What You Don't Look At: Acknowledging Race in Addressing Racial Discipline Disparities. *Urban Educ* **52**(2): 207–235. DOI: <https://doi.org/10.1177/0042085916660350>
- Casey, JA, James, P, Cushing, L, Jesdale, BM** and **Morello-Frosch, R.** 2017. Race, Ethnicity, Income Concentration and 10-Year Change in Urban Greenness in the United States. *Int J Environ Res Public*

- Health* **14**(12): 1546. DOI: <https://doi.org/10.3390/ijerph14121546>
- Centers for Disease Control and Prevention.** 2019. The Whole School, Whole Community, Whole Child Model. Available at https://www.cdc.gov/healthyouth/wsc/pdf/wsc_fact_sheet_508c.pdf.
- Change Lab Solutions.** 2019. State Memos on Shared Use Liability. Available at <https://www.changelabsolutions.org/product/state-memos-shared-use-liability>. Accessed 2019 Dec 16.
- Chawla, L.** 2015. Benefits of Nature Contact for Children. In: Nasar, JL (ed.), *J Plan Lit* **30**(4): 433–452. DOI: <https://doi.org/10.1177/0885412215595441>
- Chawla, L, Keena, K, Pevec, I and Stanley, E.** 2014. Green schoolyards as havens from stress and resources for resilience in childhood and adolescence. *Health Place* **28**: 1–13. DOI: <https://doi.org/10.1016/j.healthplace.2014.03.001>
- Children & Nature Network.** 2016a. Building a National Movement for Green Schoolyards in Every Community. Available at https://www.childrenandnature.org/wp-content/uploads/2015/03/CNN_GSY_Report2016_Final.pdf. Accessed 2019 Aug 28.
- Children & Nature Network.** 2016b. Schoolyards Infographics. *Children & Nature Network*. Available at <https://www.childrenandnature.org/initiatives/draftschoolyards-infographics/>. Accessed 2019 Dec 16.
- Children & Nature Network.** 2017a. Children & Nature Network 2017–20 Strategic Agenda. Available at <https://www.childrenandnature.org/wp-content/uploads/2018/04/2017-2020-STRATEGIC-AGENDA.pdf>. Accessed 2019 Dec 16.
- Children & Nature Network.** 2017b. Green Schoolyards Evaluation Framework. Available at <https://www.childrenandnature.org/wp-content/uploads/2017/07/CNN-Green-Schoolyards-Evaluation-Framework.pdf>.
- Children & Nature Network.** 2018. Green Schoolyards Action Agenda. Available at <https://www.childrenandnature.org/wp-content/uploads/GSAA-agenda2018.pdf>.
- Dadvand, P, Nieuwenhuijsen, MJ, Esnaola, M, Fornis, J, Basagaña, X, Alvarez-Pedrerol, M, Rivas, I, López-Vicente, M, De Castro Pascual, M, Su, J, Jerrett, M, Querol, X and Sunyer, J.** 2015. Green spaces and cognitive development in primary schoolchildren. *Proc Natl Acad Sci* **112**(26): 7937–7942. DOI: <https://doi.org/10.1073/pnas.1503402112>
- Dadvand, P, Wright, J, Martinez, D, Basagaña, X, McEachan, RRC, Cirach, M, Gidlow, CJ, de Hoogh, K, Gražulevičienė, R and Nieuwenhuijsen, MJ.** 2014. Inequality, green spaces, and pregnant women: Roles of ethnicity and individual and neighbourhood socioeconomic status. *Environ Int* **71**: 101–108. DOI: <https://doi.org/10.1016/j.envint.2014.06.010>
- Duncan, M, Clarke, N, Birch, S, Tallis, J, Hankey, J, Bryant, E and Eyre, E.** 2014. The Effect of Green Exercise on Blood Pressure, Heart Rate and Mood State in Primary School Children. *Int J Environ Res Public Health* **11**(4): 3678–3688. DOI: <https://doi.org/10.3390/ijerph110403678>
- Dutu, R and Sicari, P.** 2016. Public Spending Efficiency in the OECD: Benchmarking health care, education and general administration. *OECD Econ Dep Work Pap Paris* (1278): 0_1, 3, 5–25. DOI: <https://doi.org/10.1787/5jm3st732jnj-en>
- Ernst, J.** 2009. Influences on US middle school teachers' use of environment-based education. *Environ Educ Res* **15**(1): 71–92. DOI: <https://doi.org/10.1080/13504620802710599>
- Ernst, J.** 2012. Influences on and obstacles to K-12 administrators' support for environment-based education. *J Environ Educ* **43**(2): 73–92. DOI: <https://doi.org/10.1080/00958964.2011.602759>
- Fiscella, K and Kitzman, H.** 2009. Disparities in Academic Achievement and Health: The Intersection of Child Education and Health Policy. *Pediatrics* **123**(3): 1073–1080. DOI: <https://doi.org/10.1542/peds.2008-0533>
- Fitzgerald, J and Laufer, J.** 2017. Governing green stormwater infrastructure: the Philadelphia experience. *Local Environ* **22**(2): 256–268. DOI: <https://doi.org/10.1080/13549839.2016.1191063>
- Galindo, C and Sanders, MG.** 2018. Achieving Equity in Education Through Full-Service Community Schools. In: Sheldon, SB and Turner-Vorbeck, TA (eds.), *The Wiley Handbook of Family, School, and Community Relationships in Education*, 511–530. Hoboken, NJ, USA: John Wiley & Sons, Inc. DOI: <https://doi.org/10.1002/9781119083054.ch24>
- Gregory, A and Roberts, G.** 2017. Teacher Beliefs and the Overrepresentation of Black Students in Classroom Discipline. *Theory Into Practice* **56**(3): 187–194. DOI: <https://doi.org/10.1080/00405841.2017.1336035>
- Heynen, N and Robbins, P.** 2005. The neoliberalization of nature: Governance, privatization, enclosure and valuation. *Capital Nat Social* **16**(1): 5–8. DOI: <https://doi.org/10.1080/1045575052000335339>
- Hoang, L and Fenner, RA.** 2016. System interactions of stormwater management using sustainable urban drainage systems and green infrastructure. *Urban Water J* **13**(7): 739–758. DOI: <https://doi.org/10.1080/1573062X.2015.1036083>
- Hodson, CB and Sander, HA.** 2019. Relationships between vegetation in student environments and academic achievement across the continental U.S. *Landsc Urban Plan* **189**: 212–224. DOI: <https://doi.org/10.1016/j.landurbplan.2019.04.027>
- Honold, J, Lakes, T, Beyer, R and van der Meer, E.** 2016. Restoration in Urban Spaces: Nature Views From Home, Greenways, and Public Parks. *Environ Behav* **48**(6): 796–825. DOI: <https://doi.org/10.1177/0013916514568556>
- Internal Revenue Service.** 2019 Sep 20. Community Health Needs Assessment for Charitable Hospital Organizations – Section 501(r)(3). Available at <https://www.irs.gov/charities-non-profits/community-health-needs-assessment-for-charitable-hospital-organizations-section-501r3>. Accessed 2019 Dec 16.

- Jennings, V, Browning, MHEM and Rigolon, A.** 2019. Urban Green Space at the Nexus of Environmental Justice and Health Equity. In: Jennings, V, Browning, MHEM and Rigolon, A (eds.), *Urban Green Spaces: Public Health and Sustainability in the United States*, 47–69. Cham: Springer International Publishing. DOI: https://doi.org/10.1007/978-3-030-10469-6_4
- Jordan, C and Chawla, L.** 2019. A Coordinated Research Agenda for Nature-Based Learning. *Front Psychol* **10**. DOI: <https://doi.org/10.3389/fpsyg.2019.00766>
- Joye, Y and Dewitte, S.** 2018. Nature's broken path to restoration. A critical look at Attention Restoration Theory. *J Environ Psychol* **59**: 1–8. DOI: <https://doi.org/10.1016/j.jenvp.2018.08.006>
- Kuo, M, Barnes, M and Jordan, C.** 2019. Do experiences with nature promote learning? Converging evidence of a cause-and-effect relationship. *Front Psychol* **10**: 305. DOI: <https://doi.org/10.3389/fpsyg.2019.00305>
- Kuo, M, Browning, MHEM and Penner, ML.** 2018. Do lessons in nature boost subsequent classroom engagement? Refueling students in flight. *Front Psychol* **8**: 2253. DOI: <https://doi.org/10.3389/fpsyg.2017.02253>
- Kuo, M, Browning, MHEM, Sachdeva, S, Lee, K and Westphal, L.** 2018. Might School Performance Grow on Trees? Examining the Link Between “Greenness” and Academic Achievement in Urban, High-Poverty Schools. *Front Psychol* **9**. DOI: <https://doi.org/10.3389/fpsyg.2018.01669>
- Li, D, Chiang, Y-C, Sang, H and Sullivan, WC.** 2019. Beyond the school grounds: Links between density of tree cover in school surroundings and high school academic performance. *Urban For Urban Green* **38**: 42–53. DOI: <https://doi.org/10.1016/j.ufug.2018.11.001>
- Li, D and Sullivan, WC.** 2016. Impact of views to school landscapes on recovery from stress and mental fatigue. *Landsc Urban Plan* **148**: 149–158. DOI: <https://doi.org/10.1016/j.landurbplan.2015.12.015>
- Mallett, CA.** 2017. The School-to-Prison Pipeline: Disproportionate Impact on Vulnerable Children and Adolescents. *Educ Urban Soc* **49**(6): 563–592. DOI: <https://doi.org/10.1177/0013124516644053>
- Milakovich, ME and Wise, J-M.** 2019. *Common Core, Local Control, and High-Stakes Testing*. Edward Elgar Publishing. Available at https://www.elgaronline.com/abstract/9781788979450/13_chapter6.xhtml. Accessed 2019 Dec 16.
- Mitchell, RJ, Richardson, EA, Shortt, NK and Pearce, JR.** 2015. Neighborhood Environments and Socioeconomic Inequalities in Mental Well-Being. *Am J Prev Med* **49**(1): 80–84. DOI: <https://doi.org/10.1016/j.amepre.2015.01.017>
- Neff, KD, Long, P, Knox, MC, Davidson, O, Kuchar, A, Costigan, A, Williamson, Z, Rohleder, N, Tóth-Király, I and Breines, JG.** 2018. The forest and the trees: Examining the association of self-compassion and its positive and negative components with psychological functioning. *Self Identity* **17**(6): 627–645. DOI: <https://doi.org/10.1080/15298868.2018.1436587>
- North American Association of Environmental Education.** 2014. State Environmental Literacy Plans: 2014 Status Report. Washington, DC: North American Association of Environmental Education. Available at <https://cdn.naaee.org/sites/default/files/2014-selp.2.25.15.pdf>. Accessed 2019 Dec 16.
- Ordóñez-Barona, C.** 2017. How different ethno-cultural groups value urban forests and its implications for managing urban nature in a multicultural landscape: A systematic review of the literature. *Urban For Urban Green* **26**: 65–77. DOI: <https://doi.org/10.1016/j.ufug.2017.06.006>
- Osher, D, Kidron, Y, Brackett, M, Dymnicki, A, Jones, S and Weissberg, RP.** 2016. Advancing the Science and Practice of Social and Emotional Learning: Looking Back and Moving Forward. *Rev Res Educ* **40**(1): 644–681. DOI: <https://doi.org/10.3102/0091732X16673595>
- Oswald Beiler, MR, Miller, G and Brown, M.** 2018. Transportation and Recreational Infrastructure Development: Transport and Land Use Measures for Public Health Comparisons. *J Urban Plan Dev* **144**(4): 04018030. DOI: [https://doi.org/10.1061/\(ASCE\)UP.1943-5444.0000468](https://doi.org/10.1061/(ASCE)UP.1943-5444.0000468)
- Otte, CR, Bølling, M, Stevenson, MP, Ejbye-Ernst, N, Nielsen, G and Bentsen, P.** 2019. Education outside the classroom increases children's reading performance: Results from a one-year quasi-experimental study. *Int J Educ Res* **94**: 42–51. DOI: <https://doi.org/10.1016/j.ijer.2019.01.009>
- Peters, K, Elands, B and Buijs, A.** 2010. Social interactions in urban parks: Stimulating social cohesion? *Urban For Urban Green* **9**(2): 93–100. DOI: <https://doi.org/10.1016/j.ufug.2009.11.003>
- Quade, Q.** 2018. *Financing Education: The Struggle between Governmental Monopoly and Parental Control*. Routledge. DOI: <https://doi.org/10.4324/9781351292528>
- Quin, D.** 2017. Longitudinal and Contextual Associations Between Teacher–Student Relationships and Student Engagement: A Systematic Review. *Rev Educ Res* **87**(2): 345–387. DOI: <https://doi.org/10.3102/0034654316669434>
- Reckhow, S.** 2015. Beyond Blueprints: Questioning the Replication Model in Education Philanthropy. *Society* **52**(6): 552–558. DOI: <https://doi.org/10.1007/s12115-015-9947-6>
- Rigolon, A.** 2016. A complex landscape of inequity in access to urban parks: A literature review. *Landsc Urban Plan* **153**: 160–169. DOI: <https://doi.org/10.1016/j.landurbplan.2016.05.017>
- Roe, J and Aspinall, P.** 2011. The restorative benefits of walking in urban and rural settings in adults with good and poor mental health. *Health Place* **17**(1): 103–113. DOI: <https://doi.org/10.1016/j.healthplace.2010.09.003>
- Snäll, T, Lehtomäki, J, Arponen, A, Elith, J and Moilanen, A.** 2016. Green Infrastructure Design Based on Spatial Conservation Prioritization and

- Modeling of Biodiversity Features and Ecosystem Services. *Environ Manage* **57**(2): 251–256. DOI: <https://doi.org/10.1007/s00267-015-0613-y>
- South, EC, Hohl, BC, Kondo, MC, MacDonald, JM and Branas, CC.** 2018. Effect of Greening Vacant Land on Mental Health of Community-Dwelling Adults: A Cluster Randomized Trial. *JAMA Netw Open* **1**(3): e180298. DOI: <https://doi.org/10.1001/jamanetworkopen.2018.0298>
- Sterrett, W, Imig, S and Moore, D.** 2014. US Department of Education Green Ribbon Schools Leadership Insights and Implications. *J Organ Learn Leadersh* **12**(2): 1–18.
- Stevenson, KT, Peterson, MN, Bondell, HD, Mertig, AG and Moore, SE.** 2013. Environmental, institutional, and demographic predictors of environmental literacy among middle school children. Patterson RL, editor. *Plos One* **8**(3): e59519. DOI: <https://doi.org/10.1371/journal.pone.0059519>
- Stevenson, KT, Peterson, MN, Carrier, SJ, Strnad, RL, Olson, RA and Szczytko, RE.** 2019. Making the case for a null effects framework in environmental education and K-12 academic outcomes: When “just as good” Is a great thing. *Front Commun* **3**: 59. DOI: <https://doi.org/10.3389/fcomm.2018.00059>
- Stevenson, KT, Peterson, MN and Dunn, RR.** 2018. Leveraging natural capital to solve the shared education and conservation crisis. *Conserv Biol* **32**(2): 490–492. DOI: <https://doi.org/10.1111/cobi.13039>
- Tallis, H, Bratman, GN, Samhouri, JF and Fargione, J.** 2018. Are California Elementary School Test Scores More Strongly Associated With Urban Trees Than Poverty? *Front Psychol* **9**: 2074. DOI: <https://doi.org/10.3389/fpsyg.2018.02074>
- Taylor, AF, Kuo, FE and Sullivan, WC.** 2001. Coping with add: The Surprising Connection to Green Play Settings. *Environ Behav* **33**(1): 54–77. DOI: <https://doi.org/10.1177/00139160121972864>
- Tuen Veronica Leung, W, Yee Tiffany Tam, T, Pan, W-C, Wu, C-D, Candice Lung, S-C and Spengler, JD.** 2019. How is environmental greenness related to students’ academic performance in English and Mathematics? *Landsc Urban Plan* **181**: 118–124. DOI: <https://doi.org/10.1016/j.landurbplan.2018.09.021>
- United Nations.** 2019. Sustainable Development Goals. United Nations Sustainable Development. Available at <https://www.un.org/sustainabledevelopment/sustainable-development-goals/>. Accessed 2019 Dec 16.
- U.S. Department of Education.** 2015. Every Student Succeeds Act (ESSA). Available at <https://www.ed.gov/essa?src=rn>. Accessed 2019 Dec 16.
- US Department of Education.** 2019 Feb 8. Office for Civil Rights. Available at <https://www2.ed.gov/about/offices/list/ocr/index.html>. Accessed 2019 Dec 16.
- US EPA O.** 2013 Feb 22. Summary of the Clean Water Act. US EPA. Available at <https://www.epa.gov/laws-regulations/summary-clean-water-act>. Accessed 2019 Dec 16.
- Valli, L, Stefanski, A and Jacobson, R.** 2016. Typologizing School–Community Partnerships: A Framework for Analysis and Action. *Urban Educ* **51**(7): 719–747. DOI: <https://doi.org/10.1177/0042085914549366>
- van Dijk-Wesselius, JE, Maas, J, Hovinga, D, van Vugt, M and van den Berg, AE.** 2018. The impact of greening schoolyards on the appreciation, and physical, cognitive and social-emotional well-being of schoolchildren: A prospective intervention study. *Landsc Urban Plan* **180**: 15–26. DOI: <https://doi.org/10.1016/j.landurbplan.2018.08.003>
- Wells, NM and Evans, GW.** 2003. Nearby Nature: A Buffer of Life Stress among Rural Children. *Environ Behav* **35**(3): 311–330. DOI: <https://doi.org/10.1177/0013916503035003001>
- Wen, M, Zhang, X, Harris, CD, Holt, JB and Croft, JB.** 2013. Spatial Disparities in the Distribution of Parks and Green Spaces in the USA. *Ann Behav Med Publ Soc Behav Med* **45**(Suppl 1): 18–27. DOI: <https://doi.org/10.1007/s12160-012-9426-x>
- Whipp, JL and Geronime, L.** 2017. Experiences That Predict Early Career Teacher Commitment to and Retention in High-Poverty Urban Schools. *Urban Educ* **52**(7): 799–828. DOI: <https://doi.org/10.1177/0042085915574531>
- Wolfe, MK and Mennis, J.** 2012. Does vegetation encourage or suppress urban crime? Evidence from Philadelphia, PA. *Landsc Urban Plan* **108**(2–4): 112–122. DOI: <https://doi.org/10.1016/j.landurbplan.2012.08.006>

How to cite this article: Stevenson, KT, Moore, R, Cosco, N, Floyd, MF, Sullivan, W, Brink, L, Gerstein, D, Jordan, C and Zapalatosch, J. 2020. A national research agenda supporting green schoolyard development and equitable access to nature. *Elem Sci Anth*, 8: 10. DOI: <https://doi.org/10.1525/elementa.406>

Knowledge Domain: Sustainability Transitions

Domain Editor-in-Chief: Alastair Iles, Environmental Science, Policy and Management, University of California Berkeley, US

Submitted: 22 July 2019 **Accepted:** 06 February 2020 **Published:** 04 March 2020

Copyright: © 2020 The Author(s). This is an open-access article distributed under the terms of the Creative Commons Attribution 4.0 International License (CC-BY 4.0), which permits unrestricted use, distribution, and reproduction in any medium, provided the original author and source are credited. See <http://creativecommons.org/licenses/by/4.0/>.



Elem Sci Anth is a peer-reviewed open access journal published by University of California Press.

