# How Green Schoolyards Create Economic Value

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SOUTHMOOR ELEMENTARY, DENVER. PHOTO COURTESY OF DESIGN CONCEPTS.

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## About the author

Rob Grunewald is an independent economics and public policy consultant. Previously he held economist and analyst positions at the Federal Reserve Bank of Minneapolis from 1993 to 2022. Grunewald has authored over 200 articles and reports on topics ranging from regional economic conditions and banking to education and early childhood research and policy, including a widely cited 2003 paper with Arthur Rolnick, *Early Childhood Development: Economic Development with a High Public Return.* He holds an M.S. in Applied Economics from the University of Minnesota and a B.A. in Economics and Religion from St. Olaf College. Grunewald lives on a rural homestead in northwest Wisconsin with his wife and daughter.


## Acknowledgements

Much of the data and analyses of this report are based on *An Analysis of Learning Landscapes: Lessons Learned for a National Movement* by Lois Brink, chief strategist at The Big SandBox, Inc., and analysts from Autocase Economic Advisory, which estimates the effects of Denver Public Schools' Learning Landscapes on children's learning, environment, health and wellness, and school district-related economic outcomes. Peter Anthamatten, associate professor of geography and environmental sciences at the University of Colorado Denver, contributed analysis on residential property values and populations proximate to Learning Landscape schools. Children & Nature Network's Priya Cook, director of green schoolyards and communities, and Cathy Jordan, consulting director of research, advised on existing green schoolyard-related research and provided feedback on report drafts. Timothy Bartik, senior economist at the W.E. Upjohn Institute for Employment Research, provided feedback on an earlier draft. The report was commissioned by Children & Nature Network.


OAKLAND ELEMENTARY, DENVER. PHOTO COURTESY OF LOIS BRINK.

# Executive Summary

Converting paved schoolyards at elementary schools to nature-filled green schoolyards creates economic value by boosting children's learning, enhancing environmental sustainability, and supporting community development and health. A green schoolyard is a nature-filled, multi-functional school ground that offers spaces to play, learn, explore, and grow. Natural elements include trees, native plants, and vegetable gardens.

During the school day children are more active on green schoolyards. This additional time spent in nature is associated with reducing stress and restoring attention span – both of which can benefit children's learning. According to results from a study of green schoolyard conversions at Denver's public elementary schools, the districtwide student mobility rate decreased 7 percentage points on average after a conversion.[1] These results are based on a quasi-experimental design that compares school-level trends prior to implementation with trends post-implementation against data from unconverted schools over the same period. Lower student mobility is associated with stronger academic achievement which, years later, can nudge high school graduation rates higher and improve employment and income outcomes.

Due to increased tree canopy and vegetation, the Denver study estimates an average 15-degree reduction in the average ambient temperature during the summer months. Across all the converted schoolyards, the study estimates average annual sequestration of nearly 1,300 tons of carbon and removal of 400 pounds of air pollutants. And based on a sample of three schools, rainwater runoff decreased by an estimated average of 241,000 gallons annually. Each of these contribute to climate change adaptation and resilience and stronger community health.

Green schoolyards have similar benefits as a neighborhood park when they are open to the community after school hours, including weekends and summers, like they are in Denver. As reflected in research on community parks, green schoolyards are associated with increased residential property values and local property tax revenue, community cohesion, and public safety. They also facilitate increased physical activity and can positively affect mental health for all ages, reducing the risks of costly chronic diseases.

A green schoolyard conversion moves indicators across several different sectors and therefore doesn't depend on gains in just one domain to achieve robust value. Furthermore, many

CONSERVATORY GREEN MIDDLE SCHOOL, DENVER. PHOTO COURTESY OF DESIGN CONCEPTS.

[1] The Big SandBox, Inc., & Autocase Economic Advisory. (2023). *An Analysis of Learning Landscapes: Lessons Learned for a National Movement.* Grant report commissioned by Children & Nature Network. Student mobility rate refers to the percentage of students who leave a school during the school year.

# Executive Summary

of the benefits accrue not only to the children who attend schools with green schoolyards, but to society as a whole, a condition that generally leads to underinvestment. Schoolyard conversions also have implications for equity, as paved schoolyards are more concentrated in low-income and racially and ethnically diverse urban neighborhoods.

This report reviews research on the effects of green schoolyard conversions, identifies outcomes with economic implications, converts those outcomes to dollar values, and compares the sum of those values with the cost of a green schoolyard conversion. Additional research is needed to fully estimate the economic value of green schoolyard benefits relative to costs. However, across statistical estimates of environmental sustainability outcomes and local property tax revenue increases, 60 cents are returned for every dollar invested.

Economic effects on children's learning and community health are also likely considerable. Since statistical estimates are not available, a hypothetical example is included for each domain. A modest gain in either the high school graduation rate or improvements in community health would produce a positive return on investment, that is, a ratio of benefits-to-costs above $1 for every dollar invested. The report concludes by showing how modest gains in both high school graduation rates and community health could achieve a return of over $3 for every dollar invested.

| Prospective Economic Effects of Green Schoolyards | |
|---|---|
| **Children's learning and health** | Increase student achievement and high school graduation rate |
| | Improve children's long-term health |
| **Environmental sustainability** | Reduce air temperature |
| | Sequester carbon |
| | Remove air pollutants |
| | Increase stormwater capture |
| | Increase pollinator habitat |
| | Increase children's long-term sustainability behaviors |
| **Community development and health** | Increase residential property values and local property taxes |
| | Boost community cohesion and public safety |
| | Improve community physical and mental health |

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# Introduction

ELLIS ELEMENTARY, DENVER. PHOTO COURTESY OF BRENDA KESSLER.

ELLIS ELEMENTARY, DENVER. PHOTO COURTESY OF PRIYA COOK.

## Introduction

I was in fourth grade when I walked outside for recess on my first day of school after my family moved to a new city in southern Wisconsin. I was met by an asphalt schoolyard with metal playground equipment, a tetherball court, and basketball hoops. It was the middle of winter, so snow covered the painted lines for four-square games and a small patch of lawn. At the time, paved outdoor schoolyards like this one were common in smaller cities and large urban areas throughout the country.

Forty years later, several communities are converting asphalt and other hard-surface playgrounds to green schoolyards by planting trees and other vegetation, creating play areas with both synthetic playground equipment and loose natural elements, and making space for vegetable gardens. But at many more schoolyards, asphalt with sparse tree cover and vegetation remains the norm, including at my old elementary school.

### *What is a green schoolyard?*

A green schoolyard is a nature-filled, multi-functional school ground that offers spaces to play, learn, explore, and grow. Natural elements may include trees, native plants, and vegetable gardens. Green schoolyards also offer multiple play areas with both synthetic playground and nature play features that include loose natural materials such as stumps, logs, river rocks, and sand. While green schoolyards may also include paved areas for court sports like basketball, they are balanced by diverse natural play areas. Many green schoolyards also include outdoor classrooms where teachers can engage children in hands-on, nature-based learning activities.

Environmental sustainability is a key design feature in green schoolyards, such as converting impervious surfaces to permeable surfaces and installing other features to capture stormwater and reduce runoff. Green schoolyards typically feature trees and vegetation that reduce ambient temperatures, sequester carbon, remove air pollutants, and increase pollinator habitats.

Green schoolyards are often open for community use during evenings, weekends, and summers when school is not in session, increasing access to park space with opportunities for physical activity and connecting with neighbors. Community members may also have opportunities to volunteer with maintaining green schoolyards.

### *Applying economic analysis to green schoolyards*

Green schoolyards have a variety of benefits for children's learning and health, environmental sustainability, and community development and health. This analysis walks through research on green schoolyards and highlights connections to economic value, identifying which sectors and communities likely benefit the most.

To do so, the analysis focuses on research that establishes measurable outcomes associated with green schoolyards with an emphasis on studies that establish causal connections to those outcomes. The analysis then identifies outcomes that have economic implications, converts those outcomes to dollar values, and compares the sum of those values with the cost of a green schoolyard conversion.

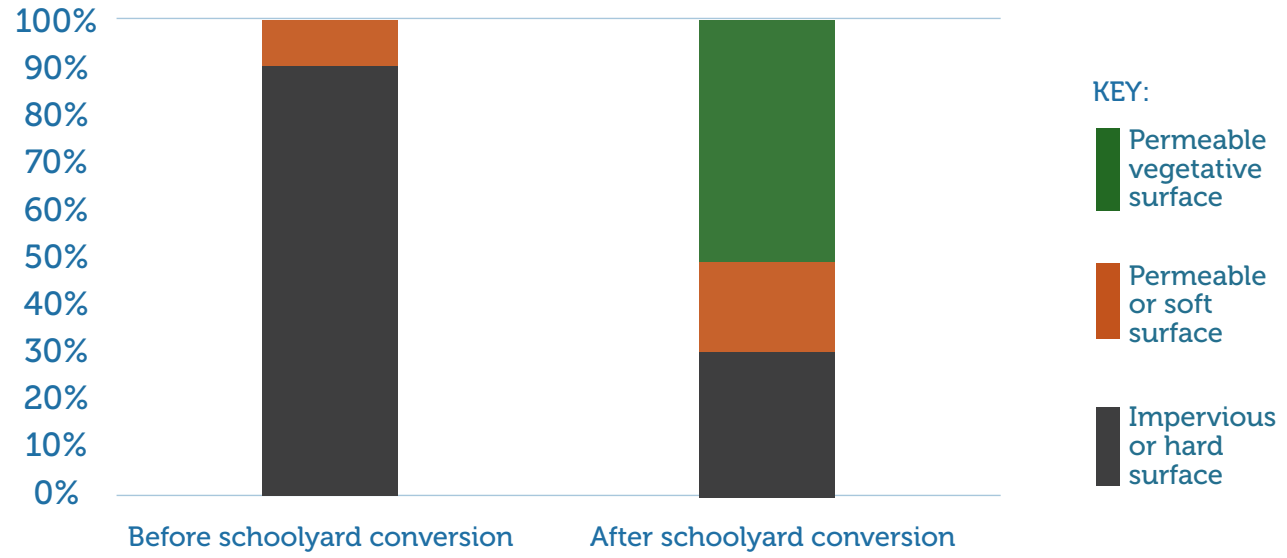
*Denver as a case study*

A large-scale green schoolyard conversion project in Denver illustrates the benefits of green schoolyards. From 2000 to 2012, Denver Public Schools (DPS) converted 99 elementary schoolyards encompassing 306 acres to "Learning Landscapes."

Learning Landscapes combine natural elements, spaces for physical activity and creative play, and educational elements such as historical timelines and quotations to help children learn as they play. Distinctive features of Learning Landscapes include outdoor classroom and STEM elements, grass playing fields, vegetable gardens, nature play areas, and habitat areas. An average Learning Landscapes schoolyard is just over three acres; schoolyard conversions cost an average of $630,012 (dollar values throughout the report are converted to 2022 dollars using the Consumer Price Index).

Prior to Learning Landscape conversions, surfaces categorized as impervious or hard comprised 90% of an average DPS schoolyard; permeable or soft surfaces comprised 10%.[2] After the conversions, permeable vegetative surfaces comprised 51% of an average schoolyard, permeable or soft surface 18%, and impervious or hard surface comprised 31% (see chart).

**Composition of average Denver elementary schoolyard surfaces before and after Learning Landscapes conversions**




[2]Impervious/hard surface includes asphalt and smooth, bare, packed soil, while permeable/soft surface includes play/pit/soft surface and irrigated and unirrigated landscape.

# Before & After in Denver

PHOTOS COURTESY OF LEARNING LANDSCAPES





Children & Nature Network funded a statistical analysis conducted by The Big SandBox, Inc. and Autocase Economic Advisory to estimate effects of Learning Landscapes on children's learning, environment, health and wellness, and DPS-related economic outcomes. Several small studies investigate the relationship between green schoolyards and outcomes within one domain, but the Denver study is the first to use longitudinal data from a districtwide green schoolyard conversion project in a large urban school district to estimate effects across multiple domains.[3]

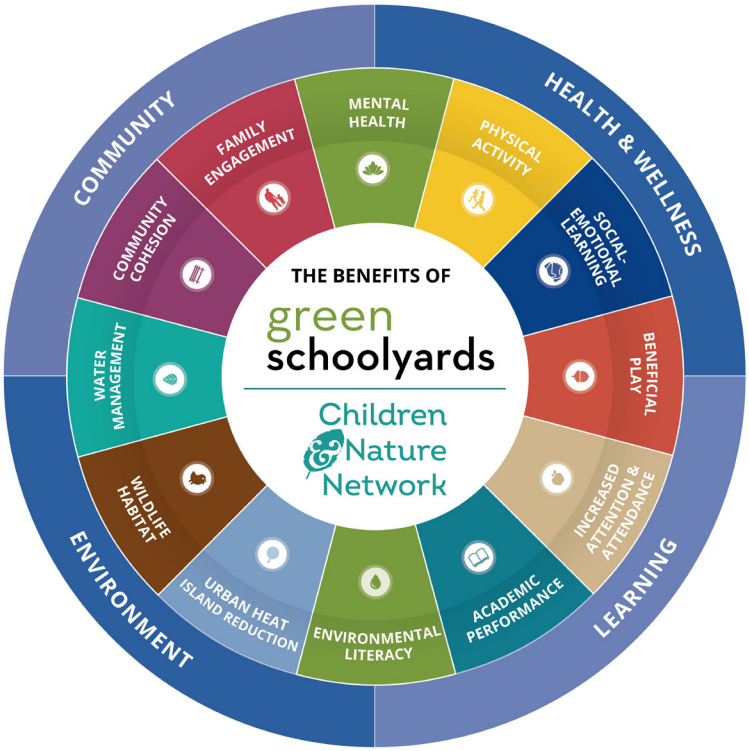
The study takes advantage of the rolling implementation of Learning Landscapes over 12 years to compare school-level trends prior to implementation with trends post-implementation against data from unconverted schools over the same period, including Denver schools that converted schoolyards later in the 12-year period and a group of elementary schools in neighboring districts. This quasi-experimental design allows for causal claims for some outcomes, not just correlational evidence.[4]

*What the evidence reveals*

The Denver study, combined with previous research, pushes the evidence base closer to, and in some cases reaches, the conditions necessary to establish causal relationships between schoolyard conversions and outcomes that can convert to monetary values. A key finding from the Denver study and other green schoolyard evidence is that many of the benefits accrue not only to the children who attend schools with green schoolyards, but to society as a whole, a condition that generally leads to underinvestment.[5]

Furthermore, green schoolyards cross a diverse group of stakeholders in education, environmental sustainability, public health, and community development. They also have implications for equity as asphalt schoolyards are more concentrated in low-income and racially and ethnically diverse urban neighborhoods.[6] Based on the evidence below, green schoolyards are a strategy that can help close gaps in education attainment, health outcomes, and community investment often found between low-income communities and more affluent ones.

While more research is needed, evidence related to the economic value of green schoolyards and the broad reach of their benefits makes a solid circumstantial case that the value of green schoolyards is likely larger than costs. The next three sections look deeper into the effects of green schoolyards on children's learning and health, environmental sustainability, and community development and health. The report concludes with an analysis of the economic value of green schoolyard benefits relative to costs, recommendations for future green schoolyard research, and a discussion on green schoolyard implementation and financing through cross-sector collaboration.




[3] The Big SandBox, Inc., & Autocase Economic Advisory. (2023). *An Analysis of Learning Landscapes: Lessons Learned for a National Movement.* Grant report commissioned by Children & Nature Network.
[4] For example, a section of the analysis uses a difference-in-differences approach that compares differences between a treatment group and a control group before and after the treatment year.
[5] When benefits of a product or service spill over to external parties, markets will produce too little relative to the societal benefits associated with the product or service.
[6] Trust for Public Land. (2021). *Community Schoolyards Projects: A Game-Changing Solution to America's Park Equity Problem.*

# Children's Learning and Health


UNIVERSITY PARK ELEMENTARY, DENVER. PHOTO COURTESY OF LOIS BRINK.

## Children's Learning and Health

Strengthening children's learning and health can place children on a trajectory toward success that lasts well into adulthood. Not only do children benefit, but so does society. Children who succeed in school and graduate from high school grow up to become adults who, on average, earn more income, pay more in taxes, and are less likely to commit crime or need social services.

Green schoolyards have several elements associated with supporting children's learning and physical and mental health and the interaction among them. That is, the effects of green schoolyards on physical health, social-emotional well-being, and student achievement accumulate in value and reinforce each other.

*How green schoolyards support children's learning*

Research shows that children are more active and less sedentary on schoolyards with natural features, diverse play areas, and moveable materials. A 2010 study of the Learning Landscapes schoolyards in Denver found that children attending schools with schoolyard renovations were more physically active in schoolyards than children attending schools without renovations.[7] Another study found that children were more physically active in parts of schoolyards with increased density of playground features, a common trait of green schoolyards.[8] Reflecting on my own fourth-grade experience, the play areas of an asphalt schoolyard were primarily built for court sports and the children who liked and were skilled at these games. Trees, vegetation, and moveable natural materials offer many more options for children to move, explore, and create.[9]

Not only does increased physical activity help children release energy and feel refreshed for classroom learning, exposure to nature itself, such as the natural elements found on green schoolyards, can reduce stress and restore attention.[10] Environmental psychology research shows that direct perceptual experience of nature can help counteract the effects of stress and boost recovery from mental fatigue.[11] Even nature viewed through a school's windows supports stress recovery.[12]

Meanwhile, researchers in the Netherlands observed positive effects of green schoolyards on both physical activity and post-recess attention restoration when comparing children who had access to a recently converted schoolyard with children who played on an unrenovated, paved schoolyard.[13]

Green schoolyards often include school gardens, which are also linked with increased student engagement and reductions in sedentary behavior.[14] Green schoolyards and gardens are also associated with more

[7] Brink, L.A., Nigg, C.R., Lampe, S.M.R., Kingston, B.A., Mootz, A.L., & van Vliet, W. (2010). Influence of Schoolyard Renovations on Children's Physical Activity: The Learning Landscapes Program. *American Journal of Public Health,* 100(9).
[8] Anthamatten, P., Fiene, E., Kutchman, E., Mainer, M., Brink, L., Browning, R., & Nigg, C.R. (2014). A Microgeographic Analysis of Physical Activity Behavior Within Elementary School Grounds. *American Journal of Health Promotion, 28*(6). Bohnert, A. M., Nicholson, L. M., Mertz, L., Bates, C. R., & Gerstein, D.E. (2021). Green schoolyard renovations in low-income urban neighborhoods: Benefits to students, schools, and the surrounding community. *American Journal of Community Psychology 69*(3–4), 463–473.
[9] Samborski, S., (2010). Biodiverse or barren school grounds: Their effects on children. *Children, Youth and Environments, 20*(2), 67-115.
[10] Chawla, L., Keena, K., Pevec, I., & Stanley, E. (2014). Green schoolyards as havens from stress and resources for resilience in childhood and adolescence. *Health & Place 28*, 1–13.
[11] Joye, Y., & Dewitte, S. (2018). Nature's broken path to restoration. A critical look at Attention Restoration Theory. *Journal of Environmental Psychology*, *59,* 1–8.
[12] Li, D., & Sullivan, W. C. (2016). Impact of views to school landscapes on recovery from stress and mental fatigue. *Landscape and Urban Planning*, 148, 149-158.
[13] van Dijk-Wesselius, J.E., Maas, J., Hovinga, D., van Vugt, M., & van den Berg, A.E. (2018). The impact of greening schoolyards on the appreciation, and physical, cognitive and social-emotional well-being of schoolchildren: A prospective intervention study. *Landscape and Urban Planning, 180,* 15-26.
[14] Khan, M., & Bell, R. (2019). Effects of a School Based Intervention on Children's Physical Activity and Healthy Eating: A Mixed-Methods Study. *International Journal of Environmental Research and Public Health, 16*(22).

cooperative behaviors among students and reductions in physical and verbal conflicts.[15] And when green schoolyards are used during instructional periods, research indicates that children are more engaged with the subject material.[16]

*Connections between children's learning and student achievement*

Reducing stress while increasing physical activity, attention restoration, cooperative behaviors, and engagement with subject material all create a positive environment for learning. To establish the economic value of green schoolyards related to children's learning, we investigate how the positive effects on learning environments may affect student achievement measures, including high school graduation rates.

For context, improving student achievement is a vexing issue for policymakers as test scores have made limited gains over the past few decades and remain well behind those of students in many other countries.[17] Furthermore, the list of successful school-age education-based interventions that demonstrate impact on student achievement is relatively short.[18] While a green schoolyard conversion may move the needle on student achievement, we don't expect it to be the only solution. With that said, the Denver study of elementary schoolyard conversions does offer several outcomes related to student achievement.[19]

The student mobility rate at Denver elementary schools decreased 7 percentage points on average after converting to a green schoolyard, equivalent to cutting the districtwide elementary school student mobility rate by as much as one-third.[20] Reducing student mobility benefits those students who move less, or not at all, as well as the overall school learning environment. Research shows that changing schools can disrupt relationships with peers and teachers and alter a student's education program in ways that have negative consequences for achievement test scores and high school graduation.[21]

At the school level, one research study shows that higher student mobility induced by residential moves imposes negative effects on achievement test scores at the receiving school.[22] That is, student turnover at a school, particularly during the school year, not only affects students who move, but the student body as a whole at the receiving school. As discussed above, due to the quasi-experimental design used in the study, the reduction in the student mobility rate is likely caused by the green schoolyard conversions, not just correlated with them.

The Denver study also shows a small increase in a school-level student performance framework measure[23] and a small decrease in the truancy rate equivalent to over 700 fewer unexcused absence days districtwide. Post schoolyard conversion data on math and writing growth indicates that Denver

[15] Raney, M.A., Hendry, C.F., & Yee, S.A. (2019). Physical Activity and Social Behaviors of Urban Children in Green Playgrounds. *American Journal of Preventive Medicine, 56*(4), 522-529. Pollin, S., & Retzlaff-Fürst, C. (2021). The School Garden: A Social and Emotional Place. *Frontiers in Psychology*, 12.
[16] Kuo, M., Browning, M.H.E.M., & Penner, M.L. (2018). Do Lessons in Nature Boost Subsequent Classroom Engagement? Refueling Students in Flight. *Frontiers in Psychology, 8*.
[17] Hanushek, E.A. (2021). United States: The Uphill School's Struggle. In: Crato, N. (ed) *Improving a Country's Education*. Springer Link.
[18] Grunewald, R., & Nath, A. (2019). A Statewide Crisis: Minnesota's Education Achievement Gaps. Federal Reserve Bank of Minneapolis. See pages 26-29 for examples of initiatives that boost outcomes for children from minority groups or low-income families.
[19] Denver study results reported here are statistically significant at 95% level.
[20] Student mobility rate is calculated as total mobility incidences of all elementary school students divided by the number of elementary school students over a 1-year period.
[21] Rumberger, R. W. (2015). *Student Mobility: Causes, Consequences, and Solutions*. National Education Policy Center, University of Colorado.
[22] Bradbury, K., Burke, M. A., & Triest, R. K. (2015). Within-School Spillover Effects of Foreclosures and Student Mobility on Student Academic Performance. Working paper No. 15-6. Federal Reserve Bank of Boston.
[23] Colorado Department of Education website. (2023). Performance Framework Reports and Improvement Plans. Accessed December 7, 2023.

HARRINGTON ELEMENTARY, DENVER. PHOTO COURTESY OF LOIS BRINK.

elementary schools had higher growth than comparison elementary schools in districts bordering Denver (8.5% versus 5.4% annually, respectively). While it's not known whether Denver schools already had higher math and writing growth before schoolyard conversions,[24] these findings are consistent with previous research that links characteristics of green schoolyard conversions with improved academic performance. For example, tree cover on schoolyards at Chicago public schools predicted statistically better school performance on standardized math tests with marginally statistically significant results for reading, even after controlling for poverty and minority status.[25] Research also indicates a relationship between school gardens and related experiential curriculum and students' academic performance.[26]

While not definitive, research on the relationship between green schoolyards and children's learning points to a likely impact on student achievement and related test scores.[27]

### *How green schoolyards may affect student achievement trajectories*

To estimate the economic value of gains in children's learning we can consider potential changes in student achievement trajectories, such as high school graduation. Changing the trajectory of students who are likely to drop out of high school to graduating from high school generates substantial economic benefits, much of which accrue to graduates as they move into the labor force as adults. For example, median earnings for a high school graduate aged 25 and over with no college are 25% higher than those for a worker without a high school degree.[28] But taxpayers also benefit from higher high school graduation rates due to increased tax revenue and reductions in social service costs, including costs associated with crime. Present value estimates of public benefits associated with an additional high school graduation are estimated at $97,000 while private (individual) benefits from increased earnings are estimated at $261,000.[29]

To the extent that green schoolyards impact achievement scores in elementary school, research shows that third-grade achievement is predictive of high school graduation. That is, if green schoolyards can improve student achievement in elementary school, they likely have a positive impact on high school graduation rates.

For example, an analysis of data from a nationally representative longitudinal survey finds that 16% of children who are not reading proficiently by the end of third grade do not graduate from high school on time,

[24] Without data prior to schoolyard conversions, it is difficult for researchers to isolate schoolyard conversions as the factor associated with higher math and writing growth at Denver elementary schools. The Denver study attempts to address this concern by matching Denver elementary schools with schools in neighboring school districts with similar socio-economic characteristics.
[25] Kuo, M., Browning, M.H.E.M., Sachdeva, S., Lee, K., & Westphal, L. (2018). Might School Performance Grow on Trees? Examining the Link Between "Greenness" and Academic Achievement in Urban, High-Poverty Schools. *Frontiers in Psychology, 9*.
[26] Berezowitz, C.K., Bontrager Yoder, A.B., & Schoeller, D.A. (2015). School gardens enhance academic performance and dietary outcomes in children. *Journal of School Health, 85*(8), 508-518.
[27] Not specifically focused on green schoolyards but rather the broader relationship between children's experiences with nature and learning, see Kuo, M., Barnes, M., & Jordan, C. (2019). Do Experiences With Nature Promote Learning? Converging Evidence of a Cause-and-Effect Relationship. *Frontiers in Psychology, 10*. They write, "Until recently, claims outstripped evidence on this question. But the field has matured, not only substantiating previously unwarranted claims but deepening our understanding of the cause-and-effect relationship between nature and learning."
[28] Bureau of Labor Statistics website. Data on display: Education Pays, 2022. Accessed June 27, 2023.
[29] See Vining, A.R., & Weimer, D.L. (2019). The Value of High School Graduation in the United States: Per-Person Shadow Price Estimates for Use in Cost–Benefit Analysis. *Administrative Sciences. 9*(4). Public or external benefits include reducing participation in crime, improving consumption and fertility choices, and enhancing intra-family productivity, among others. This estimate draws on several studies to specify a range of external benefits expressed as a fraction of total compensation; range is estimated between 0.13 and 0.42, modal value is 0.37.

a rate four times greater than proficient readers.[30] In addition, a recent study of longitudinal data from seven states shows that test rankings as early as third grade are highly predictive of eighth-grade and high school test rankings.[31]

With Denver's 76.5% high school graduation rate (2022), and in the case of other school districts with similar or even lower graduation rates, many children are not on track to graduate from high school.[32] If a green schoolyard could affect the trajectory of even just a few students, society could reap substantial benefits. For example, the net present value of a Learning Landscape conversion that changed the trajectory of one high school dropout to a high school graduate every five years over a 40-year period is about $340,000 in public benefits and over $900,000 in private benefits.[33]

*Long-term impact on children's health*

While increased physical activity and mental health benefits of green schoolyards support children's learning, they can also boost children's health and healthy behaviors that continue into adulthood. While the Denver study didn't directly measure children's health, researchers noted that green schoolyard conversions helped spur an increase in school vegetable gardens (55% of conversions included gardens), districtwide implementation of salad bars in school cafeterias, and a school district initiative to grow its own vegetables.[34] In addition, previous research on the relationship between green schoolyards and increased physical activity suggests associations with children's health.

In regards to nutrition, research on school gardens finds associations with children's knowledge and preferences for fruits and vegetables, but limited effects on children's diets.[35] However, one study found that making school garden produce available in the cafeteria was associated with increased purchases of salads.[36] In the Denver study, 13 of the 99 Learning Landscapes schools developed garden-to-cafeteria programs.

Research offers some evidence that physical activity in childhood is associated with physical activity as an adult. For example, a 21-year study that tracked physical activity from childhood to adulthood in Finland reveals low to moderate correlations between physical activity in childhood and physical activity in adulthood.[37]

[30] Hernandez, D. J. (2011). Double Jeopardy: How Third-Grade Reading Skills and Poverty Influence High School Graduation. Annie E. Casey Foundation.
[31] Austin, W., Figlio, D., Goldhaber, D., Hanushek, E.A., Kilbride, T., Koedel, C., Lee, J.S., Lou, J., Özek, U., Parsons, E., Rivkin, S.G., Sass, T.R., & Strunk, K.O. (2023). Academic Mobility in U.S. Public Schools: Evidence from Nearly 3 Million Students. National Center for Analysis of Longitudinal Data in Education Research. CALDER Working Paper No. 227-0323-3.
[32] Robles, Y. (2023, June 10). Colorado graduation rates went up. So did the number of dropouts. *Chalkbeat Colorado*.
[33] Based on Vining and Weimer, 2019. Assume one additional high school graduate in years 10, 15, 20, 25, 30, 35, and 40 after Learning Landscape conversion, discount rate 3%.
[34] Denver Public School's farms produced an average of $85,000 of vegetables from 2012 to 2017. The Big SandBox, Inc., & Autocase Economic Advisory. (2023). *An Analysis of Learning Landscapes: Lessons Learned for a National Movement.*
[35] Huys, N., Cardon, G., De Craemer, M., Hermans, N., Renard, S., Roesbeke, M., Stevens, W., De Lepeleere, S., & Deforche, B. (2019). Effect and process evaluation of a real-world school garden program on vegetable consumption and its determinants in primary schoolchildren. *PLoS One 14*(3).
[36] Cotugna, N., Manning, C.K., & DiDomenico, J. (2012). Impact of the Use of Produce Grown in an Elementary School Garden on Consumption of Vegetables at School Lunch. *Journal of Hunger & Environmental Nutrition 7*(1), 11-19.
[37] Telama R., Yang, X., Viikari, J., Välimäki, I., Wanne, O., & Raitakari, O. (2005). Physical activity from childhood to adulthood: a 21-year tracking study. *American Journal of Preventive Medicine 28*(3), 267-73.

## Return on Investment for School Districts

School boards and school district administrators have particular interest in the impact green schoolyards can have on student enrollment, sustaining enrollment, and teacher retention. During the Denver study period, results show increased enrollment by an annual average of 152 students districtwide following green schoolyard conversions. In a large district like Denver's this represents a relatively modest gain in Denver's elementary school population, about 0.3%. Nevertheless, these enrollment gains bring an annual average $1,341,777 in state education funding to the school district, as noted in the Denver study. With a lower student mobility rate as noted previously, new students in the district are also less likely to move after a green schoolyard conversion.

Other research suggests that the presence of green schoolyards is perceived as an improvement in teacher working conditions and could increase retention, particularly when using green schoolyards as outdoor classrooms. A study of an outdoor learning program in South Wales, United Kingdom, found that students and teachers noticed improvements in students' engagement with learning, concentration, and behavior, as well as positive impacts on teachers' job satisfaction.[38]

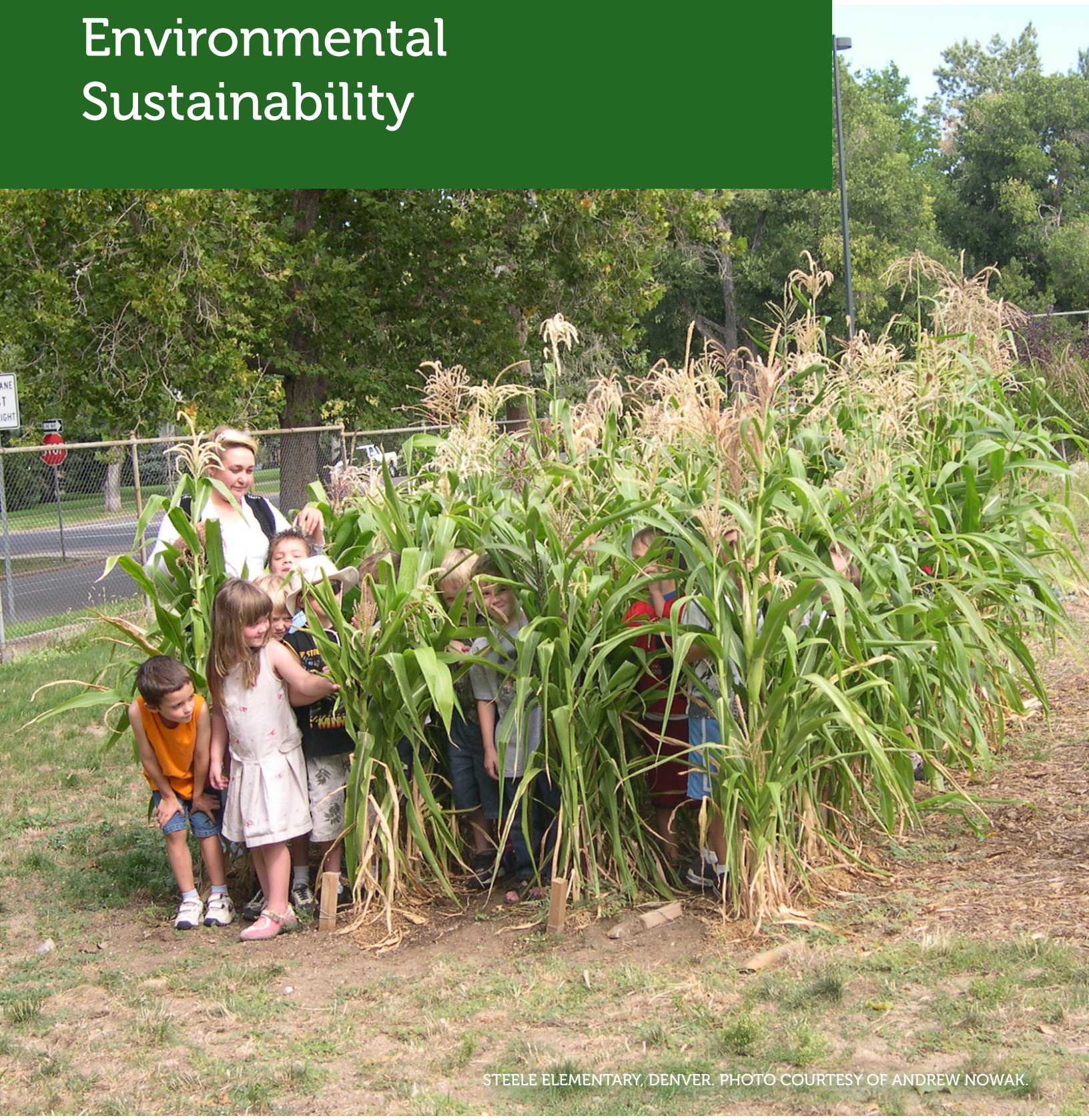
The Denver study suggests that green schoolyard projects can help attract support for bond measures that not only fund green schoolyards but also deferred capital projects and education needs. Researchers of the Denver study noted that Learning Landscapes was the most visible capital project in the voter-approved bond, which funded schoolyard conversions as well as a backlog of other projects.

As discussed in the Conclusions, school districts that make green schoolyards available to the public can also better leverage other funding sources to pay for

GREEN SCHOOLYARD, AUSTIN, TEXAS. PHOTO COURTESY OF ANNE MULLER

[38] Marchant, E., Todd, C., Cooksey, R., Dredge, S., Jones, H., Reynolds, D., Stratton, G., Dwyer, R., Lyons, R., & Brophy, S. (2019). Curriculum- based outdoor learning for children aged 9-11: A qualitative analysis of pupils' and teachers' views. *PLoS ONE*, 14(5).

# Environmental Sustainability



STEELE ELEMENTARY, DENVER. PHOTO COURTESY OF ANDREW NOWAK.

## Environmental Sustainability

While the design of a green schoolyard conversion is primarily dedicated to creating space for school children to move and explore, many economic benefits extend beyond this objective as well as the schoolyard boundary. This section discusses how green schoolyard features impact environmental sustainability in ways that adapt to and mitigate climate change and boost community health. The Denver study uses site survey analysis to determine the impact of converting asphalt and other impervious pre-conversion surfaces to trees, vegetation, and other permeable surfaces. These outcomes are therefore considered to be caused by the green schoolyard conversions, not just correlated with them.

### *Mitigating negative effects of urban heat islands*

Due to increased tree canopy and vegetation, the Denver study estimates an average 15-degree reduction in the average ambient temperature during the summer months. According to a recent study, the current U.S. urban tree canopy cools air temperatures thus avoiding heat-related deaths and health problems as well as reducing electricity consumption with a combined estimated value of $6.5 billion to $14.9 billion annually, nationwide.[39]

COLUMBIAN ELEMENTARY, DENVER. PHOTO COURTESY OF BAMBI YOST.

[39] McDonald, R.I., Kroeger, T., Zhang, P., & Hamel, P. (2020). The Value of US Urban Tree Cover for Reducing Heat-Related Health Impacts and Electricity Consumption. *Ecosystems, 23*, 137–150.

# Environmental Sustainability

The USDA Forest Service estimates the U.S. urban tree leaf area at 127 million acres.[40] Therefore, the Denver elementary schoolyard proportionate share of value based on the lower estimate is $15,768 annually districtwide and $159 per school.[41]

Adding to this evidence, studies in the United States and Canada indicate that exposure to extreme heat events during the first trimester of pregnancy is associated with higher incidences of congenital heart defects.[42] Reducing localized air temperatures may also have a positive effect on student learning, particularly for schools without air conditioning. A study based on student PSAT scores shows that without air conditioning, a 1 degree Fahrenheit warmer school year reduces that year's learning by 1 percent.[43] Meanwhile, a research project in Texas established that third- and fourth-grade children are more likely to position themselves under trees during periods of high heat.[44]

### *Carbon sequestration and removing air pollutants*

Across all converted schoolyards, the Denver study estimates annual average sequestration of 1,284 tons of carbon (13 tons per school on average) and annual average removal of at least 404 lbs of air pollutants (4 lbs per school on average). Each of these contribute to climate change mitigation and stronger community health.

Carbon dioxide comprises 79% of greenhouse gasses, which refers to gasses that trap heat in the atmosphere.[45] Trees and other vegetation reduce carbon dioxide through the accumulation of carbon in above- and below-ground plant biomass and in the soil beneath the vegetation as soil organic carbon.

According to the U.S. Environmental Protection Agency (EPA), 13 tons of carbon—equivalent to 47.7 tons of carbon dioxide—is comparable to 9.6 gasoline-powered vehicles driven for one year, 5.5 homes' energy use for one year, or 100 barrels of oil consumed.[46]

The monetary value of reducing 47.7 tons of carbon dioxide depends on the price. For example, the Biden administration estimates the social cost of carbon dioxide at $51 per ton; in 2022, EPA proposed increasing the price to $190.[47] The social cost includes a range of climate impacts, such as sea level rise, more severe tropical cyclones, and additional wildfires. Meanwhile, the California and Quebec carbon allowance secondary market price in second quarter 2023 traded at just over $30 per metric ton.[48] Using this market price, the average annual value of Denver green schoolyard carbon sequestration is $1,290.

Meanwhile, removing air pollutants can help reduce serious health effects, particularly

[40] Nowak, D.J., & Greenfield, E.J. (2018). US Urban Forest Statistics, Values, and Projections. *Journal of Forestry, 116*(2), 164-177.
[41] Assume Denver elementary school's conversion of 306 acres of schoolyards to Learning Landscapes is equivalent to adding 306 acres of urban tree leaf area. Using the higher estimate, the Denver elementary schoolyard proportionate share of value is $29,154 districtwide and $294 per school.
[42] Lin, S., Lin, Z., Ou, Y., Soim, A., Shrestha, S., Lu, Y., Sheridan, S., Luben, T.J., Fitzgerald, E., Bell, E., Shaw, G.M., Reefhuis, J., Langlois, P.H., Romitti, P., Feldkamp, M.L., Malik, S., Pantea, C., Nayak, S., Hwang, S-A., & Browne, M. (2018). Maternal ambient heat exposure during early pregnancy in summer and spring and congenital heart defects – A large US population-based, case-control study. *Environment International, 118*, 211-221. Auger, N., Fraser, W.D., Sauve, R., Bilodeau-Bertrand, M., & Kosatsky, T. (2017). Risk of Congenital Heart Defects after Ambient Heat Exposure Early in Pregnancy. *Environmental Health Perspectives, 125*(1).
[43] Park, R.J., Goodman, J., Hurwitz, M., & Smith, J. (2020). Heat and Learning. *American Economic Journal: Economic Policy, 12*(2), 306-39.
[44] Lanza, K., Alcazar, M., Hoelscher, D.M., & Kohl III, H.W. (2021). Effects of trees, gardens, and nature trails on heat index and child health: design and methods of the Green Schoolyards Project. *BMC Public Health, 21*(98).
[45] U.S. Environmental Protection Agency website. (2023). Global Greenhouse Gas Emissions Data. Accessed August 8, 2023.
[46] U.S. Environmental Protection Agency website. (2023). Greenhouse Gas Equivalencies Calculator. Accessed August 8, 2023.
[47] Asdourian, E., & Wessel, D. (2023). What is the social cost of carbon? *Brookings*.
[48] California Air Resources Board website. Carbon Allowance Prices. Accessed August 8, 2023.

respiratory ailments that may include chest pain, coughing, aggravation of asthma, and even premature death.[49] Researchers of the Denver study estimate the annual effects of Denver's green schoolyard conversions on the removal of nitrogen oxide (5.5 tons), sulfur dioxide (1.4 tons), and particulate matter (PM2.5, 0.43 tons) over a 40-year period.[50]

The EPA's CO-Benefits Risk Assessment Health Impacts Screening and Mapping Tool (COBRA) estimates the economic value of health benefits associated with removing these types of air pollutants.[51] Based on the Denver study data, average annual health benefits associated with a single green schoolyard conversion are valued at $1,928 for Denver County, and $3,392 for the contiguous 48 states.[52]

*Increased stormwater capture*

In addition to reducing air temperatures, sequestering carbon, and removing air pollution, converting impervious surfaces to permeable surfaces contributes to increased stormwater capture. Reducing rainwater runoff can help prevent water pollution, reduce flooding, and protect drinking water resources.[53] The EPA's National Stormwater Calculator estimates the amount of rainwater and frequency of runoff from a specific site based on soil type, average annual precipitation, and use of green infrastructure, such as conversion to permeable surfaces and rain gardens.[54]

Based on pre- and post-conversion data from three Denver elementary campuses and an average rainfall of 14 inches, the average annual runoff reduction was 1.7 inches across 4.8 acres, or 240,746 gallons. The USDA Forest Service estimates the U.S. average value of avoided runoff at $0.008936/gallon.[55] Therefore, the average value of avoided runoff at the three Denver elementary schools is $2,151 annually.

While rainfall in Denver is less than in many other cities, similar green schoolyard conversions in a rainier city could reduce much more runoff. For example, an elementary school in Philadelphia that is planning to convert its schoolyard this summer has average annual rainfall of 44 inches and is expected to reduce annual runoff by 1.7 million gallons, valued at $15,491.[56]

*Increased pollinator habitats*

Increased vegetation coverage and tree canopy on green schoolyards can have a positive effect on pollinator habitats. The economic value of an urban pollinator-friendly garden or tree depends on the amount of pollinator-dependent crops grown within and nearby a city and the relative availability of pollinator habitats. Close proximity to pollinator-dependent crops and relative scarcity of pollinator habitats increase the value of high-quality and diverse, urban pollinator forage.[57]

[49] U.S. Environmental Protection Agency website. (2023). Benefits of Green Infrastructure. Accessed August 20, 2023.
[50] PM2.5 refers to fine inhalable particles with diameters that are generally 2.5 micrometers and smaller.
[51] U.S. Environmental Protection Agency website. (2023). CO-Benefits Risk Assessment Health Impacts Screening and Mapping Tool. Accessed August 22, 2023.
[52] Based on COBRA's low estimate. High estimate is $4,331 for Denver, CO, and $7,631 for the contiguous 48 states. COBRA requires choosing an industry related to emissions reductions. These results are an average of Other Industrial Processes, Fuel Combustion: Other, and Fuel Combustion: Industrial. Each of these industries has the required baseline levels of $NO_x$, $SO_2$, and PM2.5 to build a scenario with the Denver study data.
[53] U.S. Environmental Protection Agency website. (2023). Soak Up the Rain: What's the Problem? Accessed August 30, 2023.
[54] U.S. Environmental Protection Agency website. (2023). National Stormwater Calculator. Accessed August 30, 2023.
[55] Based on avoided runoff due to trees; see Nowak, D.J. (2021). *Understanding i-Tree: 2021 Summary of Programs and Methods*. General Technical Report NRS-200-2021. USDA Forest Service, Northern Research Station.
[56] Data and calculations by The Big SandBox, Inc.
[57] Donkersley, P., Witchalls, S., Bloom, E.H., & Crowder, D.W. (2023). A little does a lot: Can small-scale planting for pollinators make a difference? *Agriculture, Ecosystems & Environment 343.*

# Environmental Sustainability

Researchers at the University of Pittsburgh and Penn State University estimate that the economic value of insect pollinators was $43 billion in the United States in 2012 based on crops that depend on insect pollination.[58] However, there currently isn't a method to estimate the value of specific pollinator habitats at green schoolyards.

Even if an urban area has a relatively healthy pollinator population, due to present and potential future environmental pressures, building resilience among pollinators today would seem to mitigate potential risks of pollinator decline in the future.

### *Increase in children's long-term sustainability behaviors*

Long-term environmental conservation is likely related to children's early exposure to, and connection with, nature. Research indicates that children's connectedness to nature has a positive relationship with sustainable behaviors.[59] Future environmental conservation-related behaviors depend on the extent to which nature connection and sustainable behaviors among children attending green schoolyards continue beyond their time there. While methods are not currently available, future research may establish models to predict the impact of children's connectedness on adult sustainable behaviors years later.

### *Green schoolyard effects on climate resiliency*

Boosting climate resiliency is a key motivation to implement green schoolyards due to predicted increases in severe climate – related events, such as flooding and heatwaves. The estimates in this report are primarily based on current climate conditions and related costs, except for carbon sequestration, since expectations of future climate-related costs are included in carbon market pricing. To the extent that extreme weather events increase as predicted, the environmental sustainability estimates in this section are likely too low. For example, in the context of more frequent flooding, green schoolyards will be able to capture more stormwater runoff over a particular time.

STEELE ELEMENTARY, DENVER.
PHOTO COURTESY OF ANDREW NOWAK.

[58] University of Pittsburgh. (2021, February 3) The business of bees: The economic value of insect pollination services is much higher than previously thought in the US. *ScienceDaily*.
[59] van Heel, B.F., van den Born, R.J.G., & Aarts, N. (2023). Nature Experiences in Childhood as a Driver of Connectedness with Nature and Action for Nature: A Review. *Ecopsychology*. Barrera-Hernández, L.F., Sotelo-Castillo, M.A., Echeverría-Castro, S.B., & Tapia-Fonllem, C.O. (2020). Connectedness to Nature: Its Impact on Sustainable Behaviors and Happiness in Children. *Frontiers in Psychology, 26*. Hughes, J., Richardson, M., & Lumber, R., (2018). Evaluating connection to nature and the relationship with conservation behaviour in children. *Journal for Nature Conservation, 45*, 11-19.

# Community Development and Health


GARDEN PLACE ACADEMY, DENVER. PHOTO COURTESY OF LOIS BRINK.

## Community Development and Health

Without opening schoolyards to the public, natural and aesthetic improvements on green schoolyards likely have some impact on neighborhood residential property values and positive effects on neighbors' mental health. However, many more community development and health benefits are generated when green schoolyards also serve as a community park outside of school hours, including weekends and summers, like they are in Denver.[60] And while there is variation in practice, green schoolyards can be designed with all end users in mind, not just children, such as including walking tracks, community gardens, and exercise stations. Trust for Public Land (TPL) estimates that if every public schoolyard in America functioned as a shared outdoor space, 20 million more children and adults would have access to a park within a 10-minute walk from their home.[61]

PHOTO COURTESY OF GRAND RAPIDS DEPARTMENT OF PARKS & RECREATION

[60] To open schoolyards to the community, a school district may enter into a joint use agreement with a municipal government, but this can also be facilitated by other formal and informal agreements between schools, school districts, other government agencies or nonprofit organizations.
[61] Trust for Public Land. (2023). *Transforming Schoolyards*.

## Community Development and Health

Some of the immediate benefits of green schoolyards are related to how much children, parents, and the community enjoy them. As discussed in the Conclusions section, surveys and contingent valuation studies could help estimate the value of these types of immediate benefits and how they may contribute to long-term benefits. The evidence below is based on community park research related to community development and health outcomes, and how those results apply to green schoolyards.

### *Increased home values, community cohesion and public safety*

As a community park, research shows that green schoolyards can increase the value of neighborhood assets, particularly residential property, and boost community cohesion and public safety. TPL's Center for City Park Excellence assesses how parks and their features impact nearby properties. Effects include lower single-family home turnover rates, an increase in the sale price of single-family homes, and an increase in asking rents in buildings surrounding parks.[62]

In TPL's 2010 study of Denver's park and recreation system, the authors estimate that property values increase by 5% when located within 500 feet of a park.[63] Based on these assumptions, in 2009 there were 47,085 residential properties within 500 feet of Denver parks with a combined market value of nearly $20 billion. The share of market value associated with park proximity was nearly $1 billion. Based on the assessed taxable value of properties near parks and mill rates, local property tax revenue from properties within 500 feet of parks was $5.6 million or $118 per property. Note that this study doesn't break out the effects of green schoolyard conversions in Denver, in part because Learning Landscapes were still in development.

To estimate the impact of Denver's green schoolyards on residential property market values and local property tax revenue, the Denver TPL study framework is applied to recent American Community Survey data. According to analysis by Peter Anthamatten, associate professor of geography and environmental sciences at the University of Colorado Denver, an estimated average of 47 owner-occupied housing units and 37 renter-occupied housing units are located within 500 feet of a Denver elementary school with a Learning Landscape schoolyard. Furthermore, the median home value of owner-occupied single-family houses within 500 feet of a Learning Landscape school is $480,367.[64] To better match the Denver TPL study framework, the number of occupied housing units is converted to the number of properties based on the share of Denver residential structures by total units in each structure.[65] Assuming single-family house values reflect the median home value, and properties with two or more units are valued at 90% of the median home value per unit,[66] current assessed property values and mill levy rate[67]

[62] Trust for Public Land. (2013). *The Return on Investment in Parks and Open Space in Massachusetts*.
[63] Trust for Public Land. (2010). *The Economic Benefits of Denver's Park and Recreation System*.
[64] Drawing from spatial data of 88 Denver schools with Learning Landscape conversions, polygons were built with a 500-foot radius around each school. Individual polygons were dissolved into a single polygon to account for any overlap so that each area is counted only once. Owner-occupied housing units, renter-occupied housing units, total households, and median home value are based on American Community Survey 2017-2021 5-year estimates (block group level), retrieved from the City of Denver's Open Data Catalog. The percentage of a block group contained in the polygon is used to estimate the number of occupied housing units, households, and median home value, therefore these estimates rely on the assumption that housing unit and household attributes are evenly distributed throughout the block group.
[65] Infoplease website. Denver, CO, Housing Statistics. Accessed November 3, 2023. See table "Units in Structure" (2000 Census data).
[66] Based on author's review of national sales prices of existing homes at National Association of REALTORS®. Accessed November 5, 2023.
[67] Denver The Mile High City website. Property Taxes. Accessed November 4, 2023. See "How are my property taxes calculated?"

indicate that average annual tax revenue associated with proximity to a Learning Landscape is $126 per housing unit or $10,475 per school.

While increasing property values builds equity for owners and increases the local tax base, it could also cause the unintended consequence of displacing current residents. For example, proximity to a Learning Landscape is assumed to account for $24,000 of the median home value, which is associated with an annual local tax obligation of $133 in Denver. That is, the tradeoff for a larger capital gain at the time of sale and increased leverage in applying for home equity financing is larger annual local tax payments. Furthermore, increased demand for rental housing units near green schoolyards can push rental prices higher.

To address concerns about potential displacement, authors of the study "Greening Without Gentrification," emphasize the importance of starting community engagement early and collaborating closely with communities to understand their specific concerns.[68] In addition, mechanisms like community land trusts (CLT) have the potential to improve home affordability where homeowners own the home, while the trust organization owns the land and leases it back to the homeowner for a nominal fee. In exchange for a CLT property at an affordable price, buyers agree to resell in the future at an affordable price.[69]

The 11th Street Bridge Park project, which is converting an out-of-use commuter bridge into a public park in Washington, D.C., has adopted these practices, including starting a CLT. From the project's inception in 2011, leaders have focused on equity, particularly for Black residents living nearby. One of the four equity focus areas is housing with the goal of creating and preserving affordable housing and spreading information and advocacy for housing affordability through partnerships with community organizations.[70] For example, 130 renters have become homebuyers through the Ward 8 Home Buyers Club, a partnership effort that helps renters become first-time homeowners.

In addition to increased property values and local tax revenue, research indicates that parks and urban green space have a positive effect on social cohesion and sense of belonging, and that engagement with park spaces can facilitate attachment to communities.[71] Positive interactions in urban green spaces can catalyze social capital and social cohesion.[72] A study based on 1,611 completed surveys of parents with children aged 5 to 10 living in low-income communities showed that park satisfaction had the strongest connection with social capital.[73] In addition to community cohesion, research indicates that vegetation abundance is significantly associated with lower rates of assault, robbery, and burglary, but not theft.[74]

### *Impact on community physical and mental health*

Park proximity is linked to increased park use and associated with increased physical activity, and exposure to nature is associated

[68] Rigolon, A., & Christensen, J. *Greening without Gentrification: Learning from Parks-Related Anti-Displacement Strategies Nationwide*. UCLA Institute of the Environment & Sustainability.
[69] Weekly, F. (2022). *How Community Land Trusts Can Advance Black Homeownership*. Federal Reserve Bank of St. Louis.
[70] 11th Street Bridge Park website. Accessed June 28, 2023.
[71] Cohen, M., Burrowes, K., & Gwam, P. (2022). The Health Benefits of Parks and their Economic Impacts: A Review of the Literature. *Urban Institute*.
[72] Jennings, V., & Bamkole, O. (2019). The Relationship between Social Cohesion and Urban Green Space: An Avenue for Health Promotion. *International Journal of Environmental Research and Public Health, 16*(3), 452.
[73] Mullenbach, L.E., Larson, L.R., Floyd, M.F., Marquet, O., Huang, J., Alberico, C., Ogletree, S.S., & Hipp, J.A. (2022). Cultivating social capital in diverse, low-income neighborhoods: The value of parks for parents with young children. *Landscape and Urban Planning, 219*.
[74] Wolfe, M.K., & Mennis, J. (2012). Does vegetation encourage or suppress urban crime? Evidence from Philadelphia, PA. *Landscape and Urban Planning 108*(2–4), 112–122.

with positive effects on mental health. As described in Section One regarding children, benefits to physical and mental health interact with each other in positive ways.

There is large economic potential in improving physical and mental health. According to the Centers for Disease Control and Prevention (CDC), 90 percent of the nation's $4.6 trillion in annual health care expenditures are for people with chronic physical and mental health conditions. Each year, heart disease and strokes cost the healthcare system $258 billion and diabetes costs $283 billion.[75] According to the Office of the Surgeon General, physical inactivity costs the nation $149 billion a year for related health care.[76] A key component of chronic physical and mental health disease prevention is physical activity, which parks can play a key role in facilitating.

Research shows that proximity to and use of parks, green space, and tree cover are correlated with greater levels of physical activity.[77] A study of green schoolyard conversions at two schools in Chicago showed that more individuals, mostly youth, used the schoolyards outside of school time after the renovations than before the renovations. Researchers also observed an increase in physical activity after the renovations.[78] A study of adults aged 45 to 84 indicates that higher density of recreational resources is associated with increased physical activity.[79]

TPL's New York City park study estimates that the average annual medical care cost difference between active and inactive persons between 18-64 years old is $1,436 and the average annual medical care difference between active and inactive persons over 65 years old is $2,873.[80] According to analysis by Peter Anthamatten, an average of 2,523 people aged 18-64 and 525 people over age 64 live within a 10-minute walk of a Denver school with a Learning Landscape schoolyard conversion.[81] Using these measures, if each year a green schoolyard helped boost or maintain the physical activity of 10 adults aged 18-64 (0.4% of the age 18-64 population) and 2 adults age 65+ (0.4% of the age 65+ population) to CDC recommended levels who would otherwise fall below CDC recommended levels, society could save $20,000 annually in reduced health care system expenditure.

Research also connects parks with positive effects on individual mental health and well-being.[82] For example, time spent in green space has been linked to improved mental health outcomes, including reduced stress levels.[83] Spending at least 120 minutes per week in natural environments, whether one long visit or several shorter visits, is associated with higher levels of reported good health or well-being.[84]

[75] Center for Disease Control and Prevention website. Health and Economic Costs of Chronic Diseases. Accessed June 28, 2023.
[76] U.S. Department of Health and Human Services. *Step It Up! The Surgeon General's Call to Action to Promote Walking and Walkable Communities*. Washington, DC: U.S. Dept of Health and Human Services, Office of the Surgeon General; 2015.
[77] Cohen, M., Burrowes, K., & Gwam, P. (2022).
[78] Bohnert, A.M., Nicholson, L.M., Mertz, L., Bates, C.R., & Gerstein, D.E. (2021).
[79] Roux, A.V.D., Evenson, K.R., McGinn, A.P., Brown, D.G., Moore, L., Brines, S., & Jacobs Jr., D.R. (2007). Availability of Recreational Resources and Physical Activity in Adults. *American Journal of Public Health, 97*(3), 493–99.
[80] Trust for Public Land. (2022). *The Economic Benefits of Parks in New York City*.
[81] Drawing from spatial data of 88 Denver schools with Learning Landscape conversions, service area polygons were built around each school representing a 10-minute walk or less. Individual polygons were dissolved into a single polygon to account for any overlap so that each area is counted only once. Population counts are based on American Community Survey 2017-2021 5-year estimates (block group level), retrieved from the City of Denver's Open Data Catalog. The percentage of a block group contained in the polygon is used to estimate the number of residents in each age category, therefore these estimates rely on the assumption that population and population attributes are evenly distributed throughout the block group.
[82] Cohen, M., Burrowes, K., & Gwam, P. (2022).
[83] Ibid.
[84] White, M.P., Alcock, I., Grellier, J., Wheeler, B.W., Hartig, T., Warber, S.L., Bone, A., Depledge, M.H., & Fleming, L.E. (2019). Spending at least 120 minutes a week in nature is associated with good health and wellbeing. *Scientific Reports 9*(1).

# Conclusions

DORA MOORE ELEMENTARY, DENVER. PHOTO COURTESY OF DESIGNSCAPES, INC.

# Conclusions

*Report conclusions*

Research shows that green schoolyards can move the needle forward on measures of children's learning and health, environmental sustainability, and community development and health. While additional research is needed, the current evidence makes a solid circumstantial case that the value of green schoolyards is likely larger than the cost.

The table below shows net present value estimates of a green schoolyard conversion based on results from statistical analysis or hypothetical examples presented above. The economic benefits associated with environmental sustainability are based on the Denver study results and valued at $131,895 over 40 years. Increased local tax revenue benefits are based on a statistical estimate and valued at $242,127 over 40 years. Relative to the cost of a green schoolyard conversion ($630,012), environmental sustainability outcomes and local property tax revenue increases return 60 cents for every dollar invested.

Economic effects on children's learning and community health are also likely considerable. Since statistical estimates are not available, a hypothetical example is included for each domain, which, when combined with results from statistical analysis, shift the value of public and private benefits higher than the cost of a green schoolyard conversion.[85] A modest gain in either the high school graduation rate (shift the trajectory of one high school dropout to a high school graduate) or improvements in community health (boost or maintain the physical activity of 10 adults aged 18-64 and 2 adults age 65+ to CDC recommended levels annually) would produce a positive return on investment, that is, a ratio of benefits to costs above $1 for every dollar invested. The table illustrates how modest gains in both high school graduation rates and community health could boost the return to over $3 for every dollar invested.

Monetary values are not included for several potential economic effects, including children's long-term health, increased pollinator habitat, increased children's long-term sustainability behaviors, and boosted community cohesion and public safety. These values are likely positive, but methods are not available to estimate them. As discussed below, additional research is needed to fully estimate the economic value of green schoolyard benefits relative to costs.

MONTCLAIR ELEMENTARY, DENVER. PHOTO COURTESY OF TROY GARNER.

[85]Denver Public Schools grounds maintenance data doesn't show a long-term change in post-Learning Landscape conversion full-time equivalent employees for maintaining schoolyards, therefore assume annual maintenance costs did not change after conversions. However, more research is needed to assess potential differences in maintenance costs between green and paved schoolyards.

| Prospective Net Present Value Estimates of a Green Scholyard Conversion | | | Net Present Values Over 40 Years[a] | | | |
|---|---|---|---|---|---|---|
| Economic Effects of Green Schoolyards | | Description of Statistical Estimate or Hypothetical Example | Public | Private (Individual) | Total | Ratio of Benefits to Total Costs |
| **Children's Learning and Health** | Increase student achievement and high school graduation rate | Change trajectory of 1 high school dropout to a high school graduate every 5 years | **$338,643** | **$911,194** | **$1,249,837** | **$1.98** |
| | Improve children's long-term health | | | | | |
| **Environmental Sustainability** | Reduce air temperatures[b] | 15 degree reduction in air temperature | **$3,312** | | **$3,312** | **$0.01** |
| | Sequester carbon[b] | Sequester 13 tons annually | **$26,875** | | **$26,875** | **$0.04** |
| | Remove air pollutants[c] | Remove 4 lbs annually | **$51,988** | | **$51,988** | **$0.08** |
| | Reduce rainwater runoff | Reduce by 240,746 gallons annually | **$49,720** | | **$49,720** | **$0.08** |
| | Increase pollinator habitat | | | | | |
| | Increase children's long-term sustainability behaviors | | | | | |
| **Community Development and Health** | Increase in local property taxes due to increased property values | Average of 84 housing units within 500 feet of green schoolyard conversion | **$242,127** | | **$242,127** | **$0.38** |
| | Boost community cohesion and public safety | | | | | |
| | Improve community physical and mental health | Boost or maintain the physical activity of 10 adults aged 18-64 and 2 adults age 65+ to CDC recommended levels annually[d] | **$413,624** | **$51,122** | **$464,746** | **$0.74** |
| | | **Total Benefits** | **$1,126,289** | **$962,316** | **$2,088,605** | |
| | | **Total Costs**[e] | **$630,012** | **$630,012** | **$630,012** | |
| | | **Net Present Value** | **$496,277** | **$332,304** | **$1,458,593** | |
| | | **Ratio of Benefits to Costs** | **$1.79** | **$1.53** | **$3.32** | |

**KEY:**

**Statistical Estimate**

**Hypothetical Example**

[a]3% Discount rate

[b]Since trees are a key input, NPV estimates start at 0.5 the average value in year 1 when trees are small and gradually increase to 1.5 the average in year 40 when trees are fully grown.

[c]Since trees are a key input, start accruing value in year 10 when trees are larger.

[d]Assume 11% are private benefits, 89% public

[e]Initial construction and implementation, assume annual maintenance costs are same as paved schoolyard.

A green schoolyard conversion moves indicators across several different sectors and therefore doesn't depend on gains in just one domain to achieve robust value. Much of the benefits also accrue not only to the children who attend schools with green schoolyards, but to society as a whole, a condition that generally leads to underinvestment.

Furthermore, some benefits not listed here specifically accrue to school districts, such as increased enrollment and state education funding, improved working conditions for teachers, and ability to attract support for bond measures that not only fund green schoolyards but also deferred capital projects and education needs.

# Conclusions

Green schoolyards can also help close gaps on measures of education attainment, health outcomes, and community investment often found between low-income communities and more affluent ones. Although access to nature, such as the natural elements found in green schoolyards, might be good for all children, it's especially good for those who might be at risk for poorer health, mental health, social, and educational outcomes due to conditions associated with limited financial resources.[86] Since paved schoolyards are more concentrated in low-income and ethnically diverse urban neighborhoods,[87] green schoolyard conversions in these neighborhoods likely have a relatively larger effect on community development and health than conversions in more affluent ones.

### *Report limitations*

While there are advantages to analyzing a comprehensive set of data on green schoolyard conversions in a single school district, there are limitations in generalizing these results to other school districts. Student, climate, and community characteristics, as well as green schoolyard implementation in other school districts will affect the benefits and costs. For example, school districts in rainier climates will likely accrue stronger rainwater capture benefits, while green schoolyards in areas with less access to parks and nature will likely have stronger effects on community health. In addition, other school districts might accentuate some design elements, such as planting more trees or building more rain gardens, which would affect outcomes and costs.

As noted in the Introduction, dollar values throughout the report are converted to 2022 dollars using the Consumer Price Index. However, over the past 10 to 20 years prices in some sectors of the economy grew faster than others, which can affect the relative value of benefits to costs. For example, between 2012 and 2022 the CPI increased 24% while construction materials, a substantial component of green schoolyard conversion costs, increased 66%.[88]

### *Future research and next steps*

Ongoing and new research could substantiate the economic impact of green schoolyards[89] and identify best practices for implementing and using new green schoolyards.

First, future research could confirm causality between green schoolyard conversions and children's learning and health and community development and health outcomes. For example, future studies could adopt a research design that links school- or student-level data to changes in elementary school student achievement scores that are predictive of high school graduation rates. Ideally using student-level data, researchers could compare elementary school students who have access to green schoolyards with those without access, following them into middle school and possibly through high school. Another use for student-level data is assessing student entry and exit rates at a

[86] Children & Nature Network. (2020). The Equigenic Effect: How Nature Access Can Level the Playing Field for Children. *Finding Nature News*.
[87] Trust for Public Land. (2021).
[88] Federal Reserve Bank of St. Louis website. (2024). Federal Reserve Economic Data, Producer Price Index by Commodity: Special Indexes: Construction Materials. Accessed March 1, 2024. Converting average DPS green schoolyard conversion costs using Construction Materials PPI instead of CPI increases costs from $630,012 to $847,817. Using this result, the environmental sustainability outcomes and local property tax revenue benefit-cost ratio decreases from 60 cents to 45 cents and the benefit-cost ratio related to modest gains in both high school graduation rates and community health decreases from over $3 per dollar invested to about $2.50. It's likely some benefit values increased slower or faster than the CPI but were not investigated.
[89] As noted in Stevenson, K.T., Moore, R., Cosco, N., Floyd, M.F., Sullivan, W., Brink, L., Gerstein, D., Jordan, C., & Zaplatosch, J. (2020). A national research agenda supporting green schoolyard development and equitable access to nature. *Elementa: Science of the Anthropocene 8*(1), cost-benefit analysis is highlighted as a research priority, as well as student academic performance and individual and community health.

school to determine effects of in-migration and out-migration before and after a green schoolyard conversion. [90]

In addition, future research could assess community development and health effects of green schoolyards, such as analyzing pre- and post-conversion data on nearby property values and community health. Researchers could also assess community use of green schoolyards as community parks before and after conversions. Surveys could ask families and community members about their use, enjoyment, and perceived value of green schoolyards. Contingent valuation studies could measure willingness to pay for immediate green schoolyard benefits which could inform the value of longer-term benefits such as higher property values and improved community health.

Second, research could clarify children's preferences for particular natural features in green schoolyards [91] and best practices for how teachers can support children's learning in natural environments. In "A Coordinated Research Agenda for Nature-Based Learning," Jordan and Chawla note the need for research on how to best prepare teachers to work successfully in nature and how to support their adoption of nature-based learning approaches. [92]

### *Districtwide green schoolyard conversions—advantages of scale*

While individual green schoolyard conversions have several benefits, there are likely advantages to adopting green schoolyard conversions districtwide. As found in the Denver study, school districts may find it easier to acquire financing for all or a substantial portion of their elementary schools at one time than financing individual elementary school projects one at a time.

The environmental and community development benefits related to green schoolyards may be subject to tipping points where achieving a threshold level boosts benefits more than proportionally higher, such as benefits related to reducing air temperatures, sequestering carbon, removing air pollution, or increasing pollinator habitat. For example, reducing stormwater at one school reduces the use of sewer infrastructure, but reducing stormwater at several schools could keep runoff below a threshold that would require water infrastructure upgrades or new construction.

Effects related to scale may also emerge in community development. For example, effects of districtwide schoolyard conversions on property values and community cohesion may be proportionally stronger than those related to one or a few isolated conversions. In each of these cases it may be challenging to identify the specific tipping point levels, but they are more likely to occur with districtwide projects than individual school projects.

### *Cross-sector collaboration and early community engagement*

Since the benefits of green schoolyards cross several different sectors, there is value in developing mechanisms and best practices to facilitate cross-sector collaboration and financing. In many cases the benefits to children's learning and to teachers and staff have justified school district financing to pay for schoolyard conversions. However, since the benefits also extend to surrounding communities, strategies that convene stakeholders who represent these broader

[90] For an example of methodology, see Bartik, T.J., Eberts, R., and Haung, W-J. "The Kalamazoo Promise, and Enrollment and Achievement Trends in Kalamazoo Public Schools." Presented at the PromiseNet 2010 Conference, June 16-18, Kalamazoo, MI.
[91] Aminpour, F., (2021). The physical characteristics of children's preferred natural settings in primary school grounds. Urban Forestry & Urban Greening, 62. Lindemann-Matthies, P., & Köhler, K. (2019). Naturalized versus traditional school grounds: Which elements do students prefer and why? Urban Forestry & Urban Greening, 46.
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# Conclusions

FORCE ELEMENTARY, DENVER. PHOTO COURTESY OF DESIGNSCAPES, INC.

benefits with school districts could help move green schoolyard projects forward.

Potential project partners include school districts; city and county governments; local park and recreation agencies and related non-profit organizations; neighborhood and affordable housing organizations; community development organizations; community health organizations and local health care systems; and philanthropic organizations. Potential funding sources include general revenue; bonds, and referendums by school districts, cities, and counties; state and federal government grants; philanthropic organizations; businesses; and banks. [93]

Finally, a key theme in green schoolyard implementation is engaging students, teachers, parents, and community members early and consistently in planning and designing a new green schoolyard. Green schoolyard projects that effectively address the needs and concerns of people within the school community and surrounding neighborhoods are more likely to achieve the highest value.

[93] A bank contribution or grant to a green schoolyard project at a school with over 50% Free and Reduced Priced Lunch student population may qualify for Community Reinvestment Act consideration. Also see Investment Connection, a forum hosted by the Federal Reserve Bank of Kansas City that connects organizations with community and economic development proposals with potential funders, including financial institutions, government, corporate enterprises, and community foundations.

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