California School Tree Study

Annual Report 2024

Contents

Cover Image: New schoolyard forest at Parkway Elementary. Source: Luisa Velasquez-Camacho (2024).

I. Study Overview

Trees on school campuses can improve quality of life for students by providing shade on school grounds and reducing temperatures. This is especially important in a state like California, where school grounds often consist of extensive impervious surfaces, such as asphalt, which can absorb and re-radiate heat, thereby raising local temperatures and decreasing thermal comfort. It is particularly important to have tree shade in the schoolyards where children play. Trees and greenspaces on K-12 school campuses have numerous other benefits for children's physical, mental, and social wellbeing.

Our project aligns with state and school district investments in green schools and ongoing efforts to grow schoolyard canopy equitably. Our study goals are to:

1. Investigate policies that have created and reinforce extensive impervious cover on school grounds, and describe land cover patterns on school campuses;
2. Assess tree microclimate benefits, and develop future scenarios for such benefits based on varying tree configurations;
3. Assess the vulnerability of campus tree species to climate change; and
4. Characterize landscape management perspectives and needs from school principals, teachers, and parents, as well as facilities staff at school and district levels, and nonprofit greening partners.

The study is a collaboration between researchers at the United States Department of Agriculture (USDA) Forest Service, Pacific Southwest Research Station (PSW); University of California, Berkeley (UC Berkeley); University of California, Davis (UC Davis); and University of California, Los Angeles (UCLA), in partnership with the USDA Forest Service Region 5; California Department of Forestry & Fire Protection (CAL FIRE); and Green Schoolyards America.

To learn more about this study, check out the project websites from the Forest Service and UCLA. The study is also affiliated with the Los Angeles Center for Urban Natural Resources Sustainability.

II. Building the Team

The year 2024 was spent building a team of researchers with diverse expertise and planning each component of the study. The team is composed of scholars with extensive experience in various disciplines, including urban forestry, forest ecology, urban ecology, tree management, ecosystem services, climate change, remote sensing, public health, and schoolyard greening. Through a transdisciplinary collaborative effort, the team is dedicated to producing useful findings for state agencies, school districts, non-profit organizations, and others involved in school tree planting and management.

Please see a brief bio for each of the research team members below:

Research leads

USDA Forest Service

Lara Roman, PhD, Research Ecologist, USDA Forest Service

Lara Roman is a Research Ecologist with the USDA Forest Service, Pacific Southwest Research Station. Her research centers on the temporal dynamics of urban forests, including tree mortality and growth, canopy cover change, historical legacies, species composition change, and the factors constraining or enabling tree planting in varied neighborhoods. These studies involve collaborations with municipal agencies and nonprofit organizations, and her contributions to urban forestry practice were recognized with an Early-Career Scientist Award from the International Society of Arboriculture. She received a PhD from UC Berkeley, and Bachelor's in Biology and Master of Environmental Studies from the University of Pennsylvania.

Natalie van Doorn, PhD, Research Urban Ecologist, USDA Forest Service

Natalie van Doorn is a Research Urban Ecologist with the USDA Forest Service, Pacific Southwest Research Station. She is interested in what drives change in urban and wildland forests, how forests are vulnerable to disturbances and stressors, and what can be done to improve their resilience. Her research utilizes and builds on long-term datasets tracking populations and individual trees; measuring forest structure and dynamics. She is a co-PI on the Climate-ready Trees study – a data-driven approach to evaluate the ability of promising underused species to tolerate stressors of future climates. She earned her Bachelors, Masters, and Doctorate degrees from UC Berkeley.

Universities

Iryna Dronova, PhD, Associate Professor, UC Berkeley

Iryna Dronova is an associate professor jointly appointed in the Departments of Environmental Science, Policy & Management (Rausser College of Natural Resources) and Landscape Architecture & Environmental Planning (College of Environmental Design). She is interested in diverse aspects of landscape ecology and its potential to inform sustainable, multi-functional landscape-designs and decision-making in environmental planning. Her research combines field ecological methods with remote sensing, geographic information systems (GIS) and spatial analysis to perform analyses of multi-scale structure of ecosystems, to facilitate scaling of ecological processes from local to regional levels and to develop remote sensing-based monitoring approaches for vulnerable areas and sites with limited field access. Since May 2017 she is also an affiliate Professor of Geography at UC Berkeley Department of Geography. She holds a PhD in Environmental Science, Policy and Management from UC Berkeley, a MS degree in Natural Resources/Terrestrial Ecology and Management and a Certificate in Spatial Analysis from the School of Natural Resource and Environment at the University of Michigan, Ann Arbor and a BS degree in Ecology from the National University of Kyiv-Mohyla Academy, Ukraine.

Alessandro Ossola, PhD, Assistant Professor, UC Davis

Alessandro Ossola is a professor at UC Davis. He is an honorary research fellow at the University of Melbourne, Australia, where he obtained a PhD in urban ecology. He is a former US National Academy of Sciences, Engineering and Medicine NRC Associate and a recipient of a 2022 New Innovator Award from the Foundation for Food and Agriculture Research. His research encompasses several topics including urban forestry, ecology, climate change, water management, urban planning and design. Alessandro currently serves the Chair of the Saratoga Horticultural Research Endowment (SHRE) and he is a member of the Executive Oversight Team of the Los Angeles Center for Urban Natural Resources Sustainability.

Kirsten Schwarz, PhD, Associate Professor, UCLA

Kirsten Schwarz is an urban ecologist and holds a joint appointment in the Departments of Urban Planning and Environmental Health Sciences at UCLA. Her research aims to understand how the ways in which we build and shape cities affect environment, health, and justice. Using transdisciplinary, community-engaged, and mixed method approaches, her research explores the spatial distribution of environmental hazards and amenities in cities and the resulting inequities. She embraces community-engaged practices as a mechanism to move beyond mapping such inequities and support research processes that can facilitate dismantling them. Her expertise in science communication and engaging communities in the co-production of science was recognized by the American Association for the Advancement of Science (AAAS) naming her a Fellow in the Leshner Leadership Institute in the Center for Public Engagement with Science and Technology. Prior to joining UCLA, she was an Associate Professor of Environmental Science at Northern Kentucky University where she directed their Ecological Stewardship Institute. Kirsten has a BA in Human Ecology from College of the Atlantic and a PhD in Ecology from Rutgers University.

Fellows, Interns and Post-doctoral Researchers

Levon Bigelow, MS, ORISE Urban Forestry Fellow

Levon Bigelow is a research fellow with the Oak Ridge Institute for Science and Education (ORISE), in collaboration with the USDA Forest Service. His current role involves working with data to support research decisions on a variety of projects focused on trees in California schoolyards. Levon started his career at Rutgers University, where he earned a BS in Ecology, Evolution and Natural Resources and interned with the New Jersey Urban & Community Forestry program. From there, he worked as a street tree planting forester at New York City Parks & Recreation before earning his MS in Natural Resources and the Environment and a certificate in GIS from the University of Connecticut. His master's thesis focused on street tree dynamics in a large city (Philadelphia).

Jared Coffelt, Graduate Fellow, UCLA

Jared Coffelt is a PhD student at UCLA's Institute of the Environment and Sustainability. His research interests revolve around community engagement during the design, implementation, and maintenance of sustainable infrastructure and how such infrastructure can be used to develop more peaceful and democratic relations. His current projects include analysis of factors contributing to the implementation and endurance of impermeable surfaces on school grounds and how they prevent greening efforts, as well as the development of the hydrogen energy economy in the US and beyond. He has a Bachelors in chemical engineering from the University of Pittsburgh.

Steve Jang, Undergraduate Intern, UCLA

Steve Jang is a third-year undergraduate student at UCLA with a major in environmental science and a minor in environmental engineering. He is an undergraduate student under the mentorship of UCLA's Kirsten Schwarz.

Sam Muir, MS, CAPAL Intern

Sam Muir is a recent graduate from the master's program in Environmental Data Science program at the University of California, Santa Barbara. While there, he served as a student representative on the Bren School's Master's Curriculum Committee and sat on the Dean's Advisory Council. His Master's project aimed to create an interactive, geospatial field survey planning tool to aid the Santa Barbara Botanic Garden in their monarch butterfly and early-season milkweed conservation efforts. In all of his work, Sam aims to elevate and incorporate the experiences of underrepresented populations and ultimately hopes to develop environmental data tools to aid these groups. As a School Campus Tree Study Intern through the Conference on Asian Pacific American Leadership (CAPAL) and the US Forest Service, Sam was excited to further environmental equity in public schools. Sam holds a BS in Biology, a BA in Environmental Studies, and a minor in French Language and Culture from St. Mary's College of Maryland.

Melody Ng, Graduate Fellow, UCLA

Melody Ng is a PhD student in the Urban Planning program at the UCLA Luskin School of Public Affairs. She focuses on community-engaged research, the relationship between land tenure and community food access, land tenure as an environmental justice issue, and how legal and socio-cultural systems shape food systems and broader environmental outcomes. She received a Bachelors in Legal Studies and English, and a Master of Public Policy from the University of California, Berkeley.

Elizabeth Riedman, PhD, Post-doctoral Researcher, UCLA

Elizabeth Riedman is a feminist, urban geographer who specializes in qualitative research, with a focus on urban greening initiatives and volunteer labor. Currently, her research investigates issues of equity within urban forestry, green infrastructure, community well-being and health. She utilizes a range of methods, including ethnography, interviews and surveys to collaborate across community partners and disciplines. As part of the schoolyard greening project, she seeks to understand tree management and maintenance strategies across various California schools. She received a PhD in Geography and Urban Studies at Temple University and a Masters in Anthropology from Wayne State University.

Eric Romero, Graduate Research Assistant, UC Berkeley
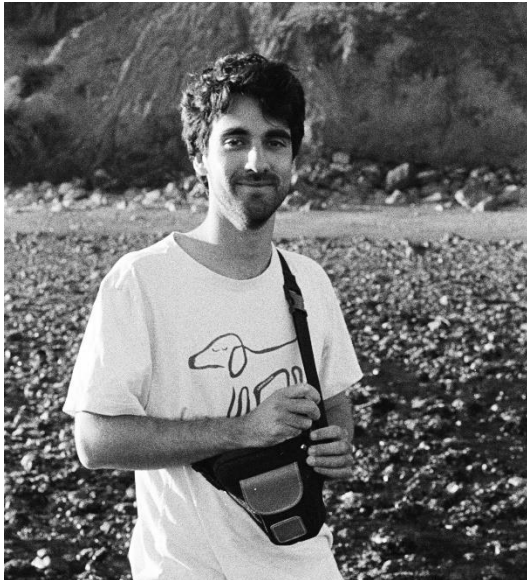
Eric Romero is a PhD Candidate at UC Berkeley in the Department of Environmental Science, Policy & Management. His dissertation research focuses on quantifying carbon fluxes in restored wetlands of California's Sacramento-San Joaquin Delta using a combination of satellite remote sensing and eddy covariance measurements. Before Berkeley, Eric worked at NASA Goddard Space Flight Center in the Division of Earth Science. During his time at Goddard, Eric worked on projects leveraging high resolution satellite imagery to map individual tree canopies throughout sub-Saharan Africa using machine learning. He received a Bachelor of Science in Environmental Engineering and minored in Geospatial Technology at the University of Vermont.

Cailyn Schmidt, Graduate Fellow, UCLA

Cailyn Schmidt is a Masters student in the Urban and Regional Planning program at UCLA. Her current research with the LA Center for Urban Natural Resources Sustainability involves cultural ecosystem services of school trees. Before beginning her masters, Cailyn spent three years working in urban forestry in Honolulu, Hawai'i, managing a nonprofit and coordinating culturally relevant fruit tree plantings at under-resourced schools. Cailyn has a BS in Conservation and Resource Studies and a BA in Music from the University of California, Berkeley.

Luisa Velasquez Camacho, PhD, Post-doctoral Researcher, UC Davis

Luisa Velásquez is a postdoc currently focused on assessing tree cooling benefits across California's K-12 schoolyards. Luisa holds a BS in Forestry Engineering at the District University in Bogotá, Colombia, a MS in Data Science applied to Forestry from the University of Valladolid, Spain and a PhD in Forest Management from the University of Lleida. Her PhD research focused on the automation of urban tree mapping, analyzing their distribution patterns in cities, and the assessment of ecosystem services using deep learning techniques and multiple remote sensing data sources. Luisa has extensive experience in urban forestry, remote sensing, modeling, spatiotemporal analysis, and artificial intelligence.

Samantha Venegas, Undergraduate Intern, UCLA

Samantha Venegas is a second-year physiological science major at UCLA. She is an undergraduate student researcher under the mentorship of UCLA's Kirsten Schwarz.

III. Forging Partnerships

This project could not be possible without the collaboration between our researchers and professionals who are involved with urban forestry and school greening efforts in California. Our Core Partners include the following:

- USDA Forest Service Region 5, Urban & Community Forestry Program: Miranda Hutten, Laura Wolf, Pauline Ordonez, and Michelle Carr
- CAL FIRE Urban & Community Forestry Program: Walter Passmore, Julia Gowin, Henry Herrera, Jazmyn Winczner, Rachel O'Leary, Darrik Carlson, and Marco DeAnda
- Green Schoolyards America: Sharon Gamson Danks, Alejandra Chiesa, Rachel Pringle, Mikaela Randolph, Lauren McKenna, and Ayesha Ercelawn

To further inform and improve the quality and impact of our work, we have engaged in ongoing dialogue and collaboration with a variety of professionals at local organizations who are directly involved in urban forestry and school greening efforts on the ground. We have also sought advice from scholars studying trees and microclimates in other urban areas. We enlisted the invaluable input, advice, and perspectives of these individuals and organizations through an Advisory Committee. Please see the full list of partners and their organizations below.

- Aleigh Lewis (Angelenos for Green Schools)
- Juan Mireles and George Garcia (California Department of Education)
- Cindy Blain and Alex Binck (California ReLeaf)
- Marcy Raney (Children's Hospital Los Angeles)
- Rachel Malarich and Amy Schulenberg (City of Los Angeles)
- Gordon Matassa and David Moore (City of Oakland)
- Kevin Hocker (City of Sacramento)
- Carlos Campero and Cristina Basurto (City Plants)
- Wanda Stewart (Common Vision)
- Drew Ready and Jason Casanova (Council for Watershed Health)
- Anne Fenkner (Davey Resource Group)
- Angelic Perez (Koreatown Youth & Community Center)
- Sharyn Romano (Los Angeles Beautification Team)
- Azeneth Martinez (Nature for All)
- Aaron Thomas and Carlos Moran (North East Trees)
- Jessica Sanders (Sacramento Tree Foundation)

- Dustin Hermann (TreePeople)
- Matilda Reyes and Sarka Volejnikova (Trust for Public Land)
- Ariane Middel (University of Arizona)
- Melissa McHale (University of British Columbia)
- Igor Lacan (University of California, Division of Agriculture and Natural Resources)
- Edith de Guzman and Kelly Turner (University of California, Los Angeles)
- Marianna Babboni, Will Berelson, and Esther Margulies (University of Southern California)
- Travis Warziniack (USDA Forest Service, Rocky Mountain Research Station)
- Peter Ibsen (US Geological Survey)

Sharon Danks and Alejandra Chiesa (Green Schoolyards America) show Lara Roman a redwood grove adjacent to a play structure in an elementary school in Berkeley, CA. Source: Natalie van Doorn.

IV. Products

The first products from the research team are focused on land cover in California schools, and especially the prevalence of impervious areas. These analyses are summarized in a [StoryMap](#).
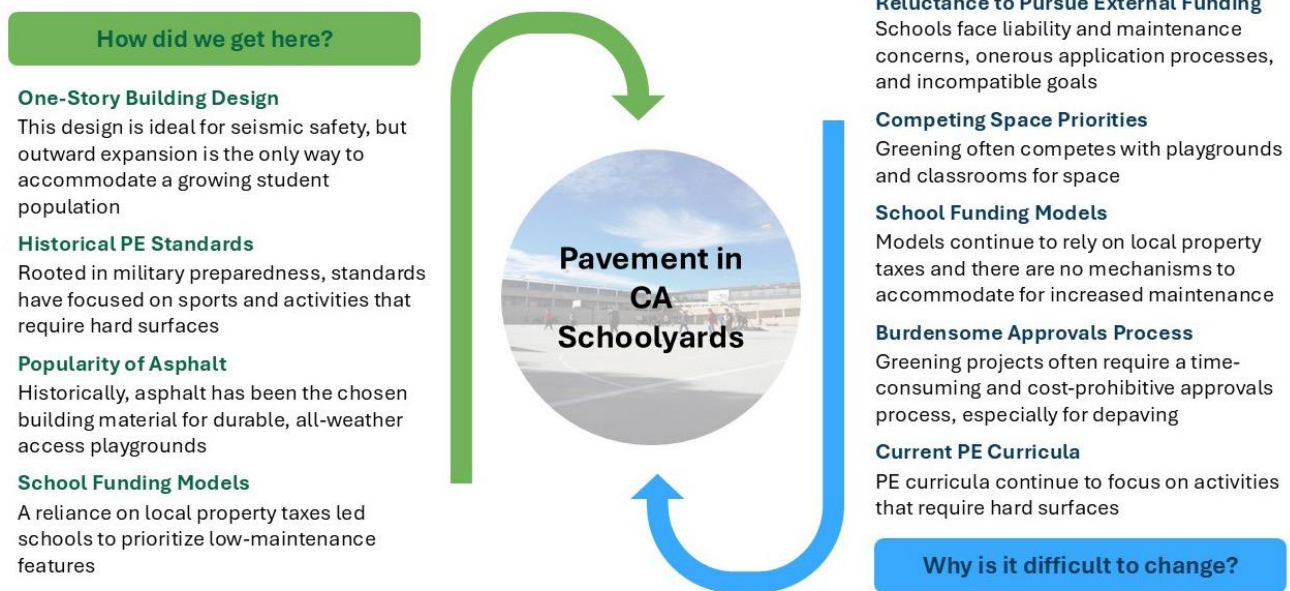
Policy report on impervious surfaces in California schools

One of the major hurdles to adding trees and greenspace to schoolyards in California is the extensive amount of asphalt and other impervious surfaces on school grounds. Researchers at UCLA compiled a [report](#) analyzing the historical policies and other drivers that have influenced this pattern thus far, and current factors that contribute to keeping the extensive impervious surface in place. These factors include historical land use planning policies designed for seismic safety, curricular dependence on hard surfaces for physical education, competition for space between vegetation and impervious campus land use needs like space for portable classrooms and conventional playgrounds, challenges regarding funding mechanisms and availability, and more (Figure 1). Despite these challenges, organizations are working to transform schoolyards through various greening projects in the state, sometimes overcoming tremendous obstacles to removing impervious surfaces.

This analysis was led by Melody Ng and Jarred Coffelt, with support from Kirsten Schwarz, Lara Roman, Natalie van Doorn, and Elizabeth Riedman.

Extensive blacktop used for physical education at Florence Nightingale Middle School in Los Angeles Unified School District. Source: Lara Roman.

How did we get here?

One-Story Building Design
This design is ideal for seismic safety, but outward expansion is the only way to accommodate a growing student population

Historical PE Standards
Rooted in military preparedness, standards have focused on sports and activities that require hard surfaces

Popularity of Asphalt
Historically, asphalt has been the chosen building material for durable, all-weather access playgrounds

School Funding Models
A reliance on local property taxes led schools to prioritize low-maintenance features

Pavement in CA Schoolyards

Reluctance to Pursue External Funding
Schools face liability and maintenance concerns, onerous application processes, and incompatible goals

Competing Space Priorities
Greening often competes with playgrounds and classrooms for space

School Funding Models
Models continue to rely on local property taxes and there are no mechanisms to accommodate for increased maintenance

Burdensome Approvals Process
Greening projects often require a time-consuming and cost-prohibitive approvals process, especially for depaving

Current PE Curricula
PE curricula continue to focus on activities that require hard surfaces

Why is it difficult to change?

The figure above shows the historical influences (green) which led to the proliferation of pavement throughout California schools, while various other factors make removal of such surfaces difficult (blue).

Land cover analysis of California elementary schools

To measure the land cover composition of elementary schools in different parts of the state, a geospatial analysis was conducted using machine learning algorithms for three large Unified School Districts in California: Los Angeles, Oakland, and Sacramento City. Three main land cover types were analyzed: 1) Trees/Shrubs, 2) Grass/Pervious, and 3) Impervious. The Impervious land cover type was further split into Building and Non-Building Impervious. This process involved creating reference image datasets using 2022 satellite imagery, collecting training and validation datasets for machine learning model development and accuracy assessment, and the training, classification, and validation of a random forest classifier. The analysis focused on K-5 and K-6 elementary schools.

This analysis was led by Eric Romero from UC Berkeley, with support from Iryna Dronova, Sam Muir, and Levon Bigelow.
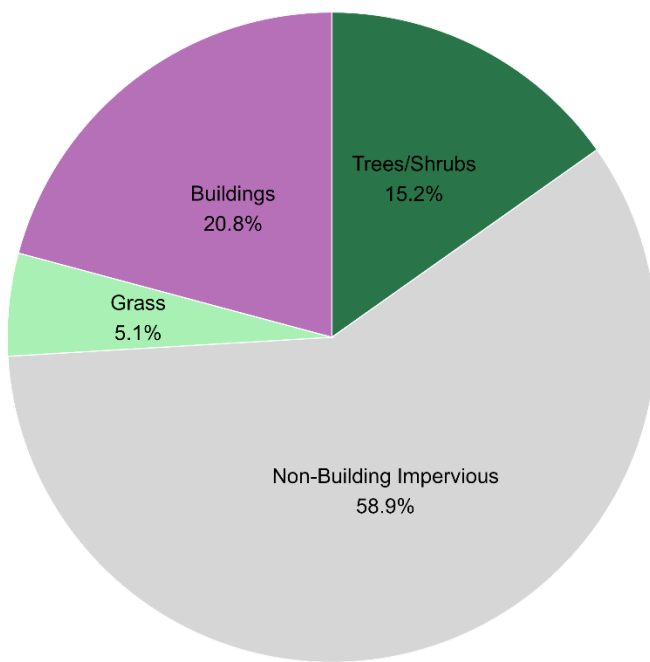
Los Angeles

Oakland

Sacramento
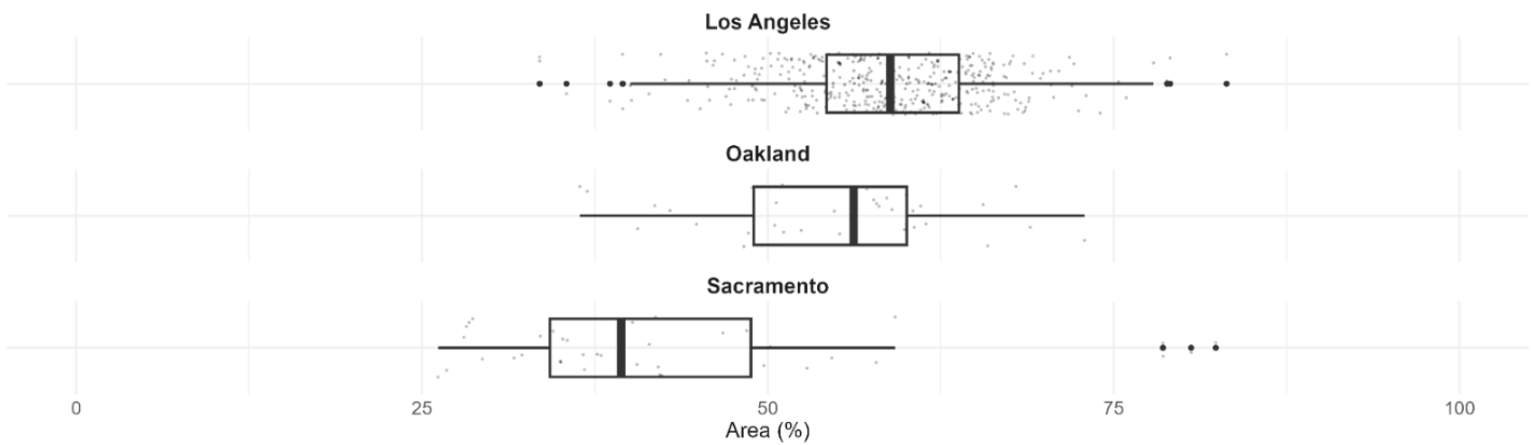
Area (%)

The figure above shows the distribution of non-building impervious cover area on school grounds, limited to non-parking lot areas of elementary school campuses in each district.

The above box-and-whisker plot shows the distribution of impervious cover within the three districts, excluding buildings and parking lots. Each dot represents an individual school. Thick vertical lines within the boxes represent district median percent impervious cover. Elementary schools in Los Angeles tend to have greater amounts of impervious cover than their counterparts in Oakland and Sacramento. Notably, Los Angeles has about ten times more elementary schools than the other two districts. In each district, there is a wide range of impervious cover on school campuses, which points to the amount of variation that exists within these districts.

Land Cover Composition Charts

In the land cover composition pie charts below, the land cover types were aggregated to the district level to enable the understanding and comparison of patterns among the three districts. These pie charts show the combined land area of K-5 and K-6 elementary schools in each district. Parking lots were excluded from this summary.

Los Angeles

398 elementary schools in Los Angeles were analyzed. More than half of the school land in this district consists of non-building impervious surface - the highest amount of the three districts.

Oakland
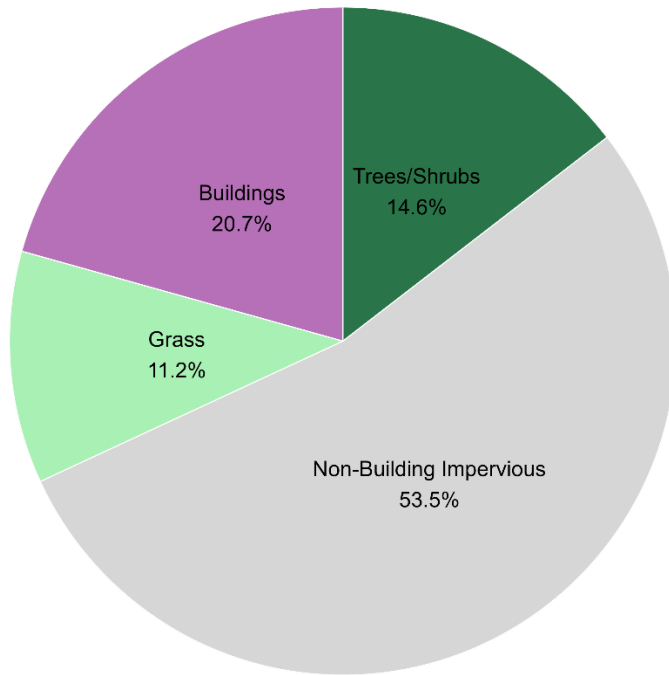
37 elementary schools in Oakland were analyzed. Just over half of the amount of school land is non-building impervious. Notably, Oakland has a slightly greater amount of grass cover than Los Angeles.

Sacramento City
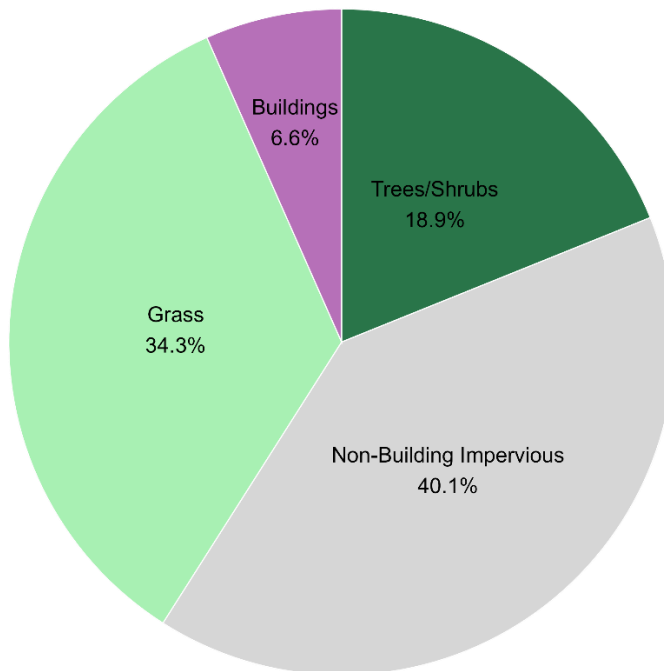
40 elementary schools in Sacramento City were analyzed. Less than half of the school land is non-building impervious - the lowest amount of the three districts. Notably, Sacramento also has a greater amount of grass and trees/shrubs than the other two districts.

Transformations

In this section, we highlight transformations that have occurred in each of the three districts from the Land Cover Analysis.

Normandie Avenue Elementary (Los Angeles)
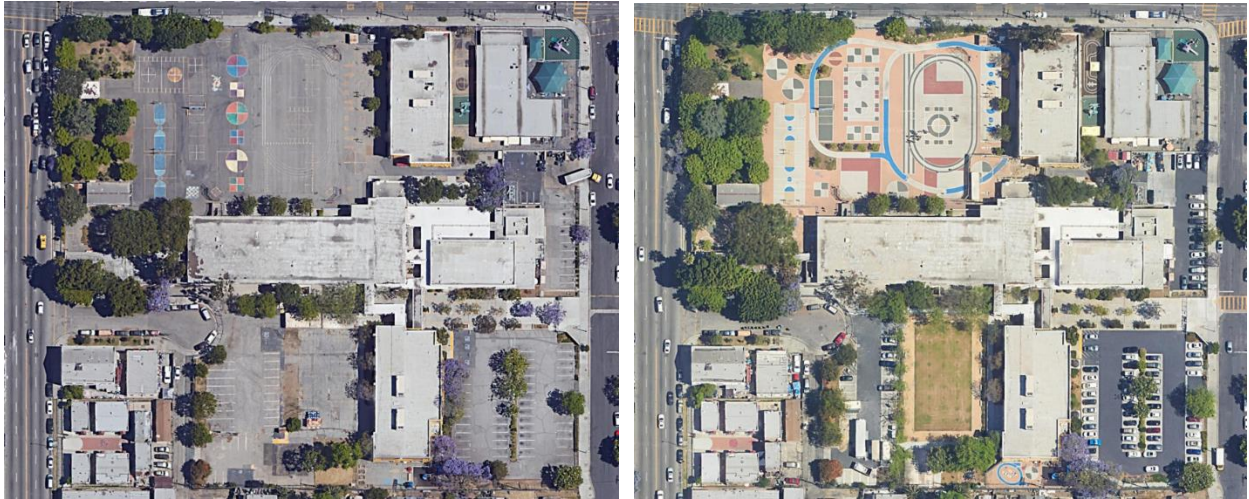
Normandie Avenue Elementary (2017 on left, 2022 on right). Images from Google Earth.

Normandie Avenue Elementary received a transformation through funding from the State Water Resource Control Board-funded Drought Response Outreach Program for Schools (DROPs) program. Through a partnership between the Los Angeles Unified School District, Council for Watershed Health, Nature Nexus Institute, TreePeople, and Studio-MLA, low-impact development best management practices were employed with the objective to achieve benefits associated with sustainable stormwater management, including the education and awareness of sustainable school landscapes. The project involved replacing 6,600 combined square feet of impermeable pavement and turf with 8,745 square feet of sustainable, climate-wise landscaping, in addition to staff training, student and community outreach, and educational materials. Read more about this project here.

Markham Elementary (Oakland)

Markham Elementary before and after the installation of a living school ground (2018 on left, 2021 on right). Source: Green Schoolyards America.

Markham Elementary's schoolyard underwent a transformation through the Oakland Living Schoolyards initiative, a partnership between the Oakland Unified School District, Trust for Public Land, and Green Schoolyards America. The Markham project involved the transformation of a predominantly asphalt schoolyard into a more vibrant space for the students and the community. Through a participatory process and community involvement, the school's renovation involved over 75 newly planted trees, a new soccer field, an orchard and flower garden, a jungle gym, a natural play area, and a newly painted basketball court. Read more about this project here.

Parkway Elementary (Sacramento City)

New schoolyard forest at Parkway Elementary. Source: Luisa Velasquez-Camacho.

Parkway Elementary is one of Green Schoolyards America's schoolyard forest pilot projects. Staff are conducting these pilot projects with schools to test replicable approaches to provide students with access to cooler and greener schools. This ongoing project, in collaboration with the Sacramento City Unified School District and Bay Tree Design, has involved school community engagement, the design and implementation of a new schoolyard forest, as well as teacher professional development. Read more about this project here. Read more about Green Schoolyard America's statewide initiative, the California Schoolyard Forest System here.

Presentations

Partners Meeting

On January 21, 2025, the team hosted the first annual all-partners meeting, during which the team provided an overview of the work completed thus far, share-outs from core partners, and next steps.

Green Schoolyards America Presentation

Lara Roman gave a talk in Green Schoolyards America's Schoolyard Forest Design Lecture Series on December 5, 2024. Her presentation was one of two during the webinar, both focusing on the maintenance and stewardship of school trees for the long-term benefits they provide. Lara's talk focused on these topics through a lens of urban forestry and related research.

The recorded presentation can be found [here](#).

Ecological Society of America Presentation

Alessandro Ossola gave an invited presentation to the Ecological Society of America meeting, which took place between August 5-8 2024 in Long Beach, California. The talk, titled "Making California's schools a 'cool refuge' for kids and teachers", was part of the Organized Oral Session "Evidence that nature-based solutions can significantly mitigate urban heat and provide cool refuge in our cities".

V. The Road Ahead

With goal 1 completed, the research team will next focus on goals 2-4, with field work taking place in 2025. After data is collected and analyzed, the research team will share the findings with Core Partners, the Advisory Committee, and beyond.

Additionally, Kirsten Schwarz at UCLA received a grant from the Tree Research and Education Endowment (TREE) Fund to lead a complementary study about bridging the stakeholders who design, plant, and maintain schoolyard trees. This will involve a statewide survey of landscape architects, staff at nonprofit organizations, and private sector arborists who work with schools, but not within school districts. Following the survey, workshops with stakeholders will take place to promote dialogue and consensus about school tree management strategies.

Established trees five years after planting at River Valley High School in Yuba City Unified School District. The Sacramento Tree Foundation supported tree plantings across Greater Sacramento through its regional Greenprint Initiative with American Recovery and Reinvestment Act funding administered by California ReLeaf. Source: Anne Fenkner.

Funding