frontiers in Ecology and Evolution

ORIGINAL RESEARCH
published: 28 January 2022
doi: 10.3389/fevo.2021.781587

# Community Knowledge and Concerns About Urban Soil Science, Practice, and Process: Perspectives From the Healthy Soils for Healthy Communities Initiative in Los Angeles, CA, United States

*Kirsten Schwarz[1,2]*, Erica L. Wohldmann[3], Yujuan Chen[4,5], Richard V. Pouyat[6], Andres Gonzalez[1], Selena Mao[1] and Susan D. Day[7]*

*[1] Department of Urban Planning, UCLA, Los Angeles, CA, United States, [2] Department of Environmental Health Sciences, UCLA, Los Angeles, CA, United States, [3] Department of Psychology, California State University, Northridge, Northridge, CA, United States, [4] Department of Policy and Research, TreePeople, Beverly Hills, CA, United States, [5] School of Architecture, University of Southern California, Los Angeles, CA, United States, [6] Scientist Emeritus, USDA Forest Service, NRS-08, Newark, DE, United States, [7] Department of Forest Resources Management, University of British Columbia, Vancouver, BC, Canada*

OPEN ACCESS

**Edited by:**
*Anna Paltseva, University of Louisiana at Lafayette, United States*

**Reviewed by:**
*Hermine Huot, UMR 7360 Laboratoire Interdisciplinaire des Environnements Continentaux (LIEC), France*
*Anne Rademacher, New York University, United States*
*Tyrell Lassair, University of Louisiana at Lafayette, United States*

***Correspondence:**
*Kirsten Schwarz*
*kschwarz@luskin.ucla.edu*

**Specialty section:**
*This article was submitted to Urban Ecology, a section of the journal Frontiers in Ecology and Evolution*

**Received:** *22 September 2021*
**Accepted:** *21 December 2021*
**Published:** *28 January 2022*

**Citation:**
*Schwarz K, Wohldmann EL, Chen Y, Pouyat RV, Gonzalez A, Mao S and Day SD (2022) Community Knowledge and Concerns About Urban Soil Science, Practice, and Process: Perspectives From the Healthy Soils for Healthy Communities Initiative in Los Angeles, CA, United States. Front. Ecol. Evol. 9:781587. doi: 10.3389/fevo.2021.781587*

Urban soil systems research has largely relied on the narrative that soils provide ecosystem services to human populations and should be studied and managed to maximize their potential value in regards to such services. However, soil scientists have not adequately engaged with diverse stakeholders to understand the needs, opportunities, and challenges related to urban soil systems. This disconnect has resulted in urban soil system research agendas that are potentially misaligned with the needs of the communities in which they are situated. Community engagement in the priorities-setting stage of research development can create research agendas that more closely align with community needs. Here we report on findings from the *Healthy Soils for Healthy Communities Initiative* in which community perceptions, needs, and concerns regarding soils in Los Angeles (LA) County, California, United States were measured through four county-wide online surveys with residents, educators, policy-makers, and professionals and a series of virtual focus groups with key community representatives. The online surveys revealed that the majority of LA County residents (76%) are very or extremely concerned about soil contaminants and pollution. Likewise, 70% of policy-makers and 77% of LA County professionals are highly concerned about soil contamination. In contrast, fewer LA County educators (48%) are concerned about soil contaminants and pollution. Even though 85% of LA County residents surveyed maintain some kind of green space, 70% self-report that their knowledge regarding factors impacting soil health is low. The focus groups revealed several themes present across stakeholder groups including a need for: (1) accessible and transparent soil data and testing; (2) effective community engagement and streamlined communication that centers underserved communities; and (3) building alliances among community,

policy, businesses, and science professionals and leveraging connections among organizations, individuals, and agencies that are focused on soil. The findings from this study have informed the future direction of urban soil research and community science in the region. The process of engaging communities in defining research agendas can serve as a model for other cities providing an opportunity to not only improve the relevance and impact of urban soil research, but also improve the sustainability of urban soil systems.

**Keywords: community science, community engagement, soil education, urban natural resources, urban soil management, soil contamination, soil testing**

## INTRODUCTION

Urban soil research and messaging have largely been framed around ecosystem services, the idea that urban soils provide benefits to human populations and thus should be managed to protect and promote such services. For example, in the current climate crisis, soils are promoted as a potential solution based on their ability to sequester carbon (Bossio et al., 2020). Indeed, urban soils provide multiple ecosystem services including food production, biodiversity, and stormwater infiltration, among others (Pavao-Zuckerman, 2012; Pouyat et al., 2020). While some of the ecosystem functions that provide these services are well studied, less is known regarding the dynamics of ecosystem functions in the face of the global climate crisis and anthropogenic inputs (Pouyat and Trammell, 2019). An ecosystem services framing of soils may help communities visualize and appreciate the functions of urban soils which, in contrast to aboveground counterparts such as trees and pollinators, are not nearly as charismatic or visible. However, such a framing is dependent on human valuation and well-being (Iniesta-Arandia et al., 2014) and researchers have not adequately engaged with communities, especially those most impacted by soil quality concerns. Specifically, communities have not been extensively consulted regarding: (1) their background knowledge regarding the ecosystem services derived from urban soils; and (2) how they prioritize and perceive opportunities and challenges regarding ecosystem services derived from urban soils. This may result in research agendas that are incongruous with community needs and researchers pursuing questions that are irrelevant or unhelpful to communities and may even be harmful to community goals (Rubert-Nason et al., 2021).

Meaningful engagement with communities is hypothesized to contribute to research with greater reach, relevance, and rigor (Balazs and Morello-Frosch, 2013), particularly when the community is engaged at all stages of the research process. When and how communities are included in decision making may result in very different outcomes (González, 2019). Engagement in the research priorities-setting phase of work can communicate the valuing of community knowledge and expertise as well as commitment to participatory approaches and the co-creation of science, while outreach only in the final phases of research projects may signal that community knowledge, perspectives, and concerns were not central to the project and findings merely need to be shared [i.e., the deficit model of science communication (U.S. Census Bureau, 2021)]. The spectrum of community engagement recognizes that it is not only when, but how, and how often communities are engaged that may alter the impact of a project (González, 2019).

TreePeople[1], an environmental non-profit organization founded in 1973 and whose stated mission is to "inspire, engage and support people to take personal responsibility for the urban environment, making it safe, healthy, fun and sustainable and to share our process as a model for the world," has a long-standing history of advancing regional sustainability, climate resilience, and environmental justice in LA through education, research, policy, and community engagement. In 2020, TreePeople launched the "Healthy Soils for Healthy Communities" Initiative[2] to better understand the potential of soils to accelerate climate resilience and build healthy communities in the LA region.

The *Healthy Soils for Healthy Communities Initiative* is a unique collaboration among local and regional non-profit organizations, local and federal governments, community groups, and university partners to understand the roles of urban soils in LA County, CA, United States. The initiative has multiple objectives: (1) elevating healthy soils as the "brown" in green infrastructure policy, planning, management, and investments in both the built and natural environments; (2) increasing public and policy-maker awareness of the importance and potential of urban soils to building climate resilience, sustaining urban ecosystem functions, and realizing desired public health outcomes; (3) conducting cutting-edge science and research that gets used to fill the information gaps; (4) facilitating policy changes to support urban soil projects; and (5) empowering communities with science-based information, best management practices, and practical tools for soil management (Chen et al., 2021).

The research presented here focuses on the community consultation regarding LA's urban soil system, which was achieved through a survey of residents, educators, policy makers, and professionals and a series of stakeholder focus groups on urban soil ecosystem services. The work addresses urban soils at a county-wide level across multiple stakeholder groups with the intended goal of informing future urban soil research and management. The approach of combining extensive (survey) and intensive (focus groups) sampling was intended to give both breadth and depth to understanding

[1] www.treepeople.org

[2] https://www.treepeople.org/healthy-soils-for-healthy-communities-initiative/

community needs, perceptions, and concerns regarding LA urban soil systems. Our study had three core objectives: (1) identify community perceptions of the most pressing urban soil issues for Los Angeles as a large North American city; (2) explore if a community engagement process based on identifying stakeholder groups could result in a community-led soil research agenda; and (3) develop a framework for future work regarding urban soil research policy, public education, and community engagement. In addition to informing future urban soil research and management, the results have also been used to inform the subsequent phase of the initiative which includes community-centered demonstration projects and the formation of a community of practice.

# MATERIALS AND METHODS

## Study Area

Covering 4,058 square miles, LA County, CA, United States has a population of approximately 10.04 million people (U.S. Census Bureau, 2021), making it the most populous county in the nation. Los Angeles has a Mediterranean climate with mild temperatures year-round, characterized by cooler and wetter winters and dry warm summers. Los Angeles's climate, penchant for sprawling car infrastructure, endless low-rise development, and history of racist housing policies have resulted in uneven and inequitable land cover distributions. County-wide, average tree canopy cover is 18% (LA County Tree Canopy Advanced Viewer); however, some wealthier neighborhoods like Beverly Hills have well over the average (35%), while less wealthy neighborhoods have less (Irwindale, 6.24%; Commerce, 5.77%; Compton 10.57%). Inversely, impervious cover (buildings, roads, and other paved surfaces) is also unevenly distributed and areas with more sealed surfaces experience higher heat, less access to greenspace, increased stormwater runoff, and less access and opportunities to interact with the urban soil systems underneath.

In 2017, the USDA-NRCS (United States Department of Agriculture Natural Resource Conservation Service) completed a soil survey for the LA Basin, one of a few that exists for major United States cities (United States Department of Agriculture [USDA] and Natural Resources Conservation Service [NRCS], 2017). Several soil types were represented; 43% of land area was characterized as sealed soils, 32% of land area was characterized as surface amended soils, 12% of land area was characterized as native (undeveloped) soils, 11% of land area was characterized as human-altered and human-transported soils, and 2% of land area was characterized as miscellaneous (Shaw and Riddle, 2019).

## Online Surveys

Four online surveys (in both English and Spanish) were developed and disseminated to residents, educators, policy-makers, and soil-related professionals in LA County to determine their needs, knowledge, current practices, and priorities. Participants were recruited through TreePeople's database, which includes over 50,000 email addresses, as well as through their extensive network of community, school, and government partners. While contacts in TreePeople's database are likely familiar with some of their environmental programs, TreePeople's focus on soil is new to their programming with the Healthy Soils for Healthy Communities Initiative being launched in 2019.

The residential survey included 46 questions aimed at assessing knowledge, values, and interests around soil; pro-soil and pro-environmental behaviors (e.g., composting, recycling, gardening, and mulching); soil-related and environmental concerns (e.g., contamination, pollution, soil quality in public spaces); and use of public green spaces. The educator survey included 40 questions assessing knowledge, values, and interests around soil; green spaces on campus; use of soil as a teaching tool; and available services on campus (e.g., composting, recycling, and gardens). The policy-maker survey included 28 questions assessing knowledge, values, and interests around soil; available services (e.g., compost facility); dedicated annual funding for soil projects; and jurisdiction needs. Finally, the professional survey included 25 questions assessing knowledge, values, and interests around soil; soil-related challenges (e.g., land use conflicts, soil compaction, and pollution); and business practices related to soil and green waste. The survey questions are included in the **Supplementary Material**.

Due to its size, LA County was divided into eight geographic regions using the California County Department of Public Health service areas (**Figure 1**). The areas included: Antelope Valley, San Fernando Valley, San Gabriel Valley, Metro, West, South, East, and South Bay/Harbor. For the residential survey, a sample size of 384 participants was calculated using a confidence level (alpha) of 95%, a confidence level of 5%, and the population size of 10,040,000 (the population of LA County in 2020). The total sample from each service area was calculated by determining the population of each region (using Census data from each city contained within a given service area), then dividing that by the total population of LA County. This proportion was then multiplied by 384. For the other three surveys (educator, policy-maker, and landscape professional), it was impossible to calculate a representative sample because the population (number of residents employed in these professions) of each profession is unknown. Although we only needed 384 residential surveys in total, we received far more. Specifically, a total of 1,349 participants participated in the four online surveys including: (1) Residential survey: 1,104; (2) Educator survey: 139; (3) Policy-maker survey: 19; and (4) Professional survey: 87.

## Focus Groups

A total of 41 participants were interviewed across a series of seven virtual focus groups to assess perceptions, needs, and concerns regarding urban soil systems. Two focus groups were held for each of the following stakeholder groups: (1) Technical aspects of soil management including engineering, urban and sustainability planning, and local government; (2) Urban residential landscaping/gardening and urban agriculture; and (3) Community non-profits and coalition groups. Each focus group brought together various experts from their respective fields for an hour-long virtual interview between October and December 2020. Participants shared in a three-part series of questions, with the first set of questions focused on the role of

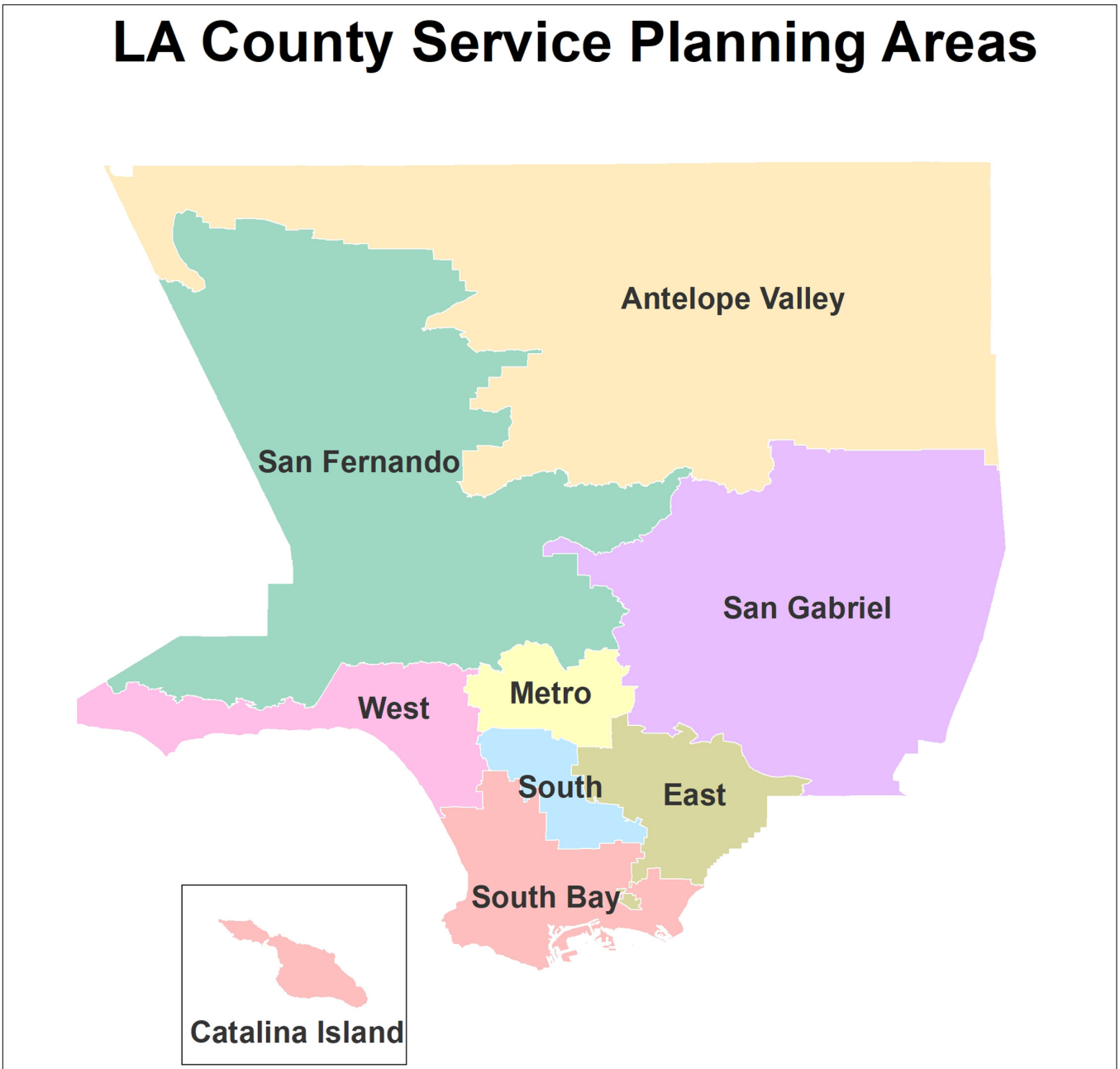


**FIGURE 1 |** The percentage of residential online surveys completed in each of the eight geographic regions. The regions were defined by the California Department of Public Health service areas. Antelope Valley = 3.38%, San Fernando = 23.38%, San Gabriel = 14.66%, Metro = 19.18%, West = 14.05%, South = 2.87%, East = 10.87%, and South Bay = 11.59%.

urban soil systems in the participants' scope of work, followed by a set of questions discussing needs and challenges identified from the Los Angeles Urban Soil Symposium (held in June 2020 and organized by TreePeople), concluding with a final set of questions that asked participants to reflect on best practices and strategies for effective engagement and collaboration across different stakeholder and practitioner groups. All participants, with the exception of policymakers, were compensated for their time. A final synthesis group included participants across all focus groups who expressed interest in the synthesis group through an exit survey shared at the end of all focus groups. Members of the synthesis group went through a series of activities and discussions facilitated through the online collaborative platform Mural, which established key strategies through two activities. In the first activity, facilitators shared back a summary of the initial focus groups and asked participants to reflect on the summary by answering the following questions: (a) Did we hear you, (b) Did we miss anything, and (c) How would you prioritize the

themes identified? In the second activity participants completed a brainwriting exercise that identified potential ideas and future directions regarding soil management in LA.

Focus groups drew from practitioners and organizations in the field identified by the research team and TreePeople. Many, though not all, of the participants in the focus groups had previously been part of the Los Angeles Urban Soil Symposium, and were familiar with some of the priorities and soil related needs identified at the Symposium. Community and coalition focus groups brought in community-based organizations, non-profits and coalitions that were active in communities across LA County. Many of these members were representatives or part of organizations within larger scale, multi-benefit partnerships with other organizations and public sector agencies. Focus groups on the technical and policy-related aspects of urban soil primarily drew from decision makers within the public sector as well as relevant researchers in the field who actively shaped soil management and policy through the provision of information, analysis of case studies, and project implementation. Finally, Gardening and Urban Agricultural groups were a mix of private and public actors more explicitly focused on the topic of soil health than the other focus groups. These ranged from businesses involved in soil management, as well as organizations and groups focused on improving and advocating for soil health in LA.

Interviews with focus groups were recorded through the telecommunications program Zoom, and later transcribed. After each focus group, researchers met to discuss key themes and subjects that emerged from each focus group. At the end of the focus groups, a codebook was developed based on thematic analysis.

# RESULTS

## Online Surveys – Residential Survey

One thousand one hundred and four participants answered two or more questions; however, because some participants chose not to answer every question, the results discussed here are based on the total number of responses for each particular question. Further, because of the exploratory nature of these surveys, the quasi-experimental design of this study, and the large difference in the sample size between each group, no statistical analyses were conducted between questions or groups.

### Summary Findings

The average age of participants was 49-years old (median = 48) and ranged from 18 to 98, and 81% of participants have either earned a 4-year college degree (42%) or a graduate degree (39%). Consequently, 46% of participants have an annual household gross income over $100,000, 65% own their home, and 70% live in a single family home. Further, 15% live alone, 38% live with just one other person, 37% with 2–3 other people, and 8% live in households with 4–6 people, in total. Most participants were female (72%) and identified as white (63%). That said, participants were well-distributed across all 8 geographic regions within the County (**Figure 1**).

Eighty-five percent of residents currently have and maintain a lawn, landscaped area, or green space, and they do so in a variety of ways (**Figure 2**). "Other" responses include, for example, applying compost, pruning and trimming plants and/or trees, planting native plants and/or vegetables, and clearing brush for fires. In addition, as shown in **Table 1**, less than half of residents use fertilizer (6% explicitly stated they use either natural fertilizer or compost) and very few use pesticides (3% use soap, vinegar, neem oil, or another "natural" way to control pests). As can also be seen in **Table 1**, more than half of participants have observed earthworms and mushrooms in their green spaces, and have taken steps to improve their soil. Almost half (40%) of these participants put the green waste from their garden into the green waste bin, 19% compost it at home, 10% leave it on the ground, and 13% use it as mulch – all three of which means green waste is being used on the property in some way. Only 5% of these participants put green waste into the trash, although almost 8% say the gardener takes care of it, which could mean it ends up in the trash. For participants who don't compost their green waste, the top three barriers included not having a compost bin, not knowing how to compost, and not having enough space. In sum, taken together, these results suggest that most people who currently maintain a yard, landscaped area, or shared green space maintain those spaces by watering and weeding, pay attention to and have observed life in the soil, do not fertilize frequently, rarely or never use pesticides, and either use the green bin (a receptacle offered by LA Sanitation for organic materials such as yard and plant trimmings, branches, flowers, and grass clippings, as well as whole fruits and vegetables) or allow green waste from their spaces to compost in some form on the property.

In addition to being asked whether residents currently maintain a lawn, landscaped area, or shared green space, all participants were asked whether they currently have or have ever had a garden. Eighty-six percent of participants said yes, and in it they grow vegetables (18%), flowers (18%), herbs (17%), succulents (17%), trees (15%), and shrubs/bushes (13%). Of those who currently garden or have gardened, 34% have done so for more than 20 years, 18% have done so for at least 10 years but less than 20, and 7% have only done so for 6 months, suggesting these folks began gardening as a result of and/or during the COVID-19 pandemic. In fact, 42% of participants reported that the COVID-19 pandemic changed their interest in and/or behavior around gardening and, more specifically, as a result of the pandemic, 22% began spending more time in their yard/garden/patio garden and 21% said gardening became more important. Interestingly, despite the fact that interest in gardening is quite high (63% are either extremely or very interested in gardening) and that most participants have been gardening for many years, knowledge about gardening is relatively low (**Table 2**).

Despite closures to many public spaces during the COVID-19 pandemic, public green spaces are used with some level of frequency (10% daily, 38% frequently, 29% sometimes, and 23% rarely or never). Noteworthy is the somewhat contradictory finding that just 55% of participants are concerned about the quality of soil in public green spaces, whereas 76% of participants are concerned about soil contaminants and pollution in their community. This difference could be a result of using the words

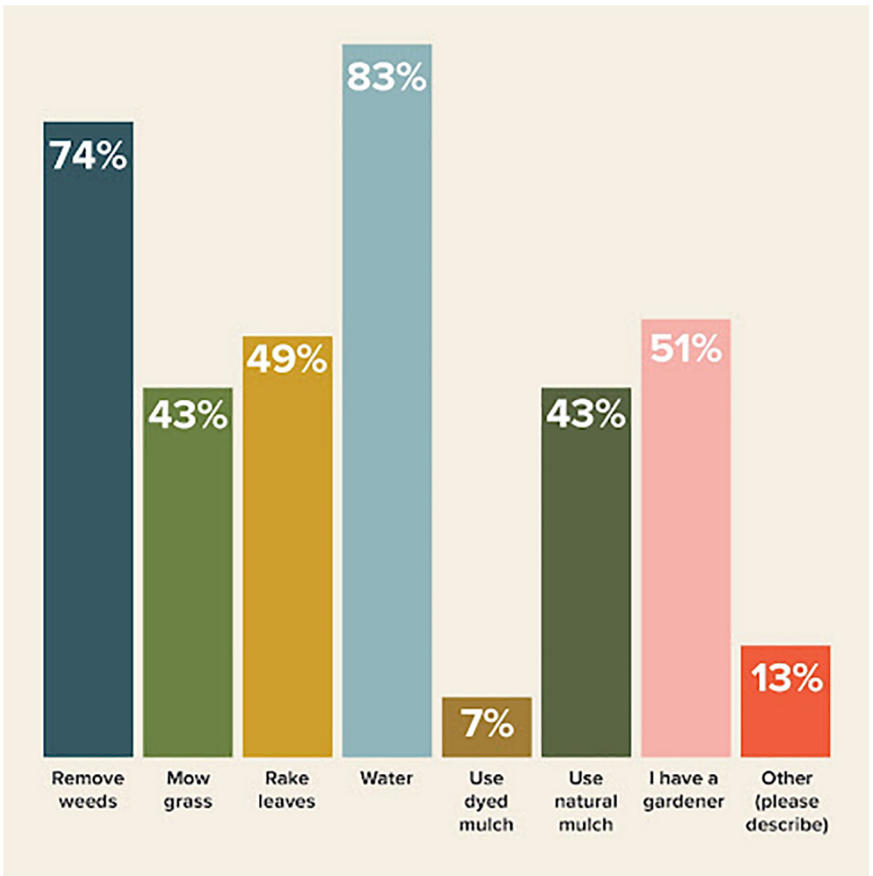


**FIGURE 2 |** Responses (and percentage for each response option) to the question "How do you maintain that area?" for the residents who report having a yard, landscaped area, or shared green space.

**TABLE 1 |** Reported treatments and observations (percentage of respondents) of soil in the green space residents maintain.

| | Yes | No | Don't know |
|---|---|---|---|
| Do you use fertilizer in that area? | 50.5% | 46.9% | 2.6% |
| Do you use pesticides in that area? | 17.6% | 79.2% | 3.2% |
| Does that area have earthworms in the soil? | 17.6% | 1% | 3% |
| Have you ever seen mushrooms growing in that area? | 59.2% | 8.9% | 31.9% |
| Have you ever taken any steps to improve the soil in that area (e.g., soil testing, compost application, mulching, etc.) | 59.6% | 35.1% | 5.3% |

**TABLE 2 |** The level of knowledge (percentage of respondents) of gardening and soil among residents.

| How knowledgeable are you about. . .? | Extremely knowledgeable | Very knowledgeable | Moderately knowledgeable | Slightly knowledgeable | Not at all knowledgeable |
|---|---|---|---|---|---|
| Gardening | 3.2% | 12.8% | 45.3% | 28.8% | 9.9% |
| Composting | 4.5% | 11.6% | 33.8% | 30.7% | 19.3% |

"soil contaminants and pollution" in the latter question, but not in the former.

Seventy-three percent of participants have and use a green waste bin, and an additional 20% say they want one. However, 38% of participants still continue to put their plant-based kitchen scraps in the black trash bin. In terms of kitchen waste, 16% of participants report using the green waste bin for their plant-based kitchen scraps, 24% of participants report composting kitchen scraps at home (a surprisingly large number), and 14% put them down the garbage disposal. Less than 2% of participants take kitchen scraps to a community compost hub. The fact that knowledge about composting is among residents is relatively low (**Table 2**), and the fact that recycling rates are high (75% always recycle and 19% usually do so), providing a green waste

bin and education about what can be put into that bin could improve composting rates. After all, participants already have a practice of sorting their trash – a practice that could easily extend to green waste.

Interest in soil-related issues (e.g., how soil impacts nutrition, stores carbon, holds water, etc.) was high among all participants (**Table 3**). In contrast, at least among residents, knowledge about factors that affect soil health was generally low (**Table 4**). Those who have primarily get information online (27%), from family and friends (15%), and from attending webinars and workshops (13%). The top 5 topics (in order) residents are most interested in learning about include: the relationship between soil and climate change; the relationship between soil and water pollution; geographic areas of LA where high levels of soil contamination exists; contamination risks associated with imported materials such as potting soil and compost; and how to reduce soil contamination exposure when gardening. This finding suggests residents are highly concerned about the potential impacts of soil contamination on health. Still, only 12% of participants have ever tested their soil, and of those participants, the most common characteristics people tested for were soil pH and NPK.

Ninety-three percent of participants are either extremely (63%) or very (30%) concerned with environmental issues (**Figure 3**), suggesting that an educational campaign and/or social marketing messages framed around the benefits of soil for environmental health could be very effective for changing public behavior. Finally, 76% of participants agreed TreePeople could contact them with more information about soil in LA, and provided their email addresses to do so.

In addition to summarizing the basic findings from the survey, some statistical analyses (including 1042 residents) were conducted to determine whether differences in home ownership status, geographic region, gender, and income, impacted participants' responses to certain questions. These analyses were not hypothesis-driven, thus, should be used only to explore relationships further, to develop and test the effectiveness of potential interventions, and to advocate for access to resources, for example, public green space, recycling bins, and compost (green) bins. The results are summarized below.

### Home Ownership

Residents who own their home are significantly more likely to have a garden than those who rent. In addition, home owners spend significantly more time gardening and are significantly more knowledgeable (as measured by self-report) about gardening than those who rent. However, homeowners and renters are equally interested in gardening, suggesting the differences in behavior and knowledge might be due to more limited access to green space for renters than for homeowners.

Although renters report using public green spaces more frequently than homeowners, both groups are equally concerned about soil contamination and pollution in public green spaces, as well as soil contamination and pollution, more generally.

No differences were found between homeowners and renters in terms of interest in soil, knowledge about factors that influence soil, or knowledge about composting. However, the COVID-19 pandemic changed interest in and behaviors around gardening and soil significantly more for renters than for homeowners. For most, gardening and soil became more important, as did spending time in the yard and/or garden. In addition, renters expressed more interest in learning about factors that impact soil than homeowners.

Although both groups have relatively high recycling rates, homeowners are somewhat more likely to recycle than renters. Further, homeowners are more likely to have (and use) a compost bin (green bin) than renters.

### Regional Differences (Using the 8 Geographic Regions Defined in the Methods)

While no differences in access to a green space or garden were found, residents in the San Gabriel Valley, the San Fernando Valley, and West LA report spending more time gardening than those in other regions. Those in South LA spend the least amount of time gardening.

Although concern about soil contamination did not differ by region, concern over environmental issues, more broadly, did. Specifically, residents in the San Gabriel Valley and the San Fernando Valley expressed the most amount of concern, while those in East LA, South LA, and the Antelope Valley expressed the least amount of concern.

In terms of knowledge of factors that impact soil, residents in the San Gabriel Valley and South LA report being more knowledgeable than those in other regions, followed by West LA, South Bay, East LA, the San Fernando Valley, the Metro/Downtown area, and the Antelope Valley.

Finally, although recycling rates are generally quite high, regional differences in recycling behaviors were found. Recycling rates are highest in West LA, the San Fernando Valley, and the Metro area, and lowest in East and South LA.

## Online Surveys – Educator Survey

One-hundred and thirty-nine participants answered two or more questions; however, again, since participants were allowed to skip questions, the results presented below are based on the total number of responses for each particular question.

This survey was intended for educators who may or may not teach about soil in their classes, in part, to better understand potential opportunities for infusing soil-related topics into the classroom, existing campus infrastructure and practices (e.g., presence of garden or green space, compost bin, and recycling), knowledge about and interest in factors that influence soil, and other practices related to maintaining healthy soil (e.g., composting, use of pesticides, herbicides, and fertilizers). Participants did an excellent job of self-selecting. In fact, based on responses to the question, "What is your title?" most participants have direct contact with students as either teachers or instructors, or principals (**Supplementary Table A**). Those who identified as teachers are primarily employed in primary and secondary (K-12) education. In addition, most (75%) educators would be considered experts, having been in their profession for more than 11 or more years, with 36% having more than 20 years of job experience. The average age of participants was 47-years old, and 97% of participants have either earned a 4-year college degree (24%)

**TABLE 3 |** The level of interest (percentage of respondents) in topics related to soil among residents, educators, and soil-related professionals, and policy-makers.

| Residents | Extremely Interested | Very Interested | Moderately Interested | Slightly Interested | Not at all Interested |
|---|---|---|---|---|---|
| How soil impacts nutrition and food security | 36.2% | 31.4% | 23.6% | 7.3% | 1.5% |
| How soil stores carbon and slows down climate change | 41.0% | 32.1% | 19.2% | 5.9% | 1.7% |
| Improving soil health | 38.8% | 34.2% | 19.9% | 5.9% | 1.2% |
| How to control weeds without synthetic pesticides | 43.1% | 33.6% | 15.4% | 5.4% | 2.5% |
| Soil water holding capacity and drought resiliency | 42.3% | 35.1% | 15.7% | 5.1% | 1.7% |
| The relationship between soil health and human health | 42.5% | 33.5% | 18.9% | 4.4% | 0.8% |
| How soil contamination affects environmental health | 44.3% | 33.9% | 16.7% | 4.5% | 0.7% |
| How improving your soil quality can benefit your plants/trees | 45.4% | 36.3% | 14.0% | 3.6% | 0.7% |
| **Educators** | | | | | |
| How soil impacts nutrition and food security | 45.0% | 30.2% | 16.1% | 8.7% | 0.0% |
| How soil stores carbon and slows down climate change | 51.7% | 27.2% | 17.0% | 4.1% | 0.0% |
| Improving soil health | 44.6% | 35.8% | 12.8% | 6.8% | 0.0% |
| How to control weeds without synthetic pesticides | 50.3% | 31.3% | 15.0% | 3.4% | 0.0% |
| Soil water holding capacity and drought resiliency | 44.6% | 37.8% | 13.5% | 4.1% | 0.0% |
| The relationship between soil health and human health | 52.3% | 28.9% | 14.1% | 4.7% | 0.0% |
| How soil contamination affects environmental health | 56.4% | 27.5% | 13.4% | 2.7% | 0.0% |
| How improving your soil quality can benefit your plants/trees | 45.0% | 30.2% | 16.1% | 8.7% | 0.0% |
| **Soil-Related Professionals** | | | | | |
| How soil impacts nutrition and food security | 43.9% | 28.0% | 18.3% | 6.1% | 3.7% |
| How soil stores carbon and slows down climate change | 62.7% | 28.9% | 2.4% | 4.8% | 1.2% |
| Improving soil health | 62.7% | 30.1% | 3.6% | 2.4% | 1.2% |
| How to control weeds without synthetic pesticides | 59.8% | 25.6% | 8.5% | 3.7% | 2.4% |
| Soil water holding capacity and drought resiliency | 69.5% | 19.5% | 4.9% | 4.9% | 1.2% |
| The relationship between soil health and human health | 53.7% | 29.3% | 12.2% | 4.9% | 0.0% |
| How soil contamination affects environmental health | 61.4% | 25.3% | 8.4% | 3.6% | 1.2% |
| How improving your soil quality can benefit your plants/trees | 67.9% | 19.8% | 9.9% | 1.2% | 1.2% |
| **Policy-Makers** | | | | | |
| How soil impacts nutrition and food security | 43.8% | 25.0% | 18.8% | 6.3% | 6.3% |
| How soil stores carbon and slows down climate change | 53.3% | 6.7% | 40.0% | 0.0% | 0.0% |
| Improving soil health | 43.8% | 25.0% | 18.8% | 12.5% | 0.0% |
| Minimizing synthetic-based fertilizers and pesticides | 43.8% | 31.3% | 25.0% | 0.0% | 0.0% |
| Soil water holding capacity and drought resiliency | 50.0% | 31.3% | 18.8% | 0.0% | 0.0% |
| The relationship between soil health and human health | 50.0% | 18.8% | 25.0% | 6.3% | 0.0% |
| How soil contamination affects environmental health | 50.0% | 18.8% | 31.3% | 0.0% | 0.0% |

or a graduate degree (73%). Most participants were female (77%) and 48% identified as white, suggesting this sample is reasonably representative of the population of educators in LA County.

Educators use of and knowledge of gardens and soil on their campuses varies (**Table 5**). Seventy-nine percent of respondents reported that their school has a green space or garden. Of those who work on campuses with green spaces and/or gardens, 48% mentioned grass in their description of the space, 65% mentioned trees, and 31% specifically mentioned vegetables and/or fruit growing in that space. Others implied the existence of potential food gardens (e.g., referring to, for example, "raised beds"), but did not specify what plants were growing in those beds. Only 13.7% were certain that pesticides and/or fertilizers were used in that area; however, many (43%) were unsure. In addition, 44% have seen earthworms in the soil, and 27% have seen mushrooms – implying that many educators have had direct contact with the soil. Further, 35% were certain that their administrators and/or landscapers have taken steps to improve the soil in that area. The most common examples of steps that have been taken include: mulching; composting; and adding soil.

Sixty-six percent of educators use (or know someone who uses) that green space in some capacity to teach classes, and in describing how that space is used, the most common responses included scientific (biological/environmental) observation, instruction, and experimentation, and food gardening. Not surprisingly, during the COVID-19 pandemic, campuses were largely closed and, thus, garden usage dropped significantly.

Many educators (25%) don't know what happens with green waste from their campus green spaces. Of those who did, 16% said it goes into the trash, 11% said it gets put into a city compost bin (green bin), 7% use it as mulch, 20% compost it on campus, and 12% leave it where it lies.

At least 74% of educators said that their school recycles, but only 31% said their campus currently has a compost bin/facility. However, 62% of educators said there is interest in having a compost bin/facility in the future. Interest in gardening and

**TABLE 4 |** The level of knowledge (percentage of respondents) about factors that influence soil among residents, educators, soil-related professionals, and policy-makers.

| Residents | Extremely knowledgeable | Very knowledgeable | Moderately knowledgeable | Slightly knowledgeable | Not at all knowledgeable |
|---|---|---|---|---|---|
| Physical composition of soil (e.g., sand, silt, clay) | 2.9% | 10.9% | 27.6% | 30.3% | 28.4% |
| Soil pH (acidity/basicity) | 1.7% | 4.7% | 21.5% | 29.1% | 43.1% |
| Soil bulk density | 1.8% | 3.3% | 14.5% | 23.9% | 56.5% |
| Soil permeability | 2.8% | 8.1% | 22.9% | 28.8% | 37.4% |
| Soil chemistry (e.g., nitrogen, phosphorous, potassium) | 1.7% | 4.6% | 19.2% | 29.7% | 44.8% |
| Soil organic matter | 2.4% | 6.4% | 20.7% | 27.3% | 43.1% |
| Soil biodiversity | 2.9% | 10.9% | 27.6% | 30.3% | 28.4% |
| **Educators** | | | | | |
| Physical composition of soil (e.g., sand, silt, clay) | 5.4% | 11.5% | 33.1% | 24.3% | 25.7% |
| Soil pH (acidity/basicity) | 3.4% | 4.1% | 27.2% | 25.2% | 40.1% |
| Soil bulk density | 0.7% | 4.1% | 19.6% | 21.6% | 54.1% |
| Soil permeability | 3.4% | 10.2% | 26.5% | 25.2% | 34.7% |
| Soil chemistry (e.g., nitrogen, phosphorous, potassium) | 2.7% | 6.8% | 23.1% | 25.9% | 41.5% |
| Soil organic matter | 2.7% | 12.8% | 27.0% | 27.7% | 29.7% |
| Soil biodiversity | 2.7% | 10.8% | 23.6% | 22.3% | 40.5% |
| **Soil-Related Professionals** | | | | | |
| Physical composition of soil (e.g., sand, silt, clay) | 5.4% | 11.5% | 33.1% | 24.3% | 25.7% |
| Soil pH (acidity/basicity) | 22.2% | 22.2% | 45.8% | 8.3% | 1.4% |
| Soil bulk density | 11.0% | 22.0% | 47.6% | 12.2% | 7.3% |
| Soil permeability | 3.9% | 16.9% | 35.1% | 20.8% | 23.4% |
| Soil chemistry (e.g., nitrogen, phosphorous, potassium) | 15.7% | 32.5% | 41.0% | 8.4% | 2.4% |
| Soil organic matter | 7.2% | 20.5% | 45.8% | 16.9% | 9.6% |
| Soil biodiversity | 22.0% | 23.2% | 35.4% | 15.9% | 3.7% |
| **Policy-Makers** | | | | | |
| Physical composition of soil (e.g., sand, silt, clay) | 6.3% | 6.3% | 0.0% | 37.5% | 50.0% |
| Soil pH (acidity/basicity) | 6.3% | 6.3% | 0.0% | 37.5% | 50.0% |
| Soil bulk density | 0.0% | 12.5% | 0.0% | 12.5% | 75.0% |
| Soil permeability | 6.3% | 6.3% | 18.8% | 31.3% | 37.5% |
| Soil chemistry (e.g., nitrogen, phosphorous, potassium) | 0.0% | 12.5% | 0.0% | 37.5% | 50.0% |
| Soil organic matter | 6.3% | 6.3% | 6.3% | 37.5% | 43.8% |
| Soil biodiversity | 6.3% | 12.5% | 0.0% | 31.3% | 50.0% |

horticultural plants was also quite high; 73% of educators were either extremely (41%) or very (32%) interested.

Most educators report lacking knowledge about composting and soil (**Table 6**). Specifically, just 19.5% consider themselves knowledgeable about composting, and only 14% consider themselves knowledgeable about soil. Furthermore, knowledge about specific factors that influence soil is also low (**Table 4**). A lack of knowledge (or a perceived lack of knowledge) might help to explain why only 30% currently teach about soil in their classes, and only 37% would feel comfortable doing so. That said, educators expressed high interest in learning more about soil (**Table 3**). With interest high and knowledge low, offering soil-related workshops to teachers might be an effective way to increase student education opportunities around soil, particularly if these workshops can be infused into those that offer Continuing Education credit.

Roughly 26% of educators have never attempted to learn about soil in any way. Of those who have, the three primary ways educators gain information about soil included reading books or online websites (26%), asking family or friends (14%), and by attending webinars, workshops and training (14%). Just 4 survey participants specifically named TreePeople as a way they have learned about soil, and only 2 reported learning from the LA Soil Survey. Taken together, these findings suggest many teachers may not be aware of existing, local resources that offer opportunities to learn.

Forty-eight percent of educators reported being concerned about soil contaminants and pollution, and 32% said they had never thought about it (**Figure 4**). Only 8% of educators knew whether or not their campus soil had been tested for contamination, and 72% were unsure. However, 88% of educators reported being "extremely" or "very" concerned for environmental issues, more broadly (**Figure 3**).

## Online Surveys – Policy-Maker Survey

Nineteen participants self-identified as policy-makers and answered more than two questions. As was the case for previous results, because some participants chose not to answer every question, percentages reported here are based on the total number of responses for a given question.

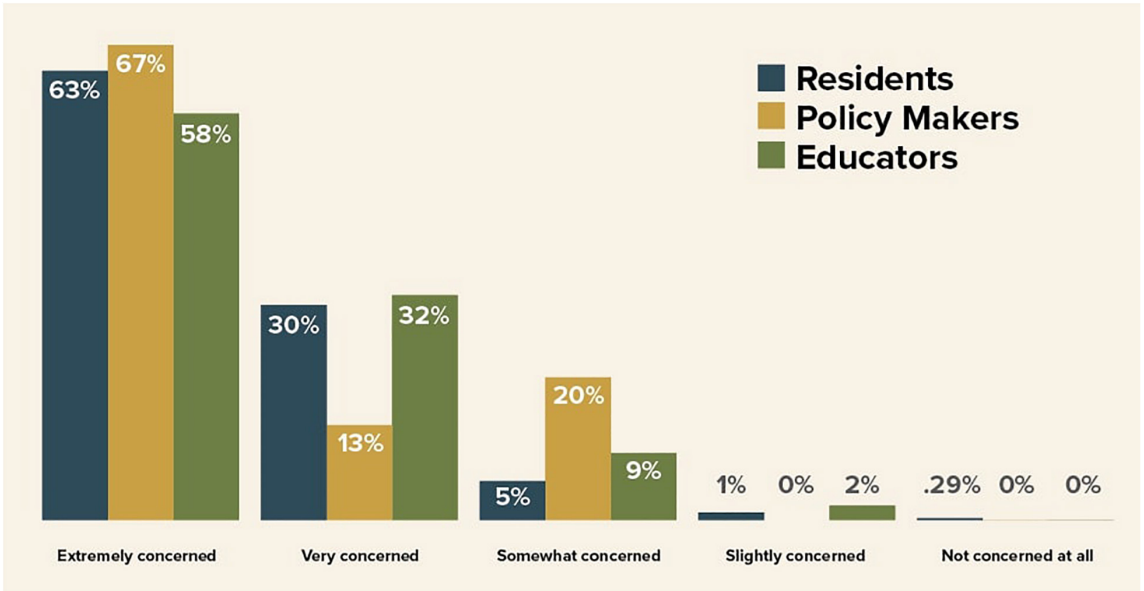


**FIGURE 3 |** Level of concern about environmental issues among residents, educators, and policy-makers.

**TABLE 5 |** Use and knowledge (percentage of respondents) of campus gardens and soil among educators.

| | Yes | No | Not Sure |
|---|---|---|---|
| Does your school have a green space or garden? | 79.3% | 19.2% | 1.5% |
| Does your school use pesticides and/or fertilizers in that area? | 58.9% | 14.2% | 1.2% |
| Do you or others at your school teach classes in that area? | 8.5% | 26.9% | 26.9% |
| Does that area have earthworms in the soil? | 39.6% | 10.7% | 40.3% |
| Have you ever seen mushrooms growing in that area? | 24.7% | 43.8% | 24.0% |
| Have your administrators/landscapers taken any steps to improve the soil in that area? | 31.3% | 32.7% | 26.7% |

**TABLE 6 |** Soil-related knowledge levels (percentage of respondents) among educators.

| How knowledgeable are you about. . .? | Extremely | Very | Moderately | Slightly | Not at all |
|---|---|---|---|---|---|
| Composting | 5.5% | 14.0% | 40.9% | 28.7% | 11.0% |
| Soil | 4.8% | 9.1% | 35.2% | 33.3% | 17.6% |

This survey was intended for elected officials and community leaders who make decisions for their neighborhoods and organizations. Participants did a reasonably good job of self-selecting (**Supplementary Table B**). That is, most participants would be considered community leaders and were either employed by the city (43%), county (21%), or state (7%). The average age of participants was 47-years old, and those who completed the survey were highly educated. All had at least a 4-year college degree and 53% had earned a postgraduate degree. The sample was divided equally between males and females, and between participants that identify as white and Hispanic/Latino/a.

Eighty-four percent of participants believe soil is either extremely (63%) or very important (21%); however, only one expressed certainty that funding would be available for soil health (e.g., contamination, remediation, testing, water conservation, etc.) in the 2020–21 fiscal year, and that person expected funding would continue in the next fiscal year. The remainder either stated funding would not be available (37%) or were uncertain (58%) about the availability of funding for soil-related projects. The biggest barrier to funding soil-related projects was budgetary constraints. One participant explained that soil-health is not as big of a priority as either "public safety or health of residents," suggesting education around the relationship between soil health and public health and safety could be effective for increasing the priority for funding. Moreover, most participants admitted to lacking knowledge about factors that affect soil health (**Table 4**), and 33% have never attempted to learn about soil in any way. These results further suggest a potential benefit for education, especially in the form of workshops and online resources, since that's how most people who had attempted to learn about soil reported gaining information.

Compost facilities are present in at least 33% of the jurisdictions, and most are maintained by the municipality

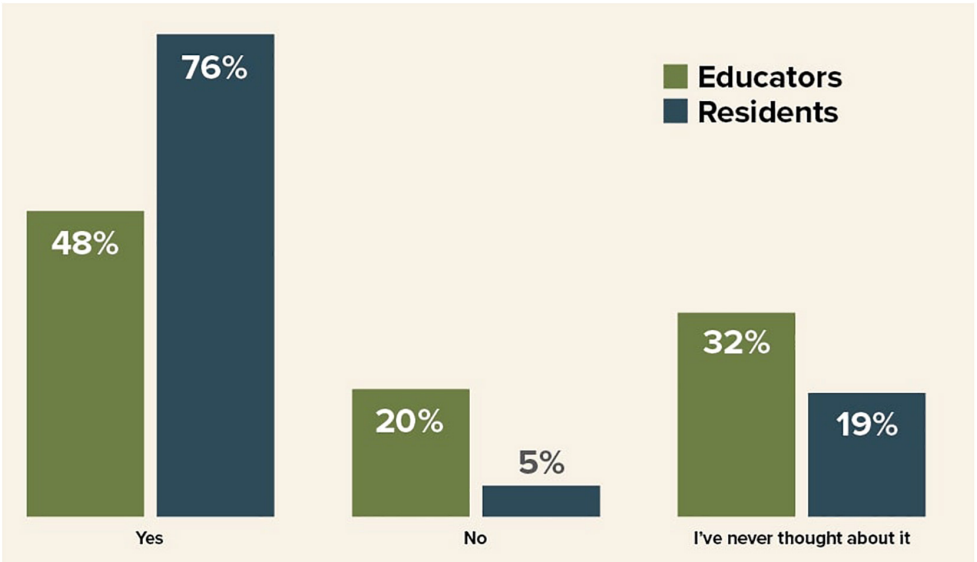


**FIGURE 4 |** Level of concern about soil contaminants and pollution among residents and educators.

(62%). The remainder are managed by NGOs (25%) and the private sector (12%). Mulching facilities are slightly more common, present in 39% of jurisdictions. Again, most facilities are maintained by the municipality (67%), with the rest being maintained by the private sector (33%).

Almost 70% of policy-makers were either extremely or very concerned about soil contaminants and pollution (**Figure 5**). However, they believed only 40% of community members feel the same way, which, again, could explain why funding for soil-related projects has not been made more broadly available. Only 30% reported having ever received a call from a resident inquiring about soil testing. In addition to being concerned about contamination and pollution, 80% of policy-makers were either extremely or very concerned about environmental issues (**Figure 3**).

General interest in learning more about soil-related topics was quite high, especially for topics including: soil policy and funding opportunities; the relationship between soil and water pollution; the relationship between soil and climate change; geographic areas of LA where soil contamination is the highest; and the need for soil specifications for particular uses (e.g., street plantings versus rain gardens).

## Online Surveys – Professional Survey

Eighty-seven participants self-identified as professionals and answered more than two questions. Again, because some participants chose not to answer every question, percentages reported below are based on the total number of responses for a given question.

This survey was intended for professionals who work with soil regularly in their jobs (**Supplementary Table C**). Most participants were, indeed, likely to encounter and work with soil in some capacity on a fairly regular basis and most had been doing so for a long time. Specifically, 63% of participants had been in their profession for more than 10 years, and 33% had more than 20 years of job experience. The average age of participants was 52-years old, and 87% of participants have either earned a 4-year college degree (34%) or a graduate degree (53%). Most participants were female (72%) and identified as white (64%), which suggests this sample may not fully reflect the population of soil professionals in LA County.

When considering the design of a green space, by far the most important aspects participants reported considering, in order of importance, were how people will use the space (100%) and climate-appropriate plants, shrubs, and trees (97%). These two factors were ranked to be even more important than their client's preferences (80%). Also more important than client's preferences was minimizing water runoff/hydrology (86%). Taken together, these results suggest that professionals who completed the survey understand the importance of water conservation and minimizing water pollution. That said, participants also reported always (48%) or usually (37%) using turf grass in their designs. While grass can be an effective tool for retaining soil moisture and preventing urban heat island effects, water consumption for turf grass can range from 50 to 70% of total urban landscape water consumption, particularly in summer months, making it a less desirable ground cover than drought-tolerant alternatives.

Eighty-three percent of professionals reporting taking steps to improve the soil, protect soil health, or replace the soil in their projects, and the top five ways they do so are by: using mulch (71%); adding compost and soil amendments (63%); testing the soil (23%); avoiding compaction (16%); and by adding mycorrhizae to the soil (11%). In addition, remediation techniques used to reduce soil contamination included: adding compost and/or mulch (28%); removing the contaminated soil (28%); and bioremediation/phytoremediation (23%). These techniques for improving soil health and reducing contamination make sense given that soil compaction (100%) and poor soil

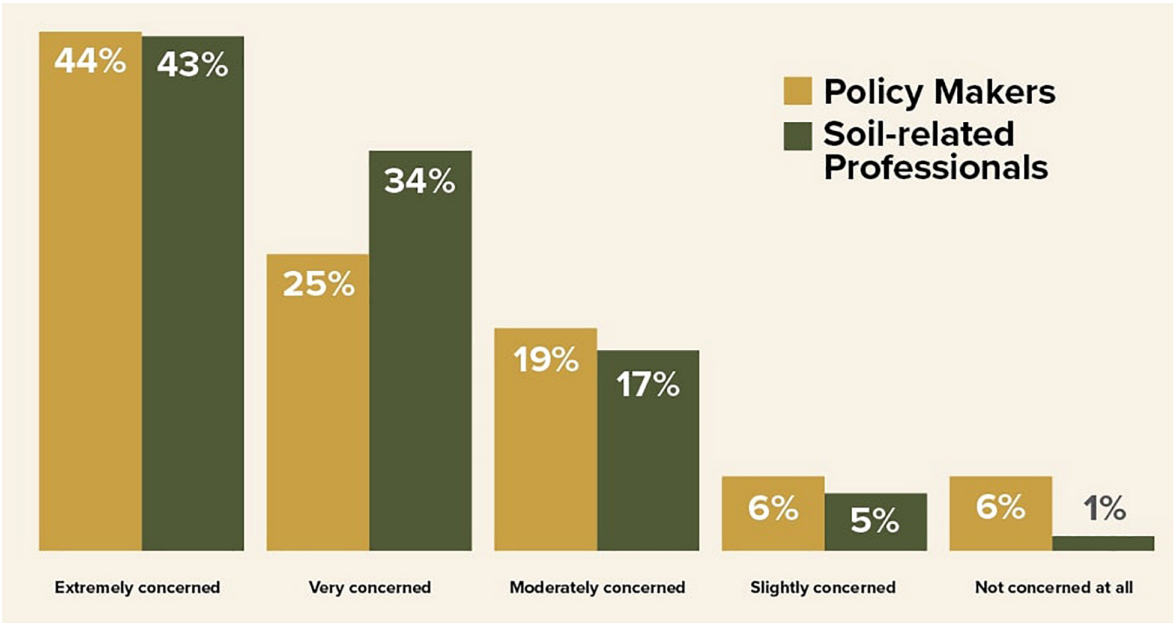


**FIGURE 5 |** Level of concern about soil contamination and pollution among policy-makers and soil-related professionals.

health/soil quality (98%) were reported as the primary soil-related challenges.

Despite the fact that 70% of participants reported using mulch, only 30% use the green waste from their projects as mulch. In addition, 31% either take green waste from their projects to a city compost facility or compost it at their business. Of those who did not compost, barriers to composting green waste included: no composting facility available (48%), insufficient time (19%), and cost (14%). Determining which of the barriers listed are perceived rather than actual barriers would be helpful for increasing the diversion rate for compostable material.

Soil-related professionals are at least moderately knowledgeable about all factors that affect soil health (**Table 4**), and only 1.5% had never attempted to learn about soil in any way. The three primary ways professionals gained information about soil were through soil testing (32%), webinars, workshops and trainings (25%), and by reading books or online websites (23%). Of the policy-makers, none reported having learned from the LA Soil Survey, which implies they may not even be aware of its existence. However, of professionals, 6.5% reported learning from that survey.

Like policy-makers, 77% of professionals were either extremely or very concerned about soil contaminants and pollution (**Figure 5**). However, they believe only 17% of their community members feel the same way (policy-makers believed 40% of their constituents felt the same way). Both groups were wrong about how concerned the general population is with soil. In fact, according to results of the residential survey, 76% of community members report being concerned about soil contaminants and pollution (**Figure 4**). This suggests a disconnect between what experts believe about the public and how the public actually feels.

General interest in learning more about soil-related topics was high, although less so than for policy-makers, which is not surprising given professionals are already quite knowledgeable. However, interest in learning was especially high for topics including the relationship between soil and climate change, and between soil and water pollution, geographic areas of LA where soil contamination is the highest, how to protect soil before, during and after construction activities, and best management practices for remediating contaminated urban soils.

## Focus Groups – Community and Coalition Focus Group

An analysis of interviewer-generated codes (**Table 7**) produced unique themes that distinguished the priorities of each group and different approaches to common issues related to soil. The Community and Coalition group, in thinking through concepts of collaboration and partnerships, repeatedly emphasized the need to avoid burdening communities, particularly with one-off projects. Efforts and initiatives from public agencies have also translated to additional labor not only for communities but also members of the Community and Coalition groups who have had to evaluate the intentions and impacts of these initiatives.

> *".I know oftentimes money tends to be a major factor to what gets implemented and what doesn't, because nobody's working for free. Oftentimes, when they [public agencies] go to activists or even grassroots organizations, they're [activists/grassroots organizations] the ones who are not just juggling, like 10 different projects, but they're also the ones who really care the most about their communities and the people that they serve, that they want to make sure that any, like educational pamphlet or information that's being given from the top down, does this work for them [communities]? You know, are they only just addressing one audience? [.] And it's*

**TABLE 7 |** Most frequent codes by focus group types.

| | Community and Coalition Groups | Technical and Policymakers | Gardening and Urban Agriculture |
|---|---|---|---|
| Priorities (Individual) | Communication and collaboration (Centering on community)<br>Resources<br>Systems Approach to Soil<br>Education (building technical capacity) | Communication and collaboration (draw on pre-existing relationships)<br>Composting, Gardens, Food<br>Health as a contested term | Equity, Power, and Past Harm<br>Systems Approach to Soil<br>Land Access |
| Priorities (Collective) | Communication<br>Education<br>Resources (primarily from Technical and Policymakers and Gardening and Urban Agriculture)<br>Policy | | |

*The parent codes included "Communication," "Collaboration," "Composting, Gardens, Food," "Education," "Equity, Power, and Past Harm," "Health as a Contested Term," "Land Access," "Policy," "Resources," "Soil Contamination/Testing," and "Systems Approach to Soil."*

*really up to us to kind of decipher through all of that math, to see what really is going to work and what isn't.*"

Similarly, participants took issue with initiatives from policymakers and local government officials that sought to implement novel green initiatives, while lacking a community centered approach. Projects focusing on sustainability, like composting and tree planting, though beneficial, did not often consider what communities themselves wanted. Participants in Community and Coalition focus groups repeatedly referenced the need for community centeredness in approaching soil management:

"*.as much as I want my community to be green, to just have more trees, because we deserve it - we deserve cleaner, we deserve green streets- I'm also thinking about, well, you know, not to say that they don't want it, but it's like, is it a priority? [. . .] We usually talk to our community members, and we talk to them about the benefits of having more trees, of having cleaner streets. Most often, they're like, 'yeah, you know, we want this, but it's like, it's taking so long for anything to happen, is it even gonna happen?' So you have all this doubt tend to just pile up and I can't blame them for that. So what I think my community wants can be completely to what they think they want. We got to always go back and ask them what is your need*?"

Although resources came up in nearly all focus groups, it was most frequently coded in conversations with the Community and Coalition groups. Participants provided mixed responses on funding accessibility. Many cited the difficulties and challenges in applying for funds that are earmarked or conditional to certain uses. Though limited resources did create some competition, many participants in the Community and Coalition groups rejected framing resource allocation as a zero-sum game.

"*I think an opportunity that could really help this is again, partnership and collaboration. It's important to really look at what you as an organization, what your strengths are, and also be able to see what the strengths of other organizations are and how to gather that. Like the work that can be accomplished, I feel, if there was a healthy way for our organizations to collaborate, to advocate for resources to be distributed to the groups, so there'll be less time trying to go out and fight for funding, and more time focused on addressing the issues, I think that would be extremely helpful.*

## Focus Groups – Technical and Policy Focus Group

For the Technical and Policy group 'Communication' was by far the most recurring topic coded across all sessions. Communication was primarily emphasized through a greater need for visibility and awareness on ongoing issues related to soil. Many members of the groups related experiences on the large competition for attention to certain issues, with soil health being more difficult to present as important relative to other, more immediate needs of community members. Interviewees in this focus group also highlighted the need for community centeredness, and ways to shape narratives to counter traditional methods of political support. One member described it as:

"*I think that putting the emphasis on political support might not be all that necessary, because I feel like political support always follows the demand. And so you create demand, and then politicians fall in line. I think it's almost a waste of time sometimes to try to get them to be leaders. Instead, so many of the politicians seem to just be followers, 'oh, I'm gonna follow this, because that's what everyone else wants'. So if you create the demand, you create the market, then the politicians kind of fall in line.*"

For Technical and Policymakers groups, codes also revealed a high emphasis on 'Composting, Gardens, and Food.' Many policy makers cited case studies within the field that had shaped policy narratives and the need to link these policies to wider and more comprehensive solutions. In designing policy solutions to soil health participants identified the historic and contextual factors involved in the local ecology when situating and evaluating the impact of a policy or program that could address needs for composting, garden, and other food related initiatives. Within these excerpts, coded as comprehensive solutions, participants outlined an awareness of local needs that grounded long term projects and initiatives to community capacity, knowledge, and resources in maintaining the longevity of any composting, garden, or food waste efforts. Many of these participants referenced anecdotes of failed projects where a lack of awareness on community conditions meant one-off projects had little, if any, long term benefits for communities and others that lacked long term infrastructure to ensure their longevity.

"*. You have compost hubs in the community gardens but we need a lot more of [. . .] distributed composting ability so that we can*

*be building up soil with something that traditionally goes to landfill. So I see potential but there are no existing policies yet, and not really enough infrastructure to do that.*"

In determining effective soil policies the Technical and Policy group also described health as a highly contested term, both as it related to soil health and community health. Isolated definitions within the context of soil policy often resulted in what participants described as a lack of clear vision and strategies. Working with soil meant a greater need to clarify not only what the definition and vision is for soil policy and initiatives, but also contextualizing the purpose of an action relative to the community context. One participant within the Technical and Policy Group described the role audience played in determining the scope of a proposal:

"*. . .the audience would probably for me determine what's most important because again, with policymakers we're able to give them statistics and data that show, you know, community health impacts based on toxic soil and other things like that, versus, again, maybe talking to communities about having healthy community gardens as a fun place to be together and grow food. Those are two different audiences that have different needs.*"

## Focus Groups – Landscape and Urban Agriculture Focus Group

While the Landscape and Urban Agriculture group cited similar issues and concerns with composting and other food-related projects, these focus groups took a more systemic approach to soil health issues. "Equity, Power, and Past Harm" was cited with more frequency than any other focus group type. Practitioners in the field of urban agriculture referred to the lack of "corporate accountability and political accountability" that had often perpetuated distrust in communities and complicated implementation of any soil related initiatives. Many of these participants drew from their own experience either in the field, or from their perspectives as part of communities targeted by environmental racism, in identifying the large degree of distrust toward business, local governments, and scientific bodies based on their failure to address the historic harm these institutions have played out. Programs and policy initiatives that did not feature environmental justice as a priority or framework were seen as disconnected from community priorities. In particular, the Exide Technologies site, a former battery recycling plant in Vernon CA, responsible for widespread contemporary soil contamination, was a frequent topic of conversation across focus groups.

"*.we had a lot of scientists that sided with polluters, and not bringing out the truth about the contamination, it worries me because although I believe in science, and I think everyone with formal education, basic education, going through our public school system that you're taught, you know, science, the water cycle, how clouds are formed, just basic information, that when we talk now about scientists, especially for those of us living in this contamination, I cannot trust that some government official, who knew, and I'm going to give just Exide, as the example, they knew the chemicals that were being used that were that they were exposing the community. The science community knew that, and what did it take for our community, our science community to come out and say, 'Hey, we know what's happening there.' No one said anything. And so although I believe in science, I do have issues with scientists who are trained and know what carcinogens are, where contaminants are, you know, with these harsh chemicals that we have been exposed to, not just for 10 years, but for decades, and that our science community didn't come out, like the doctors who take an oath to do no harm, that nobody came out to say anything.*

In working toward initiatives that addressed the more systemic and equity related issues of soil health, the Landscape and Urban Agriculture groups also referenced land access as a key issue in addressing soil issues. Factors like ordinances and a lack of awareness of local needs acted as barriers in implementing sustainable and long term soil-related projects. These focus groups referred to the role ordinances and local codes played in making more in depth soil initiatives function over the long term. In addition other considerations like the maintenance of the project and the funding available for these initiatives were key determinants in the success of these projects. One participant described their own struggles as an urban farmer.

"*. I wish that I could have more space in the city, and just knowing that land access is so, so, so challenging because of cost, because of so many just systemic, social barriers, because of capitalism. I know so many folks that would love to grow food and give it away for free and that doesn't work. When you live in Los Angeles, I need to pay rent here.*"

## Cross-Cutting Themes – All Focus Groups

Throughout all focus groups, participants addressed the need for education in approaching soil management and health. Education was coded most often with communication, and discussions often linked the two as intrinsic elements in creating an effective soil management strategy that connected to, and was relevant for communities most impacted by soil health. Participants cited examples of demonstration projects and informational materials that were often inaccessible to their communities and constituents, such as pamphlets on soil health and gardening aimed at middle class families with the space and resources for larger scale interventions. Repeatedly, the need for visibility and awareness in these interventions was necessary for communities to be able to consider these soil interventions as viable projects within their own neighborhoods and homes. The accessibility of information was an integral component of effective education strategies throughout all focus groups, with one member describing it as:

"*. availability and accessibility is really an environmental justice lens. So I think you start with that and then you go into partnerships and if you build out a foundation of environmental justice then the whole thing is put together.*"

While many of the focus groups pointed to the need for building technical capacity, the Community and Coalition group saw it as especially important. A member of the Community and Coalition focus groups summed it in the following manner:

"*I think we need to be able to use smaller demonstrations or demonstrations as the community engagement. It's kind of like, the*

*scientists need to come out and do experiments on the field, not in their mind, we need to do them in community. So, of course, that benefits community. So that's what I would suggest is more smaller demonstrations, even like pop up events of land that's going to be vacant or to do resident science activities."*

Although policy did come up consistently throughout all focus groups it was primarily discussed with the Technical and Policy group as well as the Landscape and Urban Agriculture Group. For the latter, the greatest leverage points for policy primarily came in the form of commercial and financial incentives. Those working in urban agriculture identified policy makers as being able to break down a lot of barriers holding back more effective engagement and systemic change to soil health and management.

"*There's plenty of scientists, technical experts, activists, all of these folks ready and already on the pulse. But policymakers just need to put money out there for it. All they have to do is say, here's a piece of land, we're pushing back all the permits, there's a budget, we need this expert, that expert, the expert, and the goal is to regenerate the land on this space by next fall. That's all that has to happen. But there needs to be a budget otherwise, there's no steam. I mean, these are folks who've done this for passion for free and continually will do because they know it's a mission. But unless there's money, we can set aside time and income economically you say the opportunity costs of doing this is high, unless we lower the cost by offering funding to these experts. So all the engagement can happen. There just needs to be a little more leadership focus and funding.*"

Further, policies that create market incentives and linked soil management to greater workforce development were felt by many participants to have the greatest opportunity in leading to more systemic change to how food production and soil health are taken into account. Those within the Technical and Policy group echoed these sentiments but added an emphasis on the fact that many of these relationships and initiatives already existed. Moving beyond incentivizing soil management programs, Technical and Policymakers identified the need to formalize pre-existing work and relationships and leverage policy to formalize these initiatives and partnerships. Interlinking these policies to common issues and goals was an overarching theme throughout our focus group interviews.

An interconnected approach to soil management and health with clear goals and outcomes was brought up in nearly all focus groups as key to the success of a robust soil health program. While the Technical and Policy Groups primarily characterized interconnectivity through the lens of policy, other focus groups characterized a systems approach to soil embedded within other aspects of society and the environment. In linking the issue of soils with wider public health, housing, and other issues, communities are able to support soil initiatives while addressing more immediate and visible needs for affected stakeholders. One participant in the Community and Coalition groups described it in the following way:

"*If I'm just talking about soil, or I'm just talking about birds, or just talking about all these, you know, one thing, it's going to be very hard. So usually when I do community outreach, I don't even talk about birds, I talk about the community, I talk about things that are going to connect us as a community. And we do that in a way that is going to promote trust, and promote an idea of being able to address all the issues that are affecting our communities, not just these single issues. So when I think about things like this, and how it's important- because I do believe healthy soils important- I don't just talk about the soil, I talk about the systems that promote the house that also, you know, you can't really talk about healthy soil without talking about healthy trees. And you can talk about those two, you're not talking about water, and where's your water coming from, and who needs all the stuff. So you see how there's this system and this holistic approach that you can then talk about, that brings in a lot of issues that traditionally environmental and conservation groups don't want to hear. And that's the substance abuse, that's the homelessness, the lack of affordable housing, all of those things.*"

### Focus Groups – Synthesis Focus Group

In our final synthesis group, participants from all three focus group types echoed many of the broad sentiments and cross cutting themes that had emerged. Synthesis groups prioritized the development of a city holistic soil strategy that also included social dimensions and affordable housing as well as the creation of consensus on a healthy soil definition that considered scope of impact (for who, for what, and where). Additional priorities that came up were greater inclusion of equity and actions to address harm, including the development of a city strategy that centers racial justice in urban soil work, funding that supports equitable land access, demonstration projects, and addresses legacy pollution, an evaluation of the feasibility of public land to support healthy soils, and improved communication strategies for researchers and communities.

## DISCUSSION

### Community Perceptions of Urban Soil Issues

Data regarding the most pressing urban soil issues in a large North American city reveal both commonalities and some contradictory findings within and across stakeholder groups. For LA County residents, green space is highly valued, indicated by the majority of residents maintaining some kind of green space. The valuing of green space and the services it provides, however, did not necessarily translate to high levels of knowledge regarding soil systems, with the majority reporting that their knowledge regarding factors impacting soil health is low. This contradiction is perhaps the biggest challenge to comprehensive urban soil research, policy and advocacy. While high profile tree planting campaigns indicate that the narrative around urban vegetation benefits is gaining traction in LA and nationwide, a significant disconnect seems to persist between knowledge of belowground soil systems and the valuing of aboveground vegetation and green space. This mirrors sentiments that have been shared in the literature, with authors citing a need for increased awareness, protection, and valuing of soil systems (Wall and Six, 2015; Montanarella et al., 2016). Focus group participants offered insight on this disconnect, citing that belowground systems were often ignored, less appreciated, less charismatic, and generally less supported compared to their aboveground counterparts.

Although self-reported knowledge regarding urban soils may be low among residents, they are very concerned about soil

contamination. This sentiment is shared among policy-makers and professionals; however, LA County educators are not nearly as concerned. High levels of concern regarding soil contaminants could be context dependent. For example, the high profile Exide case, a former battery recycling plant that contaminated nearby soil has been widely covered by the media, including coverage of an ongoing and contentious clean-up effort that coincided with the timing of the focus groups. Indeed, the Exide case was a frequent topic of focus group conversations. This highlights that although many of the methods of this work are transferrable, a place-based approach may be necessary to capture important regional and cultural context. The reason for lower concern regarding soil contaminants among LA County educators is unknown; however, coupled with the finding that the majority of educators are extremely interested in soil contamination, it seems like an obvious opportunity to connect area educators to an environmental health topic of regional significance.

Stakeholders did not always have an accurate perception of the needs and concerns of other groups. Interestingly, policy-makers and professionals in the online survey underestimated the extent of community concern around contamination, predicting it to be much lower than it actually was. As the role of policy-makers is to set agendas in alignment with constituent needs, this disconnect is worrying. The focus groups revealed that even when different stakeholder groups identify the same concern or need, for example, improved communication, they might frame that concern or need very differently. For example, community and coalition groups highlighted the need to address power imbalances and past harm and center community-led demonstration projects to improve communication. In contrast, policy-makers placed a greater emphasis on education and outreach in communication efforts. These are two very different approaches toward meeting communication goals. Policy-makers in the online surveys also surmised that strengthening the connection between public health and soil health could be a way to prioritize limited funding. Likewise, researchers have called to strengthen the connection between soil and human health (Wall et al., 2015). However, focus group participants identified health as a contested term and suggested that the multiple framings of both community, public, and soil health can sometimes lead to uncertainty and a lack of clarity in project goals. Both of these findings, (1) stakeholders misconceptions regarding the concerns of other groups and (2) different approaches to solving universally recognized concerns, point to the need for community-informed soil science research agendas to provide opportunities for dialog among different stakeholder groups in order to connect, share knowledge and perspective, and unlearn assumptions.

There are a few important caveats to our results. Specifically, respondents that participated in the online survey represent a more privileged community compared to LA County as a whole, with higher incomes, higher rates of home ownership, and more formal education. While demographics were not gathered for focus group participants, they are also likely biased, being comprised of stakeholders with investment and knowledge regarding urban environmental systems.

## The Role of Community Engagement in Soil Research Agendas

Community engagement in the agenda-setting stage of research development can inform the *process* of conducting research as well. For example, conversations around legacy soil pollution, specifically the former battery recycling plant, Exide, revealed an important legacy of broken trust in community-scientists relationships, with focus group participants sharing that they felt the scientific community remained silent on an important issue of public and environmental health. A lack of trust in public authorities, specifically in regard to this case, has also been noted in the literature (Johnston et al., 2019). This provides important context as to how communities may be thinking about soil contamination issues in their neighborhood as well as how research approaches and methodologies may be received. These insights can inform the *process* of doing urban soil research, recognizing that social legacies of mistrust and harm need to be addressed alongside legacies of historic pollution (Cutts et al., 2017).

Community engagement in the agenda-setting stage can also identify important community concerns that historically have not been closely associated with urban soil research, providing an opportunity to align issues of soil science and community health and well-being. For example, equitable land access was identified as central to urban gardening and food production in LA. Participants in the landscaping and urban agriculture group shared that equitable access to land was a major barrier to food production and that evaluating underutilized public space for urban agriculture and green space is a top priority. In addition, studies have documented that in addition to access, the precariousness of such access can also create a barrier to growing food (Horst et al., 2017). Soil scientists may identify issues of land access and tenure as outside their area of study or expertise; however, without access to land, the documented high interest in gardening among residents cannot be realized. Inequitable access will result in groups with greater power having greater access. For example, the online surveys demonstrated that interest in gardening is equally high among homeowners and renters, although the practice of gardening is higher for homeowners, presumably due to a lack of access for some renters. Connecting community concerns, including those associated with social justice issues, directly to urban soil systems not only informs urban soil research agendas, but provides a challenge to urban scientists to advance the framing of cities as coupled social and ecological systems. Systems research that does not create space for issues of housing, food security, public safety, and human health and well-being are missed opportunities to connect the social and ecological components of urban ecological systems.

## A Framework for Urban Soil Research Policy, Public Education and Community Engagement

Our approach provides a foundation for which to create urban soil research agendas that may be better aligned with community

need. Elements to this approach that we consider essential and transferrable to other cities include:

### Early, Sustained, and Inclusive Engagement

Community engagement around urban soil science is not common practice and projects that do engage communities may define engagement narrowly, i.e., data collection and/or not engage with communities until later in the process after research questions have been defined and priorities identified (Fernández-Viña et al., in review). This represents a missed opportunity to achieve goals of co-production and co-powerment and to incorporate knowledge from people that are actively managing urban soil systems. Early, sustained, and inclusive community engagement may communicate a commitment to community-centered approaches and could be an important future direction guiding the process of urban soil research, policy, and management. Early engagement in the research question or priorities-setting stage may present significant challenges as well. For example, it may result in a list of community-driven priorities that are not aligned with priorities set by funding agencies, resulting in false promises if expectations are not clear. Navigating these tensions and dynamic interactions, however, may lead to more resilient community-researcher partnerships (London et al., 2018).

### Centering Community Knowledge

Soils in cities are managed by a patchwork of diverse and divergent stakeholders in a myriad of ways, through watering, mulching, moving, and fertilizing soils. It is imperative in these highly altered systems, with often heterogeneous management regimes, to incorporate the knowledge, needs, and concerns of stakeholders into research, policy, and management decisions. Many stakeholders alter and interact with soil every day and management decisions at the parcel scale can impact coarser scale processes and outcomes. Community knowledge reveals a nuanced understanding of soil and associated concerns that can serve as a framework for future work regarding urban soil research policy, public education and community engagement. In the case of the *Healthy Soils for Healthy Communities Initiative*, community knowledge informed a community-centered research agenda which includes strategic planning, coalition building in the form of a Los Angeles Urban Soil Collective, demonstration projects including community-engaged soil sampling and testing, and a focus on both action-oriented solutions as well as the ecological, economic, and social impacts of such solutions.

### Clear Definitions and Goals

Respondents called for the establishment of an interconnected and systems-based approaches to soil management. This is not possible without a shared definition of healthy soil systems as well as clearly defined goals to work toward. Evident from the aligned and divergent themes identified across stakeholder groups, opportunities to develop shared understanding are needed. Equitable, community engagement strategies and partnerships that address systemic issues are also needed in order to establish soil management programs aimed at addressing histories of harm and environmental racism.

### Extensive and Intensive Approaches

The combined approach of spatially extensive online surveys and intensive stakeholder focus groups allowed us to collect information that can both inform and guide future research, policy, education, and management, as well as the formation of community-university research partnerships to advance such work. While needs may change within different urban contexts, the approach of asking *what* is known and needed through online surveys, and understanding *why* it is a concern through focus groups, is transferable to many different cities. Aligning research with community knowledge, needs, and concerns is a pathway in which to advance policy to protect our urban soil resources. The people in cities are the advocates, educators, and caretakers that soil systems need.

## DATA AVAILABILITY STATEMENT

The raw data supporting the conclusion of this article will be made available by the authors, without undue reservation.

## ETHICS STATEMENT

The studies involving human participants were reviewed and approved by the UCLA and CSUN Institutional Review Board. The patients/participants provided their informed consent to participate in this study.

## AUTHOR CONTRIBUTIONS

KS, EW, YC, RP, and SD designed the study. EW conducted analyses and interpretation of the online survey. KS, AG, and SM conducted analyses and interpretation of the focus groups. KS, EW, and AG wrote the manuscript with substantial contributions from YC, RP, and SD. All authors contributed to the article and approved the submitted version.

## FUNDING

Funding for the research was provided by Accelerate Resilience L.A., a sponsored project of Rockefeller Philanthropy Advisors.

## ACKNOWLEDGMENTS

The authors would like to thank the survey and focus group participants for their contribution and the Healthy Soils for Healthy Communities Steering Committee and Project Team for their collaboration.

## SUPPLEMENTARY MATERIAL

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fevo.2021.781587/full#supplementary-material

## REFERENCES


Balazs, C. L., and Morello-Frosch, R. (2013). The three Rs: how community-based participatory research strengthens the rigor, relevance, and reach of science. *Environ. Justice* 6, 9–16. doi: 10.1089/env.2012.0017

Bossio, D. A., Cook-Patton, S. C., Ellis, P. W., Fargione, J., Sanderman, J., Smith, P., et al. (2020). The role of soil carbon in natural climate solutions. *Nat. Sustainabil.* 3, 391–398. doi: 10.1038/s41893-020-0491-z

Chen, Y., Pouyat, R. V., Day, S. D., Wohldmann, E. L., Schwarz, K., Rees, G. L., et al. (2021). *Healthy Soils for Healthy Communities, Phase 1: Needs Assessment*. Los Angeles, CA: TreePeople.

Cutts, B. B., London, J. K., Meiners, S., Schwarz, K., and Cadenasso, M. L. (2017). Moving dirt: soil, lead, and the dynamic spatial politics of urban gardening. *Local Environ.* 22, 998–1018. doi: 10.1080/13549839.2017.1320539

Fernández-Viña, N., Chen, Y., and Schwarz, K. (in review). *Understanding Best Practices in Urban Soil Community Science*.

González, R. (2019). *The Spectrum of Community Engagement to Ownership*. Oakland, CA: Movement Strategy Center.

Horst, M., McClintock, N., and Hoey, L. (2017). The intersection of planning, urban agriculture, and food justice: a review of the literature. *J. Am. Plann. Assoc.* 83, 277–295. doi: 10.1080/01944363.2017.1322914

Iniesta-Arandia, I., García-Llorente, M., Aguilera, P. A., Montes, C., and Martín-López, B. (2014). Socio-cultural valuation of ecosystem services: uncovering the links between values, drivers of change, and human well-being. *Ecol. Econ.* 108, 36–48. doi: 10.1016/j.ecolecon.2014.09.028

Johnston, J. E., Lopez, M., Gribble, M. O., Gutschow, W., Austin, C., and Arora, M. (2019). A collaborative approach to assess legacy pollution in communities near a lead–acid battery smelter: the "Truth Fairy" project. *Health Educ. Behav.* 46, 71S–80S. doi: 10.1177/1090198119859406

London, J. K., Schwarz, K., Cadenasso, M. L., Cutts, B. B., Mason, C. Jr., Lim, J., et al. (2018). Weaving community-university research and action partnerships for environmental justice. *Act. Res.* 16, 173–189. doi: 10.1177/1476750316678915

Montanarella, L., Pennock, D. J., McKenzie, N., Badraoui, M., Chude, V., Baptista, I., et al. (2016). World's soils are under threat. *Soil* 2, 79–82. doi: 10.5194/soil-2-79-2016

Pavao-Zuckerman, M. A. (2012). *Urbanization, Soils and Ecosystem Services. Soil Ecology and Ecosystem Services*. Oxford: Oxford University Press. doi: 10.1093/acprof:oso/9780199575923.003.0023

Pouyat, R. V., and Trammell, T. L. (2019). Climate change and urban forest soils. *Dev. Soil Sci.* 36, 189–211. doi: 10.1016/b978-0-444-63998-1.00010-0

Pouyat, R. V., Day, S. D., Brown, S., Schwarz, K., Shaw, R. E., Szlavecz, K., et al. (2020). "Urban soils," in *Forest and Rangeland Soils of the United States Under Changing Conditions Pouyat*, ed. V. Richard (Cham: Springer). doi: 10.1007/978-3-030-45216-2

Rubert-Nason, K., Casper, A. A., Jurjonas, M., Mandeville, C., Potter, R., and Schwarz, K. (2021). Ecologist engagement in translational science is imperative for building resilience to global change threats. *Rethink. Ecol.* 6:65. doi: 10.3897/rethinkingecology.6.64103

Shaw, R. K., and Riddle, R. L. (2019). "NYC & LA: a comparison of soil patterns using soil survey data," in *Poster Presented at SUITMA 10 - Soils of Urban, Industrial, Traffic, Mining and Military Areas*, (Seoul).

U.S. Census Bureau (2021). *Quickfacts*. Los Angeles County, CA: U.S. Census Bureau.

United States Department of Agriculture [USDA] and Natural Resources Conservation Service [NRCS] (2017). *Supplement to the Soil Survey of Los Angeles*. Los Angeles CA: USDA.

Wall, D. H., and Six, J. (2015). Give soils their due. *Science* 347:695. doi: 10.1126/science.aaa8493

Wall, D. H., Nielsen, U. N., and Six, J. (2015). Soil biodiversity and human health. *Nature* 528, 69–76. doi: 10.1038/nature15744


**Conflict of Interest:** The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

**Publisher's Note:** All claims expressed in this article are solely those of the authors and do not necessarily represent those of their affiliated organizations, or those of the publisher, the editors and the reviewers. Any product that may be evaluated in this article, or claim that may be made by its manufacturer, is not guaranteed or endorsed by the publisher.