



# Urban Soil Safety Policies: The Next Frontier for Mitigating Lead Exposures and Promoting Sustainable Food Production

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**Key Points:**

- Urban soil safety policies (SSPs) may help protect growers from lead exposure
- Existing lead guidance for urban agriculture is inconsistent
- With guidance from the US Environmental Protection Agency, cities could promulgate SSPs to protect urban growers and promote agriculture

**Supporting Information:**

Supporting Information may be found in the online version of this article.

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**Abstract** Urban soils bear the persistent legacy of leaded gasoline and past industrial practices. Soil safety policies (SSPs) are an important public health tool with the potential to inform, identify, and mitigate potential health risks faced by urban growers, but little is known about how these policies may protect growers from exposures to lead and other soil contaminants. We reviewed and evaluated 43 urban agriculture (UA) policies in 40 US cities pertaining to soil safety. About half of these cities had a least one SSP that offered recommendations or provided services for soil testing. Eight cities had at least one SSP containing a requirement pertaining to any topic (e.g., soil testing, a specific best practice for growing). We found notable inconsistencies across SSPs for “acceptable” levels of lead in soils and the activities and behaviors recommended at each level. We specify research needed to inform revisions to US Environmental Protection Agency guidance for lead in soils specific to UA. We conclude with a series of recommendations to guide the development or revision of SSPs.

**Plain Language Summary** Urban soils may contain lead and other chemicals harmful to human health. Soil safety policies established by city governments can provide guidance and restrict behaviors to protect urban growers from exposure to harmful chemicals while growing food in urban soils. We reviewed city government websites and used Google searches to find soil safety policies related to urban agriculture in the 40 most populous cities in the US. We analyzed the type, topic(s) and scope of each policy, looking for common characteristics across policies. The most common topic addressed by these policies was soil testing. We found disagreements across policies for the amount of lead “acceptable” in soils and the activities allowed at each level. We provide recommendations to cities to ensure these policies are easy to understand, helpful, and appropriate to protect urban growers who grow food in urban soils.

## 1. Introduction

Urban soils continue to be the global reservoir for lead. They bear the persistent legacy of leaded gasoline, lead-based paint and other past and current industrial activities (Resongles et al., 2021). At the same time, these soils hold the promise to contribute to healthy, sustainable and equitable food production, and in some cases food sovereignty, through community-based urban agriculture (UA) (White, 2011). Despite the evidence of UA's benefits (Santo et al., 2016), the issue of soil lead contamination remains a critical and addressable public health challenge for city growers and those who consume their yields.

In the urban context more broadly, lead has been the focus of studies of urban soil contamination (Datko-Williams et al., 2014; Frank et al., 2019; Walls et al., 2022). Studies of metals in urban agricultural soils have consistently identified lead as a contaminant of concern (Lupolt, Santo, et al., 2021; Mitchell et al., 2014; Spliethoff et al., 2016). Growing food in cities involves extensive contact with urban soils, highlighting the relevance of UA as an important pathway of lead exposure (Clay et al., 2019; Entwistle et al., 2019). This pathway may worsen a cumulative exposure burden on already disadvantaged populations, as communities with higher levels of soil contamination may also face higher levels of air or drinking water contamination and lack the resources to mitigate those exposures and related risks (Hauptman et al., 2021; Horst et al., 2017; Malone, 2021; McClintock, 2012; Saikawa & Filippelli, 2021).

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Based on the most recent rounds of lead biomonitoring data from the National Health and Nutrition Examination Survey, the Centers for Disease Control and Prevention lowered the blood lead reference level (a level that may trigger lead-related interventions in some states) for children from 5 to 3.5  $\mu\text{g}/\text{dL}$  in 2021 (Centers for Disease Control and Prevention, 2021; Egan et al., 2021; Ettinger et al., 2020). This reduction suggests meaningful, yet incremental public health progress. Efforts aimed at reducing formerly dominant sources of lead exposure like leaded gasoline and lead-based paint have been effective in reducing exposure—both among the most exposed and across the US population as a whole. Still, since epidemiologic evidence suggests that there is no level of lead exposure without increased neurodevelopmental and other risks, further progress on improving public health outcomes is dependent upon tackling other known exposure pathways, especially those that may disproportionately burden disadvantaged urban communities (Canfield et al., 2003; Lanphear et al., 2005). While our societal benchmarks for lead have declined, a roadmap for addressing lead exposures in urban soils, including agricultural soils, does not exist.

To date, there are no federal guidelines or regulations addressing lead in agricultural soils. The US Environmental Protection Agency (EPA) established a soil screening level (SSL) for lead (400 ppm) for residential soils in 1994; this value has not been updated to reflect our current understanding of lead epidemiology (Navas-Acien et al., 2007). The SSL was never intended to be considered a safe level for the conduct of agriculture, but instead was meant to be a soil lead concentration that would trigger further risk evaluation for future planned site uses (United States Environmental Protection Agency, 1998). In 2014, the EPA Technical Review Work group for Lead opined that the SSL of 400 ppm “may not be adequate for intensive gardening activities and consumption of home grown produce” and developed guidance for metals in soils used for gardening (United States Environmental Protection Agency Technical Review Workgroup for Lead, 2014). The guidance included best practices corresponding to specific ranges of soil lead concentrations. While helpful, these recommendations are not enforceable, and there is currently no program to promote their adoption among state or city governments or by urban growers. Further, state and local governments looking to develop soil safety policies (SSPs) may not be aware of the existence of these recommendations, as no link to the Technical Review Workgroup for Lead report is available on the Agency’s UA website (United States Environmental Protection Agency, 2022). Another critical limitation of the guidance is that it does not consider that urban growers may be exposed to urban soils at greater frequencies (e.g., 5 or more days a week) and for longer durations (e.g., 8 or more hours each day) than hobby gardeners. Consequently, the recommendations may not be adequate to protect urban growers from lead exposure.

Given the lack of enforceable policies for lead and UA at the federal level, SSPs promulgated by municipal governments (either in the form of zoning regulations, program requirements, or dissemination of guidance or services developed by other entities) may be an important stopgap for reducing lead exposure in UA. We aim to characterize existing SSPs for UA among the 40 most populous cities in the US. Based on reviewing the content, scope, and type of existing SSPs, we propose a framework to assess and guide the development and revision of SSPs for UA.

## 2. Materials and Methods

This analysis builds upon a previous examination of a peer-reviewed database of UA policies among the 40 most populous US cities as of 2010 (Halvey et al., 2020). The initial examination (conducted between June 2019 and June 2020) identified 60 public policies (including city plans and priorities, regulations, guidance, city-operated programs, and policy recommendations) in 27 cities as of June 2020 that included any reference related to soils and UA. The 40 most populous cities was determined based on each city’s population as of 2010 which, at the time of writing, was the most recent comprehensive national population census available (US Census Bureau, 2012). These policies were compiled via a combination of municipal government website searches and Google searches using several keywords (i.e., “soil safety,” “soil policy,” “urban agriculture,” and “food safety”). To ensure that the search strategy adequately captured UA-related policies, government staff were contacted in each city; 43% had contacts verify the comprehensiveness of policies compiled. In October 2021, we queried (via a single email blast) members of the Food Policy Networks Listserv—a virtual network of over 2,000 stakeholders primarily in the US seeking to create more sustainable, healthier and equitable food systems through public policy at the state, regional, local and tribal levels—to obtain additional information about policies that may have been established since the initial review or that were from jurisdictions outside of the 40 most populous cities. To the authors

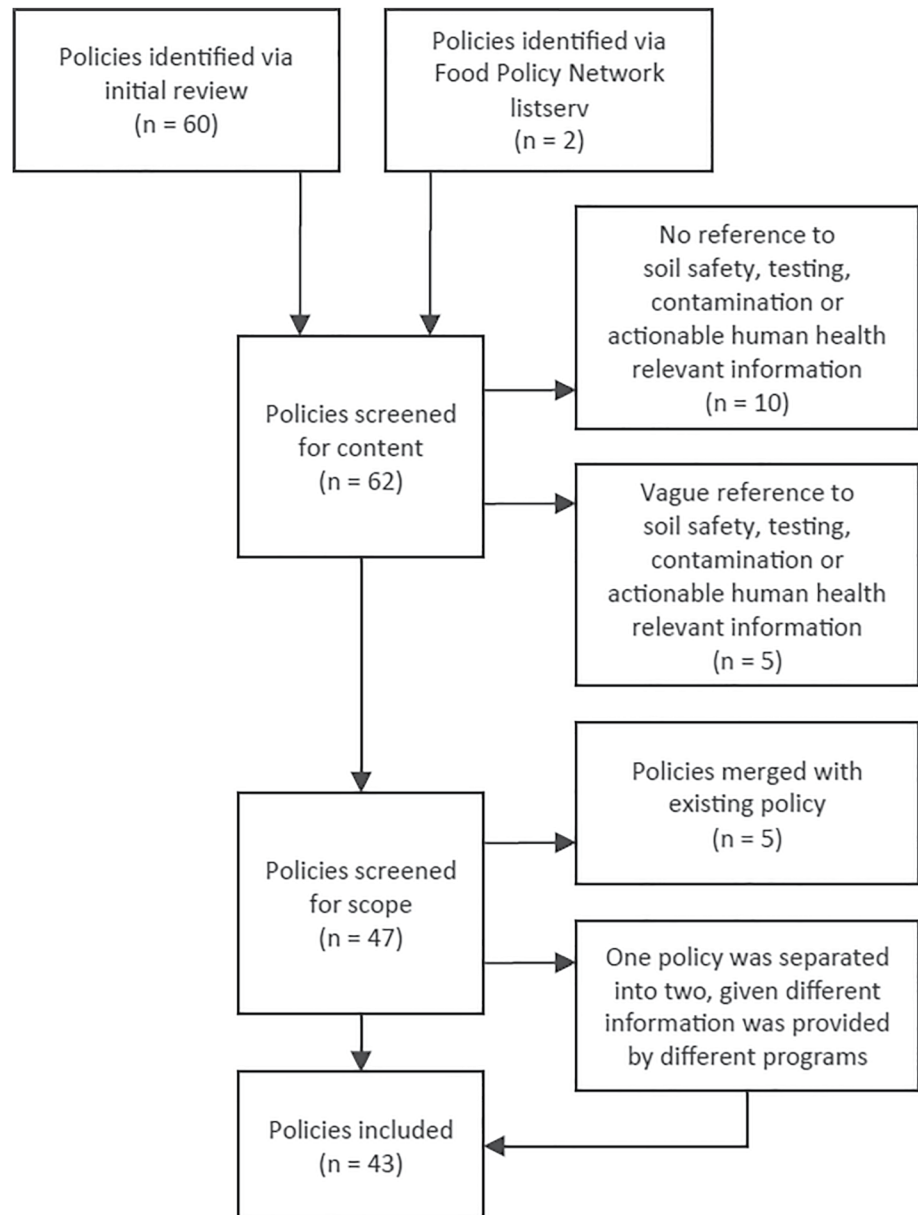
knowledge, there is no national network or listserv dedicated solely to UA policy; the Food Policy Networks listserv is the most focused network dedicated to professionals and advocates working on sub-national food policy in the U.S. Through this outreach, we were made aware of two additional cities (Minneapolis, MN and Pittsburgh, PA) outside of the 40 most populous that had UA policies relevant to soil safety. Besides not originating in one of the most populous cities in the US (as of 2010), these policies satisfied our existing inclusion criteria and were included in our investigation.

The UA policies identified in the previous examination as having some relation to soils were then further examined for type, scope, and content. For this current analysis, between August and December 2021, we further used the existing database of city-level UA policies to identify all policies pertaining to soil safety. We defined a SSP as any document or website published by municipal governments, quasi-governmental organizations, or independent organizations in partnership with municipal governments that provided guidance on contaminants in soils used to grow food in urban areas. As this investigation focuses on municipal-level SSPs for UA, we did not include or evaluate policies from other levels of government (e.g., state, federal). Upon further review, we excluded 15 policies; 10 were dropped because they did not contain any detailed information on soil safety, testing or contamination; heavy metals; or any actionable or human health relevant information; and five were dropped because they contained only vague references to soil safety, testing or contamination, or heavy metals (Figure 1). Among the policies we excluded, two contained references to “healthy soils,” a broader concept of ecological health related to soils that is not specific to soil contamination or human health, and two only contained references to soil treatments or amendments. An additional five policies were merged with existing policies because the same information (generated by the same agency, department or program) was provided and found in two different locations. One policy was separated into two because different information was provided by different programs (Nachman, 2022).

Our inclusion criteria for the 43 policies analyzed were as follows: (a) previously identified in peer-reviewed database of city-level UA policies (Halvey et al., 2020), (b) a document or website published by municipal governments, quasi-governmental organizations, or independent organizations in partnership with municipal governments providing guidance on contaminants in soils used to grow food in urban areas, and (c) containing references to soil safety, testing, contamination, or heavy metals. We excluded federal, state, or other non-municipal SSPs not directly pertaining to UA (e.g., soil cleanup, lead abatement). For a detailed list of inclusion/exclusion criteria used to compile the original database of policies analyzed for reference to soil safety, see Appendix A of Halvey et al. (2020).

### 3. Data

Using an iterative process of deductive and inductive thematic coding, we reviewed the 43 remaining documents from 22 of the 40 most populous cities and two cities later identified and classified each policy document into at least one of four (non-mutually exclusive) types of SSPs based on the nature of their provisions: requirements, recommendations, services, and information (Table S1 in Supporting Information S1). Requirements were the most restrictive or prescriptive policies, requiring specific actions related to soil testing or management and offering an incentive for compliance or removing an incentive if compliance is not achieved. Recommendations were non-compulsory policies suggesting specific actions related to soil testing or management that offer no incentives for compliance. Services were city-supported programs that provide soil testing, site assessments or other support services to ensure the safe conduct of UA as it pertains to soil contaminants. Information included policies that contain written resources or links to other resources related to soil contamination in urban areas, soil safety, soil testing or management, best practices for growing, exposure reduction strategies, or programs that assist growers in obtaining information about soils. We classified the scope, or specific context in which each policy would apply: all UA operations, some UA operations (e.g., community gardens, commercial farms, UA sites on public land), a specific program (e.g., a city-run farm or garden program), or not specified. Finally, we classified the content of each policy document according to six emergent themes based on the topic(s) addressed within the policy. Five themes pertained to UA practitioners: (a) best growing practices, (b) exposure reduction, (c) soil testing, (d) site history/assessment, and (e) soil contaminant guidance values. One theme (policy considerations) pertained to guidance for city or program officials who may develop/revise SSPs. We inductively reviewed SSPs for mention of produce contaminant testing recommendations and guidance values. We further reviewed SSPs with soil contaminant guidance values, specifically to assess their relevance to lead in soils. While we reviewed



**Figure 1.** Flow diagram depicting review process and inclusion and exclusion criteria of urban soil safety policies.

SSPs that related to UA soil contamination pertaining to any soil contaminant, we focused the majority of our analysis and discussion on how SSPs protect growers from lead contamination, as lead is the primary contaminant of concern for UA as identified in existing research and was described most frequently and in the most detail in the SSPs we analyzed. We also inductively reviewed each policy via a holistic and close reading of each document for evidence of equity and environmental justice considerations in the policy's content. All SSPs were independently reviewed and coded for topic, type and scope by SL and independently reviewed and coding verified by RS. When discrepancies arose, SL and RS discussed and came to a consensus. Definitions for each code are provided in Table S1 in Supporting Information S1.

## 4. Results

We reviewed 43 policies from 24 cities. 18 cities in the top 40 did not have any SSPs specific to UA. Among cities with SSPs, the number of policies per city ranged from one to five policies, with a mean of two policies per city. All SSPs we analyzed were established between 1978 and 2020.

### 4.1. Policy Type

The most common types of SSPs were recommendations (27 policies in 16 cities) and services (15 policies in 12 cities) (Tables S2 and S3 in Supporting Information S1). Only one city (New York, NY) had at least one of all policy types. Four cities (Austin, TX; Baltimore, MD; Milwaukee, WI; Pittsburgh, PA) had three types of policies.

The most common recommendations for growers pertained to best growing practices, soil testing, and strategies to reduce exposure. Eight cities had at least one SSP with at least one recommendation pertaining to the development or implementation of a SSP for city or program officials.

Eleven cities provided at least one service to UA operations related to soil safety. Soil testing services for UA operations were the most common service provided, either via local USDA Extension or research labs (e.g., Columbus, OH; Denver, CO; Louisville KY; New York, NY; Washington, DC), health departments (e.g., Milwaukee, WI; Minneapolis, MN; Phoenix, AZ), or other departments (Austin, TX; Philadelphia, PA). In addition to soil testing, four cities (Los Angeles, CA; Phoenix, AZ; Philadelphia, PA; Tucson, AZ) offered site history/assessment services for UA operations via their city Brownfields Programs, though the specific parameters of these services were unclear. Costs of soil testing services ranged from \$0 to \$45, though three cities' policies did not specify costs to growers. Few cities provided information or recommendations regarding the type or frequency of soil testing provided by their services. Two of the cities that provided soil testing did not specify the metal analytes; two specified lead; three specified "heavy metals"; and one city offered "routine testing" that specified cadmium, chromium, lead and molybdenum. Only one city (New York, NY) specified the testing method (i.e., XRF) that is used.

In addition to soil testing or site history/assessment services, New York City had two additional SSPs offering soil-related services to urban growers. The New York Mayor's Office of Environmental Remediation oversees the NYC Clean Soil Bank, an innovative program that provides clean soil to UA projects at no cost. The NYC Green Thumb program also provides imported soil and untreated lumber for building raised beds to gardens affiliated with the program.

Eight cities (Albuquerque, NM; Baltimore, MD; Boston, MA; Chicago, IL; Indianapolis, IN; New York, NY; Pittsburgh, PA; Washington, DC) had at least one SSP containing at least one requirement. Seven cities required soil testing, though only five provided reference to a guidance value, or threshold value at which measured contaminants cannot exceed.

The incentives for compliance with the stated requirement varied widely across cities, ranging from a permit or license (e.g., Baltimore, MD; Boston, MA) to tax abatement (e.g., Washington, DC). For example, compliance with the soil testing requirements in Boston, MA results in a permit for food production, which is necessary for a commercial urban farm to sell its produce. In Baltimore, MD, compliance with the soil testing requirements results in a land use permit, which is required to make a farm or garden the primary, permanent use of a piece of land. In other cities, soil testing is required for UA operations on public land or participating in a city-run farm or garden program (e.g., Chicago, IL; New York, NY; Pittsburgh, PA; Washington, DC), or to comply with land use zoning codes (Albuquerque, NM; Indianapolis, IN), though there is no explicit explanation of incentives associated with compliance or penalties associated with non-compliance. Of note, no policies explicitly state a penalty for non-compliance with the requirement.

### 4.2. Policy Content

Among cities with SSPs, the most common topics were soil testing ( $n = 23$ ) and best growing practices ( $n = 16$ ) (Tables S2 and S3 in Supporting Information S1). Two cities (Baltimore, MD; New York, NY) had policies

covering all six topics we reviewed. Of note, among cities with policies pertaining to soil testing, less than half ( $n = 10$ ) also had policies pertaining to guidance values that would be used to interpret such testing.

### 4.3. Policy Scope

Most policies were quite limited in scope. Most policies pertained to only some UA operations (e.g., only community gardens, only commercial farms, or only UA operations on public land) ( $n = 23$ ) or only those within a specific program ( $n = 6$ ) (Tables S2 and S3 in Supporting Information S1). Six policies were applicable to all UA operations.

### 4.4. Contaminant-Specific Guidance Values

Soil testing and site assessments are important tools for identifying potential hazards, and best growing practices and site assessments are tools for avoiding hazards. Contaminant-specific guidance values help growers and health professionals gauge the magnitude of a potential hazard. Ten SSPs in 10 cities mention or directly provide at least one contaminant-specific guideline for metals other than lead in soil (Table S4 in Supporting Information S1). Among the contaminant-specific guidelines overall, lead was the most mentioned contaminant, with seven cities specifying certain behaviors permitted or prohibited at various levels of lead (Figure 2). 10 cities referenced a guidance value, though three cities' guidance values were either ambiguous ( $n = 1$ ) or not officially promulgated values ( $n = 2$ ) (Table 1). Guidance values for lead ranged from 34 to 1,200 ppm with a variety of different actions recommended or required at each level (Figure 2). For example, while Atlanta's guidance recommended good gardening practices for all concentrations of lead; raised beds (a best practice for growing in urban areas) were recommended only when lead levels are greater than 340 ppm. In Indianapolis, raised beds are required when lead levels are above 200 ppm. Of note, two cities' (New York, NY; San Francisco, CA) policies pertain to guidelines for soils imported from offsite rather than existing soils.

To further investigate potential discrepancies across lead guidance values, we noted references to other (i.e., state) SSPs or informational resources provided by other federal, state or city entities that may have informed the SSP (Table 1). Four cities (Albuquerque, NM; Boston, MA; Indianapolis, IN; New York, NY) reference existing state level soil standards, though two cities (Boston, MA; New York, NY) did not provide the specific guidance values in the SSP directly. Atlanta, GA and Philadelphia, PA's policies cited the City of Toronto's (Canada) SSP. Of note, Philadelphia's SSP included a review of several cities' guidelines but did not definitively establish its own guideline. We found no recommendations, requirements, or services for the testing of produce samples, nor any guidance values for contaminants in food directly, though several policies recommended against the cultivation of some types of fruits and vegetables when soil contaminants exceeded a given threshold.

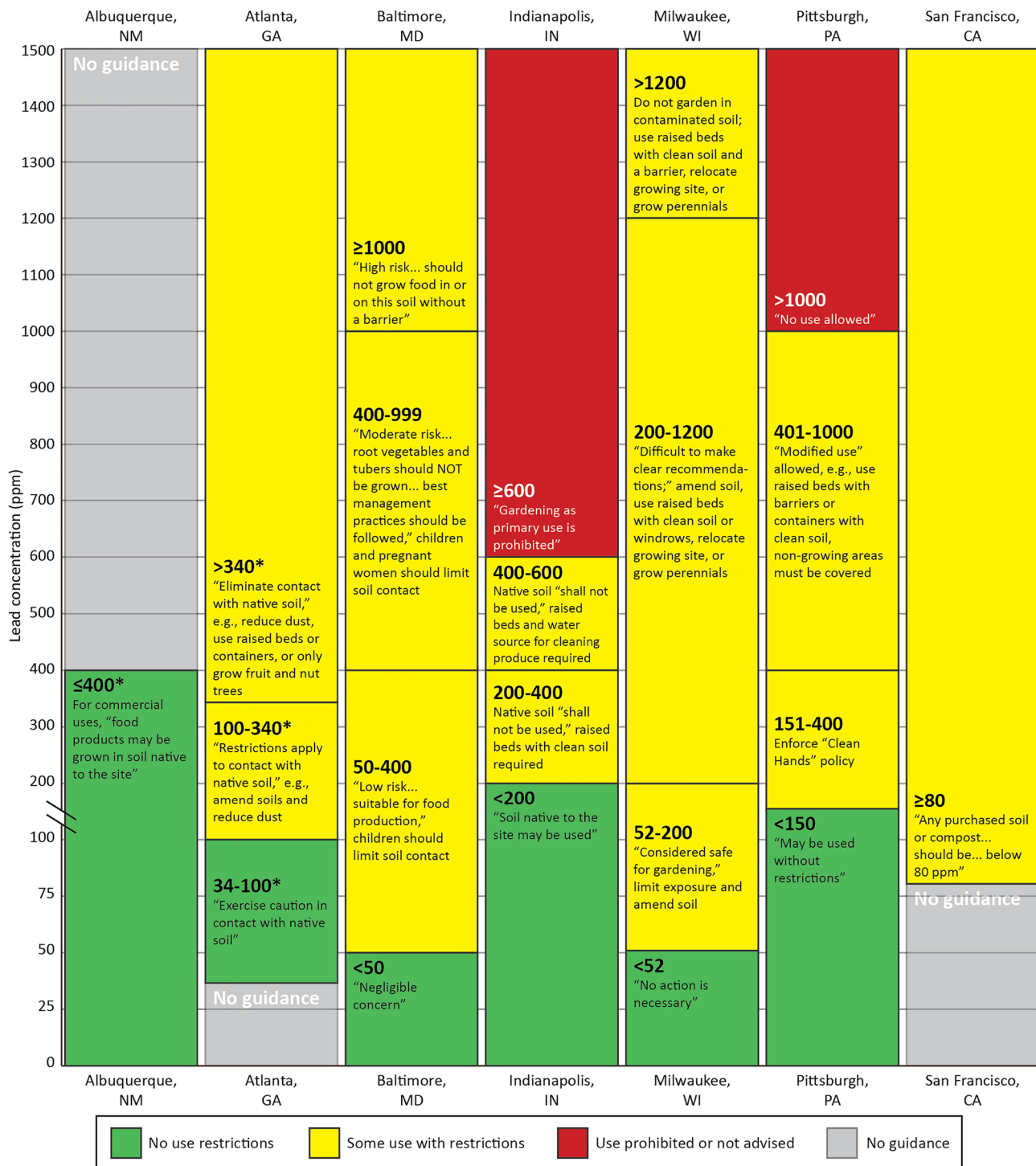
### 4.5. Equity and Environmental Justice Considerations

Six cities' SSPs contained at least one mention of equity, environmental justice, or attempts to address systemic disparities in access, exposures, or health outcomes. Of these, two cities' (Los Angeles, CA; Phoenix, AZ) discussion of equity was tied directly to the goals of the cities' existing Brownfields Program. Other mentions (in Baltimore, MD; Louisville, KY; Los Angeles, CA; Portland, OR) pertained to recommendations for city or program officials. In all these examples, equity was discussed as motivation for creating SSPs. No cities addressed equity considerations in the parameters of the policy or its implementation.

## 5. Conclusions

Our findings reveal a patchwork of SSPs inconsistent with our national resolve to eliminate lead exposures for all ages. Our policy review identified SSPs for UA in 22 (55%) of the 40 most populous US cities. Conversely, 18 (45%) of the cities we investigated lacked an SSP, suggesting a key opportunity to develop new policies to protect growers. The identified policies covered a wide range of requirements, recommendations, services, and informational resources.

We found considerable variability in lead guidance values and associated recommendations for growers across city policies. None of the SSPs we reviewed cited the EPA Technical Review Workgroup for Lead report outlining



**Figure 2.** Summary of lead guidance values provided in seven soil safety policies. \*Compliance with this policy for lead requires compliance with guidance values for several other metals as well.

lead concentration ranges and associated recommended growing behaviors. The lack of a common, authoritative source of lead guidance values and best practices for UA may explain the inconsistency across cities. As a result, the implementation of different city policies may result in inconsistent protection of growers in terms of lead exposures. It is notable, however, that every city that promulgated a lead guidance value had specified at least one value with a recommendation at or below EPA's soil SSL of 400 ppm.

**Table 1**  
*Lead Guidance Values Referenced in Soil Safety Policies*

City	State	Lead guidance value(s) provided in city's soil safety policy (ppm)	Source for lead guidance value(s) used within city's soil safety policy	Policy document # (from Table S2 in Supporting Information S1)
Albuquerque	NM	400	New Mexico Soil Exposure Direct Contact Residential Maximum	1
Atlanta	GA	34; 100; 340	Toronto Public Health "From the Ground Up: Guide for Soil Testing in Urban Gardens." 2013. <a href="https://www.toronto.ca/wp-content/uploads/2019/09/96a1-FromtheGroundUp_Guide-Soil-TestingOct2013.pdf">https://www.toronto.ca/wp-content/uploads/2019/09/96a1-FromtheGroundUp_Guide-Soil-TestingOct2013.pdf</a>	2
Baltimore	MD	50; 400; 1,000; 2,000	N/A	6
Boston	MA	Not stated in policy <sup>a</sup>	Massachusetts Department of Environmental Protection. Massachusetts Contingency Plan 310 CMR 40.00 (2019). <a href="https://www.mass.gov/regulations/310-CMR-4000-massachusetts-contingency-plan">https://www.mass.gov/regulations/310-CMR-4000-massachusetts-contingency-plan</a>	7
Indianapolis	IN	200; 400; 600	Indiana Exposure Direct Contact Residential Maximum	15
Milwaukee	WI	52; 200; 1,200	University of Wisconsin Extension "Reducing exposure to lead in your garden soil" 2015. <a href="https://soilsextension.webhosting.cals.wisc.edu/wp-content/uploads/sites/68/2015/11/Reducing-Exposure-to-Lead-A4088.pdf">https://soilsextension.webhosting.cals.wisc.edu/wp-content/uploads/sites/68/2015/11/Reducing-Exposure-to-Lead-A4088.pdf</a>	22
Minneapolis	MN	100	N/A	23
New York	NY	Not stated in policy <sup>a,c</sup>	New York State Department of Environmental Conservation, New York State Department of Health. New York State Brownfield Cleanup Program Development of Soil Cleanup Objectives: Technical Support Document. 2006. <a href="https://www.dec.ny.gov/docs/remediation_hudson_pdf/techsuppdoc.pdf">https://www.dec.ny.gov/docs/remediation_hudson_pdf/techsuppdoc.pdf</a>	25
Philadelphia	PA	<sup>b</sup>	Toronto Public Health "From the Ground Up: Guide for Soil Testing in Urban Gardens." 2013. <a href="https://www.toronto.ca/wp-content/uploads/2019/09/96a1-FromtheGroundUp_Guide-Soil-TestingOct2013.pdf">https://www.toronto.ca/wp-content/uploads/2019/09/96a1-FromtheGroundUp_Guide-Soil-TestingOct2013.pdf</a>	30
Pittsburgh	PA	150; 400; 1,000	Penn State University Extension, (generally) no specific document	34
San Francisco	CA	80 <sup>c</sup>	Revised California Human Health Screening Levels for Lead (Office of Environmental Health Hazard Assessment (OEHHA), 2009	37

<sup>a</sup>Unclear which of the values referenced in the source are applicable. <sup>b</sup>These are not final; this document is a summary of research/set of recommendations. <sup>c</sup>These are guidelines are for imported soil.

Our investigation had several limitations. First, our analysis was rooted in a previously established database of UA policies so our findings were limited to the scope and inclusion and exclusion criteria of that review. For example, we considered policies from the 40 largest cities (by population) in the US, omitting policies in non-US cities (e.g., Toronto, Canada) and in less populous cities across the US (apart from the two identified in our subsequent listserv inquiry). We did not consider federal, state, or other municipal SSPs not pertaining to UA (e.g., soil cleanup or lead abatement policies or programs). Second, we relied on web searches and reviews of city government websites to obtain all policies reviewed, supplemented with verification by city government staff in nearly half of the cities. It is possible our search methods did not return all policies in place at the time of our search. While this is a potential limitation of our methods, it is likely that urban growers would conduct similar searches to obtain this information. If any policies were missed, this speaks to the need for policies to be easily accessible to growers who may be expected to adhere to them. We were not able to evaluate the effectiveness of these policies for reducing exposure to lead, nor assess the comprehension and use of these policies by urban growers. In addition, our investigation focused on SSPs related to UA specifically; cities may have lead reduction programs or policies that address lead in soils in other settings (e.g., residential properties or rights for renters who may reside in urban dwellings with contaminated soils, or other legal situations where local governments do not have jurisdiction or authority.).

### 5.1. Recommendations

Given the rise of UA, SSPs are an important public health tool to ensure safer conduct of UA and reduce additional exposures to lead among urban growers. Based on the framework that emerged from this analysis, we make a series of recommendations pertaining to the type, content, and scope of SSPs. In addition, using the three core



functions of public health (i.e., assessment, policy development and assurance), we identify a series of next steps for the departments and programs most suited to tackle them.

#### **5.1.1. Recommendations for Assessment**

Based on our findings, we believe the EPA, as part of its Federal Lead Strategy for Reducing Disparities, should develop and promulgate guidelines for lead and other priority contaminants in soils used for agriculture that are sufficient to protect hobby community gardeners, commercial agricultural workers, and consumers of produce grown in that soil. This will require an inclusive scoping process to the regulatory decision-making process and additional research to derive more appropriate guidelines for lead in soil.

For example, most research on soil exposure and lead is focused on understanding children's exposures to soil lead, blood-lead levels and neurobehavioral outcomes. A less robust body of research exists on the health effects of adults' exposure to lead in soils, and scant research exists characterizing or estimating intentional exposure to soil among hobby-growers and professional agricultural workers (Lupolt, Agnew, et al., 2021). To generate appropriate guidance values for lead in soils used for UA, the EPA will need agricultural exposure factors, or estimates of the duration, frequency and intensity of contact with soil for workers, hobby-growers, and children who assist adults in gardening tasks. With greater confidence in exposure factors (including those accounting for agriculture-specific behaviors and time in direct contact with soil) used for characterizing exposure among these distinct populations and scenarios, more appropriate guidance values can be provided in SSPs.

#### **5.1.2. Recommendations for Policy Development**

EPA's development and promulgation of revised guidance values for lead in soils used for agriculture would be a radical and critical step in advancing cities' SSPs. With clear lead- and contaminant-specific guidance, cities can establish policies and programs that provide critical support services for UA (e.g., site assessment and soil testing) to ensure compliance with the federal guidelines. Given the non-threshold effects of lead, we agree that a tiered approach that begins with knowledge about site conditions and then integrates best growing practices and exposure reduction strategies is optimal.

Our framework identified three aspects of SSPs (type, content and scope) to consider in the development of new and evaluation of existing SSPs. We believe the ideal SSP is comprehensive in content and includes evidence-based actions for urban growers to identify (via soil testing and site assessments), interpret (via evidence-based guidance values) and reduce exposures (via best growing practices and exposure reduction strategies). To ensure adoption of these recommended actions, we recommend prioritizing services provided (at low or no cost) to urban growers, followed by requirements with a compelling incentive, and as the least prescriptive option, recommendations. Finally, to ensure the broadest adoption of safe soil practices, we encourage the application of these policies to all UA operations (e.g., urban farms, school and community gardens, regardless of land ownership or program participation) whenever feasible. The ability of a city to develop and implement a policy per our recommendations is dependent on personnel, financial resources, policymaking authority and the unique landscape of UA in the city.

To develop an effective SSP, a city may consider conducting a survey or study of existing UA policies, programs and resources or conducting a needs assessment among urban growers. At all stages of the process, it is critical for department and program officials to engage stakeholders, especially urban growers, directly. Cities may also incorporate equity across all policies and consider synergies between types of policies. For example, Black, Indigenous, communities of color or lower income may have more contamination and higher costs to comply with requirements, thus more resources should be devoted to supporting their efforts at compliance.

#### **5.1.3. Recommendations for Assurance**

Above all, these policies should be easily found and accessible to urban growers who are expected to adhere to them. It will be the responsibility of city departments and programs to implement, communicate and enforce SSPs. A key component of this will be ensuring information and resources are easily accessible and interpretable to all demographics of urban growers. Making SSPs easy to understand involves the inclusion of specific details pertaining to the scope of the policy, what is needed to comply, and the penalties for not complying. All SSPs should include information describing the environmental health concerns of growing food in urban areas, the rationale for the policies, and be free of jargon and overly technical language. Additional assurances may include recordkeeping of the extent to which services are used as well as instances of compliance and penalties levied for

noncompliance. Such efforts to ensure comprehension, accessibility, and documentation of use and compliance with SSPs will be necessary to evaluate the environmental justice implications of these policies going forward.

## 5.2. Next Steps for Policy Making

Advocates of UA may perceive these existing policies—or the revision of these policies given our recommendations—as overly burdensome policies that may deter and inhibit the expansion of UA. These perceptions may be magnified by the reality that, to date, no SSPs exist at the local, state, or federal level to produce food on non-urban land. Soils are an essential part of all food systems and safe conduct of agriculture is critical for the health of agricultural workers at any location. While our recommendations are intended for the development of policies to ensure the safe conduct of UA, many aspects may be transferrable to other agricultural contexts. Ultimately, local policy makers must determine and clearly articulate in each SSP which receptor(s) or scenario their policies are intended to protect. For example, an SSP intended to protect urban growers from lead exposures requires a fundamentally different set of considerations than an SSP intended to ensure safety of food grown in urban soils. Because of the diversity of UA systems (e.g., aquaculture systems, large scale commercial in-ground, small scale raised bed gardens, or soil-less systems) a single SSP may not effectively manage the risks for each type of UA. Given that most guidance values for soil contaminants are established based on direct contact scenarios, a movement toward ensuring food safety would represent a radical advance in both soil and food safety policies for public health.

While important strides have been made to reduce lead exposures through dust and drinking water, soil remains a largely unaddressed frontier. Policy interventions in this domain stand to deliver on two critical public health needs—protecting our urban growers from harmful and unnecessary soil lead exposures, and the promotion of a growing, sustainable and more equitable form of community-engaged food production.

## Conflict of Interest

The authors declare no conflicts of interest relevant to this study.

## Data Availability Statement

A zipped file containing PDFs of each of the individual policy documents we evaluated in this manuscript are available for free through our Open Science Framework repository: [https://osf.io/6a2wt/?view\\_only=088a752f98c34c5e85ce750910277e39](https://osf.io/6a2wt/?view_only=088a752f98c34c5e85ce750910277e39).

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