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Growing Gardens in Shrinking Cities: A Solution to the Soil Lead Problem?

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Abstract: As cities shrink, they often leave a patchwork of vacancy on the landscape. The maintenance of vacant lands and eventual transformation to sustainable land uses is a challenge all cities face, but one that is particularly pronounced in shrinking cities. Vacant lands can support sustainability initiatives, specifically the expansion of urban gardens and local food production. However, many shrinking cities are the same aging cities that have experienced the highest soil lead burdens from their industrial past as well as the historic use of lead-based paint and leaded gasoline. Elevated soil lead is often viewed as a barrier to urban agriculture and managing for multiple ecosystem services, including food production and reduced soil lead exposure, remains a challenge. In this paper, we argue that a shift in framing the soil lead and gardening issue from potential conflict to potential solution can advance both urban sustainability goals and support healthy gardening efforts. Urban gardening as a potential solution to the soil lead problem stems from investment in place and is realized through multiple activities, in particular (1) soil management, including soil testing and the addition of amendments, and (2) social network and community building that leverages resources and knowledge.

Keywords: urban; gardening; agriculture; soil; metals; lead; shrinking cities; sustainability

1. Introduction

While the dominant narrative surrounding urbanization is focused on the expansion and growth of both the physical city and urban populations, many older cities in the United States are shrinking. As cities shrink, losing financial investment, physical infrastructure and people, they often leave a network of vacancy on the landscape. This poses both a challenge and opportunity. A central challenge is the need to repurpose vacant lots and crumbling infrastructure with a decreased tax base and reduced support for public investment. However, the increase in physical space within dense urban centers also creates an opportunity to transform vacant land that can help cities transition to more sustainable trajectories. In other words, vacancy provides the space to transform place. Positive re-use is often entangled with and marred by the legacy of pollution; for gardening, this includes the legacy of lead, which is now a widespread contaminant of urban soils [1,2]. The narrative and reality around urban gardening can be changed, though, to one where urban gardening is a solution to mitigating exposure to lead by urban gardeners and others in and around gardens.

The concept of sustainability has infused urban planning initiatives nationwide and has also been used as a motivating framework for shrinking cities. However, critics have questioned the usefulness of such a broad concept as sustainability claiming it is difficult to operationalize. Costanza and Patten [3] provide a broad definition—“a sustainable system is one which survives or persists”, acknowledging the need to specify what system, for how long, and when we assess whether a system has persisted. This simple definition provides the opportunity to decouple sustainability goals from growth, a necessity as we strive to make progress in shrinking cities. Sustainability planning often places emphasis on the importance of green infrastructure, including gardens. For example, community garden advocates cite urban agriculture as a strategy to increase environmental health through recycling urban green waste as soil nutrients [4], reducing food miles [5], reducing runoff, and sequestering carbon [6]. Urban gardens have been associated with many benefits, including increased access to fresh produce, the economic benefits of producing homegrown food, and nutrition. Gardens, though, are more than a local source of nutritious food; they can help to strengthen neighborhood cohesion and build community [7]. As a result of the multi-faceted outcomes of urban gardens, the motivation to sustain them is complex. Urban community gardens have a rich history in the United States of taking on conflicted political, social and historical meanings [8]. The ability to grow culturally appropriate food and maintain a cultural gathering space in community gardens has played a particularly important role amongst some immigrant populations [9–12]. Among native people, gardening can be used as a tool for decolonization [10]. Community gardens can also provide opportunities for positive intergenerational learning [10,13–15] and positive interracial interaction [16]. By participating in community gardens, neighborhood residents also build organizing skills useful for other programs in the community [12].

Many times, race and class relations are deeply embedded in the economic and political processes that both create vacant lands and inform their selection as spaces for urban gardening [17]. Taking race, class, and social power into consideration requires a framework of just sustainability [18] in which questions of who benefits, who bears the costs, and who decides about sustainability policies and plans are foregrounded. While not always explicitly focused on a just sustainability, struggles to increase urban community gardening have been valued because of their roles in reducing or reversing urban disinvestment, building a shared sense of place, and promoting public health. Many gardens started during the early 1970s era began as adversarial projects in the context of social unrest over the Vietnam War and a counter-cultural reimagining of more ecologically-oriented cities [19–21]. In 1973, for example, a group that would later become known as the Green Guerillas threw balloons filled with seeds and bulbs over a fence in New York City onto a vacant lot now acknowledged as the first community garden in the Lower East Side [22]. Urban gardening during the 1990s and 2000s have been associated with movements for re-envisioning and rebuilding more sustainable, healthy, and just food systems and more ecologically resilient and equitable cities.

The opportunities to convert vacant land to gardens are particularly evident in shrinking cities due to the patchwork of vacant land; however, they are not unique to shrinking cities - even growing cities have neighborhoods where vacancy is a major issue. In particular, low-income people and people of color often live in neighborhoods that suffer neglect by municipal governments and a loss of local businesses. Urban gardens have been supported by city programs that reduce barriers to gardening or incentivize the activity. For example, Austin, Texas created the sustainable urban agriculture and community garden program in an effort to streamline the process of establishing and maintaining community gardens [23]. San Francisco, California has an urban agriculture program that in addition to providing financial resources and consumables like compost and mulch also uses an "Urban Ag Incentive Zone Contract" to incentivize urban gardening on private lands [24]. Philadelphia, Pennsylvania has incorporated youth education into their urban agriculture programs [25] and Cincinnati, Ohio actively acquires non-productive property with the aim of converting it to more productive uses, including urban agriculture, through their Land Reutilization Program [26]. Sacramento, CA recently addressed the issue of access and food insecurity by passing a new ordinance that allows residents with small farms, less than 3 acres, to grow and sell fruits and vegetables to their neighbors [27].

While both shrinking and growing cities may experience a resurgence in urban agriculture, many shrinking cities are the same aging cities that have experienced the highest soil lead burdens from the historic use of lead-based paint and leaded gasoline, and industrial sources, including smelters and coal-fired plants. Lead, characterized as a no-threshold neurotoxin, can be deleterious even at very low levels in the body [28–31]. Soil lead which can be unintentionally ingested is a lesser known source of human lead exposure [1]. Research has demonstrated that neighborhood soil lead levels are linked to blood lead levels in children [32]. Although humans can be exposed to small amounts of Pb by consuming produce [33,34] the greater public health challenge is direct exposure to contaminated soil, which can occur through inhaling air-borne dust or unintentionally consuming soil. For children, their high rates of hand to mouth contact make them especially vulnerable to lead poisoning when exposed to high soil lead levels [35].

While there are numerous benefits to growing food in the city, the legacy of lead in the environment often arises as a conflicting challenge. It is, surprisingly, often overlooked as a public health concern [36]. It is also an issue of social and environmental justice; low-income neighborhoods and communities of color are often burdened with the highest blood lead levels [37], and these are often the same neighborhoods with limited access to fresh fruits and vegetables due to lack of grocery stores and/or unaffordability of fresh produce. The importance of recognizing this potential conflict between urban gardening and protection from the health hazard of lead cannot be dismissed. Unfortunately, soil lead guidelines regarding urban gardening are not consistent. For example, the US Environmental Protection Agency (EPA) uses a standard of 400 ppm for children's play areas; however, a recent US EPA working group that specifically examined soil lead in the context of gardening recommended a guideline of 100 ppm [38]. In addition, some states have adopted stricter guidelines. The variability of soil lead guidelines in the US mirrors that of the international community; globally, soil lead guidelines span 3.7 orders of magnitude [39]. We therefore limit the extent of our paper to a soil lead level that a community decides is compatible with urban gardening, a decision they may make using numerous variables. The presence of elevated soil lead can compete with a community's right to grow food. However, what if urban gardening and soil lead are not always competing challenges to the local food movement—what if gardening can be part of the solution to the soil lead issue that so many of our older urban areas face?

2. Can Urban Gardening Address the Soil Lead Problem?

Urban gardening as a potential solution to the soil lead problem stems from investment in place and is realized through multiple activities, notably (1) soil management, including soil testing and the addition of amendments, and (2) social network and community building that leverages resources and knowledge. While we believe that all forms of urban gardening hold this potential—from large-scale urban agriculture to backyard residential gardens—we place particular emphasis on the transformation of vacant lots to community or individually managed gardens because we recognize vacant lots as the largest potential for green infrastructure growth in shrinking cities.

2.1. Soil Management, Amendments, and Testing

Urban gardening is an excellent example of how the interplay between social and biogeophysical forces can result in changes to ecosystem services. When communities transform vacant lots into urban gardens they alter both the social and biogeophysical system in ways that can replace, bolster, or dampen ecosystem services with the most obvious shift from regulating services to provisioning (food production) and cultural services (sense of place, mental and physical health). A more subtle shift can also occur when management of soil systems to support provisioning and cultural services also promotes an important regulating service: reduced exposure to soil lead.

Many of the same properties that gardeners manage in an effort to maintain soil health and fertility also reduce potential exposure to soil lead. For example, gardeners may add organic matter to the soil to increase soil nutrients, especially nitrogen. The addition of organic matter, via compost or manures, may also reduce potential lead exposure by tightly binding lead, making it less bioavailable, and by helping to establish vegetation that acts as a barrier between contaminated soil and humans [40].

The addition of organic matter also dilutes the concentration of lead in soil. Fertilizers containing phosphates can promote the formation of lead phosphate, or pyromorphite, which demonstrates low solubility [41,42]. Gardeners often adjust the pH of their soils, with ideal growing conditions occurring at around 6.5. Maintaining such pH values may also be beneficial from a soil lead perspective, as acidic soils can contribute to increased bioavailability [43]. Planting cover crops is another strategy commonly used to increase soil nutrients and improve soil structure. Cover crops can create a barrier between soils and human populations, reducing exposure to soil, especially during dry and windy conditions. Similarly, mulching with straw, wood chips, or other materials is recommended to maintain soil temperatures and retain moisture. This practice also creates a barrier between soil lead and human populations. While the above-mentioned practices are mutually beneficial, aligning the seemingly conflicting goals of reducing exposure to lead and promoting urban gardening activities, some practices don't align as well. For example, drip irrigation reduces water use, but at the potential cost of increased dust. Raised-bed gardens, a best management practice for soil lead, cost more compared to in-ground gardens and working within the confines of the box may dampen productivity and reduce overall growing space. Developing management practices for lead safe gardening and dialogue around those practices would benefit the gardening as solution approach. In addition, encouraging a standard of soil testing would provide knowledge to gardeners and those benefiting from the garden about safe gardening and management activities that could decrease potential exposure to soil lead.

With increased awareness regarding lead burdens to urban soils, the recommendation to test garden soil for lead is on the rise. While many gardeners test the soil prior to establishing a garden or as part of their ongoing management they may or may not specifically request lead measurements as part of that process. Soil testing can be used to assess whether or not to establish a garden, and if so, can inform garden placement. However, traditional aggregate soil sampling where low and high soil lead could be mixed together, may mask the notorious variability of soil lead, missing an opportunity to identify areas of lower soil lead on the property. More detailed testing can increase awareness regarding the issue of urban soil lead and reveal spatial patterns and areas of highest risk [2]. Understanding the spatial patterns of soil lead can elucidate sources in the environment and facilitate a broader appreciation for the processes that shape our urban places [44]. In addition to total lead, testing for bioavailable or bioaccessible lead can determine whether soil amendments are successful at reducing potential exposure [45,46]. Minca *et al.* [46] provide a decision table regarding the use of a bioaccessible lead test for urban soils with an emphasis on food production. Finally, while we have focused on lead, there are other environmental contaminants common to urban areas that can also be evaluated, including cadmium [47] and polycyclic aromatic hydrocarbons [48]. Together, soil management and testing can build knowledge of soil systems over time, providing relevant information needed to make decisions regarding the ecological sustainability of urban gardening in shrinking cities**.**

2.2. Social Network and Community Building that Leverages Resources and Knowledge

While management practices can change the physical, chemical, and biological nature of urban soils to reduce lead exposure, gardens are more than their biogeophysical components. Urban gardens are places of social transformation, especially in the case of shrinking cities where they can convert vacant land into green space and serve as places to build social capital and to transform environment injustice into just sustainability [49]. Gardens hold the potential to ground communities in place and promote investment in economic and social change. While vacancy can leave holes on the landscape and disconnect communities, networks of gardens can grow in and connect places where blight once existed. The alignment of natural and social capital through gardening can happen through many processes, but especially through transforming marginal land, connecting human and environmental health concerns, and advancing social justice goals—processes that all have the potential to leverage policy changes. The extent to which natural and social capital are aligned may depend on the type or garden and the politics surrounding its development.

Community gardens are often started on vacant or economically marginal land where they are frequently perceived as a temporary use until land values rise, at which point many gardens are displaced for new higher-profit land uses [4]. One advantage of gardening on vacant lots is that it may be easier to start a community garden without needing a lengthier process of approval by urban planning authorities. However, there are disadvantages to temporary gardening. People cite lack of stable land tenure as a reason to not garden [19] or a concern when they do garden [12]. Gardening on marginal or vacant lands can be short or long-term, structured or unstructured, but the process can build coalitions that bring about much larger change and leverage funding (e.g., community grants) which is especially important in shrinking cities where funds are limited. And even if the activity is short-lived, the manipulation of the soil has the potential to mitigate the soil lead legacy, and leave a different legacy, that of a soil improved through gardening.

Gardens can foster connections between human and environmental health. While gardens are often associated with health, sustainability, and social justice, the potential to function as environmental hazards due to soil lead or other contaminants can complicate that picture. However, knowledge and activism surrounding soil lead can bring more awareness to connections between human health and wellbeing and environmental health. In fact, as activism around environmental lead concentrations has evolved, concern has shifted from a focus on remediating the bodies of individuals and changing individual behaviors to eliminating sources of lead exposure in the environment [50,51]. This activism, though, has not produced a commitment from municipal governments to large-scale environmental improvement in central urban areas. Rather, the primary policy response has been to advocate for individual-based prevention and treatment options, which does not address the historical and persistent disinvestment in urban infrastructure, especially in neighborhoods inhabited by low-income people and people of color. As a result, these populations continue to experience high levels of environmental exposure to lead [51].

Given the weak reception by policy makers to redressing environmental hazards in disadvantaged communities, advocacy that focuses on environmental amenities, like gardens, may be more productive. It opens new opportunities to form alliances between social justice in the city and more traditional environmental groups [52]. Despite the opportunities for alignment, controversies over community gardens tend to arise because of divergent valuation of and claims upon gardens by local residents and government agencies. While often viewed as an environmental benefit by multiple actors, the informal status and fragile tenure of community gardens may lead to displacement by plans to further develop the site for uses that generate greater profits for capital and revenues for local governments [20,53–55]. Alternately, urban gardens are increasingly designed by developers as privatized amenities for the residents of their new housing and commercial developments [4]. This divergence of frames for urban gardens has led to a long history of struggles over their form, aesthetics, uses and ownership [56]. Environmental justice movements have therefore sought to build new gardens and fight the displacement of existing gardens in low-income communities and communities of color.

The politics of gardening initiatives might change the extent to which there are opportunities to align the seemingly conflicting goals of reducing exposure to lead and improving access to gardens. For example, guerrilla gardening, often seen as a radical takeover of land with the intention to take back space for the good of the neighborhood and city, may use private or gated vacant lots as sites for gardens. This may have implications for the degree to which lead issues are addressed. Potential soil contaminants could be overlooked, revising the narrative of the space from source of blight to source of pride without considering the underlying biophysical nature of lead or other contaminant risks to gardeners. On the other hand, soil contaminants could become a concern that galvanizes communities to organize and rally around. Urban environmental amenities, including urban gardens, have been associated with the larger green environmental justice movement which recognizes that environmental justice issues extend beyond the traditional focus of environmental bads or disamenities in the environment, or brown environmental justice [57]. The takeover of vacant and degraded lands may also provide a means for community members to heal from past trauma, as Angeluelovski [57] (p.10) writes:

> *"In Barcelona, the area of the Forat de la Vergonya was a vacant hole full of debris and waste as a result of municipal contractors leaving rubbish behind in 1999 after taking down buildings throughout the neighborhood. Long-time residents felt that their neighborhood was being erased and that they were pushed away from it. . . As a response to processes of neighborhood dismantlement and individual and collective loss, residents and their supporters engaged in open space cleanup, park construction and maintenance, or community garden development. Such efforts were directed at addressing trauma and grief, remaking a place for residents, and preventing further disruption. . . While many environmental endeavors are oriented toward addressing grief and loss, they also give residents greater confidence to rebuild themselves and move forward after years of neighborhood violence, disruptions, and abandonment. Several community organizers coordinating activities with children in urban farms, gardens, or community centers underline their effort to address traumatic life experiences and build a different future."*

Institutional gardens (e.g., at a school, in a city park) may be subject to politics as well—they are more likely to be legally leased vacant lots owned by the city. This may have implications for addressing lead: if lead testing is completed and lead is detected, then the temporary nature of urban gardens as a land use might make it more likely that formal institutions will avoid gardening all together. Alternatively, institutions can enact an informal "don't ask don't tell" policy, putting vulnerable populations, including children and food-stressed individuals, at risk. The temporary nature of gardens can challenge communities that have invested in place and see it as a pathway to transformation—their hard work and investment can be erased. However, cities may capitalize on the temporary nature of gardens as a way to transform areas of blight to areas of investment for future alternative land uses. This can cause tension between community members who provide the labor and investment only to be later exploited and/or potentially left out of future decision making processes [56].

3. Reframing the Soil Lead and Gardening Discussion

We define frames as systems of meaning that shape action and reframing as a change in the systems of meaning that shape action. Reframing, or the process of aligning [58] the seemingly disparate goals of reduced soil lead exposure and increasing garden access, may help support rebuilding and redistributing social and natural capital in shrinking cities, advancing the ultimate goal of the sustainable and equitable urban form. Framing around shrinking cities has been one focused on the hollowing out of urban cores, or the physical, structural changes to a city. Likewise, the framing surrounding soil lead and gardening has largely been focused on competing interest and tradeoffs. If new frames are adopted—ones that highlight opportunities for alignment and mutual advancement—can gardens move from potential conflict to part of the solution to the soil lead problem?

Case Study from Sacramento, CA

While Sacramento, CA is not a shrinking city in regards to population growth or infrastructure, it does have older neighborhoods with high rates of vacancy as are found in shrinking cities. Paired with the emphasis on using vacant land to support urban agriculture, as exemplified by the passing of recent ordinances that support both front yard gardens and the selling of residential produce, it serves as a useful case study when considering the alignment of the seemingly conflicting goals of reducing exposure to lead and improving access to gardens.

In Sacramento, CA we have established a collaborative transdisciplinary research program in which we work in partnership with a local non-profit organization whose mission is to support healthy, equitable, and empowered communities. As part of their work in the community they have installed raised-bed gardens to improve access to local foods and build community cohesion. We have tested soil lead at over 75 yards in three underserved neighborhoods in north and south Sacramento and conducted resident surveys and interviews—placing the issue of soil lead and gardens in the larger community context. As part of our research we provide high spatial resolution soil lead data which are used to inform garden placement as well as manage lead hazards in other areas of the yard. Data are shared with residents in the form of easily accessible maps that indicate where samples were taken and the corresponding lead concentrations (Figure 1). Our research is strongly rooted in community and has strengthened relationships between university researchers, local non-profits, and community gardeners and identified ecosystem services that the community values and would like to manage for—advancing the ultimate goal of healthy urban gardening.

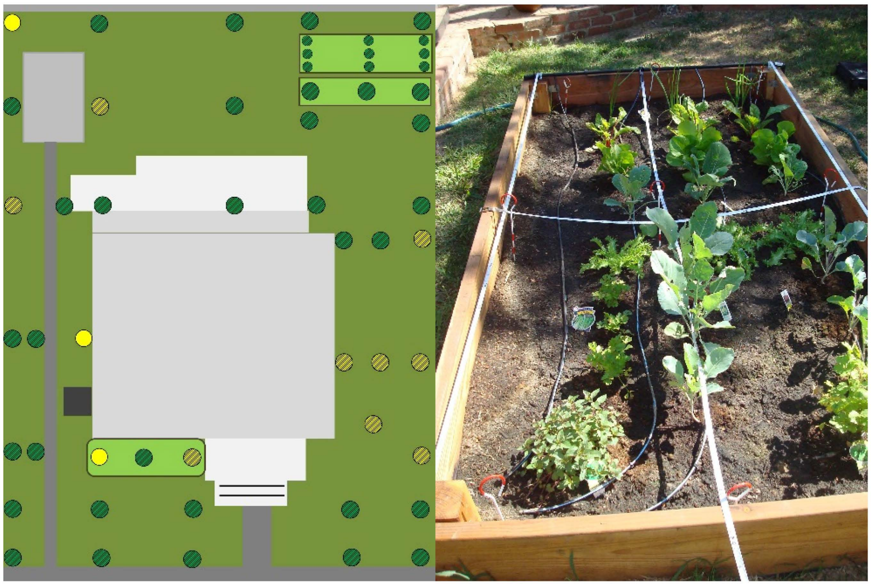

Figure 1. An example of a sampling map that is shared with study participants (left). The circles represent where the soil was tested for lead and the colors correspond to different lead levels. A raised-bed garden that was sampled for soil lead is shown on the right.

Perhaps as important as the clear communication of our research findings, we are using the project to reframe soil lead in the context of gardening, especially in our communication efforts. It's important to note that reframing is not downplaying the hazards of soil lead. It is leveraging points of alignment that can advance the management of two goals—food production and reduced soil lead exposure—that are often seen as disparate. For example, we have benefited from presenting our work as research that has the potential to advance the goals of increased food production, not research that aims to restrict or end the activity. Revealing our intentions and motivations to our community partners is critical—and especially pertinent in Sacramento where the issue of lead in soil has been used to displace/relocate residents in the past [56]. In our research we have also carefully thought about how to communicate the often confusing soil lead guidelines in a way that empowers communities and doesn't aim to stigmatize communities as contaminated or dirty. While our project has benefited from the ways in which we present soil lead exposure reduction and food access as aligning interest, there is room for improvement. For example, materials that are provided to participants are either generated with food access/production or soil lead prevention as the main focus—integrating these concepts into project materials would help enforce these goals as mutually supportive.

While the Sacramento gardening community is one that may have started like many others—as a grassroots effort to increase local food access and production, it has flourished and grown, effectively leveraging a grassroots movement to change policy. However, the question remains: how do you introduce information regarding the hazards of soil lead without degrading community movements for gardens as a health and equity promoting land use and activity? In our ongoing efforts we have found success through close alignment with community partners (Figure 2), transparent reporting of results, leveraging community resources that advance both goals, and constant communication among all parties.

Figure 2. An example of an interactive exercise completed at our annual meeting with community partners. All participants give feedback on challenges, surprises, and the most significant thing learned (left). Feedback is later summarized, categorized, assigned actionable items (if appropriate) and shared with meeting participants (right).

4. How Reframing Advances Sustainability Goals

Reframing the urban gardening and soil lead issue can help advance urban sustainability and environmental justice goals by providing a narrative that allows for the two activities to be jointly advanced through community engagement. This is especially important in shrinking cities in which opportunities to leverage the management of multiple ecosystem services, including food provisioning and reduced lead can be realized through the availability of vacant and underutilized lands. Sustainability efforts often forget about legacy with their eye towards the future; however, the legacy of lead is one that continues to change the land, and gardening, through biogeophysical and social processes, has the power to change that legacy.

In this paper we have attempted to show where possible points of alignment exist between protecting vulnerable populations from soil lead risks and efforts to increase access to local food and alleviate nutritional poverty. Crucial to the success of such an endeavor is that of community capacity to undertake and sustain urban greening efforts, especially at a scale that can match the processes of urban injustices. Growing this capacity is essential and can be supported by policy that incentivizes urban greening initiatives and supports the communities that undertake them as well as funding to finance such initiatives. We recognize that many of the proposed solutions suffer from a common critique of lead poisoning prevention efforts—placing the onus of a large societal problem on individuals and communities. Our intention is not to dismiss the role of institutions in addressing lead poisoning prevention and remediation, which is alarmingly underfunded. In addition, we recognize that gardens, in isolation of other community transformations, including transportation, affordable housing, and jobs, may have limited capacity to build well-being and address social and environmental injustices. Can urban gardening solve the soil lead problem that many cities face? That likely depends on the extent and severity of the contamination. However, we suggest that urban gardening can be part of a larger strategy to make urban neighborhoods healthier and more equitable in the face of these structural injustices.

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