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Characteristics and growing practices of Baltimore City farms and gardens

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A B S T R A C T

Paralleling growing international interest in the cultivation of crops and livestock in cities—hereafter urban agriculture (UA)—Baltimore City has developed a robust network of urban farms and gardens and UA practitioners, particularly over the past decade. Despite the city's prominent UA scene, the nature of UA in Baltimore has not been thoroughly characterized in existing literature to date. We used a survey and on-site observations of 104 urban farms and gardens participating in the Safe Urban Harvests Study to explore site characteristics; growing practices; produce production, harvest, and distribution; and contaminant history and testing. Our results demonstrate a diversity of characteristics and growing practices across the UA operations in the city, especially when comparing among community gardens, urban farms, educational gardens, donation gardens, and therapy gardens. This study illuminates the size and scope of UA operations in Baltimore, with 104 participating sites occupying nearly 10 ha of land, producing an estimated 43,000 kg of produce per growing season, and engaging approximately two percent of city residents. Most sites engaged in best practices for reducing risks from potential soil contamination, including having tested soils for contaminants, growing in raised beds, and importing growing media. The use of renewable inputs varied; most sites did not use chemical pesticides or fertilizers (non-renewable inputs), however most sites did not use rain barrels or on-site composting (practices that renew inputs) either. Our findings also suggest that residents living within neighborhoods that have limited access to grocery stores with healthy foods do not necessarily have limited access to urban farms and gardens relative to other city residents. These data will enable UA practitioners, educators, and policymakers in Baltimore to tailor their programs and policies to address the needs of local growers. Lessons learned from the survey instrument could inform research exploring UA operations in other cities.

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1. Introduction

The past two decades have seen growing interest in urban agriculture (UA), the cultivation of crops and livestock in cities. Recognized for its potential sociocultural, public health, environmental, and economic development benefits (Santo et al., 2016), the practice of UA varies widely across countries, cities, and individual growing sites. Baltimore City, Maryland (henceforth: Baltimore) has a robust network of UA practitioners supported through several non-profit organizations that provide resources, education, technical assistance, collective sales, advocacy, and land protection. Additionally, the municipal government has enabled or supported UA through zoning changes to support animal husbandry and food sales, an Adopt-A-Lot program through which residents can build a garden on a vacant city-owned lot, a more formal land leasing initiative (known as Homegrown Baltimore), an urban agriculture tax credit, a soil safety policy, and a city-run allotment garden program (known as City Farms). These and other initiatives have positioned Baltimore as one of the country's leading cities in terms of the number and scope of UA policies over the past decade (Halvey et al., 2020).

Baltimore's UA community has developed against the background of two intertwining phenomena: the city's post-industrial legacies and its persistent systemic racial and socioeconomic disparities. As a major East Coast port city and terminus of the country's oldest railroad, Baltimore formerly served as a vibrant shipping and manufacturing hub. This industrial history, along with more recent waste incinerator operations and vehicular traffic, has raised concerns about potential soil contamination throughout the city and influenced perceptions among farmers and gardeners about where, how, and what to grow (Kim et al., 2014). Knowing whether and how urban growers have tested their soils for contaminants, or engaged in other practices to mitigate exposure to contaminants (e.g., growing in raised beds, importing growing media), can inform the development of programs and resources aimed to support safe urban food growing.

Baltimore is also deeply affected by racial, socioeconomic, and geographical disparities in wealth, food security, healthy food access, and diet-related disease (Swartz et al., 2018). Nearly a quarter of residents live in Healthy Food Priority Areas (HFPAs), formerly called food deserts, where underlying structural inequities limit access healthy foods (Misiazsek et al., 2018). Specifically, HFPAs are areas in which the median household income is at or below 185 percent of the federal poverty level, over 30% of households have no vehicle, the distance to a supermarket is greater than 1/4 mile, and the area has a relatively low score on an indicator related to the availability of healthy foods within stores (Misiazsek et al., 2018). The HFPA map drives much of the city's food policies (Swartz et al., 2018), and influences the development, mission, operations, and community relations of farms and gardens throughout the city (Baltimore Office of Sustainability, 2013; Poulsen et al., 2017).

Baltimore's post-industrial legacies and persistent disparities are important to understanding the context of UA in the city. Despite the city's prominent UA community, the scope and diversity of UA operations in Baltimore has not been thoroughly characterized in existing literature to date. A number of researchers have interviewed UA practitioners in Baltimore to examine specific topics related to the practice of UA, including contributions of community gardens to food security (Corrigan, 2011), perceptions of soil contaminant risks (Kim et al., 2014), perceived benefits of community gardening (Poulsen et al., 2014a) and urban farming (Poulsen et al., 2017), educational needs (Little et al. 2019), and relationships between urban farms and local community members (Poulsen et al., 2014b). Most of this previous research entailed qualitative case studies of small number of UA operations, ranging from 1 – 13 sites (Corrigan, 2011; Poulsen et al., 2014a; Poulsen et al., 2014b; Poulsen et al., 2017) and focused on assessing either community gardens or urban farms. Two studies included surveys of urban gardeners (Kim et al., 2014) or farmers (Little et al., 2019) from numerous sites, but did not attempt to study or represent the variety of UA operation types across the city. Another study sought to quantify Baltimore's farms and gardens through satellite imagery and web scraping (Young et al., 2018), but was focused on quantifying the total number of operations and did not include ground-truthed data.

Research in other municipalities or states has characterized UA based on classifications (e.g., community gardens) or themes (e.g., financial viability). For example, studies have explored staffing and volunteerism, growing practices, crops grown, and/or produce distribution channels of urban gardens broadly (Burdine & Taylor, 2018), or community gardens specifically (Gittleman et al., 2010). Some studies have assessed factors related to the financial viability of urban farms, including modes of production, sales, and percent of produce donated (Dimitri et al., 2016), and site size, costs, and farm profitability (Hunold et al., 2017). Some have explored sustainability metrics related to garden yields and/or efficiency of input use (McDougall et al., 2019; Porter, 2018). Others have analyzed practices relevant to contaminant exposure, such as the use of raised beds and source of growing media (Johnson et al., 2016) or behaviors to reduce contaminant exposure, awareness of potential contaminants, reasons for not testing soil, and produce distribution channels (Henson et al., 2017). This previous research has examined these parameters in different combinations and levels of depth, however to our knowledge, none have explored all of them across a majority of sites within an entire city. Without a comprehensive understanding of how UA functions in a city, city agencies and support organizations are operating with limited information with which to design and evaluate UA policies and programs.

We build upon this previous research from Baltimore and other cities by conducting a comprehensive characterization of farms and gardens in Baltimore. As part of a community-driven study, we use descriptive data to explore a variety of topics of interest to UA stakeholders, including those related to site characteristics; growing practices; produce production, harvest, and distribution; and contaminant history and testing. We explore key questions related to who, where, and how food is being grown in the city. In doing so, we aim to create a broad baseline of information about the conduct of UA in Baltimore and provide a foundation upon which future research could explore specific topics in more depth.

2. Methods

To characterize UA in Baltimore, we surveyed urban farm managers and garden leaders, supplemented with on-site observations by the study team. The survey and on-site observations were collected as part of the broader Safe Urban Harvests (SUH) study, which aims to answer questions about exposures to soil contaminants among urban growers and consumers of urban-grown produce. The SUH study was a community-driven study conducted by research staff from the Johns Hopkins Center for a Livable Future in partnership with the Baltimore Office of Sustainability, Farm Alliance of Baltimore, Parks and People Foundation (and their formerly active Community Greening Resource Network), and University of Maryland Extension - Baltimore City. Recruitment, interviews, on-site observations, and data analysis were conducted by SUH research staff; partners contributed to study conceptualization and survey design, shared information for recruitment, reviewed study protocols, and participated in the interpretation and communication of findings.

2.1. Recruitment

Eligible sites grew food within Baltimore City in 2016 or 2017 and distributed their produce to more than one family (e.g., home gardens were ineligible). We did not proactively recruit school/educational gardens but did not exclude those that requested to participate. Sites were recruited through study partners' networks and other outreach channels. The SUH study team invited representatives of farms and gardens to participate in the study via phone, email, and/or social media. We sought out additional eligible sites through snowball sampling, online searches, social media and listserv recruitment, and word of mouth. A leader of the Baltimore Food and Faith Project facilitated connections with site representatives at church gardens in their network. A few sites were identified by the SUH study team while traveling to other sites.

A total of 125 potentially eligible sites (excluding educational gardens) were identified and contacted by December 2017. If no responses were received after at least two emails, phone calls and/or social media messages, the site was excluded. In terms of sample representativeness, of the 125 eligible sites, 92 (74%) agreed to participate and eight declined to participate. We have no reason to believe that non-participating sites differed from participating sites. An additional 12 educational gardens requested to participate, yielding a total of 104 participating sites.

2.2. Survey design and administration

The survey included both closed- and open-ended questions about growing practices, site history, previous contaminant testing, regular participants and infrequent volunteers, and produce harvests. The survey was completed by a site representative over age 18 who confirmed they were able to speak on behalf of the site, though in some cases, they may not have been able to speak about all site growing practices (e.g., practices differed in community gardens with individually managed plots). The survey was developed in consultation with SUH community partners. It was then pilot tested with three UA sites of varying sizes and foci prior to launch.

Survey responses were collected from July 2016 through December 2017 via phone, online, or in person (SI Appendix 1). For surveys completed online, the research team checked for misunderstandings or incomplete answers; if these were found, we followed up with the site representative via email or phone to clarify the responses. The survey took approximately 45 minutes to complete. Respondents could skip survey questions. Survey data were collected and stored in Qualtrics$^{XM}{}_{®}$ (https://www.qualtrics.com/).

2.3. On-site observations

The SUH study team conducted on-site observations using a paper checklist during the SUH study collection of soil, water, and produce samples. This checklist was developed by the SUH study team to corroborate data related to survey questions which had low or inconsistent responses (e.g., site boundaries (used to calculate site size), modes of production, irrigation water sources). Two questions were added related to methods of delivery for irrigation water and composting methods to elaborate on survey responses. Additional questions related to the history of vandalism, theft, and rats were added at the request of the SUH community partners. When possible, the observations were verified by a site manager present on-site.

2.4. Data analysis

Descriptive statistics (e.g., median, mean, interquartile ranges) for quantitative data from survey responses and on-site observations were calculated in Microsoft Excel. Open-ended qualitative data were predominately short answers asking about specific practices or inputs (e.g., potential sources of contamination, source of imported soil, type of input applied, type of contaminant tested, type of agency or lab that conducted contaminant tests, barriers to testing). These responses were reviewed and categorically coded in Microsoft Excel by two SUH team members; in cases of discrepancy in codes between the two reviewers, the larger SUH study team was consulted. "Other" responses were also reviewed to ensure that there was no redundancy with existing categorical response options. In cases where there was a discrepancy between survey responses and on-site observations, we used the latter because they were verified first-hand. Fig. 2 was generated using Python v3.6.

For four of the 104 sites, two surveys were completed by different site representatives. Since participants were recruited through multiple outreach channels, the respondents may have been unaware that the survey had been taken by another site representative. To reconcile discrepancies between duplicate surveys, we averaged responses (for quantitative responses), included both responses (for qualitative responses), or used the most recent response (for categorical responses). For questions where only one survey had a response, we used that response.

Participating sites were geocoded using ArcGIS Online, and boundaries identified using on-site observations were used to create shapefiles and calculate site sizes. To display the number of participating sites in each census tract (Fig. 1), the site boundaries were overlaid with Baltimore census tracts (U.S. Census Bureau, 2018) and HFPAs (Johns Hopkins Center for a Livable Future, 2018).

2.5. Ethical considerations

The Johns Hopkins Bloomberg School of Public Health Institutional Review Board (IRB) reviewed and approved this study protocol.

3. Results

3.1. Site characteristics

3.1.1. Site classification

Sixty-two percent of participating sites were community gardens where produce was primarily consumed by growers. These were roughly evenly split among sites with plots for individual gardeners, collectively managed plots, and sites with a mix of both (Table 1). Seventeen percent of sites were farms which grew produce primarily to be sold for revenue, 12% were educational sites (i.e., at schools and other youth-focused sites), 9% were donation gardens (i.e., produce primarily grown to be donated), 2% were therapy gardens (i.e., aimed to provide physical, emotional, and spiritual health for clients associated with an adjacent center), and 3% had a mix of characteristics that did not meet our categorization criteria. Although categorization was mutually exclusive for most sites, three farms had separate community garden sections and were counted under both categories, and one educational site donated all of its produce and was also counted as a donation garden.

3.1.2. Site locations, sizes, and land ownership

Seventy-five (36%) census tracts in Baltimore City contained at least one farm or garden participating in the study (Fig. 1). The majority of sites (79%) were located within low to moderate income census tracts (U.S. Department of Housing and Urban Development, 2020). Based on data averaged from the 2013-2017 American Community Survey (U.S. Census Bureau, 2019), 62% of sites were located within census tracts with a median household income below $49,199, which is 199% of the 2017 poverty level for a family of four (U.S. Department of Health and Human Services, 2017)(SI Table 1).

Seventy-seven percent of sites were smaller than 1/8 ha (1,250 m^2), and 4% were larger than ½ ha (5,000 m^2)(Fig. 2). Farms (median size: 0.2 ha), and to a lesser extent community gardens (median size: 0.05 ha), were most likely to be the largest sites. Therapy, educational, donation, and "other" sites were the smallest (median for each was between 0.01-0.02 ha). Altogether, the sites in this study occupied 9.9 ha (0.05% of the whole city).

Fifty-six sites (54%) were located on at least some private property; of these, 73% had received permission to grow from a landowner or landowning organization, 21% were located on an affiliated grower's personal property, and 5% had achieved access through self-help nuisance abatement (common law that allows neighbors who are

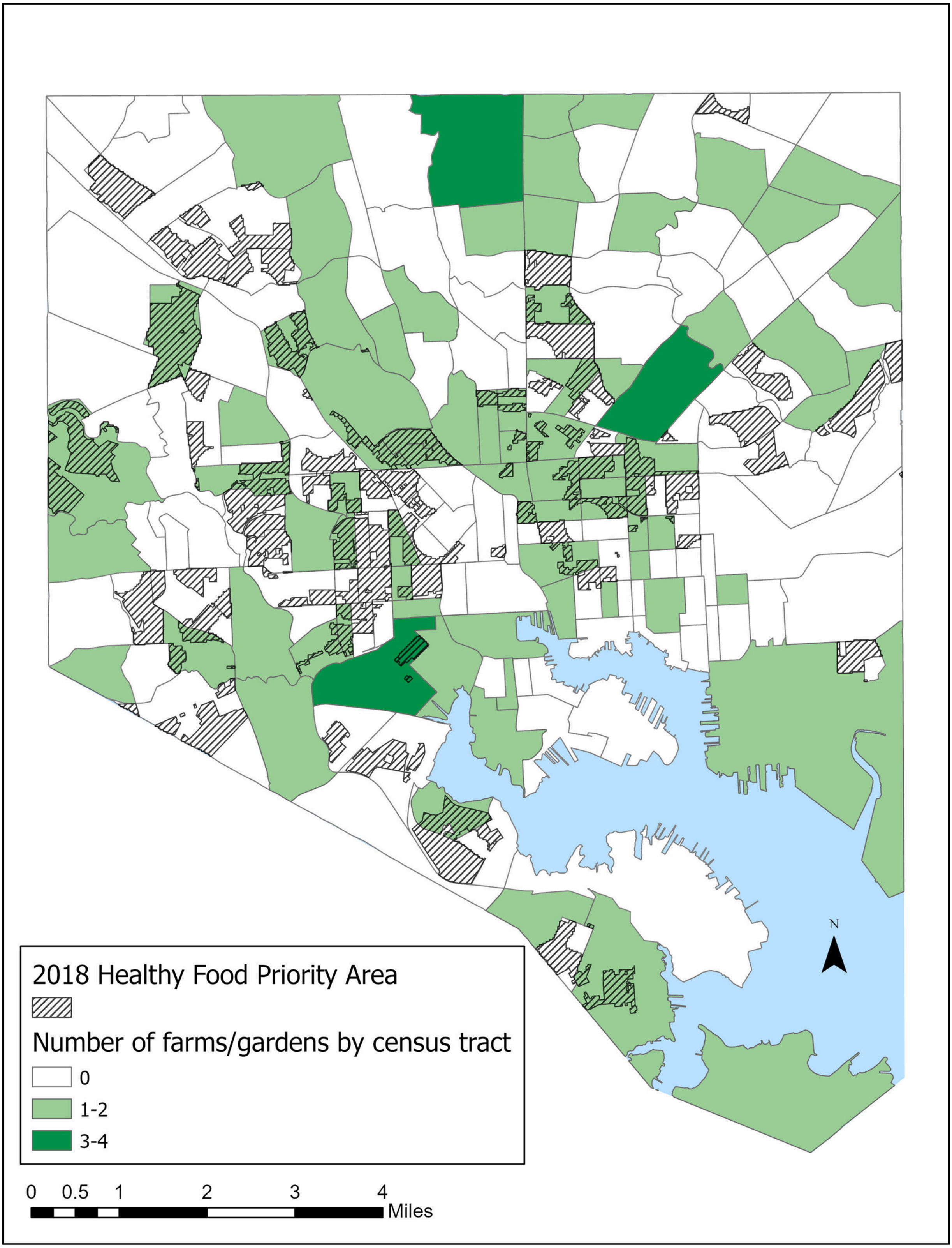

Fig. 1. Distribution of participating UA sites in Baltimore City and relationship with census tracts and Healthy Food Priority Areas.

negatively affected by a property to enter and clean up the nuisance; Witt, 2015) (Table 1). Fifty-one sites (49%) were located on at least some land owned by the city. Of these city-owned sites, 51% were managed through the city's Adopt-A-Lot program, 24% were city-run allotment gardens (i.e., City Farms), 8% were formally leased through the Homegrown Baltimore program, and 18% occupied other city property, including land managed by local schools and the housing authority. At 4% of sites, the site representative did not know or did not respond about who owned the land on which they were growing food. Six sites were located on multiple plots of land with different owners;

Table 1
Site classification and land ownership.

Question (bolded) and response option	Description	No. of sites	Percent
Site classification		**104**	
Community garden	Produce is primarily (>70%) consumed by growers, though some may be given to neighbors or donated.	64	62%
	Separated into plots for each gardener (i.e., allotments)	22	
	Collectively managed plots, produce shared among participants	22	
	Mix of separate plots and collective management	20	
Farm	Produce is primarily grown to be sold for revenue, though educational or community activities may occur.	18	17%
Educational	School or youth-focused garden in which produce is used primarily to teach growing practices. Produce is not usually sold; if it is, its revenue does not contribute majority of overall budget.	12	12%
Donation	Produce is primarily (>70%) grown to be donated to food banks, soup kitchens, or other charities; often affiliated with religious or social services organization.	9	9%
Therapy	Gardens intended to foster opportunities for physical, emotional, and spiritual health for clients associated with adjacent center.	2	2%
Other	Farms/gardens that did not meet the above criteria.	3	3%
Land ownership*		**104**	
Private property		56	54%
	Granted permission from private landowner (including landowning organization).	41	
	Personal property of farm/garden participant.	12	
	Self-help nuisance abatement.	3	
City property		51	49%
	Adopt-a-Lot program allowing residents to maintain piece of vacant city land.	26	
	City Farms site+: City-managed allotment garden on park land where residents can rent plot for growing season.	12	
	Formal lease through Homegrown Baltimore initiative; allows growers to sell food.	4	
	Other school or housing authority property.	9	
Unknown		3	3%
No response		1	1%

Classification was determined by site observations and survey responses about produce distribution and sales. Although classification was mutually exclusive for most sites, three farms had separate community garden sections and were counted under both categories, and one educational site donated all of its produce and was counted as donation garden as well.

[*] Answers not mutually exclusive.

[+] One site was embedded within a City Farms location and counted separately due to unique management practices.

thus, these results are not mutually exclusive.

Most site representatives were "very confident" (65%) or "somewhat confident" (29%) that all parts of their site would remain a farm or garden in the future. Four percent of sites were "somewhat doubtful" about at least a part of their site remaining a farm or garden, and an additional two percent were "very doubtful" about their site future. Of those who were doubtful about their land tenure, reasons cited included the site's lack of eligibility for conservation easements, concerns about the current owner closing the site, and previous experience losing land to private owners.

3.1.3. Year established

Most participating sites were established in the decade prior to the survey completion. Among the 95 sites that provided a year of establishment, two percent were established before 1980, 18% between 1981-2000, 5% between 2001-2005, 21% between 2006-2010, and 36% between 2011-2015. An additional 18% were in the process of establishment when surveyed in 2016 or 2017.

3.1.4. Participants

Over 9,500 people were calculated to be engaged in UA, based on 99 sites that provided estimates of the number of regular participants or infrequent visitors/volunteers involved with their site during the most recent complete growing season (SI Table 2). Given Baltimore's estimated population of 609,840 residents in 2017, and assuming participants were each involved in only one site and lived within city limits, approximately two percent of Baltimore City residents were regularly involved with or infrequently visited the sites participating in this study during a growing season.

Among the 98 sites with regular adult participants (18+ years), there was a median of 15 regular adult participants. Among the 64 sites that engaged youth (6-17 years) and 50 sites that engaged children (<6 years), a median of 10 youth and 5 children, respectively, participated at each site. An additional 69 sites reported having infrequent visitors/volunteers (of any age), with a median of 20 per year.

Educational sites had the largest number of youth and child participants per site, as well as the largest number of participants and visitors of all ages per site (SI Table 2). Farms reported the largest number of infrequent visitors/volunteers per site. Therapy sites engaged the fewest participants in each category and in sum across categories per site. Across all sites, community gardens accounted for the greatest number of overall participants and visitors (4,400).

Seventy-nine site representatives responded to a question asking whether any regular participants lived within a mile of the site. Of these, 81% reported that at least half of their regular participants lived within a mile of their site. Approximately 34% of the 5,734 regular participants identified across all sites in the study lived within one mile of their affiliated sites.

3.1.5. Vandalism and theft

During on-site conversations with representatives from 89 sites, 36% reported experiencing vandalism in the past 12 months and 6% reported experiencing it previously but not recently. Littering and illegal dumping were often cited in open-ended responses, as were damage to structures on site (e.g., fences, hoophouses, sheds, beehives). One site in particular had dealt with significant challenges, including multiple cars running over their fence and finding the corpse of someone who had died from a drug overdose onsite.

Forty-four percent of site representatives reported experiencing theft in the past 12 months, with an additional 6% having experienced it previously but not recently. Most of the theft reported involved produce, fruit trees/bushes, or tools/hardware (e.g., tillers, lawnmowers, hoses, copper piping). One site experienced such frequent produce theft that they had a sign up in mid-September reporting that all but four ripe tomatoes had been stolen after four months of gardening.

3.2. Growing practices

Additional details on the following subsections are provided in Table 2. Note that many of the following responses are not mutually exclusive (see asterisks in Table 2).

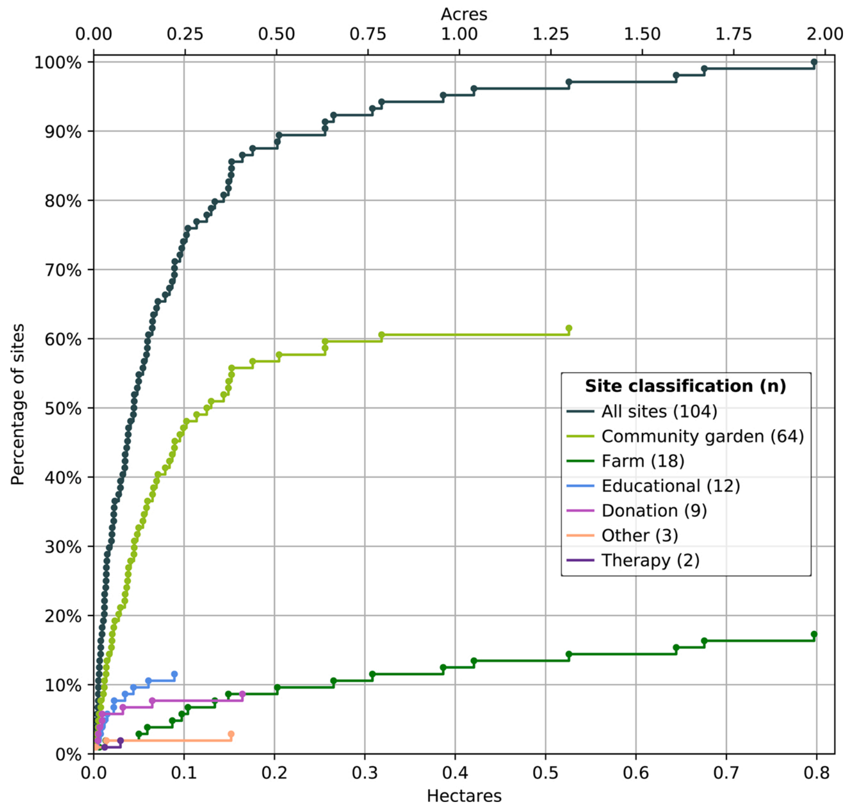

Fig. 2. Site size by classification.

3.2.1. *Modes of food production*

Over half of the sites grew at least some edible plants in above-ground framed raised beds (69% of sites) and directly in-ground without frames (57%). Twenty percent included fruit trees or bushes, 16% had a hoophouse or greenhouse, 7% grew some crops in containers such as pots and tires, and one site grew plants directly in straw bales.

3.2.2. *Imported growing media*

Of the 100 sites that responded to a question about imported growing media, 95% grew in at least some soil, compost, or mulch brought in from off-site. Among the 83 sites that responded to a follow-up question about the source(s) of imported growing media, the most commonly reported sources were local/regional industrial food waste and organics composting companies (31%) and local lumber/mulch companies (20%).

3.2.3. *Composting*

Among the 99 sites with on-site observations about composting, 41% were actively composting onsite. The type of composting systems varied, though some sites employed more than one method (Table 2). An additional 8% of sites had a compost pile or bin but had stopped maintaining it; of these, three had stopped composting due to rats.

Among the 89 site representatives that responded to a question about their experience with rats, 35% percent had observed rats onsite in the past 12 months and 8% had dealt with rats in the past but not recently and/or had resolved their rat problem. One site reported that changing their composting method to a completely contained system successfully addressed their rat problem, however, there were only slight differences in the observance of rats on sites with completely contained composting systems (36% reported recent rat sightings) compared to those that used only piles/rows (32%) or open bins (41%).

3.2.4. *Irrigation water*

Eighty-six percent of sites used municipal water accessed via a spigot, hose, or sink onsite; 14% used a rain barrel; and 7% used municipal water that was stored in barrels, tanks, or cisterns. Twelve percent had no water source onsite and brought municipal water from offsite; 11 of these were community gardens and one was an “other” classification.

Among the 94 sites with on-site observations about irrigation methods, a hose was the most common method (77%) and sprinklers/misters were the least (2%) (Table 2). Thirty-nine percent of farms used drip irrigation, compared to 0-17% of other site classifications.

3.2.5. *Chemical input use*

Chemical fertilizers were infrequently used. Of the 95 sites that provided a response, 3% used chemical fertilizers on the whole growing area, and 17% used fertilizers on a portion. Among the 10 sites that responded to a follow-up question about fertilizer used, MiracleGro® was the most commonly cited (60%). Chemical fertilizer was applied a median of 2 times (range: 1-32 times) per growing season among the 10 respondents. Sixteen sites provided a response about the method of fertilizer application, with 88% applying fertilizer directly to the soil around the plant or as part of the potting mix and 56% applying it using foliar spray, or application to the plant itself. Treated seeds and beans inoculated with nitrogen-fixing bacteria were used by one site each.

Pesticides were infrequently used. Of the 92 sites that responded, 2% applied pesticides on the whole growing area and 20% applied pesticides to a portion. The type of pesticides varied widely; some were certified for organic production by the Organic Materials Review Institute (OMRI) (e.g., pyrethrum, insecticidal soap*, Bacillus Thuringiensis*). Among the 9 sites that responded to a follow-up question about the frequency of pesticide application, the median number of applications was 5 times per growing season (range: 1-32 times). Nineteen sites provided a response about the method of pesticide application, with 68% applying pesticides via foliar spray or application to the plant directly and 16% applying pesticides directly to the soil or in the potting mix. Twenty-six percent of sites reported that pesticide application

Table 2
Growing practices.

Question (bolded) and response option	No. of sites	Percent
Modes of food production*	**104**	
Raised bed, framed (above-ground beds framed by wood or stone)	72	69%
In-ground, unframed (includes unframed mounded beds)	59	57%
Orchard (i.e., fruit trees and/or bushes)	21	20%
Hoophouse or greenhouse	17	16%
Container (e.g., pots, tires)	7	7%
Straw bails	1	1%
Unknown/not yet determined	2	2%
Irrigation water source*	**104**	
Municipal, accessed via spigot, hose, or sink on site	89	86%
Rain barrel	15	14%
Municipal, stored in barrel, tanks, or cistern	7	7%
No source on site and/or municipal water brought from offsite	12	12%
Other	3	3%
Irrigation methods*	**94**	
Hose	72	77%
Watering cans	18	19%
Drip irrigation	14	15%
Buckets/containers/bottles (often to bring water from offsite)	8	9%
Sprinkler/mist	2	2%
Composting on site*	**99**	
Method: piles/rows (with or without tarp cover)	19	19%
Method: open bins (e.g., made with pallets)	17	17%
Method: completely contained	14	14%
Has/had compost pile or bin, but stopped maintaining	8	8%
Method of composting not recorded	1	1%
No composting observed on site	50	51%
Imported growing media	**100**	
Yes, exclusively	37	37%
Yes, some	54	54%
Yes, extent not reported	4	4%
No	5	5%
Among those who imported growing media, source of imported growing media*	**95**	
Local/regional industrial food waste and organics composting company	26	27%
Local lumber/mulch/soil company	17	18%
Big box store (e.g., Home Depot, Lowes, Walmart)	12	13%
City-owned wood or leaf composting facility	12	13%
Manure from local source	9	9%
Mushroom compost[+] from local producer	8	8%
Brought in from another farm/garden site	8	8%
Compost from local source (not industrially composted, e.g., backyard pile)	4	4%
Local garden center, hardware store, or nursery	4	4%
Other	7	7%
Unknown (includes sites that knew who donated soil but not soil's original source)	12	13%
No response	12	13%
Chemical fertilizer use	**95**	
Yes, on whole growing area	3	3%
Yes, only on portion of growing area	16	17%
No	76	80%
Pesticide use	**92**	
Yes, on whole growing area	2	2%
Yes, only on portion of growing area	18	20%
No	72	78%

[*] Answers not mutually exclusive.
[+] Spent growing medium used in mushroom production; varies in composition but typically includes straw and poultry or horse manure.

methods varied by individual gardeners within the allotment gardens, though pesticide use was generally discouraged by the site managers.

3.3. Produce production, harvests and distribution

Most sites did not measure their harvests. Among the 36 sites that reported an estimate of their annual produce harvest, the median estimate was 108 kg (range: 11-9072 kg). Donation gardens (67%) and farms (56%) were most likely to provide an estimate in response to this question compared to other site classifications (response rates: 27%-50%). Farms produced more produce per growing season (median: 680 kg) compared to community gardens (91 kg), donation gardens (64 kg), and educational gardens (62 kg). Adding the responses from the 36 sites that reported an amount of produce harvested, and using the median value of each site classification to estimate harvests for the 68 sites that did not respond to the question, the sites in our study produced a collective total of 43,534 kg of produce per growing season. Using site size as a proxy for the growing area, the median yield across sites was 0.6 kg/m^2 (range: 0.03-11.4 kg/m^2).

Site respondents were asked to identify the top five crops grown at their site, based on the area in production for each crop. Among the 94 sites that responded, 86% reported at least one crop from the fruiting nightshades family among their top five crops, most commonly tomatoes and peppers; 78% reported leafy greens and brassicas, most commonly kale; 55% reported cucurbits; 32% reported herbs; 29% reported root vegetables, and 15% reported fruits. SI Table 3 details all crops mentioned by site representatives as part of their top five crops in production.

The produce was distributed in various ways. At 80% of sites, produce was consumed by growers and their households, often in substantial proportions compared to other means of distribution (Table 3). Fifty percent of sites reported giving at least some produce to volunteers or visitors, 38% donated some produce to individuals or organizations, and 22% sold produce either directly to consumers and/or to restaurants, grocery stores, or other retailers.

Table 3
Produce distribution channels.

	Sites distributing via each channel		Percent of produce distributed among those who use each channel	
Question (bolded) and response option	**No.**	**Percent**	**Median**	**IQR**
Produce distribution*	**104**			
Consumed by growers' households	83	80%	75%	35-95%
Given to volunteers or visitors	52	50%	11%	5-40%
Donated to individuals or organizations	40	38%	13%	10-30%
Sold directly to consumers	18	17%	50%	25-74%
Sold to restaurants, grocery stores, other retailers	13	13%	10%	10-25%
Other	4	4%	28%	21-38%
Unknown	13	13%		
Among those who donated produce, where was it donated*	**40**			
Food bank, food pantry, or produce giveaway program	15	38%		
Community members or neighbors	12	30%		
Soup kitchen or prepared meal giveaway program	9	23%		
Youth/after school program	5	13%		
Other	8	20%		
No response	1	3%		

[*] Answers not mutually exclusive.

Among the 39 sites which reported where they donated their produce (including through programs the site operated itself), the most common recipients were food banks, food pantries, or produce giveaway programs (38%) and community members or neighbors (31%)(Table 3).

Among the 23 sites which reported selling their produce either to consumers or to restaurants and retailers, nine provided estimates of their approximate annual revenue (median: USD $3,000/year, range USD $300-80,000) and seven provided estimates of their annual profit (median USD $300/year, range USD −$1,000-6,000). When analyzing farms only, the annual revenue (median: USD $5,000) was slightly higher, though the median profit was $0 due to the fact that one site reported a loss, and two sites reported a profit of $0.

3.4. *Contaminant history and testing*

3.4.1. *Perceived sources of site contamination*

When asked if they were aware of any current or past potential source(s) of contamination that could affect their site, 76 site representatives responded. Of these, respondents most commonly reported a building demolition onsite or nearby (34%) or that their site was formerly a dump or had experienced illegal dumping before the site was established (18%). Twenty percent of sites reported no known history of contamination. All perceived sources reported by site representatives are listed in SI Table 4.

3.4.2. *Contaminant testing*

When asked about whether they had previously tested their soil for contaminants, 95 site representatives responded. Of these, 59% reported having tested their soil for contaminants at least once prior to the current study, with 24% having tested within the last year (SI Table 4). Among the 35 site representatives who answered a follow-up question about where the soil was tested, 74% reported using Agricultural Extension labs.

Sites that had identified potential sources of contamination were more likely to have tested their soils compared to those with no known history of contamination. Among the 59 sites that reported current or past potential sources of contamination, 58% had tested their soil at least once prior to the current study. Among the 13 sites that reported no history of contaminants, 38% had tested their soil. Among the 28 sites that provided no response to the question on contaminant history, 61% had tested their soil.

Forty site representatives responded to an open-ended question about what contaminants had been previously tested. Of these, 95% had included lead in a previous contaminant test, 43% had tested for other heavy metals, and one site had tested for "solvents/fuel." Several respondents also listed nutrients (20%), pH (8%), organic matter (5%) and nitrates (one site), indicating potential confusion between contaminant and nutrient testing.

We also asked about previous water and produce testing. Six sites reported having tested their irrigation water for contaminants. When asked further details, however, it was revealed that three of these sites were just reporting that municipal water is tested by the city and another two did not know where it had been tested or what contaminants had been tested. One site reported having previously tested its produce for contaminants, but when asked to specify which contaminants, the respondent only reported soil pH, possibly indicating that the respondent misconstrued an acidity test with a contaminant test.

Forty site representatives responded to a multiple-choice question about whether the results of previous soil, water, and/or produce contaminant tests had caused site participants to change any growing practices and/or personal behavior(s). Of these, respondents most commonly reported having changed some growing practices (38%) and remediating soil, including through diluting or importing new soil (30%). Thirty-three percent of site representatives reported no changes to growing practices or participants' behavior as a result of their previous contaminant testing (with some sharing that their satisfactory results indicated no need to change anything). SI Table 4 displays responses to all options presented.

Sixty-four site representatives provided a response to an open-ended question about whether they had faced any barrier(s) to testing their soil, water, or produce. Of these, 63% reported no barriers. Expense (20%) and lack of knowledge or experience testing (13%) were the most common barriers (SI Table 4).

3.5. *Comparison of sites located within and outside of Healthy Food Priority Areas*

Twenty-five percent of sites were located within an HFPA. There was a slightly higher proportion of farms (21% were farms) among sites located within HFPAs compared to sites located outside of HFPAs (15% were farms)(Table 4). Sites located within HFPAs had a larger percentage of participants that lived within a mile of their site compared to those located outside of HFPAs (median: 90% vs. 83%). Sites within HFPAs reported selling a greater percentage of produce compared to sites outside of HFPAs (mean: 15% compared to 11%), while those outside HFPAs distributed a higher proportion to growers, volunteers, and donations (mean: 76% compared to 73%). Representatives from sites located within HFPAs were more likely to report potential sources of contamination compared to sites located outside of HFPAs (69% compared to 53%).

4. Discussion

Our study explores a wide range of site characteristics and practices across a variety of UA site classifications in Baltimore. While doing so, we gathered more-in depth information on many variables examined than has been previously reported in other studies from Baltimore and beyond, including type, source, and/or frequency of application of specific inputs used (including growing media, irrigation water, pesticides, fertilizers); composting methods; number and age of regular participants and infrequent visitors/volunteers; estimates of harvests per site; and history of challenges encountered (e.g., vandalism, theft, rats). In attempting to collect and quantify such detailed information, we encountered limitations in the amount and accuracy of information site representatives could provide (see Section 4.1). Nevertheless, we believe

Table 4
Summary characteristics of sites located within Healthy Food Priority Areas (HFPAs) compared to sites located outside HFPAs.

Characteristics (bolded)	Sites located within HFPAs	Sites located outside HFPAs
Site classification		
Community garden	61%	59%
Farm	21%	15%
Educational	11%	11%
Donation	7%	9%
Therapy	0%	3%
Other	0%	4%
All sites	25%	75%
Median percent of participants living within mile of site	90%	83%
Mean percent of produce distributed via each channel*		
Consumed by growers' households	44%	53%
Given to volunteers or visitors	19%	11%
Donated to individuals or organizations	10%	11%
Sold directly to consumers	10%	8%
Sold to restaurants, grocery stores, other retailers	5%	3%
Other	1%	1%
Unknown	12%	12%
Reported perceived current or historical sources of contamination	69%	53%

* Answers not mutually exclusive.

this study is novel in the breadth of characteristics examined, variety of UA site types included, and coverage across an entire city.

Our findings suggest that site representatives were aware and actively working to reduce risks for potential soil contamination. Study sites grew in raised beds and at least some imported growing media at a higher rate than sites in previous studies (SI Table 5). Sites had previously tested their soils for contaminants, and subsequently changed growing practices or behaviors, more than those reported in Henson et al. (2017). Few sites had previously tested water or produce for contaminants, indicating an area for further research.

The use of renewable and non-variable inputs varied. Fewer sites reported using chemical pesticides or fertilizers than sites examined in Dimitri et al. (2016) and Henson et al. (2017). Sites reported using rain barrels or catchment systems less frequently than UA operations in other studies (SI Table 5). This finding, along with the fact that fewer than half of the sites were actively composting onsite, echoes the discussion by McDougall et al. (2019) around how sites may rely on "non-renewable inputs" such as compost and municipal water from offsite rather than expending the cost and effort required to cultivate such inputs directly. Other growing practices and produce harvest and distribution parameters were like those reported in previous studies (SI Table 5).

The calculated median yield of 0.6 kg/m^2 from sites in this study was lower than the median yield of 2.7 kg/m^2 reported by McDougall et al. (2019) based on the results of 15 studies on UA systems. The site sizes reported in this current study represented the entirely of the site, including areas which were not actively growing food (e.g., picnic tables, sheds, uncultivated green spaces). It is unclear whether the yield calculations from previous studies were calculated based only cultivated areas, but if so the estimate from our study would reflect an underestimate. The wide range of yields reported between sites was also observed by McDougall et al. (2019) and Porter (2018), confirming that individual site practices significantly influence yield estimates.

Most UA operations have multi-faceted missions (e.g., many farms run educational programs and donate produce; gardens may sell some produce) and there are numerous ways to categorize UA operations given their many overlapping features (e.g., Burdine & Taylor, 2018; Dimitri et al., 2016). Acknowledging that the lines are often blurred when trying to categorize UA operations, our approach—developing a broad typology of participating sites based on produce distribution channels and sales (via "site classification")—nevertheless revealed noteworthy differences across categories in site size; harvest volumes; and the number, ages, and types of participants engaged. Community gardens were the most common site classification, and engaged nearly half of the total 9,500 individuals reported as regular site participants or infrequent visitors in the study. Educational gardens engaged the largest number of regular participants, especially youth and children, per site. Farms were the largest in size, and reported the largest amount of produce harvested, annual revenue and profit, and number of infrequent visitors/volunteers per site. While this study was not optimized for assessing financial viability, our findings echo those of previous studies suggesting that profitability is not a driving motivator of most UA operations, including farms (Dimitri et al., 2016; Hunold et al., 2017; Little et al., 2019). This underscores the importance of valuing UA operations on more than just production volumes and profits, and adjusting value criteria based on the type of site.

Our results demonstrate the wide diversity of characteristics and growing practices across Baltimore UA sites. Additionally, our study has illuminated the size and scope of UA operations in Baltimore. The sites in our study occupy nearly 10 ha of land in Baltimore City and produce an estimated 43,000 kg of produce a year. These statistics, along with the finding that approximately two percent of Baltimore residents were regularly involved with or infrequently visited the sites participating in this study during a growing season, are notable for their health, educational, social, and environmental benefits. To our knowledge, this is the first attempt to estimate the total number of a city's residents engaged in UA even if it does not represent all UA sites in the city. The extent to which UA operations address food access and food insecurity concerns is an important consideration given the numerous racial, socioeconomic, and geographic inequities in Baltimore. Fifteen percent of HFPAs in the city included a farm or garden in our study. We have no reason to believe that participating sites systematically differed from the broader Baltimore UA community. The sites in our study were located within HFPAs at approximately the same proportion (25%) as the proportion of city residents living within HFPAs (23.5%) (Misiazsek et al. 2018). Additionally, UA sites within HFPAs had larger proportions of regular participants that lived within a mile of their site. These findings suggest that while residents living within HFPAs have limited access to grocery stores with healthy foods, they do not necessarily have less access to urban farms and gardens compared to other city residents.

That said, several factors may temper simple conclusions. Firstly, the finding that there were proportionately more farms among UA operations within HFPAs, and that the operations within HFPAs sold a larger proportion of their produce—and by contrast, distributed a smaller proportion to growers, volunteers, and donation—than those located outside of HFPAs merits further investigation into the extent to which the produce being grown in HFPAs is accessible to local residents. Many urban farms report both food access and economic empowerment goals (Little et al. 2019). Achieving either goal is challenging and requires regularly evaluating whether the methods used are achieving the desired results. One literature review on how UA addresses food insecurity concluded that "the challenge has not been growing enough food per se, but rather 'producing and distributing food in ways accessible and affordable for the growing urban poor' while sustaining UA operations in a capitalist, production- and profit-oriented society" (Siegner et al. 2018).

Second, although HFPAs are not designated based on contaminant history, the finding that representatives of sites located within HFPAs were more likely to list a potential current or previous source of contamination should be further assessed. To what extent are these concerns about potential contamination corroborated by soil, water, or produce testing data?

Lastly, since beginning this research, there has been increased attention within the Baltimore UA community towards actively challenging food apartheid, or the historical and political context that has created racial and socioeconomic disparities in the food system, through fostering Black food sovereignty (Swartz et al., 2018). More research into the motivations of Baltimore UA participants, and how those motivations may influence which type of UA operation is chosen, specific growing practices, produce distribution channels, and other management decisions is merited.

Without a comprehensive understanding of how UA functions in the city, city agencies and support organizations are operating with limited information. Our results enable city government agencies as well as UA educators, non-profit organizations, and researchers to tailor their policies and programs to address the needs of local growers. For example, over half of the sites grow at least some food directly in ground (not in raised beds) demonstrating the need for city agencies and UA support organizations to continually assist with soil contaminant testing and interpretation. Some responses suggest site representatives were confused about the difference between contaminant testing and testing for nutrients or acidity, highlighting an area for further clarification in educational and safety resources for UA practitioners. Our data revealed that a high percentage of sites rely on municipal water for irrigation; for sites with limited budgets, the Baltimore City program that provides a flat fee for municipal water access for UA may mitigate an otherwise costly barrier to growing. Details on site history, growing practices, and participant ages could inform risk assessments associated with UA. The relatively infrequent use of hoophouses and greenhouses might prompt research exploring growers' interest in extending their growing season—and the degree to which food production could increase—with adequate financial and technical assistance. Additionally, our findings around the prevalence of rats, and their lack of relationship with composting methods, could inform further research into mitigating concerns associated with rats in UA.

4.1. Limitations and opportunities for future research

Our survey data portray a snapshot of growing practices as reported by a single representative of each participating site. Answers for each site may differ across growing seasons. For example, weather and pest conditions may impact which growing practices are used, or sites may rotate which produce varieties are planted and in what amounts. Site representatives did their best to summarize overall practices but may have been unaware of individual participants' practices at allotment-style sites. Some questions involved relatively subjective responses, such as those related to barriers to contaminant testing and changes adopted as a result of previous contaminant testing; responses to these questions may have differed if another site participant took the survey. Additionally, given frequent turnover in site management, some representatives may have been unaware of certain aspects of their site history (e.g., year established, potential historical sources of contamination, or previous contaminant testing conducted), or may have answered differently than former representatives (e.g., sources of imported growing media may have changed).

The format and complexity of some questions asked may have influenced responses. For example, multiple-choice questions may have limited how much detail participants could have otherwise provided in an open-ended format. Questions that required estimating the number of participants, amount of produce grown, profit, and revenue were likely easier and more accurately answered by site representatives that kept detailed records, which may have favored sites with paid staff, profit incentives, or metrics for grant reporting compared to those managed more loosely. The specificity of some questions aimed at quantifying individual crop statistics (e.g., percent of growing space devoted to certain crops, number of plantings per year) or quantifying participant activities (e.g., frequency of visits, time spent onsite per visit, proportion of activities involving direct soil contact) were challenging for most representatives to complete; due to the low response rate, these data were not analyzed. Moreover, surveys completed over the phone or in-person likely provided more valid data (i.e., participants answered what attempted to measure) than those completed independently by growers, given the ability for participants to ask clarifying questions.

While we followed up with site representatives by phone to clarify unclear or incomplete responses whenever possible, the challenges encountered with our survey instrument could inform the development of future surveys aiming to characterize UA sites and growing practices, such as by better crafting questions to align with how practitioners keep records of specific practices.

5. Conclusion

Through surveys with urban farm managers and garden leaders, supplemented with on-site observations by the study team, we documented how UA operations in Baltimore City varied in size; number and types of participants; growing practices; produce production, harvest, and distribution practices; and contaminant history and testing. These data could help UA practitioners, educators, and policymakers tailor their programs and policies to address the needs of local growers. While we expect some of the results to be similar in different cities (e.g., testing barriers, growing inputs, produce distribution channels), other cities would have to adapt aspects of the survey to fit their local context (e.g., land ownership; questions on vandalism, theft, and rats). Nevertheless, the comprehensive scope of this survey could be useful in assessing trends in the future of UA in Baltimore and in comparisons with other cities.

Author Contributions

Raychel Santo: Project administration, Investigation, Formal analysis, Writing - Original draft, Visualization; Sara Lupolt: Project administration, Investigation, Writing - Review & editing; Brent Kim: Conceptualization, Methodology, Writing - Review & editing, Visualization; Ruth Burrows: Investigation, Formal analysis, Writing - Review & editing; Eleanor Evans: Investigation; Bailey Evenson: Data curation, Formal analysis, Writing - Review & editing; Colleen Synk: Methodology, Investigation; Rachel Viqueira: Investigation, Writing - Review & editing; Abby Cocke: Conceptualization, Writing - Review & editing; Neith Little: Conceptualization, Writing - Review & editing; Valerie Rupp: Conceptualization, Writing - Review & editing; Mariya Strauss: Conceptualization, Writing – Review & editing; Keeve Nachman: Conceptualization, Supervision, Funding acquisition, Writing - Review & editing.

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Declaration of Competing Interest

The authors report no declarations of interest.

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Appendix A. Supplementary data

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