

Cultivating Opportunity: Assessing Urban Agriculture on Municipal Land in Madison

By

Maneisha Lewis

A public practice report submitted in partial
fulfillment of the requirements for the degree of

Master of Science in Agroecology

at the

University of Wisconsin – Madison

2026

Acknowledgements

Community Partners

UW – Madison Team

UW – Madison Soil & Environmental Sciences Facilities and Staff Support

The City of Madison Staff in the Economic Development Division of the Department of Planning, Community & Economic Development

Project Overview

Food insecurity stems from a multitude of factors and does not affect all people equally, the City of Madison and Dane County wish to address the issue through food councils and programs, investing in infrastructure, and partnering with local food system networks. The Madison Food Policy Council (MFPC), established in 2012, is the main body that develops and recommends policies to the mayor to support food systems in the area. Recently, there has been an interest in increasing urban agriculture (UA) as a strategy to address food insecurity. However, limited empirical assessment exists regarding the suitability of municipally-owned land for food production in Madison. The mayor, MFPC, and staff in the Economic Development Division (EDD) of the Department of Planning, Community & Economic Development have pursued information about the feasibility of increasing food production on city-owned land. Specifically, they have identified fifteen¹ sites in Madison with the potential for UA such as community gardens, food pantry gardens, and commercial production.

The EDD provided University of Wisconsin-Madison (UW) affiliated investigators with a list of the properties to consider (seven parks within the purview of Parks Department, eight other properties managed by other departments). Our UW team, led by emeritus professor Steve Ventura, evaluated these properties for suitability of UA development in the Fall of 2025, utilizing enhanced criteria derived from previous work done on community garden spaces in Madison. These enhanced criteria were developed in conjunction with EDD, Rooted Inc. (a non-profit organization coordinating Madison's community gardens) and from published literature (Eanes & Ventura, 2015).

The first chapter of this paper describes the biophysical suitability of land use, highlighting our methodological approach for assessment and findings. The second chapter outlines the social components of UA development as a strategy to address food insecurity in Madison. The purpose is to evaluate the feasibility of expanding UA on city-

¹ City staff initially identified fifteen sites. One was removed from the public report after assessment since a long-term agriculture lease was executed.

owned land in Madison, Wisconsin, with the goal of increasing local food production for emergency food outlets and food-insecure residents, additionally holding a discussion of potential challenges of expansion and feedback from community (Note: recommendations are solely the notions of the investigators and are not adopted City positions).

Chapter 1: Land Evaluation for Urban Agricultural Use

Introduction

Land suitability is determined for UA use through a multi-criteria evaluation related to physical, socioeconomic, and environmental factors at site and neighborhood scales. Evaluation is needed where parcels have a complex land use history and heterogeneous soils. Physical and biophysical conditions like fertility, drainage, and solar access affect food production. To assess whether food is safe for consumption, environmental factors like contamination are considered. When determining socioeconomic factors, we make considerations of current and historical land use, accessibility, and community engagement. This chapter details the methodological approach used to assess the physical and biophysical suitability of listed properties and presents findings with particular emphasis on soil suitability and heavy metal concentrations.

Soil quality plays an important role in understanding if land is productive and safe for UA. Soil quality refers to the ability of soil to function effectively within natural or managed ecosystems. Rather than focusing solely on nutrient content, soil quality reflects a comprehensive evaluation of the soil's physical structure, chemical composition, and biological activity and how these components interact to support overall ecosystem function (IERE Team, 2025). Soil quality is the fundamental component in agricultural production to yield healthy edible foods. Soil quality can be assessed by measuring components like nutrient availability, bulk density, and organic matter content.

Soil fertility is one component of soil quality. Achieving and maintaining appropriate levels of soil fertility, especially plant nutrient availability, is of paramount importance if agricultural land is to remain capable of sustaining crop production at an acceptable level (Johnston & Fellow, 2005). Soil analysis is an aid to managing soil nutrients efficiently to maintain soil fertility for those nutrients like nitrogen (N), phosphorus (P), potassium (K) and magnesium (Mg) that are retained in soil in plant available forms. It may also be used for more transient properties such as plant-available nitrogen and water. If the amount of any of these nutrients in such forms in soil is too small then yield is jeopardized, but increasing reserves in agricultural soils to very high levels is an unnecessary expense (Johnston & Fellow, 2005). Soil testing for nutrients is a tool to balance productivity and manage soils in a cost-effective way.

Physical properties of soil must also be considered. Bulk density is an indicator of soil compaction that affects infiltration, rooting depth, available water capacity, soil porosity and aeration, availability of nutrients for plant use, and activity of soil micro-organisms, all of which influence key soil processes and productivity (Arshad et al., 1997). Urban soil can have complicated histories of disturbance such as construction, storm drain usage, and other human activities that alter soil structure, texture, and infiltration. Assessing bulk density helps support whether soil can be cultivated or if remediation is needed. Another factor in soil structure, also impacting soil fertility, is organic matter content. Several studies have highlighted the potential for organic matter to improve various aspects of soil health in urban landscapes. However, urban soil can often contain less carbon than natural spaces due to erosion from construction and improper management (Garcia et al., 2024). Soil tests to determine percent carbon in soil can aid with assessing productivity.

Beyond productivity, soil quality information gives insight into potential economics of UA. The productivity of the soil can involve some investment, especially if the soil needs treatment. Urban soil that is degraded or contaminated may require the use of raised beds or imported soil if remediation alone is not sufficient, or long-term restoration through management of inputs and cropping systems. The cost of input must be worth the economic and social outputs. Urban farmers face significant direct cost challenges, including high startup investments, ongoing operating expenses, and difficulty achieving economies of scale. These costs vary depending on the size, type, and location of the operation, making financial sustainability a key concern for growers. Upfront expenses such as soil testing and land preparation are essential to reduce risk, while continued spending on infrastructure and management further adds to the financial burden. Despite these constraints, growers can offset some costs through community support, shared knowledge, and strategic practices. However, understanding and managing soil quality remains a critical investment, as it directly impacts productivity and long-term viability of the land. The cost and benefits for urban growers will be examined in greater detail in Chapter 2.

To strengthen claims of UA suitability on parcels, we need to look at the biophysical ability of lands to not only produce food, but to determine the safety of working in soils. These benefits of producing foods must be weighed against the potential health risks stemming from exposure to contaminants such as heavy metals and organic chemicals that may be present in urban soils (Kim et al., 2014). The ideal situation for production of agriculture products occurs where the contamination in soil does not exceed naturally occurring levels. Lead (Pb) is particularly hazardous and is found naturally in soil at a level of 10-50 parts per million (ppm), with background (combination of natural and

anthropogenic) levels typically ranging from 10-50 ppm in rural areas. Urban soil tends to exceed the naturally occurring level, the EPA estimates 25% of urban soil exceeding 200 ppm, due to both point and nonpoint sources of contaminants present from human activity. (In the case of Pb, varies anthropogenic sources from lead paint to gas spills). The EPA standard for unsafe levels caused by Pb contamination is 600 ppm in residential soil, though numerous sources suggest cautions at half this level (U.S. Environmental Protection Agency, 2025). The soil remediation standard for soil cleanup under Wisconsin spills laws specified by the Wisconsin Department of Natural Resources (DNR) is 200 ppm. For Pb background levels in Wisconsin, the standard is comparable to natural occurring levels in the driftless region, which is 52 ppm. 52-200 ppm the DNR considers a “release” to have occurred so the parcel would go on a state list of contaminated sites. Over 200 ppm the state can require remediation of the property (Wisconsin Department of Natural Resources, n.d.).

There is no known safe level of Pb in children’s blood, and exposure can severely harm mental and physical development. In adults, Pb can cause increased blood pressure, heart disease, decreased kidney function, and cancer. Targeted children’s blood lead levels are 5 micrograms per deciliter to determine remediation goals (U.S. Environmental Protection Agency, 2025). Heavy metal exposure can be induced through consumption of contaminated soil directly or through accumulation in plants. The consumption of plants with Pb exposure is considered secondary to the direct consumption of contaminated soil that may be present on plants. Plants may only accumulate small amounts of heavy metals in tissue, but if soil contaminant concentrations are high, plants and people may be at risk. Further evaluation of potential Pb exposure from consumption of home-grown produce is warranted because accumulation of Pb in consumable produce is strongly associated with crop type (Byers et al., 2020).

While many urban areas may not be contaminated at unsafe levels, perceived environmental contamination can present barriers to land use. Research has shown that urban gardeners often express concerns about soil contamination even when no clear evidence of exposure or information on mitigation strategies presents. A study interviewing 93 gardeners across 20 community gardens in St. Louis was conducted to understand community gardeners perceived risk of soil contamination. The study found that 48.4% of gardeners had concerns with heavy metal contamination with 41.9% focused particularly on lead. 68.8% of gardeners perceived benefits of building community garden spaces but more than half the gardeners were not aware of methods to reduce heavy metal exposure (Wong et al., 2018). This example emphasizes the need for clear soil assessment and communication of findings to ensure producers are safe which in turn reduces uncertainty.

Rapid screening with X-ray fluorescence (XRF) provides a fast, in-person estimate of total elemental concentrations, including heavy metal contaminants like Pb. However, XRF results are not considered legally defensible for regulatory decision-making due to the belief that it could be less precise and more variable. In contrast, the EPA has certified testing by accredited labs using specific methods to produce legally actionable data that can influence regulatory thresholds (U.S. Environmental Protection Agency, 2025). This distinction directly affects how contamination can be communicated to growers and landowners, because results can designate a parcel needing immediate remediation or placing land on restrictions potentially liable to landowners, including municipalities. Since XRF has no associated legal reporting requirements, it is a preferred first step to assess soils due to the practical and low-risk use in comparison to EPA-certified testing. Preliminary screening may suggest soil conditions are acceptable; however, only certified results can confirm exceeding actionable levels. It is important for transparent communication that distinguishes between rapid screening and regulatory reporting, as already mentioned perception around contamination can be discouraging to urban growers.

These reasons address the need for soil quality and contamination analysis. By integrating measurements of soil physical characteristics and nutrient and contaminant screenings, we can evaluate both productivity and safety of municipally owned lands for UA use. In this chapter, I describe the study done by UW-Madison investigators who evaluated the biophysical suitability of municipal sites for UA use for the City of Madison by detailing the methodological approaches done by investigators, delivering the results of analysis, and discussing findings.

Methodology

A set of criteria to evaluate the suitability of municipal lands for UA use was developed by enhancing the framework previously used (Eanes & Ventura, 2015) to assess community garden potential in Madison through interaction with the City and Rooted, Inc. staff. Our criteria include assessment of physical and biophysical characteristics such as soil compaction, contamination, fertility, texture, water holding capacity, and organic matter content which provides insight into soil quality. Additional assessments for suitability include solar access, slope, vegetation/surface type, and current/local/historical land use. Virtual site surveying through Google Maps (aerial imagery 2024) and ArcGIS were used to identify infrastructures on sites, neighboring lot spaces, and size and configuration of sites. Satellite imagery from Wisconsin State Cartographer's Office and the Dane County web-mapping site were used to identify topography and if sites had previous history of agricultural, industrial, or residential use. Zoning and neighboring demographic information

were gathered through city ArcGIS maps available on the City of Madison website. Ground-truthing, the process of making in person visits to validate landscapes (Eanes & Ventura, 2015), was used to interpret remote findings and inspect additional information on land characteristics such as vegetation type and solar access.

In person site visits included a team of two or more individuals to collect notes on landscape and to take soil samples. Soils were sampled at one to four locations, depending on the size and configuration of the potential production area. The sample locations were selected to represent dominant characteristics of production area. However, due to the variability in many urban soils, larger sites with complicated histories were generalized and were suggested for further analysis through systematic grid sampling. Coordinates of sampling locations were noted along with any anomalies around sampling areas worth mentioning. Two types of soil samples were collected – a single intact core for bulk density and soil organic matter analysis and a composite from four points 6 meters apart for heavy metal and nutrient analysis. For both types, we sampled the top six to eight inches of soil, commensurate with the rooting depth of common garden crops. Some locations we cored fifteen inches to determine if gravel or detritus could inhibit tillage. Soil samples were collected in labeled whirl bags associated to site location with bulk samples being stored at room temperature and composites being stored in a refrigerator at 0°C.

Soil analysis was conducted at the Department of Soil and Environmental Sciences, University of Wisconsin-Madison under the supervision of department faculty and staff (Geoff Siemering, Nick Balster, Nick Bero). Analyses were carried out using standard lab procedures by agroecology graduate student Maneisha Lewis. Bulk density was determined by oven drying soil at 105°C and dividing final weight by volume. Subsamples from bulk density were used for organic carbon (OC) analysis. OC was determined by loss on ignition method; soils were incinerated at 550°C. Composite soil samples were subdivided for elemental analysis and refrigerated at 0°C. From these subsamples, nitrate was extracted by KCl method while phosphate extraction was done by water. Both nutrients were analyzed by spectroscopic methods. Another subsample was air dried for analysis with X-ray fluorescence analyzer (XRF) to identify heavy metal content. The XRF device assesses lead, cadmium, strontium, arsenic, and other elements potentially found in urban soils. (XRF analysis is not a USEPA certified lab method and should only be considered a general indicator of potential hazards.) All data were stored via Google Drive and shared amongst our UW team of researchers.

Based on results of findings from virtual and actual site visits along with our analysis of soil, our UW team was able to categorize sites into four types of UA production. These categories were determined by the size of sites, pre-existing community gardening, access

to property, pre-existing infrastructure, neighborhood characteristics, and the fundamental soil characteristics that lead to food production. These categories are community garden expansion, creation of community garden, food pantry farm, and permaculture creation (such as food forests). A full report was developed and provided to the City of Madison to suggest these categories of UA use on municipal sites.

Results and Findings

To understand the suitability of UA use on municipally-owned lands, three forms of evidence were used to evaluate sites: existing web-based public records, field observations, and laboratory analysis of soil samples. Web-based public records allowed our investigative team to create preliminary spots to sample as well as approximate the area of potential UA creation/expansion based on satellite imagery of topography, soil survey data, and previous history of agricultural, industrial, or residential use.

An example of the process of layered webbed analysis is displayed in *Figure 1* for the Graham property, showing the use of topographic mapping from Wisconsin State Cartographer's Office along with Google maps estimated area tool. Once areas were designated for potential UA use from web analysis of properties, our team physically visited sites and collected notes on visually perceived potential of spaces based on analysis of percentage land cover, vegetation types, level of surface disturbance, solar access, water access, infrastructure availability, and transportation access. For clarification further using Graham as the example, our ground-truthing process concluded that Graham had no available off-street parking, no restroom availability, and was in walking distance from public transportation. The site mostly had full sun exposure except for a few large oaks creating shade north and east of property. No



Figure 1 displays contour lining of topography and measured area of potential UA creation for 5204 Graham Pl. property, just one of the listed properties under evaluation.

irrigation was installed and although this property had historical record of infrastructure removal, no visible evidence of soil disturbance was seen.

Soil sampling was done during ground-truthing on properties in the areas deemed probable for UA use. The results of sampling will be discussed below.

Finally, our team categorized types of UA use on properties based on all three forms of evidence and *Table 1* illustrates evaluated properties and the recommended UA potential. Four categories, the creation or expansion of community gardens and creation of permaculture or food pantry gardens, were used to differentiate potential types of UA use. Expansion was only suggested for sites with gardens already established. And the creation of community gardens/food pantry gardens was based on the size of available area, soil quality, solar/water access, and community accessibility. For areas lacking qualities (like a small size plot) but still yielding for plant growth, permaculture (such as food forest) was suggested. A large bold X under a category represented a highly recommended creation, while small x represented an acceptable creation. Some sites, like Reindahl, were suggested with more than one possibility, and could support more than one production but the emphasis is on bold X recommendations.

SITE Address	Community Garden Expansion	Community Garden Creation	Market/Food Pantry Farming	Permaculture Creation
829 W Washington Ave (Brittingham)	X			
924 Burr Oak Ln (Heifetz)	X			
5810 Thrush Ln (Meadowood)	X		x	
1818 Portage Rd (Reindahl)	X		X	x
115 N Eau Claire Ave (Rennebohm)	X			
5323 Raywood Rd (Waunona)	X		x	
Sigglekow Rd/ County AB (Yahara Hills)			X	
109 N Thompson Rd		X		x
1322 High Point				
513 Jacobson Ave		x	x	
2710 Post Rd		X		x
7033 East Pass		X		
3809 Hoepker Rd/ 3816 John Wall Dr			X	
5204 Graham Pl		X		x
5603 Fen Oak Dr			X	X

Table 1 Shown are our recommendations for types of UA projects that municipal lands can support. No recommendations are provided for Jacobson. A bold X represents highly recommended projects.

Two sites were limited to drive-by assessment – Yahara Hills (land held crops that were not harvested until after the ground was frozen) and High Point Road (insufficient area suitable for gardening). Yahara Hills ground-truthing was limited to drive-by assessment due to the inaccessibility of lands from being in production of crops at the time of surveying. Web-analysis of High Point led to the drive-by ground-truthing. No recommendations were given to High Point location. After web investigation and drive-by assessment, it was determined that this site is narrow and has a very steep (>12%) slope, unsuitable for any type of urban agriculture. In addition, soil sampling was not done at Jacobson Avenue during ground-truthing; this was determined by web analysis. Jacobson’s web analysis found that the land had changed significantly over time with high association to soil disturbance, such as clearing of infrastructures and the construction of a nearby highway. Given Jacobson’s land use history and proximity to transportation corridors (railway and highway) we are not recommending gardening in extant soil due to the likelihood of contamination. Production on this property was suggested to be in raised beds or over imported soils and barriers such as landscape fabric.

These recommendations have not been considered by the City of Madison as of spring 2026. These are purely suggested recommendations based on evidence collected by investigative team at UW. Sites with more than one recommendation are not suggested simultaneously but provide options of adoption. These recommendations provide information only about agricultural potential and are primarily based on the three forms of evidence collected. Initiatives to use these properties will involve collaboration and support from community and partnerships with public and private entities further discussed in Chapter 2 of this paper.

Soil Bulk Density and Organic Matter Content

Table 2 below shows the results of bulk density and percent organic matter content analysis. Bulk density for all sites was between 1.1-1.4 g/cm³. None of the sites showed signs of compaction. Ranges that illustrate “normal” soil structure is between 1.0-1.4 g/cm³. Ranges higher than this threshold can indicate compaction that could restrict root growth and reduce water holding capacity (Minnesota Pollution Control Agency, 2021). These threshold values can vary from soil types, but all analyzed soils from sites were confirmed to be a silt loam and well drained. At sites like Reindahl, a bulk density sample was taken more than once to compare different sample locations on site due to curiosity upon visit (to understand anthropogenic influence or to confirm soil types). These values were averaged but raw data is available for individual sample locations. Bulk density samples were not taken at Yahara Hills, High Point, and Jacobson. This was due to the soil

being either unsuitable for UA use based on virtual assessment or the property being inaccessible during the time of sampling.

Additionally, sites did not show signs of depletion or excess in organic matter content. As soils for all sites ranged from 5-10% in organic matter content. Most Wisconsin soils contain about 1-6% organic matter. For crop production, reasonable values for organic matter are between 3-5%, but crop production itself can reduce organic matter content over time (Cooperband, 2002). No needed inputs are suggested; we are solely reporting the current values so producers can decide whether inputs are needed.

SITE Address	Bulk Density (g/cm³)	% Soil Organic Matter
924 Burr Oak Ln (Heifetz)	1.14	10.3
5810 Thrush Ln (Meadowood)	1.15	10.02
1818 Portage Rd (Reindahl)	1.15*	8.14*
115 N Eau Claire Ave (Rennebohm)	1.3	8.29
5323 Raywood Rd (Waunona)	1.16	8.29
109 N Thompson Rd	1.18	10.16
2710 Post Rd	1.4*	5.75*
7033 East Pass	1.2	7.55
3809 Hoepker Rd/ 3816 John Wall Dr	1.34	5.63
5204 Graham Pl	1.19	6.66
5603 Fen Oak Dr	1.37	5.8

*Table 2 Displayed are measured values for bulk density and % carbon found on sites. * Represents average measurements from multiple sample locations on site.*

Soil disturbances like excessive tillage, tree removal, or passing with machinery destroy soil organic matter and weaken the natural stability of soil aggregates, making them susceptible to erosion by water and wind. Making multiple trips across a site with heavy equipment and other disturbances also compact the soil. So during ground-truthing, notes on visual soil surface disturbance were taken. Based on ground-truthing observations, soil did not show signs of surface disturbance besides Hoepker/John Wall and Fen Oak sites. Web analysis of Hoepker/John Wall and Fen Oak sites showed a history of management change. Hoepker/John Wall had a recent conversion in 2024 from agricultural production to being fallow surrounded by business development. Ground-truthing observations showed signs of intensive tree and shrub removal. For Fen Oak, history showed a conversion from agricultural production in the mid-1990s to being staged for development in early 2000s. Since then, infrastructure has been removed and the area was left unmanaged and overgrown. A few unpaved machinery tracks extend through the property. Both properties seemed to be disturbed in previous eras, potentially contributing to their higher bulk density values and lower % organic matter.

Nitrogen and Phosphorous Concentrations

Below *Table 3* and *Table 4* illustrate results from nutrient and heavy metal analysis. Across all sites ammonium-nitrogen (NH₄-N) concentrations ranged from 1.1-4.9 ppm, nitrate-nitrogen (NO₃-N) concentrations ranged from 1.4-67.8 ppm, and phosphate-phosphorus (PO₄-P) concentrations ranged from 4.3-21.1 ppm. Ammonium concentrations are typically low in well-aerated soils because they are rapidly converted to nitrate through nitrification but may accumulate under cold or saturated soil conditions. In contrast, nitrate levels are highly variable and reflect current soil nitrogen availability rather than a stable “ideal” range. Nitrate concentrations exceeding approximately 50 ppm indicate excess nitrogen that is highly susceptible to leaching due to its mobility in soil water. Soil test phosphorus levels between 20 and 50 ppm (Bray P-1) are generally considered optimal for plant growth, while concentrations above 100 ppm are considered very high and increase the risk of nutrient loss, primarily through surface runoff and erosion, potentially contributing to water quality degradation (University of Wisconsin–Madison Division of Extension, 2021).

SITE Address	Total Soil NH₄-N (ppm)	Total Soil NO₃-N (ppm)	Total PO₄-P (ppm)
924 Burr Oak Ln (Heifetz)	1.5	27.9	4.3
7033 East Pass	1.4	15.7	5.1
5603 Fen Oak Dr	2.0	22.2	13.5
5204 Graham Pl	1.5	5.9	5.0
3809 Hoepker Rd/ 3816 John Wall Dr	4.9	1.4	16.2
115 N Eau Claire Ave (Rennebohm)	1.7	60.8	21.1
1818 Portage Rd (Reindahl)	3.0	19.1	19.8
2710 Post Rd	1.1	10.6	5.9
5323 Raywood Rd (Waunona)	1.8	67.8	13.2
109 N Thompson Rd	2.0	10.0	4.8
5810 Thrush Ln (Meadowood)	2.1	43.0	5.2
829 W Washington Ave (Brittingham)	1.3	30.9	6.7

Table 3 Displayed are measured values of nitrogen (in the forms of ammonia and nitrate) and phosphorous (in the form of phosphate). Most sites had more than one sample location and those values were averaged.

Ammonium concentrations were consistent with expected low levels in well-aerated soils. Nitrate concentrations varied widely (1.4–67.8 ppm), indicating substantial differences in nitrogen availability among sites; lower values suggest limited plant-available nitrogen, whereas concentrations exceeding 50 ppm indicate excess nitrogen with a high potential for leaching. Phosphate concentrations generally fell within low to moderate levels relative to typical optimal ranges, suggesting that phosphorus may be

limited at some sites but does not pose a significant risk of loss. Most values for both N and P were averaged from more than one sample location on site. Overall, these results indicate variability. No recommendation to amend the soil for N or P was made. Typically, the addition of amendments for N will be based on crops and desired yield.

Elemental Concentrations in Urban Soils

SITE Address	S	Cl	K	Ca	Cr	Cu	Zn	Cd	Pb	U
924 Burr Oak Ln (Heifetz)	ND	ND	8737	4134	32	25	*125	42	37	ND
7033 East Pass	ND	ND	8584	6699	28	19	51	ND	14	ND
5603 Fen Oak Dr	ND	ND	6806	*13508	20	15	46	29	16	ND
5204 Graham Pl	670	ND	8604	*9139	31	19	46	30	17	ND
3809 Hoepker Rd/ 3816 John Wall Dr	ND	ND	8373	1858	27	16	50	ND	18	ND
115 N Eau Claire Ave (Rennebohm)	ND	ND	8251	*6266	21	18	51	32	18	Nd
1818 Portage Rd (Reindahl)	ND	ND	8993	3424	33	16	57	ND	21	10
2710 Post Rd	10276	272	8988	*11304	21	17	40	ND	16	ND
5323 Raywood Rd (Waunona)	1017	ND	8542	4844	25	21	65	ND	30	11
109 N Thompson Rd	ND	ND	7249	3613	25	17	59	ND	17	ND
5810 Thrush Ln (Meadowood)	ND	ND	8002	2240	34	23	64	ND	21	ND
829 W Washington Ave (Brittingham)	1544	ND	7945	*15468	17	20	50	ND	21	ND

*Table 4 Shown are values from soil analysis of heavy metal content from municipal sites. Most sites had multiple composite samples that were taken, so values are averaged. ND means "not detected." * Represent values that contain outliers.*

Measured values must be compared to Wisconsin soil performance and residual contaminant levels, established under NR 700/720, in order to determine whether observed soil concentrations for heavy metals pose a regulatory concern. If soils exceed these values, state regulations would require management or remedial action (Wisconsin Department of Natural Resources, n.d.). No sites surpassed the Wisconsin NR 700/720 remediation level, according to our findings. (These values were averaged but raw data is available for individual sample locations.)

Elemental concentrations varied across sampling locations between major nutrients and trace elements. Potassium concentrations were consistently high and relatively uniform, ranging from approximately 7,200 to 9,600 ppm, which is consistent with Wisconsin soils frequently displaying stable potassium levels (University of Wisconsin–

Madison Division of Extension, 2021). In contrast, calcium (Ca) showed significant variability, with most values between ~1,000 and 11,000 ppm, but several outliers exceeding 15,000 to 29,000 ppm at Fen Oak Dr, Post Road, and W Washington sites (University of Wisconsin–Madison Division of Extension, 2021).

Sulfur (S) and chlorine (Cl) were largely undetected across most samples, but isolated spikes, including elevated sulfur and chlorine concentrations at Post Road and several W Washington samples suggest site-specific inputs, possibly from anthropogenic sources or localized fertilization regimes. Such variability in sulfur and chlorine is typical in urban or agricultural soils where inputs vary spatially (Kabata-Pendias, 2011).

Trace metals including chromium (Cr), copper (Cu), and zinc (Zn) occurred at relatively low concentrations with moderate variability across sites. The notable zinc spike (208 ppm) at Burr Oak Lane indicates localized accumulation, which may result from historical anthropogenic activity or natural soil heterogeneity (Kabata-Pendias, 2011). Cadmium (Cd) was mostly undetected but appeared intermittently at low concentrations (~29–42 ppm), consistent with background levels or minor contamination in Wisconsin soils, while lead (Pb) was consistently present at low levels across most sites, reflecting widespread low-level deposition commonly found in urban and suburban soils due to historical leaded gasoline and paint usage (University of Wisconsin–Madison Division of Extension, 2021; US EPA, 2022). Uranium (U) was almost entirely absent, with only a few low-level detections, in line with typical crustal abundance and limited anthropogenic input (Kabata-Pendias, 2011).

Major nutrients (K and Ca) dominate the soil elemental composition, with calcium exhibiting the greatest variability. Trace metals generally occurred at low concentrations with occasional localized elevations, suggesting limited widespread contamination but some isolated occurrences. These findings are consistent with Wisconsin NR 700/720 soil standards that recognize variable natural background levels while identifying potential hotspots requiring monitoring or management (Wisconsin Department of Natural Resources, 2024).

Lastly, composite samples for nutrient and heavy metal content were not taken at Yahara Hills, High Point, and Jacobson due to the soil being either unsuitable for UA use based on virtual assessment or the property being inaccessible during the time of sampling.

Summary of Land Evaluation for Urban Agricultural Use

The aim of this chapter was to detail the methodological approach used to assess the physical and biophysical suitability of municipally owned properties and to present

findings with particular emphasis on soil quality and heavy metal concentrations. To assess the potential of UA use on the City of Madison sites, we screened the soils in these sites for physical, chemical, and biological indicators of soil quality such as nutrient availability, bulk density, and organic matter content which allowed our investigators to make assumptions about the urban land's ability to support food production. Soil quality remains a foundation to understand a soil's influence on crop yield and ecosystem functionality but also can indicate the economic feasibility of UA through its impact to inputs and long-term land management.

The findings from our investigation indicate that, across the assessed municipally owned sites, lands generally exhibited suitable chemical and physical characteristics for UA, with some site-specific variability. After initial site identification using public records, such as land use history, topography, and soil survey, field visits allowed for the direct assessment of conditions not captured remotely. These visits documented current land use and evidence of past land use, like soil disturbances. Evaluations of solar exposure, vegetation cover, access to transportation, infrastructure access, parking, and irrigation were also noted and considered when making recommendations of UA on sites. Again noted, based on initial remote analysis properties Yahara Hills and High Point were not visited in person; therefore, no evidence was collected to confirm soils, and visual assessments were limited to drive-by. Additionally, Jacobson property was found by remote assessment to be likely contaminated so, recommendations were given only by considering the addition of raised beds or imported soils.

Nutrient analysis showed that potassium levels were consistently high and uniformly distributed across sites, while phosphorus concentrations were generally within low to moderate ranges, suggesting that some locations may require phosphorus inputs for optimal plant growth but do not pose a significant environmental risk. Nitrogen availability, particularly nitrate, varied widely among sites, with some areas exhibiting low concentrations and others exceeding typical ranges, suggesting a risk of leaching due to nitrate mobility in the soil. Ammonium concentrations remained low across sites, consistent with well-aerated soils where rapid nitrification occurs.

The results of the elemental analysis revealed that the concentrations of calcium varied considerably, with several sites exhibiting elevated levels. Apart from a few isolated spikes that suggested localized inputs, sulfur and chlorine remained mostly undetected. Trace metals, including chromium, copper, and zinc, were present at low concentrations with moderate variability and occasionally elevated values. Potential heavy metal contaminants such as cadmium and lead were detected at low or intermittent levels, and uranium was largely absent. Importantly, none of the observed concentrations exceeded

regulatory thresholds established under Wisconsin Department of Natural Resources NR 700/720 standards, indicating no immediate need for remediation.

Despite these generally favorable conditions, the observed heterogeneity in both nutrients and trace elements makes site-specific assessment essential. Even when concentrations are within regulatory limits, perceived and real risks can be influenced by the history of urban land use and spatial heterogeneity. This suggests that more extensive soil testing, continuous monitoring, and transparent communication are necessary.

In general, the evaluation suggests that many municipally owned parcels are suitable for UA from a soil quality perspective, though management practices may need to be tailored to individual site conditions. While sites with elevated heavy metal concentrations or uncertainty may benefit from mitigation techniques like raised beds or imported soil, places with nutrient lacking may need targeted fertilization. These findings aided our investigators in developing recommendations for the City of Madison, supporting informed decision-making regarding the use of these parcels for UA.

Although these recommendations are based on physical and biophysical fit, successful implementation will ultimately depend on broader socioeconomic factors, such as institutional support, community engagement, and resource availability. This integrated perspective reinforces that UA viability is not solely a function of soil conditions, but of the dynamic relationship between environmental quality, human health, and community investment.

This project led by the interest of the City of Madison to determine if municipal lands are suitable for UA use is ongoing. The City has asked for additional information that gives insights into the economic and community engagement aspects of UA feasibility. Chapter 2 of this paper will highlight plans for the future of this project in the realms of community investment.

Chapter 2: Assessing Development Potential for Urban Agriculture

Introduction

The City of Madison has shown a growing interest in using UA as a form of resistance to food insecurity, prompting a request for detailed information on whether city-owned lands can safely and effectively support food production. In response to this desire from the City, our team evaluated fifteen municipally owned parcels, assessing their physical and biophysical characteristics. This work resulted in a comprehensive report provided to the City, including site-specific recommendations for potential UA uses. While Chapter 1 established that many sites possess the necessary biophysical conditions, these findings represent only one dimension of feasibility. Chapter 2 builds on the findings of the previous analysis by examining the social, economic, and community dimensions of UA development. This chapter will emphasize that these sociological factors ultimately determine whether UA is a strategy to address food insecurity in Madison by detailing what food insecurity is, how UA can be used as a pathway to food security, what are the challenges to food security, and what are the next steps to UA development in Madison.

Understanding Food Insecurity

Food insecurity remains a persistent public health and social equity challenge in the United States, affecting millions of households each year. The United States Dept of Agriculture (USDA) estimates that 13.5% of Americans (over 44 million people) were food insecure in 2023. In Wisconsin, 10.7% of all households were food insecure in 2023 (U.S. Department of Agriculture, Economic Research Service, 2025). Focusing on Wisconsin, specifically Dane County, 1 in every 10 households experience food insecurity (Public Health Madison & Dane County, 2025). Food insecurity is defined by the USDA as a household-level economic and social condition of limited or uncertain access to adequate food (U.S. Department of Agriculture, Economic Research Service, 2025). Imagine coming home after a long day at work, you open your refrigerator and your options to eat are a bologna sandwich or sleep. For some this may be ideal, possibly because you love bologna and need a nap. But for others, this may scream a need to escape from Hell. The reality for some Americans is having to decide between the bare minimum or nothing at all, such as having to make the hard decision to go hungry or to have the lights on in their homes.

In addition, food insecurity disproportionately affects ethnic minorities and low-income individuals. According to national data from the USDA Economic Research Service, in 2021, nearly one in five households (19.8 percent) with Black, non-Hispanic reference persons were food insecure; 16.2 percent of households with Hispanic reference persons were food insecure; 10.2 percent of households with other, non-Hispanic reference

persons were food insecure; and 7.0 percent of households with white, non-Hispanic reference persons were food insecure (Hales & Coleman-Jensen, 2024). Income is recognized to be closely associated with food insecurity for all populations; the extent to which other socioeconomic factors explain the differences in food insecurity among different racial and ethnic groups continues to be examined. Even when Black and white households have equal levels of education, income, and homeownership, Black households still have a higher predicted probability of food insecurity compared with white households (Berning et al., 2022). This phenomenon can be attributed to historical and institutional marginalization of certain racial or ethnic groups.

There are many avenues to directly and indirectly address food insecurity in households. While increasing household income and reducing the cost of food would have the greatest impact on improving food security, these solutions are often constrained by broader economic and policy factors. As a result, communities have increasingly turned to UA as a food security and complementary public health strategy. UA has offered resilience capacity through food diversification at the household level, which further can be developed for the local and global food market in support of economic stability (Begum et al., 2011; Hashim et al., 2018). UA development can be seen not only as essential for the advancement of agricultural practices, but also as a socio-economic resolution. The capability and adaptability of UA practices can offer solutions to meet a basic human need - food access.

A Pathway Through Which Urban Agriculture Addresses Food Insecurity

UA has emerged as a supplemental strategy for addressing urban food insecurity by increasing local food production, strengthening distribution networks, and improving equitable access to fresh and nutritious foods. In Midwestern cities such as Madison, UA projects demonstrate how community-based food systems can support long-term food security while also fostering social and economic resilience. The nonprofit organization Rooted serves as an example of how UA can operate as both a food production system and a community development initiative. Formed in 2020 through the merger of Center for Resilient Cities and Community GroundWorks, Rooted manages Madison's community garden spaces while distributing thousands of pounds of produce to food pantries and neighborhood centers (Rooted, n.d.). Along with distributing food, Rooted organizes community activities that promote neighborhood gardening projects and collaborates with schools to offer hands-on agricultural education. Rooted exhibits how UA may support long-term food security and neighborhood resiliency by combining food production with education and community connections.

In other Midwestern cities, UA also contributes to local economic development by creating employment opportunities, workforce training programs, and pathways for small-scale entrepreneurship. Urban farms can support local economies through food cultivation and distribution, education, and market activities while providing employment opportunities for low-income residents (Nugent, 2000). Additional research indicates that UA can reduce household food costs and generate supplemental income through the sale of surplus produce (Wadumestrigie Dona et al., 2021).

To illustrate these claims, we look at Growing Power, a nonprofit organization in Milwaukee that gained national recognition for combining economic empowerment with food production. It operated on the only land zoned "farmland" inside the city boundaries, in a part of the city that is considered a low food access area. Growing Power expanded community engagement through job training and educational programming while producing and distributing fresh food to locals (Bybee, 2009). "The training, learning, and benefits of Growing Power will be felt for years to come," said Ricardo Salvador, director of the food and environment program at the Union of Concerned Scientists and a former program officer for the Kellogg Foundation. (Bybee, 2009; Satterfield, 2018).

Similarly, Urban Growers Collective (UGC) in Chicago runs several farm locations that distribute produce via community-supported agriculture (CSA) programs, farmers markets, and food access programs (Urban Growers Collective, n.d.). UGC promotes professional development by offering career pathways and paid training opportunities in the agricultural and environmental sectors, particularly with historically underrepresented communities (Urban Growers Collective, n.d.). These examples show how UA may address underlying causes of food insecurity such as low household income while improving long-term economic stability and community resilience by merging workforce development with locally produced food. By emphasizing the distribution of fresh produce to households facing food insecurity and lowering reliance on external food supply chains, UA can improve local food systems. UA contributes to household food security and economic resilience by improving access to affordable foods and supporting localized food networks (Nugent, 2000).

Beyond the production and distribution of food, UA also produces wider social and educational advantages that strengthen and empower communities. Community gardens and urban farms turn unutilized urban areas into communal spaces focused on food production, education, and intercultural exchange. These spaces provide opportunities for residents to build relationships, participate in collective decision-making, and strengthen neighborhood cohesion (Ilieva et al., 2022). Community-based gardening initiatives often encourage collaboration among diverse cultural, social, and age groups while promoting

civic participation and inclusion. In addition, urban agriculture creates valuable educational opportunities by teaching gardening, nutrition, environmental stewardship, and leadership skills to both youth and adults (Ilieva et al., 2022). Programs like those offered through Rooted and UGC illustrate how UA can foster community empowerment by combining food access initiatives with skill development and public engagement.

Limitations of Urban Agriculture as a Sole Solution

In the end, UA cannot be used as a stand-alone remedy for food insecurity. While UA improves local food access and creates opportunities for community engagement and economic development, its overall impact is constrained by greater systemic issues tied to poverty, job insecurity, rising housing costs, and unequal access to healthcare and transportation. Increasing food production does not necessarily ensure that households possess the financial resources needed to consistently access healthy food. UA can supplement household diets and reduce some food expenses, broader income-based solutions such as living wages, affordable housing, and expanded social welfare programs remain necessary to address the systemic causes of food insecurity (Nugent, 2000). UA should be understood as “one of many means to an end rather than an end unto itself,” emphasizing that UA alone cannot resolve the structural inequities embedded within food systems (McClintock, 2014).

UA faces many limitations related to scale of production, land access, and long-term sustainability. Urban farms and community gardens typically operate on small plots and cannot produce enough food to meet the needs of entire populations. Expansion is constrained by limited land availability, zoning restrictions, soil contamination, and competition with urban development (Wadumestrigie Dona et al., 2021). UA often develops on vacant or underutilized land in economically declining neighborhoods, making it vulnerable to redevelopment as property values rise (McClintock, 2014). In this regard, UA functions best as a supplementary strategy to enhance local food networks and community resilience.

Economic sustainability is a significant challenge to UA addressing food insecurity for populations. Urban farmers often face difficulties securing funding, achieving economies of scale, and managing high capital and operating costs associated with land, infrastructure, water, labor, and equipment (Singer & Brumfield, 2017). These costs vary depending on the size and type of agricultural production as well as the location of production within urban areas. Despite these barriers, some producers are able to develop comparative advantages through strong community support, volunteer labor, direct consumer relationships, and collaboration with other urban producers and agricultural experts (Singer & Brumfield, 2017). Diversifying production strategies, such as

incorporating greenhouses or extending seasonal production, may also help increase financial stability and productivity. However, many UA initiatives remain heavily dependent on grants, donations, nonprofit partnerships, and volunteer labor to sustain operations, making long-term economic viability difficult to maintain. An example to follow is the collapse of Growing Power. Although Growing Power became internationally recognized, the organization dissolved in 2017 due to mounting debt. Reporting from Civil Eats, the organization struggled to sustain rapid expansion while balancing expensive educational programs and nonprofit operations (Satterfield, 2018). This example illustrates how even highly successful UA organizations may struggle to remain economically sustainable without long-term investment and stable public funding.

Government support can help address some of these economic limitations by providing financial assistance and technical resources for UA projects. Planning and implementation funding from the US Department of Agriculture, for example, assist eligible nonprofits, tribal governments, and school districts in their efforts to increase access to regional foods. Many UA projects are supported by these awards. These funding sources can increase UA projects' long-term viability, but they also show how many initiatives rely on outside money to stay in operation.

Participation in UA initiatives can also be uneven and inaccessible for all communities. Access to urban farms and community gardens often depends on a range of factors, including time, transportation, physical capabilities, land availability, and gardening expertise. Low-income community members who work multiple jobs might not be able to engage in gardening. Furthermore, renters and residents in densely developed neighborhoods may lack access to nearby green spaces. Academics also warn that some UA initiatives may unintentionally reinforce neoliberal ideas of individual responsibility by framing food insecurity as a problem solved through personal participation and self-sufficiency rather than collective structural change (McClintock, 2014). Additionally, urban greening projects associated with UA can contribute to processes of green gentrification, where environmental improvements increase neighborhood desirability and property values, potentially displacing lower-income residents (Ilieva et al., 2022). These disparities show that the advantages of UA are not always shared fairly and might reflect broader patterns of systemic inequality.

Despite these disadvantages, UA remains an essential part to more robust and equitable food systems. Its greatest strength is in complementing economic and food policies through localized food production and community empowerment. Therefore, more comprehensive structural reforms aimed at reducing poverty, increasing equitable access

to resources, and expanding affordable housing must be combined with UA measures to alleviate food insecurity.

Plans Forward in Madison

The long-term success of UA development depends on more than land biophysical suitability. It includes community-centered, economically sustainable planning. Therefore, the City of Madison's next course of action should be assessing how land controlled by the city might enable fair, accessible, and productive UA development. Two recent initiatives will contribute to this planning process – a survey by the City and an analysis by UW-Madison students.

In Fall 2025, the City of Madison conducted a Request for Interest (RFI) survey to identify local organizations, growers, nonprofits, and residents interested in participating in or managing future UA developments on municipally owned land. During the spring semester of 2026, undergraduate students in the UW–Madison Department of Agricultural & Applied Economics completed a capstone project that developed economic profiles for the 15 potential UA sites. The students evaluated startup and operational costs, projected food production, neighborhood need, and broader community impacts to assess the feasibility of UA development. These efforts provide the City with important insights into the most effective strategies for improving food access and addressing food insecurity in Madison.

The RFI survey conducted by the City of Madison's EDD showed strong community interest in UA development on municipal lands. The survey received 43 responses, 25 of which came from representatives of local organizations. The survey highlighted widespread interest in both community and market garden management. Respondents shared information on their experience with food production and marketing, also expressing the importance of UA development in Madison. Many participants expressed a desire for UA spaces that extend beyond food cultivation emphasizing the need for education and entrepreneurship opportunities and neighborhood gathering spaces. Some organizations were interested in managing gardens for their own programming needs, while others were interested in supporting broader community participation and individual producers.

The capstone project found that UA could serve as a viable strategy for reducing food insecurity when paired with economic planning and community-focused implementation. Through detailed cost analyses, production estimates, and demographic research, the project identified the most feasible and impactful sites for future development. Brittingham Park, Heifetz Park, Meadowood Park, and Rennebohm Park emerged as the highest-priority locations for community garden expansion, while Yahara

Hills showed the greatest potential for market farming and Reindahl Park ranked highest for permaculture development. The results indicated that, in contrast to permaculture systems (which need longer establishment times before reaching full productivity), community gardens and market farming offer the best prospects for immediate improvements in food access because they have lower implementation barriers, predictable costs, and greater short-term production potential.

Discussion

As a next step, the City of Madison could consider organizing a series of targeted focus group meetings informed by both the RFI survey results and the capstone project findings. These meetings could bring together community organization leaders, individual growers, residents, and City officials to further explore interest in leasing and managing specific sites. Focus groups could be organized by site location or type of UA development. Additional meetings could focus on the highest-priority sites identified through the capstone project to better understand community preferences, operational capacity, and potential partnership opportunities. These discussions would allow the City to gather more detailed feedback regarding desired land uses, management structures, funding needs, accessibility concerns, and long-term visions for UA in Madison. The City could also engage in direct discussion with local non-profit organizations already working in food security such as Rooted, REAP, Urban Triage, Madison Food Pantry Gardens, and Second Harvest Food Bank.

Additionally, the City could consider selecting one high-priority site as a pilot or case study project to demonstrate the potential success of UA development when guided by community needs. Developing a single site initially would allow the City and its partners to test different management models, evaluate community participation, measure food production and food access impacts, and identify operational challenges before expanding efforts citywide. A pilot project could also serve as a visible example of how UA can support neighborhood wellness, education, entrepreneurship, and community engagement alongside food production. Lessons learned from a case study could then inform future development strategies, funding approaches, and partnership structures for additional sites across Madison.

Conclusion

In conclusion, this paper highlights that many of the evaluated municipally owned lands in Madison possess the physical and biophysical characteristics necessary to support UA development while additionally discussing the broader social and economic considerations required for long-term success. The soil evaluations and land assessments

conducted by the UW–Madison investigative team suggest that several sites could feasibly support UA projects with appropriate management strategies. At the same time, the broader discussion of food insecurity emphasizes that UA alone cannot solve the structural causes of unequal food access but is best as one component of a larger community food systems strategy. The findings from the City’s RFI survey and the UW–Madison capstone project shines light on strong community interest in UA and provide important insights into the economic feasibility, neighborhood impacts, and operational possibilities for future development. These efforts illustrate that successful UA development must be rooted not only in land suitability, but also in community priorities, economic sustainability, equitable access, and long-term institutional support.

Moving forward, the City of Madison has an opportunity to build upon this foundation through continued collaboration with residents, nonprofit organizations, and growers. Organizing targeted focus group discussions based on the RFI survey and capstone findings would allow the City to better understand which entities are interested in leasing and managing land, what forms of UA best align with neighborhood needs, and how these spaces can serve broader goals related to food access, education, entrepreneurship, and community wellness. Additionally, establishing one high-priority site as a pilot or case study project would provide an opportunity to evaluate how UA functions in practice when guided by community-centered planning. Such a project could serve as a model for future expansion by identifying successful management approaches, partnership structures, funding needs, and measurable impacts on food access and community engagement. But ultimately, the final decision for UA development will require ongoing collaboration with the people most impacted and the power wielders that can structurally change systems.

References

- Arshad, M. A., Lowery, B., & Grossman, B. (1997). Physical tests for monitoring soil quality. In J. W. Doran & A. J. Jones (Eds.), *Methods for assessing soil quality* (pp. 123–141). Soil Science Society of America. <https://doi.org/10.2136/sssaspecpub49.c7>
- Begum, R. A., Siwar, C., Abidin, R. D. Z. R. Z., & Pereira, J. J. (2011). Vulnerability of climate change and hardcore poverty in Malaysia. *Journal of Environmental Science and Technology*, 4(2), 112–117. <https://doi.org/10.3923/jest.2011.112.117>
- Berning, J., Bonanno, A., & Cleary, R. (2022). Disparities in food insecurity among Black and White households: An analysis by age cohort, poverty, education, and home ownership. *Applied Economic Perspectives and Policy*, 44(4), 1962–1982. <https://doi.org/10.1002/aepp.13220>
- Bybee, R. (2009, July 16). Growing Power in an urban food desert. The Cornucopia Institute.
- Cooperband, L. (2002). Building soil organic matter with organic amendments. Center for Integrated Agricultural Systems, University of Wisconsin–Madison.
- Eanes, F., & Ventura, S. J. (2015). Inventorying land availability and suitability for community gardens in Madison, Wisconsin. *Cities and the Environment (CATE)*, 8(2), 2.
- Garcia, J., Mondragon-Becerra, M., Martinez, I., Nocco, M., & Lazcano, C. (2024). Organic amendments alter urban soil microbiomes and improve crop quality. *Applied Soil Ecology*, 204, 105731. <https://doi.org/10.1016/j.apsoil.2024.105731>
- Hales, L. J., & Coleman-Jensen, A. (2024). Household food insecurity across race and ethnicity in the United States, 2016–21 (Economic Information Bulletin No. 269). U.S. Department of Agriculture, Economic Research Service. https://ers.usda.gov/sites/default/files/_laserfiche/publications/108905/EIB-269.pdf
- Hashim, N. H., Mohd Hussain, N. H., & Ismail, A. (2018). The rise of rooftop urban farming at George Town, Penang. *Environment-Behaviour Proceedings Journal*, 3(7), 351–355. <https://doi.org/10.21834/e-bpj.v3i7.1242>
- Ilieva, R. T., et al. (2022). The socio-cultural benefits of urban agriculture: A review of the literature. *Land*, 11(5), 622. <https://doi.org/10.3390/land11050622>
- Johnston, J. (2005). Assessing soil fertility: The importance of soil analysis and its interpretation. Potash Development Association.

- Kabata-Pendias, A. (2011). Trace elements in soils and plants (4th ed.). CRC Press.
- Krikser, T., Zasada, I., & Piore, A. (2019). Socio-economic viability of urban agriculture—A comparative analysis of success factors in Germany. *Sustainability*, 11(7), 1999. <https://doi.org/10.3390/su11071999>
- McClintock, N. (2014). Radical, reformist, and garden-variety neoliberal: Coming to terms with urban agriculture's contradictions. *Local Environment*, 19(2), 147–171. <https://doi.org/10.1080/13549839.2012.752797>
- Minnesota Pollution Control Agency. (2021, June 29). Soil health indicator sheet: Soil compaction (bulk density). https://stormwater.pca.state.mn.us/soil_health_indicator_sheet_soil_compaction_bulk_density
- Nugent, R. (2000). The impact of urban agriculture on the household and local economies. In N. Bakker, M. Dubbeling, S. Guendel, U. Sabel-Koschella, & H. de Zeeuw (Eds.), *Growing cities, growing food: Urban agriculture on the policy agenda*. Deutsche Stiftung für Internationale Entwicklung (DSE).
- Public Health Madison & Dane County. (2025). Food insecurity in Dane County. https://publichealthmdc.com/documents/food_insecurity_dane_county.pdf
- Rooted. (n.d.). About Rooted. <https://rootedwi.org/about-us/about-rooted/>
- Satterfield, S. (2018, March 13). Behind the rise and fall of Growing Power. *Civil Eats*. <https://civileats.com/2018/03/13/behind-the-rise-and-fall-of-growing-power/>
- Singer, C., & Brumfield, R. G. (2017). An economic analysis of urban agriculture. *International Journal of Agricultural Science*, 2(1), 42–45. <https://doi.org/10.14546/ijas.2017.02.001>
- University of Wisconsin–Madison Division of Extension. (2021). SoilWise nutrient guide. <https://door.extension.wisc.edu/files/2021/09/SoilWise-Nutrient-Guide.pdf>
- Urban Growers Collective. (n.d.). Our story. <https://www.urbangrowerscollective.org/our-story>
- U.S. Department of Agriculture, Economic Research Service. (2025, January 8). Food security in the United States. <https://www.ers.usda.gov/topics/food-nutrition-assistance/food-security-in-the-us>
- U.S. Environmental Protection Agency. (2022). Lead in soil: A guide for health professionals. <https://www.epa.gov/lead/lead-soil-guide-health-professionals>

Wadumestrige Dona, C. G., Mohan, G., & Fukushi, K. (2021). Promoting urban agriculture and its opportunities and challenges—A global review. *Sustainability*, 13(17), 9609. <https://doi.org/10.3390/su13179609>

Wisconsin Department of Natural Resources. (n.d.). Contaminated soil and sediment. <https://dnr.wisconsin.gov/topic/Brownfields/soil.html>

Wisconsin Department of Natural Resources. (2024). NR 700/720: Soil cleanup standards and residual contaminant levels. https://docs.legis.wisconsin.gov/code/admin_code/nr/700/720

Wong, R., Gable, L., & Rivera-Núñez, Z. (2018). Perceived benefits of participation and risks of soil contamination in St. Louis urban community gardens. *Journal of Community Health*, 43(3), 604–610.