Title: Urban Agriculture: Equity, Sustainability, and Community Development

Issues and Justification:

Urban agriculture has the potential to contribute solutions to multiple contemporary issues, including food security, sustainable development, and climate change mitigation. The Northeast United States is an excellent region to serve as a research testbed to examine the dimensions of urban agriculture and the potential that urban agriculture poses. The region is a microcosm of urban agricultural issues found across the country: dense population, small land area, large cities, and diverse peoples. Further, the Northeast has a significant concentration of Land-grant Universities and Experiment Stations. Institutional proximity (to each other and to urban areas) constitutes a powerful, accessible intellectual framework. Leveraging the research capabilities and outreach expertise of the regional Land-grant Universities and Experiment Stations is a powerful approach to addressing the challenges of urban agriculture.

While the challenges faced by urban agriculture in the Northeast are multidimensional, they are not intractable. The challenges include: equality and equity surrounding information access and understanding on the part of growers, access to growing space (ownership of space and long-term use), soil suitability, natural resource management, economic viability, agricultural sustainability, and access to growing resources. We propose to examine these challenges, and in doing so, lead research efforts that seek to expand urban agriculture and explore strategies to increase community engagement, promote equitable development of urban agriculture sites, ensure food sovereignty, and provide sustainability of urban agrifood systems.

Our project has four objectives dedicated to: examining how the regulatory environment impacts urban ag; assessing the natural resource inputs for urban ag; identifying the challenges and opportunities for urban ag, farm to table; and determining the human impact of urban ag on community diversity, equity, inclusion, and One Health. The overarching goal of this multistate project is to **assess impact and improve outcomes of urban ag on environmental quality, socioeconomic vitality, food security, and community resilience, and equity**.

Related Current and Previous Work:

Introduction

Urban agriculture provides a wide range of ecosystem services on a variety of spatial and temporal scales. Depending on the design of the green space these ecosystem services can include stormwater management (Almaaitah and Joksimovic, 2022; Fassman-Beck et al, 2013; Gong et al., 2019; Karczmarczyk et al., 2000; Rowe, 2011; Whittinghill et al., 2014a), reduction of the urban heat island effect (UHI) (Jadaa et al., 2019; Saadatian et al., 2013), increased biodiversity and habitat (Baumann, 2006; Benvenitu, 2024; Cook-Patton and Bauerle, 2012; Tonietto et al., 2011; Madre et al., 2013), reduced noise and air pollution (Speak et al., 2012; Van Renterghem and Botteldooren, 2011; Yang and Gong, 2008), and carbon sequestration (Getter et al., 2009; Whittinghill et al., 2014b))

Urban agriculture has been studied from a variety of perspectives, particularly through social lenses pertaining to:

- food access (Metcalf and Widener, 2011; Saha and Eckelman, 2017);
- fresh produce intake (Alaimo et al 2008, McCormack et 2010);
- food justice (Alkon, 2014; Billings and Cabbil, 2011; Horst et al, 2017; Myers and Sbicca, 2015 ; Ramírez, 2015; White, 2011);
- food sovereignty (Jarosz, 2014),
- health benefits (McCormack, 2010; Clatworthy et al, 2013; Kingsley, 2009; Subica, 2015; Van Den Berg and Custers, 2011); and
- politics of land development and access to land (Lindemann, 2022)

• community wellbeing (Hung, 2004; Kingsley et al, 2006; Okvat and Zautra, 2011; Saldivar-Tanaka and Krasny, 2004; Teig, et al 2009).

While research on the horticultural aspects of urban agriculture is growing, and current agronomic knowledge is applicable, urban agriculture specific research is still limited when compared to rural or truckcrop type agricultural production. This especially applies to forms of urban agriculture that do not integrate well with large-scale mechanized farming or emerging forms of urban agriculture, such as the use of green roof technology to produce food.

Soils

These above areas of research have produced a significant body of work examining the possibilities and challenges of urban agriculture, but research on urban soils is not as abundant. Research examining soil quality in urban spaces investigates the effects on biodiversity and ecosystem services (Lin et al, 2015), the significance in terms of reclaiming vacant land (Beniston and Lal, 2012; Carlet et al, 2017; Kremer et al, 2013), sustainable land use planning (Lovell, 2010), and the potential to exist as novel agroecosystems (Pearson et al 2010; Egerer et al, 2018). The most common attention given to urban soils, however, pertains to the presence of ongoing and legacy inorganic and organic contaminants such as a lead and other heavy metals (Brown et al, 2016; Kessler, 2013; Marquez-Bravo et al, 2016; McBride et al, 2014; Mielke et al, 1983; Mitchell et al, 2014; Sipter et al, 2008; Spliethoff et al, 2016).

While understanding potential contaminant sources and fluxes in urban agriculture is an important issue, these areas of inquiry are often conducted without consideration of other soil biological, chemical, and physical properties, and rarely consider the soil parent materials therein. Though there may be cases in which urban farmers are growing in soils formed from native, undisturbed soil, most urban farmers deliberately avoid such practices in order to mitigate potential contaminant exposure. As such, most urban agriculturalists grow in soil mixtures that they have constructed over time and are therefore generating a wide range of previously unclassified constructed soils (called Technosols in the World Reference Base for Soils (IUSS, 2022). Research in NYC demonstrates that community growing spaces are less contaminated than home gardens or yards (Cheng et al, 2015). If contaminants are present in soil, it is often physically and logistically challenging to remove or extract them without removing the entire substrate, which may also be quite costly (Mielke, 2015). Additionally, given that urban agriculture is a form of agriculture that is often highly motivated by a social or community-based vision, research on urban soils has not often integrated attention to socio-ecological relationships to the soil, or soil relationality, in understanding how urban farmers relate to and understand their interactions with the soil (Krzywoszynska, 2019; Krzywoszynska and Marchesi, 2020).

Nutrient Leaching

Efficient nutrient and irrigation management are two of the horticultural issues that need to be addressed in urban agriculture. Under application of nutrients or irrigation water can lead to plant stress, increases in pest and disease pressure, a reduction in crop quality, and yield losses. Overapplication of nutrients and irrigation water can lead to nutrient leaching, a known issue in agricultural settings. This is of particular concern in urban areas because of the higher percentage of impermeable surfaces and the impact that stormwater runoff can have in exacerbating nutrient leaching into urban watersheds. Overapplication of irrigation can also lead to plant health and soil quality issues that also impact yield. A growing number of research studies demonstrate the inefficient use of nutrients in urban agriculture, which is sometimes linked with observable increases in soil nutrient content or runoff water measurements or records of fertilizer applications and crop yields (Abdulkdir et al, 2013; Arrobas et al, 2017; Cameira et al, 2014; Dewaelheyns et al, 2013; Huang et al, 2006; Salomon et al, 2020; Small et al, 2019; Weilemaker et al, 2019; Witzling et al, 2011). Fewer studies have examined the issue of irrigation water use in urban agriculture. Numerous barriers to efficient nutrient and irrigation management exist for urban growers, which could be addressed through a combination of research and extension efforts.

Several of these barriers relate to the ability of small-scale urban farmers to access and interpret soil test results and use nutrient recommendations. Soil testing is uncommon in urban agriculture (D. Medina, personal communication, November 3, 2021; Small et al, 2019; Whittinghill and Sarr, 2021; Witzling et al, 2011). There may be a variety of reasons for this including uncertainty about how to collect samples, where to obtain testing, and what tests should be requested. Without soil test results, the use of nutrient recommendations may be difficult as most for phosphorus and potassium, including those available for New England, recommend application rates based on soil test results for those nutrients (Sideman et al., 2023). Even if soil tests have been performed, nutrient recommendations are commonly given in pounds of nutrient per acre for a single crop or crop group (e.g., Sideman et al., 2023) while urban farms grow a high diversity of crops in a small area (McDougall et al, 2019; Salomon et al, 2020; Wielemaker et al, 2019). Converting the pounds per acre measurements down to the smaller scale, in square feet or feet of row, can be a challenge, especially for beginning farmers, and these farms have a greater tendency to over apply nutrients (Wielemaker et al, 2019). Nutrient recommendations are also easier to follow when farmers use commercial or synthetic fertilizers with clear nutrient analyses and release times. Urban growers tend to prefer the use of compost (Cameira et al, 2014; Dewaelheyns et al, 2013; Small et al, 2019; Wielemaker et al, 2019), which have lower fertilizer nutrient equivalencies (Maltris-Landry et al, 2016; Mikkelsen and Hartz, 2008; Wielemaker et al, 2019), and release nitrogen depending on variable climatic and soil factors affecting mineralization, which makes following nutrient recommendations using compost much more complicated.

Considering these issues, a need has been expressed for research to better understand the nutrient management practices may affect nutrient export (Cameira et al, 2014; Dewaelheyns et al, 2013; Huang et al, 2006; McDougall et al, 2019; Shrestha et al, 2020; Wielemaker et al, 2019; Witzling et al, 2011). Urban farm irrigation practices may further influence nutrient export from urban agriculture, and as with nutrient management, record keeping for irrigation is generally non-existent or incomplete (Small et al, 2019; Whittinghill et al, 2016; Whittinghill and Sarr; 2021; Wielemaker et. al, 2019). Although annual precipitation is expected to increase in the Eastern United States, this increase may not take place during the growing seasons (USGCRP, 2018), thus, implementation of efficient irrigation management will become more important under a changing climate. This coupled with increases in temperatures, consecutive dry days, and water costs, stresses the importance of irrigation management for urban growers.

Alternative Growing Methods for Urban Agriculture

A lack of land area for production in urban centers is one of the major barriers to urban agriculture. This has resulted in numerous production methods that make use of space in and on buildings. The use of container gardens, vertical gardens, and green roof technology to produce food on rooftops is not a new concept but is growing in practice in modern urban agriculture (Appolloni et al, 2021; Buehler and Junge, 2016). Green roof technology makes use of light weight growing media and other layers such as filter fabric, water retention fabric and drainage layers, to enable plant growth on rooftops while minimizing added weight to the underlying building structure (Whittinghill and Rowe, 2012). Modern green roofs offer many of the same ecosystem services as urban green space, many of which are well studies including stormwater retention and quality improvement (Almaaitah and Joksimovic, 2022; Fassman-Beck et al, 2013; Karczmarczyk et al, 2020; Rowe, 2011), noise and air pollution reduction (Rowe, 2011; Van Renterghem and Botteldoren, 2011; Yang et al, 2008), mitigation of the urban heat island and energy savings to the underlying building (Jadaa et al, 2019; Saadatian et al, 2013), and increased biodiversity and habitat (Baumann 2006; Benvenuti, 2014; Colla et al 2009; Cook-Patton and Bauerle, 2012; Madre et al 2013; Tonietto et al, 2011) . The extent to which green roofs provide these ecosystem services depends on a variety of factors including media depth and composition, water holding capacity, and the plant community that it supports.

Ornamental green roofs installed on existing buildings are shallow with a limited plant pallet (typically mixes of sedum species) because of roof-load restrictions (Dvorak and Volder, 2010). These green roofs are often designed to require little maintenance after the plant community is established and are often composed of drought resistant plants with limited nutrient requirements. Switching from these ornamental plant communities to an agricultural crop system requires changes in management. First, green roof media is designed to hold water but drain quicky, and even deeper media depths are recommended for ornamental herbaceous perennials and crop plants. Regardless of media depth, if deeper media is possible, crop plants will likely require the use of irrigation. The use of irrigation on a green roof changes its capacity to retain stormwater (Almaaitah and Joksimovic, 2022; Harada et al, 2018a; Harada et al, 2020; Whittinghill et al, 2014a; Whittinghill et al, 2015). The few studies that have examined this issue have found that agricultural green roofs retain less storm water than their ornamental counterparts. This can be linked to reduced media dry down between storms because of irrigation and therefore lowered capacity to hold water in following storms, with cropping cycles, and with media composition. Second, greater nutrient inputs will be required for the rooftop to support crop plant growth and production. This can be supplied in the form of fertilizers, composts, and other amendments (Grard et al, 2015; Harada et al, 2018a; Whittinghill et al, 2016). Currently, there are no nutrient application recommendations for growing crops in green roof media, so recommendations for soil-based agriculture are likely used. Green roof media does, however, differ from agricultural soils in several ways, including having a low cation exchange capacity (Whittinghill et al, 2016). This suggests that nutrient applications may need to differ from typical agriculture. The use of fertilizers and composts has been examined in ornamental green roofs, and both are linked with increased nutrient leaching (Buffam et al, 2016; Clark and Zheng, 2013, 2014; Czemiel Berndtsson, 2010; Hathaway et al, 2008; Ntoulas et al, 2015; Rowe, 2011). There are many fewer studies examining the effects of nutrient applications to agricultural rooftops are fewer, demonstrate high nutrient leaching with some differences among nutrient sources for the extent to which they contribute to leaching (Elstien et al, 2008; Harada et al, 2017; Harada et al, 2018b; Harada et al, 2020; Kong et al, 2015; Matlock and Rowe, 2017; Whittinghill et al, 2015; Whittinghill et al, 2016; Whittinghill et al, 2024). Few of these studies examine nutrient cycling withing the green roof media or the potential dynamics that microbial communities or other media factors could play in nutrient leaching on agricultural green roofs (Harada et al, 2018b; Harada et al, 2020).

Few studies have examined the impacts of switching from ornamental to agricultural plant communities have on ecosystem services typically provided by green roofs beyond stormwater management. No studies have been found that examine air and noise pollution reduction by agricultural green roofs; although three monitored atmospheric deposition (Harada et al, 2018b; Harada et al, 2019; Tong et al, 2016). The first study (Harada et al, 2018b) focused on atmospheric deposition of nitrogen, the second (Harada et al, 2019) focused on heavy metal atmospheric deposition and media content. The third compared particulate matter on the roof to street level but did not make comparisons to a nearby conventional roof. Another study measured heavy metals in green roof media, and vegetables grown on that roof, but did not monitor atmospheric deposition (Grard et al, 2015). They did test the media three times a year over a two-year experiment but saw no changes over time. It is unclear how the results from any of these studies could be generalized to discuss the system's ability to reduce air pollution. Two studies have explored carbon sequestration (Begam et al, 2021; Whittinghill et al, 2014b). Of these, only the study by Whittinghill et al. (2014b) compared carbon sequestration on agricultural green roofs with ornamental green roofs. Three other studies investigated how green roofs can mitigate urban heat islands and reduce building energy use (Almaaitah and Joksimovic, 2022; Begum et al, 2021; Elstein et al, 2008). These observed that the growth stage of the vegetation affects the extent of cooling but that agricultural green roofs do provide a cooling

benefit when compared to a bare roof (Almaaitah and Joksimovic, 2022; Begum et al, 2021). One of those studies also identified differences in cooling among different crop plants (Almaaitah and Joksimovic, 2022).

Very little work has examined the impacts of agricultural green roofs on urban wildlife habitat and biodiversity, especially as compared to ornamental green roofs or ground level systems. More, but still limited work has been done on how the green roof environment affects agricultural production, including aspects like crop variety selection, yields, crop quality and food safety. In this work the focus has been predominantly on yield (Aloisio et al. , 2016; Buckley et al., 2022, Butts, 2017; Eksi et al., 2015; Eksi et al., 2016; Lacarne et al., 2021; Martini et al., 2017, Matlock and Rowe, 2017, Mower e tal., 2019, Olsezewski and Eisenman, 2017; Orsini et al., 2014; Oullette et al., 2013; Varela et al., 20221, Walters et al., 2022, Walters et al., 2023, Whittinghill et al., 2013; Whittinghill et al., 2016b; Whittinghill and Poudel 2020) and not crop quality (Ahmed et al., 2017; Eksi et al., 2015; Lacarne et al., 2021; Whittinghill et al. 2013; Whittinghill et al., 2016b) or food safety (Grard et al., 2015). However, only a few of these include comparisons with more traditional agricultural yields (Aloisio et al., 2016; Whittinghill et al., 2016b; Whittinghill and Poudel, 2020) or include ground level soil-based plots in the experiment for comparison (Eksi et al., 2015; Whittinghill et al., 2013; Whittinghill et al., 2016b; Whittinghill and Poudel, 2020), making it difficult to determine the effects of the green roof systems on crop production. This indicates a need for more research to develop best management practices for green roof crop production. Such practices would help optimize the tradeoffs between crop production and the provisioning of ecosystem services.

Urban Grower Changing Demographics

A national urban agriculture needs assessment was conducted by the National Center for Appropriate Technology (NCAT) in 2013 and received a total of 315 responses (Oberholtzer et al., 2016). The assessment found most urban farmers are generally younger (average 44 years) and have been farming for 10 years on average. This aligns with findings in a needs assessment conducted by the Cornell Vegetable Program in 2019 for urban growers in the City of Buffalo, where 14/15 (93%) of growers have been growing for 10 years or less. The USDA defines "beginning farmers" as those that have been farming for 10 years or less. These farmers are often targeted for special funding and research opportunities as it is likely they have less production experience, limited access to capital, and are less likely to be tied into service provider networks. Across the United States, only 908,274 producers (27%) have been farming for 10 years or less out of a total of 3,399,834 producers. (USDA 2017). In Buffalo, NY, not only are many urban farmers classified as "beginner" they are also predominantly located in USDA designated "food deserts", neighborhoods that are low-income and have limited access to healthy and affordable foods (Van Ploeg, 2011).

Oberholtzer et al. (2016) also found that 37.3% of growers farm on multiple production sites and approximately 71.3% of growers do not own land that was purchased. The bulk of respondents are either borrowing land through an informal agreement, are on a short term (year to year) lease, or a long-term lease. The lack of secure tenancy and number of production sites adds another layer of challenges for pest management in urban settings. Urban growers may be less likely to invest in long-term crop rotation plans, infrastructure, or IPM controls like developing beneficial habitat for natural enemies if they do not know how long they will have access to a property. When asked to rank production risks and challenges, managing pests and managing weeds ranked as the second and third most challenging below production costs.

Urban communities are more demographically diverse than rural areas and urban farms often strive to grow culturally relevant foods for their neighborhoods. This may mean growing crops that are not typical for that climate and very little may be known about managing pests or diseases of these new crops (Parket, 2018). Distinct from most rural agriculture, urban farmers are often nested within not-for-profits that prioritize social issues. (Anderson and Gonzalez, 2018).

Summary

Numerous sources offer evidence of social benefits of urban agriculture. The context of production methods and their risks and benefits reveals opportunities for further research on urban soils, green roofs, nutrient and irrigation management, and effective outreach methods to these audiences.

Objectives:

- 1. Investigate the regulatory, policy, and economic environment on the establishment and sustainability of urban agriculture enterprises.
	- a. Comment: This objective is dedicated to the examination of the impact of the regulatory environment which could include federal, state, municipal, financial, environmental, and other policies on urban agriculture. This objective also includes economic feasibility as it relates to access to financial resources.
- 2. Assess the availability, use, and sustainability of natural resources in urban agriculture.
	- Comment: This objective examines resource inputs associated with urban agriculture and the potential contributions of urban agriculture to biodiversity, climate change adaptation, and mitigation.
- 3. Identify and examine the challenges and opportunities for improving the equitable development and promotion of urban agri-food systems.
	- a. Comment: This objective focuses on urban agricultural endeavors, from farm to plate, and assesses the impact that urban agriculture has on agricultural sustainability and food security.
- 4. Identify and examine the factors that contribute to advancing human diversity, inclusion, and community engagement in urban agriculture.
	- a. Comment: This objective also examines issues of food sovereignty and promotion of One Health.

Methods:

Objective 1. Investigate the impact of the regulatory policy, and economic environment on the establishment and sustainability of urban agriculture initiatives.

We propose to comprehensively investigate the multifaceted impact of the regulatory environment on urban agriculture. This entails a thorough analysis of federal, state, municipal, financial, environmental, and other pertinent policies that shape the landscape of urban agriculture. Our focus will also explore the economic feasibility of urban agriculture, with a particular emphasis on the accessibility of financial resources for prospective urban farmers. By integrating a holistic approach, this research aims to provide a comprehensive understanding of the challenges and opportunities inherent in urban agriculture, with the ultimate goal of facilitating informed policy decisions and promoting sustainable urban agricultural practices.

Examples of studies to be undertaken include policy-oriented, community-based, or applied research projects that:

- Analyze urban zoning policy across different geographies, including assessment of zoning tools and implementation of such tools.
- Perform quantitative and/or qualitative analyses of scope of urban agriculture as it relates to different zoning or urban planning contexts.
- Assess how different zoning tools are used to promote or exclude urban agriculture; assessment of innovative zoning policies and/or tools (including different types of land banks).
- Map (including participant/resident mapping) of different urban land uses across cities.
- Interview focus groups, city planners, and other relevant officials (e.g., CDC staff, departments of sustainability or community development) about the tools they use to support urban ag and their perception of success of these tools.
- Investigate knowledge of or experience with local zoning ordinances, food policy, urban policy, or others that might present barriers to or opportunities for urban food production.
- Perform interviews with focus groups or individual participants related to knowledge, perspectives, and advocacy of participants in urban agriculture.
- Engage in qualitative and comparative analyses of key stakeholders (e.g., people, organizations, land banks, local officials, municipalities, counties, etc.) involved in creating and implementing land policy, as well as the extent of resident involvement in such endeavors.
- Analyze how urban producers access land in cities across the U.S. (e.g., private vs. public land, leased or purchased land).
- Undertake qualitative or mixed methods case studies (e.g., focus groups, surveys, semi-structured or structured interviews, policy review, archival methods, document analysis) focused on residents, and other key stakeholders, as well as past and present urban agriculture in a place. Analyze zoning records, land and deed transfer records.
- Assess the criteria groups/organizers/people use to select land for urban agriculture and how do they differ from recommended criteria.
- Perform quantitative assessment, mapping, of health indicators of community members in places (e.g., census defined places, census tracts) with differing percentages of urban land under agricultural production.
- Perform time lag regression or spatial analysis to investigate impacts of urban food production across time and space.

Objective 2. Assess the availability, use, and sustainability of natural resources in urban agriculture.

We propose to conduct a thorough examination of the reciprocal relationship between resource inputs and urban agriculture activities, with a specific emphasis on the potential contributions of urban agriculture to biodiversity, climate change adaptation, and mitigation. Our research will entail a comprehensive analysis of the diverse inputs available in urban areas, ranging from brownfields, waste streams, and urban infrastructure to local labor forces, and the potential roles these inputs have on shaping the dynamics of urban agriculture. Concurrently, we will investigate the impact of urban agriculture on biodiversity, climate change adaptation, and mitigation, considering factors such as green infrastructure, carbon sequestration, and the promotion of sustainable ecosystems. This multifaceted approach aims to shed light on the intricate interplay between urban settings and agriculture, with the ultimate goal of identifying strategies that enhance urban agriculture's role in fostering biodiversity, climate resilience, and mitigating the effects of climate change in urban environments.

Examples of studies to be undertaken include basic or applied research projects that:

- Analyze how urban farm irrigation and nutrient management practices impact plant stress and nutrient leaching.
- Evaluate instrumentation on urban farms that monitor water use, soil moisture at several depths, and local environmental conditions.
- Monitor water and nutrient losses from the root zone including the impact that changes in farm management practices have on nutrient leaching.
- Soil test for nutrient content.
- Create strategies for nutrient applications by farm management.
- Analyze nutrient budgets and create nutrient best management application recommendations.
- Monitor how soil health or compost use changes agronomic outcomes (e.g., soil moisture, nutrient leaching, and plant stress).
- Assess contamination in urban soils.
- Examine the development of XRF calibrations for local soils to test for heavy metal contamination
- Link to the effectiveness of heavy metal contamination mitigation measures on urban farms and assess the effectiveness of organic amendments, such as compost and biochar, on contaminant retention and immobilization in a time study.
- Evaluate the impact of heavy metal contamination on food safety from urban agriculture by developing portable XRF method on testing on plant and fruit tissues. On On
- Analyze the types of materials that are reused, recycled, or utilized as an input/advantage on urban farms or community gardens and quantify economic and environmental value of use of the materials.
- Consider grey water capture and storm water management as a means for irrigation.
- Examine the quality of municipal water for irrigation and its possible effects on soil properties.
- Assess the quality of locally sourced composts used by urban agriculture practitioners.
- Determine micro- and macro-plastic contamination in the urban environment.

Examples of approaches to be used to accomplish basic or applied research projects:

- On farm research or research in collaboration with urban farms and gardens involving:
	- o Soil sample collection

	o Leachate water sample Leachate water sample collection using lysimeters buried under productive areas
	- o Instrumentation for water use monitoring, soil moisture monitoring, ET and weather monitoring
		- Compost sample collection
	- o Collection of produce samples
	- In situ testing of soil and crop produce with XRF technology
- Controlled experiments on research farms involving using relevant urban agricultural production practices:
	- o Soil sample collection
	- o Leachate water sample collection using lysimeters buried under productive areas
	- Instrumentation for water use monitoring, soil moisture monitoring, ET and weather
	- monitoring
- Soil and compost testing including but not limited to:
	- Extraction and spectrographic analysis for nitrate, ammonia, and phosphate
	- o Acid digestion and analysis using ICP-OES or ICP-MS for mineral nutrients and heavy metals
	- XRF testing in laboratory conditions to assist in the validation of in situ test results
	- Leachate, municipal, and gray water analysis including but not limited to:
		- Volume measurements in the field
		- o pH and conductivity measurements
		- Spectrographic analysis for nitrate, ammonia, and phosphate
		- o Analysis using ICP-OES or ICP-MS for mineral nutrients and heavy metals.
- Produce analysis including but not limited to:
	- o Total and marketable yield measurements
	- Spectrographic analysis for nitrate
	- o Acid digestion and analysis using ICP-OES or ICP-MS for mineral nutrients and heavy metals
	- Plant stress indicators including but not limited to:
		- o Canopy temperature measurements by thermal imaging o Leaf water potential
			- o Leaf chlorophyll fluorescence
			- o Stomatal conductance
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Formatted Formatted Formatted Formatted *Objective 3*. Identify and examine the challenges and opportunities for improving the equitable development and promotion of urban agri-food systems.

The focus of this objective is to rigorously examine urban agricultural practices, processes, and endeavors along the entire supply chain, from farm to plate, and to evaluate the broader impacts of urban agriculture on urban agricultural sustainability and food security. Our research approach will encompass a comprehensive investigation into various facets of urban agricultural systems, including cultivation techniques, distribution networks, and consumption patterns, and the role of NGOs and/or communitybased organizations (CBOs) community residents in hyper-local agrifood systems. This analysis will enable an understanding of how urban agriculture affects not only the ecological and economic dimensions of urban food production but also its role in enhancing food security within urban areas. We will investigate the complex dynamics and potential synergies between urban agriculture and sustainable food systems, with an aim to provide valuable insights for urban planners, policymakers, and practitioners to foster resilient and secure food production in urban environments.

Examples of studies to be undertaken include basic or applied research projects that:

- Monitor plant stress indicators during the growing season and drought.
- Classify farm practices for comparisons between farms.
- Evaluate innovative agronomic strategies that are easily implemented and consider scale of implementation.
- Determine the extent the built environment can be and is being used to develop urban agriculture (e.g., rooftop urban agriculture).
- Evaluate vegetable production in open air, media-based rooftop systems and determine how such systems might provide environmental benefits by green roof agriculture.
- Determine how growing in green roof media affects crop management (e.g., irrigation, nutrient management recommendations, crop variety selection) and how growth in the rooftop environment affects plant yield and nutrient content.
- Assess the impact of nutrient management/compost additions to such roofs on nutrient leaching.
- Evaluate the opportunities and challenges of urban areas serving as heat sinks.
- Determine and categorize underutilized resources that urban farmers could incorporate into their operation that could have an economic or environmental benefit.
- Identify criteria for siting urban agricultural enterprises.
- Develop nutrient management recommendations that increase yields and crop nutrient quality.
- Develop or assess the impact and improve outcomes of urban agriculture on environmental and equitable socioeconomic sustainability.
- Examine and evaluate the landscape of NGOs or CBOs and their role in education or promotion of urban ag-related practices.
- Research with urban growers that identifies challenges and barriers in growing, access to markets,
- assessing market demand, and/or aggregating product for marketability.

Examples of approaches to be used to accomplish basic or applied research projects:

- On farm research or research in collaboration with urban farms and gardens involving: o Testing and monitoring methods as in objective 2
	- o Surveys of farm and garden practices

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- Controlled experiments on green roof experimental platforms that would be monitored for: o Media properties over time
	- o Leachate water volume and quality over time
	- o Crop yields, USDA quality standards, and nutrient content (using methods described in objective 2)

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- Soil and growing media testing as in objective 2
- Leachate water analysis as in objective 2
- Plant stress indicators as in objective 2

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Objective 4. Identify and examine the factors that contribute to human diversity, inclusion, and community engagement in urban agriculture.

We plan to identify and comprehensively examine the multifaceted factors that underpin human diversity, equity, inclusion, and community engagement within the urban agriculture domain. This research will provide a nuanced understanding of how urban agriculture not only addresses food security but also serves as a catalyst for fostering diversity, inclusivity, and community cohesion. This objective also includes consideration of food sovereignty and the promotion of One Health, the nexus between human and environmental health. Ultimately, we expect to offer valuable insights for policy development and implementation that can promote equitable and sustainable urban agricultural practices, thereby contributing to the broader well-being of urban populations.

Examples of studies to be undertaken include basic or applied research projects that:

- Directly utilize longitudinal, cross-sectional, causal, or correlational study design to inventory, survey, and analyze programs and projects involved in urban agriculture for DEI measures.
- Analyze spatial relationships between social determinants of health, presence of urban agriculture operations, resources (financial and otherwise) dedicated to such operations, location of other food retail infrastructure, and vacant land and/or green space availability for urban food production.
- Perform urban agriculture-focused primary and meta-analyses of participant and production data, engaging in action research, or executing experimental research related to measures of race and ethnicity, gender/gender identity and sexual orientation, socioeconomic composition, neurodiversity, and disability status.
- Undertake qualitative, quantitative, mixed method, interpretive research or ethnographies related to participants attitudes, beliefs, group dynamics, life experiences, sense of community, cultural norms, and talents of those engaged in urban agriculture projects and programs.
- Collect data, analyze, and interpret expressions of ideas, perspectives, and abilities of participants in urban agriculture.
- Employ case studies, focus groups, structured interviews, or implementation of methods in programs that are thought to elevate equity, activate diversity, lead with inclusivity, or promote relevant activities in socially, culturally, and economically disadvantaged populations.
- Implement and analyze informal and formal educational opportunities or mentorship/sponsorship outcomes related to urban agriculture and their effectiveness toward DEI goals, including career outcomes; educational matriculation, retention, and recruitment; and measurements of participant well-being.
- Map, inventory, and assess local and regional food supply chain engagement by participants of urban agriculture.
- Implement and analyze projects that promote community engagement or provide mutual aid in the context of regional food systems and agriculture-centered activities.
- Develop, implement, and analyze talent and culture practices, mentorship, or education strategies within urban agriculture, community food program development, or regional food system development, with special focus on outcomes.
- Identify and engage in professional development opportunities for DEI-focus participants.
- Prioritize accessibility of project research processes and educational outputs for diverse audiences by conducting language and preferred delivery assessment of translation services at cooperating urban farms. Language preference will be assessed via in-person interviews and

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written materials translated into appropriate languages and where possible contract interpreters for verbal research and education events.

Measurement of Progress and Results:

Project Outputs:

The multistate research team will **train undergraduate and graduate students** in qualitative research (e.g., conducting focus groups, qualitative data collection and analysis, participant observation, collaborative and engaged research methodologies analyzing focus group transcripts), quantitative research (e.g., data collection, data analysis), professional and scientific writing, and laboratory skills.

The multistate research team will **submit collaborative grant applications** to external funding agencies and organizations.

The multistate research team will **publish research findings** in refereed journal publications.

The multistate research team will **present research findings** at scientific meetings and other public presentation events.

The multistate research team will **work closely with colleagues in Extension to create and disseminate relevant findings** to stakeholders per the Outreach plan.

The multistate research team will **work closely with communications experts to craft compelling, accessible, and relevant messaging** to all constituencies.

Project Outcomes:

Clearly identify the regulatory, policy, and economic environment on the establishment and sustainability of urban agriculture enterprises.

Create models for economic feasibility of urban agricultural enterprises.

Identify the availability, use, and sustainability of natural resources in urban agriculture.

Improve the equitable development and promotion of urban agri-food systems.

Identify and examine the factors that contribute to advancing human diversity, inclusion, and community engagement in urban agriculture.

Outreach Plan:

This multistate research project focuses on the impact of urban agriculture on environmental quality, socioeconomic vitality, food security, community resilience, and equity. While there are many stakeholder groups to interact with, our Multistate project team is well positioned to provide broad dissemination of the results of this project. To that end, project participants include individuals with Extension appointments and station scientists closely linked to Cooperative Extension faculty, educators, and staff at their Landgrant university. Hence, research findings will be disseminated to urban farmers, agricultural businesses, urban stakeholders, decision makers, scientists, and other clientele through a variety of outreach strategies. The technical team also plans to seek input from all stakeholder groups to ensure that the research is meeting the needs of stakeholders. To move information in a two-way fashion, we expect to use the following strategies:

• **Traditional Extension Outputs:**

• Develop concise and informative fact sheets summarizing key research findings.

- Utilize Extension networks and channels to distribute fact sheets to urban farmers and stakeholders.
- Host informational workshops at urban and peri-urban Extension offices to engage directly with local communities.
- **Digital Tools and Platforms:**
	- Create user-friendly digital tools (e.g., decision making tools, interactive maps, etc.) to enhance accessibility to research outcomes.
	- Employ the project website on NIMSS to aggregate a list of resources generated by project participants.
	- Leverage social media platforms for regular updates and engagement.
- **Workshops and Field Days:**
	- Organize hands-on workshops and field days to provide practical insights and demonstrations.
	- Deploy Extension educators to coordinate regional events that cater to diverse urban agricultural communities.
- **Peer-Reviewed Publications:**
	- Produce peer-reviewed publications for professionals in the field.
	- Collaborate with academic journals and Extension publications to disseminate in-depth research findings.
- **Professional Conferences, Groups, and Organizations:**
	- Present research results at relevant national and regional professional conferences.
	- Foster partnerships with other multistate research projects, especially those with urban ag dimensions.
- **Reaching Underrepresented Communities:**
	- Develop tailored outreach materials addressing the specific needs and challenges of underrepresented communities.
	- Collaborate with community leaders and organizations to ensure effective communication and engagement.
- **Engage With Urban Agriculture Networks:**
	- Engage with existing urban agriculture networks and projects (e.g., NE2206: Green Stormwater Infrastructure and Agriculture.)
	- Attend and present at conferences focused on urban agriculture to expand the project's reach.
- **Recruitment and Participation:**
	- Implement inclusive recruitment strategies to ensure a diverse and representative participant pool.
	- Establish mentorship programs to support underrepresented participants throughout the project.
- **Stakeholder Interaction:**
	- Incorporate diversity, equity, and inclusion principles in all interactions with stakeholders.
	- Solicit feedback from diverse stakeholders to inform project direction and priorities.
- **Cultural Sensitivity:**
	- Ensure that all outreach materials and events are culturally sensitive and accessible.
	- Collaborate with community organizations to facilitate the dissemination of research in a manner that respects and aligns with diverse cultural perspectives.

Last, the Technical Team will implement feedback mechanisms, such as surveys and focus groups, to assess the effectiveness of outreach strategies and use feedback to adapt and refine outreach efforts throughout the project.

Organization/Governance:

The technical committee will organize itself by annually appointing an incoming secretary, who will then serve as the secretary for the following year. The secretary will complete a one-year term and then serve as the committee chair the following year. Therefore, officers serve two-year terms. This limits the time commitment requested from incoming officers yet provides sufficient institutional memory about the project. Annual meetings will be organized on a rotating basis after the technical committee membership has been polled for availability and interest. If a face-to-face meeting is not feasible, a virtual annual meeting will be held. For decision making, all Appendix E participants may vote. A quorum for technical committee deliberations will be 51% of the Appendix E participants. Motions pass by simple majority.

Literature Cited:

Abdulkdir, A., P.A. Leffelaar, J.O. Agbenin, K.E. Giller. (2013). Nutrient flows and balances in urban and peri-urban agroecosystems of Kano, Nigeria. *Nutr Cycle Agroecosyst, 95*, 231-254.

Ahmed, S, Buckley, S, Stratton, AE, Asefaha, F, Butler, C, Reynolds, M, Orians, C. 2018. Sedum Groundcover Variably Enhances performance and Phenolic Concentrations of perennial Culinary Hers in an Urban Edible Green Roof. Agroecology and Sustainable Food Systems. 41(5):487-504. DOI: 10.1080/21683565.2017.1279703

Alaimo, K., Packnett, E., Miles, R. A., Kruger, D. J. (2008). Fruit and Vegetable Intake among Urban Community Gardeners. *Journal of Nutrition Education and Behavior*, *40*(2), 94–101. <https://doi.org/10.1016/j.jneb.2006.12.003>

Alkon, A. H. (2014). Food Justice and the Challenge to Neoliberalism. *Gastronomica: The Journal of Critical Food Studies*, *14*(2), 27–40.<https://doi.org/10.1525/gfc.2014.14.2.27>

Almaaitah, T., Joksimovic, D. (2022). Hydrologic and thermal performance of a full-scale farmed bluegreen roof. *Water*, 14, 1700.<https://doi.org/10.3390/w14111700>

Aloisio, J.M., A.R. Tuininga, and J.D. Lewis. 2016. Crop species selection effects on stormwater runoff and edible biomass in an agricultural green roof microcosm. Ecological Engineering. 88:20-27.

Appolloni E., Francesco O., Specht K., Thomaier S., Sanyé-Mengual E., Pennisi G., Gianquinto G. (2021). The global rise of urban rooftop agriculture: A review of worldwide cases. *Journal of Cleaner Production*, 261:126556.<https://doi.org/10.1016/j.jclepro.2021.126556>

Arrobas M, Lopes H & Rodrigues MÂ. (2017). Urban agriculture in Bragança, Northeast Portugal: assessing the nutrient dynamic in the soil and plants, and their contamination with trace metals. *Biological Agriculture & Horticulture*, 33:1, 1-13, DOI:10.1080/01448765.2016.1172345

Baumann N. (2006). Ground-Nesting Birds on Green Roofs in Switzerland: Preliminary observations. *Urban Habitats*. http://www.urbanhabitats.org/v04n01/birds_full.html

Field Code Changed

Begum, M.S., Bala, S.K., Islam, A.S., Roy, D. (2021). Environmental and Social Dynamics of Urban Rooftop Agriculture (URTA) and Their Impacts on Microclimate Change. *Sustainability*, 13, 9053. <https://doi.org/10.3390/su13169053>

Beniston, J., Lal, R. (2012). Improving Soil Quality for Urban Agriculture in the North Central U.S. In *Carbon Sequestration in Urban Ecosystems* (pp. 279–313). Springer, Dordrecht. https://doi.org/10.1007/978-94-007-2366-5_15

Benvenuti S. (2014). Wildflower green roofs for urban landscaping, ecological sustainability and biodiversity. *Landscape and Urban Planning*. 124:151-161. <http://dx.doi.org/10.1016/j.landurbplan.2014.01.004>

Beuhler, D., Junge R. (2016). Global Trends and Current Status of Commercial Urban Rooftop Farming. *Sustainability*, 8:1108. doi:10.3390/su8111108.

Billings, D., Cabbil, L. (2011). Food Justice: What's Race Got to Do with It? *Race/Ethnicity: Multidisciplinary Global Contexts*, *5*(1), 103–112.<https://doi.org/10.2979/racethmulglocon.5.1.103>

Brown, S. L., Chaney, R. L., Hettiarachchi, G. M. (2016). Lead in Urban Soils: A Real or Perceived Concern for Urban Agriculture? *Journal of Environment Quality*, *45*(1), 26[. https://doi.org/10.2134/jeq2015.07.0376](https://doi.org/10.2134/jeq2015.07.0376)

Buckley S, Sparks R, Cowdery E, Stirling F, Marsching J and Phillips N. (2022) Enhancing crop growth in rooftop farms by repurposing CO2 from human respiration inside Bildings. Front. Sustain. Food Syst. 6:918027. doi: 10.3389/fsufs.2022.918027

Buffam, I., Mitchell, M. E., Durtsche, R. D. (2016). Environmental drivers of seasonal variation in green roof runoff water quality. *Ecological Engineering*, 91, 506–514. <https://doi.org/10.1016/j.ecoleng.2016.02.044>

Butts, P. 2017. Green Roof Vegetable Production in Three Different Growth Media. Masters of Science in Environmental Science. Southern illinois University.

Cameira, M. R., Tedesco, S., Leitão, T. E. (2014). Water and nitrogen budgets under different production systems in Lisbon urban farming. *Biosystems Engineering*, *125*, 65–79. <https://doi.org/10.1016/j.biosystemseng.2014.06.020>

Carlet, F., Schilling, J., Heckert, M. (2017). Greening U.S. legacy cities: Urban agriculture as a strategy for reclaiming vacant land. *Agroecology and Sustainable Food Systems*, *41*(8), 887–906. <https://doi.org/10.1080/21683565.2017.1311288>

Clark, M. J., Zheng, Y. (2013). Plant Nutrition Requirements for an Installed Sedum-Vegetated Green Roof Module System : Effects of Fertilizer Rate and Type on Plant Growth and Leachate Nutrient Content. *HortScience*, *48*(9), 1173–1180.

Clark, M. J., Zheng, Y. (2014). Fertilizer rate and type affect sedum-vegetate green roof mat plat performace nad leachate nutrient content. *HortScience*, 49(3), 328-335.

Cheng, Z., Paltseva, A., Li, I., Morin, T., Huot, H., Egendorf, S., Su, Z., Yolanda, R., Singh, K., Lee, L., Grinshtein, M., Liu, Y., Green, K., Wai, W., Wazed, B., Shaw, R. (2015). Trace Metal Contamination in New York City Garden Soils. *Soil Science*, *180*, 167–174.<https://doi.org/10.1097/ss.0000000000000126>

Clatworthy, J., Hinds, J., Camic, P. M. (2013). Gardening as a mental health intervention: A review. *Mental Health Review Journal*, 18(4), 214–225.<https://doi.org/10.1108/MHRJ-02-2013-0007>

Colla SR, Willis E, Packer L. (2009). Can green roofs provide habitat for urban bees (Hymenoptera: Apidae)?. *Cities and the Environment*, 2(1): article 4, 12 pp.<http://escholarship.bc.edu/cate/vol2/iss1/4>

Cook-Patton SC, Bauerle TL. (2012). Potential benefits of plant diversity on vegetated roofs: A literature review. *Journal of Environmental Management*, 106: 85-92. doi:10.1016/j.jenvman.2012.04.003

Czemiel Berndtsson, J. (2010). Green roof performance towards management of runoff water quantity and quality: A review. *Ecol. Eng*. 36, 351–360. doi:10.1016/j.ecoleng.2009.12.014

Dewaelheyns, V., Elsen, A., Vandendriessche, H., Gulinck, H. (2013). Garden management and soil fertility in Flemish domestic gardens. *Landscape and Urban Planning*, 116, 25–35. <https://doi.org/10.1016/j.landurbplan.2013.03.010>

Dvorak, B., Volder, A. (2010). Green roof vegetation for North American ecoregions: A literature review. Landsc. *Urban Plan*. 96, 197–213. doi:10.1016/j.landurbplan.2010.04.009

Egerer, M., Ossola, A., Lin, B. B. (2018). Creating Socioecological Novelty in Urban Agroecosystems from the Ground Up. *BioScience*, *68*(1), 25–34.<https://doi.org/10.1093/biosci/bix144>

Eksi, M., D.B. Rowe, R. Fernández-Cañero, and B.M. Cregg. 2015. Effect of substrate compost percentage on green roof vegetable production. Urban Forestry & Urban Greening. 14:315-322.

Eksi, M. and D.B. Rowe. 2016. Green roof substrates: Effect of recycled crushed porcelain and foamed glass on plant growth and water retention. Urban Forestry & Urban Greening, 20:81-88.

Elstein, J., G.E. Welbaum, D.A. Stweart, D.R. Borys. (2008). Evaluating growing media for a shallowrooted vegetable crop production system on a green roof. *Acta Hort*. 782:177-184.

Fassman-Beck, E., Voyde, E., Simcock, R., Hong, Y. S. (2013). 4 Living roofs in 3 locations: Does configuration affect runoff mitigation? Journal of Hydrology, 490, 11–20. configuration affect runoff mitigation? *Journal of Hydrology*, 490, 11–20. <https://doi.org/10.1016/j.jhydrol.2013.03.004>

Getter, K. L., Rowe, D. B., Robertson, G. P., Cregg, B. M., Andresen, J. A. (2009). Carbon sequestration potential of extensive green roofs. *Environmental Science and Technology*, 43(19), 7564–7570. <http://dx.doi.org/10.1021/es901539x>

Gong, Y., Yin, D., Li, J., Zhang, X., Wang, W., Fang, X., Shi, H., Wang, Q. (2019). Performance assessment of extensive green roof runoff flow and quality control capacity based on pilot experiments. *Science of the Total Environment*, 687, 505–515.<https://doi.org/10.1016/j.scitotenv.2019.06.100>

Gonzalez & Anderson: The Challenges of Farming in New York City. November 12, 2018. <https://www.youtube.com/watch?v=1ng2Zb-ROyk>

Grard, B.J., N. Bel, N. Marchal, F. Madre, J.-F. Castell, P. Cambier, S. Houot, N. Manouchehri, S. Besancon, J.-C. Michel J.-C., C. Chenu, N. Frascaria-Lacoste, C. Aubry. (2015). Recycling urban waste as possible use for rooftop vegetable garden. *Future of Food: Journal on Food, Agriculture and Society*, 3(1), 21-34

Harada Y., Whitlow T.H., Walter M.T., Bassuk N.L., Russell-Anelli J., Schindelbeck, R.R. (2018a). Hydrology of the Brooklyn Grange, an urban rooftop farm. *Urban Ecosystems*. 21: 673-689. <https://doi.org/10.1007/s11252-018-0749-7>

Harada Y., Whitlow T.H., Bassuk N.L., Russell-Anelli, J. (2020). Rooftop Farm Soils for Sustainable Water and Nitrogen Management. *Front. Sustain. Food Syst*. 4:123. doi: 10.3389/fsufs.2020.00123

Harada, Y., T.H. Whitlow, N.L. Bassuk, J. Russell-Anelli. (2017). Biogeochemistry of Rooftop Farms. In *Urban Soils*. Eds. R. Lal and B.A. Stewart. CRC Press. Boca Raton.

Harada Y., Whitlow T.H., Templer P.H., Howarth R.W., Walter M.T., Bassuk NL Russell-Anelli J. (2018). Nitrogen Biogeochemistry of an Urban Rooftop Farms. *Front. Ecol. Evol*. 6:153. doi: 10.3389/fevo.2018.00153

Harada, Y., Whitlow T.H., Russell-Aneilli J., Walter M.T., Badduk N.L., Rutzeke M.A. (2019). The heavy metal budget of an urban rooftop farm. *Science of the Total Environment*. 660:115-125. <https://doi.org/10.1016/j.scitotenv.2018.12.463>

Hathaway, A.M., Hunt, W.F., Jennings, G.D. (2008). A field study of green roof hydrologic and water quality performace. *Trans. ASABE* 51, 37–44.

Horst, M., McClintock, N., Hoey, L. (2017). The Intersection of Planning, Urban Agriculture, and Food Justice: A Review of the Literature. *Journal of the American Planning Association*, 83(3), 277–295. <https://doi.org/10.1080/01944363.2017.1322914>

Huang, B., X. Shi, D. Yu, I. Öborn, K. Blombäck, T. F. Pagella, H. Wang, W. Sun, F.J. Sinclair. (2006). Envronmental assessment of small-scale vegetable farming system sin peri-urban areas of the Yangtze river delta region, China. *Agriculture, Ecosystems and Environment, 112*, 391-402.

Hung, Y. (2004). East New York Farms: Youth Participation in Community Development and Urban Agriculture. *Children, Youth and Environments*, *14*(1), 56–8.

IUSS 2022. World Reference Base for Soil Resources. IUSS Working Group. International soil classification system for naming soils and creating legends for soil maps. 4th edition. International Union of Soil Sciences (IUSS), Vienna, Austria.

Jadaa, D. Al, Raed, A. A., Taleb, H. (2019). Assessing the thermal effectiveness of implementing green roofs in the urban neighborhood. *Jordan Journal of Mechanical and Industrial Engineering*, 13(3), 161– 174.

Jarosz, L. (2014). Comparing food security and food sovereignty discourses. *Dialogues in Human Geography*, *4*(2), 168–181.<https://doi.org/10.1177/2043820614537161>

Karczmarczyk, A., Baryła, A., Fronczyk, J., Bus, A., Mosiej, J. (2020). Phosphorus and metals leaching from green roof substrates and aggregates used in their composition. *Minerals*, 10(2), 1–12. <https://doi.org/10.3390/min10020112>

Kelbaugh, D. (2019). *The Urban Fix: Resilient Cities in the War Against Climate Change, Heat Islands, and Overpopulation.* Routledge: New York and London.

Kessler, R. (2013). Urban Gardening: Managing the Risks of Contaminated Soil. *Environmental Health Perspectives*, *121*(11–12), A326–A333.<https://doi.org/10.1289/ehp.121-A326>

Kingsley, J. 'Yotti,' Townsend, M., Henderson-Wilson, C. (2009). Cultivating health and wellbeing: Members' perceptions of the health benefits of a Port Melbourne community garden. *Leisure Studies*, 28(2), 207–219.<https://doi.org/10.1080/02614360902769894>

Formatted: Spanish (Spain)

Kingsley, J. 'Yotti,' Townsend, M. (2006). 'Dig In' to Social Capital: Community Gardens as Mechanisms for Growing Urban Social Connectedness. *Urban Policy and Research*, 24(4), 525–537. <https://doi.org/10.1080/08111140601035200>

Kong, A.Y.Y., Rosenzweig, C., Ark, J. (2015). Nitrogen dynamics associated with organic and inorganic inputs to substrate commonly used on rooftop farms. *HortScience*. 50(6):806-813.

Kremer, P., Hamstead, Z. A., McPhearson, T. (2013). A social–ecological assessment of vacant lots in New York City. *Landscape and Urban Planning*, 120, 218–233. <https://doi.org/10.1016/j.landurbplan.2013.05.003>

Krzywoszynska, A. (2019). Caring for soil life in the Anthropocene: the role of attentiveness in more-thanhuman ethics. *Transactions of the Institute of British Geographers*, 44(4), 661-675. https://doi.org/10.1111/tran.12293

Krzywoszynska, A., & Marchesi, G. (2020). Toward a relational materiality of soils: Introduction. *Environmental Humanities*, 12(1), 190-204. https://doi.org/10.1215/22011919-8142297

Lacarne, I., M. Dang, and S. Shafie. 2021. Using biochar as an amendment for engineered green roof soil blend. Ecological Farmers Association of Ontario. Research Report. Available at <https://efao.ca/research/using-biochar-as-an-amendment-for-engineered-green-roof-soil-blend/>

Lin, B. B., Philpott, S. M., Jha, S. (2015). The future of urban agriculture and biodiversity-ecosystem services: Challenges and next steps. *Basic and Applied Ecology*, 16(3), 189–201. <https://doi.org/10.1016/j.baae.2015.01.005>

Lindemann, J. (2022). "A little portion of our 40 acres": A black agrarian imaginary in the city. *Environment and Planning E: Nature and Space,* 6(3), 1804-1824.<https://doi.org/10.1177/25148486221129408>

Lovell, S. T. (2010). Multifunctional Urban Agriculture for Sustainable Land Use Planning in the United States. *Sustainability*, 2(8), 2499–2522.<https://doi.org/10.3390/su2082499>

Madre F. Vergnes A, Machon N, Clergeau P. (2013). A comparison of 3 types of green roof as habitats for arthropods. *Ecological Engineering,* 57: 109-117.<http://dx.doi.org/10.1016/j.ecoleng.2013.04.029>

Maltais-Landry, G., K. Scow, E. Brennan, E. Torbert, P. Vitousek. (2016). Higher flexibility in input N:P ratios results in more balanced phosphorus budgets in two long-term experimental agroecosystems. *Agriculture, Ecosystems and Environment, 223*, 197-210.

Marquez-Bravo, L. G., Briggs, D., Shayler, H., McBride, M., Lopp, D., Stone, E., Ferenz, G., Bogdan, K. G., Mitchell, R. G., Spliethoff, H. M. (2016). Concentrations of polycyclic aromatic hydrocarbons in New York City community garden soils: Potential sources and influential factors. *Environmental Toxicology and Chemistry*, *35*(2), 357–367.<https://doi.org/10.1002/etc.3215>

Martini, A.N., Papafotiou, M. and Evangelopoulos, K. (2017). Effect of substrate type and depth on the establishment of the edible and medicinal native species *Crithmum maritimum* on an extensive urban Mediterranean green roof. Acta Hortic. 1189, 451-454 Mediterranean green roof. Acta Hortic. <https://doi.org/10.17660/ActaHortic.2017.1189.89>

Formatted: English (United States)

Matlock, J. M., Rowe, D. B. (2017). Does Compost Selection Impact Green Roof Substrate Performance? Measuring Physical Properties, Plant Development, and Runoff Water Quality. *Compost Science and Utilization*, *25*(4), 231–241.<https://doi.org/10.1080/1065657X.2017.1295887>

McBride, M. B., Shayler, H. A., Spliethoff, H. M., Mitchell, R. G., Marquez-Bravo, L. G., Ferenz, G. S., Russell-Anelli, J. M., Casey, L., Bachman, S. (2014). Concentrations of lead, cadmium and barium in urban garden-grown vegetables: The impact of soil variables. *Environ Pollut*, *194*, 254–261. <https://doi.org/10.1016/j.envpol.2014.07.036>

McCormack, L. A., Laska, M. N., Larson, N. I., Story, M. (2010). Review of the Nutritional Implications of Farmers' Markets and Community Gardens: A Call for Evaluation and Research Efforts. *Journal of the American Dietetic Association*, 110(3), 399–408[. https://doi.org/10.1016/j.jada.2009.11.023](https://doi.org/10.1016/j.jada.2009.11.023)

McDougall, R., P. Kristiansen, R. Rader. (2019). Small-scale urban agriculture results in high yields but requires judicious management of inputs to achieve sustainability. *PNAS*, *116*(1), 129-134.

Metcalf, S. S., & Widener, M. J. (2011). Growing Buffalo's capacity for local food: A systems framework for sustainable agriculture. *Applied Geography*, *31*(4), 1242–1251. <https://doi.org/10.1016/j.apgeog.2011.01.008>

Mielke, H. W. (2015). Soils and Health: Closing the Soil Knowledge Gap. *Soil Horizons*, 56, 0. <https://doi.org/10.2136/sh2015-56-4-gc>

Mielke, H. W., Anderson, J. C., Berry, K. J., Mielke, P. W., Chaney, R. L., & Leech, M. (1983). Lead Concentrations in Inner-City Soils as a Factor in the Child Lead Problem. *American Journal of Public Health*, 73(12), 1366.

Mikkelsen, R., T.K. Hartz. (2008). Nitrogen sources of organic crop production. *Better Crops,* 92(4), 16-19.

Mitchell, R. G., Spliethoff, H. M., Ribaudo, L. N., Lopp, D. M., Shayler, H. A., Marquez-Bravo, L. G., Lambert, V. T., Ferenz, G. S., Russell-Anelli, J. M., Stone, E. B., McBride, M. B. (2014). Lead (Pb) and other metals in New York City community garden soils: Factors influencing contaminant distributions. *Environ Pollut*, *187*, 162–169.<https://doi.org/10.1016/j.envpol.2014.01.007>

Mowrer, J., J. Merrill, D. Conlee, J. Marble, B. Dvorak. 2019. Rooftop urban agriculture for the small stakeholder, Journal of Living Architecture. 6(2): 1-16

Myers, J. S., Sbicca, J. (2015). Bridging good food and good jobs: From secession to confrontation within alternative food movement politics. *Geoforum*, *61*, 17–26.<https://doi.org/10.1016/j.geoforum.2015.02.003>

Ntoulas N, Nektarios, PA, Kapsali, T-E, Kaltsidi, M-P, Han L, & Yin S. (2015). Determination of the physical, chemical, and huydraulic characteristics of locally available materials for formulating extensive green roof susbstrates.

Oberholtzer, L. Dimitri, C., Pressman, A. (2016). Urban Agriculture in the United States: Baseline Findings of a Nationwide Survey. *ATTRA Sustainable Agriculture, 2016*. [https://attra.ncat.org/product/Urban-](https://attra.ncat.org/product/Urban-Agriculture-in-the-United-States-Baseline-Findings-of-a-Nationwide-Survey/)[Agriculture-in-the-United-States-Baseline-Findings-of-a-Nationwide-Survey/](https://attra.ncat.org/product/Urban-Agriculture-in-the-United-States-Baseline-Findings-of-a-Nationwide-Survey/)

Oberholtzer, L., Dimitri, C., Pressman, A. 2016. Urban Agriculture in the United States:

Field Code Changed

Field Code Changed

Field Code Changed

Formatted: English (United States)

Baseline Findings of a Nationwide Survey. ATTRA Sustainable Agriculture, National Center for
Appropriate technology. Available at: https://attradev.ncat.org/wpAppropriate technology. Available at: [https://attradev.ncat.org/wp](https://attradev.ncat.org/wp-content/uploads/2022/06/urbanagriculture.pdf)[content/uploads/2022/06/urbanagriculture.pdf A](https://attradev.ncat.org/wp-content/uploads/2022/06/urbanagriculture.pdf)ccessed June 12, 2025.

Okvat, H. A., Zautra, A. J. (2011). Community Gardening: A Parsimonious Path to Individual, Community, and Environmental Resilience. *American Journal of Community Psychology*, 47(3–4), 374–387. <https://doi.org/10.1007/s10464-010-9404-z>

Olszewski, M.W., Eisenman, S.W. 2017. Influence of biochar amendment on herb growth in a green roof substrate. *Hortic. Environ. Biotechnol.* **58**, 406–413. https://doi.org/10.1007/s13580-017-0180-7

Orsini, F., Gasperi, D., Marchetti, L., Piovene, C, Draghetti, S, Ramazzotti S, Bazocchi G, Gianquinto G. 2014. Exploring the production capacity of rooftop gardens (RTGs) in urban agriculture: the potential impact on food and nutrition security, biodiversity and other ecosystem services in the city of Bologna. Food Sec. 6, 781–792. https://doi.org/10.1007/s12571-014-0389-6

Ouellette, N., Walters, S.A., Midden, K.S., 2013. Fertility management for tomato production on an extensive green roof. Journal of Living Architecture. 1(1): 1-14. extensive green roof. Journal of Living Architecture. 1(1): 1-14. http://greenroofs.org/resources/JOLA2013Volume1(Issue1)Ouellette(etal

Parket, Kim. (2018). Demographic and economic trends in urban, suburban, and rural communities. [https://www.pewsocialtrends.org/2018/05/22/demographic-and-economic-trends-in-urban-suburban-and](https://www.pewsocialtrends.org/2018/05/22/demographic-and-economic-trends-in-urban-suburban-and-rural-communities/)[rural-communities/](https://www.pewsocialtrends.org/2018/05/22/demographic-and-economic-trends-in-urban-suburban-and-rural-communities/)

Pearson, L. J., Pearson, L., Pearson, C. J. (2010). Sustainable urban agriculture: Stocktake and opportunities. *International Journal of Agricultural Sustainability*, 8(1–2), 7–19. <https://doi.org/10.3763/ijas.2009.0468>

Ramírez, M. M. (2015). The Elusive Inclusive: Black Food Geographies and Racialized Food Spaces. *Antipode*, 47(3), 748–769.<https://doi.org/10.1111/anti.12131>

Rowe, D.B. (2011). Green roofs as a means of pollution abatement. *Environ. Pollut*. 159, 2100–10. <doi:10.1016/j.envpol.2010.10.029>

Saadatian, O., Sopian, K., Salleh, E., Lim, C. H., Riffat, S., Saadatian, E., Toudeshki, A., Sulaiman, M. Y. (2013). A review of energy aspects of green roofs. *Renewable and Sustainable Energy Reviews*, 23, 155– 168.

Saha, M., Eckelman, M. J. (2017). Growing fresh fruits and vegetables in an urban landscape: A geospatial assessment of ground level and rooftop urban agriculture potential in Boston, USA. *Landscape and Urban Planning*, 165, 130–141.<https://doi.org/10.1016/j.landurbplan.2017.04.015>

Saldivar-Tanaka, L., Krasny, M. E. (2004). Culturing community development, neighborhood open space, and civic agriculture: The case of Latino community gardens in New York City. *Agriculture and Human Values*, *21*(4), 399–412.<https://doi.org/10.1023/B:AHUM.0000047207.57128.a5>

Salomon, M.J., S.J. Watts-Williams, M.J. McLaughlin, T.R. Cavagnaro. (2020). Urban soil health: A citywide survey of chemical and biological properties of urban agriculture soils. *Journal of Cleaner Production*, *275*, 122900.

Sideman, R., L. McKeag, K. Ghantous, A. Smart, A. Wallingford, & E Gallandt Eds. (2023). New England Vegetable Management Guide 2020-2021 Edition. University of Massachusetts Extension Vegetable Program.

Sipter, E., Rozsa, E., Gruiz, K., Tatrai, E., Morvai, V. (2008). Site-specific risk assessment in contaminated vegetable gardens. *Chemosphere*, *71*, 1301–1307.<https://doi.org/10.1016/j.chemosphere.2007.11.039>

Small, G., P. Shrestha, G. S. Metson, K. Polsky, I. Jimenez, A. Kay. (2019). Excess phosphorus from compost applications in urban gardens creates potential pollution hotspots. *Environmental Research Communications,* 1,<https://doi.org/10.1088/2515-7620/ab3b8c>

Speak AF, Rothwell JJ, Lindley SJ, Smith CL. (2012). Urban particular pollution reduction by four species of green roof vegetation in a UK city. *Atmospheric Environment,* 61: 283-293. <http://dx.doi.org/10.1016/j.atmosenv.2012.07.043>

Spliethoff, H. M., Mitchell, R. G., Shayler, H., Marquez-Bravo, L. G., Russell-Anelli, J., Ferenz, G., McBride, M. (2016). Estimated lead (Pb) exposures for a population of urban community gardeners. *Environmental Geochemistry and Health*, 38(4), 955–971.<https://doi.org/10.1007/s10653-016-9790-8>

Subica, A. M., Grills, C. T., Douglas, J. A., Villanueva, S. (2015). Communities of Color Creating Healthy Environments to Combat Childhood Obesity. *American Journal of Public Health*, 106(1), 79–86. <https://doi.org/10.2105/AJPH.2015.302887>

Teig, E., Amulya, J., Bardwell, L., Buchenau, M., Marshall, J. A., Litt, J. S. (2009). Collective efficacy in Denver, Colorado: Strengthening neighborhoods and health through community gardens. *Health & Place*, *15*(4), 1115–1122.<https://doi.org/10.1016/j.healthplace.2009.06.003>

Tong Z, Whitlow TH, Landers A, Flanner B. (2016). A case study of air quality above an urban roof top vegetable farm. *Environmental Pollution*. 208:256-260.<http://dx.doi.org/10.1016/j.envpol.2015.07.006>

Tonietto, R., Fant, J., Ascher, J., Ellis, K. Larkin, D. (2011). A comparison of bee communities of Chicago green roofs, parks and prairies. *Landscape and Urban Planning*, 103(1), 102-108.

U.S. Global Climate Change Research Program (USGCRP). (2018). *Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment, Volume II* [Reidmiller, D.R., C.W. Avery, D.R. Easterling, K.E. Kunkel, K.L.M. Lewis, T.K. Maycock, and B.C. Stewart (eds.)]. U.S. Global Change Research Program, Washington, DC, USA, 1515 pp. doi: 10.7930/NCA4.2018. 28 Dec 2022. <https://nca2018.globalchange.gov/>

USDA National Agricultural Statistics Service. (2017). Census of agriculture. Selected Producer Characteristics: 2017 and 2012. [https://www.nass.usda.gov/Publications/AgCensus/2017/Full_Report/Volume_1,_Chapter_1_US/st99_1_](https://www.nass.usda.gov/Publications/AgCensus/2017/Full_Report/Volume_1,_Chapter_1_US/st99_1_0052_0052.pdf) [0052_0052.pdf](https://www.nass.usda.gov/Publications/AgCensus/2017/Full_Report/Volume_1,_Chapter_1_US/st99_1_0052_0052.pdf)

Van Den Berg, A. E., Custers, M. H. G. (2011). Gardening Promotes Neuroendocrine and Affective Restoration from Stress. *Journal of Health Psychology*, *16*(1), 3–11. <https://doi.org/10.1177/1359105310365577>

Van Ploeg, M., Nulph, D., Williams, R. (2011). Mapping Food Deserts in the United States. *Economic Research Service – United States Department of Agriculture*, 2011. [https://www.ers.usda.gov/amber](https://www.ers.usda.gov/amber-waves/2011/december/data-feature-mapping-food-deserts-in-the-us/)[waves/2011/december/data-feature-mapping-food-deserts-in-the-us/](https://www.ers.usda.gov/amber-waves/2011/december/data-feature-mapping-food-deserts-in-the-us/)

Van Renterghem T, Botteldooren D. (2011). In-situ measurements of sound propagating over extensive green roofs. *Building and Environment,* 46:729-738.<doi:10.1016/j.buildenv.2010.10.006>

Varela, A, Sandoval-Albán, A, Muñoz, Gómez, AG, Gogoya JM, Combariza G. 2021. Evaluation of green roof structures and substrates for *Lactucua sativa* L. in torpical conditions. Urban Forestry & Urban Greening. 60:127063. [https://doi.org/10.1016/j.ufug.2021.127063.](https://doi.org/10.1016/j.ufug.2021.127063)

Walters, S.A.; Gajewski, C.; Sadeghpour, A.; Groninger, J.W. 2022.Mitigation of Climate Change for Urban Agriculture: Water Management of Culinary Herbs Grown in an Extensive Green Roof Environment. Climate 10:180. [https://doi.org/10.3390/cli10110180.](https://doi.org/10.3390/cli10110180)

Walters, SA, Thomas V, Midden, KS, Groninger, JW. 2023. Autum Productoin of Romaine Lettuce on an Extensive Green Roof. Journal of Living Architecture. 10(1): 13-25. DOI: 10.46534/jliv.2023.10.01.013.

White, M. M. (2011). Sisters of the Soil: Urban Gardening as Resistance in Detroit. *Race/Ethnicity: Multidisciplinary Global Contexts*, *5*(1), 13–2.

Whittinghill, L. J., Hsueh, D., Culligan, P., Plunz, R. (2016). Stormwater performance of a full scale rooftop farm: Runoff water quality. *Ecological Engineering*, *91*, 195–206. <https://doi.org/10.1016/j.ecoleng.2016.01.047>

Whittinghill, L.J., Rowe, D.B. (2012). The role of green roof technology in urban agriculture. *Renew. Agric. Food Syst*.<https://doi.org/10.1017/S174217051100038X>

Whittinghill, L.J. S. Sarr. (2021). Sustainable Urban Agriculture: A Case Study of Louisville, Kentucky's Largest City. *Urban Science*. *5*, 92. [https://doi.org/10.3390/ u](https://doi.org/10.3390/)rbansci5040092

Whittinghill, L.J., P. Culligan, R. Plunz, D. Hsueh, T. Carson, D. Marasco. (2014a). Stormwater performance of a full scale rooftop farm. *Ecological Society of America: 99th Annual Meeting*. Aug 11-15. Sacramento, CA.

Whittinghill, L.J., Jackson, C, and P. Poudel. 2024. The Effects of Compost Addition to Agricultural Green Roofs on Runoff Water Quality. HortScience. 59(3):307–322. https://doi.org/10.21273/HORTSCI17556- 23Whittinghill, L.J., D.B. Rowe, R. Schutzki, B.M. Cregg. (2014b). Quantifying carbon sequestration of various green roof and ornamental landscape systems. *Landscape and Urban Planning*. 123:41-48.

Whittinghill, L.J., D.B. Rowe, J.A. Andresen, B.M. Cregg. (2015). Comparison of stormwater runoff from sedum, native prairie, and vegetable producing green roofs. *Urban Ecosystems*. 18:13–29. DOI 10.1007/s11252-014-0386-8

Whittinghill, L.J., D.B. Rowe, M. Ngouajio, and B.M. Cregg. 2016b. Evaluation of nutrient management and mulching strategies for vegetable production on an extensive green roof. Agroecology and Sustainable Food Systems. 40(4) 297-318.<http://dx.doi.org/10.1080/21683565.2015.1129011>

Whittinghill, L, and P. Poudel. 2020. Yields of relay cropped greens grown in green roof production systems. Urban Food Systems Symposium.<https://newprairiepress.org/ufss/2020/proceedings/15>

Wielemaker R., O. Oenema, G. Zeeman, J. Weijma. (2019). Fertile cities: Nutrient management practices in urban agriculture. *Science of the Total Environmen*t, 668, 1277-1288. <https://doi.org/10.1016/j.scitotenv.2019.02.424>

Witzling, L., M. Wander, E. Phillips. (2011). Testing and educating on urban soil lead: A case of Chicago community gardens. *Journal of Agriculture, Food Systems, and Community Development, 1(2), 167-186.*

Yang J, Yu Q, Gong P. 2008. Quantifying air pollution removal by green roofs in Chicago. Atmospheric Environment. 42:7266-7273. doi:10.1016/j.atmosenv.2008.07.003