Collaborative Evaluation of Ecosystem Services Provided by Urban Agricultural Best Management Practices in the Twin Cities

N.A. Jelinski[1], J.A. Nicklay[1], M.A. Rogers[1], K. LaBine[1], G.E. Small[2], K.V. Cadieux[3], P.J. Rice[4]

[1]University of Minnesota, St. Paul, MN; [2]University of St. Thomas, St. Paul, MN
[3]Hamline University, St. Paul, MN; [4]USDA-ARS, St. Paul, MN

2018 Urban Food Systems Symposium, Minneapolis, MN 8-11 August 2018

Background and Objectives:

Rapidly expanding interest in and implementation of urban agricultural activities in the Twin Cities Metropolitan Area (TCMA) has transformed urban land use discussions, as evidenced by significant changes in local policy in the past decade. Urban producers of all types and experience face unique challenges which affect their success, livelihoods, and the sustainability of their operations. Navigating the politics of land-use and land tenure, constraints on land access, and high public visibility are just a few of these challenges. Increased public awareness of urban agriculture and the ecosystem services provided by it has the potential to further influence local policies and enhance the health and wealth of communities. Thus, there is a need for a local, data-driven evaluation of ecosystem services provided by urban agricultural land use to maximize the benefit from proposed land use strategies.

This work aims to evaluate and quantify a suite of ecosystem services provided by urban agriculture in the TCMA and includes a suite of regulating, supporting and cultural services in addition to the provisioning service of crop yields. Urban agricultural land uses have the potential to generate a high degree of synergy among ecosystem services and thus provide significant benefits to urban populations relative to competing land uses such as vacant lots or turfgrass. A broader, more holistic perspective on these services will lead to better, more informed decisions by policy-makers regarding the benefits of UA in the TCMA.

The carefully cultivated University-community partner relationships leveraged in this project are the result of more than 2 years of preparatory meetings, preliminary efforts, and collaborative discussions. A 2016 working group brought together community partners and academic collaborators from three institutions (M.A. Rogers, G.E. Small, N.,A. Jelinski, K.V. Cadieux) . The objectives developed by this 2016 working group were integrated into a 3-year USDA North Central RegionSustainable Research and Education Grant in 2017. Figure 1 shows the linkages between previous work and the objectives of the current project.

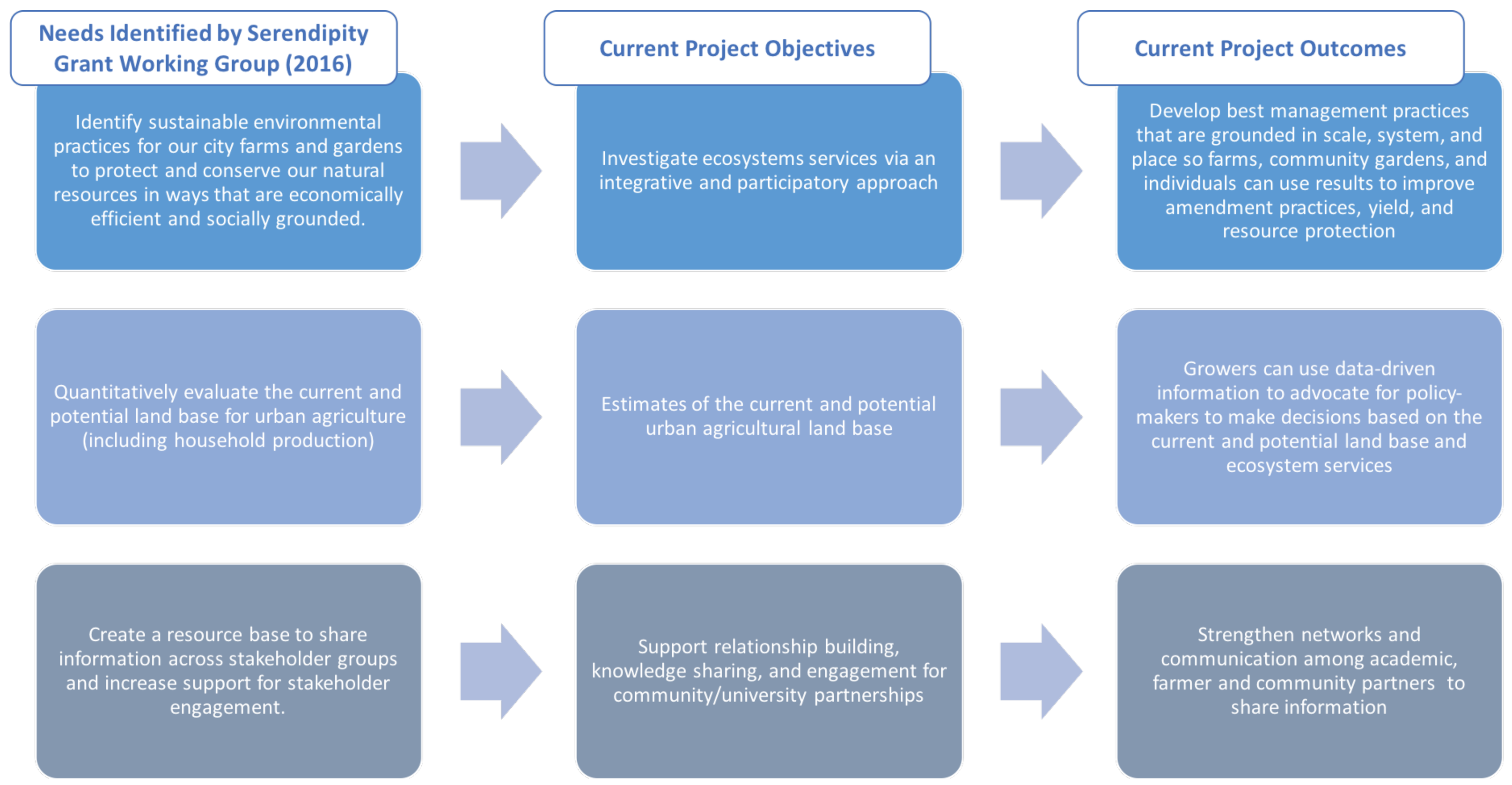


Figure 1. Logic model demonstrating the relationship between needs identified by a 2016 working group comprised of academic and community partners, current project objectives and desired outcomes.

Integrated Experimental Design:

Our experimental design was developed and built upon collective experiences from pilot work completed in the 2016 growing season. In urban agricultural systems, space is the critical limitation to conducting replicated research. Thus, we combine foundational work on off-farm replicated plots under a wide variety of crops and treatments (University of St. Thomas) with on-farm relicated plots under a single crop and fewer treatments. Finally, measurements are made on unreplicated observational plots under no research intervention. An extensive planning discussion with partners resulted in Collards as the crop of community choice across sites for on-farm research. On-farm plots included a grower's choice treatment (unique to each site and designed by growers) which facilitates a participatory perspective and partner engagement in the research process (Fig 2).

How does management impact ecosystem services?

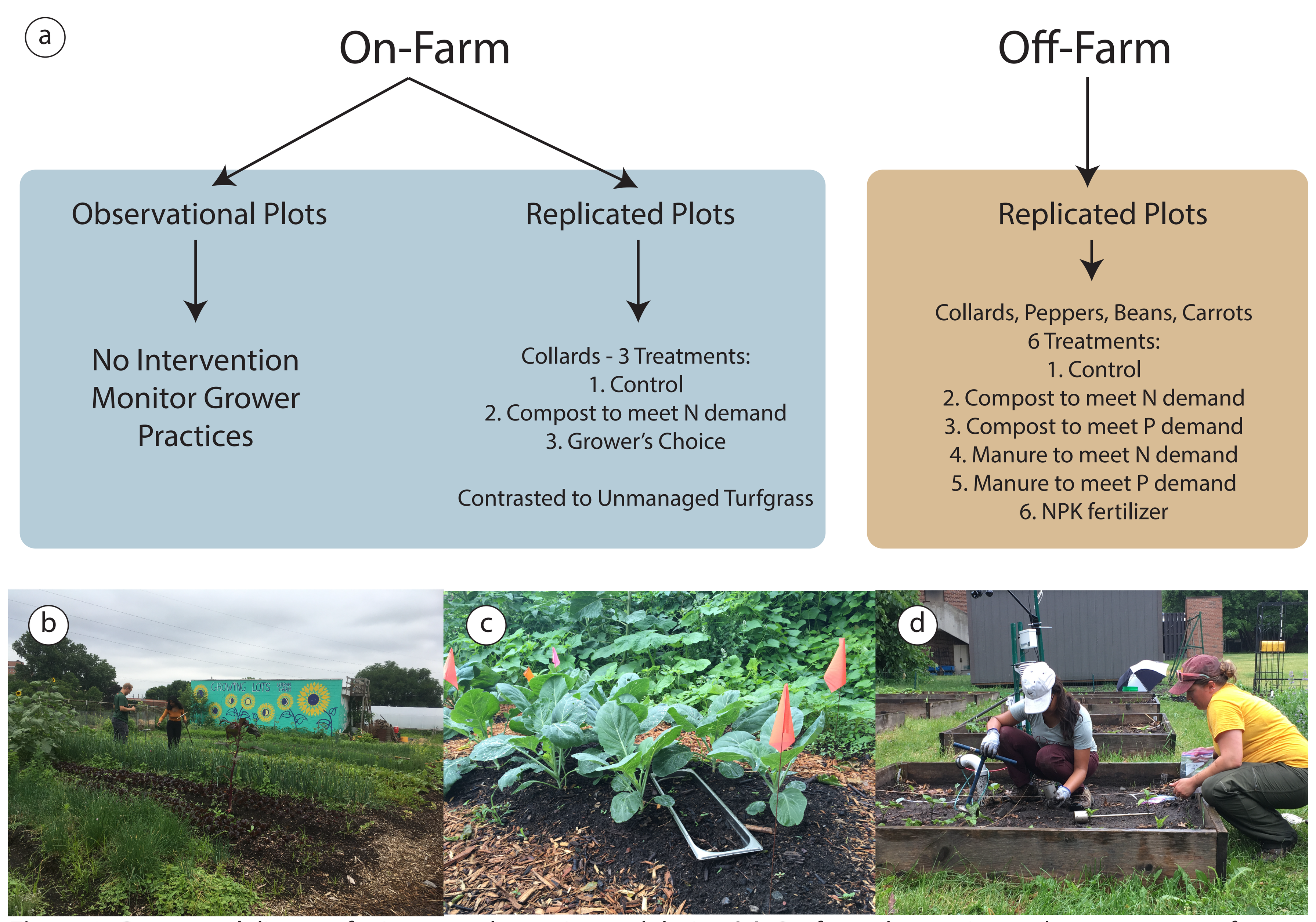


Figure 2. Conceptual diagram for integrated experimental design **(a)**. On-farm observation and measurement of ongoing grower practices **(b)** are built upon a foundation of on-farm replicated plots with a single crop (Collards) under three treatments **(c)**. These on-farm replicated plots are in turn supported by off-farm replicated plots at the University of St. Thomas, with 4 crops under six different treatments (P. Shrestha and K. LaBine) **(d)**.

Collaborative Activities:

Community partners involved in this collaborative research provide physical space, research coordination, and site support. Partners involved in this research include: **Frogtown Park and Farm** (St. Paul) , **Urban Farm and Garden Alliance** (UFGA - St. Paul), **Growing Lots Urban Farm** (Minneapolis), **Mashkikii Gitigan-24th Street Urban Farm Coalition** (Minneapolis), and **Waite House** (Minneapolis, MN). Research staff (Undergraduate/Graduate Students, Research Technicians) also dedicate weekly hours to community partners for the completion of routine farm activities to defray time and labor expenses incurred by community partners while providing research support. This mutually beneficial approach was suggested by partners during pilot work in 2016 and has resulted in increased communication and understanding.

Figure 4. Research staff with Taya Schulte (co-owner and farm manager, Growing Lots Urban Farm, Minneapolis, MN). L-R: Matt Wagner (Undergraduate Research Assistant, UMN), Karl Buttel (Undergraduate Research Assistant, St. Thomas), Tulsi Patel (Undergraduate Research Assistant, Macalester College), Jennifer Nicklay (Ph.D. student, Land and Atmospheric Science, UMN), Naomy Candelaria (Visiting Undergraduate LSSRP Fellow, University of Puerto Rico), Kat LaBine (Research Technician, UMN), Taya Schulte (Growing Lots Urban Farm).

Evaluation of Ecosystem Services (Year 1):

Figure 3. Making measurements of parameters relevant to ecosystem service evaluation. **(a)** Soil sampling (K. Buttel), **(b)** Pitfall traps to evaluate insect diversity, **(c)** Measuring saturated hydraulic conductivity (K. Buttel), **(d)** Gas flux measurements (J. Nicklay), **(e)** Lysimeter installation, **(f)** Crop yield and quality.

In this work, we utilize the integrated experimental design to contrast urban agricultural management practices with turfgrass and unmanaged vacant lots – the two most probable open-space alternative land uses to urban agriculture in the TCMA and other cities. Using turfgrass and vacant lot plots and sites as a reference, we are collecting and synthesizing data across sites and treatments to evaluate the ecosystem services provided by urban agricultural land uses. This ecosystem service assessment will involve quantifying the services listed below using the following methodologies:

Provisioning services: the quantitative assessment of these services will be based on the sum of crop yields on a per-hectare basis from on- and off-farm replicated plots, observational plots, and partner reported yields. Differences in plant quality between a range of potential urban agricultural management practices will be assessed.

Regulating services: Nitrogen (N) and phosphorus (P) losses through leachate water from urban agricultural and reference land uses will be quantified on an annual basis from water volumes and N and P concentrations measured in leachate waters. Static carbon storage differences between land uses and urban agricultural treatments will be assessed on a per-hectare basis using bulk density and soil organic carbon data.

Supporting services: Evaluate insect, earthworm, and plant abundance and diversity across multiple scales: α-diversity (plot-scale), γ-diversity (site-scale), and β-diversity (turnover between plots at a single site). Nutrient cycling efficiency and loss from urban agriculture and reference treatments will be quantified.

Cultural services: The perceived importance of a range of cultural services will be compared to reference land uses through differences in value rankings among respondents.

Ecosystem Services Evaluation Strategies

Provisioning Services

- **Crop yield**
- **Plant quality** (foliar nitrate & chlorophyll)

Regulating services

- **Water storage** (soil moisture, precipitation, and lysimeter volumes)
- **Water quality** (nitrate and phosphate concentrations from lysimeters)
- **Water infiltration** (infiltrometer and saturated hydraulic conductivity measurements)
- **Carbon storage and sequestration** (estimated using DAYCENT model (CSU-NREL, 2012), parameterized by soil variables, CO2 fluxes, plant biomass production, and soil organic carbon)

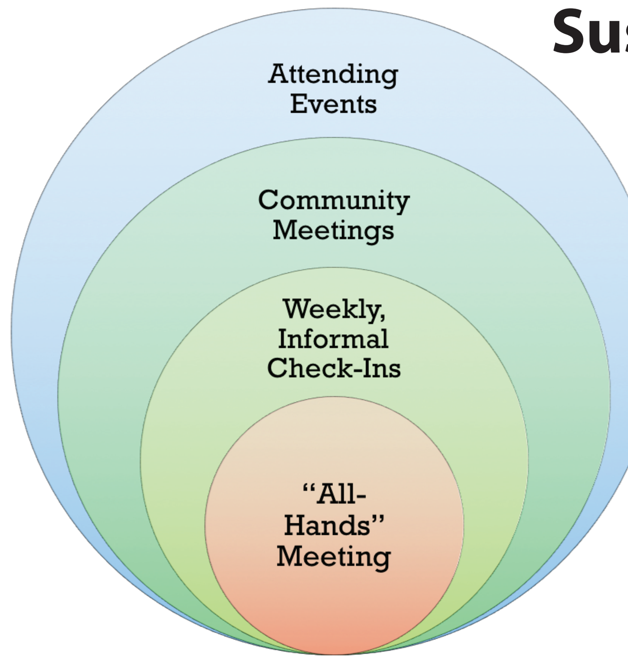
Supporting Services

- **Biodiversity** (insect sampling - sticky cards and pitfall traps, earthworm densities, plant diversity)
- **Nutrient cycling** (integrate results from biomass N and P, leachate N and P, soil N and P, and gaseous fluxes of N to calculate nutrient budgets)
- **Soil quality** (organic matter, organic carbon, permanganate-oxidizable carbon (POX-C), available P, pH, nitrate, ammonium, bulk density, aggregate stability, contaminants (heavy metals and metalloids, organics))

Cultural Services

- **Education, aesthetics, and discovery** (assessed through the results of surveys and semi-structured interview data)

Sustained Engagement Plan:



A critical aspect of this project is layers of sustained engagement that are explicitly built into the project plan (Fig 5). A yearly "all-hands" meeting is the most formal of these interactions, when academic and community partners meet together to plan for the season. During the growing season, weekly check-ins with community partners are designed to discuss emerging challenges. Research staff attends community meetings run by our partners. These regular, repeated interactions build trust and creates spaces where we can iteratively evaluate project goals.

Figure 5. Conceptual diagram of sustained engagement plan. The plan is anchored by annual "All Hands" meetings, but buttressed by more frequent and lower level interactions with research personnel and community partners at meetings and community events.

Acknowledgements:

This work is supported by USDA-NCR-SARE Research and Education Grant #2017-38640-26916 (N.A. Jelinski, PI), a National Science Foundation CAREER grant to G.E. Small, a University of Minnesota Diversity of Views and Experiences (DOVE) fellowship and a UMN Consortium on Law and Values in Health, Environment, and the Life Sciences to J.A. Nicklay, and a UMN LSSRP Summer Fellowship to N. Candelaria. Thanks and appreciation to P. Shrestha, N. Hecht, M. Wagner, T. Patel, K. Buttel, and N. Candelaria for their hard work and dedication, in addition to numerous community partners and community members who have dedicated their time, energy and enthusiasm to initiating this project.