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LANDSCAPE ECOLOGY IN PRACTICE

The social and spatial dynamics of community food production: a landscape approach to policy and program development

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Abstract Community food production in the form of home gardening, community gardening, school gardening, and urban farming continues to increase in popularity in many parts of the world. This interest has led to public and private investment in community food production and increased need for urban agricultural planning as a way to manage growth and prioritize resource allocation. Municipal planning and thoughtful institutional support for the practice will require program evaluation and greater attention to the spatial composition and configuration of this widely dispersed practice. This article explores the results of community-supported landscape socio-ecological research in Madison, WI (USA) to assess the spatial and social dynamics of community food production. Results indicate that community food production resources are unevenly distributed across the study area. Historic community garden placement does appear to be consistent with community prioritization which dictates placing resources in areas with low median household income. However, home garden presence and recent community garden placement both occur in areas of higher than average median household income. Specific focus is placed on how an understanding of landscape placement and pattern has helped inform attempts to meet municipal and regional objectives in addressing urban food insecurity.

Keywords Urban agriculture · Urban planning · Community food security · Community food production · Socioeconomics · Spatial pattern

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Introduction

Over the past decade there has been a steady re-emergence of individuals and communities actively engaged in small-scale locally-based food production. These production systems come in the form of home gardens, community gardens, food pantry gardens, school gardens, urban farms and other community-based food production initiatives. Growing food explicitly within a community, for that community, and by that community is what we refer to here as community food production or CFP. CFP is a special case of what many in the international development

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community have titled urban or peri-urban agriculture (Mougeot 2000; Bruinsma and Hertog 2003). However, unlike urban and peri-urban agriculture which are explicitly defined by "where" production takes place (Mougeot 2000); CFP so far has been defined by "who" participates in production and to whom the benefits of production are allocated. CFP is also a form of what sociologist Thomas Lyson referred to as civic agriculture, or an agricultural enterprise defined by an explicit community (Lyson 2000; Lyson 2004).

The landscape-level socio-ecological nature of CFP fits well within the model of landscape ecological assessment in which the patterns and processes of ecosystems are considered (Golley 1996). However, CFP research at present has relied primarily on sociological methods as a means to better understand motivations and impacts. Pijanowski noted in his work on poverty that landscape-level sociological research stands to benefit from a landscape ecological approach through contributing an emphasis on spatial arrangements and patterns (Pijanowski et al. 2010). By taking what we have termed a "landscape socio-ecological approach", we have sought to bring the 'where' question, along with the sociological 'who' question into CFP research. Cumming recently argued that this extension of landscape ecology to questions of landscape sustainability and/or resilience has a high potential to contribute to sustainability science (Cumming 2011). Our research demonstrates this potential to employ landscape ecology in a socio-ecological context in community-based problem solving.

A study of landscape configuration offers both a way to understand who realizes any potential value from CFP and whether specific sites within a community appear either differentially suited for CFP or differentially demand CFP. The intentional landscape approach to this urban ecological research study involved numerous iterative observations and interviews. While it was initially clear that the extent and location of CFP on the urban and regional landscape were unknown, to what extent this data could contribute to an understanding of the socioeconomic values of CFP was not clear until well into research development. We and our stakeholders sought to uncover the value of CFP as a form of community food security in the Madison, Wisconsin, USA urban area.

The landscape socio-ecological approach we have taken here was designed in concert with CFP practitioners and decision-makers as a tool to inform both the current socioeconomic impact of CFP and where future resources might be best placed. Specifically, our research outlines this approach through a case study. The requirements of this method address: (1) the current extent, composition, and configuration of CFP on the landscape, (2) the ways in which current configuration of CFP relate to socioeconomic and/or demographic data from aggregated study units within this area, and (3) what relationships between spatial configuration and socioeconomic data suggest about the role of CFP in combating food insecurity.

Several municipalities across the United States now explicitly plan for and even zone for the emerging land use of growing food (Mendes et al. 2008; Mannion 2009; Mukherji and Morales 2010). Despite widespread growth and promotion, the research community has not yet given considerable attention to the perceived values or socioeconomic impacts of the practice.

CFP in one or more of its various forms occurs worldwide (Koc et al. 1999; Mougeot 2006; Veenhuizen 2006). In many developing nations the growth of urban CFP is widely reported to be the result of growing urban food insecurity (Bruinsma and Hertog 2003), though others have argued that a more diverse set of drivers may be playing a role (Mullinix et al. 2009). In developed nations, the motivations behind the re-emergence of CFP are more diffuse (Patel 1991; Hynes and Howe 2004; Butterfield 2009). CFP is a condition in which all community residents have access to safe, culturally acceptable, and nutritious food through a sustainable food system maximizing self-reliance, social, justice, and sovereignty (Hamm and Bellows 2003). Community food security is still a major force behind CFP program development and funding, as cited in the six principles of community food security listed on the community food security coalition website (http://foodsecurity.org/what-is-community-food-security/; see also Koc et al. 1999). However, the range of values attributed to CFP extends well beyond food security among practitioners (Butterfield 2009). Individuals and communities may view CFP as a form of food security, community development, workforce training, cultural exchange, as relationship with agricultural heritage, as a form of control over chemical use in production, as a source of cultural diversity, as a vehicle for outdoor recreation, for beautification of home place, and for still other reasons.

Still, the potential for CFP to mitigate food insecurity has been a primary motivator for many supporting organizations and funders of the practice. In 2009 it was estimated that over 35.5 million people, including 12.6 million children, face a constant struggle against hunger in the U.S. alone (The Food Research and Action Center 2009). These individuals, families, and in some cases communities, are said to be "food insecure" (Nord et al. 2008). They lack access to food or are uncertain about whether their food needs will be met. At the micro-scale, individuals and households can experience food insecurity for a wide range of reasons.

Community food security advocates explore the underlying community or regional-scale drivers of this insecurity and have argued for an increase in CFP at all levels (Hamm and Bellows 2003). Thus, while practitioners, especially home gardeners, may report a very wide-range of benefits associated with CFP, municipal and organizational support has tended to focus on providing specific target populations with access to food, and especially access to fresh fruits and vegetables.

Non-profit organizations, municipalities, and other groups widely report programmatic objectives for CFP development and many report a specific interest in food security. However, there has been little research conducted on either the realized or perceived value of participation as it pertains to food security. The potential for difference between organizational objectives, participant objectives, and realized values suggests the need for program evaluation on the local scale and applied research of CFP value at a larger scale (D'Abundo and Carden 2008). This presents a knowledge gap for policy. Understanding the degree to which the spatial distribution of CFP resources coincides with food insecure communities could shed light on (1) whether food insecure communities are themselves investing in CFP and (2) whether organizations and institutions are locating CFP (spatially) in ways that specifically address food insecurity.

CFP assessment and evaluation in Madison, Wisconsin (USA)

Madison, WI (USA) and the broader Madison Urban Area (MUA) is home to more than 40 organizations devoted to CFP, boasts more than 60 community gardens, supports a public charter school based on urban agriculture, and continues to support new and innovative CFP programming publicly and privately. This wide investment has led to growing concern over resource allocation and a significant interest in assessment and evaluation. However, many of the questions being asked by individual organizations through evaluation are in fact broader questions of CFP as a practice. In Madison, assessing the perceived and actual value of CFP; a practice supported through municipal and regional training, material resources, and professional resources demands identifying where CFP resources are on the landscape. This mapping of resources has been a challenge for stakeholders and, for us, proved an opportunity for a public–private research partnership between practitioners and researchers.

In the winter of 2007 we began working with CFP practitioners in the MUA to better understand the needs of the CFP community collectively and individually. This process led to a formalized interview process beginning in 2009 to identify key themes of concern and research needs. Individual CFP practitioners including home gardeners, community gardeners, and school garden community leaders were interviewed as were agency representatives, municipal authorities, and non-profit administrators. Collectively, through an iterative process of balancing individual programmatic needs, broader questions of CFP as a phenomenon, and our individual strengths as researchers, we developed a mixed-method interdisciplinary research approach to assess the socioeconomic value and spatial complexity of CFP in the MUA. From the perspective of collaborating organizations and practitioners, it was considered highly important to understand whether CFP can be thought of as a tool to combat community and household food insecurity.

Methods

The MUA is defined by the United States Census Bureau based on population density and includes the city of Madison, WI as well as its broader urban footprint including several smaller suburban cities, towns, and villages (See Fig. 1a). U.S. "urban areas" consist of contiguous, densely settled census block groups and census blocks of at least 386 people per

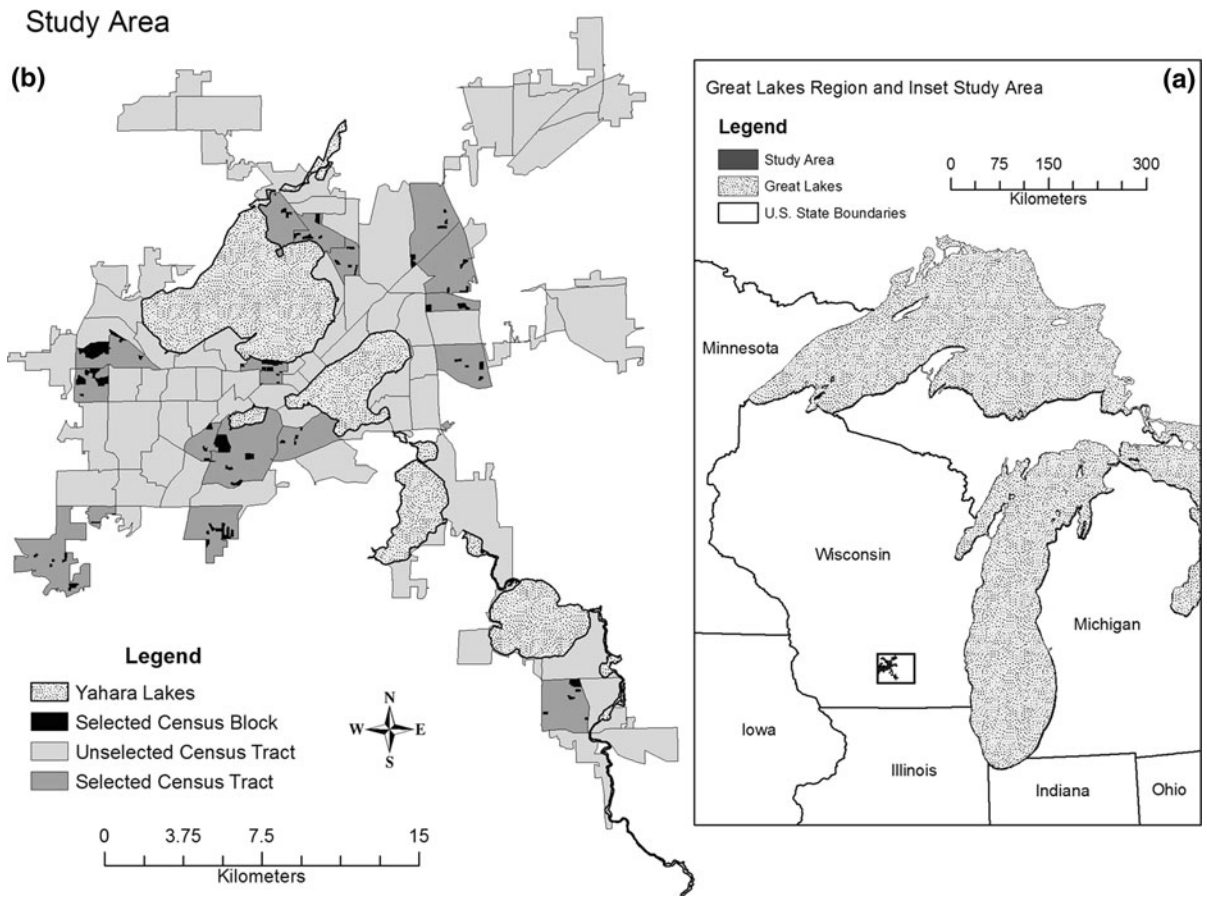


Fig. 1 **a** Geographic extent of the Madison Urban Area (MUA) and Yahara Lakes in the context of the Great Lakes Region (USA) **b** Home garden sampling design displaying the census tracts and chosen census blocks within those tracts selected for analysis

square km (1,000 people per square mile), along with adjacent census blocks of at least 193 people per square km, (500 people per square mile) that together encompass a population of at least 50,000. The MUA comprises 309 square km and has a population of 346,496 individuals or 158,313 households as determined by the 2009 American Community Survey 5-year estimate.

Significant investment in CFP in its many forms was known to exist within the study area prior to our research. However the spatial distribution of these CFP resources was largely unknown. One of our non-profit collaborators dedicated to the development of school gardens, community gardens, and food pantry gardens was able to contribute a list of all known gardens of this type. All community gardens, food pantry gardens, and school gardens were then contacted to obtain physical addresses. All addresses were then geocoded as points in the context of the study area. Community garden, school garden, food pantry garden, and collaborator contacts were interviewed to collect attribute data for each garden. Attributes collected included: number of plots, number of families served, total garden area, and tenure. Several contacts were unable to supply total garden area. In each of these cases, the garden was measured by a member of our research team.

Home gardens, a far more dispersed yet abundant form of CFP, had not been previously mapped. A multistage probability sampling procedure (Adler and Clark 2011) was used to estimate home garden presence and size over the study area. Median household income for each of the 89 census tracts within the MUA was determined from the 2000 U.S. Census and then grouped by quartile. Four tracts from each of the income quartiles were then randomly

selected for a total of 16 selected census tracts. Eight census blocks from within each of the selected 16 census tracts were then randomly selected for sampling as illustrated in Fig. 1b. The resulting selection included a total of 2,454 unique addresses across the study area and across income categories.

During the summer of 2010, these 2,454 addresses were visited by our research team. Research teams determined whether CFP at any scale was present at the selected address. If CFP was present, the area under production was estimated and further surveying and/or interviews were conducted with gardeners (Smith 2011). All identified addresses were geocoded, and attributes were added to each as identified in the survey procedure.

Presence of home gardens and community gardens (including food pantry gardens and school gardens) were then explored against socioeconomic data to better understand where gardens are located in relation to household income and home ownership status (owned versus rented). The 2000 U.S. Census was used to identify block group and tract level median household income (MedInc), assign an income category by quartile (IncCat), identify percent of single family homes, and identify percent of homes owned versus rented (OwnRate). Variables were considered for their potential in illustrating the extent to which CFP presence is spatially related to household socioeconomic variables at the block group and tract level.

We assessed the relationship between home garden participation and socioeconomic variables by performing single variable and multi-variable regression analysis against median household income (MedInc), percent single-family unattached housing, and percent home ownership (OwnRate) in step-wise fashion.

Because home garden presence was sampled only in eight selected blocks within 16 selected tracts, a continuous spatial pattern assessment across the MUA, (e.g. average nearest neighbor) would not be relevant, rather it would be highly clustered due to sampling design. In response, we ran multi-distance spatial pattern analysis (Ripley's K) to identify distances at which clustering drops off. In addition, we examined the percent of households participating in home gardening by tract income category (IncCat), and we explored the frequency of community gardens by income at the block group level and by ownership rate. We additionally summarized the shape of resulting histograms.

Key stakeholders, decision-makers, and representatives were subsequently interviewed to assess why community gardens and school gardens had been placed at present locations and where future placement might take place. Home gardeners were asked to address their decision to participate in CFP through both questionnaires and in-depth interviews. To the extent these findings compliment the spatial context of CFP, they are included here. A thorough reporting of findings from interviews and questionnaires of participants is available in Smith (2011).

Results

Home gardens

The percent of households participating in home gardening at any scale within selected tracts was determined from multistage random sampling and mapped in Fig. 2a. Home gardens were significantly clustered across the study area regardless of distance but approached a dispersed distribution at distances greater than 20,000 m, the approximate extent of the study area.

All economic correlates were found to have a statistically significant linear relationship with home garden participation (median household income, $p = 0.0386$, percent single family unattached housing, $p = 0.01818$, percent home ownership, $p = 0.0085$). The single best regression model consists solely of percent home ownership as noted in Table 1. Box plots of home garden frequency by tract level median household income category support the regression results (Fig. 3).

Interpolation of home garden participation based on regressive trends permits a spatial estimation of CFP across the landscape. Median household income was used as the regression variable to interpolate participation in CFP in un-sampled tracts. Median household income was used in the regression as it proved to be the most reliable variable available across the study area. The result provides a partial perspective of CFP composition and landscape configuration (See Fig. 3b). Additional perspective is leant by visualizing the extent to which this configuration correlates to economic variables such as the one on which this interpolation is based and the more publicly utilized variable of median household income (Fig. 4).

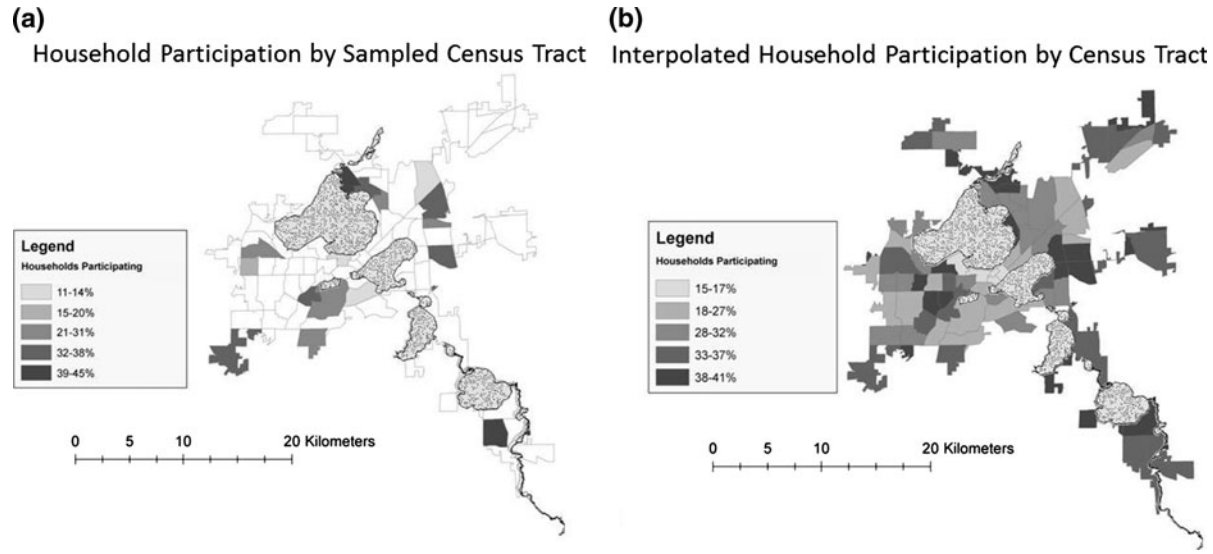


Fig. 2 **a** Percent of households participating in home food production at any scale in sampled census tracts **b** Interpolated percent of households participating in home food production by census tract. Interpolation has been based on the significant relationship between garden presence and median household income

Table 1 Results of linear regression models of garden frequency versus tract characteristics

Model	R squared	F statistic	*p* value
Income	0.2192	5.211	0.0386*
Ratio single family unattached	0.2907	7.147	0.01818*
Ratio ownership	0.3577	9.354	0.0085*

* Statistically significant

Community gardens

The spatial pattern of community gardens across the MUA is only slightly clustered at distances within 3,000 m, but near random beyond that distance. Community garden frequency by income and ownership indicate a different pattern than that of home gardens. Community garden presence relative to median household income and home ownership were assessed at the census block group level, as block groups best reflected the geographic area served by individual community gardens. Plotted against the block group income variable (MedHhldInc) mean income was $45,502 (std 18,702, median 41,862), and right skewed toward lower incomes (skewness 1.199, kurtosis 5.76) (Fig. 5a).

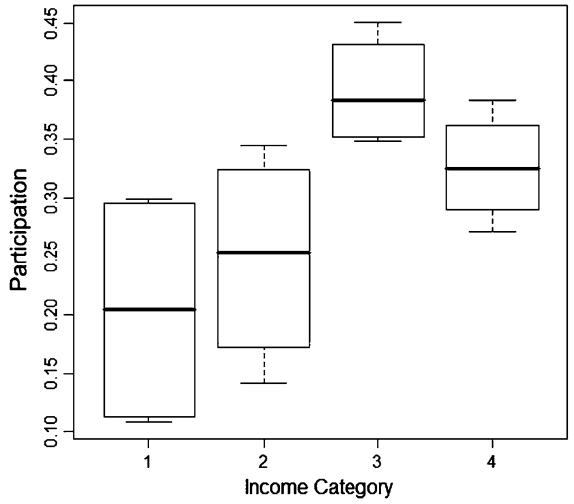


Fig. 3 Ratio of households participating in home gardening by income quartile

The presence of community gardens by the block group variable for ownership (PerHhldRent) approaches a normal distribution with a mean of 50.201 (std 26.001, median 49.019), and hardly skewed (skewness 0.07, Fig. 5b). Together these results indicate that CG placement was following policy priorities.

Program prioritization criteria suggest that community gardens are to be placed in areas of lower

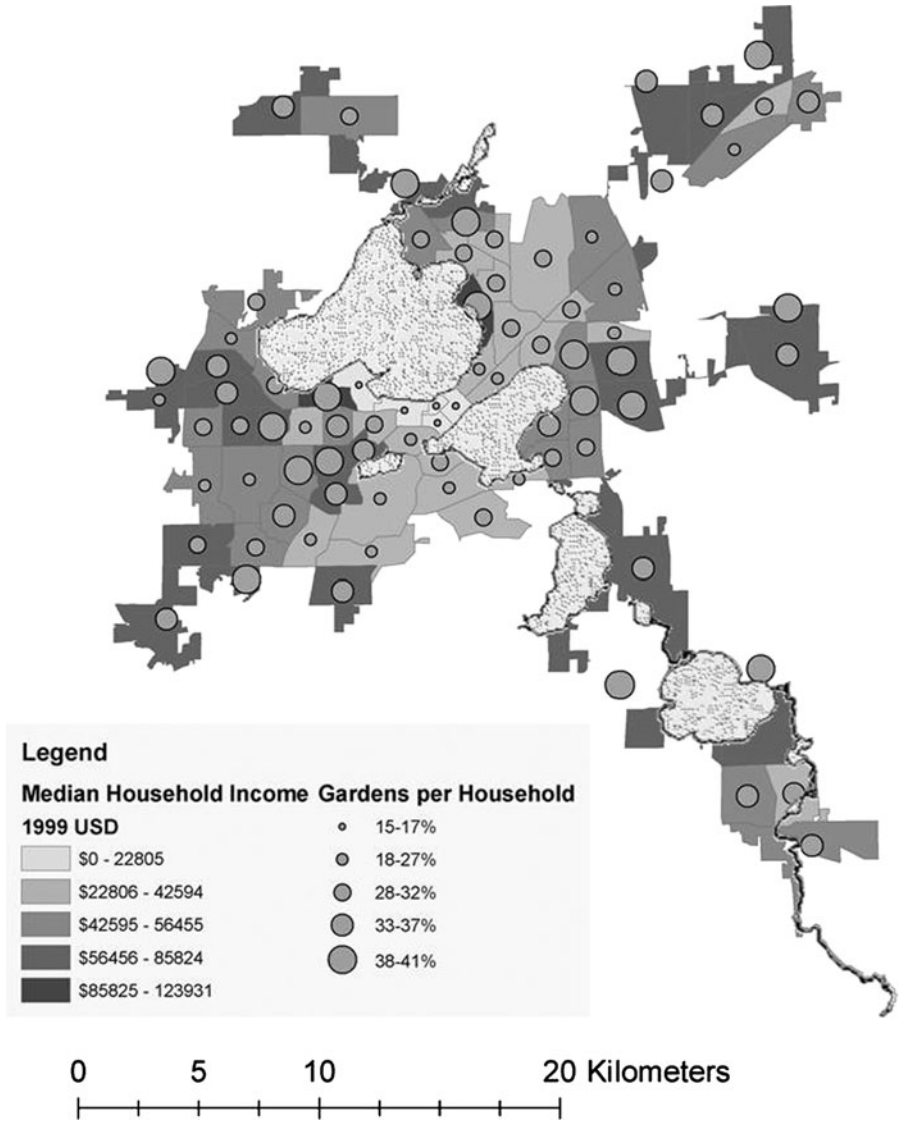
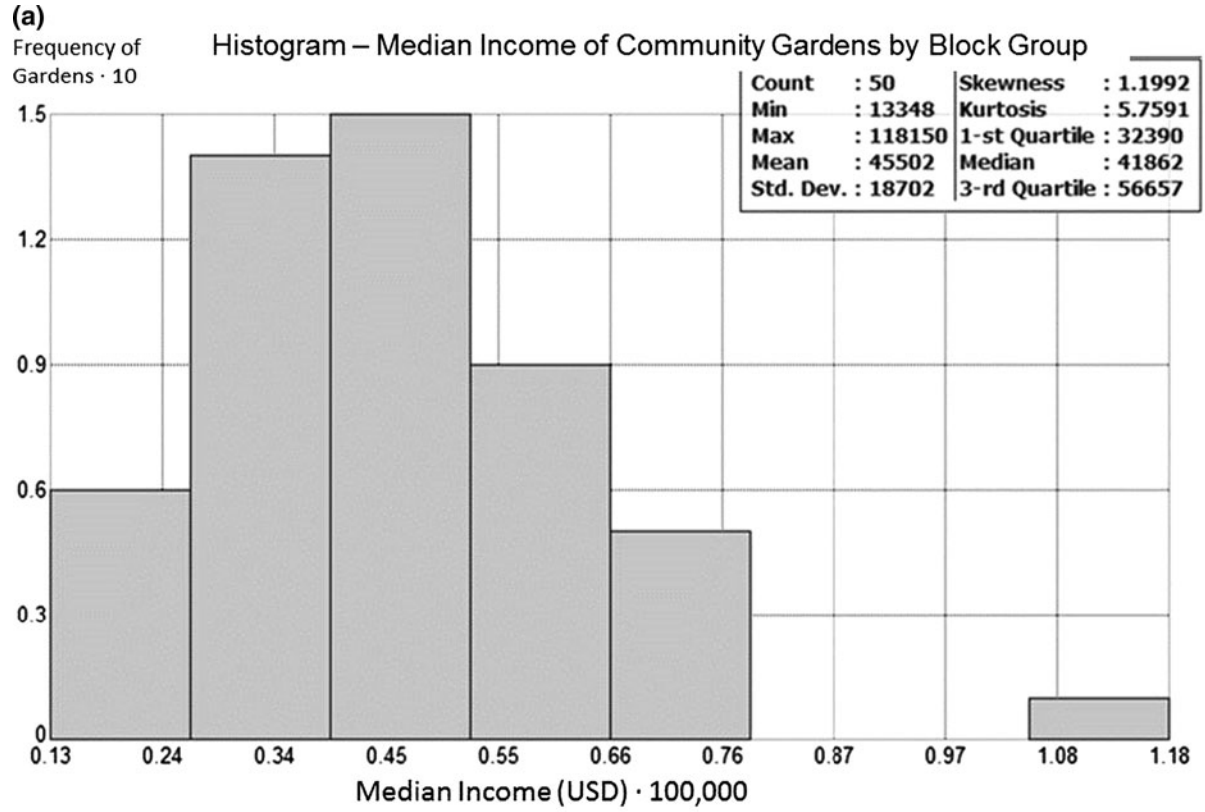


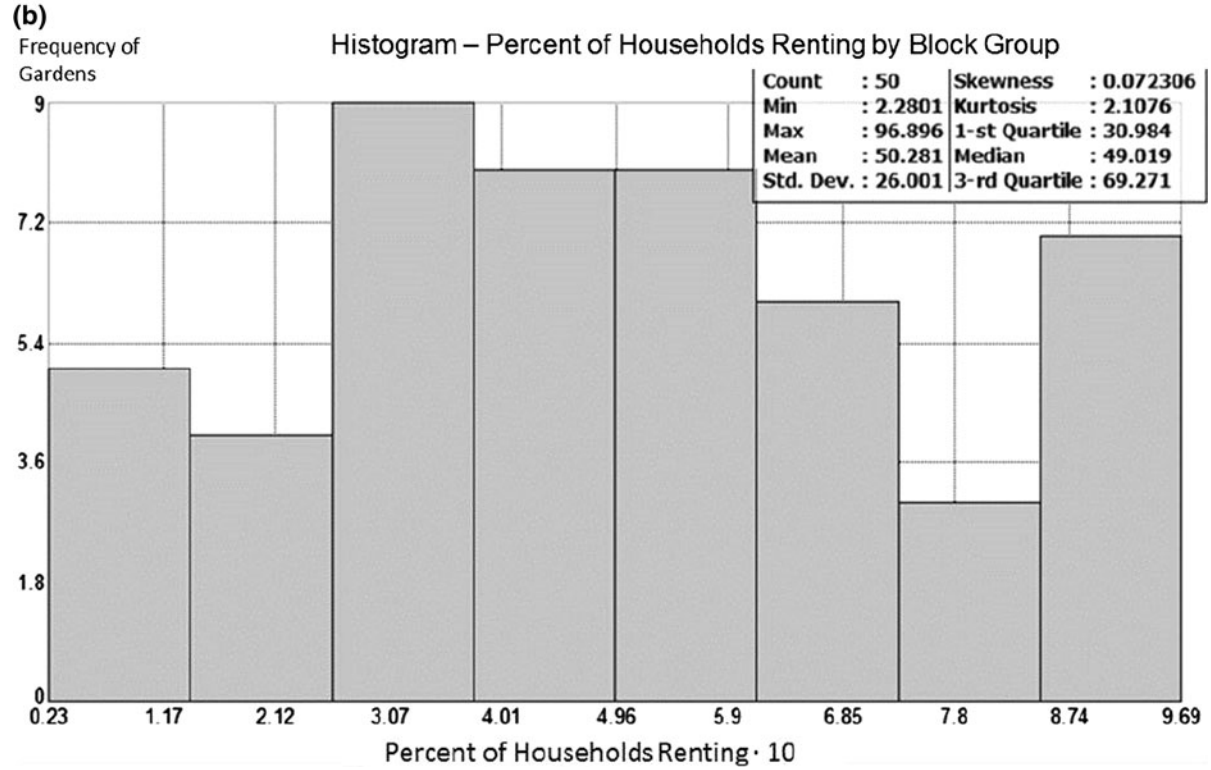
Fig. 4 Interpolated percent of households participating in home food production displayed with median household income

median household income. Garden placement appears to follow prioritization criteria historically. However, recent investment in community gardening from neighborhoods and institutions that are not entirely dependent on external sources of funding is occurring in or around areas with higher median household income as noted in Fig. 6.

Additionally, supplemental data collected from questionnaires of home gardeners suggests the median income of CFP practitioners (home gardeners = $93,000 and community gardeners = $58,074) are higher on average than the median household income of the study area as a whole ($54,057) (Smith 2011).

Community, school and food pantry gardens were scattered widely across the MUA, and did not necessarily adhere to garden placement guidelines developed by one of our non-profit collaborators and a city committee on community gardens. These guidelines, interpreted from interviews and archival research, included prioritizing neighborhoods with low median household income, high concentrations of renter occupied households, and high ethnic diversity. When gardens were compared with a ranked overlay of demographic variables specified by these placement guidelines, only a small concentration of gardens were located in a prioritized area. Outside of this


(a)
Frequency of Gardens · 10
Histogram – Median Income of Community Gardens by Block Group
Count : 50
Min : 13348
Max : 118150
Mean : 45502
Std. Dev. : 18702
Skewness : 1.1992
Kurtosis : 5.7591
1-st Quartile : 32390
Median : 41862
3-rd Quartile : 56657
1.5
1.2
0.9
0.6
0.3
0
0.13
0.24
0.34
0.45
0.55
0.66
0.76
0.87
0.97
1.08
1.18
Median Income (USD) · 100,000


(b)
Frequency of Gardens
Histogram – Percent of Households Renting by Block Group
Count : 50
Min : 2.2801
Max : 96.896
Mean : 50.281
Std. Dev. : 26.001
Skewness : 0.072306
Kurtosis : 2.1076
1-st Quartile : 30.984
Median : 49.019
3-rd Quartile : 69.271
9
7.2
5.4
3.6
1.8
0
0.23
1.17
2.12
3.07
4.01
4.96
5.9
6.85
7.8
8.74
9.69
Percent of Households Renting · 10

◀**Fig. 5** **a** Histogram and corresponding statistics for frequency of home gardens by median household income (MedHhdInc) in US dollars across block groups **b** Histogram and corresponding statistics for frequency of home gardens by ownership rate (PercHhldRent) across 16 sampled tracts

concentration, gardens were generally placed in areas with a lower ranking.

Interviews with decision-makers indicate that garden placement is more often influenced by nearby property owners or overall community interests. In addition, placement of gardens in close proximity to mid-high income neighborhoods was reported as facilitating ongoing maintenance and preservation of gardens, whereas many gardens in low-income neighborhoods have been forced to relocate due to development pressures and lack of support. This recognition on the part of decision-makers suggests several challenges in using CFP as a form of food security in low-income areas.

Municipal agencies have also suggested that areas with high population density be prioritized in planning for community, school and food pantry gardens, yet few gardens have been created in such areas. Over time, gardens have increasingly been established through neighborhood planning processes outside of the urban core.

Combined home garden and community garden results

The total number of community gardens, food pantry gardens, school gardens, and the interpolated number of home gardens along with total area were determined (See Table 2). Community gardens and school

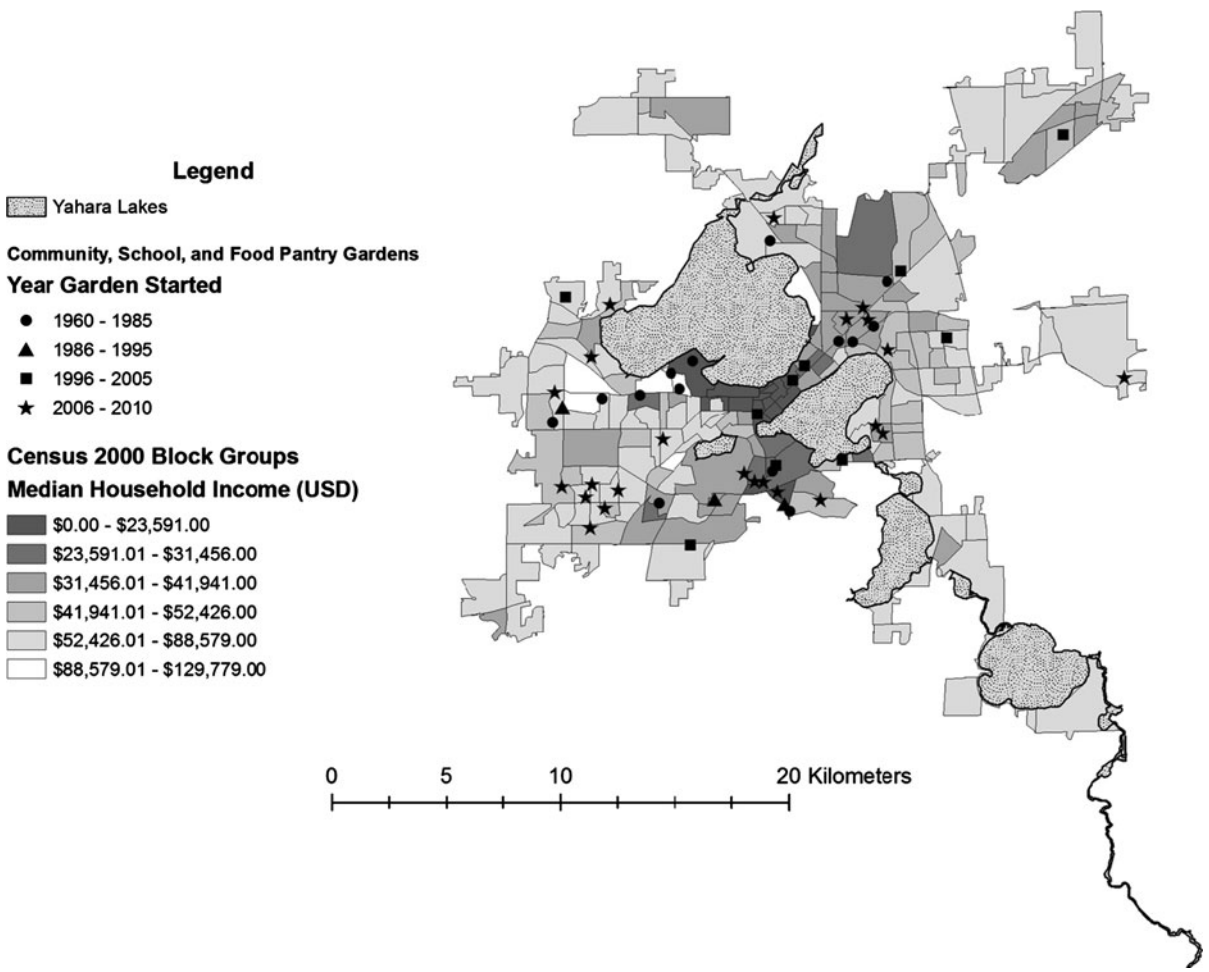


Fig. 6 Community, school, and food pantry gardens, their dates of origin and background median household income

Table 2 Total interpolated number of home gardens, community gardens, food pantry gardens, and school gardens (collectively community gardens) and their respective area

	Home gardens	Community gardens	Total gardens
Gardens	45,193	2,991	48,184
Area of gardens (m^2)	491,219	110,551	601,770

gardens are frequently more visible and publicly acknowledged than home food production. However, in terms of total area, home gardens occupy a much larger portion of the landscape than do the other larger less dispersed forms of CFP. In terms of food security planning, this finding suggests the need to consider not only community garden placement as a tool, but also the potential for food insecure households to garden at home and what barriers may exist for them.

In summary, an estimated 33 % of MUA residents are growing food at one or more locations in the MUA based on our spatial interpolation. This estimate is comparable to the estimate of the National Gardening Association that reported 31 % of all U.S. households were participating in CFP in some form in 2010 (Butterfield 2009). The data collected in our study, however, reveals a spatially and economically disconnected pattern. These findings lead to further discussion as to whether CFP in its present form and placement do in fact serve as tools for community or household food security, or whether they satisfy other interests in food system participation. The findings also illustrate how current resource distribution can enable future resource allocation decisions.

Discussion and practice

Method contributions

The spatial data we have compiled and analyzed here suggests the need to more closely examine both the motives for participation in CFP and its overall role in food security. CFP is practiced for a wide range of reasons as we've already described. However, the majority of funding for CFP at present and its coverage in popular media have revolved heavily around its potential use in combatting food insecurity. By mapping for the first time, the current extent, composition, and configuration of CFP on the landscape, we found the ways in which current configuration of CFP relate to socioeconomic and/or demographic data within this area, is not necessarily what policy or advocates would state (Hamm and Bellows 2003; D'Abundo and Carden 2008; Butterfield 2009). Moreover, our study considered what relationships between spatial configuration and socioeconomic data suggest about the role of CFP in combating food insecurity. Our findings are similar for community and home gardens, but qualify arguments currently in the literature about the ways in which CFP leads to food security by noting that whether CFP leads to community food security depends on placement and motive. Furthermore, our iterative involvement with stakeholders in both designing the questions, and in supplementing analytical findings with their experiential knowledge, assures that this work is more accurate and relevant for future policy and CFP decision-making.

Home gardens

Home gardening is in many ways distinct as a form of CFP in that its practice is largely determined at the household level rather than by larger institutional structures. That said, municipal zoning ordinances, community planning, neighborhood association policy, rental policies, and access to training all impact the degree to which CFP can actually be practiced at home. The choice to participate in CFP, then, even for home gardeners is determined at least in part by landscape-level interests.

The reality that home gardening participation is strongly correlated with home ownership and income suggests that some component or many components of economic advantage determine whether an individual will be able to participate in CFP. Interviews and questionnaires with participants have suggested in our work, as has been suggested by others (Butterfield 2009; Lovell 2010), that these advantages may include time, money, and reliable access to land. In our surveying of home gardening, we found evidence of CFP participation by renters, including apartment renters. While this context typically involves container plantings on a small scope, it does suggest that participation is possible. That said, the number of apartment renters participating is far lower than the number of homeowners participating.

Community gardens

In this study, community gardens were not always created in areas with the lowest income. Newer community gardens in the study area have been placed in or adjacent to areas of medium to high median income, suggesting that spatial decision making for community garden placement was based on factors other than the aims of the food security policy and proximity to food insecure populations, despite what might be stated publicly (e.g. Patel 1991). In addition, recent shifts in the CFP resource planning process emphasizing garden placement in areas of projected growth and development, as opposed to existing development, may widen gaps between CFP and food insecure populations. Thus, organizational forms of CFP such as community gardening and school gardening depend on institutional and or municipal decision-making that may or may not favor access to CFP by food insecure populations.

Our methods revealed these inconsistencies by placing community and home gardens in a spatial context with socio-economic variables and qualitative input. In addition to surveying and comprehensively mapping gardens in the Madison area for the first time, no other studies to our knowledge, have related spatial configuration of CFP to its socio-ecological context in this kind of landscape approach.

Impact on practice

The public–private research collaboration developed here has been instrumental in the long-term planning of CFP within the MUA. Our landscape ecological approach has allowed key stakeholders a way to visualize the dynamic configuration of CFP within the Madison area, through sharing mapped distributions of community and home gardens. It has further been useful in identifying broad trends in CFP occurrence. In the case of community gardens, school gardens, and food pantry gardens this pattern in occurrence is indicative of community interest as well as supporting agency commitment to institutional policies governing placement in food insecure communities. In the case of home gardening, occurrence is suggestive of home owner interest, but is also useful in determining institutional or political barriers to home food production such as neighborhood policies, municipal zoning, and landlord concerns. Our method illuminated inconsistencies between policy aims and CFP realization on the ground. Working with local stakeholders and CFP practitioners helped us to explore and answer why these inconsistencies might exist.

In practice, the use of a landscape socio-ecological approach and landscape planning principles has been difficult for non-profit administrators, regional decision-makers, and municipal government. In this case, barriers to their uptake appear to be a lack of knowledge about the potential value of these spatial contexts and approaches to inform decision-making and overall lack of resources to develop and implement research on any scale. Nevertheless, locally our work has been presented to, and reports shared with the Community Action Coalition and City Council, by their request, for future decision-making.

As researchers, we too faced barriers in the application of a landscape socio-ecological approach in the context of a community-driven question. Incomplete spatial data, mismatches between census-based demographic data and community-level resources, along with challenges in surveying home garden presence complicated our approach. Likewise, other data might have complemented our analysis. For example, the resolution of data sets such as land cover is insufficient in addressing problems on the municipal scale. We would have liked to look at the occurrence of CFP against urban tree canopy data. However, even the resolution of municipal-wide urban tree canopy data could not be used to identify home gardens due to insufficient resolution.

Our research was also complicated by CFP placement policies and governance that have been implemented at varying scales. As a result, our application of a landscape socio-ecological approach necessitated an understanding of the relationships between patterns in CFP occurrence and decision making at neighborhood, municipal and regional levels. Thus the role of stakeholders throughout the research process was crucial in navigating these complexities. While complex relationships between scale and pattern provided challenges for us as researchers, it is precisely this attentiveness to concepts central to landscape ecology that practitioners have expressed interest in partnering to understand. Likewise, we believe the approach taken here facilitated a new understanding of the socio-spatial complexities of CFP, and that this contributes to the broader theoretical knowledge related to food security and landscape resilience.

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