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Can Urban And Peri-Urban Agriculture Create Food Sovereign Communities? Case Studies In Cuba And Burlington, Vt

Bennett LaFond
University of Vermont

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CAN URBAN AND PERI-URBAN AGRICULTURE CREATE FOOD SOVEREIGN COMMUNITIES?
CASE STUDIES IN CUBA AND BURLINGTON, VT

A Thesis Presented

by

Bennett LaFond

to

The Faculty of the Graduate College

of

The University of Vermont

In Partial Fulfillment of the Requirements
for the Degree of Master of Science
Specializing in Plant and Soil Science

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Thesis Examination Committee:

Ernesto Mendez, Ph.D., Advisor
David Conner, Ph.D., Chairperson
Josef Gorres, Ph.D.
Cynthia J. Forehand, Ph.D., Dean of the Graduate College
Abstract

Case studies from Cuba's Urban and Peri-Urban agriculture (UPA) revolution show that urban growing can fuel locally driven production of essential foods with minimal inputs, creating unprecedented opportunities for community food sovereignty. The fact that Cuba produces 60-70% of its vegetable needs on 25% of the land shows that the barriers that UPA faces are more sociopolitical than agronomic. As an agricultural hub with an abundance of rural land within close proximity of the city, the need for UPA in Burlington, VT may not be as readily apparent. When compared to nearby small vegetable growers through the lens of a typical agronomic analysis, UPA nearly always comes out at a disadvantage. Yet community gardens and urban growers are multiplying in the small city. Research suggests this boom is owed to numerous multi-functional benefits provided by community gardens, including the potential for UPA to allow communities who may otherwise have limited agency in food choice with an opportunity to access culturally preferred produce. However, while extensive evidence identifies the social benefits of community gardens, these results remain disparate from the economic analyses that most often find their ways into the hands of decision makers.

This research proposes a valuation metric called Crop Value Index (CVI), and uses it to evaluate which crops and management techniques best take advantage of limited urban space in Burlington community gardens. This tool ranks crops by their ability to save gardeners money or profit and by their perceived cultural value by the gardener, and combines the two to identify which crops are the most successful in producing overall value. Through demonstrating the high functionality of UPA in the production of certain crops, CVI contributes to findings that indicate that UPA may be better able to serve niche community food needs than commercial growers, while simultaneously providing urban growers with food security and creating food sovereignty and food justice.
Dedication

This thesis project is dedicated to all those who are far from home, longing for one more taste of the foods that make them feel whole.
Acknowledgements

As the collaborative process is integral in all knowledge creation, so was it in the development of this thesis.

A special thanks to the Gund Institute, whose contribution of a small grant allowed travel to Cuba and the opportunity to see Cuban organoponicos first hand. In the writing of the analysis of Cuba, Richard Chourlaton and his colleague Gabriella Hernandez at the World Health Programme Cuba provided essential insight.

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And last but not least, my parents, grandmother, and little sister, for none of this would have been possible without their ongoing love and support.
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List of Abbreviations and Uncommon Terms

Abbreviations

UPA - Urban and Peri-Urban Agriculture
CCS - Credit Service Cooperatives
ANAP - National Association of Small Growers
MinAgri - Cuban Ministry of Agriculture
CVI - Crop Value Index
VM - Value Metric
NET - Scaled and ranked net per ft$^2$ as component of CVI
PAR - Participatory Action Research
ALC - Agroecology and Livelihoods Collaborative
CIMEX - Top Cuban supermarket chain
CES - Cultural Ecosystem Services
VCGN - Vermont Community Garden Network
NFNA - New Farms for New Americans
CTG - Community Teaching Garden
LUV - Land Use Value

Non-English/Uncommon Words

Milpa - traditional Latin American bean/corn/squash intercrop
Organoponico - Cuban urban farm
Acopio - Cuban state food ration acquisition
Libreta - Cuban state food ration
Mula - Nepali/Bhutanese diakon radish
Rayo saag - Nepali red mustard green
Inhori - African white/green eggplant
Jukuni - Pointed Gourd
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Chapter 1: Introduction

Urban and Peri-Urban Agriculture (UPA) has become a rapidly growing global movement in the past ten to fifteen years (Birky & Strom, 2013; Fernandez, Méndez, Mares, & Schattman, 2016; Ghose & Pettygrove, 2014). The rise in urban growing is due not only to the value of locally produced food, but to multifunctional social, psychological, and health benefits; a range of ecological and cultural ecosystem services (EES & CES) it creates; and the potential to empower urban populations to gain sovereignty over their food production and food choices (Brown & Jameton, 2000; Clarke & Jenerette, 2015; Fernandez et al., 2016; Gould et al., 2014; Hartwig & Mason, 2016; J. R. Taylor, Lovell, Wortman, & Chan, 2017; S. Taylor & John, 2013; Tornaghi, 2016; Vitiello, Ann, Whiteside, & Fischman, 2015).

While research shows that the yields obtained in UPA may be equal to those seen by commercial vegetable producers on rural land (Algert, Baameur, & Renvall, 2014; M. a Altieri et al., 1999; Funes, Altieri, & Rosset, 2009; Gittleman, Jordan, & Brelsford, 2012; Vitiello & Wolf-powers, 2014), the economics of urban agriculture, and especially community gardens, may be less lucrative (Badami & Ramankutty, 2015; Ghose & Pettygrove, 2014; Mok et al., 2014). Many critics of the movement draw concerns that UPA inefficiently uses water resources and contaminates the urban environment with pesticide and fertilizer (Barthel & Isendahl, 2013; Rothwell, Ridoutt, Page, & Bellotti, 2016), or, alternately, that the heavy metals in the soil or atmospheric pollution in the urban environment may contaminate food grown in UPA (Kohrman & Chamberlain, 2014; Richards, Farrell, Tom, Williams, & Fletcher, 2015; Specht et al., 2014). These concerns are compounded by the fact that while urban growing often begins on idle or
neglected land, as neighborhoods change, land values can increase, causing a rise in competing interests in the space and threats to land tenure (Dubbeling, Zeeuw, & Veenhuizen, 2010; Garrett & Leeds, 2015; Veenhuizen, Danso, & G., 2007).

Yet urban growing has the potential to improve access to fresh, locally grown foods (Corrigan, 2011). Beyond food security, UPA empowers growers and gives them increased agency in food choice (Tornaghi, 2016; Vitiello et al., 2015). For growers from minorities and low-income groups, this type of agency is paramount in addressing the challenges created by an agri-food system which is neither designed nor controlled by or for them (Cohen & Reynolds, 2014; Ghose & Pettygrove, 2014; Pearson, Pearson, & Pearson, 2010; Tornaghi, 2016). Yet UPA's capacity to serve community needs is constantly challenged by its need for land, subsidy, and policy support; necessitating research that investigates UPA's agronomic functionality in providing local food to cities, and the difficult-to-quantify multifunctional benefits it creates. Examining case studies, identifying successes, and developing means of communicating these functions are the elemental first steps in working toward the scalability and broader application of UPA (Armar-Klemesu, 2000; Clarke & Jenerette, 2015; Gómez-baggethun & Barton, 2013; Pearson et al., 2010).

This thesis draws on lessons from the UPA revolution in Cuba that took place during the severe food shortages in the Special Period following the fall of the Soviet Union. It examines how successfully the unilateral push for UPA was able to create food sovereignty for the island nation, addresses concerns of how urban growing will be affected by Cuba's current ongoing transition into the global economy, and identifies lessons that could be adapted to the application of UPA in other countries.
In order to understand how urban growers in the United States can apply these lessons and optimize their use of contested urban space and financial resources, this thesis proposes a metric for studying the valuation of services provided by UPA at a crop and grower level. This metric is used to examine four community gardens in the Burlington area, shedding light on the efficacy of the tool and providing insight into the functions of food sovereignty and food justice that community gardens provide.

**Organization of this Thesis**

The body of this thesis is divided into three sections: a literature review and two articles.

*Chapter 2: Literature Review* draws from over 120 documents written on urban growing. It explores the history of UPA, as well as literature that examines the yields, multifunctional benefits, and economics of UPA. It focuses primarily on works that address UPA in the US, but also includes research on Cuba and global applications.

*Chapter 3: The Role of Urban Agriculture in Cuban Food Sovereignty* examines literature on the successes of UPA in Cuba in comparison to critiques of the movement, literature of Cuban food security and agronomics, and FAO/WHO statistics. It addresses the challenges to the Cuban UPA movement faced in a transition economy, as well as challenges to UPA owed to Cuban dietary preference and culture. It pays particular attention to the frequently cited (but difficult to track down) figure that Cuba imports 80% of its food, which is often used as an argument against the successes of Cuban UPA. Finally, it identifies agronomic and economic barriers to food security in Cuba, and
recognizes potential opportunities for UPA to contribute to food security and food sovereignty on the island.

Chapter 4: Using Valuation Metrics to Measure the Food Sovereignty Benefits of Community Gardens proposes Crop Value Index (CVI) as a tool for combining valuation of cultural ecosystem services (CES) with calculations of net profit/savings and allows analysis of these functions at a crop and grower specific level. It applies this metric to the study of gardeners at four community garden sites in Burlington, VT, and analyzes the implications of these findings in how they relate to food sovereignty and food justice. It is divided up by the same sections typical of research papers; with an introduction, methods, results, discussion, and conclusion section. The discussion is divided into an assessment of CVI's efficacy as a metric and an interpretation of the findings of the study using CVI on Burlington community gardens.

Chapter 5: Conclusion synthesizes the lessons gleaned from the literature review, findings on UPA's role in Cuban food sovereignty, and findings from Burlington community gardens. It discusses how the combination of these research areas demonstrates the importance of UPA as a tool for creating food sovereign communities.
Chapter 2: Literature Review

Introduction

Urban and peri-urban agriculture (UPA) has been steadily gaining momentum in recent years for a diverse range of reasons. In the international development community, UPA has shown promise as a method of increasing food security for rapidly urbanizing populations (Blay-Palmer, Renting, & Dubbeling, 2015; Gert Groening, 2005; Veenhuizen et al., 2007), while in depressed cities like Detroit, UPA has been touted as a way to improve nutrition and generate micro-enterprise (Draus, Roddy, & McDuffie, 2014; Kaufman & Bailkey, 2000; Walker, 2016). Community gardens have sprung up in many different cities and in many different forms; ranging from rented garden plots to teaching and meeting spaces for new American families (Hartwig & Mason, 2016; Hondagneu-Sotelo, 2017; Saldivar-Tanaka, 2004; Zasada, 2011). Many longer standing gardens, especially those in larger cities with large immigrant populations, serve as essential social spaces for communities (Algert et al., 2014; Corrigan, 2011; Vitiello & Nairn, 2009).

As the number and type of UPA spaces have increased, so has the need for research that investigates what functions they serve. Many urban farm and garden spaces are in constant threat of appropriation and development, and UPA practitioners are in need of tools to communicate their value in concrete terms to policy makers and the community (Golden, 2013; Vitiello & Nairn, 2009). One frequent concern about UPA is the contamination of habitable spaces by the use of pesticides, or alternately, the contamination of crops by heavy metals and urban pollutants (Borysiak, Mizgajski, & Speak, 2017; Veenhuizen et al., 2007; Warren, Hawkesworth, & Knai, 2015). As well,
many urban and peri-urban sites begin on neglected or abandoned land, but as land use patterns change and land value increases, tenure comes under dispute, threatening the longevity of garden sites (Koont, 2009; Vitiello & Nairn, 2009; Walker, 2016).

The approach of many researchers has been to focus on the social benefits which community gardens create (Blay-Palmer et al., 2015; Golden, 2013; Warren et al., 2015). Regardless of whether or not community gardens and urban farms are capable of producing food in an economically viable way, they provide unique spaces of social gathering (Boukharaeva & Marloie, 2006; Cohen & Reynolds, 2014; Golden, 2013; Lovell, 2010; Pitt, 2014). For urban communities, these spaces function as an extension of their homes: places for cooking, sharing traditions, recipes, and discussing the wellbeing of the neighborhood (Pitt, 2014; Purcell & Tyman, 2015; Saldívar-Tanaka, 2004). Additionally, outside of the nutritional benefits associated with growing and eating more produce, the act of gardening provides opportunities for exercise and other therapeutic benefits gained from being outdoors (Boukharaeva & Marloie, 2006; Corrigan, 2011; Pitt, 2014).

While ultimately the social benefits that UPA provides and the subsequent savings on other social programs may be sufficient to rationalize investments by donors and local government (Brown & Jameton, 2000; Ellis & Sumberg, 1998; La Rosa, Barbarossa, Privitera, & Martinico, 2014; Nihart, 2013; Warren et al., 2015), at the time being, gardeners are looking for ways to justify ongoing support for their projects (Ellis & Sumberg, 1998; Gröning, 1996; Nihart, 2013). A significant amount of research has gone into investigating the social elements of UPA, but surprisingly little has focused on biophysical elements such as plant and soil health, crop diversity, and yield, and still less
has investigated the economic viability of UPA in its various forms (Golden, 2013; Pearson et al., 2010; Warren et al., 2015). This is, in part, due to the multifaceted nature of UPA. Sites are often dispersed throughout widely differing neighborhoods within a city and broken into multiple small plots under different management, making studies difficult to replicate and data which can be used in making predictions difficult to obtain (Gittleman et al., 2012). It's this reality that necessitates the development of tools that focus on the specific values generated in an urban farm setting and can be applied equally to varying sites.

The research that is available on yields and economics seems to draw inconsistent conclusions. Studies in the US come up with high per-acre estimates of yield and net profit, which may very well be valid, but fail to take into account the increased amount of labor per plant involved in biointensive farms, or other factors such as the cost of rent and the cost of water (Gittleman et al., 2012; D. Guitart, Pickering, & Byrne, 2012; Vitiello & Nairn, 2009). Other studies which approach the issue from a more classical agronomics perspective identify a low cost-benefit ratio in urban farms, but often treat the crops grown in UPA as equivalent to those grown in commercial farms, and fail to take into account crop quality or community food access (Goldstein, Hauschild, Fernández, & Birkved, 2016; Mok et al., 2014; Polling, Mergenthaler, & Lorleberg, 2016; Vitiello & Wolf-powers, 2014).

These same inconsistencies are present in assessments of UPA abroad and in developing countries. One study will show the increased nutrition of families participating in UPA, while another will counter it by stating that no nutritional advantage has been noted (Aubry et al., 2012; Warren et al., 2015). Likely, this is an
issue of specificity. UPA is neither one-size-fits-all nor homogenous, and the ways which it does or doesn't benefit its users may change on a case-by-case basis (Corrigan, 2011; Gittleman et al., 2012; Golden, 2013; Pearson et al., 2010; Vitiello & Nairn, 2009). Even when looking at a specific site, geography, or population, different conclusions seem to arise. In the case of Havana, Cuba, for instance, some research indicates incredible, above average production in Cuba's organoponicos, while other numbers demonstrate the opposite (M. a Altieri et al., 1999; Nelson, Scott, Cukier, & Galín, 2009). Again, this is due to a maelstrom of political ideology and a very complex research subject which can be painted in different ways depending on which elements are selected for inclusion (Funes-monzote, 2009; Peter M. Rosset & Altieri, 1997).

In combination with the dearth of research regarding biophysical properties and economics of UPA, it is this need for geographically and culturally context-specific research which necessitates this thesis project (Birky & Strom, 2013; Walker, 2016). While the hope and ultimate goal of forming an index with which to evaluate the overall value of crops is to provide test tools that could potentially serve for a broad-scale comparison, it's just as necessary to conduct further research on the Burlington area. Thanks to the ongoing work of researchers at UVM, many of Burlington's urban farm and garden projects have been the subject of at least one peer reviewed study, and some of these as multifunctionality assessments (Berlin, Hamilton, & Schattman, 2011; Lovell, 2010; Nihart, 2013). However, with the exception of some of the farms at the Intervale that keep track of their own data, very few sites have any kind of yield estimate, estimate of crop diversity, or analysis of specific crops. Considering that literature traces back the history of UPA in the United States and Great Britain to the "Victory Gardens" promoted
as a food security strategy during WWII, the scarcity of research on certain aspects of the movement can be alarming (Chan, DuBois, & Tidball, 2015; Ghose & Pettygrove, 2014; Kaufman & Bailkey, 2000).

The most recent wave of community gardening began in the 60s and 70s, and some of these gardens are still around today (Hartwig & Mason, 2016; Vitiello & Nairn, 2009). The history of some of the eldest of these, such as Las Parcelas in Philadelphia and Added Value in Brooklyn, has been well chronicled both in prose and in academic literature (Angotti, 2015; Vitiello & Nairn, 2009). More recently, new growth in community gardens has come through technological advances such as aquaponics, hydroponics, and green architecture that have allowed for the creation of growing spaces in previously inaccessible areas (Cohen & Reynolds, 2014; Nihart, 2013; Orsini et al., 2014; Specht et al., 2014). The other has been the effect of the growing popularity of the local food movement (Born & Purcell, 2006).

The 'locavore' movement has searched for solutions to reducing food miles while living in a city (Birky & Strom, 2013), but some literature suggests that in fact, the energy costs associated with UPA may be higher than that of foods trucked into the city (Born & Purcell, 2006; Goldstein et al., 2016; Hendrickson & Porth, 2012; Veenhuizen et al., 2007). Meanwhile, others debate the net energy cost of UPA by showing the possibility of achieving high yields with low inputs, as has been seen in Cuba (M. Altieri, Pallud, & Glettner, 2014; Peter M. Rosset & Altieri, 1997; Vitiello & Nairn, 2009). Sheila Golden (2013). Leonie Pearson et al. (2010) further the discussion by addressing the possibility that whether or not UPA is energy efficient comes down to what is being grown and how.
But despite some of the unresolved issues surrounding UPA, the evidence base around the benefits of urban farms and community gardens is strong and warrants further research. In Cuba, where support for UPA at a government level has been ongoing, small producers and cooperatives produce 65-70% of agricultural products on 25-30% of the arable land (Funes-monzote, 2009). The yields achieved by Cuban organoponicos are reportedly comparable or in excess of commercial agriculture, and this is achieved without chemical inputs (M. a Altieri et al., 1999; P. Rosset & Benjamin, 1994). Furthermore, UPA has simultaneously increased access to fresh foods in Cuban cities and created micro-enterprise for urban Cubans during an economic downturn (M. a Altieri et al., 1999; Koont, 2008).

The case of UPA in Cuba is unique because of the type of overarching government support the movement has received following the Special Period, but studies both in developing and developed countries demonstrate similar potential globally (Curzi & Pacca, 2015; Midmore & Jansen, 2003; Vagneron, 2007; Veenhuizen et al., 2007). In his 2012 paper, Miguel Altieri uses a series of case studies to show the capacity of agroecology to achieve equal or greater yields with less energy and chemical input. This includes a number of small urban and peri-urban farms. Zezza and Tescotti (2010) strengthen this case by examining UPA in developing countries. They demonstrate the potential of UPA as a food security strategy, but observe that it excels primarily as a strategy to increase dietary quality and nutrient density rather than increase overall caloric intake.

In consumer economies and developed countries, UPA plays a different role. While country-wide food security is generally less of a challenge, low-income
populations frequently inhabit food-deserts; areas where access to food is limited to processed, packaged foods with low nutritional value (Alaimo, Packnett, Miles, & Kruger, 2008; Armstrong, 2000; Patel, 1991; Teig et al., 2009; Wang, Qiu, & Swallow, 2014). Transportation to points of sale is a key issue facing the urban poor, and UPA has the potential to reduce the distance needed to travel to fruit and vegetable vendors (Armstrong, 2000). For immigrant communities, in addition to transportation, language makes purchasing groceries yet more difficult (Corlett & Dean, 2003; Hartwig & Mason, 2016; Hondagneu-Sotelo, 2017; Saldivar-Tanaka, 2004). Not only does UPA provide an opportunity for at-risk, low-income, and New American communities to participate in an exchange of fresh goods within their own cultural groups, but it gives these groups a say in what type of food they're growing, buying, and eating (Clarke & Jenerette, 2015; Corlett & Dean, 2003; Hondagneu-Sotelo, 2017; Saldivar-Tanaka, 2004; Tornaghi, 2016).

**Research Gaps and Justification**

This thesis aims to: 1) draw on lessons learned from Cuba; and 2) examine the functionality of UPA, in Burlington, to support food security, food justice, and food sovereignty. The literature at hand shows the degree to which it is necessary to understand geographical and cultural contexts of UPA programs in order to make recommendations about steps toward scalability. While some literature is available around issues of economic efficiency in UPA, the mainstream economic approach fails to address the non-monetary value generated by community gardens. This research will combine a cost-benefit analysis with assessments of cultural and community value, and
focus not only on specific garden sites and specific communities but also on specific crops and management styles, thereby giving an understanding of how UPA can function in the context at hand. The literature available supports the need for case specific studies, and shows the lack of data estimating yields in many settings, an essential component of understanding UPA function.

The development of the Crop Value Index (CVI) works to provide a tool to streamline this type of assessment in ongoing work. The multifunctionality framework, community capital assessments, and valuation of Cultural Ecosystem Services (CES) have become commonly used tools by researchers working with small farms and food security (Carolan & Hale, 2016; Gómez-baggethun & Barton, 2013; Gould et al., 2014; Nihart, 2013; S. Taylor et al., 2010; S. Taylor & John, 2013; White, 2016; Zasada, 2011). These frameworks are highly useful for researchers looking to understand a broader community function of urban farms, but due to their qualitative approach to outputs, can draw inconsistent conclusions about UPA yields and the value of production (Gómez-baggethun & Barton, 2013). A 2015 RUAF study identifies "data access and cost, fragmentation, robustness of sources, and comparability" as serious gaps in UPA research and highlights the need for standardized metrics (Blay-Palmer et al., 2015). CVI does not seek to replace multifunctionality or community capital frameworks, but rather to address a research gap by integrating a concrete quantifiable component into biophysical assessments. Potentially, CVI could be integrated into physical and financial elements of multifunctionality assessments of UPA projects, increasing replicability and the overall weight of this type of study.
Another key research gap in the study of UPA is an understanding of peri-urban production. Studies like Wang's (2014), Peters'(2016), and Opitz (2016) are some of the few which delineate the different productive potential of farms which are urban and peri-urban based. There are many studies that focus on urban production, and nearly as many which focus on community gardens. As well, some of the community gardens involved in these studies are in fact peri-urban (Armstrong, 2000), but by failing to classify them as such have yet to begin to build a body of research or an understanding of the potential of peri-urban production. Burlington is a unique case in terms of UPA, as it exists as an urban center in a largely rural and agricultural state (Lovell, 2010; Nihart, 2013). While there are food deserts such as those in the Old North End, their severity and size is less than that seen in larger urban centers (Figures 1 and 2). Because of this, the needs that Burlington's UPA must fill are different than UPA in larger urban environments, and studying these particular farms could shed light on a different set of needs which UPA is capable of filling.

**Multifunctionality and the Social, Cultural, and Health Benefits of UPA**

Multifunctional, social, cultural, and health benefits are by far the most widely studied elements of UPA in the US, Great Britain, Canada, and Europe. The 24 entries in the annotated bibliography at this time are only the tip of the iceberg, and belie the widely documented community, cultural, psychological, and health benefits of UPA. For the purpose of this thesis, it's important to understand these many benefits in order to highlight the connection of specific crops to the creation of some of these benefits. While some benefits, such as psychological and social benefits, are more tied to gardens
themselves than specific crops, others are directly connected to being able to access culturally relevant produce, which is the subject of this research. It is important to note that when speaking of cultural relevance, this does not merely focus on non-North-American populations, and the aim of this research will be to treat the differences between different upbringings within the US with equal importance to those present in immigrant communities of different backgrounds.

The inspiration for this research project was borne out of the Agroecology and Livelihoods Collaborative's approach to analyzing the benefits of UPA in Burlington, which developed alongside multifunctionality assessments like those used by Fernando Funes, Miguel Altieri, and Ernesto Mendez across multiple projects working with smallholders and agroecological producers. In her MS thesis, Allison Nihart (2013) draws heavily on research by Hogson, (2011), Draper & Freedman (2010), Allen (1999) and others that show benefits of UPA for communities that go beyond simple food production. Nihart uses this base of research in combination with governance theory (Koliba et al, 2011) and examples of urban agriculture policy in North American cities to identify gaps and make recommendations for possible areas of improvement in the urban agricultural policies of Burlington, Vermont (Lovell, 2010; Mendes, Balmer, Kaethler, & Rhoads, 2008; Nihart, 2013).

A colleague and previous collaborator on this thesis project, Alissa White, compiled a literature review that sought to examine research on the effects of urban agriculture and agroecology on resilience. She used a multifunctionality approach to understand the definition of resilience as based on multiple pillars of agricultural and social function. White highlights the work of Mendez (2015) and Molina (2016) in
developing a transdisciplinary approach to sustainability and resilience where research and discourse "aptly complements social research on human capability, poverty, food sovereignty and social change" (Mendez et al., 2015, Francis et al., 2003, Chappell and LaValle 2011, Wezel et al., 2009, Amekawa 2011, Adinsall 2015). Her review emphasizes the important role that UPA plays in dynamics of community empowerment, social equity, and food access in urban contexts that "bring new dimensions of place-making, social capital, and resource scarcity which could both ameliorate and exacerbate dynamics of inequity, access and social justice" (White, 2016, p. 1), and focuses heavily on the importance of systems level approaches to deal with the nuanced nature of resilience in an urban context; particularly addressing the importance of human and social capital in creating resilience. White also addresses the lack of research using the term Agroecology, and work that understands the positive effects of UPA through a whole-systems, transdisciplinary approach, as opposed to siloed studies on UPA that tend to address the subject through a solely sociological, psychological, environmental or nutritional lens. She notes the work of Stacy Philpott (2015, 2016) (later discussed in the Biophysical portion of this review) in its employment of the term agroecology, and it's treatment of plant and insect biodiversity as an extension of human sociology and geography.

Yet while few papers have managed to successfully integrate the many facets of research in urban agriculture (and this should certainly be a future direction for UPA research), the understanding of the multifunctional benefits of UPA is prevalent in the research community. The comparative extent of research into human benefits could be the result of the humanistic and sociological inclination of the type of researcher
interested in UPA, which, while approaching the mainstream, could still be considered a 'fringe' agricultural practice (Ghose & Pettygrove, 2014; Montenegro, 2013; Montenegro de Wit & Iles, 2016). Alternately it could be the result of the difficulty of obtaining economic and yield data for farms which are often subsidized, involve volunteer labor, frequently rely on barter for goods and labor, and have unstable and often overtaxed governing organizations (Garnett, 1999; Kaufman & Bailkey, 2000; Vitiello & Wolf-powers, 2014).

The papers examined in this review focus on differing populations benefiting from UPA. These could be classified as upper-middle class, senior citizen, Latino, African American, and New American. While these populations overlap in many UPA and community garden projects, these distinctions are important because the needs of these communities are distinct as are their uses of garden space (Airriess & Clawson, 1994; Corlett & Dean, 2003; Corrigan, 2011; Hondagneu-Sotelo, 2017; Saldivar-Tanaka, 2004; J. R. Taylor et al., 2017; Tei, Benincasa, Farneselli, & Caprai, 2010). Most likely due to the lack of imperative need, upper-middle class populations are often not the focus of research, though many papers note that the highest concentration of UPA spaces and practitioners are within these populations (Angotti, 2015; Vitiello et al., 2015; Vitiello & Wolf-powers, 2014; Walker, 2016).

Many of the most well-established community gardens, those that have become hallmarks of the movement such as the Duncan Street Miracle Garden (DSMC) in Baltimore and Prospect Farm and Added Value in Brooklyn, are centered around African American communities that suffer from a history of poverty (Angotti, 2015; Cohen & Reynolds, 2014; Corrigan, 2011; ETC (Urban Agriculture Programme), 2001; Garrett &
Leeds, 2015). This is largely due to the fact that these low-income neighborhoods in urban centers have much to gain from successful community garden projects and are more likely to have the space to establish gardens (Cohen & Reynolds, 2014; Gittleman et al., 2012; Teig et al., 2009).

In New York City, particularly, many of the city's oldest farms and gardens rose out of times of economic crisis in poor, frequently African American, neighborhoods. Disinvestment led to abandoned spaces, which served as opportunities to create green spaces (Angotti, 2015; Birky & Strom, 2013; Gittleman et al., 2012). These areas have been shown to increase food access and dietary diversity in their surrounding communities, but often began with the goal of 'cleaning up the neighborhood', getting rid of pieces of property used as dumps or sites for drug dealing (Brown & Jameton, 2000; Draus et al., 2014; Saldivar-Tanaka, 2004; Teig et al., 2009).

In many low-income urban areas, community gardens have served as spaces in which city inhabitants reclaimed not only food sovereignty but a sense of community and a sense of identity (Angotti, 2015; Birky & Strom, 2013; Brown & Jameton, 2000; Dixon, Donati, Pike, & Hattersley, 2009; Draus et al., 2014; Saldivar-Tanaka, 2004; Teig et al., 2009). Unfortunately, the improved community networks and neighborhood aesthetics, and their resultant increases in property value, have a tendency to act as a double-edged sword for long term residents (Voicu & Been, 2008). When Rudolph Giuliani took note of rebounding property values in these neighborhoods in the late 80's and attempted to re-appropriate the 'abandoned' plots for the city, the communities resisted, and NYC's community gardens became a battleground for the right to produce food in cities (Angotti, 2015; Gittleman et al., 2012; Kaufman & Bailkey, 2000). A
number of supporting NGOs bought or signed leases on many of the gardens' land to secure tenure, though in some case only temporarily (Angotti, 2015; Birky & Strom, 2013; Gittleman et al., 2012). Since the 80's, many of the neighborhoods these gardens center around have gentrified to some degree or another (Broadway, 2009; Garrett & Leeds, 2015; Ghose & Pettygrove, 2014; Golden, 2013; D. Guitart et al., 2012; Nihart, 2013; Teitel-payne, Kuhns, & Nasr, 2016; Vitiello & Nairn, 2009), but the African American populations that initiated and built the gardens maintain a strong role in their management and continue to benefit from their presence (Armstrong, 2000; Garrett & Leeds, 2015; Hendrickson & Porth, 2012; Macias, 2008; Saldivar-Tanaka, 2004; J. R. Taylor & Lovell, 2014; Teig et al., 2009; Tornaghi, 2016; Vitiello & Wolf-powers, 2014; Walker, 2016; Weissman, 2015). A similar scenario was seen at Las Parcelas in Philadelphia, where philanthropic organizations came to the aid of a garden started in the early 90s by a group of Puerto Rican women in what was once a drug market (Vitiello & Nairn, 2009). The garden has become a hallmark site of the UPA movement, and attracts thousands of visitors every year even as an established part of the community, yet its tenure still remains under threat (Vitiello & Nairn, 2009; Vitiello & Wolf-powers, 2014).

However, while many of the motivations that started community gardens, and the challenges they face, are similar to those found in inner city African American neighborhoods, the gardens which serve Latino communities seem to fill a different role (Hondagneu-Sotelo, 2017; Saldivar-Tanaka, 2004). Latino culture emphasizes strong family ties, and choices around where to immigrate to often focus on where family networks are already present (Birky & Strom, 2013; Cohen & Reynolds, 2014; Teig et al., 2009). Many immigrants, including those in Latino communities, come from an
agricultural background or have home gardens in their places of origin (Airriess & Clawson, 1994; Birky & Strom, 2013; Corlett & Dean, 2003; Fernandez et al., 2016; Hondagneu-Sotelo, 2017; Saldívar-Tanaka, 2004). In New York, many Puerto Rican gardens feature simple structures called Casitas, which replicate meeting spaces found in Puerto Rico (Saldívar-Tanaka, 2004). Some of these have been documented to include kitchens and picnic areas (Saldívar-Tanaka, 2004). What's more, many Latino community gardens produce culturally specific crops, including poblano chilies, papalo, cilantro, and traditional varieties of tomato and onion (Hondagneu-Sotelo, 2017; Saldívar-Tanaka, 2004). Through the combination of open meeting spaces and culturally relevant crops, Latino communities form extensions of their homes and their places of origin in community gardens (Hondagneu-Sotelo, 2017; Pitt, 2014; Romero-Gwynn et al., 1993). The gardens offer opportunities for second and third generation families and well established New Americans of Latino descent to meet other Latino immigrants in familiar, homelike spaces, and to subsequently help them to reduce the stresses of immigration and to maintain a cultural identity rooted in common recipes and common language (Fernandez et al., 2016; Hondagneu-Sotelo, 2017; Tornaghi, 2016; Vitiello et al., 2015). Not only does this coincide with significant cultural benefits and an increased capacity for the community to represent itself and its issues cohesively, but it improves nutrition for participants by allowing them to maintain the diets to which they are accustomed (Romero-Gwynn et al., 1993; Tornaghi, 2016).

As can be seen in Latino communities, language and food cultures play an integral role in New American populations. An outstanding study conducted by Jan L. Corlette (2003) follows crop diversity in Hmong gardens in California. Her findings
identify an incredible diversity of plants that the Hmong community would have significant difficulty sourcing locally. Corlette notes that many of these plants come attached to deep cultural traditions as medicine or herbs. The Hmong gardens in California function not only as spaces for the cultivation of crops, but also as living catalogues for traditions of food and medicine.

Hartwig (2016) documents a number of gardens in St. Paul and Minneapolis, Minnesota serving Karen and Bhutanese communities. She makes note of the psychological stresses and PTSD that many immigrants frequently bring with them from conflict zones. Due to issues of language and access, these conditions frequently go untreated, and are compounded by poverty and food insecurity. Hartwig finds inconclusive results about the potential of UPA to meet food security needs, but identifies undeniable psychological benefits associated with the strong networks that these refugee communities form through community gardens. These cases are far from isolated. Across many different nationalities and in many different cities, the community gardens have served refugee and immigrant communities by providing unique cultural spaces where individuals can find common language, food, and networks (Airriess & Clawson, 1994; Broadway, 2009; Corlett & Dean, 2003; ETC (Urban Agriculture Programme), 2001; Golden, 2013; Hartwig & Mason, 2016; Vitiello & Wolf-powers, 2014).

In communities of any nationality and background, time in the garden has been shown to have numerous health and psychological benefits, especially when this time is combined with a social element, as it is in community gardens (Corrigan, 2011; Hartwig & Mason, 2016; Hondagneu-Sotelo, 2017; Teig et al., 2009). The British Government has maintained Allotment Gardens for low income citizens since the 70s (Garnett, 1999).
Frequently, these allotment gardens serve as spaces of leisure and healing for the elderly, and are used for the cultivation of ornamentals (Airriess & Clawson, 1994; Martinho da Silva, Oliveira Fernandes, Castiglione, & Costa, 2016). Chiara Tornaghi (2016) addresses how users of allotment gardens are able to make choices about how and what they eat that other low-income individuals may not be able to. Garnett (1999) expands on this by indicating that beneficiaries are able to have more choice in their diet than they may in a welfare program, and other studies have shown improved nutrition for community gardeners (Alaimo et al., 2008). In New York City, after Hurricane Sandy, networks formed through gardens served to connect community members in their reconstruction efforts (Chan et al., 2015); and community gardens have repeatedly been shown to serve as key spaces for forming networks, which improve neighborhood networks, education, nutrition, and psychological health (Alaimo et al., 2008; Armstrong, 2000; Brown & Jameton, 2000; Corrigan, 2011; Garrett & Leeds, 2015; Golden, 2013; G Groening, 1995; Hartwig & Mason, 2016; O’Kane, 2012; Teig et al., 2009; Teitel-payne et al., 2016; Vitiello & Wolf-powers, 2014; Zasada, 2011)

**Economics, Profitability, and Financial Viability**

Compared to the plethora of papers that focus on the social benefits of UPA, relatively little research has been conducted on the financial viability of urban farm projects. In terms of community gardens, this is probably due to the difficulty of collecting financial data in spaces managed by multiple stakeholders and lacking central management. Some community gardens maintain incomplete records or do not keep
records at all (Gittleman et al., 2012; Specht et al., 2014), which would force researchers to ask direct financial questions of survey respondents.

What's more surprising is that broad analysis of commercial UPA is scarce (Specht et al., 2014), even though many urban farms, such as Added Value in Brooklyn, or the Intervale in Burlington, VT, keep detailed financial records, and a number of these have remained profitable for a number of years (Angotti, 2015; Cohen & Reynolds, 2014). Yet it may be difficult for researchers to assert these cases as proof of UPA's scalability or economic viability, as many of these farms have non-profit status, and tend to sell products in upscale markets, or as boutique goods. The premiums these farms receive on their products furnish a style of intensive farming that requires large amounts of labor, which some researchers have considered indicative of UPA's long term lack of sustainability (Angotti, 2015; Mok et al., 2014; Veenhuizen et al., 2007; Vitiello & Wolf-powers, 2014; Warren et al., 2015).

Critics assert that UPA is limited in terms of its capacity to produce the caloric needs of cities (Badami & Ramankutty, 2015; Mok et al., 2014). While many urban farms achieve greater or higher yields than those found on commercial vegetable farms, these yields may be disproportionately costly to achieve (Blay-Palmer et al., 2015; Cabannes, 2012; Deelstra & Girardet, 1990; dos Santos, 2016; Mok et al., 2014; Veenhuizen et al., 2007). Yet the UPA movement has inherently come out of need, as can be seen in the study of Cuba's urban farms and the history of American UPA. A growing base of evidence demonstrates has begun to demonstrate its successes, in addition to its challenges (M. a Altieri et al., 1999; Fernandez et al., 2016). Some of the first community gardens began during the 1893 depression in Detroit, when the mayor encouraged
unemployed citizens to begin gardening (Draus et al., 2014; Garrett & Leeds, 2015; Kohlstedt, 2008; Walker, 2016). It is estimated that during WWII, Victory Gardens yielded 40% of fresh vegetables in the US (Garrett & Leeds, 2015). As well, UPA has rapidly grown in the international development community as a strategy for both economic growth and food security, and should high-value products be selected and have an available market, it has been shown to be a viable basis for microbusiness (Midmore & Jansen, 2003; Vagneron, 2007; Veenhuizen et al., 2007)

Another significant financial constraint is that few urban farms are able to utilize the urban soil on-site at the time of beginning of gardening activities (the Intervale is a clear local exception to this), due to contamination or lack of fertility (Kohrman & Chamberlain, 2014). This necessitates either bioremediation or importing soil for the construction of raised beds (Heffernan et al., 2005; Koont, 2008). Bioremediation of heavy metals can be labor intensive and take many years, while importing soil is frequently cost prohibitive (Kohrman & Chamberlain, 2014; Veenhuizen et al., 2007). Some projects have begun producing compost on a large scale from municipal wastes (Angotti, 2015; Aubry et al., 2012; Birky & Strom, 2013; Lohrberg, Licka, Scazzosi, & Timpe, 2016). With NYC spending nearly 1.3 billion on garbage per year, Angotti (2015) suggests that the use of food wastes for cultivation could ultimately be a huge opportunity for the progress of financially sustainable UPA, but the infrastructure for this kind of waste management is in its infancy.

Even on established sites, the ongoing financial management of urban farms is challenging, and access to capital is frequently a problem (Hendrickson & Porth, 2012).
Many papers on grassroots UPA projects and community gardens focus on "cost savings" but these tend to overlook the costs of labor and other inputs (Algert et al., 2014; Vitiello & Wolf-powers, 2014). Patel (1991) and Algert (2014) show cost savings of around $400-$500 after relatively small input costs of around $25 per season are subtracted. But as Algert admits, this does not factor in labor, which makes these earnings seem comparatively small. At the upper end of these estimates, $500 in a 4 month growing period, it would only require around 6 hours of labor per week over the course of the growing season to drop garden earnings per hour below a federal minimum wage of $7.25 an hour. As well, research into entrepreneurial UPA suggests that most operations produce only modest gains even when subsidized (Kaufman & Bailkey, 2000). On top of relatively low margins, an unsupportive policy environment, issues of vandalism, and lack of secure tenure discourage the higher levels of investment necessary for growth in the sector (Hendrickson & Porth, 2012; Huang & Drescher, 2015; Kaufman & Bailkey, 2000; Polling et al., 2016; Veenhuizen et al., 2007).

Land tenure repeatedly comes up as a principal issue for urban farms (Deelstra & Girardet, 1990; Hendrickson & Porth, 2012; Polling et al., 2016; Saldivar-Tanaka, 2004; Vitiello & Wolf-powers, 2014). Especially for immigrant communities, a lack of tenure leads to a decrease in garden participation (Garrett & Leeds, 2015). Disconnects between the UPA community, policy makers, and the real estate market lead to urban farm users having little agency in decisions about the future of their land, and they frequently lack the tools to navigate the bureaucracy necessary to secure a greater level of security (Dubbeling et al., 2010; Ghose & Pettygrove, 2014; Huang & Drescher, 2015; Tornaghi, 2016; Veenhuizen et al., 2007). In certain instances, non-profits have secured urban farm
land tenure through grants, but it's doubtful that this kind of subsidized farming can function as a long term solution without achieving more significant returns on investment (Ellis & Sumberg, 1998; Gittleman et al., 2012; Mok et al., 2014).

Another significant economic challenge faced by commercial UPA practitioners is aggregation and distribution of products (Hendrickson & Porth, 2012; Kaufman & Bailkey, 2000; Veenhuizen et al., 2007). Even in the instance that a farm is able to produce crops efficiently, it's unlikely that they can produce in volumes required for bulk wholesaling practiced in conventional supply chains (Ellis & Sumberg, 1998; ETC (Urban Agriculture Programme), 2001; Patel, 1991; Zezza et al., 1995). Many commercial producers sell in farmer’s markets; but while this can furnish high premiums for produce, they also require a significant amount of additional work on the part of the farmer (Kaufman & Bailkey, 2000; Polling et al., 2016). Additionally, the added costs and higher prices associated with farmer’s markets make much of the produce unattainable for low-income populations (ETC (Urban Agriculture Programme), 2001; MacIas, 2008; Weissman, 2015). Emerging food hubs and similar alternatives have attempted to solve this issue by creating smaller, local, non-traditional distribution systems, but these are also faced with numerous economic challenges, which compared to regional distribution and wholesaling are comparatively energy intensive (Cabannes, 2012; Heffernan et al., 2005; Leblanc, Conner, Mcrae, & Darby, 2014; Peters et al., 2016).

Even though research suggests that urban areas would need 2-25 times more growing space to feed the population of most cities (Badami & Ramankutty, 2015; Warren et al., 2015) and face significant market challenges (Mok et al., 2014;
Veenhuizen et al., 2007), the wise use of urban space in agricultural production has the potential to make significant contributions to regional production (Gittleman et al., 2012; Golden, 2013; Pearson et al., 2010). Capitalizing on UPA's potential requires understanding the nuanced differences between urban, peri-urban, and rural production. While both urban and peri-urban production have limitations growing area, the issue of contaminated, infertile, or impermeable soil in urban agriculture is usually less of an issue in peri-urban agriculture (Tsuchiya, Hara, & Thaitakoo, 2015; Vagneron, 2007; Winarso, Hudalah, & Firman, 2015). Golden (2013) and Pearson (2010) show that many of the most profitable farms are those that exist in the urban periphery, due to the combination of access to soil, water, and mechanical resources that are present in rural areas, combined with easy access to populated urban markets. While there are successful models of high-value products being produced in an urban setting, peri-urban producers are able to capitalize on different markets and resources, in a similar way as rural producers (Midmore & Jansen, 2003; Opitz et al., 2016; Pribadi & Pauellet, 2015; Wang et al., 2014).

Christian Peters (Peters, Bills, Lembo, Wilkins, & Fick, 2011; Peters et al., 2016) uses data analysis to find the "highest and best use" of agricultural land throughout New York state. This approach calculates an economic Land Use Value (LUV) for six key crops (grains, vegetables, fruits, dairy, meat and eggs) through a hybridized GIS model. The model compares production estimates based on information on agricultural land cover, soil productivity and average food yields, combined with information on community food needs, and also including transportation costs and energy requirements between production and consumption spaces. In Peters' model, this results in the
production of grains, fruits, and low-value crops being displaced only to areas where other food needs have already been met, while production of products such as eggs and vegetables have opportunities to be produced closer to their areas of use. This leads to the suggestion of increasing the production of these crops in peri-urban settings.

While research disagrees about the direct economic potential of commercial UPA and the cost-savings of community gardening for farmers and practitioners, the widely documented and strongly supported social benefits of UPA coincide with economic benefits (Gómez-baggethun & Barton, 2013; Haase et al., 2014). Amelia Garrett and Michael A. Leeds (2015) find that rising home values as a result of UPA's community improvement result in a gross tax benefit to NYC of $503 million over 20 years. Subsidizing all NYC gardens would cost the city $177 million, resulting in a net tax benefit of over $325 million, or $512,000 per garden. Another study finds that the presence of gardens raised property values as much as 9.4% within five years of establishment (Voicu & Been, 2008). The educational and therapeutic benefits of community gardens have the potential to save local governments money on other social programs, though these potential savings are challenging to quantify (Boukharaeva & Marloie, 2006; Brown & Jameton, 2000; Gómez-baggethun & Barton, 2013; Pitt, 2014). Additionally, the benefits to household nutrition associated with urban farming could reduce strain on urban healthcare systems (Brown & Jameton, 2000; Freudenberg, McDonough, & Tsui, 2011; Hartwig & Mason, 2016; Specht et al., 2014).

Many researchers show that UPA can create jobs, subsidize low-income families, and improve economies (Garrett & Leeds, 2015; Golden, 2013; Nugent, 2000; Vitiello & Nairn, 2009), but the economic realities that UPA faces may make many of the claims
about the production quantity that UPA is able to attain seem less sustainable or scalable in the long term. Further research is needed to understand the economic realities facing efforts to use UPA to support food security, food sovereignty, and food justice (Macias, 2008; Vitiello et al., 2015; Wilson, Warren, Sodeke, & Wilson, 2013).

Yields and Biophysical Data

Of the research which has been conducted thus far in the field of UPA, biophysical data is the most scarce (Blay-Palmer et al., 2015; Golden, 2013; Warren et al., 2015). This is especially true in regards to data on yield, which is often challenging to collect due to the fragmented management of urban farm sites (Ellis & Sumberg, 1998; Gittleman et al., 2012). In addition, there is a surprising lack of data in regards to what is being grown in UPA (Airriess & Clawson, 1994; Borysiak et al., 2017; Clarke & Jenerette, 2015; Corlett & Dean, 2003; Galluzzi, Eyzaguirre, & Negri, 2010). The studies that have been conducted aren't sufficient to represent the breadth of projects present in the United States (Opitz et al., 2016). Much of this research approaches the issue from an environmental lens, either focusing on UPA's potential benefits in serving as green spaces for species, or considering UPA as a method for preserving agrobiodiversity (Barthel, Colding, Elmqvist, & Folke, 2005; Benis & Ferrao, 2017; Borysiak et al., 2017; Speak, Mizgajski, & Borysiak, 2015).

Habitat for increased biodiversity and space for increased agrobiodiversity are frequently cited as benefits of urban farming (Galluzzi et al., 2010; Otoshi, Bichier, & Philpott, 2015; Zasada, 2011). Because of this, studies on the environmental benefits of urban farming are relatively common. Stacy Philpott and her lab at UC Santa Cruz have
taken a transdisciplinary look at the overlap between ethnobotany, agroecology, and urban agriculture. In a proposal to NIFA in 2015, Philpott examined how cultural diversity and garden management affect biodiversity and the consequent ecosystem services that they provide. Philpott's lab examines subjects such as *Local and landscape correlates of spider activity density and species richness in Urban Gardens* (2015), which connects garden management with their services as spider habitat and the resultant services of the gardens in balancing urban pest populations (Otoshi et al., 2015). The sampling method used in this survey, a stratified sample that breaks 100m² into quadrants and sub-sections, has become a standardized and replicable biophysical sampling method for urban gardens (Lin, Philpott, & Jha, 2015).

This type of study reflects a common trend in UPA research toward understanding how UPA can support urban spaces to provide a variety of ecosystem services (M. A. Altieri, Funes-monzote, & Petersen, 2012; Borysiak et al., 2017; Breuste, 2010; Breuste & Artmann, 2014; Chan et al., 2015; Clarke & Jenerette, 2015; Cook, Oviatt, Main, Kaur, & Brett, 2015; ETC (Urban Agriculture Programme), 2001; Filkobski, Rofe, & Tal, 2016; Galluzzi et al., 2010; Goldstein et al., 2016; D. A. Guitart, Pickering, & Byrne, 2014; La Rosa et al., 2014; Orsini et al., 2014; Orsini, Dubbeling, & Gianquinto, 2015; Peng, Liu, Liu, Hu, & Wang, 2015; Richnau, Brunet, Nielsen, & Wistrom, 2016; S. Taylor et al., 2010). The annotated bibliography compiled by ETC (2001) contains more than 10 entries focusing on ecological benefits and ecosystem services provided by UPA, and many of these focus on the benefits of UPA in treating urban wastes and wastewater, as well as some focused on improvements of air quality and species habitat. Taylor (2010) draws on her own studies and that of Gliessman (2007) to link UPA plant
diversity to healthy ecosystems that regulate pest populations. The arguments proposed by Deelstra (1990) suggest that this kind of diversity and balanced ecosystem is not just essential for plant and animal health, but for humans existing as part of an ‘urban ecosystem’ setting.

Along with their effects on overall species diversity in an urban setting, UPA has been shown to have an important role in conserving agrobiodiversity (Drescher, Holmer, & Iaquinta, 2006; Galluzzi et al., 2010; D. A. Guitart et al., 2014). Plant species with undocumented medicinal and nutritional benefits that have not yet found commercial markets have been found in family home gardens (Corlett & Dean, 2003; D. A. Guitart et al., 2014). These crops are intrinsically tied to lifestyles and are culturally important to the communities that grow them (Airriess & Clawson, 1994; Corlett & Dean, 2003; Galluzzi et al., 2010). Galluzzi uses literature to highlight the breadth of uses that homegardens take in different countries, showing some countries, such as Peru and Hungary, which are devoted to perennial fruits, and others, such as Russia, which are more inclined toward horticulture. Galuzzi also takes into account the various uses of plants that are being cultivated in homegardens. He makes note that to increase the capacity of homegardens to support conservation, it is important to understand the smallest number of a species necessary to contribute to preserve it, and the need to work with growers to focus on threatened species.

Sprinkled throughout many of these studies are important pieces of data on what is being grown in urban gardens. However, without a specific focus on crop diversity, very little of the data which could help understand urban growing practices gets published. Even many of the studies which focus on yields, lack specific data about what
crops specifically are being cultivated (Golden, 2013; D. Guitart et al., 2012; Lovell, 2010). Corlette (2003) conducts a particularly detailed assessment of what is being grown in Hmong homegardens and community gardens in an urban setting. Along with a complete record of a number of gardens in her case study, her work highlights a couple of interesting issues, as follows. Corlette and Clarke (2015) identified how challenging it can be to quantify a given species when genealogy is not particularly discreet, such as is in cases where there are many edible varietals of the same species. For example, the species *Brassica oleracea* encompasses a variety of cultivars, which include broccoli, kohlrabi, cabbage, and collards. In particular, Corlette faced the challenge of identifying uncommon medicinal plants in Hmong gardens, some of which identified with certainty by several university taxonomists. Borsyiak (2017) conducted similar research by taking counts of the number of plants of specific species found in surveyed gardens in Poland. Other papers employ a similar strategy, but data on crop species are too few and far between to serve as any real tool to make predictions about what might be found in UPA in a given city.

Data quantifying yields in community gardens is also exceedingly scarce. When available, more often than not, this research quantifies a total yield by weight for a garden site without disaggregating by crop (Goldstein et al., 2016; Orsini et al., 2014; P. Rosset & Benjamin, 1994). This is problematic, as weight is not necessarily indicative of either nutritional value or potential profit. For instance, potatoes are very high-yielding in terms of weight, but don't offer anywhere near the same nutritional value as that of a green like chard, or the dollar value by weight of an herb like basil (Warren et al., 2015).
The *Community Gardening in Philadelphia: 2008 Harvest Report* by Domenic Vitiello and Michael Nairn (2009) is one of the more detailed reports on community garden yield, and is heavily cited by other authors as an example of UPA's potential. The authors examine cases of Philadelphia community gardens and use the square footage of observed crops to estimate yield in the study sites. From this data they estimate a potential yield and potential sale value based on the values of produce observed in local farmers markets. Unfortunately, their data on which crops are being grown is not published in the report. However, their estimates of yield show the potential of producing a significant amount of food and income for practitioners. Vitiello and Nairn estimated that community gardening in Philadelphia produces $4.9 million in summer vegetables (excluding spring and fall plantings), which is more than the total sales of all of the city's farmers markets combined in 2008.

While often the best tool for estimating the production of UPA available to researchers, estimations of yield by area are notoriously unreliable due to the large number of variables present, including environmental conditions (soil, water, sunlight, etc.) and growing techniques; not to mention what types of crops or food are being evaluated (Gittleman et al., 2012). Yet for a researcher or research team to monitor the weekly or daily yield of multiple garden sites of heterogeneous types is too labor intensive to be viable, in terms of time and budget. Mara Gittleman and the team at Farming Concrete in NYC attempt to solve this problem by employing citizen science to measure yield; calling upon volunteers for both weighing produce and conducting crop inventories. Employing paid organizers and providing volunteers with better tools for inventories helped overcome problems in the first year of research. Gittleman shows
some of the most concrete results available on yield data in UPA, both with exact
numbers of plants observed and production weights disaggregated by crop. In 2010,
Gittleman et al studied 67 gardens, producing 187,690 pounds of produce, worth
approximately $214,060, or 1.2 pounds and $3 per square foot. In 2011, fewer gardens
participated. Thirty-five gardens produced 13,000 pounds worth approximately $47,000,
or about 0.3 pounds and $1.15 per square foot. The researchers attribute the change in
value to the inclusion of fruit trees in 2011 as well as school gardens, which are often
dormant in summer months. Even with the decrease in overall production, Gittleman et al
find that the numbers shown in the study are much higher than USDA predictions, and
more closely align with biointensive methods. However, due to the nature of the study
and the heterogeneity of community garden projects, Gittleman cautions against the use
of this research for making predictions about the production of other gardens, even within
New York City.

Inconsistencies in yield estimates are a common theme in UPA research, which
makes it hard to take any of them at face value. Cuba is a prime example of this. While
more detailed records of overall production in Cuban UPA exist than in the United States,
estimates of overall production, production per hectare, and contribution to food
sovereignty are widely varied and often contradictory. The literature around this issue is
more completely explored in other sections of this thesis, however it is worth noting the
discrepancy between the Cuban Ministry of Agriculture’s (MinAgri) estimate of
3,100,000 tonnes of food produced through UPA, and the FAO's drastically different
estimate of 84,700 of produce, while in *Sustainable Agriculture and the Revolution*,
Funes estimates production at 850,000,000 tonnes.
The lack of studies on yield and crop type found through this research process are indicative of a larger gap in research. In a detailed literature review Golden (2013) notes the skepticism of the productive potential of UPA and the need for studies that examine the micro- and macro-economic realities of UPA programs. Guitart zeros in specifically on a lack of biophysical data and the curiosity of many policy-makers in regards to yield and production. Though more economically inclined, Pearson (2010) also supports the need for economic information based upon biophysical data. While conducting research to attain this data may be difficult, researchers like Gittleman and Vitiello and Nairn lay out appropriate, replicable frameworks. Applying these methods broadly enough to gather sufficient data to make generalizations and predictions about UPA could provide evidence and legitimacy of the real potential of UPA, and serve both farmers and researchers interested in UPA.
Chapter 3: The Role of Urban Agriculture in Cuban Food Sovereignty

Abstract

In Cuba, a perfect storm of necessity during the special period and a strong central government gave rise to a push to develop UPA as a food security strategy. This has led to some of the most well developed low-input, agroecological urban agriculture in the world. Through the review of literature, this article will develop ideas around what went right to get Cuba to where it is today, and what we can learn from their rapid progression in UPA. As well, it will call into question some of the literature that has a tendency to idealize Cuba's agricultural revolution by examining articles that show the country as still highly food insecure; and call into question the functionality of the national UPA movement. The aim of this section will be to understand how much UPA is really contributing to national food security, what urban growers can learn from Cuba, and what would have to change to perfect the UPA systems in Cuba.

Intro

Cuba's UPA has become a prime exemplar of the possibilities of growing food in cities. Cuba's small urban producers, or organoponicos, have been recorded to produce over 1kg of vegetables per capita per day according to some estimates, more than 3 times the FAO recommendation of 300g per capita per day for an average adult (Assis, 2015; Badami & Ramankutty, 2015; P. Rosset & Benjamin, 1994). Through the Special Period (Cuba's euphemism for the economic crisis following the fall of the Soviet Union in 1989, which bought the majority of Cuban sugar production at preferential rates, and
supplied more than 50% of Cuba’s top 13 food items at a discount), Cuba rapidly
developed agricultural technologies that negated or reduced the longstanding need for
petrochemicals in agriculture, and in doing so answered many of the food needs of the
country (Cederlöf, 2016; Koont, 2008, 2009). Organoponicos arose out of necessity and
made incredible leaps and bounds in their capacity to produce substantive food for Cuba
(Cederlöf, 2016; Koont, 2004; Viljoen & Bohn, 2012), but the sociopolitical climate in
Cuba is shifting. After the death of long-standing president Fidel Castro, his brother, Raul
Castro, is now in power. Raul has taken a softer stance on international trade than his
nationalistic brother (Messina, Stefanou, & Royce, 2016), and begun to ease strictly
imposed sanctions on the import-export market. For the first time in decades, private
investment in Cuba's agriculture has begun to look like a possibility (M. A. Altieri &
Funes-Monzote, 2012; Messina et al., 2016).

There is no doubt that the private sector is eager for such an opportunity (Messina
et al., 2016; Taub, 2010; Wilkinson, 2017). With approximately 6,406,000 acres of
agricultural land, and 3,088,000 ha of arable land, many of which are devoted to high-
value export crops, such as sugar and some of the world's finest tobacco, Cuba is an
investment market with nearly guaranteed returns (Healy & Evans, 2016; Taub, 2010;
W.H.O., 2015; Wilkinson, 2017). Some organizations believe that this private investment
is key to the maintenance of food security in Cuba (Messina, Spreen, Moseley, & Adams,
1992; Riera & Swinnen, 2015). Agribusiness development could allow for the
introduction of technologies which would increase yields and the potential for Cuba to
meet its own food needs, as well as to meet the food standards necessary to enter into the
international agricultural market (Corzo, 2011). Additionally, the revitalization of the
sugar industry could lead to a strong positive impact on the country's GDP (Alvarez & Pérez-lópez, 2006; Messina et al., 1992; Riera & Swinnen, 2015; Sánchez, 2011).

Yet proponents of sustainable agriculture see this as a potential loss in food sovereignty for a country that has made incredible bounds in the right direction (M. A. Altieri & Funes-Monzote, 2012; Funes et al., 2009). Through organoponicos (or urban farms), and cooperative farms, Cuba has successfully managed to achieve a yield per hectare that is comparable to those seen in mechanized agriculture, and has done so using small scale production of biopesticides, unrivaled levels of on-farm composting and vermicomposting, and the implementation of agroecological practices such as the use of nitrogen fixers and trap crops (P. Rosset & Benjamin, 1994; Peter Michael Rosset, Sosa, Jaime, & Lozano, 2011). A step toward the privatization of agriculture could mean a step away from food sovereignty, and a greater degree of reliance both on the petrochemical industry and on the international market (Funes et al., 2009; Peter Michael Rosset et al., 2011; Spoor & Thiemann, 2016).

A series of questions lie at the base of this debate. Can Cuba produce all of its own food? Does Cuba need its monocrop exports to sustain its economy? Would a greater degree of mechanization in agriculture, and the resultant economic boost, create a greater degree of food security than the transition toward a legitimized agroecological food production system? In order to get closer to the answers to these questions, it is essential to understand how successful Cuba has truly been in producing food using small-scale agroecological production. However, the nature of information regarding Cuba's agriculture is highly filtered and is frequently biased, making analysis challenging. Authors writing about food security in Cuba are often academics with a
focus on agroecology and sustainable agriculture (M. a Altieri et al., 1999; Funes et al., 2009), while those writing about finance and economics may be more fiscally conservative and vested in agribusiness (Alvarez, Jose Hagelberg, 2007; Sánchez, 2011). The Cuban government censors data in such a way as to serve their political needs (Spoor & Thiemann, 2016). Simultaneously, development organizations like the FAO take a broad view of their own data but may miss some of the important nuances of the situation, and trend toward a neoclassical view of the value-chain, which reduces the context of Cuba's unique food system down to simplified figures such as inputs, production, and costs (Friedrich, 2015).

A unique set of factors made Cuba able to accomplish great strides in sustainable food production, and in a way that no other country has been able to (Badami & Ramankutty, 2015; P. Rosset & Benjamin, 1994; Spoor & Thiemann, 2016). During the Special Period, Cuba lost its subsidized supply of fossil fuels, and was forced to develop strategies of subsistence with a minimal use of petroleum based products (Deere, 1993; Funes et al., 2003). Cuba's strong central government and the state ownership of many major industries enabled a cohesive, unilateral push for sustainable food systems (Funes-monzote, 2009; Funes et al., 2003). Simultaneously, Cuba's high-quality free educational system and an educated population enabled them to approach issues of the food system as farmer-researchers, and to address issues in the field through analytical methods (M. a Altieri et al., 1999; Deere, 1993; P. Rosset & Benjamin, 1994; Spoor & Thiemann, 2016).

In as little as 10 years, Cuba had capitalized on over 50,000 hectares of previously unused urban land for the cultivation of produce (M. A. Altieri et al., 2012). While yields
began low, they soon skyrocketed to production levels close to those of conventional agriculture (M. a Altieri et al., 1999; Funes et al., 2003; Koont, 2008; P. Rosset & Benjamin, 1994). Along with producing nearly 3 times the FAO recommended per capita vegetable needs, urban farms have created more than 350,000 high paying jobs (Koont, 2008). The importance of the organoponicos to the communities in and around Havana is apparent. Young children can frequently point to the location of the nearest organoponico, and the storefronts that sell fresh, organic produce directly from the garden can be seen with a small line out front (personal observation). Along with food production, the gardens serve an aesthetic function; neatly organized long beds of mixed vegetables lined with ceramic tile, capped at each end and around the garden's margins by flowering trap crops and fruiting trees (Figure 3; Crawford, 2003).

Figure 1: Cuba, Organoponico La Sazon

Challenges in a transition economy

The beauty of Cuba's urban farms or their capacity to provide high quality produce to the neighborhoods they inhabit may not be enough to keep them functioning
should Cuba transition back toward conventional agriculture (Riera & Swinnen, 2015). *Organoponicos* are labor intensive, requiring near-constant care by a team of educated workers (Oppenheim, 2001). This is feasible in Cuba, and was especially feasible during the Special Period, for a number of reasons (Funes et al., 2003). All Cuban workers, regardless of their position, make close to the same amount. The salaries of workers in *organoponicos* are subsidized at a standard rate, independent of what they grow and sell (Crawford, 2003; Maschio, 2017). Workers are motivated to produce by a quota determined per growing area, which they must meet in order to continue receiving their salary (González & Gonzalez-Corzo, 2015). This quota is 'donated' to the *libreta* or the state food distribution program, as well as to neighborhood institutions such as senior housing and orphanages, or sold at state mandated prices through the farm stand. Recent policy changes have allowed farmers to sell any food produced above the quota at the farm stand or through other markets (Corzo, 2011; Nova Gonzalez, 2013). This additional farm income is divided amongst workers at the *organoponico*, and translates into a sometimes significant wage boost, making farming one of the better paid jobs on the island (Crawford, 2003; Funes et al., 2003). The nature of the additional sales, however, has become one of the primary critiques of the *organoponico* (Alvarez, Jose Hagelberg, 2007; Riera & Swinnen, 2016).

Many *organoponicos* sell substantial portions of their produce to *paladares*, or high end restaurants which cater to tourists (Leitgeb, Schneider, & Vogl, 2016; Taub, 2010). This point of sale is essentially a nutritional export (Castañeda, 2011; Messina et al., 2016). In a fully privatized market selling to the highest bidder, this wouldn't be problematic: as a greater number of growers began offering the same product, demand
would increase and price would be reduced (Friedrich, 2015). In Cuba, these sales to *paladares* come at the cost of the state, which subsidizes the livelihood of their farmers, supposedly for the greater good of the people. On the other hand, farmers earn this additional grey-market income strictly for personal benefit (Alvarez, Jose Hagelberg, 2007; Friedrich, 2017; Leitgeb et al., 2016; Riera & Swinnen, 2016). While the deregulation of commercial sales in 2011 incentivized agricultural production, it had the simultaneous effect of dividing the vegetable market into a low-end state market and a high-end tourist market. Because of this division, the state-market receives little of the *organoponico's* additional production, and buyers in the nationalized food economy do not benefit from the typical price reductions of increased supply that would normally be incurred on a supply-demand curve (Leitgeb et al., 2016). Simultaneously, with a large portion of their production still devoted to state enterprises, the earnings from private commercial sales remain insufficient for *organoponicos* to invest in growth (Leitgeb et al., 2016; Spoor & Thiemann, 2016).

However, while the food in farm stands is subsidized by the government, it still isn't necessarily accessible to much of Cuba's population (Leitgeb et al., 2016; Messina et al., 1992). Cuba has relatively low rates of unemployment. Yet wages are often not sufficient for dealing with the stresses of raising a family, especially for a single parent, and many families spend upwards of 80% of their income on food (Leitgeb et al., 2016; Messina et al., 2016). Most buyers are still looking to maximize their calories per peso at the store, and vegetables can't compete with meat or grains. While families will buy the occasional vegetable as a flavoring for a meal, many do not consume nearly enough vegetables from a nutritional standpoint (Alberto, Cañero, & Ph, 2017; Porrata, 2008).
This makes the fact that Cuban organoponicos are producing 700g per capita per day (Koont, 2008) somewhat irrelevant in terms of food sovereignty when one considers that most of that 700g of production is being directed toward the tourist market (Leitgeb et al., 2016). Additionally, Cuba is a net food importer, and despite organoponico and cooperative production, approximately 40% of Cuba's vegetables are imported (FAO, 2014). This is partly because the prices the government pays farmers (or is essentially paying them a fixed salary to donate) is greater than what they pay for conventionally produced food to be imported (Alvarez, Jose Hagelberg, 2007). To further disincentive investment in local farms, many high ranking officials are highly invested in CIMEX, the owner of the majority of Cuba's supermarkets (Spoor & Thiemann, 2016). Because of their control over the market, CIMEX earns a significant rent based on charging high prices for produce, and their current aggregation and distribution system is largely designed around an import market with transaction costs that are ultimately lower than those involved in capitalizing on domestic production (Spoor & Thiemann, 2016).

**Challenges of diet, cultural preference, and livelihoods**

On top of the economic challenges of providing produce to the population, Cubans don't have a food culture of vegetable consumption (Pérez, 2009; Porrata, 2008). Most meals are based around meat and animal products (Porrata, 2008). Even if vegetables were less expensive, Cubans may not eat enough of them. Cuba was never particularly reliant on US imports of vegetables (Coleman, 2001), but nutritional and dietary surveys may indicate that a larger than expected proportion is being consumed by the tourist market. Anecdotally, few plates I encountered during a short trip to Cuba
included much in the way of vegetables, with most focusing specifically on Cuba's import products: meat and grain. It begs to ask if Cuba's food security problems, at least in terms of the percentage of production vs. import, are less production related, and more driven by dietary preferences.

Despite national programs to promote better nutrition, the predilection of the Cuban people toward fatty fried foods appears to be ingrained in Cuban food culture, and this is only increasing as the economic status of the country improves (Pérez, 2009). Carmen Porrata writes, "The ham and cheese sandwich is Cuba's number one favorite food". According to the Second National Survey on Risk Factors and Chronic Diseases (2001), only 17% of adults consumed adequate vegetables, but this was primarily a matter of taste preference. Simultaneously, 82% of Cubans said they ate at least one meal from street or fast food vendors daily (Porrata, 2008). In a strange twist of fate, while overall mortality increased during the Special Period, there were substantial decreases in mortality from specific causes including chronic heart disease, diabetes, and cancer, presumably from a relative decreased consumption of meat and dairy products (Alberto et al., 2017; Franco et al., 2007). No one would argue in favor of the under-nutrition that Cubans faced during the nineties, but this data may be indicative of a trend toward a more healthful, plant based diet Cuban's ate while the nation relied more heavily on its own production systems, based on cooperatives and organoponicos. It also demonstrates one potential advantage of decreasing meat and grain imports in favor of locally produced vegetables.
The contentious 80% figure

In his 2009 paper "Cubans Starve on a Diet of Lies", Dennis Avery contended that Cuba's high import figures showed the failure of the organoponico movement (Funes et al., 2009). Funes, Altieri, and Rosset counter this argument by showing that while Cuba is not entirely food sovereign, most other Latin American countries aren't either. Unlike other Latin American countries, however, Cuba was able to weather massive shortages, embargo, and an economic crisis. Furthermore, with comparatively little in the way of agrochemical inputs, Cuba has been able to achieve similar production levels to those seen in countries which rely on production reliant on fossil fuels (Funes et al., 2009). Funes et al. cite the 2003 FAO balance sheets to show figures closer to a 16% import dependency as opposed to the 84% upon which Avery's article is based. This figure also resembles the most recent 2013 FAO balance sheet. Yet this 84% (or 80%) figure is a constant critique of Cuba's capacity to achieve a degree of food sovereignty, and its exact origins are hazy.

Apart from the Funes et. al paper debating that figure, four of the 60 papers directly relating to Cuba that were reviewed during this study mention the 80% or 84% import, and only Messina (2016) offers a citation, tracing it back to Granma, 2007 (Messina even suggests that the actual figure is likely lower). The fact that the only available citation is derived from a government publication, along with some anecdotal evidence, suggests that this 80% is not Cuba's net import, but in fact the proportion of the *libreta*, Cuba's food provisioning program, which is comprised of imported food. This would make sense, considering that much of the libreta is comprised of staple foods such as meat or grain.
The FAO shows that of the 3,654,000 tonnes of food imported to Cuba in 2013, 2,017,000 tonnes were basic grains (FAO, 2014). Unsurprisingly, given the fall in milk production following the Special Period and the inability of the industry to recover, dairy comes in a distant second, at 594,000 tonnes. *Only 12,000 tonnes of vegetables were imported in 2013, compared to the 2,456,012 tonnes produced.* If the figure from Funes' 2009 paper holds true and can be considered representative of UPA's production (*"383,000 urban farms, covering 50 thousand hectares of otherwise unused land and produced more than 1.5 million tons of vegetables"*), this would put UPA as contributing 60% of the country's total vegetable production on 25.3% of the land. While this falls slightly short of Funes' own similar estimate (70%), it should show that the argument is not whether or not Cuban urban agroecology can produce sufficient food to feed the population, but why this has not translated it into 100% of total vegetable consumption in Cuba. This is especially important considering that Cuba's fruit and vegetable inputs costs the country nearly $86,762,000 annually (for approximately 22-28,000 tonnes of fruit and vegetables combined), at only around 1.1% of total vegetable consumption. Finally, the key question remaining is if, and how, Cuba could produce more or all of its staple grain and meat needs. And if it could, would it be possible to do so without becoming increasingly dependent on foreign petroleum.

**Cuba's UPA**

Cuba's capacity to rapidly support UPA after the fall of the Soviet Union is unique. The combination of a strong central government with a highly educated populace, the necessity created by the Special Period, and the communal inclination of citizens
raised on Marxism and indoctrinated with the concept of the greater good, all led to a capacity to rapidly and completely change the way a country cultivates its food (Funes et al., 2003; Koont, 2008). At the core of this movement was a thick legitimacy given to urban agriculture by the government, which saw the capability of UPA to reduce the island's dependence on both their unreliable allies and the markets to which they did not have access due to the embargo (M. A. Altieri et al., 2012; Koont, 2008; Montenegro de Wit & Iles, 2016).

The creation of Organoponicos began before the Special Period, as early as the 1970s, when government bodies were created to preempt the possible restriction of the petroleum supply (Koont, 2008). Organoponicos had begun being established at armed-forces headquarters 4 years before the start of the Special Period, and the first civilian organoponico, INRE-1, had been established by 1991 (Koont, 2008). Thus, by the time the crisis made it necessary to reduce fossil fuel use and take advantage of urban land,
practices and tools were already in place (Koont, 2008). By 1994 a legal framework had been established, and the government was able to begin to oversee the systematic introduction of UPA (Koont, 2008).

By 2006, approximately 4.2 million tons of vegetables were being produced in 70,000 acres of urban farms in Cuba (Koont, 2008), and that number had increased to 87,000 by 2009 (Koont, 2009). This production is supported by a local infrastructure of biopesticide producers (CREEs), and the technical assistance of state and non-government organizations (Koont, 2008; P M Rosset & Moore, 1997). The National Program of Urban Agriculture reaches and assists more than 350,000 producers, and the National Association of Small Farmers (ANAP), more than 100,000 families (Funes-monzote, 2009). Some estimates assert that through this consolidated effort, small diversified farmers produce 65-70% of Cuba's agricultural goods on 25-30% of the agricultural area (Funes-monzote, 2009). This production is particularly remarkable when one considers that it goes along with a reduction in fossil fuel use. Additionally, these diversified farms are far more resistant to agricultural stressors such as weather, as could be seen during the hurricane that hit Cuba in 2008, when diversified farms only lost approximately 50% of their crop, while monocultures lost nearly 100% (Funes-monzote, 2009).

As has been widely documented in urban agriculture in the United States and globally, urban farms in Cuba offer more than simply production; providing community meeting places, green areas in cities, and a degree of urban beautification (a facet which could have additional benefits given the rise of the tourism industry in the country) (Crawford, 2003). UPA in Cuba has created more than 350,000 jobs, and there is an
effort to 'dignify' urban agricultural work, moving it away from stigmas of necessity to a profession driven by science and technical expertise (Koont, 2008; Peter Michael Rosset et al., 2011). Farmers are paid a state salary, and the sales of excess production constitute additional earnings, which raises the salary of most agricultural workers to a job which pays better than average (Oppenheim, 2001).

At the base of the Cuban government's push for urban agriculture is a desire to increase the island's food sovereignty by simultaneously reducing the need for the import of petrochemicals and food (Gonzalez, 2003; Oppenheim, 2001). When one considers the debatable figure of 80% imports (which has thus far been established is likely more relevant to meat and grain imports), it's possible to argue that they have succeeded in this goal only enough to survive, but not enough to thrive. However, for a country as small, densely populated, and urban as Cuba, they stand alone in their capacity to provide fresh produce to their people through local growing (Corzo, 2011; Friedrich, 2017; Funes et al., 2009; González & Gonzalez-Corzo, 2015). While Cuba may still be a net importer, the fact that they have succeeded in drastically reducing import dependency steadily since the 70s should indicate the successes in the changes enacted in their food system (Corzo, 2011; Funes et al., 2009). Through farm stalls, urbanites lacking adequate transportation have ready access to fresh produce (Corzo, 2011). Above all, speaking volumes to the success of Cuba's agricultural recovery, while undernourishment initially spiked steeply from 7.3% (already low of other countries at the time of similar income) to 20% during the economic challenges of the Special Period, undernourishment decreased between
1990 and 2011/2013 by 92%, when it reached the remarkably low level of 0.6%\(^1\) (Riera & Swinnen, 2015).

**The inputs argument**

Authors approaching the issue of food security in Cuba tend to take a polarized perspective; either supporting private investment in agriculture in order to bring them up to speed with capitalist/neoliberal agronomy, or a centralized and unilateral approach to agroecology (Corzo, 2011; Funes et al., 2009; Riera & Swinnen, 2016; Peter Michael Rosset et al., 2011). While both of these arguments have a breadth of publications which support them, the former perspective comes backed with the economic power of private agribusiness, international development organizations, and elements of the Cuban government (Alvarez, Jose Hagelberg, 2007; Alvarez, 2013; Castañeda, 2011; Coleman, 2001; Corzo, 2011; Deere, 1993; Feinberg, 2013; Friedrich, 2015; Funes et al., 2009; Healy & Evans, 2016; Messina et al., 1992; Riera & Swinnen, 2015; Spoor & Thiemann, 2016; Taub, 2010). Even many of Cuban urban agroecology's proponents understand that Cuba has a serious problem with lack of capital (Friedrich, 2017; González & Gonzalez-Corzo, 2015).

From a production standpoint, Cuba's agriculture is suffering. Yields are generally lower than what they were pre-special period, and few farmers have the resources necessary to return to their former yields in a conventional model (Alvarez, Jose Hagelberg, 2007; Corzo, 2011; Friedrich, 2017; González & Gonzalez-Corzo, 2015; Healy & Evans, 2016; Spoor & Thiemann, 2016). This has created something of a

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\(^1\) As defined by the proportion of the population in the country with a level of Dietary Energy Consumption lower than the Dietary Energy Requirements.
vicious cycle of ongoing subsidy, in which farmers are unable to meet production goals or achieve high enough earnings, and so are unable to purchase the equipment or make the changes necessary to reach their goals (Alvarez, Jose Hagelberg, 2007; Corzo, 2011; Friedrich, 2015). Markets continue to buy produce from farmers at fixed prices, but these prices are distinct from the actual value of production, leading to farmers to be unable to cover costs (Spoor & Thiemann, 2016). This same issue impacts consumers, who may only have the option to buy lower quality produce for the same fixed price. In the event that there is less demand for this overpriced product, the reduced sales will again impact the farmer (Alvarez, Jose Hagelberg, 2007).

The Cuban government is aware of the inefficiencies in the food production system, but as of yet has been unable or unwilling to rectify them. As early as 2002 the government began to attempt to repurpose sugar production land, but by 2007, nearly 40% of the appropriated 807,000 ha remained idle (Alvarez, Jose Hagelberg, 2007). In 2007 and 2008, the government passed two critical measures meant to increase productivity. The first was increased payment by the acopio, or the government food buyer for the libreta, intended to provide producers with increased income in order to allow them to buy inputs and make improvements on their farm (Corzo, 2011; Leitgeb et al., 2016). The second was to again attempt to push more idle agricultural land owned by the state, which across Cuba totaled nearly 1,758,962 ha, back into the production of vegetables and animal products (Corzo, 2011). While this has resulted in the increase in the share of agricultural land held by Credit and Service Cooperatives (CCS) and private farmers from 18% in 2007 to 36% in 2013, the overall acreage of idle land continued to increase to more than 992,259 in 2014; and many growers still feel that they lack
financing and access to input markets necessary to develop the land (Alvarez, Jose Hagelberg, 2007; Gonzalez-corzo & Justo, 2017; González & Gonzalez-Corzo, 2015; Spoor & Thiemann, 2016)

Sugar and Land

The cyclical lack of yields and lack of necessary inputs to increase productivity is particularly apparent in sugarcane production, which has long been a mainstay of Cuba's export economy. While sugar is still one of Cuba's principal exports, the quantities of export have fallen drastically (Alvarez, Jose Hagelberg, 2007; Sánchez, 2011). Cuba's sugar production moved toward mechanization in the 1970's, utilizing machinery provided by the Soviet Union. But as occurred with much of the country's agriculture, the fall of the USSR led to an inability to service machinery or acquire new parts (Alvarez & Pérez-lópez, 2006; Sánchez, 2011). After a number of years of falling production due to reduced access to machinery and lack of investment, Cuba's trade balance fell into the black in 1997, and the red by 2001 (Alvarez, Jose Hagelberg, 2007).

The food security challenges that Cuba faced during the Special Period were a direct result of its history of land use. Like much of the rest of Latin America and many other developing countries, a history of colonization and latifundio (large scale farms owned by powerful families) agriculture resulted in Cuba's food economy focusing on the export of a singular agricultural product (Gonzalez, 2003; Nova Gonzalez, 2013; Peter Michael Rosset et al., 2011). In Cuba, while tobacco has always played an important role, nothing has comprised such a large portion of the economy as sugar. Sugar has been the basis of Cuba's economy since the 60s, and to a large degree still remains so (Fischer,
During the revolution, the appropriation of *haciendas* became the backbone of the export-led sugarcane-based agro-industrial system, and its revenues were used to pay for Cuba’s food security (Peter Michael Rosset et al., 2011; Spoor & Thiemann, 2016). The Soviet Union strengthened this model by paying for Cuba's exports at highly preferential rates in order to support their ally in the West (Riera & Swinnen, 2016). At one time, 30 percent of agricultural land was devoted to sugarcane, generating 75 percent of export revenues, while 57 percent of all food was imported (Peter Michael Rosset et al., 2011). Before the fall of the Soviet Union, sugar in Cuba generated $600 million in foreign exchange and employed approximately 400,000 agricultural workers, but as Cuba recovers from economic strife, and with the passing of Fidel Castro, the transition is also influencing sugar’s agroindustrial complex (Alvarez & Pérez-lópez, 2006; Crawford, 2003). Fluctuations in the market price of sugar and Cuba's increased capacity to export other products such as tobacco and medical services have significantly reduced the percentage contribution of sugar to the Cuban economy, yet the overall trend of export dependence has persisted (Alvarez & Pérez-lópez, 2006; Hoag, 2017; Spoor & Thiemann, 2016).

The prevalence of sugar on an island of relatively small total area may make it appear that Cuba's issues of food security are rooted in prioritization of export based monocultures and the failing of petroleum dependent technologies from the era of the green revolution (Peter Michael Rosset et al., 2011). There is some truth to this, but a closer inspection reveals a sugar industry that is on its last legs and under increasing pressure by the government to either achieve higher yields or sell its land so that the state may appropriate it for food production purposes (Alvarez & Pérez-lópez, 2006;
Crawford, 2003; Sánchez, 2011). The increasing turmoil in Venezuela, one of Cuba's primary trade partners, and one to which it is considerably indebted, and their resultant reduced buying power may only exacerbate the problem (Birnbaum et al., 2016). Meanwhile, the machinery and inputs that Cuban sugar producers rely on are outdated and scarce (Sánchez, 2011).

The extent of persistently idle land is yet another strong argument in favor of the need for foreign direct investment. The same issues of a lack of financial resources and investment that plague the sugar agro-industry seem to have halted progress in the development of sugar lands that have been appropriated for other uses. In the meantime, the invasive species marabú, a spiky, deep-rooting perennial, has populated the vacant space, making the overhead necessary to develop the land that much greater (Alvarez, Jose Hagelberg, 2007; Castañeda, 2011; Friedrich, 2017; Gamboa, Abel; Gonzales, Roberto; Herrera, 2013; Leitgeb et al., 2016; Riera & Swinnen, 2016; Spoor & Thiemann, 2016). Local researchers are attempting to develop methods to use marabú biomass as fuel, but these techniques have yet to be applied (Spoor & Thiemann, 2016). In the current state, land that remains unused quickly becomes populated by this pest species, and for most small producers removal is cost-prohibitive. In fact, the cost per hectare is so high as to be a disincentive for Cuban agribusiness (De & McCormack, 2017).

Proponents of private sector financing argue that the public sector and socialized agriculture will be unable to make the sufficient investment to either take advantage of this land in non-sugar agriculture or to effectively cultivate cane on existing sugar production area (Corzo, 2011; Sánchez, 2011). While Cuban sugarcane production could generate 1.2 billion dollars in yearly revenue, it would take years to reach this point, and
would require a 2 billion dollar initial investment (Sánchez, 2011). Such an investment opportunity would be untenable for the government, but could be welcome by foreign investors, and could potentially economically benefit Cuba's government and citizens (Sánchez, 2011).

**Non-sugar agriculture**

While yields in non-sugar production are less troubling, distribution and sales infrastructure face similar challenges to those encountered in the sugar industry (Alvarez, 2013; Corzo, 2011). Cuba boasts both a rampant need for increased production and a ready market. Vertical integration of supply chains would streamline harvest and distribution processes. Should this opportunity exist, it could provide investors with incentives to improve distribution systems and better utilize productive land, while simultaneously providing the Cuban people with lower cost produce (Alvarez, Jose Hagelberg, 2007). Alternately, investment in small scale local agriculture with local distribution systems could reduce transport costs and wastes, as well as using land more effectively (Corzo, 2011).

But regardless of how the problem is approached, inefficiencies are rampant in Cuban agriculture. According to the last available data, as much as 15% of Cuba's food production was wasted (Alvarez, 2013). Some distributors report that as much as 60% of their trucks for distribution are non-functioning and in need of repair with parts, which are too expensive or unavailable, and the slow speeds of transport result in higher rates of food waste and reduced returns on damaged produce (Alvarez, Jose Hagelberg, 2007). Other inefficiencies are rife in Cuba's bureaucratic agriculture, with public investments in
sectors like potatoes seeing little production benefit, with large portions of investments going to high levels of centralized micromanagement (Alvarez, Jose Hagelberg, 2007; Alvarez, 2013). Among many unsettling figures indicating these inefficiencies, perhaps none is more telling than the fact that agriculture constitutes 20% of the country's workforce but only 3.2% of the GDP (Alvarez, Jose Hagelberg, 2007).

**Cuba's potential yields and opportunities for Foreign Direct Investment**

With so much idle land and a relatively small population, Cuba possesses incredible potential for food sovereignty, but faces numerous and complex barriers to taking advantage of its full productive potential. It would only require approximately 100,000 ha to produce the equivalent of Cuba's cereal import (conservative estimate based on FAO figures for import quantity and yield, 2013 - 2.017mt/ha) (FAO, 2014). Dairy and meat products would be more complicated to produce. Given the extremely low rate of 1.5 tonnes/ha for milk production, it would require nearly 400,000ha just to stock the cows necessary to produce the 594,000 tons of milk, which Cuba imports each year. This doesn't include the necessary land to produce feed, which at this time is also a major import in Cuba. Solutions to Cuba's dairy import would need to center around increasing stocking density (possibly through a combination of intensive grazing, silvopastoral systems, and urban production (Figure 4), reducing the quantity in the Cuban diet, or both (Funes-Monzote, Monzote, Lantinga, & Van Keulen, 2009).

Fully localized vegetable production, however, is well within Cuba's reach. Given Funes' (2009) 30ton/ha figure for urban production, the remaining 1% or 28,000 tonnes of Cuba's vegetable needs could be met with only 1,000 additional ha of organoponicos.
If potential market value is equal to the current cost of imports, gross revenue could be as high as US $86.8million. While this figure may initially seem like an overestimate, when one considers the high-labor, biointensive methods being used on organoponicos, it seems possible if not probable (with crops earning only roughly average $1.5/lb.), and may in fact be relatively low when one considers total labor hours.

Anecdotal evidence, and the researcher's experience, suggests that a single hectare of organoponico may take upwards of 7-10 workers. This could reduce average gross revenue per person per year to a mere $8,600. However, given that the average Cuban's salary is around 513CUP/mo. or US $19.50/mo., or little under US $240 per year, plus a US $50-120 two year bonus, a large majority of the farm's gross revenue could be devoted to expenses (Hoag, 2017). Considering that many farm inputs are produced on site and tools are basic, this paints a picture of an agricultural model which, once established (and establishment costs, originally incurred in Cuba via heavy government subsidy in the Special Period, would be high) could be both profitable in a free market and generate jobs of above average income, as Koont asserts in his 2008 article. This glimpse of organoponicos' finance suggests that the principal barriers to the growth of urban vegetable production in Cuba are neither a matter of agronomy or available land, but market-based. Some propose that free markets would allow for startup investment and more efficient markets with lower transaction costs.

The problems that plague growth in the sugar-industry are just as present in non-sugar agriculture (Alvarez, 2013; Corzo, 2011; Riera & Swinnen, 2016). Despite the ability of workers to sell excess to earn additional wages beyond their state salary, once quotas are met, low state-determined market prices and poor markets limit their earning
potential. This results in extremely constrained financial resources for individual farmers (González & Gonzalez-Corzo, 2015; Spoor & Thiemann, 2016). Even CCSs (Credit Service Cooperatives) are rarely able to invest far beyond the necessary costs of maintenance. In comparison to wages earned, the cost of even a simple piece of equipment like a hoop house can be the equivalent to two years earnings (Spoor & Thiemann, 2016). Except in rare cases where farmers have managed to maintain old equipment or are exceptionally skilled, this makes it difficult to attain the technology necessary for positive growth cycles (Spoor & Thiemann, 2016). Even more difficult is for farmers and cooperatives to save the necessary amounts to invest in developing new land. Farmers often fear taking out loans to improve new land, as the combination of the high costs of preparing land and the uncertain access to inputs, either organic or otherwise, makes their ability to repay their debts uncertain (Leitgeb et al., 2016).

Land tenure plays an additional disincentivizing role in farmer investment in Cuban farms (M. A. Altieri & Funes-Monzote, 2012; Peter Michael Rosset et al., 2011; Spoor & Thiemann, 2016). While the government has provided farms for urban production at low or no cost, it does so based on criteria that the land will be in production. Even a small amount of marabú, or a small unused space can be sufficient to disqualify farmers from land use (De & Mccormack, 2017; Spoor & Thiemann, 2016). Especially in urban areas, farmers worry about potential redistribution of land for urban development projects, leading to an absence of investment (Spoor & Thiemann, 2016). Additionally, wages paid by the state to farmers have at times failed to be paid on time, leading to an overall lack of trust in the state to support agricultural ventures (Leitgeb et al., 2016).
There is, as well, a problem that is constant in the Cuban labor force. Skilled workers earn relatively little (Hoag, 2017). This has two direct results, one being that low wages result in poor economic growth. This is seen clearly in agriculture, where members of the family are unwilling or incapable of using their off-farm income to aid in farm growth (Riera & Swinnen, 2016). The other is what has been referred to as Cuba's "brain drain", where skilled workers who have been educated in Cuba's subsidized education take their abilities to countries where they will be able to earn more with their knowledge (Hoag, 2017; Wilkinson, 2017). This is most widely documented in the medical industry, but inevitably takes place in agricultural science as well (Wilkinson, 2017). This, in combination with state regulation of who farmers can hire as employees, reduces skilled workers' motivation to participate in agriculture and limits farmer access to qualified labor (Gonzalez-corzo & Justo, 2017)

Even should Cuban farmers succeed in overcoming the many obstacles to starting a farm or developing additional land, markets and distribution may make any earnings negligible (Corzo, 2011; González & Gonzalez-Corzo, 2015; Spoor & Thiemann, 2016; Wilkinson, 2017). Prices are set by state institutions and are often not coherent with the price of production (Spoor & Thiemann, 2016). As much as 60% of Cuba’s agricultural transportation system is defunct or in need of repair, leading to produce arriving at market already wilted or nearing the end of its shelf life, resulting in it being sold at a lower than desirable price (Corzo, 2011; Spoor & Thiemann, 2016). As has been discussed before, this is at least partly the result of high ranking government officials' investment in import based supermarkets (and their resistance to the success of other markets could be considered as competition), and partly a result of an inability of Cuba's
urban growers to invest in transportation infrastructure themselves (Corzo, 2011; González & Gonzalez-Corzo, 2015).

**Barriers and Solutions - where UPA plays a role**

Simply because Cuba imports such a large percentage of its meats and grains should not be indicative of a failing of UPA (Corzo, 2011; Spoor & Thiemann, 2016). In fact, Cuba has managed to reach extremely high levels of food security despite unparalleled challenges (Riera & Swinnen, 2015). Cuba's urban agriculture should serve as an example for the rest of the world, both in terms of the agroecological technical methodology and the capacity to strengthen food systems through community action (Peter Michael Rosset et al., 2011). But just as Cuba should serve as an example of the potential of urban agriculture, it can also function as a learning opportunity (Leitgeb et al., 2016).

There is a tendency among proponents of agroecology and sustainable agriculture to treat Cuba's issues with food security as primarily a technological problem rooted in effectively taking advantage of space, and cultivating it in a manner that is low-input and healthy for citizens and the environment. The belief in the potential of social, political, and scientific agroecology as a methodology for food sovereignty has a strong base of evidence, as does the belief in the potential of Cuban agriculture to supersede its current struggles and become a model of food production the world could learn from (M. A. Altieri & Funes-Monzote, 2012; Funes et al., 2009; Nelson et al., 2009; Peter Michael Rosset et al., 2011; Tornaghi, 2016; Wezel et al., 2009). Yet the anxiety that private investment will topple the fragile architecture of Cuba's food sovereignty movement may
be the precise sentiment that prevents its scalability and its capacity to meet production gaps (Friedrich, 2017; González & Gonzalez-Corzo, 2015).

Observing Cuba through a critical lens is essential for understanding the implications of the successes and failures of Cuba's urban agroecology movement. While the country has been able to produce the majority of its vegetable needs with UPA, political and cultural barriers stand in the way of its capacity to provide a higher level of food security to the island (Leitgeb et al., 2016; Riera & Swinnen, 2016). Among these are the dietary preferences of the Cuban people, the investment of high ranking officials in an import-export model, and a lack of confidence in long-term land tenure (Alberto et al., 2017; Deere, 1993; Leitgeb et al., 2016; Porrata, 2008; Spoor & Thiemann, 2016). Ironically, the Cuban Socialist model, the same system which was effectively able to mobilize the population around the idea of agroecological food sovereignty, has become UPA's number one opponent; mostly by limiting growth cycles through restrictions in private ownership and private investment (Corzo, 2011; Peter Michael Rosset et al., 2011; Spoor & Thiemann, 2016).

It should be noted that organoponicos alone cannot solve the issue of Cuban food security. Even if the small scale production of sufficient raw grains is feasible, cereals require proper storage, milling, and threshing; processes that possess a high degree of asset fixity and which are astronomically more energy efficient when done at scale (Deelstra & Girardet, 1990; Messina et al., 2016). This is a situation in which the perfect must not become the enemy of the good. Cuba sits at a tipping point, with increasing reliance on foreign markets and foreign debt, and with increasing likelihood of improved trade relations and opportunities for foreign direct investment (Alvarez, Jose Hagelberg,
2007; Birnbaum et al., 2016; Messina et al., 2016). If Cuba were to allow full access to private investors in its agricultural sector, it could quickly see the re-establishment of mechanized monocultures and other industrialized practices, and lose the opportunity to develop domestic production without reliance on the petrochemical industry (Friedrich, 2017; Healy & Evans, 2016; Taub, 2010). However, some authors assert that with intelligent and regulated investment, as has been seen in impact investment and green investment programs, Cuba could become an agroecological and food sovereign nation (Birnbaum et al., 2016; Corzo, 2011; Feinberg, 2013; Gonzalez-corzo & Justo, 2017; González & Gonzalez-Corzo, 2015; Ramon-Valdés, 2017; Riera & Swinnen, 2016).

Because of Cuba's infrastructure of production for organic pest controls, bio-pesticides, organic fertility amendments, its highly educated population with a breadth of skills in agroecology, and its ready labor force, cooperatives looking to fill production gaps and meet the needs of a ready market could offer an unusually high return on investment (Healy & Evans, 2016; Taub, 2010). For food hubs in the United States, and much of the world, aggregation and distribution is a significant challenge (Leblanc et al., 2014; Low et al., 2015), but with a population accustomed to functioning communally, and a government with the scaffolding of a strong aggregation and distribution infrastructure already in place, there is an increased potential for the design of successful transportation systems for small scale farmers, albeit requiring investment in necessary resources for trucks, refrigeration, and storage (Funes et al., 2009; P. Rosset & Benjamin, 1994; Peter Michael Rosset et al., 2011). The potential to meet the needs of a ready market through increased access to finance and markets suggests a possible scenario in which the Cuban government allows certain investment schemes, such as stock offerings
in cooperatives, markets, and transport for peasant agriculture. Through the injection of funds into these systems, small enterprises, cooperatives, and individuals could work toward a positive growth cycle in Cuban agroecology (González & Gonzalez-Corzo, 2015; Nova Gonzalez, 2013; Ramon-Valdés, 2017; Spoor & Thiemann, 2016). While this may seem like an improbable investment at this point in time for many companies, it could be of interest for enterprises which value social entrepreneurship, or a more effective investment for the dollars involved in Cuban development funds from NGOs and the international development sector. As the capacity of the sector to support itself grows, it could provide opportunities for green investment in a maturing economy (Feinberg, 2013; Leitgeb et al., 2016; Ramon-Valdés, 2017).

Investigations in other countries have shown the negative production impacts of governmental repression of private investment in agriculture (Betournay, 2015; Carballo-Mendivil, Arellano-Gonzalez, & Ríos-Vazquez, 2017; Jalaee, Shafei, & Javadinia, 2014). Microloans and impact investment are a growing trend in international development, and have been shown to capacitate communities and enterprises to improve themselves through enabled collective action (Etzion, Gehman, Ferraro, & Avidan, 2017). As a strategy for growth, research shows that investment in Small and Medium Enterprises are often more innovative and flexible, and employ more workers per dollar invested than large firms (Feinberg, 2013). Meanwhile, the breadth of research which identifies the need for a loosening of economic restrictions and greater autonomy for farm decision making only grows (Feinberg, 2013; Friedrich, 2017; Gonzalez-corzo & Justo, 2017; González & Gonzalez-Corzo, 2015; Leitgeb et al., 2016; Nova Gonzalez, 2013).
In June 2011, Cuba began allowing banks to extend a limited amount of credit to small scale agricultural producers to finance working capital and farm improvements (Corzo, 2011). These measures, meant to build upon reforms in 2007 and 2008 and largely catalyzed by a response to the 2011 food price-crisis, granted new land to citizens and aimed to improve distribution channels (Leitgeb et al., 2016). Since 2011, both area cultivated and yields have increased, particularly on private farms, who in comparison to state run agribusiness have nearly tripled their area under production (Gonzalez-corzo & Justo, 2017; González & Gonzalez-Corzo, 2015). Data on individual farmers is scarce, but what is available suggests that a large portion of this growth was on the part of small-scale private landholders (Gonzalez-corzo & Justo, 2017; Nova Gonzalez, 2013). However, access to credit is still limited, and the majority of farmers struggle with obsolete equipment, compounded by challenges of high production costs and low yields due to poor soils and fertility (Friedrich, 2017). Food production increased 30,000 tons in a single year in 2013 and food access improved; yet access to inputs and overcoming resource scarcity are still a primary challenge for Cuban growers, even those with low-input agroecological models (González & Gonzalez-Corzo, 2015; Leitgeb et al., 2016; Peter Michael Rosset et al., 2011).

**Conclusion**

Raul Castro’s more open economic policies have put Cuba in a precarious place. The systemic implementation of Urban and Peri-Urban Agroecology for the achievement of national food sovereignty, a hallmark achievement of the revolution, stands threatened by eager agribusinesses that could overpower and displace small farmers. Many authors
believe that the production of Cuba's food needs with its current system is unattainable, but a more in depth analysis shows the movement's great successes. Cuba is able to meet the majority of its vegetable needs, create jobs, and strengthen communities through its urban farms. For the island to achieve true food sovereignty, it will be essential for small farmers and campesinos to reach economic sustainability and growth. As well, Cuba will need to expand into vast swaths of idle land, overcoming overhead costs, a lack of mechanization for inputs, challenging markets, and the pestilence of marabú.

Figure 3: Organoponico using shade cover, drip irrigation, and intercropping

A total loosening of economic restrictions on investment could result in foreign agribusiness taking possession of Cuba's agriculture and markets. Yet, without some way of re-enervating the Cuban agricultural economy and providing farmers with the resources to develop new land into local production, organoponicos and Cuba's UPA may be unable to meet production gaps and to fulfill Cuba's food needs. One possible solution could be restricted investment in ventures that support national food sovereignty.
combined with increased access and control over markets for farmers. Similar strategies of green investment have been successful when employed by NGOs and international development firms in rural development and the support of small enterprises. Cuba, with governmental regulation in support of local producers already in place, has the potential to successfully mitigate investment in a way that allows small farmers access to finance to achieve positive growth cycles without allowing the Cuban food system to be bought by foreign interests.

Should Cuban farmers receive greater access to finance in combination with an increase in decentralized, farmer-centric policies that favor longer land tenure, allow for the participation of non-state economic actors, and allow farmers with autonomy in marketing and commercialization decisions; and should the government continue to support campesino and urban agriculture over large agri-business, Cuban agroecology could go beyond its irreproducible and country specific model to achieve a functioning system of food sovereignty which would truly become the exemplar Cuban agroecology is touted to be.
Chapter 4: Using Valuation Metrics to Measure the Food Sovereignty Benefits of Community Gardens

Introduction

In a town like Burlington, Vermont, issues around food are more nuanced than a simple discussion of food access or food security. Burlington is the urban center of a mostly agricultural and rural state, and might only be considered urban under certain definitions. With a population of roughly 42,500 people, Burlington is the least populated city to be the most populous within a state (Census Bureau, 2016). At the fringes of the city, the line between urban, suburban, and rural rapidly blurs. Numerous working farms exist within a 10-mile radius of the city center, and many of the farms considered urban for this research have an appearance that would more closely resemble a rural farm in a more densely populated state.

Vermont has made a name for itself as an agricultural hub (Bittermann, 2007). While traditionally known for its dairy and maple sugar production, the agricultural landscape has been shifting (J. R. Taylor & Lovell, 2014). Rising dairy prices have forced the conglomerate of small and medium-sized family owned dairies (Daloz, 2011; Kirschenmann, Stevenson, Buttel, Lyson, & Duffy, 2008; Mount, 2012). Meanwhile, supportive progressive politics and an educated youth population have fueled a surge of new vegetable producers (Lovell, 2010; Macias, 2008; Niewolny & Lillard, 2010). Programs like the Intervale Center's farmer training program have further energized the movement (Niewolny & Lillard, 2010).

With such availability of agricultural land and access to farming, it might be difficult to justify community gardens through a neoclassical economic lens, especially in
an agriculturally rich place like Chittenden County, Vermont (M. Altieri et al., 2014; Badami & Ramankutty, 2015; Ghose & Pettygrove, 2014). High quality fresh, if not organic, produce is readily available to much of the population at easily accessible local supermarkets, farmers markets, and coops (Bittermann, 2007). This produce comes from commercial farms, which urban gardens are unlikely to be able to match in labor and cost efficiency (Franzlubbers & Haney, 2006; Goldstein et al., 2016; Low et al., 2015).

Nonetheless, urban agriculture is on the rise in the Burlington area (Nihart, 2013; S. Taylor et al., 2010). This is particularly true in the case of community gardens, of which there are a handful in each of Burlington's neighborhoods; each serving different populations.

The subsidies and land which local governments, non-profits, and charitable donations provide may be more beneficial to communities when used in other ways (Ellis & Sumberg, 1998; Mok et al., 2014). Critics argue that on a municipal scale, Burlington's urban land could do more good for the city by bringing in wealthier taxpayers or serving as space for local business than it could in community gardens, especially should food needs be capable of being met by nearby farmers growing more efficiently on cheaper land (Garrett & Leeds, 2015; Mok et al., 2014; Nihart, 2013). Community gardens in peri-urban areas capitalize on agriculturally rich land in or near urban centers. This makes high quality farmland with prime market access unavailable to commercial vegetable growers, who may be able to produce more on an equivalent amount of space for a lower energy expenditure and a lower cost (Badami & Ramankutty, 2015; Goldstein et al., 2016). Unused urban land could also be developed for commercial or residential uses that
have the potential to generate local economy and to bring in more money for municipalities in tax earnings (Mok et al., 2014).

From an agronomic standpoint, community gardens are rife with inefficiency (Mok et al., 2014; Veenhuizen et al., 2007). Some users are not trained farmers, and many are limited in the time they can commit (Mok et al., 2014). Even those that are skilled, and are able to invest time, manage such small quantities of farmland without mechanization that their growing capacity is limited (Badami & Ramankutty, 2015; Goldstein et al., 2016; Mok et al., 2014). One poorly tended plot can function as a bank of weed, disease, and pest populations that will affect the entire garden (Veenhuizen et al., 2007). Most community gardens lack complex irrigation systems, meaning gardeners are watering by hose or bucket and apply water unevenly and below or above plant requirements, resulting in water waste, crop root inundation, compaction, or soil salinization (Baudron, Tittonell, Corbeels, Letourmy, & Giller, 2012; Franzlubbers & Haney, 2006; Franzluebbers, 2002). In garden plots without greenhouses, farmers are forced to direct seed, resulting in wasted space should seeds fail to germinate, and a greater reliance on good weather patterns for growing (Kelley & Boyhan, 2014).

Because of the agronomic challenges that community gardens face, assessing inputs and outputs or calculating costs, gross, and net, as is commonly a measure of farm efficiency, is more than likely to paint community gardens in a negative light (Garrett & Leeds, 2015; Mok et al., 2014; Veenhuizen et al., 2007). Even without this type of financial assessment, the fact that most community gardens rely on public or private subsidies to stay afloat does not bode well for their financial viability (Mok et al., 2014; Pearson et al., 2010). However, a wealth of research shows that community gardens
provide multifunctional benefits and Cultural Ecosystem Services (CES) that range from improvements in neighborhood involvement, psychological wellbeing, nutrition, and more (Brown & Jameton, 2000; Fernandez et al., 2016; Galluzzi et al., 2010; Gould et al., 2014; Hartwig & Mason, 2016; Lin et al., 2015; J. R. Taylor & Lovell, 2014; S. Taylor & John, 2013). This has been enough to justify marginal support on the part of small non-profits and local governments, but never enough to foment a truly enabling environment for these organizations (Dubbeling et al., 2010; Fernandez et al., 2016; Nihart, 2013).

Burlington's low-income population in particular stands to benefit from community gardens. While many of Vermont's citizens are fortunate to have access to some of the best produce the US has to offer, those living below the poverty line have little agency in making choices about what they eat (Berlin et al., 2011; Clarke & Jenerette, 2015; Ghose & Pettygrove, 2014; S. Taylor & John, 2013; Tornaghi, 2016; Vitiello et al., 2015). *Cultural, racial, and class minorities are less likely to possess sufficient market power for markets to respond by providing them with their choice in products.* This is especially true for migrant, refugee, and immigrant communities, who may not be able to access foods which are not part of the common American gastronomy at Vermont grocery stores (Hartwig & Mason, 2016; Hondagneu-Sotelo, 2017; Romero-Gwynn et al., 1993; Saldivar-Tanaka, 2004; Tornaghi, 2016). When these ingredients are available, they frequently come at a high energy cost through substantial transport, and are often not fresh. Even should consumers be able to access an uncommon crop, it may not be a variety that they are accustomed to.

The forced adjustment to the American diet is in many ways a type of systemic violence, resulting in psychological stress associated with the loss of cultural identity and
negative health impacts from an unfamiliarity with how to prepare other ingredients (Berlin et al., 2011; Ghose & Pettygrove, 2014; Hartwig & Mason, 2016; Tornaghi, 2016). The deficiency of culturally relevant produce has a strong effect both on mental health and wellbeing, as well as on physical health (Freudenberg et al., 2011; Hartwig & Mason, 2016; Tornaghi, 2016). Communities which are unable to access crops to which they are accustomed may respond by eating less vegetables or by substituting vegetables with processed foods, resulting in a negative effect on household nutrition (Romero-Gwynn et al., 1993).


The benefits of participating in gardening are not relegated strictly to migrant communities. African American and Latino communities have been able to cultivate spaces for sharing culture in community gardens, and low income Americans across the country have succeeded in making spaces which serve community needs on multiple levels (Teig et al., 2009; Vitiello & Wolf-powers, 2014). Food access is still often a challenge for Burlington's low income population (Berlin et al., 2011; S. Taylor & John, 2013; Tornaghi, 2016). Affordable housing units are frequently not centrally located or
are not located within walking distance of food vendors (Berlin et al., 2011). As progressive a state as Vermont is, Burlington's public transit is limited (Macias, 2008; Nihart, 2013). Without a car, individuals are forced to walk, take the bus, and bike with groceries. They are limited by what they can carry and how frequently they are capable of making this often time-consuming journey (Corrigan, 2011). This worsened by Burlington's long and harsh winters, which further impede travel. The opportunity cost of transport time to vegetable vendors alone could justify the labor in on-site garden plots in affordable housing zones, such as those seen at Harrington or many of the small gardens in Burlington's North End that were not part of this study.

As with travel costs associated with procuring produce, some of the services that community gardens provide come with quantifiable material and monetary value. Methods like willingness to pay, travel cost, avoided cost, and hedonic pricing have been shown to be functional metrics for the monetary valuation of Cultural Ecosystem Services (CES) (Berkel & Verburg, 2012; Gómez-Baggethun & Barton, 2013; Gould et al., 2014; Groot, Alkemade, Braat, Hein, & Willemen, 2015; Haase et al., 2014). Through avoided cost it could be possible to quantify the mental and physical health benefits of community gardens and their indirect economic impacts such as reduced strain on subsidized healthcare systems (Clarke & Jenerette, 2015; Garrett & Leeds, 2015). Hedonic pricing has been applied as a method to demonstrate the positive impacts of urban greening on neighborhood property values (Voicu & Been, 2008).

The ability of community gardens to supply niche produce has a direct economic benefit. In the case of more obscure produce, such as bitter melon or snake gourd for instance, the low demand may make it difficult to produce on a sufficient scale for
economic viability, requiring specific treatments and a specialized distribution system to reach demanding communities while the produce is fresh. Alternately, imports of niche products from production areas in small quantities would come with a high energy cost and high transaction costs (Goldstein et al., 2016; Peters et al., 2011). It can be possible to quantify the benefit of UPA in addressing such supply chain inefficiencies by measuring the difference in incurred costs of bringing these products to consumers through conventional markets against those of subsidizing community gardens (Goldstein et al., 2016; Peters et al., 2011).

When one considers the multifunctional benefits of community gardens and the cultural ecosystem services that they provide, the potential value of UPA justifies its use of contentious urban spaces. However, its essential that the academic community finds metrics for the valuation of these benefits that are sufficiently specific for decision making contexts and which can be demonstrated to decision makers (Gómez-baggethun & Barton, 2013; Pearson et al., 2010). Furthermore, due to the limited availability of urban growing space, it is especially important to maximize the capacity of gardens to provide social and multifunctional benefits and to grow food that fills niches in the local food system. This research proposes a tool called Crop Value Index (CVI)\(^2\) to combine factors of cultural value and access with a classical agronomical assessment of potential yields and inputs in order to identify which crops produced in community gardens are creating the most value with contentious urban spaces.

\(^2\) Crop Value Index is a metric developed for this thesis research which ranks crops on a scale of 0-1 in terms of the net savings they produce (NET) and their cultural importance as determined by a set of survey questions (VM)
Crop Value Index

Currently, little research has been done showing what is being grown in community gardens and urban farms, or which crops and management techniques are best serving communities. CVI aims to function as a tool that demonstrates the cultural importance associated with crops to their net profit or savings on an equal scale. In doing so, it seeks to examine which crops specifically are effectively and economically producing food, which are producing culturally valuable food, and to identify crops at intersections of the two: those which serve cultural needs while producing food in the most cost effective manner possible.

While other statistical analysis may be able to demonstrate similar correlations between cultural value and net profit or savings, the use of CVI has two major advantages. One is that by ranking crops in their relationship to a grower, equal importance is given to each factor for further analysis (and, in fact, in the future it could be quite interesting to weight these factors based around other survey questions which indicate the importance of each to respondents). The other is the relative simplicity with which CVI displays results; easily interpretable values that require no further analysis to be understood. This makes the values generated by CVI equally accessible to policy makers, garden managers, and gardeners, broadening the spectrum of applications.

Analysis of CVI results can be used to aid garden managers in decision-making, as comparative tests across growers can identify crops that are especially capable of generating savings and important within a community group. For garden managers, this could provide important information as to which types of seeds, tools, and growing spaces may be most valuable and suitable to their gardeners. By combining CVI values
with demographic surveys, analysis can help shed light on what other factors may influence the growth of high CVI crops (for instance, if New Americans are more likely to use space for both economic and cultural purposes). Additionally, analysis relating garden management to CVI could help gardeners and garden managers identify practices and methods that increase effective use of urban space.

**Research Questions**

1. How much food are community gardens capable of producing?
   a. How does this production compare to commercial growers in terms of yield?
   b. How much savings/profit are community gardens able to generate?
2. What Cultural Ecosystem Services are served by the crops grown in community gardens?
   a. Can CVI demonstrate the reasoning behind choices being made in community gardens?
   b. Can CVI help identify crops that are both profitable and culturally valued?
3. How do different management styles affect gardens' capacity to produce financially and culturally valuable food?
   a. What decision-making factors influence management decisions?

**Methods**

**CVI components**

To gather the necessary information about net profit/savings and valuation of cultural importance, two methods were used: a biophysical assay of plots in community gardens and interviews with the users of the surveyed plots. The biophysical survey consisted of collecting a count of plants of each crop type in garden plots and measuring the amount of area that a crop type takes up. This resulted in plants per square foot; a
number from which yields were approximated using the yield estimates available from university extensions which are given in yield per row foot within a given bed width\(^3\).

The survey needed to fill in a number of essential pieces of data for CVI. Among these were the crop-specific questions used to generate a Value Metric (VM), as well as questions about management that would help the researchers identify costs associated with growing a given crop. The survey also asked questions aimed at determining which management practices gardeners were using, with the goal of understanding of how management aligns with labor hours, outputs, and CVI.

\[ \left( \frac{\text{# plants}}{\text{width} \times \text{length}} \right) \times \left( \frac{\text{USDA yield per row foot}}{\text{USDA recommended planting distance}} \right) = \text{est. yield per ft}^2 \]
Selection of Partners

Figure 4: Location of surveyed gardens in relation to Burlington, VT

Participating partner organizations for this project were chosen by their interest in the project, their capacity to participate, their positive relationship with the University of Vermont (UVM), The Agroecology and Livelihoods Collaborative (ALC), and the principal investigator, and ultimately, their niche in the research project. While CVI was not designed specifically for community gardens, the methodology for collecting the data necessary to generate CVI would differ between a community garden and a commercial farm. Because CVI looks to highlight advantages tied to culture, community garden projects that aim to serve various subsets of the Burlington population were chosen. The management and nature of each of these were similar in that they consisted of a
governing body allocating plots to users for a set rent. Some organizations provided other materials and even technical assistance. Three of the four organizations were designed to serve specific communities of race, class, and/or socioeconomic status.

The most specialized of the four in terms of user-base was Harrington Community Garden, a small site located in the backyard of an affordable housing complex. The garden contains 18 plots in 8'x4' raised beds. Champlain Housing Trust in partnership with the Vermont Community Garden Network (VCGN) work to provide garden spaces to low-income residents of the units, which sit on Route 7 just South of central Burlington. The ownership of the plots changes from year to year depending on the buildings' inhabitants, but many farm there year after year.

Also run by VCGN is the Community Teaching Garden, located in the Intervale Center. The Community Teaching Garden (CTG) differs from the other gardens in that its purpose is primarily educational. CTG offers small plots to beginning gardeners for a fee that includes rent, resources, and participation in a weekly afternoon class. Gardeners are encouraged to take care of their gardens on their own time, but are also allowed work time during their normal meetings. Some of the spaces in the garden are communally cared for, such as perennial beds growing Nanking and sour cherries, or the lawn space used for teaching in.
CTG and Harrington were both selected due to a university connection with VCGN and VCGN's ongoing interest in the ALC’s UPA project. Carolina Lukacs at VCGN was contacted through the university. During meetings with the ALC she was asked to select gardens which would both be feasible to survey participants in and which would benefit from the results of this research. CTG was chosen due to Carolina's close participation in the project, along with its serving of a different niche within the research. Harrington was selected because of the researchers' interest in identifying a garden serving specifically low-income communities. VCGN recommended contacting their partner Anna Herman at the Champlain Housing Trust, who selected Harrington Garden due to the high level of participation of its members, which would facilitate easier sampling during the interview phase.

*New Farms for New Americans (NFNA)* operates out of the Ethan Allen Homestead. Compared to CTG and Harrington, the plots are much larger. Plots at NFNA are specifically offered to refugees. Due to limitations created by the lack of funds for translators, no available translator service, and lack of time availability for arranging
meetings on the part of the director, subjects were limited only to those who spoke sufficient English to understand the survey without a translator.

![Image](image.png)

**Figure 6: Gardeners tend and water peppers at Pine Island**

Alternately, at *Pine Island Community Farm*, another community garden serving the New American community, some translation was available. By far the largest site in terms of plot size and number of plots, Pine Island offered the greatest opportunity for a large sample size. Originally started as a space for participants to raise and slaughter goats according to cultural tradition, Pine Island has since expanded to include chicken production and to offer spaces for growing vegetables.

**PAR in Methodology and Survey Design**

In designing the survey for interviews and determining the overall focus of this research, a Participatory Action Research (PAR) approach was applied, and will continue to be applied by the Agroecology and Livelihoods Collaborative in their ongoing work with research partners (Fernandez et al., 2016; Méndez et al., 2013). The PAR approach
uses phases of planning, acting, observing, and reflecting to allow research partners to take a participatory role in the research process. Due to the short length of a Master's program, the limited length of the growing season, and the sometimes-challenging nature of arranging meetings with a number of partners, the number of cycles in this PAR process was constrained. However, this research has emerged from the combined needs of the partners and researchers, and has been a collaborative process with collaborative goals.

During initial discussions between partners and the ALC, yields were of particular interest to partners. Also of interest was a survey of what was being grown in participants' gardens and how. At the inception of the project, another grad student at the University of Vermont, Alissa White, had intended to conduct a multifunctionality assessment with the partners that would coincide with this research. This aligned well with the partners' goal of creating documents assessing the non-material benefits created by community gardens.

As shown in the literature review, there is a significant gap in data around yields and biodiversity in community gardens, but I sought to know more about how the food grown in UPA affected issues of food security and food justice. This research using CVI was designed to address both the needs of research partners and the scientific community to learn more about the biophysical elements of UPA, along with informing this thesis' focus on how these biophysical elements play into the community food system.

The interview component of this research informed the biophysical data collected in the field. Interview questions were designed through an iterative process with partners, where partners were able to both add in questions that would serve their interests as well
as to comment on the nature of questions as to better tailor them to their gardens' users. One interesting example of this would be how Casey Engels at Pine Island worked with the researcher to reformulate questions about time spent working on garden plots. Casey noted that many participants at Pine Island do not keep track of time while in their gardens, and would be unlikely to do so while working on their plots. This would make it difficult for them to respond to questions such as "How many hours a week do you spend in the garden?". Instead, questions were reformulated to break the week into days and times of day, to get an overall sense of the amount of time allocated for gardening by users without them producing an hour estimate which may be arbitrary.

Similarly, Alisha at NFNA was concerned about questions regarding management practices and decision-making in the garden. Through feedback from Alisha at NFNA, illustrations were developed to reduce the need for technical language in aspects of management (Figure 10). In another instance, a question about sustainability was changed to ask if participants considered their impact on the environment, and included in a broader question about what participants thought about while making management decisions.
Biophysical Survey

Quantifying yields in a community garden setting is exceedingly difficult. Garden users employ complex garden systems. They harvest sporadically, as crops produce or at their convenience, and for a researcher to be present at the time of each harvest is nearly impossible (Algert et al., 2014; Gittleman et al., 2012). In some gardens with a longer tenure it has been possible for researchers to form partnerships with participants and to pay them for their time spent collecting data on yields. For others, the money that researchers can offer participants is insufficient to justify the added labor of data collection (Gittleman et al., 2012; Vitiello & Nairn, 2009). The ALC had considered using a replica plot at a garden and quantifying the plot's production as conducted by Algert (2014), but this would fail to address the wide range of management styles at play in gardens.
The three most common practices for estimating garden yields are estimates from interview questions (such as questions about household savings or the number of meals consumed from food in the garden (Armstrong, 2000)), trial plots (Algert et al., 2014), the citizen science approach (Gittleman et al., 2012), and field estimates from planted crop area (Vitiello & Nairn, 2009). Using interview questions to ask directly about production quantity is highly prone to bias, as without any kind of quantifiable measurement taking place, outside factors are likely to affect participants' perceptions of garden output. As well, its difficult while using an interview method to collect data disaggregated by crop type. While a good way to get a general idea of how participants feel about their own crop production, for the purpose of this research the interview method was decidedly neither sufficiently accurate nor specific.

The citizen science approach, employed by Gittleman (2012) and Farming Concrete in NYC, uses gardeners as researchers in recording their own yields. While subject to underestimation due to exclusion of crops consumed before harvest in weighing, this method produces some of the most tangible data on yields of community farm projects. However, it is difficult to replicate, as it requires a number of accurate scales, a method of paying gardeners sufficiently for their time investment, and involved, interested gardeners with extra time to spare for research. Gittleman makes note of how during the first year of research the data was full of gaps, and successfully carrying out the model required hiring paid staff to oversee the collection of data at various farm sites. This was not feasible within the given time frame and without funding for this project, but could be extremely useful for the ALC's UPA partners going forward with this
research in order to provide a quantifiable dataset of crop specific yields in a real world community garden and urban farm setting.

For the purpose of this research, sampling the number of plants and planting area was decided to be the optimal method. Because of its feasibility on a broad scale, this method has been the most widely employed in community garden research. Vitiello's (2009) widely cited Philadelphia Harvest Report used this data collection model, and other papers such as (Orsini et al., 2014) use similar methods within a controlled experiment to generate estimates of potential yield. Patel (1991) uses an estimate by area to calculate profits. As well, this methodology is not uncommon in examining the economic potential of UPA as a tool for food security in developing countries. Researchers like Cook et al. (2015) have employed crop area estimates to estimate the yield potential of UPA for cities as a whole. However, with the exception of Vitiello and Nairn, most of these studies fail to disaggregate their results by crop.

The survey was designed with the knowledge in mind than any interviews would have to be concurrent with biophysically recorded plots, reducing the available population for interviews to that of the biophysical surveys. In order to maximize the possible interview sample size, all of the available plots were sampled in the biophysical survey at Harrington and CTG. This was made easier by the relatively small size of the gardens. At NFNA, arranging interviews with non-English speaking participants was not feasible. Of the participants 60 participants, approximately 25 spoke English, and so their plots were sampled in their entirety.

At Pine Island, many participants spoke a sufficient level of English, and for those that did not, bilingual farm managers from each community organize the farm, and were
able to offer their translation services. Participants were sampled in two groups, one of 60 gardeners and another of 9 garden leaders. Names were assigned values of 1-60 or 1-9, and a random number generator was used to choose 25 out of 60 and 5 out of 9 names.

Plots at all 4 partner organizations were sampled during mid July through mid-August in the summer of 2017. Samples were collected by the principal investigator using a tape measurer and visual observation. For each crop, total number of plants per \(\text{ft}^2\), \(X\), was given by the formula

\[
X = \left( \frac{x_1}{w_1 \cdot l_1} \right) + \left( \frac{x_2}{w_2 \cdot l_2} \right) + \ldots + \left( \frac{x_n}{w_n \cdot l_n} \right),
\]

where \(w\) is width of a planted area, \(l\) is length of a planted area, and \(x\) is the number of plants within a planted area. In the instance of large plantings of a single crop on even spacing, such as with corn, 5 measurements of length and 5 measurements of width were measured between plants, averaged, and rounded to the nearest half foot to estimate plant spacing as shown by the formula

\[
X = \frac{W + L}{\left( \frac{l_1 + l_2 + l_3 + l_4 + l_5}{5} \right) \left( \frac{w_1 + w_2 + w_3 + w_4 + w_5}{5} \right)},
\]

where \(W\) equals the total planted area width and \(L\) is the total planted area length. In the instance of intercropped areas, the number of plants per \(\text{ft}^2\), \(X\), was given by the formula

\[
X = \frac{x}{(W + L)/s},
\]

where \(W\) is the total area of the intercrop, \(L\) is the total length of the intercrop, and \(s\) is the number of intercropped species.

Field identification of vegetables was a key concern in the development of methods. The researcher was confident in their ability to identify common species of vegetables, but was unable to differentiate individual cultivars in the field. As well, some types of cucurbits and brassicas could be particularly challenging to differentiate (e.g., the difference between a pumpkin and winter squash). This was made yet more challenging by the fact that many New American gardeners are growing varieties of
vegetables that are next to non-existent in the United States, such as the 'Inhori' variety of white or green eggplant seen abundantly throughout Burlington's African garden sites or the white radish which is a staple of Bhutanese and Nepalese communities, which they consider different from what is commonly referred to as 'daikon radish'. This is further compounded by the frequent appearance of vegetables that are relatively unknown in the American diet, such as bitter melon, amaranth, and musk melon. While the researcher was able to identify many of these and was helped in the field at times by farmers who were present, there may have been others that could have been recorded as other plants (such as recording a musk melon as a melon) or written down with basic identifying features and a corresponding photo.

Figure 8: Nepali "pumpkin" at Harrington

In order to mitigate and alleviate problems of identification, the survey was designed in such a way to allow for respondents to further clarify the species and varieties of plants grown in their gardens. For each crop value question, respondents were
asked to write the name of the crop along with the name they know for the crop in their native language. This allowed for the research team to look up translations of the name, find the corresponding plant from the initial data collection, and enter in crop species and variety with greater detail during the data entry phase. When necessary, gardeners and garden managers were shown pictures of observed crops and asked to provide additional identification information.

**Interview Questions**

The survey was collected in a convenience sample by contacting willing gardeners whose plots had been part of the biophysical survey. Respondents were encouraged to read through the survey on their own with the researcher present.

The survey consisted of a section of demographics questions, a series of questions about management techniques, questions about decision making factors, and a set of questions about times and costs of various garden tasks aimed at providing information for estimations of net profit. A small section at the end of the survey provided space for a set of qualitative short and long-answer questions. A second portion of the survey asked respondents to write down the crops grown in their garden and rate them on four questions about their value and importance to the gardener.

The demographics section investigated profession, age, number of people eating from the garden (household size), and years of farm experience. While a point of interest, questions about nationality and point of origin were avoided due to concerns about exposing data around a vulnerable population; and due to the complicated nature of this
question, especially for refugee communities which have been relocating for much of their lives.

Management questions focused on agricultural practices such as trellising, fertility management, season extension, and seed starting. Gardeners were provided with pictures of the practices and additional description from the researcher, and asked to fill out a yes/no response. Gardeners rated decision-making factors on a Likert scale of 0-5, where 0 was equal to not at all and 5 as extremely important. Factors analyzed the importance of profit, enjoyment, and environmental functions to gardeners.

Questions about time spent on various tasks were used to calculate total labor hours by the principal gardener, total man-hours by the gardener and assistants, the distribution of labor among tasks, and water use. The labor hours for each task (weeding, fertility management, and pest control) were calculated by asking gardeners to estimate the percentage of time in their garden that they spent on each. As many gardeners were inclined to write in answers that did not add up to 100%, these answers were treated as a scale. The amount of time gardeners spent on a given task, \( T_w \) (weeding), \( T_f \) (fertility), or \( T_p \) (pest control), was calculated using the formula \( T_w = T_h \left( \frac{t_w}{t_w + t_f + t_p} \right) \), where \( T_h \) is the total hours spent in the garden, \( t_w \) is the supposed percentage of time indicated as spent on weeding, \( t_f \) the percentage of time spent indicated spent on fertility, and \( t_p \) the percentage of time indicated as spent on pest control. Also included in this section were questions asking gardeners to estimate a dollar value of what they paid in rent and for fertility and pest management products.

The primary purpose of the qualitative questions at the end of the survey was to get a sense of what perceived benefits gardeners received were. These included questions
about how much food the garden provided, how much gardeners believed they were saving, and why they believed community gardens are important.

**Development of the Crop Value Index**

*CVI Surveys*

One key issue in developing a Value Metric (VM) using survey questions about crop value was the issue of the relativity of responses. Initially the intent had been to ask respondents 4 questions on a Likert scale of 0-5 and to find the total of these four questions. However, this relies the problematic assumption that one respondent's 5 is greater than another respondent's 3. In order to address this problem, respondent's answers were normalized on a scale of 0-1, resulting in their responses to cultural value questions essentially ranking crops on a set of criteria from least to most important.

In the survey, gardeners were asked to write in the names of the crops they were growing. In the instance that the gardener was related to a plot with crops that the researcher had had difficulty identifying, the researcher used photographs to show the respondent the crop and attain at least a common name from which further information could be derived.

Gardeners rated each plant they listed on four criteria: issues of access (For me/my family, this crop is hard to find or too expensive at grocery stores/markets), issues of cultural importance (This crop is important to me/my family culturally), issues of taste and enjoyment (Me/my family enjoy cooking/eating this crop), and perceived nutritional value (This crop is important to me/my family nutritionally). Respondents rated responses on a Likert scale (0-5). These questions were selected as they corresponded to
commonly cited important functions of the food produced in community gardens in relation to access and food justice (Airriess & Clawson, 1994; Corlett & Dean, 2003; Fernandez et al., 2016; Romero-Gwynn et al., 1993; Tornaghi, 2016).

**CVI Yields and Profit Calculations**

Data from biophysical surveys and interviews were put into an excel spreadsheet which calculated yield and net profits for crops. Yields were calculated using an estimation by area similar to that in the frequently cited "2008 Philadelphia Harvest Report" (Vitiello & Nairn, 2009). However, two key alterations were made to their methodology. Instead of calculating yields based on per ft² crop estimates from commercial growers estimated by the USDA and extension as done by Vitiello & Nairn,
yield estimates (obtained from the UVM extension, MOFGA, and UC Davis) were divided by planting density in order to attain a figure for yield per plant, as recommended by Gittleman et al (2012) as the preferred method for extrapolating Farming Concrete's findings to other gardens. The predicted yield per plant in pounds, \( y \), was multiplied by the number of plants, \( x \), and divided by the planted \( \text{ft}^2, W*L \), in order to attain a yield in \( \text{lbs/ft}^2, Y \).

\[
Y = \frac{y * x}{W * L}
\]

In order to address and avoid overestimates as those seen in the remarkably high yield predictions generated by Vitiello & Nairn, yield per \( \text{ft}^2 \) was multiplied by a health multiplier based on qualitative observation of A (1), B (.65), or C (.25). Plants in participating gardens were given an A, B, or C grade. Plants with no visible signs of illness and of reasonable size and fruit set for the season were given an A, meaning that they would likely fall somewhere in the middle of a yield range should conditions not change. Plants given a B either had suboptimal fruit/flower load or stature, or had fruit but some sign of illness. It could be guessed that these plants would fall far below optimal yields, but would still produce some food and therefore not be discounted. Plants given a C were visibly ill, small, or damaged, and were determined to be unlikely to produce any more than a minimal yield, if any\(^4\).

Gross was calculated by multiplying \( \text{lbs/ft}^2 \) by estimates of market price obtained from UVM extension, MOFGA, and the USDA (MOFGA, 2017; University of Vermont, 2017; USDA, 2011). The prices of some specialty crops such as Momordica were

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\(^4\) While admittedly risky as a novel method, a similar multiplier was used in profit by area calculations used by Patel (1991). The reasoning behind this that it is safer to draw conclusions of garden benefits from underestimates rather than overestimates justifies the use of this subjective qualifier.
compiled from local food vendors, including some Asian specialty markets, in the Winooski area. *Net profit or savings per ft²*, was calculated by dividing total costs for a plot as estimated from the survey by total ft² of a plot.

\[
\text{Profit per ft}^2 = \frac{\text{Costs}}{\text{Area}}
\]

Costs of a plot were comprised of 5 categories - labor, fertilizer, pest control, water, and rent. Fertilizer, pest control, and rent costs were based on gardener estimates. The estimated hours of labor per gardener per week, \(l_g\), was calculated by multiplying the number of garden sessions as indicated by a respondent, \(s\), by the number of hours spent at an average session, \(l_s\), using the formula \(l_g = s \cdot l_s\). Total man hours, \(L\), were found by using the percentage of time which gardeners indicated they were receiving help in the garden (all the time - 100%, couple days a week - 50%, once or twice a month - 25%), \(h_t\), multiplying it by the number of people which they indicated were helping them, \(h_n\), and adding this figure to the primary gardener's labor hours, \(l_g\), using the figure \(L = l_g + l_g (h_t \cdot h_n)\). The cost of labor was calculated at $10/hr. Per week figures were multiplied by 22 weeks of the growing season. The final formula for the cost of labor in dollars, \(C_L\), was as follows:

\[
C_L = \left( (s \cdot l_s) + (s \cdot l_s) (h_t + h_n) \right) \times 10 \times 22
\]

Water was calculated by multiplying the percent of time which gardeners estimated they were watering, \(i_g\), by the primary gardener's labor hours, \(l_g\), to attain a figure for estimated watering hours per week. This was multiplied by the estimated water use of the instrument which they indicated using, \(i_m\) (watering can/bucket - 40gal/hr, hose 1020 gal/hr, drip irrigation 225 gal/hr) to attain gallons of water used per week, which
was multiplied by 22 weeks of growing and by the municipal cost of a gallon of water ($0.0055) to obtain an estimate of total water cost per season, $C_i$.

$$C_i = (i_g * l_g)_{im} * $0.0055 * 22$$

**Data analysis**

Results from net profit estimations for each crop were normalized on a scale of 1-0 using feature scaling\(^5\) to obtain an index factor for NET ('NET' will refer to the ranked net profit per ft\(^2\) index factor from here on out). Cultural value questions for each crop were summed\(^6\) and normalized using feature scaling to obtain a Value Metric (VM)\(^7\). CVI was calculated as the sum of these components, ranking crops on a scale of 0-2.

Further analysis of CVI was conducted using datasets generated from grower's highest CVI crop and from the average CVI of all of their crops. As well, a single data set of all recorded CVI values was used. These datasets were analyzed with descriptive statistics before further analysis using comparative tests were performed.

Growers' responses to survey questions were paired with top CVI data and average CVI data. Non-parametric tests (run through SPSS) were used to allow for the comparison of means between smaller groups within the larger overall data set. Except for a few exceptions where SPSS preferred a Mann-Whitney U test, the majority of comparative analysis was conducted using a Kruskal-Wallis Test. In order to keep in line with the use of non-parametric tests, tests for correlation between factors were conducted

\(^5\) $x' = \frac{x - \text{min}(x)}{\text{max}(x) - \text{min}(x)}$

\(^6\) $q_T = (q_1 + q_2 + q_3 + q_4)$

\(^7\) $VM' = \frac{q_T - \text{min}(q_T)}{\text{max}(q_T) - \text{min}(q_T)}$
using Spearman's rank correlation. Multivariate analysis were conducted using Tukey's HSD.

Answers to qualitative questions were hand-coded. 'Yes/no' questions in the survey were compared by assessing the percentage of respondents who had indicated a certain answer. Trends in CVI in comparison to the use of a given management practice were identified by using a yes or no response as a grouping factor and comparing the mean CVI, NET, and VM.

**Results**

**Demographics**

Due to a combination of concerns about collecting nationality information about vulnerable populations and the difficulty that trial respondents had in answering, no question about *country of origin* was included in the survey. However, qualitative observations indicated that many gardeners from Harrington were Vermont natives, that there was some spread of place of origin including gardeners from Spain and the Netherlands at CTG, and that gardeners from NFNA and Pine Island included Himalayan communities (Nepali, Bhutanese), as well as African communities (Somali-Bhattu, Rwandan, Tanzanian, Congolese, and a number who merely called themselves 'African').

Community garden participants ranged in ages from 27 to 58, with a mean of 37.47 and a standard deviation of 9.34. The spread of ages varied between gardens, though without statistically significant differences. Pine Island possessed the oldest gardeners with an average age of 53.5 and the youngest belonged to CTG, with an average age of 34. Refugee gardeners were generally shown to be older than non-refugee
gardeners, with respective mean ages of 40.6 and 35.53, though again without statistical significance.

*Years of farm experience* and age were positively correlated at 0.483 with a significance of 0.042; however, there was a large spread in the data. Gardeners listed anywhere between 2-58, with a mean of 12 years of experience and a standard deviation of 16, indicating a skewness in the data toward the lower end. The majority of gardeners listed less than 8 years of experience, while 17% indicated more than 20 years of experience. No values appeared within the range of 8-20 years of farm experience.

![Image: Proportion of crop diversity in community gardens by type](image)

*Figure 10: Proportion of crop diversity in community gardens by type*

*Professions* varied between gardens, with the refugee gardens and Harrington showing a higher frequency of lower income professions. Refugee gardeners frequently cited professions including caregiver/nurse and janitor. Gardeners at Harrington worked a spread of jobs including machine operator, chef, and realtor. Respondents at CTG fell into two groups; one with 'alternative' jobs working as cheesemakers, non-profit coordinators, and a number of alternative educators, and another holding white collar jobs including engineer, financial analyst, and executive assistant.

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The number of *people eating from gardens* was significantly different (p<0.001) between refugee and non-refugee groups, with 1-2 people typically eating from non-refugee gardens and 5-6 eating from refugee gardens.

Data did not support the hypothesis that there were trends in CVI associated with differences between refugee and non-refugee gardens. There was an especially high likeness of means (p=1) between groups and their NET value. However, a highly significant positive correlation between age and average CVI was seen (0.675 with a significance of p=0.001). This coincided with an even higher correlation between VM and age (0.758, p<0.001), but not with NET.

**Agro-Biodiversity**

49 species of crops, not including weeds or flowers, were observed across all garden sites. Of these, 14.2% were 'rare' and could not be found easily in grocery stores. 25% were green leafy vegetables, 25% were fruiting vegetables, 22.9% were legumes, 16.7% were herbs, 8.3% were legumes, and 2.1% were grains (Figure 14).

The *most commonly seen crops* were peppers, which appeared in 69% of plots, followed by tomatoes (15%), kale (13%), and carrots (11%). Maize occupied the largest percent of planted area (23.14%), followed by amaranth (12.60%), potatoes (11.41%), and mustard greens (10.70%). 34 crops which accounted for 71% of total species diversity occupied only 9.16% of the total planted area of the surveyed gardens.
Species richness per plot was relatively the same across gardens and garden types, with a mean of 9.04 crops per plot. However, using a Tukey's HSD identified significant differences in species richness per ft² (using total allotted area, though similar results with total planted area) showing Harrington as possessing -0.293 less crops per ft² (p=0.021) than Pine Island. Differences with low significance levels (0.1-0.2) arise between Harrington and CTG (-0.13, p=0.188) and Harrington and NFNA (-0.16, p=0.105), showing that Harrington's overall mean species richness is lower.

A Spearman test for correlation shows a strong negative correlation between number of species per ft² and allotted area (-0.934, p<0.001).
### Yields and Profit

The size of gardens is not normally distributed, with a minimum of 32 ft\(^2\) and a maximum of 6944 ft\(^2\). The upper range of these belongs to refugee gardens while the lower range belongs to non-refugee gardens. There is a strong negative correlation between total area and yield per ft\(^2\) (total -0.750, p<0.001, planted -0.754, p<0.001).

The average predicted yield across sites was 0.60 lbs per planted ft\(^2\) (s=0.42). This is equivalent to 13.09 tons per acre or 29.2 tonnes per hectare. Tukey's HSD shows that Harrington had a statistically significantly higher yield per planted ft\(^2\) than other garden sites (avg = 0.93, s = 0.65), while the others have no difference from one another. Among the crops included in CVI data, amaranth (grown for greens) was predicted to have the greatest overall production (1246 lbs across surveyed plots), followed by mustard greens (809 lbs), potatoes (681 lbs), and maize (464 lbs).

#### Table 1: Yield and net per planted ft\(^2\) disaggregated by garden

<table>
<thead>
<tr>
<th></th>
<th>avg lbs/ft(^2)</th>
<th>stdev</th>
<th>avg net/ft(^2)</th>
<th>stdev</th>
</tr>
</thead>
<tbody>
<tr>
<td>All gardens</td>
<td>0.60</td>
<td>0.42</td>
<td>-$2.06</td>
<td>5.5</td>
</tr>
<tr>
<td>CTG</td>
<td>0.57</td>
<td>0.14</td>
<td>-$5.81</td>
<td>6.16</td>
</tr>
<tr>
<td>NFNA</td>
<td>0.37</td>
<td>0.19</td>
<td>$0.97</td>
<td>0.89</td>
</tr>
<tr>
<td>Pine island</td>
<td>0.16</td>
<td>0.05</td>
<td>$0.53</td>
<td>0.13</td>
</tr>
<tr>
<td>Harrington</td>
<td>1.11</td>
<td>0.65</td>
<td>$0.75</td>
<td>0.75</td>
</tr>
</tbody>
</table>

Average net per ft\(^2\) was predicted across gardens at -$2.06/ft\(^2\) (s=5.5). This predicted net loss is the result of CTG, whose average net is -$5.81/ft\(^2\) (s=6.16). When CTG was removed from the data, the average predicted net was $0.82/ft\(^2\) (s=2.52), the equivalent of $35,567/acre.
Gardeners estimated on average producing 51% of their annual vegetable consumption, through some estimated as much as 100%. Yield estimates predicted that surveyed community garden plots produced 47.83 lbs of vegetables per person per year. According to the W.H.O. recommended minimum vegetable consumption of 400g per person per day, the equivalent of 322lbs per person per year, this is equal to 14.86% of necessary annual vegetable consumption (Hall, Moore, Harper, & Lynch, 2009). However, growers on the larger plots provided to refugee gardeners averaged 31.7% of their vegetable need, with some exceptional growers nearing 60-70%.

Thyme ($14.93), followed by cilantro ($11.14), pac choi ($9.27) and basil ($7.60), were shown to have the highest gross value per ft². On average, gardeners perceived that they were saving $260 on produce per year. However, these same gardeners were shown to have an average net of $530 per year. The range of net production varied drastically between gardeners, resulting in no statistical significance in the different between perceived savings and net.

**Management practices**

Hypotheses that related management practices to CVI were not statistically supported. Some correlations, however, were observed between certain management practices and labor and water use.

Results with a low level of significance (p=0.1-0.2) were seen between farmers who used no-till and those who did not. 45% of respondents were consciously practicing no-till. The no-till group spent less money on fertility (y=10.00, s=82.56, p=0.110) but used more water (y=253.4, s=1083.98, p=0.202) and labored more hours (y=6.039,
Additionally, more gardeners from the no-till group listed flooding as a problem.

81% of gardeners reported using intercropping. Of these, the group that used intercropping also reported a statistically higher amount of hours spent on improving soil fertility ($y=1.991$, $s=0.500$, $p=0.020$). For fertility management specific questions, and 95% of respondents reported using soil amendments such as compost, 80% using liquid or granular fertilizer, and 65% using mulch. On average, gardeners paid $70.25 (s=45.31) per season for fertilizer or other soil amendments.

![Figure 12: Percent of respondents using a given management practice](image)

Pest control was a large time investment for gardeners, taking an average of 2.25 hours/week. The average spending for pest control was only $14.11 per season ($s=18.49$). All gardeners reported using only hand weeding or basic implements such as hoe or hori-hori, though 4.3% also considered mulch a weed control method. Watering stood out as the largest time investment across gardens (mean=3.4 hours). Time investment was statistically greater with watering vs. pest control ($p=0.041$) and watering vs. fertility $1.70$ ($p=0.029$).
Only 59% of gardeners indicated they knew who paid for their water, and none paid for their water themselves. Mean water use was 811.53 (s=954.4) gallons per week per gardener. When disaggregated by gardener and divided by planted square foot, gardeners showed a mean water use of 775,204 gallons per week.

Comparing refugee and non-refugee gardeners using a Mann-Whitney U test indicated significant differences in the labor hours gardeners invested. Refugee gardeners averaged 11.45 hours of labor per week compared to non-refugee gardeners, who averaged 3.96 hours per week (p=0.002). As well, refugee gardeners averaged 28.31 of total man-hours per week compared to non-refugee gardeners, who averaged 5.02 of total man-hours per week (p<0.001). The other place that this difference in management was apparent was in total water use, where refugee gardeners averaged 1620.84 gallons per week, while non-refugee gardeners averaged 222.93 (p<0.001), though considering that refugee gardeners managed larger plots (2951 ft² versus 61 ft² for non-refugee) this was likely a function of garden size.

**Decision-making factors and motivations**

Spearman tests for correlation showed relationships between decision-making factors and motivations and CVI, NET and VM, as well as with age. Some correlation between factors was also observed.

Age was positively correlated with growing crops that don't require a lot of space (0.56, p=0.010) and negatively correlated with choosing crops based on soil (-0.727, p=0.001). Saving money and growing food that's difficult to access were positively
correlated between each other (0.649, sig=0.009). Reducing water use and enjoyment were also positively correlated with one another (0.663, p=0.003).

In Likert responses, gardeners most frequently ranked protecting the environment (Median=5, IQR=1), growing nutritional food (Median=5, IQR=0.75), and enjoyment (Median=5, IQR=1) as important factors influencing decision-making. In the long-answer write-in section, some frequently included motivations were: food choice (what I like to eat, stuff from home country, stuff without packaging) (22%), and getting fresh vegetables (13%). There was also one write in about aesthetics.

Using gardener's average CVI's in comparison to questions about decision-making identified three primary correlations. The level of importance indicated for 'enjoyment' as a factor was strongly positively correlated with CVI (0.667, p=0.002). Choosing crops that are easy to grow was negatively correlated with CVI (-0.586, p=0.008). A weaker positive correlation was observed between growing nutritional food as a motivation and CVI (CVI 0.545, p=0.016), as was a similar correlation with a between the same question and NET (0.52, p=.020).

Pests and diseases were shown to be the greatest stressor for gardeners (median=4, IQR 1), while drought was shown to be the least problematic (median=2, IQR=1). Responses for other factors (flooding, vandalism, heat) varied substantially. Using Tukey's HSD, pests and diseases had a statistically significantly higher median than drought, flooding, and vandalism (p<0.001) and less significant difference compared against heat (p=0.081).
Best Crops

Of the 22 gardeners from which CVI values were attained, Kale was the most common top crop (5) followed by peppers (4) tomatoes (3), and basil (3). Amaranth, eggplant, maize, okra, onion, pointed gourd, and spearmint all appeared once. Peppers and herbs came out with significantly higher mean CVI when compared against others using a Kruskal-Wallace test. However, the contribution of VM and NET varied between top CVI crops, and no correlation was seen between the two factors.

*Peppers* (mean=1.14, s=.52), were shown to have a higher mean than other crops (mean .76, s=.47). Additionally, there was a significant difference in NET, (mean of 0.62, s=0.266) compared to other crops (0.26, s=0.30), however, VM was the same across categories (p=0.828).
Herbs showed a significant difference in CVI (p=0.015), but only a slightly significant difference in NET (p=0.096) or VM (p=0.099). Among herbs, basil stands out as having a higher CVI (p=0.011) and higher NET (p=0.014).

Rare crops (plants identified as those being grown with out of country varieties or species or difficult to access in the grocery store: winter squash, daikon radish, pumpkin, pointed gourd, okra, rayo saag, maize, eggplant, amaranth) had no significant difference in CVI or NET. However, they were shown to have a higher mean VM than other crops (p=0.029). Within this group maize was the only crop which was shown to have a higher mean VM on it's own (p=0.016), however it did not show a difference in CVI or NET. One particular instance goes against this finding, which shows that daikon radish had a significantly lower CVI (p=0.001) and a lower VM (p=0.002), than other crops, but showed no difference in NET.

Value Metrics

Table 2: Mean Likert-scale responses to VM questions for top ranking crops

<table>
<thead>
<tr>
<th></th>
<th>avg</th>
<th>s</th>
</tr>
</thead>
<tbody>
<tr>
<td>access/cost</td>
<td>2.73</td>
<td>2.09</td>
</tr>
<tr>
<td>importance</td>
<td>2.59</td>
<td>2.06</td>
</tr>
<tr>
<td>taste</td>
<td>4.36</td>
<td>.72</td>
</tr>
<tr>
<td>nutrition</td>
<td>4.27</td>
<td>.77</td>
</tr>
</tbody>
</table>

Among the highest ranking CVI crops for each gardener, taste and nutrition were much more frequently reported as contributors to VM, with near zero p-values (using Kruskal-Wallace) when compared against issues of cost and access. Access/cost and
relevance to culture of origin were frequently rated the lowest. This same trend can be seen when analyzing *peppers* and *herbs* (using Wilcoxon-signed rank) within top CVI crops in which taste and nutrition come out as the most highly ranked.

**Reasons for Using Community Gardens**

The final, long answer question at the end of the survey allowed gardeners to highlight the reasons that they believe make community gardens important. 43% of gardeners expressed sentiment that gardens allow users to grow organic, fresh, healthy food. The second most frequently cited reason was food choice, appearing in 26% of responses. Gardeners also wrote about gardens creating outdoor space for exercise and enjoying the environment (13% of responses), learning for themselves and their families (13%), and community involvement (9%). Of particular note was the one respondent who wrote in "to make sure we get the right kind of corn"

![Excerpts from qualitative responses](image)

*Figure 14: Excerpts from qualitative responses*
Discussion

Growth and Production

Agrobiodiversity

Agrobiodiversity was a resultant dataset of this research but not the primary focus. However, information about agrobiodiversity aids in an understanding of how gardeners are using their plots. At an average of 9.04 crops per plot and 49 total species across 4 gardens, the agrobiodiversity observed in this study was generally lower than that observed by other researchers. Some researchers have focused on species diversity without disaggregating crops by edibility, or have refrained from differentiating ornamentals from edibles, making it difficult to draw comparisons with this research (Borysiak et al., 2017; Lin et al., 2015). Even then, studies that do include numbers specifically for edibles show a larger number of species per plot. Airress (1994) notes that 38 percent of Vietnamese gardens in New Orleans contain 16 or more cultivars. Corlett (2003) finds 73 species of edible plant in 18 Hmong gardens in the Berkley, CA, areas. Guitart, Pickering and Byrne (D. A. Guitart et al., 2014) observe as many as 132 types of edible plant per garden in Australian school community gardens. This is likely result of their methodology, which uses garden managers to report agrobiodiversity to researchers. This not only allows for a larger sample, but also spans more growing seasons and allows for identification of species by familiar parties. Taylor and Lovell (2017) find 123 edible plant taxa from 61 family gardens. Along similar lines, Clarke & Jenerette (Clarke & Jenerette, 2015) identify 229 edible species across 14 community gardens. This could partly be the result of the larger number of gardens sampled. However, even in sub-strata such as immigrant gardens in the Clarke study, of which
only 3 were sampled, 135 species of edibles were still observed. Clarke does not indicate how species and cultivar were divided, and this could be part of the result of the discrepancy. Lovell et al, however, notes that some species were divided by subgroup (as was done in this study), and it is possible that that more specific distinctions were made, such as dividing tomatoes by color variety in the Guitart (2014) study. Clarke does not note crop plant richness, but shows that average species richness per garden was 11.79 taxa. This not disproportionately higher than this study's results, especially given the observation that taxa per garden varies substantially across ethnic groups, and that Taylor observed longer-tenure home gardens which included fruit trees.

![African "inhori" eggplant at Pine Island](image)

**Figure 15: African "inhori" eggplant at Pine Island**

The observed negative correlation between species richness and growing area suggests that growers do not take advantage of larger spaces by planting more species, and rather plant more of select species when provided with larger spaces. This finding is
supported by Taylor et al (2017) but refuted by Clarke (2015). The result that 71% of species diversity was found on 9.16% of the total surveyed land further supports the idea that larger areas are not planted with a larger variety of crops, but instead are used to plant more of a single crop.

Harrington was shown to have lower mean species richness per plot than other gardens. While this goes against the idea that smaller plots harbor greater richness, when compared against CTG, a garden comprised of a similar ethnic group, it is concurrent with Clarke's finding that lower species richness is found in gardens belonging to households of lower income. Harrington's lower species richness in comparison to the refugee gardens Pine Island and NFNA is also concurrent with Taylor's (2017) findings that there is a link between ethnicity and species richness. Many authors put forward the idea that ethnic food production is an essential function of community gardens (Airriess & Clawson, 1994; Clarke & Jenerette, 2015; Corlett & Dean, 2003; Hartwig & Mason, 2016; S. Taylor & John, 2013). The high incidence of crops brought from refugee's country of origin seen in Burlington community gardens in this study further supports this concept.

Crops and varieties for which gardeners mentioned specifically bringing seeds, or having family members bring for them, include bodi (a variety of black eyed pea), bitter gourd, maize, Nepali mustard green (rayo saag), pointed gourd, daikon radish, ground nut, amaranth greens, inhori (a small, white or green, bitter eggplant (figure 18)), roselle (hibiscus), and water spinach. Many of these are of particular cultural significance to the communities that brought them, especially certain varieties of maize. 'Mula' daikon radish
is also of note, as it is seen as it is the key ingredient in the classic Nepali dish *Mula ko Achar*.

**Yields and Profits**

The estimates of yields obtained by this study showed numbers in accordance with other studies and USDA records for the Northeast (Keough, 2016). The average predicted yield per acre of community gardens of 13 tons may be slightly higher than expected, but is reasonable when considering this is a measure of planted space and not total allotted area, and so does not account for driving space or inter-row spacing. Funes (2009) estimates that Cuba's urban farms produce 30 tonnes/ha, which is equal to 13 tons/acre, or exactly in agreement with this result. Algert et al (Algert et al., 2014) used a pilot garden to study yields, and found a slightly higher estimate of the equivalent of 16 tons/acre. Vitiello & Nairn (2009), using a growing area calculation, draw an even higher estimate of 26 tons acre. The lowest estimate identified was by Gittleman (2012) using a citizen science approach, at 6 tons/acre. This yield is still substantial, and Gittleman notes that it may be lower than real production figures due to the crops not being weighed when picked during garden work, eaten by passing children, or stolen by animals.

The average net per acre for studied gardens is more difficult to judge. When CTG was included in the data, a site in which gardeners paid high rent per ft$^2$ due to the added benefits of working in a learning garden, the average net per ft$^2$ was -$2.09$. When CTG was removed from the data, the average predicted net was $0.82/ft^2$ (s=2.52), the equivalent of $35,567/acre. Considering that the other gardeners paid minimal rent or inputs, this data is not far off from the findings of Gittleman, who identifies a gross
approximately $47,000 per acre or of $1.15/ft²; or that of Algert (2014) whose findings calculate out to the equivalent of $1.14/ft². The average gross per planted ft² across crops identified in this research of $2.25/ft² is still lower than the Vitiello & Nairn prediction of $3.28 gross per ft². However, if their high yield estimates of 1.41 lbs per square foot were to be adjusted to be equivalent to the findings of this study and those of the USDA of 0.6lbs/ft², Vitiello & Nairn's gross would also be close to other estimates at $1.39/ft². This supports the concept that estimates of yield from area without taking into account health will exceed results found by weighing vegetable mass. The higher gross per ft² identified here is most likely attributable to the inclusion of high price per pound estimates for fresh herbs and certain specialty crops, which could not be identified from extension market prices and instead had to be derived from price listings from local grocery stores and specialty markets.

Amaranth greens are a particularly interesting example, as they are predicted to have a very high yield per ft² as well as a high price per pound. This is believable, as amaranth greens are a rare, specialty crop, and also grow like a weed. However, even though amaranth greens are costly for buyers, the market is so small that growers would be unlikely wouldn't be able to earn the predicted net on any substantial quantity of production.

A strong negative correlation was seen between total allotted area of plots and yield per ft². This correlation coincides with the negative correlation with crop diversity, as it does with the findings that show that the majority of growing area is devoted to the minority of crops. While amaranth greens were shown to be both highly productive and highly valuable, and have a large amount of space devoted to them, the largest portions of
space were devoted to a few low-savings crops such as maize, potatoes, and onions. Overall, Vitiello & Nairn's study refutes this finding, showing that the highest production per ft\(^2\) is on gardens of 1-5 acres. However, in the same study, comparing gardens of 1000ft\(^2\) to 1/4 acre (such as Pine Island and NFNA) to those of less than 1,000ft\(^2\) (such as CTG and Harrington) are concurrent with this study, showing that gardens of less than 1,000ft\(^2\) produce nearly twice that of next size category up per ft\(^2\).

**Management decisions in relation to common UPA problems**

**Soil Health**

Choosing crops based on soil health as a motivator had a comparatively low median rating of 3 (IQR=1) among survey respondents, however, the majority of respondents indicated that they did some sort of qualitative soil health analysis. 95% of respondents reported using soil amendments such as compost, and 80% using liquid or granular fertilizer. Yet the results of soil tests from NFNA and CTG show excessively high levels of P and low levels of K. This, in combination with the low average spending on fertility of $70/season indicates that gardeners may be applying suboptimal levels of compost, insufficient to create a soil microbiome for plants to metabolize nutrients, resulting in reduction in plant health and a higher likelihood of phosphorus leaching (Evanylo et al., 2008; Sharpley, Mcdowell, & Kleinman, 2001).

The 45% of gardeners who indicated using no-till practices also were more likely to indicate flooding as a problem. Of the gardens surveyed, CTG was the only garden that did not use soil mix (Harrington) or till as a whole garden (NFNA, Pine Island). This might simply be a function of the high level of flooding at the Intervale. However, Pine
Island, NFNA, and CTG were all located on or near the Winooski River. This finding elicits those of other studies which indicate that no-till practices without sufficient addition of organic matter can increase issues of compaction and reduce yields (Hoyt, Greg, 1999). While the high incidence of intercropping may help reduce issues of leaching and improve fertility beyond what the low inputs indicated by fertility spending and fertility labor, it could contribute to poor growing conditions by increasing competition, increasing pest, disease, and nematode habitat, reducing soil temperatures, and if improperly managed, reducing soil porosity (Abawi & Widmer, 2000; Friedman, Hubbs, Tugel, Seybold, & Sucik, 2001; Fujiyoshi, Gliessman, & Langenheim, 2007).

**Water Use**

The University of Kentucky and Penn State extension estimate peak water use of 57,000 gallons per week per acre for commercial vegetable growers (Coolong, 2017), yet the estimates of this survey show that with current use practices, gardeners would use nearly 775,204 gallons per week per acre. This is based on the fact that the majority of gardeners indicated using a hose for their irrigation and hose water use was calculated at 1,020 gallons per hour, or 17 gallons per minute. While the garden hose flow rate for estimates of water use was calculated near the higher end of possible water pressure for a shorter hose, it was still only around 75% of the maximum flow for a 25 foot hose at 40 P.S.I., 24 gallons per minute (WSU, n.d.). It is possible that the large amount of time indicated by gardeners for water was due to low P.S.I., an issue observed at Pine Island, or due to longer hoses. At NFNA, however, there were spigots near the end of most plots. While this apparent overwatering could be to some degree justified by the sandy loam
soils of the Winooski floodplain on which NFNA, Pine Island, and CTG are located, it is more likely a result of the habits of gardeners, who may be inclined to water regardless of rain, as observed at one session at CTG, and/or because of the consistent use of flood irrigation by Nepali and Bhutanese gardeners observed at NFNA.

While startlingly high, this number still does not include leaks in the system, a problem seen multiple times at Pine Island. This suggests an unsustainable pattern of water use in Burlington's community gardens, perhaps justifying the need for improved irrigation methods such as drip. This point is hit home by the fact that Pine Island is currently in the process of drilling a second well to meet garden water needs.

**Pest Control**

Contamination of urban spaces by pesticides is a common concern with urban gardens (Tornaghi, 2016). The gardens in this study either did not allow or strongly discouraged pesticide use, and growing organic food without chemicals was among the strongest motivators for community garden use. As well, gardeners cited spending only and average of only $14.11 per season on pest control, suggesting minimal or negligible use of pest control products. However, pest and disease problems were the top-ranked stressor for gardeners, and qualitative observation showed high incidence of flea beetle, Colorado potato beetle, squash bug, and blight. The problem is exacerbated by the close proximity of three out of four participating gardens to commercial growers using either organic or chemical pesticide, making their non-treated crops an especially attractive host for pests and disease.
The Advantages of CVI as a Metric

Urban agriculture has the potential to move cities away from agricultural methods which exploit nearby rural areas while negating urban citizens' means of production (Tornaghi, 2016). With relatively low inputs, UPA can take advantage of unused land and produce significant yields (Algert et al., 2014; Funes et al., 2009; Gittleman et al., 2012; Vitiello & Nairn, 2009). A breadth of other studies show the numerous social benefits of UPA (Golden, 2013). But while methodologies like evaluations of Cultural Ecosystem Services (CES) and multifunctionality have valuable applications, researchers consistently show the need for improved metrics of valuation in decision making contexts (Clarke & Jenerette, 2015; Gómez-baggethun & Barton, 2013; Haase et al., 2014; S. Taylor & John, 2013). The results of this study demonstrate how CVI can integrate estimates of yield and cultural ecosystem services generated by gardens, as well as identifying what specific elements of gardens best create value.

Gómez-baggethun & Barton (2013) show that urban ecosystem services are associated with economic values. Examples of this would be how the loss of green space results in increased cooling expenses, or the connection between air purification and noise reduction services and health care costs (Gómez-baggethun & Barton, 2013). In regard to urban agriculture, their work specifically identifies the economic value of willingness to pay for local, fresh produce, and the recreational value of home gardens. CVI is designed around the need for improved metrics for valuations of these functions, but intends to not only include willingness to pay for fresh produce but also intrinsic cultural and personal values associated with urban production.
CVI is not intended to serve as an alternative to other methods such as the multifunctionality framework (Lovell, 2010; Zasada, 2011) or valuations of CES (Gould et al., 2014), but as a metric which can bolster these methodologies in their understanding of urban production. Many studies address either ecological or cultural benefits of a practice, but struggle to integrate the two (Haase et al., 2014). Multifunctionality frameworks are important for understanding gardens in relation to the environment and the community, but tend to focus disproportionately on ecosystem services and landscape functionality, without addressing human and food needs (Zasada, 2011). CES also focuses on a wide range of functions without addressing food needs specifically, yet the methods used by CES researchers could be integrated into further valuations of VM.

CVI is limited in terms of how much of the cultural value created by a crop it can assess using its 4 question set. Gould et al (2014) argue that open-ended, qualitative analyses are necessary to truly address the complexity of CES. Their study delves deep into issues of identity, connection to place, dynamic practices, ethics, social capital, value of the in-ecosystem experience, and intergenerational value; elements which are essential to the same concepts about the value of food culture. Of this, CVI only directly addresses issues of identity (this crop is important to me culturally), dynamic practices (I enjoy cooking/eating this crop), and some intergenerational value (I enjoy cooking/eating this crop & this crop is important to me culturally). While CVI also addresses issues of access/cost, as those which might be addressed with a Willingness to Pay (WTP) model (Berkel & Verburg, 2012), and nutrition, it fails to address any of these to the depth with which qualitative analysis is able to elicit non-material benefits tied to urban green spaces (Gould et al., 2014). WTP for cultural ES could more accurately reflect the relationship
between NET and VM on a singular, monetary scale. However, CVI has an advantage over qualitative analysis in terms of time per study (15 minutes vs. the 1-4 hours cited by Gould et al) and over both qualitative analysis and WTP in its capacity to disaggregate CES by crop. It begs to ask if WTP and qualitative analysis about specific crops could be used as parallel analysis in future use of CVI in order to strengthen and double-check VM findings.

**CVI in Application**

In order to understand the advantages of CVI for a valuation metric in decision-making contexts, it helps to examine a hypothetical example:

_Gardeners A and B, are growing jukuni gourd and bitter melon. Gardener C is growing bitter melon but not jukuni. Using CVI, gardeners A and B identify that jukuni is of equal VM but higher NET. Meanwhile, bitter melon has low NET but equal VM._

If gardener C is of the same community/familiar with jukuni, gardener C may be encouraged to plant and grow jukuni seeds, offering more of the crop to his community. Alternately or complimentarily, gardeners A, B, and C, may all appreciate and want to grow bitter melon, noting its importance in their diet, but may also be made aware of the need to grow it in a more economically efficient manner. Managers could respond to this information by working with gardeners to increase the NET of bitter melon and/or provide spaces or tools better suited to growing these high VM crops. Policy makers could take note that these crops (which are commonly found in refugee community gardens but rare in grocery stores) are of consistent importance to certain communities, and provide subsidies to continue their cultivation. Should growing space or resources be
a limiting factor either at a policy-maker or manager level, support could be appropriately allocated to these financially valuable and culturally important crops.

![Purple chilies growing at Pine Island](image)

**Figure 16: Purple chilies growing at Pine Island**

Another testament to CVI's functionality as a combined valuation metric is an examination of the top crops selected for each gardener through CVI analysis. Top CVI crops for surveyed gardeners include kale (5 growers), peppers (4 growers), tomatoes (3 growers) and basil (3 growers), as well as amaranth, eggplant, maize, okra, onion, pointed gourd, and spearmint (1 grower each). Tomatoes are an extremely common crop in community gardens (Gittleman et al., 2012; Vitiello & Nairn, 2009), however, when crops are analyzed only by NET, tomato disappears from the list of top crops. Tomatoes are an important crop to growers of many cultures, but their susceptibility to disease and water stressors makes them unlikely to yield as high a net profit without careful management as some other crops (Kelley & Boyhan, 2014). The fact that valuation of
VM prioritizes tomatoes over other crops with higher NET shows how CVI could help researchers understand why tomatoes are as prevalent as they are. This same scenario can be seen for maize, which appears throughout nearly all refugee gardens in the Burlington area despite having very small profit margins. While maize does not show significantly higher CVI as a crop group, it does have a higher VM, and appears as one grower's top CVI crop.

The identification of peppers and herbs as high CVI crops both for single gardeners and across gardeners shows how CVI can identify opportunities in urban growing, as they are logical candidates for high CVI values and effective use of community garden space. Herbs are highly culturally important to many gardeners (Airriess & Clawson, 1994; Corlett & Dean, 2003; Saldivar-Tanaka, 2004), as well as fetching a very attractive market price when fresh and organic (USDA, 2017). Similarly, while difficult to grow organically in the Burlington area, both sweet and chili peppers are also highly valuable (USDA, 2017) and essential to cultural dishes globally (Airriess & Clawson, 1994; Corlett & Dean, 2003; Saldivar-Tanaka, 2004). This combination makes them an ideal crop to be grown in community gardens, especially when space is limited.

**Implications for Food Sovereignty and Food Justice**

Findings in this research both in terms of quantitative analysis, qualitative interview responses, and results from CVI, show that UPA can play a key role in increasing urban food sovereignty, food justice, and decreasing parasitic urbanization (Cohen & Reynolds, 2014; Fernandez et al., 2016; Montenegro, 2013; Tornaghi, 2016).
Fernandez et al (2016) cite via Campesina's definition of food sovereignty as "The right of peoples to healthy and culturally appropriate food produced through ecologically sound and sustainable methods, and their right to define their own food and agriculture systems. It puts those who produce, distribute, and consume food at the heart of foodsystems and policies, rather than the demands of markets and corporations." CVI, and the other information gathered through a CVI study, address this issue by assessing the agronomic and environmental sustainability of UPA's production as well as its cultural relevance.

![Image](image_url)

**Figure 17: Vegetable intercrop tucked into heritage maize field at Pine Island**

Our findings demonstrate that growers are creating food sovereignty in community gardens by cultivating a substantial portion of their vegetable needs on small garden plots. As seen with organoponicos in Cuba, gardeners achieve these yields with limited inputs and limited dependency on petrochemical industries or conventional agribusiness supply chains. While subsidized like other programs that aim to provide local foods such as food hubs, community gardens have the advantage in their capacity to
supply consumers with products of their choosing without accruing the substantial transaction costs, financially or in terms of energy, associated with aggregation and distribution (Mount, 2012; Peters et al., 2011). For low-income growers, community gardens are especially valuable, as they empower growers to take control of their own food production rather than forcing them to rely on food stamps or donations (Vitiello et al., 2015). In the case of the elderly and refugee communities this can be doubly true, as gardens create opportunities for actors to participate in the production of something valuable and give them a sense of purpose (Airriess & Clawson, 1994; Cohen & Reynolds, 2014; Tornaghi, 2014; Vitiello & Wolf-powers, 2014).

The findings of this study indicate that the production of community gardens in the Burlington area makes substantial contributions to household nutrition. Growers estimate that they produced 51% of their vegetable needs per year, with some stating that they produced all of their annual vegetable needs with their garden. Yet this survey puts the physical average much lower, showing that gardeners produce an average of 15% of the W.H.O. recommended minimum vegetable consumption per person per year (Hall et al., 2009) while a few select gardeners were predicted to be growing 60-70%. However, gardeners' prediction of producing 50-100% of annual vegetable need seems more probable when considering that many growers, especially from the refugee community, manage multiple community garden plots, or combine a community garden plot with a home garden. As only one garden per grower was surveyed, it is possible that the findings for this study were lower than the actual percentage of produce cultivated in community gardens by surveyed growers. This possibility is reinforced by the independent study of Casey Engels, garden manager at Pine Island, conducted in 2016,
which surveyed 5 growers from the garden site and found that most were producing 100% of their vegetable needs on site and freezing a substantial portion of produce through the winter.

The substantial production of vegetable needs grown in community gardens coincides with considerable savings for households. While gardeners predicted savings of an average of $260 per season, analysis indicated an average savings of nearly twice that, at $530 per person per year. This estimate is not far off from those found by other researchers, who predicted savings between $250-$500 per person per year (Alaimo et al., 2008; Algert et al., 2014; Armstrong, 2000; Patel, 1991).

Nutrition and access to healthy, fresh food repeatedly came up as primary motivations for gardeners, and numerous studies show that household nutrition is improved among community garden participants (Alaimo et al., 2008; Freudenberg et al., 2011; Romero-Gwynn et al., 1993; Warren et al., 2015). Other studies show that community gardens allow communities to define their own nutrition in accordance to cultural traditions; an element that can reduce immigration trauma while simultaneously increasing household nutrition (Corlett & Dean, 2003; Corrigan, 2011; Hartwig & Mason, 2016; Hondagneu-Sotelo, 2017; Romero-Gwynn et al., 1993; Saldivar-Tanaka, 2004). In qualitative analysis, the most frequently included response for reasons for using community gardening (43%) was sentiment that gardens allow users to grow organic, fresh, healthy food. Gardeners who listed growing nutritional food as a motivation were shown to have higher average CVI and NET values. Additionally, in the top CVI crops for each gardener, nutrition was mostly highly ranked as part of the crop's VM. The alignment of the importance of nutrition in CVI with its occurrence as a primary
motivator suggests that CVI is succeeding in demonstrating UPA's capacity to address the primary gardener motivation (and food sovereignty factor) of access to nutritional food.

The fact that taste was observed as one of the largest factors in determining the high VM of high CVI crops, combined with the finding that level of importance indicated for 'enjoyment' as a decision making factor was strongly positively correlated with CVI (0.667, sig=0.002) suggest that beyond production, a key element of the creation of value in community gardens is based in pleasurable gardening experience (Patel, 1991). It stands to reason that gardeners who enjoy the act of gardening are more likely to spend more time taking care of their crops; as well as gaining additional multifunctional social and health benefits from the act of growing food (Corrigan, 2011; S. Taylor & John, 2013). Additionally, gardeners who grow for enjoyment are most likely to prioritize crops for cultural or non-monetary reasons, furthering their ability to grow crops with the highest VM (Corrigan, 2011; Ghose & Pettygrove, 2014).

Issues of enjoyment, savings, nutrition, and food preference and access are highly intertwined with food sovereignty. While gardens are not altogether able to resolve issues of food insecurity, they provide gardeners with access to fresh foods of their choosing at a local level (Corrigan, 2011; Kobayashi, Tyson, & Abi-Nader, 2009), allowing gardeners to grow crops which they could not otherwise buy (Boukharava & Marloie, 2006). This idea is reinforced by the findings of this study, which indicate a high correlation between saving money as a motivator and growing food that's difficult to access. While it's impossible to draw causality from factors such as socioeconomic status,
this correlation shows that for growers for whom saving money is a motivation, food access is also a key issue.

Community gardens serve as a bastion of preferred crops for communities regardless of socioeconomic class, but are especially important to low income, refugee, and immigrant communities. (Clarke & Jenerette, 2015; Hondagneu-Sotelo, 2017; Saldivar-Tanaka, 2004; S. Taylor & John, 2013). Corlett (2003) writes "urban gardens should be viewed as cultural markers, items that provide consumers with common identities and a means to reinforce cultural practices." The fact that highest species density was observed on the minority of the land shows that many gardeners are producing small amounts of many niche crops on a portion of gardens of every size. In the studied gardens, maize, amaranth, and mustard greens take up a large percentage of the land. As well maize, amaranth, okra, and pointed gourd all top the lists of CVIs, and maize ranked more highly in VM than other crops, showing the importance of community gardens for providing spaces for culturally preferred foods. One grower even listed "growing the maize my family likes" as their primary reason for gardening in the qualitative section. These culturally important crops, which gardeners brought from their home countries, are incredibly important in terms of food access, nutrition, and a sense of place and culture that is tied to food (Airriess & Clawson, 1994; Boukhararova & Marloie, 2006; Clarke & Jenerette, 2015; Corrigan, 2011; Hartwig & Mason, 2016; Hondagneu-Sotelo, 2017), but would be difficult for growers to access without community gardens.

Even outside of refugee gardens, a number of growers still mentioned choosing specific crops because they were special or difficult to find in grocery stores. One grower
wrote that they liked growing Romanesco broccoli because they enjoyed fractals. Another grew Celeriac because it reminded them of the Balkan dishes served in their childhood home. At Harrington, a veteran had devoted his plot specifically to medicinal and high value herbs, which he both used himself and sold dried for significant profit.

The capacity to afford, access, and control production of crops that are familiar, nutritional, and enjoyable sits at the core of food sovereignty. The large contribution of taste and nutrition as factors to VM reinforces the potential of CVI as a metric for assessing contributions to food sovereignty and food justice. Taste is a strong indicator for food preference, and, as an indicator assessed in VM, nutrition goes beyond meeting basic nutritional needs, and incorporates elements of psychological health. Both of these indicators touch directly upon gardeners non-monetary perception of what is good and good for them. The growth of crops which create CES is important for gardeners from different socioeconomic classes to overcome the barriers and injustices of an agri-food system which was not designed to serve their needs (Clarke & Jenerette, 2015; S. Taylor & John, 2013). Through eliciting issues of access, preference, and cultural value, along with demonstrating potential savings, CVI provides valuation metrics that show relationships between growers and the crops they grow which inform food sovereignty and food justice.

**Outreach**

Crop choice is a complex problem that falls within a larger wicked problem of food sovereignty in an urban setting, an issue which involves a range of invested stakeholders with a high degree of value conflict and a high degree of uncertainty of
outcomes (Batie, 2008; Peterson, 2009). Additionally, food sovereignty is tied to larger sociopolitical and socioeconomic contexts which increase its wickedness (Cohen & Reynolds, 2014; Fernandez et al., 2016; Tornaghi, 2014, 2016).

Peterson (2009) asserts that it is through collaboratively formed new knowledge that improvements in sustainability will come from food-system actors; actors motivated by the potential for rent and strategic advantage gained in the possession of new knowledge. This type of rent is precisely what CVI seeks to identify. Gardeners and managers may be motivated by moving toward greater levels of cultivation of high CVI crops for personal benefit, while municipalities will benefit from the increased savings and increased psychological wellbeing or social services provided by cultivating high CVI crops on a community level.

An agroecological PAR approach in research aims to set the stage for the emergence of new knowledge through the inclusion of multiplicitious voices in a process of critical examination of the ecology of food systems (Mendez et al., 2016). By using CVI in a PAR process, actors would gain insight into concerns around access, nutrition, savings, and cultural preferences. The feedback that gardeners receive through CVI would help them to identify crops and practices that generate value, and to shift their practices and crop choices accordingly. Meanwhile, data collected and analyzed by PAR researchers could provide information to garden managers and policy makers as to how and where to allocate resources to community gardens to best meet community needs, ultimately facilitating collaboration which could lead to the development of best practices and lead to scalability (Gómez-baggethun & Barton, 2013; Pearson et al., 2010).
Through participatory research over multiple seasons involving community gardens, CVI would allow actors across strata in decision making contexts to reflect on which crops and practices are generating the benefit for growers; and to observe changes in the creation of multifunctional value at a crop, land, and grower-specific level. By creating a reflective tool for knowledge-sharing, CVI intends to enable a multifaceted examination of an important component of the wickedness of food sovereignty in an urban context, increasing clear lines of non-hierarchical communication necessary for the scaling of urban growing (Pearson et al., 2010).

**Limitations and Directions for Future Research**

One major limitation in drawing broader conclusions from this study's findings was the overall sample size of CVI results. While nearly 100 gardens were surveyed in the biophysical assay and 31 gardeners were interviewed, the useable data for CVI was limited to 23 samples. The reduction in sample size was the result of three issues: lack of English ability (despite gardeners/garden managers indicating that the respondent was an English speaker) and a translator resulting in invalid interview responses, incomplete interview responses which failed to fully address VM questions, and most importantly, a number of gardeners who answered the survey but whose plots were not part of the biophysical sample (at which point the season had changed enough to negate the possibility of further sampling). Considering that interview samples ended up being selected by convenience from the limited number of biophysical samples, this issue could be improved in future research by an altered order of operations in research methodology. This would constitute: selecting a larger number of garden-partners, selecting a larger
sample of willing interviewees from these gardens, and then surveying their plots - both saving time and increasing the usable quantity of data.

Daikon radish is a strange example on the Crop Value Index. Despite anecdotal evidence that it is an extremely important crop for the Nepalese and Bhutanese gardeners who are growing it, it received a very low VM. This points to the issue raised by Gould (2014) that qualitative methods are best suited to eliciting non-material values, and that forcing gardeners to rank crops explicitly on four values within a Likert scale may exclude key CES. Future research would do well to address concerns of omissions of CES due to a limited scope of VM questions, potentially by using follow-up qualitative CES interviews to find gaps and better develop questions in subsequent studies.

A key concern in drawing conclusions from CVI is the calculations of the cost of labor. Omitting labor as a cost has a tendency to inflate findings of savings (Patel, 1991; Vitiello & Nairn, 2009). However, there is no ideal method to calculate opportunity cost. Calculating costs based on a worker's salary in their employment outside of community gardens may either neglect to value their time, should they be unemployed, or will quickly drive down estimations of profit if they come from higher income brackets. Meanwhile, many gardeners cite enjoyment and time spent outside as a key motivator, bringing up the possibility that gardening may actually be a leisure activity and not a labor cost. Studies using CVI in the future will need to develop a way of addressing how gardeners value their own labor, and incorporate this into NET calculations.
Estimates of yield are also a key challenge in calculating CVI. The fact that the findings of this study are concurrent with physical measurements of yield and USDA predictions on a per acre basis is reassuring, and suggests that using a health multiplier and to adjust the predicted yield assists in reducing the issues associated with drawing yield predictions based on area (Algert et al., 2014; Gittleman et al., 2012). As well, using per-plant estimates helps create a more accurate measure of yield based on area (Gittleman et al., 2012), but risks overestimates in high-planting-density gardens without a health multiplier. However, estimates of yield are only predictions, and do not address the physical realities of variation between soil, season, disease, and climate.

Additionally, intercropping is a challenging element of urban gardens to properly deal with in terms of a yield estimate, as it is possible that the intercropping of two species will lead to growing conditions which are ideal for neither, leading to a reduction in potential yield (Fujiyoshi et al., 2007). It is also possible that the two will not negatively affect each other, and will produce a greater yield in a smaller growing space. Other studies using yield estimates which have failed to account for the negative impacts of two crops grown with one another may have resulted in artificial inflation of their predictions (Fujiyoshi et al., 2007; Vitiello & Nairn, 2009). Generally, the difference in plant health from these negative interactions was readily visible in the field, and is reflected in the plant health grades that each observation received. However, while these types of interactions have been studied some, such as in the case of milpas, it is this type of difficult-to-predict interaction that will eventually necessitate recording yields of UPA in the field. As with issues of VM, follow up studies on select gardens could provide useful feedback and allow for adjustments in future yield predictions.
Conclusion

Despite critics' assertions otherwise, community gardens are able to produce a yield per acre equivalent to commercial growers. This yield, however, comes with some substantial inefficiencies. Soil health management is a primary concern, as seen with a general lack of focus on soil health and fertility management shown by surveys and by the concerning soil tests shared by NFNA and CTG. Furthermore, the calculations of net found in this study showed that higher rents for garden plots could quickly drive growers into the red, as seen with CTG. This demonstrates that subsidies are still a necessary to support community gardens. However, the valuation of numerous CES generated in gardens, in combination with impressive figures in regards to yield and net per acre, justify these subsidies. It is the hope of this researcher that the information gathered through CVI surveying can continue to identify opportunities for improvement in community gardens, both in terms of economic efficiency and in terms of their ability to provide CES.

CVI aims to allow community garden users to share growing knowledge amongst one another and across socioeconomic strata in regards to how it correlates to savings; and to identify crops which may be most worthwhile to grow in collective spaces. This index meets the needs cited by Lovell (2013), Gómez-baggethun (Gómez-baggethun & Barton, 2013), Haase (Haase et al., 2014), and Clarke (Clarke & Jenerette, 2015) for improved metrics of valuation for decision making contexts; and for these metrics to address the challenges faced by gardeners attempting to operate with in the constraints of an agri-food system which were not made by or for them (Cohen & Reynolds, 2014; Pearson et al., 2010). CVI aims communicate the importance of garden spaces to non-
garden actors including managers and policy makers in a way that provides a higher level of detail, both in terms of production and savings and in terms of cultural ES in their relation to specific crops. Through this reflective process, it is hoped that CVI can give rise to a higher degree of collaboration across actors involved in community gardens, maximizing the effective use of urban growing spaces and protecting their ability to support communities in cultivating food sovereignty in the urban environment.

In a complex sea of opinions and voices, issues of communication between communities are paramount. In order to address concerns, it will be essential to form better means of communication between groups, especially by giving voice to community members who stand to benefit from urban growing but may not have the agency to make their voices heard. CVI, by creating a more accurate metric for the understanding the value created by specific crops and management practices in community gardens, creates a platform for research on how to maximize the potential of urban growing for community empowerment and food sovereignty.
Chapter 5: Conclusion

What is necessary to create food sovereign urban communities varies by contexts of class, race, nationality, and geography, but Urban and Peri-Urban Agriculture has the potential to make contributions to each. In developing countries, UPA may contribute to citizens’ ability to seek higher paying jobs in cities while retaining the ability to access fresh food. By providing UPA practitioners with control over food systems and food choices, UPA can give communities in food export nations independence from the colonial and imperial agricultural systems that are so intrinsically linked with the origins of wealth disparity in developing countries. The need for this type of sovereignty was forced upon Cuba through the fall of the Soviet Union, and as UPA grew as a movement, it provided Cubans with a food system that was not reliant on petrochemicals or the agro-industrial global agrifood system. Simultaneously as Cuba struggled to supply its people with basic needs, UPA gave Cubans opportunities to create local economies and local job markets while taking an active role in the alleviation of hunger.

In the United States, the acute food insecurity seen in Cuba is far more rare, yet UPA is still applicable as a strategy for creating food sovereign communities. In particular, urban community gardens offer growers the ability to produce culturally relevant food in accordance with their heritage and traditions. They empower the unemployed to take agency in production and consumption rather than relying on donations or social services. Perhaps most importantly, by giving participants a space to interact with food production regardless of class, race, or nationality, they serve as catalysts for forming the networks which support and provision food justice.
Yet urban growers in community gardens are faced with agronomic barriers such as persistent pest and weed pressure, excess water consumption, and a lack of technical guidance for the proper management of soil resources. These barriers serve as justifications for the resistance to increasing support for UPA on a sociopolitical level. However, lessons from Cuba reveal the potential to resolve barriers to scaling UPA in the US. The unilateral implementation of urban growing for food security in Cuba resulted in actors collaboratively developing solutions to many of the agronomic challenges in urban growing, such as the wide scale production of homemade bio pesticides in CEES, the development of groups of trap plants that suited organoponicos, and appropriate technology for irrigation. At the foundation of the development of these technical advances was the government support of organoponicos at startup and ongoing research at a national level, leading to more efficient growing systems that required lower inputs in the long term.

The high yields of UPA, both in Cuban organoponicos and US community gardens, refute the notion that sufficient production can't be reached with urban and peri-urban growing, but critics still may cite overall net losses in UPA in the United States due to higher costs of land and labor. However, while the cost, or opportunity cost, of labor may be substantially higher in the US, it's been shown that many growers value the act of gardening and eating what they grow in and of itself. Many growers from disadvantaged communities may be participating in community gardening or urban growing in absence of job opportunities or regardless of its contribution to their income. Therefore, accounting for labor as an economic factor requires careful consideration of context; and assertions that the high labor requirements of community gardens negate their production
benefits won't have a strong basis to be included in cost in some contexts. Yet regardless of which values are and are not quantified as a factor in cost, as of now, most community gardens require some kind of subsidy through municipalities or non-profits. In order to support their long-term sustainability, it will be important to identify opportunities for intervention that will reduce costs and increase the multifunctional benefits gardens serve.

The valuation of CES and multifunctional benefits provided by community gardens is vital to justifying their ongoing support to decision makers. The monetary value of multifunctional benefits and the subsequent reduction of strain on social services may actually be greater than the costs of supporting these services through other programs, such as food stamps or Medicaid, that treat the symptoms of food injustice without addressing the underlying causes. Even if this is not currently the case, a wealth of evidence from this and other studies indicates that improving the uses of urban growing spaces could make it so.

Crop Value Index has been shown to be effective as a tool to increase the functionality of UPA by identifying key crops and management factors in their ability to produce monetary value and CES; and to demonstrate how these vary between contexts. Through working with CVI, and through other agronomic analysis and CES valuation methods in a PAR process, academics, gardeners, and policy makers will be able to identify opportunities for interventions. By increasing opportunities for communication and the co-creation of knowledge across food system actors, CVI poses the potential to facilitate the development of new methods of management in urban growing, and to increase UPA's already significant capacity to create food sovereign communities.
References


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Appendices

Appendix A: Survey

Farm and Plot # [FOR PI]: ________________

Demographics
1) Profession: _____________________________
2) Age: _____________________________
3) Number of people eating from garden (or household size): _____________
4) How long have you been farming at this location? _____________ years
5) How long have you been practicing some form of farming or gardening? _______ years
6) Use of farm/garden (check one or more):
   - Commercial
   - Family vegetable garden
   - Family herb garden
   - Ornamental
   - Educational

Management
7) Do you employ the following garden/farm management techniques? (Y/N)

   a) **Trellising**

   b) **liquid or granular fertilizer** (agricultural product purchased from store)

   c) **Soil amendments** (such as compost or manure)

   d) **High tunnels, hoop houses, green houses, or other season extension**

   e) **Row cover**
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<th>Yes</th>
<th>No</th>
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<tr>
<td><strong>f) Cover Cropping</strong> (using plant cover to improve soil health in unused space or on rotation)</td>
<td><img src="image" alt="Cover Crop" /></td>
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<td><strong>g) Intercropping</strong> (mixing different types of crops in the same space)</td>
<td><img src="image" alt="Radish/Tomato Intercrop" /></td>
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<td><strong>h) crop rotation</strong> (changing which crop is being grown in a planting space)</td>
<td><img src="image" alt="Year 1 Year 2 Year 3" /></td>
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<td><strong>i) mulch</strong> (using wood chips, paper, or other plant material to cover soil)</td>
<td><img src="image" alt="Mulch" /></td>
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<td><strong>j) tillage</strong> (using a plow or tractor to turn over/aerate soil)</td>
<td><img src="image" alt="Tillage" /></td>
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<td><strong>k) no-till</strong> (intentionally not using tillage to keep from disturbing soil)</td>
<td><img src="image" alt="No-Till" /></td>
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<td><strong>l) Seed starting indoors</strong> (such as with greenhouse or grow light)</td>
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<td><strong>m) Laboratory soil testing</strong> (sending soil samples to laboratory for chemical analysis)</td>
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<td><strong>n) On-site soil analysis</strong> (using other indicators/tests to analyze soil health, such as feel or of soil, presence of worms, etc)</td>
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8) **How important are the following to you in choosing what you grow and how you grow it?**

Please rate answers on a scale of 0-5 where 0=not at all, and 5=extremely important.

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<td>a) protecting the environment</td>
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<td>b) growing crops which don't require a lot of work</td>
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<td>c) growing crops which don't require a lot of space</td>
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<td>d) growing nutritional food</td>
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<td>e) growing food I can't get easily in Burlington</td>
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<td>f) reducing water use</td>
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<td>g) enjoyment</td>
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<td>h) which crops grow best in my soil</td>
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<tr>
<td>i) which crops grow best in the Burlington area</td>
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<td>j) which crops make or save me the most money</td>
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9) **What other factors are important in making management decisions?**

_________________________________________________________________________________________________
_________________________________________________________________________________________________

10) **How often do the following affect production in your farm/garden?**

Choose 0-5 (0:Never, 1: once every 5 years, 2: Once every 2 years, 3: Once a year, 4: More than once a year, 5: Almost always)

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<td>a) drought</td>
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<td>b) flooding</td>
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<td>c) vandalism</td>
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<td>d) heat</td>
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<td>e) Pests and diseases</td>
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11) **How much do you pay in rent for your garden plot?**

(Please indicate if one time per season, weekly, or monthly) $________________ per ____________________
12) In the average week, which days and times of day do you work in the garden? (please put an X in each box that applies)

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<th>Day</th>
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13) About how long do you spend in the garden each time you come to work? __________ hours

14) How many people help out in your garden? _____

Do they help: ☐ everyday  ☐ a couple days a week  ☐ once or twice a month

15) How many days a week do you water? ____________________________

16) Approximately how much of the time you spend in your garden are you watering or using irrigation?

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</table>

17) What do you use to water? ☐ watering can/bucket  ☐ hose  ☐ sprinkler  ☐ drip irrigation  ☐ other __________

18) Who pays for the water used in your garden? ____________________________

19) How much of the time you spend in your garden are you weeding?

<table>
<thead>
<tr>
<th></th>
<th>0%</th>
<th>10%</th>
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</tbody>
</table>

20) What tools, practices, or products do you use to control weeds in your garden? ____________________________

21) How much of the time you spend in your garden is focused on pest control?

<table>
<thead>
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<th>0%</th>
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</tbody>
</table>

151
22) How much do you spend on pest control products?
$__________________ per __________________

23) How much of the time you spend in your garden is focused on improving soil fertility?

<table>
<thead>
<tr>
<th>0%</th>
<th>10%</th>
<th>20%</th>
<th>30%</th>
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</table>

24) What do you spend on fertilizer, compost, or other amendments?
$__________________ per __________________

25) When do you start your first seeds (in the field or greenhouse) and what do you plant?
Date _______________   Crop(s) _______________

26) What percentage of your/your family's vegetable consumption comes from your garden during the growing season? ____%

27) Do you sell anything from your garden?
   a) ☐ Yes   ☐ No
   b) If yes, how much do you earn from sales? $_________ per ______________

28) What is the estimated total dollar value of the food you produce in your garden over the course of the season? $________________________

29) How much/what types of food from your garden do you preserve?
_________________________________________________________________________________________________
_________________________________________________________________________________________________
_________________________________________________________________________________________________

30) Why are community gardens and urban farms important to you and your family?
_________________________________________________________________________________________________
_________________________________________________________________________________________________
_________________________________________________________________________________________________
_________________________________________________________________________________________________

152
Crop Specifics
Please list all the types of plants your remember growing this season

__________________________________________________________________________
__________________________________________________________________________
__________________________________________________________________________
__________________________________________________________________________
__________________________________________________________________________

For each plant, please write the name of the crop and variety in your native language and answer these 4 questions about it.
- Please write the crop name in English and the variety or common name in your native language
- Answer on a scale of 0 to 5, where 0: is not at all important and 5 is extremely important.

EXAMPLE 1
Crop name _______ Eggplant _______ Common/Variety Name _______ Inhori _______

<table>
<thead>
<tr>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
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</table>

For me/my family, this crop is hard to find or too expensive at grocery stores/markets X
This crop is important to me/my family culturally X
Me/my family enjoy cooking/eating this crop X
This crop is important to me/my family nutritionally X

EXAMPLE 2
Crop name _______ Tomato _______ Common/Variety Name _______ Beefsteak _______

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<th>0</th>
<th>1</th>
<th>2</th>
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<th>5</th>
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For me/my family, this crop is hard to find or too expensive at grocery stores/markets X
This crop is important to me/my family culturally X
Me/my family enjoy cooking/eating this crop X
This crop is important to me/my family nutritionally X

153
<table>
<thead>
<tr>
<th>Crop name __________________</th>
<th>Common/Variety Name __________________</th>
</tr>
</thead>
<tbody>
<tr>
<td>For me/my family, this crop is hard to find or too expensive at grocery stores/markets</td>
<td>0 1 2 3 4 5</td>
</tr>
<tr>
<td>This crop is important to me/my family culturally</td>
<td></td>
</tr>
<tr>
<td>Me/my family enjoy cooking/eating this crop</td>
<td></td>
</tr>
<tr>
<td>This crop is important to me/my family nutritionally</td>
<td></td>
</tr>
</tbody>
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<td></td>
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<td></td>
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154
### Appendix B: Example Soil Tests from CTG and NFNA

CTG - Thommy Thompson

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#### Soil Test Report

Agricultural & Environmental Testing Laboratory and UVM Extension

**Prepared For:**

Carolina Lukac  
Vermont Community Garden Network  
12 North St, Suite 5  
Burlington, VT  05401

carolina@vcgn.org  
860-391-3536

**Sample Information:**

Order #: 2494  
Lab ID: S16-00886  
CTG - Tommy Thompson  
Received: 4/18/2016  
Reported: 5/3/2016  
VT County: Chittenden

### Results

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>Low</th>
<th>Medium</th>
<th>Optimum</th>
<th>High or Excessive</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phosphorus (P):</td>
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<tr>
<td>Potassium (K):</td>
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<tr>
<td>Magnesium (Mg):</td>
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</table>

#### Analysis

<table>
<thead>
<tr>
<th>Analysis</th>
<th>Value Found</th>
<th>Optimum Range (or Average *)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soil pH (2:1, water)</td>
<td>6.7</td>
<td></td>
</tr>
<tr>
<td>Modified Morgan extractable, ppm</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Macronutrients</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Phosphorus (P)</td>
<td>26.8</td>
<td>4-10</td>
</tr>
<tr>
<td>Potassium (K)</td>
<td>32</td>
<td>100-160</td>
</tr>
<tr>
<td>Calcium (Ca)</td>
<td>1204</td>
<td>**</td>
</tr>
<tr>
<td>Magnesium (Mg)</td>
<td>97</td>
<td>50-120</td>
</tr>
<tr>
<td>Sulfur (S)</td>
<td>3.0</td>
<td>11*</td>
</tr>
<tr>
<td>Micronutrients</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Iron (Fe)</td>
<td>4.4</td>
<td>7.0*</td>
</tr>
<tr>
<td>Manganese (Mn)</td>
<td>3.4</td>
<td>8.0*</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Analysis</th>
<th>Value Found</th>
<th>Optimum Range (or Average *)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Boron (B)</td>
<td>0.3</td>
<td>0.3*</td>
</tr>
<tr>
<td>Copper (Cu)</td>
<td>0.2</td>
<td>0.3*</td>
</tr>
<tr>
<td>Zinc (Zn)</td>
<td>1.6</td>
<td>2.0*</td>
</tr>
<tr>
<td>Sodium (Na)</td>
<td>8.0</td>
<td>20*</td>
</tr>
<tr>
<td>Aluminum (Al)</td>
<td>8</td>
<td>35*</td>
</tr>
<tr>
<td>Soil Organic Matter %</td>
<td>2.0</td>
<td>**</td>
</tr>
<tr>
<td>Effective CEC, meq/100g</td>
<td>6.9</td>
<td>**</td>
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</tbody>
</table>

| Base Saturation, %              |             |                             |
| Calcium Saturation              | 87.1        | 40-80                       |
| Potassium Saturation            | 1.2         | 2.0-7.0                     |
| Magnesium Saturation            | 11.7        | 10-30                       |

* Micronutrient and S deficiencies are rare in Vermont and optimum ranges are not defined; thus average values in Vermont soils are shown instead.  

** Ranges for Calcium, Organic Matter, and Effective CEC vary with soil type and crop.

<table>
<thead>
<tr>
<th>Heavy Metal</th>
<th>Value Found</th>
<th>Normal *</th>
<th>High</th>
</tr>
</thead>
<tbody>
<tr>
<td>Copper (Cu)</td>
<td>0.2</td>
<td>0.3*</td>
<td>more than 10</td>
</tr>
<tr>
<td>Zinc (Zn)</td>
<td>1.6</td>
<td>2.0*</td>
<td>more than 80</td>
</tr>
<tr>
<td>Cadmium (Cd)</td>
<td>0.1</td>
<td>0.1*</td>
<td>more than 2</td>
</tr>
<tr>
<td>Chromium (Cr)</td>
<td>0.0</td>
<td>1.0*</td>
<td>more than 20</td>
</tr>
<tr>
<td>Nickel (Ni)</td>
<td>0.1</td>
<td>1.0*</td>
<td>more than 20</td>
</tr>
<tr>
<td>Lead (Pb)</td>
<td>0.3</td>
<td>1.0*</td>
<td>more than 50</td>
</tr>
</tbody>
</table>

* Normal levels are Vermont averages from non-contaminated soils, and are given for comparison. Results higher than normal but lower than the "high level" are not considered dangerous for growing vegetables.
NFNA - Ethan Allen Homestead

Soil Test Report
Agricultural & Environmental Testing Laboratory and UVM Extension

Prepared For:
Alisha Laramee
NFNA -- AALV
20 Allen St
Burlington, VT 05402
alaramee@aalv-vt.org
802-735-7617

Sample Information:
Order #: 4026
Lab ID: S17-00613
Field 3
Area Sampled: 0.5 acres
Received: 4/18/2017
Reported: 5/1/2017
VT County: Chittenden

Results

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>Low</th>
<th>Medium</th>
<th>Optimum</th>
<th>High or Excessive</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phosphorus (P):</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Potassium (K):</td>
<td></td>
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<tr>
<td>Magnesium (Mg):</td>
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</tbody>
</table>

Phosphorus is excessive!!!

<table>
<thead>
<tr>
<th>Analysis</th>
<th>Value Found</th>
<th>Optimum Range (or Average *)</th>
<th>Analysis</th>
<th>Value Found</th>
<th>Optimum Range (or Average *)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soil pH (2:1, water)</td>
<td>7.4</td>
<td></td>
<td>Boron (B)</td>
<td>0.5</td>
<td>0.3*</td>
</tr>
<tr>
<td>Modified Morgan extractable, ppm</td>
<td></td>
<td></td>
<td>Copper (Cu)</td>
<td>0.4</td>
<td>0.3*</td>
</tr>
<tr>
<td>Macronutrients</td>
<td></td>
<td></td>
<td>Zinc (Zn)</td>
<td>3.1</td>
<td>2.0*</td>
</tr>
<tr>
<td>Phosphorus (P)</td>
<td>127.1</td>
<td>4-10</td>
<td>Sodium (Na)</td>
<td>10.0</td>
<td>20*</td>
</tr>
<tr>
<td>Potassium (K)</td>
<td>57</td>
<td>100-160</td>
<td>Aluminum (Al)</td>
<td>9</td>
<td>35*</td>
</tr>
<tr>
<td>Calcium (Ca)</td>
<td>2613</td>
<td>**</td>
<td>Soil Organic Matter %</td>
<td>2.6</td>
<td>**</td>
</tr>
<tr>
<td>Magnesium (Mg)</td>
<td>149</td>
<td>50-120</td>
<td>Effective CEC, meq/100g</td>
<td>14.5</td>
<td>**</td>
</tr>
<tr>
<td>Sulfur (S)</td>
<td>5.0</td>
<td>11*</td>
<td>Base CEC, %</td>
<td>90.4</td>
<td>40-80</td>
</tr>
<tr>
<td>Micronutrients</td>
<td></td>
<td></td>
<td>Calcium Saturation</td>
<td>1.0</td>
<td>10-30</td>
</tr>
<tr>
<td>Iron (Fe)</td>
<td>5.8</td>
<td>7.0*</td>
<td>Potassium Saturation</td>
<td>2.0-7.0</td>
<td></td>
</tr>
<tr>
<td>Manganese (Mn)</td>
<td>8.6</td>
<td>8.0*</td>
<td>Magnesium Saturation</td>
<td>8.6</td>
<td>10-30</td>
</tr>
</tbody>
</table>

* Micronutrient and S deficiencies are rare in Vermont and optimum ranges are not defined; thus average values in Vermont soils are shown instead.
** Ranges for Calcium, Organic Matter, and Effective CEC vary with soil type and crop.

Recommendations for Sweet Corn, Full Season (VSWF)

<table>
<thead>
<tr>
<th>Limestone (Target pH of 6.8)</th>
<th>Nitrogen, N</th>
<th>Phosphate, P₂O₅</th>
<th>Potash, K₂O</th>
</tr>
</thead>
<tbody>
<tr>
<td>tons / Acre</td>
<td>lbs / Acre</td>
<td>lbs / Acre</td>
<td>lbs / Acre</td>
</tr>
<tr>
<td>0</td>
<td>100 - 130</td>
<td>0</td>
<td>120</td>
</tr>
</tbody>
</table>

Comments:
If your micronutrients are low, the addition of compost or a volcanic material such as Azomite may be beneficial.
To convert fertilizer pounds per acre to pounds per 1,000 sq ft, divide by 50.
Early plantings of corn should ideally be on light, well-drained soil to speed soil warming and growth. Heavier soils are preferable for later plantings to maintain soil moisture during warm, dry periods. Plowing under corn stalks and cover crops to maintain high levels of organic matter is recommended. Planting seed into soils colder than 55°F increases risk of poor germination. If banding soluble fertilizer at planting, apply no more than 80 lb/acre combined weight of actual N plus potash avoid salt injury to seedlings. Take a PSNT soil test sample when corn is 6 to 12 inches tall to determine how much N, if any, is needed as a sidedressing or topdressing.
Soil test values for phosphorus are above optimum. Do not add additional phosphorus at this time.

Lab ID: S17-00613
Page 1 of 2
Field 3
## Appendix C: CVI values for top crops

<table>
<thead>
<tr>
<th>Farm and Plot #</th>
<th>top nrml CVI crop</th>
<th>nrml CVI</th>
<th>nrml NET</th>
<th>nrml VM</th>
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</thead>
<tbody>
<tr>
<td>C2</td>
<td>kale</td>
<td>1.16</td>
<td>0.16</td>
<td>1.00</td>
</tr>
<tr>
<td>C3</td>
<td>Kale</td>
<td>1.57</td>
<td>1.00</td>
<td>0.57</td>
</tr>
<tr>
<td>C4</td>
<td>tomatoes</td>
<td>1.05</td>
<td>0.05</td>
<td>1.00</td>
</tr>
<tr>
<td>C7</td>
<td>peppers</td>
<td>2.00</td>
<td>1.00</td>
<td>1.00</td>
</tr>
<tr>
<td>C8</td>
<td>Kale</td>
<td>1.00</td>
<td>0.40</td>
<td>0.60</td>
</tr>
<tr>
<td>C10</td>
<td>tomatoes</td>
<td>0.88</td>
<td>0.59</td>
<td>0.29</td>
</tr>
<tr>
<td>C12</td>
<td>Basil</td>
<td>1.91</td>
<td>1.00</td>
<td>0.91</td>
</tr>
<tr>
<td>C13</td>
<td>Kale</td>
<td>1.37</td>
<td>0.37</td>
<td>1.00</td>
</tr>
<tr>
<td>C14</td>
<td>Basil</td>
<td>1.43</td>
<td>1.00</td>
<td>0.43</td>
</tr>
<tr>
<td>C15</td>
<td>Kale</td>
<td>1.15</td>
<td>0.15</td>
<td>1.00</td>
</tr>
<tr>
<td>N1</td>
<td>amaranth (lenga lenga)</td>
<td>2.00</td>
<td>1.00</td>
<td>1.00</td>
</tr>
<tr>
<td>N4</td>
<td>onion</td>
<td>0.95</td>
<td>0.04</td>
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<td>N7</td>
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<td>0.50</td>
<td>0.83</td>
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<tr>
<td>N14</td>
<td>peppers</td>
<td>1.23</td>
<td>0.23</td>
<td>1.00</td>
</tr>
<tr>
<td>N21</td>
<td>peppers</td>
<td>1.79</td>
<td>0.79</td>
<td>1.00</td>
</tr>
<tr>
<td>N22</td>
<td>maize (makai)</td>
<td>1.03</td>
<td>0.03</td>
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</tr>
<tr>
<td>P3</td>
<td>peppers</td>
<td>1.35</td>
<td>0.68</td>
<td>0.67</td>
</tr>
<tr>
<td>P21</td>
<td>Eggplant</td>
<td>1.63</td>
<td>0.63</td>
<td>1.00</td>
</tr>
<tr>
<td>H8</td>
<td>spearmint</td>
<td>1.38</td>
<td>1.00</td>
<td>0.38</td>
</tr>
<tr>
<td>H10</td>
<td>Basil</td>
<td>1.77</td>
<td>1.00</td>
<td>0.77</td>
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<tr>
<td>H13</td>
<td>pointed gourd (jukuni)</td>
<td>1.88</td>
<td>1.00</td>
<td>0.88</td>
</tr>
<tr>
<td>H15</td>
<td>Okra</td>
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<td>0.00</td>
<td>1.00</td>
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</table>
## Appendix D: Yield and Net per ft²

<table>
<thead>
<tr>
<th></th>
<th>total plot area</th>
<th>planted area</th>
<th>potential yield</th>
<th>yield per ft² (total)</th>
<th>Yield per ft² (planted)</th>
<th>Average net per ft² (planted)</th>
<th>% Land use</th>
</tr>
</thead>
<tbody>
<tr>
<td>C2</td>
<td>80</td>
<td>49.5</td>
<td>15.58</td>
<td>0.195</td>
<td>0.315</td>
<td>-5.06</td>
<td>61.9%</td>
</tr>
<tr>
<td>C3</td>
<td>72</td>
<td>48</td>
<td>17.294</td>
<td>0.240</td>
<td>0.360</td>
<td>-0.41</td>
<td>66.7%</td>
</tr>
<tr>
<td>C4</td>
<td>72</td>
<td>65.81</td>
<td>34.84</td>
<td>0.484</td>
<td>0.529</td>
<td>-2.06</td>
<td>91.4%</td>
</tr>
<tr>
<td>C7</td>
<td>72</td>
<td>49.75</td>
<td>25.2</td>
<td>0.350</td>
<td>0.507</td>
<td>-4.38</td>
<td>69.1%</td>
</tr>
<tr>
<td>C8</td>
<td>72</td>
<td>39.25</td>
<td>21.7</td>
<td>0.301</td>
<td>0.553</td>
<td>-7.49</td>
<td>54.5%</td>
</tr>
<tr>
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<td>72</td>
<td>30.5</td>
<td>10.63</td>
<td>0.148</td>
<td>0.349</td>
<td>-12.09</td>
<td>42.4%</td>
</tr>
<tr>
<td>C12</td>
<td>72</td>
<td>29.75</td>
<td>26.18</td>
<td>0.364</td>
<td>0.880</td>
<td>-8.04</td>
<td>41.3%</td>
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<tr>
<td>C13</td>
<td>72</td>
<td>64</td>
<td>39.82</td>
<td>0.553</td>
<td>0.622</td>
<td>-2.80</td>
<td>88.9%</td>
</tr>
<tr>
<td>C14</td>
<td>72</td>
<td>47</td>
<td>37.42</td>
<td>0.520</td>
<td>0.796</td>
<td>2.89</td>
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<tr>
<td>C15</td>
<td>72</td>
<td>18.25</td>
<td>15.22</td>
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<td>0.834</td>
<td>-18.62</td>
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<td>2149</td>
<td>1297.16</td>
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<td>952</td>
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<td>0.214</td>
<td>0.46</td>
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</tr>
<tr>
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<td>2133</td>
<td>302.95</td>
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<td>0.142</td>
<td>0.12</td>
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<tr>
<td>N14</td>
<td>2310</td>
<td>2065</td>
<td>878.1</td>
<td>0.380</td>
<td>0.425</td>
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</tr>
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<td>N21</td>
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<td>678</td>
<td>336.82</td>
<td>0.128</td>
<td>0.497</td>
<td>0.09</td>
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</tr>
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<td>N22</td>
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<td>1150</td>
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<td>0.312</td>
<td>1.26</td>
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<td>6944</td>
<td>3352</td>
<td>544</td>
<td>0.078</td>
<td>0.162</td>
<td>0.63</td>
<td>48.3%</td>
</tr>
<tr>
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<td>2400</td>
<td>2400</td>
<td>372.02</td>
<td>0.155</td>
<td>0.155</td>
<td>0.44</td>
<td>100.0%</td>
</tr>
<tr>
<td>H8</td>
<td>32</td>
<td>27.25</td>
<td>14.32</td>
<td>0.448</td>
<td>0.526</td>
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</tr>
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</tr>
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<td>32</td>
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<td>26</td>
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## Appendix E: All CVI Data

<table>
<thead>
<tr>
<th>Farm and Plot #</th>
<th>crop</th>
<th>nrml CVI</th>
<th>nrml NET</th>
<th>nrml VM</th>
</tr>
</thead>
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<tr>
<td>N1</td>
<td>amaranth (lenga lenga)</td>
<td>2.000</td>
<td>1.000</td>
<td>1.000</td>
</tr>
<tr>
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<td>peppers</td>
<td>2.000</td>
<td>1.000</td>
<td>1.000</td>
</tr>
<tr>
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<td>1.000</td>
<td>0.909</td>
</tr>
<tr>
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</tr>
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</tr>
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<tr>
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</tr>
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</tr>
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<td>0.151</td>
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<td>0.094</td>
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</tr>
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<td>0.053</td>
<td>1.000</td>
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<tr>
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<td>0.000</td>
</tr>
<tr>
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<td>Name</td>
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<td>0.929</td>
</tr>
<tr>
<td>-----</td>
<td>---------------------------------</td>
<td>---------</td>
<td>---------</td>
<td>---------</td>
</tr>
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</tr>
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<td>0.571</td>
</tr>
<tr>
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<td>0.818</td>
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<td>Basil</td>
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