Food Security Analysis: Community Garden Distribution and Potential Yield of Austin, Texas

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Abstract

Food security is of emerging concern because of the loss of farmland through urbanization over the last century. A food desert is now commonly referred to as an area with low household incomes and low access to fresh food. Community gardens are noted part of the solution for increasing food security in areas like these. For our research project, we are calculating the potential yield of community gardens in Austin, Texas. We did field studies collecting data about the size of individual plot areas for each of the 18 certified public community gardens around the City of Austin. By using a Garmin GPS device to get the total area of each community garden, and by collecting data, contacting city officials, and referring to public databases, we were able to calculate a potential agricultural output for the total community garden area. Additionally, we calculated the amount of land currently being used for food production and compared this to the total area of the community garden to get percent utilization of the garden. Ultimately, we used ArcGIS to create maps, which compared the distribution of the community gardens to the food insecure regions, eligible urban agriculture sites, and prime farmland in Austin. We made recommendations to city officials as to the ideal locations for the potential future develop of community gardens throughout Austin, Texas. These recommendations were based off of several variables displayed in an ArcGIS Map: food insecurity, eligible sites set forth by the City of Austin, and prime farmland.

1. Introduction

Since the earliest days of city life, urban agriculture has taken on many forms and definitions to adapt to the culture of the day. For the scope of this paper, urban agriculture is broadly any food production in the city (Taylor & Lovell, 2012, p. 1). The focus of our research is on community gardens in the city of Austin, Texas. The research project had three main objectives:

1. To measure the individual plot areas and total areas of 18 certified public community garden in Austin, TX (potential yield and percent utilization);

2. To create maps overlaying existing urban farming with food insecurity, prime farmland, and eligible sites set forth by the City of Austin;

3. To provide ideal site recommendations to the City of Austin for future development of urban agriculture.

Despite community gardens contributing only a small fraction of produce to our food system, their relevance is becoming ever more important in the present day because they represent a reliable local food source. The United Nations announced in December 2013 that the world will have to produce 70 percent more food, as measured by calories, to support the projected growth of the human population, which is said to reach about nine billion people by the year 2050 (*Trade and Environmental Review*, 2013). At the Conference on Trade and Development, the United Nations stressed the severity of the issue of food security and urged that we achieve food security by changing the way we produce and consume our food (*Trade and Environmental Review*, 2013). The “contemporary community gardening movement” was brought about in the 1970’s and 1980’s when cities became economically depressed and there was an interest in reviving abandoned lots and turning them into “green space”(Saldivar-tanaka & Krasny, 2004, p. 399). Urban agriculture, including community gardens, will become increasingly more important if we are to adapt to a changing climate and embrace the idea of growing our food locally.

For those of us in developed countries, it may seem like a radical notion to be growing food in the city in the present day. Developing countries, however, have long recognized the importance of urban agriculture to their food system (Taylor & Lovell, 2012, p. 1). Our study aims to provide insight on the local food economy of Austin by looking at these community gardens and aims to increase the food security for the residents of Austin by making recommendations for future development of community gardens. Since the City of Austin has a goal to reach of net zero community-wide greenhouse gas emissions by 2050, local food could play an integral part in helping this become reality by providing residents with food that is not transported long distances using fossil fuels, but rather is produced and consumed by local residents. The United States Department of Agriculture (USDA) has provided us with information regarding who has access to fresh, local produce in Austin, Texas ("USDA: Food Access Research," 2015). This information could be used to make recommendations to the city on future development plans that incorporates more space for urban agriculture in the places most appropriate.

Furthermore, there are many economic and social impacts of the current way we produce our food in the United States. It has become increasingly important for communities today to have access to fresh produce because people are becoming increasingly dependent on a food sourced from great distances from home, and this threatens the food security of these communities ("American Planning Association Policy," n.d.). The food system has huge implications for the social and economic stability of communities in the future. Globalization of food markets has made it possible for consumers to be ignorant of where their food is actually coming from, and often this food is coming from locations that are increasingly further away from the cities ("American Planning Association Policy," n.d.). The fact that food is traveling such far distances, leaves city communities more vulnerable to supply shortages in times of natural or human-caused crises, than if they had a food source in the city. Since the modern industrial food system grows food on large monoculture farms in very distinct regions around the world, there is also the risk of shortages in food supply due to climate change, which may cause crop failures in these regions.

Within The United States, a study conducted by a non-profit organization called Feeding America ranked Texas among the top five states in both categories for overall Food Insecurity Rate, as well as Child Food Insecurity Rate ("House Committee on Agriculture," 2012). The national average for Food Insecurity Rate was 16.6% in 2009, while the Child Food Insecurity Rate was 23.2%. At the same time, Texas had 17.8% of its population with food access problems, and an even higher Child Food Insecurity Rate of 28.2% ("House Committee on Agriculture," 2012). With food security being a major issue for the residents of Texas, there is a need to produce food closer to home to create a more sustainable food source in these locations. Community gardens are viewed by many as part of the solution to the failures of our current food system.

One particular study took place in the city of Chicago, where a team of researchers sought to identify all the land being used for food production in Chicago (Taylor & Lovell, 2012, p. 1). The researchers identified sites of private and public food production and mapped them using ArcGIS software and high-resolution Google Maps (Taylor & Lovell, 2012, p. 1). The results showed that only 13 percent of the agricultural sites identified and mapped were community gardens (Taylor & Lovell, 2012, p. 1). Although this is only a fraction of all the urban agriculture in Chicago, home gardening accounted for three times as much food production than community gardens.

Moreover, the current way we produce most of our food has a tremendous impact on the ecological environment. If you add in all of the costs before the industrial farmed vegetable or meat product reaches your home, such as the chemical fertilizers and water used to grow the crops, the oil to transport the crops, to the coal burned in the power plant to cool the refrigeration systems of the supermarket, our food system is quite expensive and taxing on the ecological environment. The runoff from these large agricultural operations also has a huge impact on aquatic ecosystems. For example the Dead Zone in the Gulf of Mexico is one of the largest examples of an ecological disaster that can result from too much industrial agriculture runoff ("American Planning Association Policy," n.d.). Additionally, the loss of biodiversity among crop varieties being planted around the world is another huge ecological issue stemming from large scale industrial farming. Large agricultural companies, such as Monsanto and Cargil, produce and plant only one or two varieties of a crop on a colossal scale because these varieties have been genetically engineered to be able to withstand the pesticide treatments applied to these crops. This results in the overuse of pesticides and a reduction in the variety of each crop being produced around the world. Ecological systems with lower diversity overall tend to produce populations with less genetic diversity, therefore making them more susceptible to disease.

As we look at agriculture in the modern day we see people are no longer planting small gardens in their backyards at the rates we used to. The food system is not dominated by diverse small farmers, but instead it is relying on large scale industrial farming techniques to grow a few varieties of certain crops that corporations deem to be profitable. Urban agriculture offers an alternative to the current food system and can contribute to the food system meaningfully to communities who desperately need access to fresh food.

Since there is already consolidated information about urban agricultural distribution across Austin, Texas, one of the aims of our study is to start by identifying the distribution of community gardens across the area in relation to certain environmental and social factors. As for the City of Austin, there is an interactive map developed by the city’s Parks and Recreation Department showing the distribution of existing urban agriculture, eligible sites for future development of urban agriculture, as well as other data on the different sites. There is, however, little agricultural yield data on any of these sites. Additionally, we sought to quantify the potential output of public certified community gardens, as well as to overlay social and environmental factors to the map created by the city of Austin’s Parks and Recreation Department in order to make ideal site recommendations for future community gardens.

2. Methods

Study site and field collection. We chose 18 randomly dispersed sites of the total 53 community gardens based off a list provided to us by the City of Austin Parks and Recreation. In order to calculate the potential yield and percent utilization, we used measuring tapes to measure all plots currently under production (utilized areas) and a Garmin GPS unit to collect total areas of each 18 sites. We recorded all our data in an excel database to perform the following calculations.

2.1 Percent Utilization

To perform this calculation, we used the collected total areas of the community gardens and the utilized areas of the 18 individual sites. We divided the utilized areas by the total areas respectively for each site and recorded these calculations in excel. The values were then used to perform a column statistical analysis using GraphPad Prism version 6.0 for Windows, GraphPad Software. The output was a table of descriptive data. **(Figure 1)**

2.2 Potential Yield

Actual yield data was obtained through a citizen science approach from one of the study sites, Sunshine Gardens ("Sunshine Community Gardens," n.d.). The site's volunteers provided actual yield data for one crop (tomatoes) spanning over four years. We took this actual yield data for the four years and divided it by the area utilized which gave us their pounds per square foot. This index of productivity was then multiplied individually by all the utilized areas determined for the 18 community gardens. This provided a range of productivity values for each garden. Each site's utilized area was paired with the range of productivity values which were then used to perform a paired column statistical analysis using GraphPad Prism version 6.00 for Windows, GraphPad Software. The output was a table of descriptive data. (**Figure 2**)

2.3. Methods for Overlay Maps 1-2

Study site and software. The research is focused on the City of Austin, Texas. ArcGIS overlay maps are an excellent way to visually demonstrate relationships that otherwise may go unnoticed. A study in England was able to visually demonstrate areas where most deprived individuals had the least amount of access to green spaces (Sotoudehnia & Comber, 2010). The USDA Food Atlas Map displays areas which residential members are low income (LI) according to federal standards (Poverty Guidelines, USHHS). These areas also have low access (LA) to food sources. Using data and maps collected from Imagine Austin Comprehensive Plan, we gained some valuable insight into which areas to focus on when developing the overlay maps. The areas from the comprehensive plan outline regions of prime farmland (Department of Planning City, 1980, p. [168,157]). The interactive USDA Food Access Map reveals regions of food deserts within Austin, Texas ("USDA: Food Access Research," 2015). The City of Austin Parks and Recreation has developed an interactive map of urban agriculture distribution throughout Austin, Texas (Maxwell, n.d.). Using all these resources the data was downloaded into ArcGIS as *.xsl* files and joined together with a Travis County census tract shape file provided to us by the GIS department of The City of Austin Parks and Recreation to create Maps 1-2.

2.4 Methods for Ideal Site Recommendations Map 3-4

A list of Eligible sites for future agricultural development was developed by the city based off a set of Criteria determined by Watershed Protection Department (WPD) of Austin, Texas.

<u>WPD List of Criteria:</u>

1. Site may not be within 100 feet of a creek centerline.
2. Site may not be on heavily wooded lot.
3. Site may not on be on steep slopes.
4. Site may not be in a channel.
5. Site may not be in pond.
6. Site must be accessible by public.

This criteria was then sent to other city departments to create a list of eligible sites for future development of public gardens, which we used for the creation of Map 1. For this study, we expanded this set of criteria to incorporate these additional parameters:

Three additional parameters for future development:

1.) A region with the highest number of city recommendations.
2.) A region with Prime farmland.
3.) In a food desert.

Before we were able to solidify our recommendations we did not want to ignore the fact that existing urban farms are mitigating food deserts. Therefore, using ArcGIS we created visual buffers ½ mile around each existing urban farm since the average community gardens is only utilizing 17.79% of their land we chose the USDA food desert lower limit of ½ mile as to not overestimate the reach of these existing gardens for creation of Map 3. After, these additional layers we chose two primary locations based off our combined criteria from the city and our additional variables. These site recommendations are not all inclusive just where primary resources should be allocated towards displayed in Map 4.

Figure 1. Percent Utilization

Mean	**17.79%**
Min	0.21%
Max	54.24%

This table outlines percent calculations of the 18 community garden sites chosen for this study. They are producing on an average of 17.79% of their land. The lowest percent of land currently being utilized is 0.21% and the highest percent land being utilized is 54.24%.

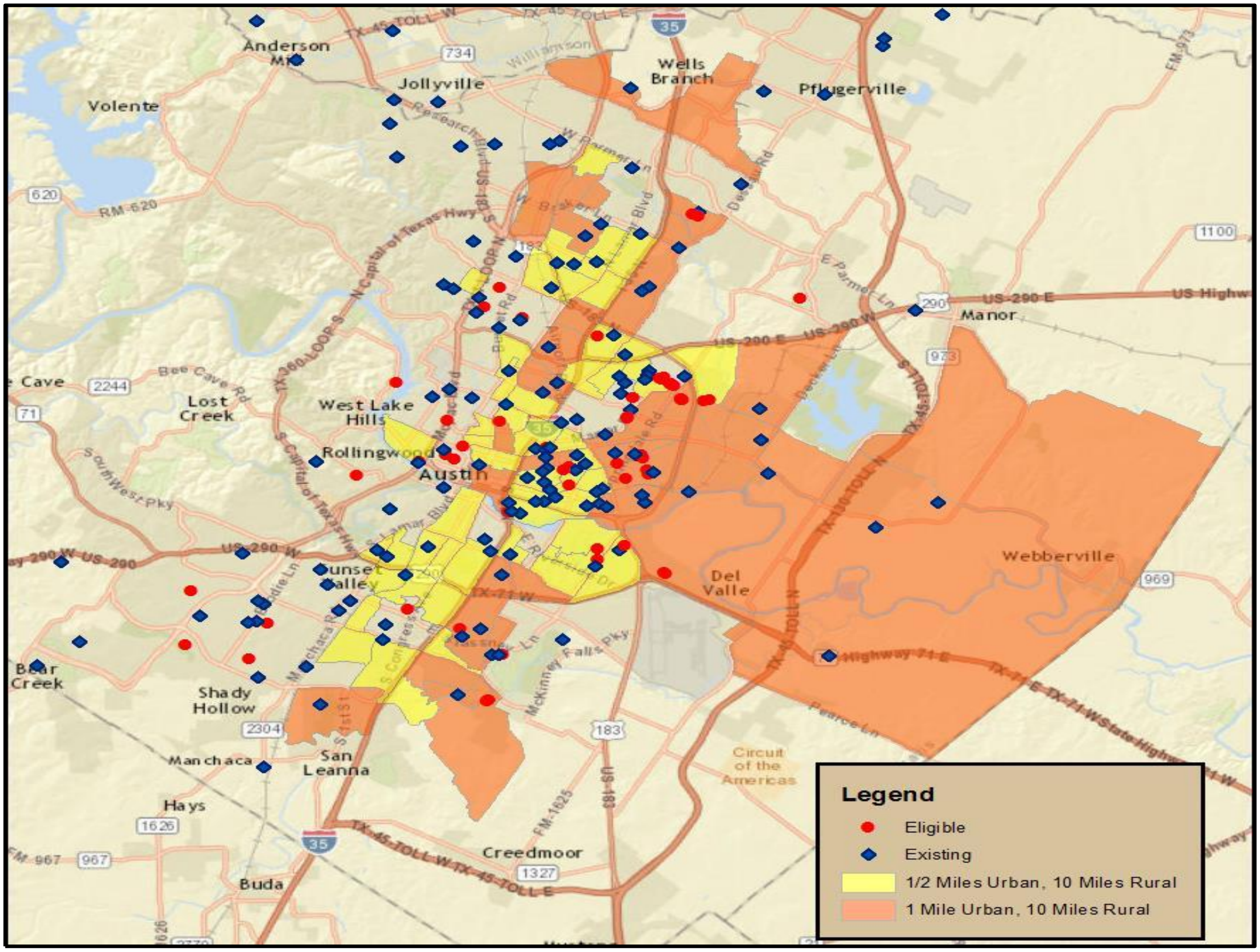
Figure 2. Potential Yield

DESCRIPTIVE STATISTICS	
n	**18**
Average Area	32,121.20 Square Feet
Minimum	21.28 lbs/yr
Maximum	18,620 lbs/yr
Mean	**1,914 lbs/yr**
Standard Deviation	+/- 4,407 lbs/yr
Sum	**34,459 lbs/yr**

This table outlines calculations based off the utilized areas of the 18 study sites. The average garden studied can potentially yield 1,914 pounds annually and aggregately they can potentially yield around 34,459 pounds annually.

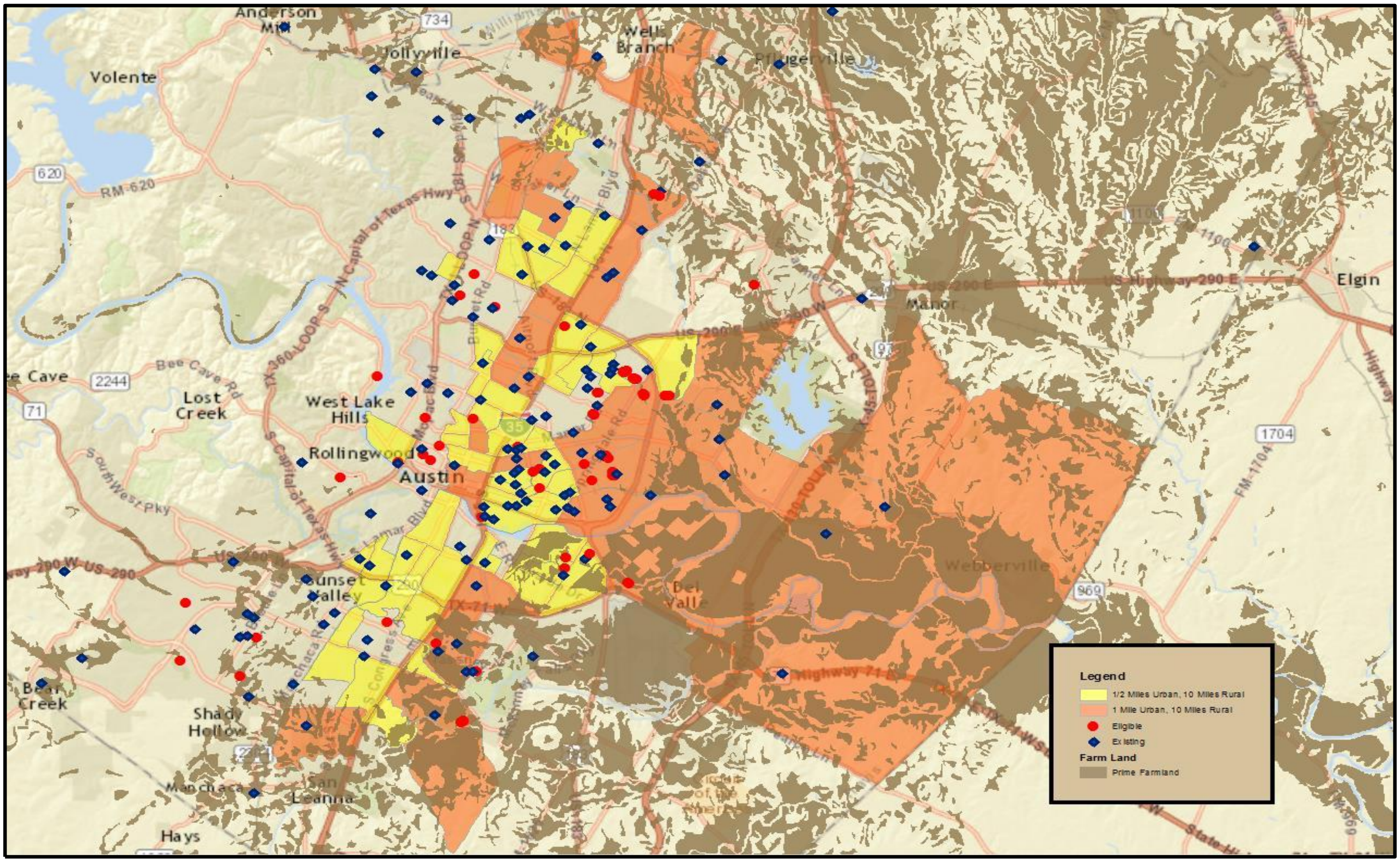
3.1 Results for Overlay Maps

Map 1. Food Desert and Distribution of Eligible and Existing Urban Agriculture in Austin, Texas.



This map of Austin, Texas food desert is overlayed with distributions of eligible and existing agricultural sites. Eligible sites for future agricultural development are displayed as red circles. Existing agricultural sites are displayed as blue diamonds. The yellow is where urban residents are ½ a mile from fresh produce and the orange is where urban residents are 1 mile away. Rural residents in both colors are 10 miles away.

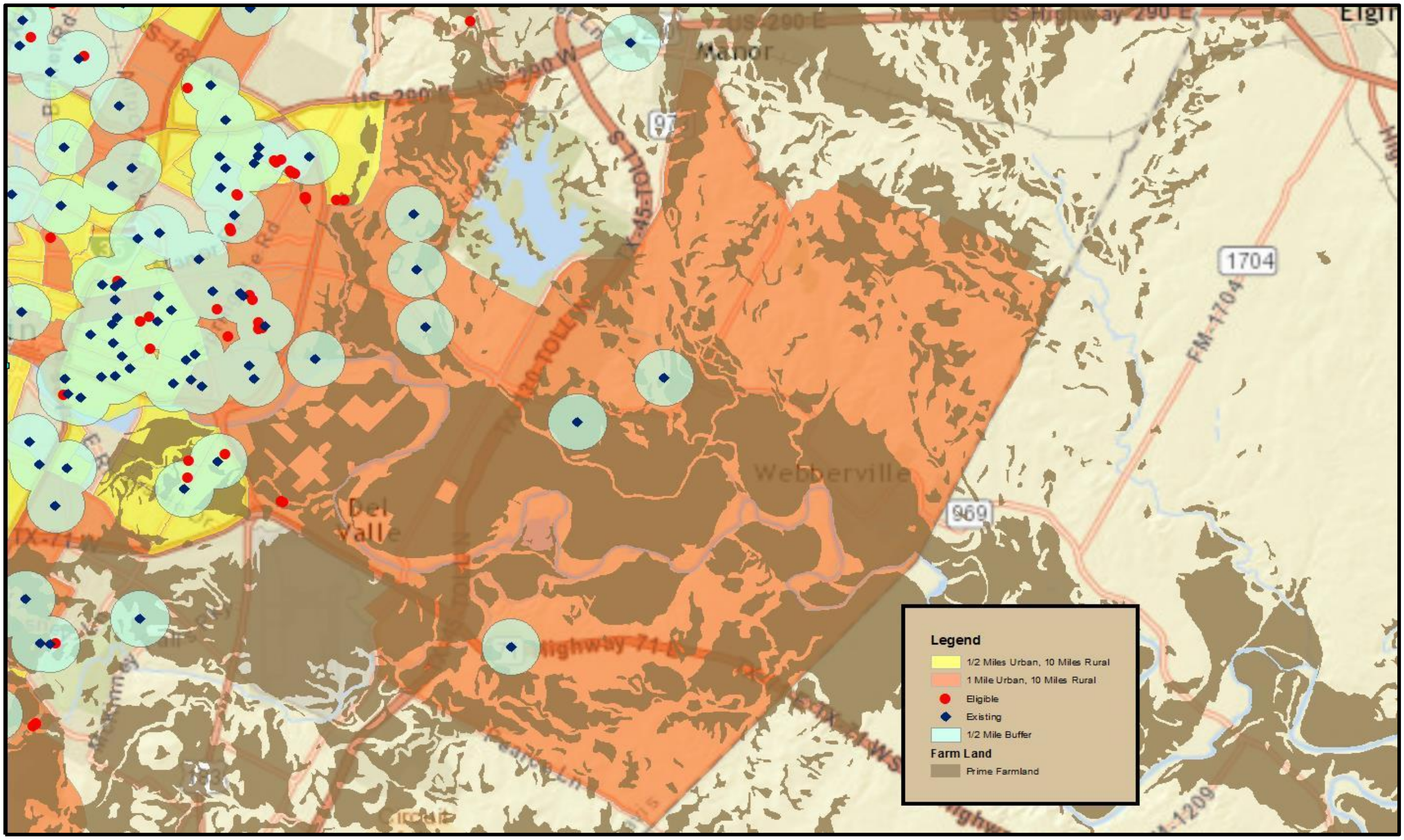
Map 2. Food Desert and Distribution of Eligible and Existing Urban Agriculture paired with Prime Farmland in Austin, Texas.



This map of Austin, Texas food desert is an overlay with distributions of eligible and existing agricultural sites and Prime Farmland. Eligible sites for future agricultural development are displayed as red circles. Existing agricultural sites are displayed as blue diamonds. The yellow is where urban residents are a half mile from fresh produce and the orange is where urban residents are 1 mile. Rural residents in both colors are 10 miles away. The Prime farmland is displayed in light brown.

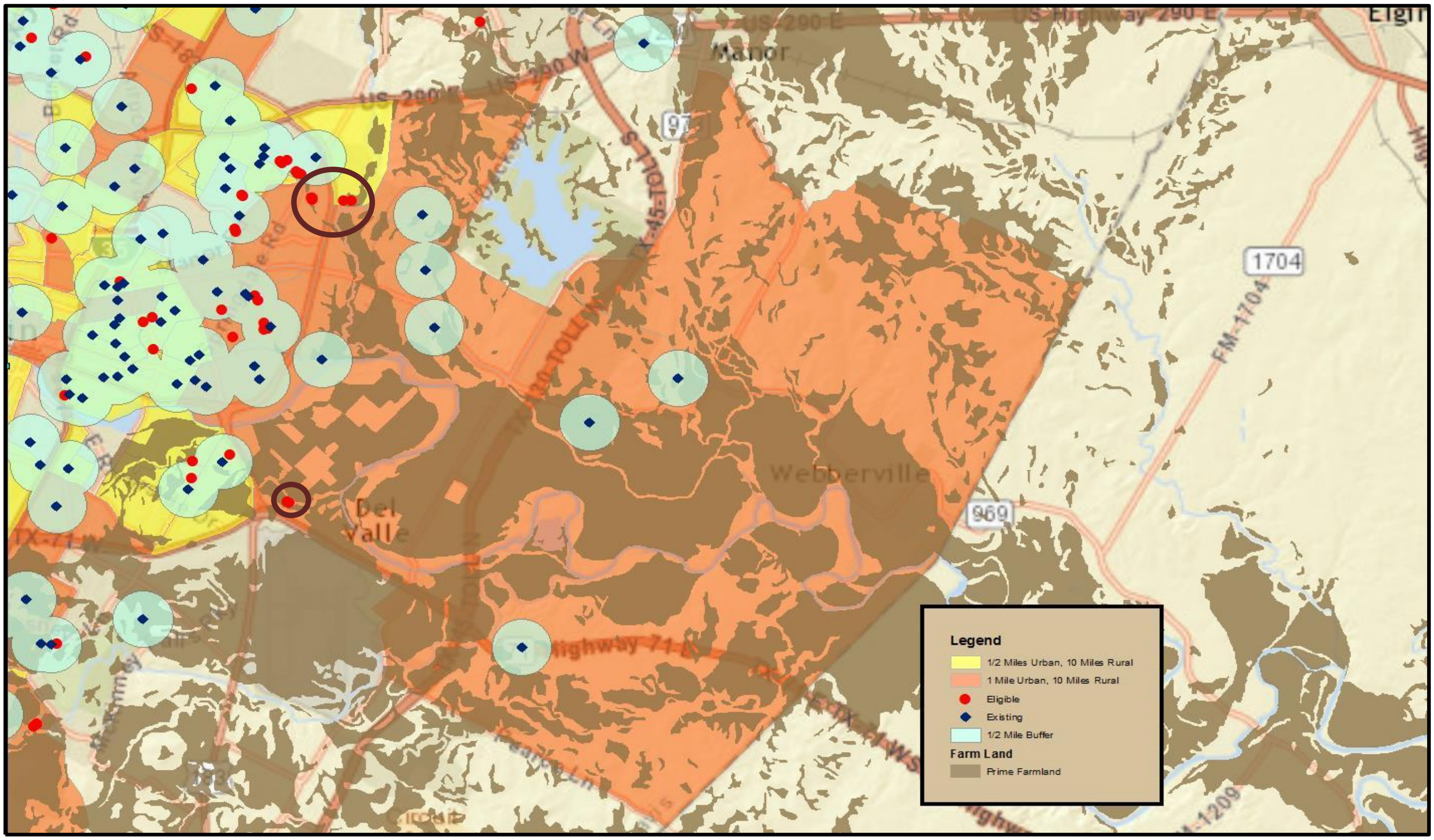
3.2 Results for Ideal Site Recommendations

Map 3. Food Desert and Distribution of Eligible and Buffered Existing Urban Agriculture paired with Prime Farmland in Austin, Texas.



This map of Austin, Texas food desert is an overlay with distributions of eligible and existing agricultural sites and Prime Farmland. Eligible sites for future agricultural development are displayed as red circles. Existing agricultural sites are displayed as blue diamonds. The yellow is where urban residents are a half mile from fresh produce and the orange is where urban residents are 1 mile away. Rural residents in both colors are 10 miles away. The Prime farmland is displayed in light brown. Existing sites have a half mile buffers around them to eliminate regions of food insecurity.

Map 4. Ideal Site Recommendations for future agricultural development based on social, environmental and city criteria.



This map displays ideal site locations for future agricultural development displayed in dark circles. The region in orange is an area that should be focused on when considering future development.

4. Discussion

As mentioned earlier in the introduction to this proposal, the issue of food security is one that the United Nations has recognized as a threat posed by climate change and the nature of our food system (*Trade and Environmental Review*, 2013).. With climate becoming more extreme and unpredictable, we need crops that are resilient to these types of environmental change. To continue planting large-scale productions of monoculture crops would be a disastrous for the sustainability of our environment, the economy, and society if we are to take the threats of climate change on our food system seriously. To deal with the issue of food security, we need to move away from large-scale industrial farming techniques and back to producing our food by smaller, more diverse farms. According to the American Planning Association (APA), farms between 50-500 acres and 500-1,000 acres have “decreased by 7 and 11 percent respectively between 1997 and 2002,” while farms over 2,000 acres have increased by 5 percent ("American Planning Association Policy," n.d.). If we continue in this direction, the smaller, more biodiverse farms will be threatened by the planting of large monoculture crops by following the industrial farming model of the last century.

Biodiversity in any system improves resilience and stability of the system as a whole. For instance, if a great deal of time and money is spent planting one variety of corn, and this particular variety happens to have no defense mechanism to fight off a new strain of agricultural pest, then you will end up with a significant decrease in agricultural yield due to large portions of the crop or the entire crop failing from a pest invasion. Now, if instead the farms were smaller, more diversified, with different varieties of the same crop with different crops planted in various locations around the farm, this farm will be more stable and resilient if a new strain of a pest comes along. Even if one crop fails, you still have the entire agricultural yield from the other crops that were not affected by the pest. With the threats of climate change, unpredictable weather patterns are also giving rise to massive crop failures because we plant our crops in very centralized locations. When these areas experience a shift in climatic factors, food will become increasingly more difficult to produce in these areas.

Urban agriculture will undoubtedly play a huge role in the food system if we are to move toward more sustainable trends, being that between 40% and 55% of the world’s population lives in an urban environment, depending on the definition used for urban centers (Satterthwaite, 2000, p. 1143). By moving the source of food production closer to home, people’s food security would also increase because of transportation being shorter.

Moreover, an interesting case study is the Cuban response to the loss of trade that marked “the end of deliveries of agricultural machinery, spare parts, petroleum, and petroleum derivatives from COMECON countries” following the fall of the Soviet bloc in 1989, by establishing a thriving urban agricultural system (Altieri et al., 1999, p. 131) (Koont, 2008, p. 285). With little or no access to cheap nitrogen based synthetic fertilizers following this loss of trade, the Cuban people had to develop a system that emphasized ecological principles, the use of local resources, composting, and recycling (Altieri et al., 1999, p. 131). The practices have been admired by scientists and policy makers in other countries interested in developing urban agriculture mainly because of Cuba's model of a self-reliant, low input, organic system of producing food in an urban setting (Rosset, Funes, García, Bourque, & Pérez, 2002, p.1). Additionally, the productivity of this type of urban agriculture in Cuba is extremely impressive. The yield of their produce for the city of Havana has been increasing in the recent past, from 20.7 thousand metric tons of vegetables produced in 1997 to 272 thousand metric tons in 2005 (Koont, 2009, p. 63). This example of the Cuban people adapting to a food crisis offers a glimpse into what would need to happen in the United States and elsewhere if there were shortages in the supply of oil and other products used for conventional industrial farming practices.

Finally, noteworthy studies used to formulate this project's methods include those that measure agricultural output of community gardens. A unique approach by a team of researchers in New York City uses citizen science in order to determine the yield of the over 500 community gardens distributed across the city (Gittleman, Jordan, & Brelsford, 2012). Citizen science "attempts to make the knowledge-making process of a science more democratic by giving a community some degree of decision-making power over what is studied, how it is studied, the collection of data, and the conclusions drawn from the research" (Gittleman, Jordan, & Brelsford, 2012). Farming Concrete is the name of the project using citizen science to try and quantify the agricultural outputs of the community gardens in New York City.

The first phase of the Farming Concrete project is mostly outreach to these gardens to get them to participate in collecting some data about their crop yields. The gardeners are asked to measure the pound of produce produced per foot of land, to record the type of plant being analyzed, and to count the number of plants in a given area. Once they have established participants, they record the data and combine it with the other community gardens to form a database. The result of the study included 45 participants who recorded the number of each plant they harvested, the type of each plant, and the weight of the output from each crop type for the years 2010 and 2011 (Gittleman, Jordan, & Brelsford, 2012).

In order to calculate the output of each crop, Farming Concrete used two studies as models. The first was a study conducted by a team of researchers at the University of Pennsylvania, who measured the yield of a variety of crops in food-producing sites in Philadelphia, Pennsylvania; Camden, New Jersey; and Trenton, New Jersey. For larger sites, they accounted for 10 percent of the crops and estimated the total yields from there (Gittleman, Jordan, & Brelsford, 2012). At smaller sites, the researchers were able to account for the total crop yield of the garden for a particular season. The researchers were then able to estimate the yields of other community gardens based on their findings in the surveyed community gardens (Gittleman, Jordan, & Brelsford, 2012). For this paper, potential yield estimations were calculated using a similar technique where data was provided to us by a gardener at one of our study sites, Sunshine Gardens.

The other study Farming Concrete looked at was one conducted in 2011 by the Urban Design Lab at Columbia University. The researchers estimated the output of New York City gardens "using average commercial crop yields from the USDA and yields recorded from biointensive farming in How to Grow More Vegetables by John Jeavons"(Gittleman, Jordan, &

Brelsford, 2012). This is a technique was considered for application in our research project to calculate potential yield of community garden plots in Austin, Texas, but actual yield data from one of our study sites was used to make this estimation.

Farming Concrete did not fully adopt any one of these methods, but chose a citizen science approach of letting the gardeners collect the data. In a similar fashion as the University of Pennsylvania study, this data was reported back to be analyzed by the researchers at Farming Concrete. This method is more preferable than trying to go to each of the 500 community gardens and measuring the output of each garden and does not extrapolate the yields from just studying one plot or by going off of standard yields to estimate the particular yield of a given garden in New York City. Farming Concrete aims to establish literature reflecting accurate data of agricultural yields from each individual community garden in New York City using citizen science to gather this information. Because of time constraints and the variability in the growing season, our research project will derive the potential yield estimation for the community gardens in Austin, Texas by comparing it to actual yield data spanning over four years, which was obtained from one of the 18 public certified community gardens in our study. Further researchers wishing to obtain actual yield data should employ a citizen science approach, possibly distributing scales to weigh the produce of each growing season on these study sites.

5. Conclusion

The focus of our research was on community gardens in the city of Austin, Texas. The research project had three main objectives:

1. To measure the plot areas and total areas of 18 certified public community garden in Austin, TX (potential yield and percent utilization).
2. To create maps overlaying existing urban farming with food insecurity, prime farmland, and eligible sites set forth by the City of Austin.
3. To provide ideal site recommendations to the City of Austin for future development of urban agriculture.

To address the first objective we collected field data by measuring total areas and utilized areas for 18 of the total 53 community garden sites in Austin, Texas. Based on the utilized areas of the 18 study sites, we estimated the average garden is producing on 17.79% studied can potentially yield 1,914 pounds annually and aggregately they can potentially yield around 34,459 pounds annually. For the last two objectives using ArcGIS and public data we created overlay maps 1-4. To conclude we measured over 300 plots, 18 sites and identified future locations based off several social and environmental factors. The goal of our research is to share our data with the city and public to create a more sustainable food system.

Acknowledgements

Experts in the field of Agricultural Production, GIS systems and City Departments are a valuable resource for discovering accurate data and finding trends/variables to research that may be useful for future direction of the development for the City of Austin, Texas. We would like to thank the participating gardens for granting us access to these locations. Additionally, we are grateful for all the volunteers and producers/heads of gardens because they are the ones who know the most about their sites and were always more than willing to help. This made gathering data a pleasure. A special thanks to Sunshine Community Garden for providing us with actual yield data.
We contacted various City of Austin departments/staff and gained insight into current questions that steered our scope to investigate areas of interest. Some of the departments and staff we are collaborated with: The Office of Sustainability: Edwin Marty-Austin's Food Policy Manager, Lydia Jarjoura- Public Information Specialist; The City of Austin Parks and Recreation: Allison Hardy - Senior GIS analyst; Meredith Grey- Community Garden Specialist and Gillian Roos -GIS technician. The Sustainable Food Center: Sari Albornoz-Grow Local Program Director; St. Edward's University: John Cotter, Assistant Professor of Geography; Amy Belaire, Ph.D-Natural Resources Manager & Coordinator of Education and Research; Michael Wasserman, Ph.D - Environmental Science & Policy School of Behavioral & Social Sciences, and each of our graduate advisors helped us with guidance throughout the project. We are currently completing the Professional Science Master's (PSM) in Environmental Management and Sustainability at St. Edward's University. We developed this research topic due to our past experiences in the agricultural field and personal interests for environmental sustainability.

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