CALIFORNIA STATE UNIVERSITY, NORTHRIDGE

SPOILED YET DEPRIVED

MAPPING THE SF BAY AREA LOCAL FOODSHED

A thesis submitted in partial fulfillment of the requirements

For the degree of Master of Arts in Geography, GIS

By

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This thesis is culmination of years of my learning. The evolution of my thought process, from just two years ago, is quite significant. I always worried that this final project would not be to the level that I wanted and would regret not working harder on it. I can honestly say that I do not have any regrets. The first person I would like to acknowledge is myself for finally getting it done. There are a number of mentors that have shaped my thought processes over the years and would like to acknowledge them. They are, in no particular order: Dr. Soheil Boroushaki, Dr. Richard Taketa, Dr. Sean Watts, Marsha Habib, Dr. Regan Maas, Dr. Yifei Sun, Dr. Ron Davidson, Dr. Iris Stewart-Frey, Dr. Patrick Archie, Dr. Clara Nicholls and Dr. Michelle Bezanson. Lastly, I want to thank my parents for giving me many great opportunities to succeed.

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ABSTRACT

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This thesis sheds light on the potential that an area has in sourcing its food locally as well as why it should. The methods uncover a reality of the local food potential of the San Francisco Bay Area. An interaction between technology, modern lifestyles, changing values, and disregarding geographical relationships has led to food being sourced from across the globe. The analyses employed, reveal and describe the current local food potential by quantifying and showing the accessibility of consumers to food producers and food producers to consumers. Utilizing the well-documented Two Step Floating Catchment Area method, this thesis effectively demonstrates that spatial accessibility methodology can be applied to local foodshed analysis.

1. INTRODUCTION

This thesis argues for a paradigm shift in the way that communities are fed. There are fundamental problems with the contemporary food production system. At the pinnacle of these issues is the concept of commodity fetishism. This Marxian philosophy states that capitalistic society's producers of commodities remain, for the most part, invisible (Marx, 1867). When this happens, consumers only see the end product disregarding all the work and social relationships involved in creating it. This disconnection is evident in the contemporary food production system. Increasing distances and complex supply chains are separating the consumer from the food producer. The explicit consequences of this are land consolidation and animal densification.

The causes of this disconnect are time space compression, the modern lifestyle, and entrenched agro-economic relations. Time space compression is an accelerating process fueled by improving transportation technologies and logistics (Massey, 1994). Essentially, things are traveling far distances progressively faster and cheaper. The modern lifestyle creates significant time constraints which in turn require consumption patterns to be simple and time efficient. Lastly, entrenched agro-economic relations have led to dominant agribusiness firms controlling a majority of food science, production, processing, distribution and sales.

This research contributes to the sustainable food and environmental literature by integrating geographical concepts and theories. Policy makers, food producers, chefs and home chefs would be most interested in this research. These groups display high affinity towards fresh high quality food. Also, ABAG or the Association of Bay Area Governments may discover applicable value in these findings. In two separate studies, it is made very clear that taste and freshness are the most important characteristic consumers look for in food purchasing (Zepeda and Li, 2004; Curtis and Cowee, 2009). Purchasing local food innately gives one the best chance at acquiring food displaying these qualities. This thesis will point out important cogs necessary for more locally resilient food systems.

Today, most food is treated as a commodity. This means it is sold in the marketplace and typically travels long distances. Presently, the food marketplace is the entire globe. Even with the incredible advancement in communication and transportation technologies once food is transported a certain distance, from where it was produced, it no longer can be considered local. The local marketplace is the only arena where local food can be traded. Intrinsically, this transfer between producer and consumer will be on a more personal level. Community Supported Agriculture or CSA is in essence the decommodification of food because an individual purchases a 'share' of a farm that they receive on a schedule (Hinrichs, 2000). The classic argument for a more sustainable food system is a curbing of environmental impact. This thesis argues that understanding the spatial make up of food producers in relation to the population they serve may potentially alter the current societal trend of food commodity fetishism.

2. LITERATURE REVIEW

The rationale behind a transition to a more locally resilient food system cannot be understood without proper contextualization. It is more than the individual concepts of the foodshed, territoriality, place, local food and spatial accessibility; it is a synergy. These concepts will be synthesized into a cohesive strategy in order to address weaknesses in the sustainable food literature. This literature review will weave together the concepts of the foodshed, territoriality, place, local food and spatial accessibility; and it will conclude with four past local food studies.

The following page displays an illustration of New York City's foodshed in 1925. It was first provided by Walter P. Hedden, Port of New York Authority, papers on marketing within the port of New York District; there will be more on Hedden later. The picture was taken from the article: Feeding the City authored by Gregory Donofrio (2007). This was the reality in 1925; it is 2014.

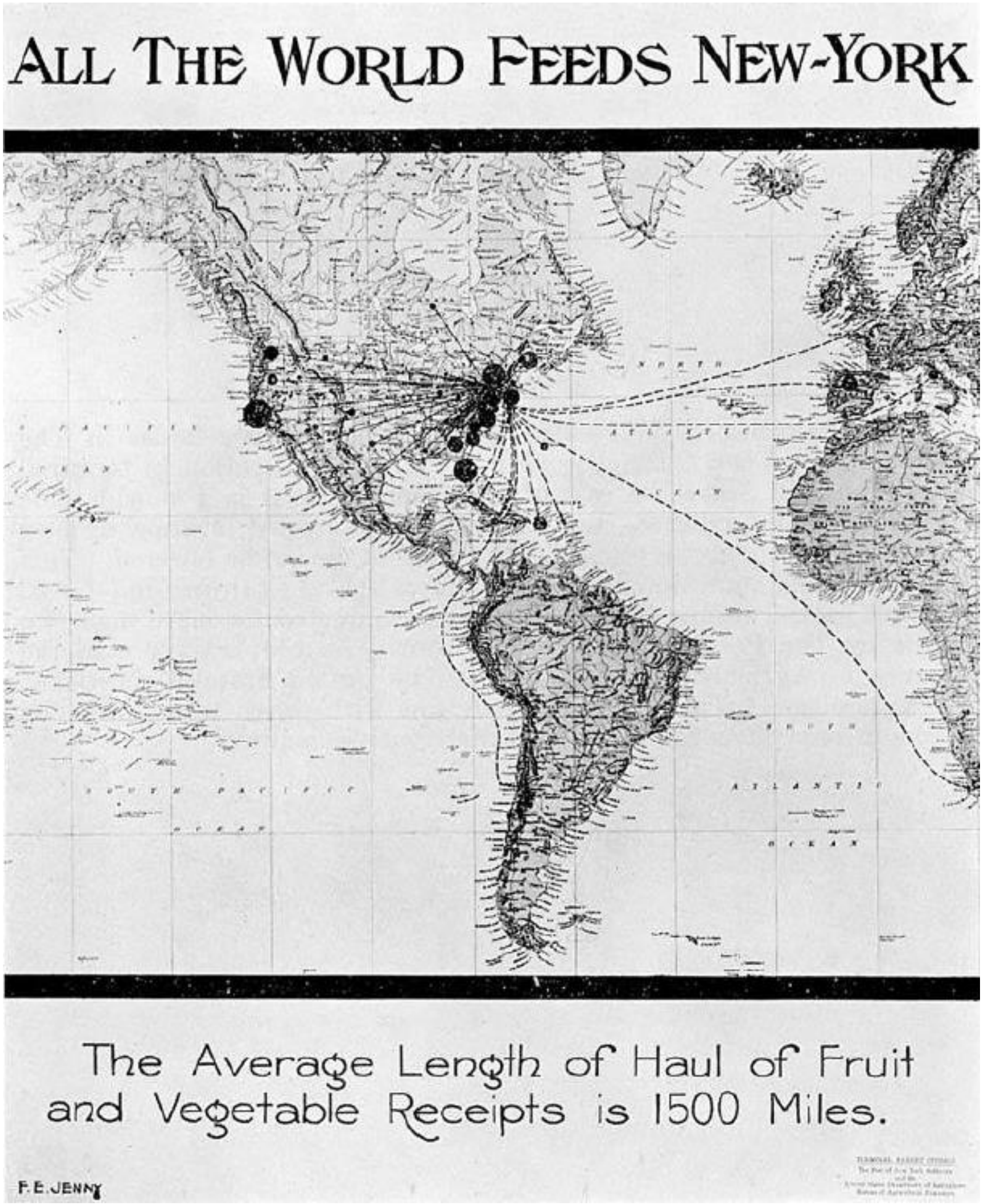


Figure 2.1: A 1925 Illustration of New York City's Global Food Sourcing

2.1 What is the Foodshed?

The Foodshed has always and will always exist. It is the area that humans and their food production sources share. The foodshed is an analogue to the more commonly known term watershed. The main difference is that instead of water flowing, it is food flowing. In pre-agricultural times, this was the area that humans hunted and foraged. This is called Home Range (Dyson-Hudson and Smith, 1978). In contemporary times, the foodshed manifests into the entire globe due to sophisticated communication and transportation technologies. It is amazing, yet alarming, that this transition occurred.

The first evidence in the literature that humans must begin considering the ramifications of the expanding foodshed was in Walter Hedden's 1929 book, *How Great Cities are Fed*. This book was a response to the New York Railroad strike of 1925 that threatened the food supply of highly urbanized New York City. It is not an environmental manifesto like Rachel Carson's *Silent Spring* in 1962, but a pragmatic approach to analysis that allows important conjectures to be drawn. Hedden coined the term foodshed so this is a logical point to start this discussion. He was the chief of the Bureau of Commerce for the Port of New York Authority, making him a genuine expert in the flow of food from producer to marketplace (Knapp, 1930). Hedden discusses many intricate details of innovative food transportation and preservation technologies including the refrigerated train car. These types of technologies allowed cities to source food from new areas and thus sustain increasingly larger and denser populations (Hedden, 1929). This book makes it clear that humans have been very focused on being able to feed large populations for a significant amount of time. Modern society is reaping the benefits of years of technological and infrastructure advancements that led to a vast and reliable, insofar as punctual, food supply. However is it sustainable?

The concept of the Foodshed lay dormant until it was revisited in Arthur Getz's 1989 paper "Urban Foodsheds". Getz employs the concept of foodshed because as with the watershed it implies something that must be protected (Getz, 1989). Similar to Hedden, Getz vividly illustrates that food is sourced from the entirety of the globe.

> "…our most rudimentary map of a foodshed might cover the globe, or resemble an octopus with long tentacles extending out from a large urban supermarket to remote tropical plantations, vast Midwestern grain acreage, and California irrigated valleys of fruits and vegetables." (Getz, 1989).

This imagery is very powerful and is quite accurate. However, the global food production system is very complex with many different processing and distribution steps. Complete knowledge of this system will most likely never be fully understood. Also, Getz alludes to a new breed of farmer that is environmentally conscious and is finding a niche, the urban marketplace, by intensively farming smaller pieces of land (Getz, 1989). The success of this new breed of farmer will most definitely play a role in the localization of food. Getz's article serves as an informational piece leading the reader to wonder how to positively impact the snowballing global foodshed.

It was not until Jack Kloppenburg Jr.'s 1996 article, "Coming into the Foodshed", that a strategy for strengthening local food resiliency, through 'foodshed work' was articulated. There are a plethora of ideas that the author illuminates as potential avenues for positively affecting the global foodshed.

Becoming native to a place is the idea that people have the potential to engage with their locality in a meaningful manner. To become native to a place involves one finding place within that space such as participating in civic agriculture. The concept of distancing is discussed as a primary reason for the consumer disconnect from the land. This idea is intuitive to understand because it witnessed on a daily basis. By living in dense expanding urban environments, the space for farmland gets pushed further and further away. However, this is only part of the story; our values have been significantly augmented as well.

Five principles are listed that exemplify "foodshed work". The first is that the foodshed fits into a 'Moral Economy'. This means that the current status quo of food production for profit needs to be replaced with food production to feed people. To the untrained mind, this appears to be highly socialistic. Does a policeman or doctor go into their profession in order to acquire vast wealth? Maybe some do, but many choose their occupation in order to uphold a set of values. Kloppenburg is alluding to the fact that food producers should be in their occupation in order to make their communities healthy. Secondly, the foodshed is a commensal community. The word commensal is very important when used in regards to human behavior because it suggests a level of benevolence towards each other and the land. Food producers as well as consumers are stewards of the land they occupy. Their choices have profound physical and social ramifications. Thirdly, there must be groups that oppose the transnational agribusinesses by acting sustainably. Seed savers and the ALBA farm school are examples of resistance towards the dominant agribusiness firms. Fourthly, proximity is a fundamental aspect to the foodshed, but the author states that boundaries are not definite. The foodshed should be self-reliant not necessary self-sufficient. This means that the foodshed relies on other places to a lesser degree, but acknowledges the value of external trade relations. A balance between past lessons and modernity is needed. Lastly, humans dominate nature rather than work with it. By working with nature, humans "may begin to produce and eat in harmony with and within the rhythms and patterns of the places in which we live." (Kloppenburg, 1996). In order for foodshed work to take place, one must understand his or her own local foodshed.

2.2 Territoriality's role in creating a foodshed

Capitalism operates at a global scale. However, in so doing it conflicts with the necessity for creating territories at various scales. Humans create geographical boundaries for numerous reasons. For example, human created boundaries include: nation, state, region, county, water district, metropolitan areas, city or town, zip code, congressional district, school district, neighborhood, statistical areas, parcel, and finally the fence around the home. Each boundary serves a specific purpose in order to facilitate a complex society. A shift has taken place that in western culture simply living within a certain area allows one to be a member of that community (Sack, 1989). Traditional or primitive communities were smaller that allowed members to become familiar with each other without the need for a territory (Sack, 1989). This societal mindset is a major factor in the logic behind localizing foodsheds. Delineating the foodshed connects the producer to the consumer by making the shared space overtly conspicuous. Much like the way regionalism fuels support of sports teams. Thus, the two groups are part of the same food production community or foodshed.

Territoriality facilitates social relationships. Food producers ought to feel a responsibility to those they share a community with. And the consumers ought to reciprocate this relationship. It is made abundantly clear through numerous studies that there are many local food definitions. Keep this in mind as this thesis progresses. This lack of consensus is problematic because it keeps this relationship, for the most part, an impersonal business relationship. Capitalism helps us see the earth's surface as a spatial framework where events are contingently and temporally located (Sack, 1989). Sack's interpretation of capitalism illuminates the cold reality of the way resources are transported. What is missing is the social relationship. Building community resiliency and cohesion, through defining the shared space of consumers and producers, is an important first step.

2.3 Finding place through territoriality

It is human nature to have a sense of ownership of the areas that one inhabits. It is fair to say that events that take place increasingly further away experience decreasing acknowledgment. This dichotomy is deeply ingrained in the human psyche. Because of this, two behavioral poles emerge regarding the way in which humans act upon the Earth: Dominance or Symbiosis. An example of dominance is clear cutting the rainforest in order to create a soybean monoculture. A simple example of symbiosis is recycling. The fundamental difference is that dominance disregards everything besides the end goal, while symbiosis acknowledges the steps in between. Agriculture is a significant transformative force that is also uniquely human. Obviously, due to the plethora of sustainable food literature, humans are acknowledging this fact. However, in this literature the concept of place is underutilized when it is at the core of this issue.

The foodshed is an example of ‘Existential Space’. It is an integral aspect of how a group internalizes a given area. E. Relph discusses this concept in his book *Place and Placelessness*. It is the way that the whole, not the individual parts, perceive a space. It is only meaningful within one group. A foodshed area only has meaning to those that reside inside of it.

A foodshed and a community would reinforce the identity of each other (Relph, 1976). Kloppenburg suggested that the individual becomes native to a place by engaging with it (Kloppenburg, 1996). This relationship between the land and those that shape it, food producers, is a strong rationale for a sense of place.

2.4 Local Food

The problem is not that enough food is produced, but from where it is coming from. Relying on sophisticated life cycles of food production is entrenching detrimental environmental and social practices. During World War Two, nearly forty percent of domestic produce was grown in backyards; these production areas were justly labeled victory gardens for the role that they played in the war effort (Miller, 2003). Victory gardens are a testament to the human spirit, but something worthy of examination because only during explicitly extreme circumstances that something powerful and unprecedented occurred.

Another instance of a group coming together to produce food locally occurred when the Soviet Union collapsed in 1989. The island nation of Cuba suddenly stopped receiving agricultural support/technologies. In response, the Cuban people created a home grown food production system that is an isolated marvel of modern civilization

(Warwick, 2001). Civilization is currently in a grace period, which allows for a global scale food production system. It is unclear whether food production at this scale is sustainable. Three things need to occur during this grace period re-scaling, re-spacing, and re-connection (Kneafsey, 2010)

Re-scaling is the process of shrinking the global foodshed by sourcing food more locally. The marketplace is quite powerful insofar as being able to feed large populations (Peters, 2010). The sheer scale of the flow of food from producers to consumers across the world probably, if calculated, would be one of the most intensive operations on the planet. If food travels less miles, is less processed and is grown using agroecological methods, the impact on the planet is less severe or even harmonic. Coming back to the commodity fetishism concept, the global scale is accepted because the majority of modern civilization only cares about the end product.

Re-spacing simply means increasing the opportunities of encountering something either by increasing the amount in space and or strategic placement. Modern life creates time constraints that make utilizing alternative food outlets (farmers markets, farm stores) difficult (Kneafsey, 2010). Re-spacing by promoting local food would create more opportunities and locations for individuals to transition to a more local palate. The Community Supported Agriculture (CSA) concept alleviates these time constraints because the consumer and the producer enter a contract that specifies home delivery or an agreed upon pick up location.

This brings this discussion to a very important point, re-connection. This refers to three relationships: consumer-producer, producer-producer, and producer-land relationship.

The principal example, of re-connection, occurred in Japan during the 1970s. Groups of Japanese women, primarily from large conurbations (Tokyo, Osaka, Kyoto), became concerned over food safety and nutrition of food produced in Japan's industrialized agricultural system (Parker, 2005) These groups then approached farmers that they trusted and paid them up front for the entire growing season. The rules were simple: whatever was grown the women accepted. Obviously, the women would not continue working with the farmers for the next growing season if there was not mutual trust. The women ceased existing as consumers because they were able have input into what was grown for them. This relationship is called Teikei pronounced 'Tay Kay', roughly translated to 'food with the farmers face on it'. This is the origin of the CSA co-partnership mentioned earlier. The difference is that the consumer approached the producer. In both cases food ceases to be a commodity because the consumer buys a portion of whatever is produced or a share of the farm. This is the extreme example of knowing what has gone into producing one's food. On the opposite extreme is highly processed food that would be very difficult to conduct life cycle analyses.

The way in which agricultural research is performed disconnects humans from organisms (produce, livestock) and prevents a 'holistic understanding of ecological systems' from taking place (Kloppenbug, 1991). Traditional or rather local knowledge is either lost or not created because it does not fit what is considered modern agricultural science. Farmers are sophisticated knowledge producers in their own right (Kloppenbug, 1991). Not only can farmers learn from each other, they can collaborate in order to be more successful in the local marketplace. At the very least, securing a transportation cost advantage results in a higher percentage of the wholesale price securable for food producers (Hedden, 1929). Collaboration is a multi-faceted act that can have a profound impact on all parties involved.

2.5 Spatial Accessibility

Spatial Accessibility is group of analyses that exist in order to facilitate representation and or justice in space. It is typically a health geography topic. However, these types of methods can be employed to display local food accessibility due to the flexibility of these analyses. Examples of spatial accessibility research include: primary care physicians, supermarkets, urban amenities, railroads, open space, retail establishments, etc. For this thesis, it is important to implement a methodology that takes into account both the farmer's and consumer's primary transportation challenge: automobile travel time.

Remember, the foodshed is an analogue to the watershed; in this case it is food flowing not water. Catchment area is a concept that is highly connected to the watershed concept and, interestingly, it is also applied to spatial accessibility. A water catchment is defined as: "the drainage area that contributes water to a particular point along a channel network (or a depression), based on its surface topography. The catchment forms a landscape element (at various scales) that integrates all aspects of the hydrologic cycle within a defined area that can be studied, quantified, and acted upon." (Wagener, 2004). A spatial accessibility catchment is defined as: "the geographical area delineated around an institution or business that describes the population that utilizes its services. Normally catchments divide geographic space into contiguous regions, but in some contexts, they can overlap to reflect competition within an area between service providers." (Birkin, 2005).

A staple method for analyzing spatial accessibility is the Two Step Floating Catchment Area Method or 2SFCA, first proposed by Radke and Mu (2000). It is a computation that spatially analyzes and displays a facility to population or population to facility ratio. The ratio is attached to a certain area, like a census tract, that can be visualized, quantified, and or used as a variable in statistical analyses. The facility locations can be substituted for farm locations. The 2SFCA method is a robust way to measure spatial accessibility because it utilizes a street network rather than Euclidian distance. In contemporary society, things move via roads.

One vital aspect yet to be explored in sustainable food research is the interaction that food producers and consumers share in a given area. This is important for the understanding of both the consumer and producer because the areas of lowest local food accessibility require the greatest amount of effort for both parties to come in contact. This specific type of analysis displays the reality of both parties; it is a way for the two sides to show where they stand together. By connecting the consumer to producer ratio to other data such as demographic and socioeconomic, robust statistical analyses can be employed.

2.6 Foodshed Research

A myriad of local food systems' studies have been conducted in the last 20 years. The vernacular of many of these articles includes the concept of the foodshed that this thesis is focused. Consistently, two aspects are explored: where food is produced and where it is consumed. I will mention four studies here to demonstrate the different approaches and highlight aspects that will shape this thesis.

Firstly, Peters et al (2009) quantified the amount of food produced and consumed in the state of New York. It examined soil data, land cover data, urban areas data, population data, and utilized a diet sub-model (Peters et al, 2009). This study literally calculated the amount of calories produced and the amount consumed in the state of New York, as well as where the calories came from. A clear take away was that New York City is an incredible consumptive force that makes it impossible for New York State to source its food from within (Peters, 2009).

Secondly, “Local food practices and growing potential: Mapping the Case of Philadelphia” by Peleg Kremer and Tracy L. DeLiberty. This article demonstrates a methodology for analyzing farms and their markets within Philadelphia. It required farm location data and the corresponding outlet or market within Philadelphia. All of the farms that bring food into Philadelphia were utilized in this analysis. The two authors created a farmers’ market food shed that encompassed only the space that the farms and markets shared and no more. This article makes it clear that what is considered local for one place, in this case Philadelphia, will be different from another place. Also, this study demonstrated that Euclidean distance or “as the crow flies” is a poor representation for promoting local food.

Thirdly, “Place, taste, or face-to-face? Understanding producer-consumer networks in “local” food systems in Washington State’” by Theresa Selfa and Joan Qazi.

This study is particularly valuable because it demonstrates regional variability of what consumers and producers consider local. The authors conducted three case studies of three different counties in Washington State. They conducted interviews with the agro-food network actors in each county, a survey of every producer in the state and a 950 person consumer survey in the case study counties. Depending on the area, the definition of local changed drastically. The two rural counties were more export oriented, while the urban county was more import oriented. This research challenges how one conceptualizes and draws boundaries around local, sustainable, and or alternative food systems (Selfa and Qazi, 2004).

Lastly, in 2007 the Farmland Trust conducted a foodshed assessment of San Francisco and surrounding Bay Area. Much like the New York study, this assessment quantified how much food is produced within one hundred miles of San Francisco and how much is consumed. This assessment is very valuable because it demonstrates that the Bay Area region has significant potential for creating a more resilient and more locally based food system. What is not known from this study is how much consumption is due to local food producers within the area (Farmland, 2007).

These four studies provide sophistication for this thesis by shaping the direction of the analysis by integrating population size, roads and scale into a logical study area.

3. RESEARCH QUESTIONS

In order to rescale the foodshed, the way in which the local foodsheds make up the regional foodshed is important to understand. Kremer and DeLiberty define local as where one single place (population center) sources its food (Kremer and DeLiberty, 2010). This analysis demonstrates the reality that consumers and producers face regarding accessibility to one another in the San Francisco Bay Area; not just a single place. The San Francisco Bay Area is used because it already has been shown to be able to source most of its food within 100 miles (Farmland, 2007). It also contains a very progressive population open to change. For example, the Locavore lifestyle was originated in the San Francisco Bay Area. This entails making a concerted effort to eat as locally as possible. These three factors are the reasons that San Francisco Bay Area is used in this thesis. Below are three questions that will be examined:

1. What areas display the greatest accessibility for food producers to the Bay Area population within the study area? What areas display the least?
2. What areas have the highest and lowest population to food producer ratio?
3. What accessibility patterns emerge for both the consumer and for the producer?

4. DATA AND METHODOLOGY

4.1 Food Producer Data

The locations of California farms were acquired from USDA certified organic database 2013, Localharvest.org, and CAFF.org (California Alliance of Family Farmers). These three data sources were combined into one location point feature class. The locational data was geocoded using ESRI's ArcGIS 10.1 geocoding tools as well as the geocoder service provided by gpsvisualizer.com. Regarding producers that only provided their mailing address, the Feature to Point tool was used to create an approximation centroid point of the zip code the producer resides in (Kremer and DeLiberty, 2010).

Farms that have acquired pesticide spraying permits from their county agricultural commissioner were not used in this analysis. The reason was a severe lack in uniformity between the ways in which counties maintain data. Some counties keep records for every single field that is sprayed while others keep records of nonagricultural land sprayed for pest control purposes. The data criteria for this analysis were location and food production. This analysis used the locational data of all USDA certified food producers and a thoroughly compiled list of sustainable food producers. In the end, 2,027 food producers were used in this study, ranging from mixed vegetable production to grass-fed beef.

4.2 Census Data

The study area is the nine Bay Area Counties displayed in Map 5.1. This geospatial boundary data is provided from the U.S. Census. In order to create an accurate coastline, these counties were clipped using the California coastline shapefile provided by

Cal Atlas. Peters (2009) used census Urbanized Areas and Urban Clusters (UAUC) as the individual population centers, however, this analysis utilized census tracts. The rational for this choice is increased spatial resolution because there are significantly more census tracts than UAUC polygons allowing for more centroids to be derived. Also, census zipcode shapefile was used in order to analyze and display the food producer accessibility to the bay area.

4.3 Network Data

To reiterate, it is safe to assume that local food travels via roads. In order to bring that aspect into this analysis, a street network was created. This network dataset of California was provided by NAVTEQ. Utilizing the speed limit attribute field, a given network street segment's time of travel was derived. For each census tract, a ninety minute service area polygon was created using ESRI's ArcGIS 10.1 Service Area Network Analyst extension tool. Network Analyst is based off of the classic Dijkstra's algorithm. This algorithm finds the shortest path along a set of edges (street segments) and junctions (intersections). "The polygons are generated by putting the geometry of the lines traversed by the Service Area solver into a triangulated irregular network (TIN) data structure." (ESRI, 2014).The Service Area solver allows break values to be inputted in order to control the size of the areas created. An area will be carved out up until the specified break value. This process is a better representation of how things are transported in modern society. The more basic alternative would be to create a simple Euclidean distance buffer that disregards barriers such as water bodies, extreme terrain and other non-traversable barriers.

4.3 Two Step Floating Catchment Area Analysis

Service areas of ninety minutes were created for census tract centroids within the nine bay area counties. Next, the food producer locations were spatially joined and summed for each service area. Each census tract was given a new attribute value of total population divided by number of food producers within its ninety minute service area. This process represents a one-step floating catchment area expressed by the following equation.

Step 1:

$$R_j = \frac{S_j}{\sum_{k \in \{d_{kj} \in D_r\}} P_k W_r}$$

R_j is the ratio of population of a census tract S_j divided by the sum of farms for a ninety minute service area for that census tract centroid and j is the area within 90 minutes of a census tract centroid. Search all farm locations (k) that are within the 90 minute service area.

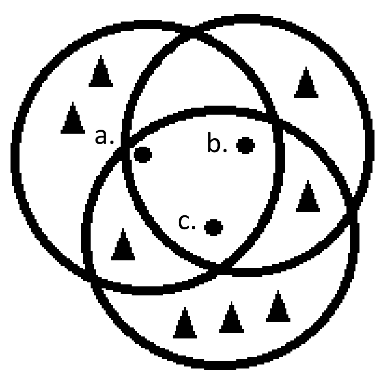


Figure 4.1: Illustration of the One Step Float Catchment Area Method

The Illustration depicted by Figure 4.1 shows an example One Step Floating Catchment Area Method analysis using census tract centroids points (a,b,c). Around each centroid point there is a simplified Euclidean service area. The triangles represent farm locations. Centroid **a.** has three farms within its service area. Centroid **b.** has two farms within its service area. Centroid **c.** has five farms within its service area. The ratio $R_j$is then is simply the population of the census tract divided by the number of farms within its service area. For this simplified example each census tract centroid has a population of one. Centroid **c.** has the largest population to farm ratio while centroid **b.** has the smallest.

In order to become a two-step floating catchment area, a ninety minute service area is created for all of the food producers used in the first step. Then the census tract centroids containing the population to food producer ratio attribute were spatially joined and summed to each food producers' service area.

Step 2:

$$A_i^F = \sum_{k \in \{d_{ij} \in D_r\}} R_k W_r$$

A_i^F is the sum of the census tract centroids population to food producer ratio within a given food producer service area.

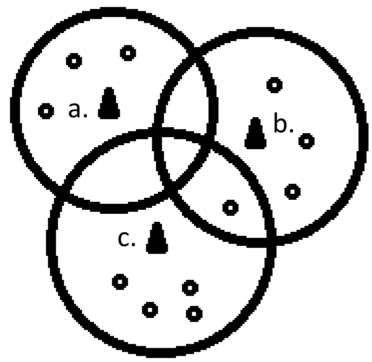


Figure 4.2: Illustration of the Two Step Float Catchment Area Method

The illustration of the second step depicted by Figure 4.2 displays the service areas created around the farm locations denoted as triangles. The points are the census tract centroids with population to food producer ratio R_j that was previously calculated in the one step floating catchment area method. For this example, each centroid has an equal population to farm ratio of one. The value generated from the summed population to farm ratio is the accessibility score of each individual food producer. The resulting accessibility score for farm locations **a.**, **b.** and **c.** are 3, 4 and 5.

4.5 Statistical Analyses

Using IBM's SPSS software package, a number of statistical tests were used to enrich the interpretation of the results. Descriptive statistics of Percent White, Black, Asian, Hispanic and Median Household Income and Percent Median Household Income at the census tract level were first created. An independent sample t-test was employed in order to detect whether a statistical difference exists within different demographic variables using the median as the cut point. The independent variable that all variables are compared to is the population to food producer ratio. A simple Pearson's Correlation was performed to show the relationship between the population to food producer ratio and the demographic variables.

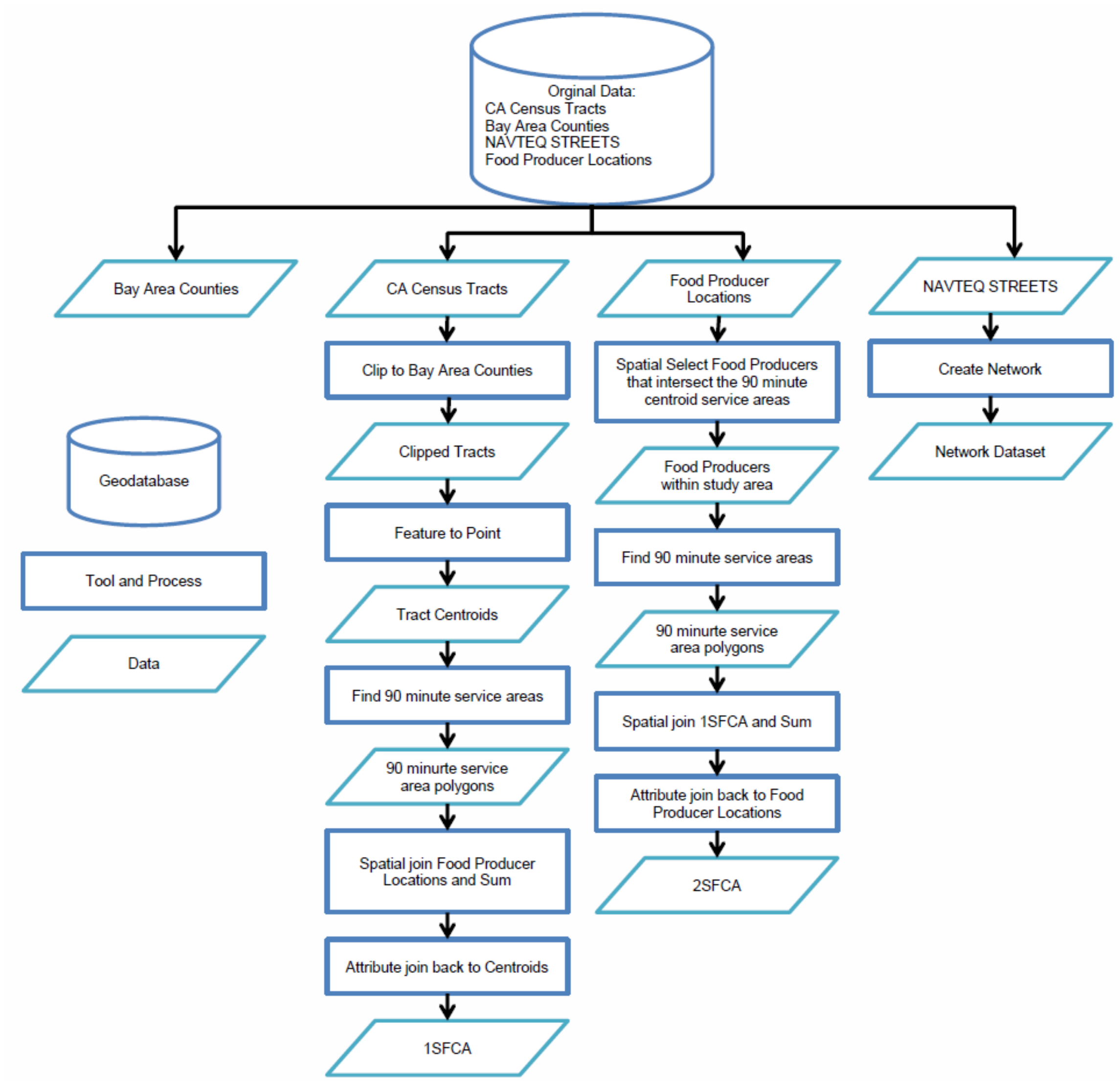


Figure 4.3: Flowchart of the complete 2SFCA method

5. RESULTS

5.1 One Step Floating Catchment Area Analysis

The first finding of this analysis was the creation of the first step of the two step floating catchment area method. The first step or 1SFCA method was created using 1,578 census tract centroids created from the census tract polygons of the bay area counties.

Figure 5.1 displays descriptive statistics of the demographic variables for the 1,578 census tracts along with the population to farm ratio created in the first step of the 2SFCA method. The population to farm ratio is interpreted as total population per farm within the 90 minute census tract centroid service area. Additionally, the remaining variables display the demographic descriptive statistics for these census tracts. The average number of residents per farm, for all census tracts, is 4.29. The average Median Household Income is $82,945. The average percentage of White residents in census tracts is 53%. The average percentage of Black residents is 7%. The average percentage of Asian residents is 22%. The average percentage of Hispanic residents is 22%.

Variables	Mean	Median	Std. Deviation	Min.	Max.
Population to Farm Ratio	4.29	3.97	1.91	0.01	13.63
Percent White	53.40	53.42	21.96	4.66	95.34
Percent Black	7.17	2.88	10.32	0.08	67.32
Percent Asian	22.49	16.23	18.68	0.00	89.85
Percent Hispanic	22.54	17.64	17.38	1.19	90.45
Median Household Income ($)	82945.41	77944.17	34200.97	0.00	250001.00

Figure 5.1: Descriptive Statistics of variables used in analysis

Figure 5.2 displays an independent t-test using the median as the mid-point in order to determine if a statistical difference between groups (census tracts) above or below the median exists. The grouping variable is the population to farm ratio. Percent

Black is significant ($p < 0.000$); this t-test shows that below the median percent Black for census tracts have 4.65 persons to a farm and for above the median have 3.93 persons to a farm. Percent Hispanic is also significant ($p < 0.000$), where low percent Hispanic census tracts have 4.01 persons to a farm and above the median tracts have 4.57 persons to a farm. Percent Asian and White are not significant for this test. Lastly, median household income is significant ($p < 0.000$), where low income census tracts have 4.12 persons to a farm and high income tracts have 4.46 persons to a farm.

	Average Below Mid-Point	Average Above Mid-Point	T-Statistic	Sig.
Percent White	4.25	4.33	0.807	0.420
Percent Black	4.65	3.93	-7.634	0.000***
Percent Asian	4.3	4.28	-0.281	0.779
Percent Hispanic	4.01	4.57	5.862	0.000***
Median HH Income	4.12	4.46	3.615	0.000***

Figure 5.2: t-Test of variables with the Population to Farm ratio as the grouping variable

Figure 5.3 displays a bivariate Pearson correlation of the population to farm ratio and the demographic variables. Percent White is shown to have a 0.054 positive significant correlation ($p < 0.05$). In detail, for every increase of one person to a farm the percentage of White residents increases by 0.054 percent. Percent Black is shown to have a 0.249 negative significant correlation ($p < 0.01$). For every decrease of one person to a farm the percentage of Black residents increases by 0.249 percent. Percent Hispanic is shown to have a 0.128 positive significant correlation with a ($p < 0.01$). For every increase of one person to a farm the percentage of Hispanic residents increases by 0.128 percent. The relationship between population to farm ratio and Percent Asian is not significant. Percent Median Household Income is shown to have a 0.104 positive significant correlation ($p < 0.01$). For every one person increase to the population to farm ratio percent median household income increases by 0.104 percent. This is an increase of 0.104 percent of the total median household income of the entire bay area census tracts.

Population to Farm Ratio	Pearson Correlation	1	
	Sig. (2-tailed)		
	N		1578
Percent White	Pearson Correlation	.054*	
	Sig. (2-tailed)		0.032
	N		1578
Percent Black	Pearson Correlation	-.249**	
	Sig. (2-tailed)		0.000
	N		1578
Percent Asian	Pearson Correlation	0.027	
	Sig. (2-tailed)		0.282
	N		1578
Percent Hispanic	Pearson Correlation	.128**	
	Sig. (2-tailed)		0.000
	N		1578
Percent Median Household Income	Pearson Correlation	.104**	
	Sig. (2-tailed)		0.000
	N		1578

Figure 5.3: Bivariate Pearson Correlation for the Population to Farm Ratio and variables

* Correlation is significant at the 0.05 level (2-tailed)
** Correlation is significant at the 0.01 level (2-tailed)

Map 5.3 displays the census tract centroids joined to their corresponding ninety minute catchment symbolized by a star representing the 250 highest food producer counts and a triangle representing the 250 lowest producer counts. The highest counts are concentrated in the East Bay counties of Alameda and Contra Costa. The lowest counts are primarily located in the North and South Bay.

Map 5.4 is the map of the population to farm ratio attribute joined from the census tract centroids to the census tract polygons. They are classified into five classes using the quantile classification method. This method creates equal amounts of observations within each value range for each class. The darker the polygon, the lower the population to farm ratio the census tract has. The lowest population to farm ratio can be observed in Napa, Marin, and areas nearest to the bay in Alameda and Contra Costa Counties. Having a low population to farm ratio means less people to a farm. To reiterate what the population to farm ratio is, if there is a census tract with 1000 residents and there are 100 farms within its centroids ninety minute services area the population to farm ratio is 10 to 1.

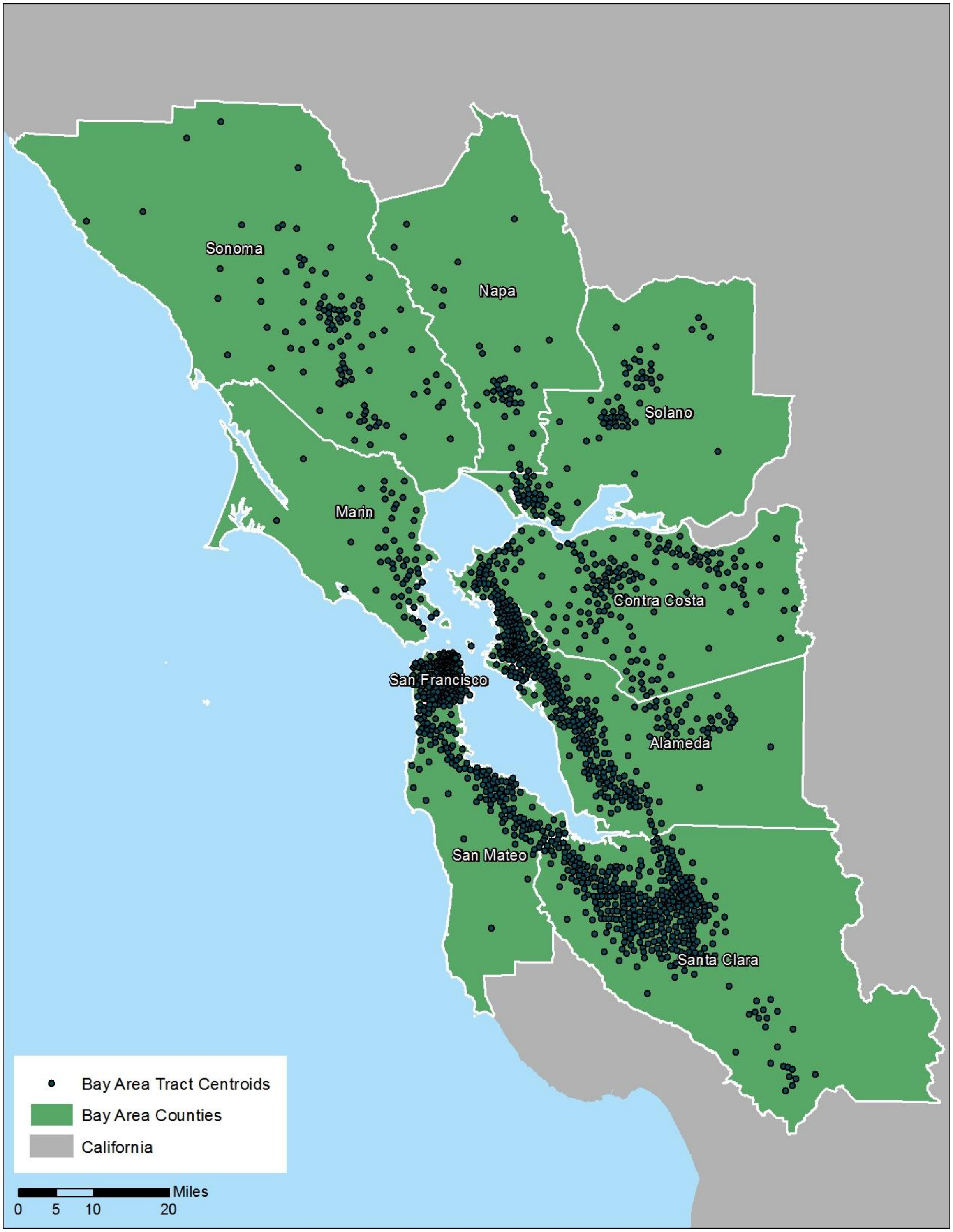
5.2 Two Step Floating Catchment Area Analysis 2SFCA

Maps 5.5 through 5.8 are used visualize the results of the 2SFCA. The first two maps of this set simply show the locations and the density of farm locations used in this analysis. Map 5.5 displays the 2,027 locations of the farms used in this analysis. No farm is located more than ninety minutes away from the centroids of the nine bay counties. Map 5.6 displays a spatial join of farm location points to zipcode polygons. It is classified into a five class natural breaks classification in order to highlight the zipcodes with the highest food producer counts.

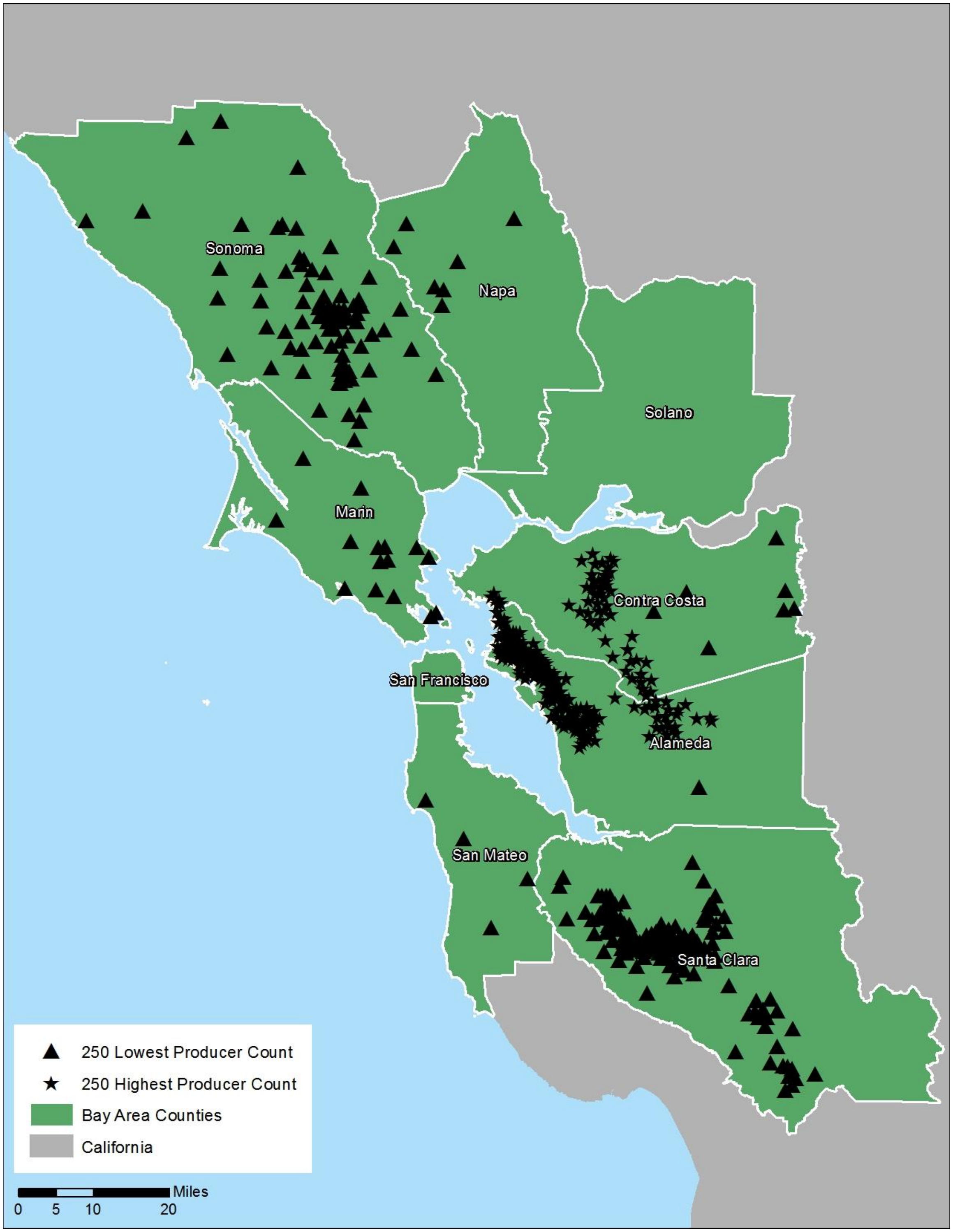
Map 5.7 is the map of the Accessibility Score calculated by spatially joining the census tract centroids to the farm service areas and summing the population to farm ratio and finally attribute joining back to the farm locations. These points were then spatially joined to a census zipcode feature class and summed. This was performed in order to use a very readable Choropleth map visualization technique. The alternative would be to have used graduated symbols technique which would symbolize every farm location point to a certain size based off of its accessibility score. The darker the zipcode polygon the lower the Accessibility Score for that zipcode is. This map is classified using a four class quantile classification. This classification method is defined by having equal amount of observations per class. The lowest accessibility scores which translate to less people per farm are located furthest away from the denser populations of the bay area.

Map 5.8 displays the Accessibility Score but classified using a six class standard deviation classification. The red through light orange categories represents positive standard deviations. The dark blue through yellow categories represents negative standard deviations. The darker the color the further the standard deviation of the accessibility score is from the mean score.

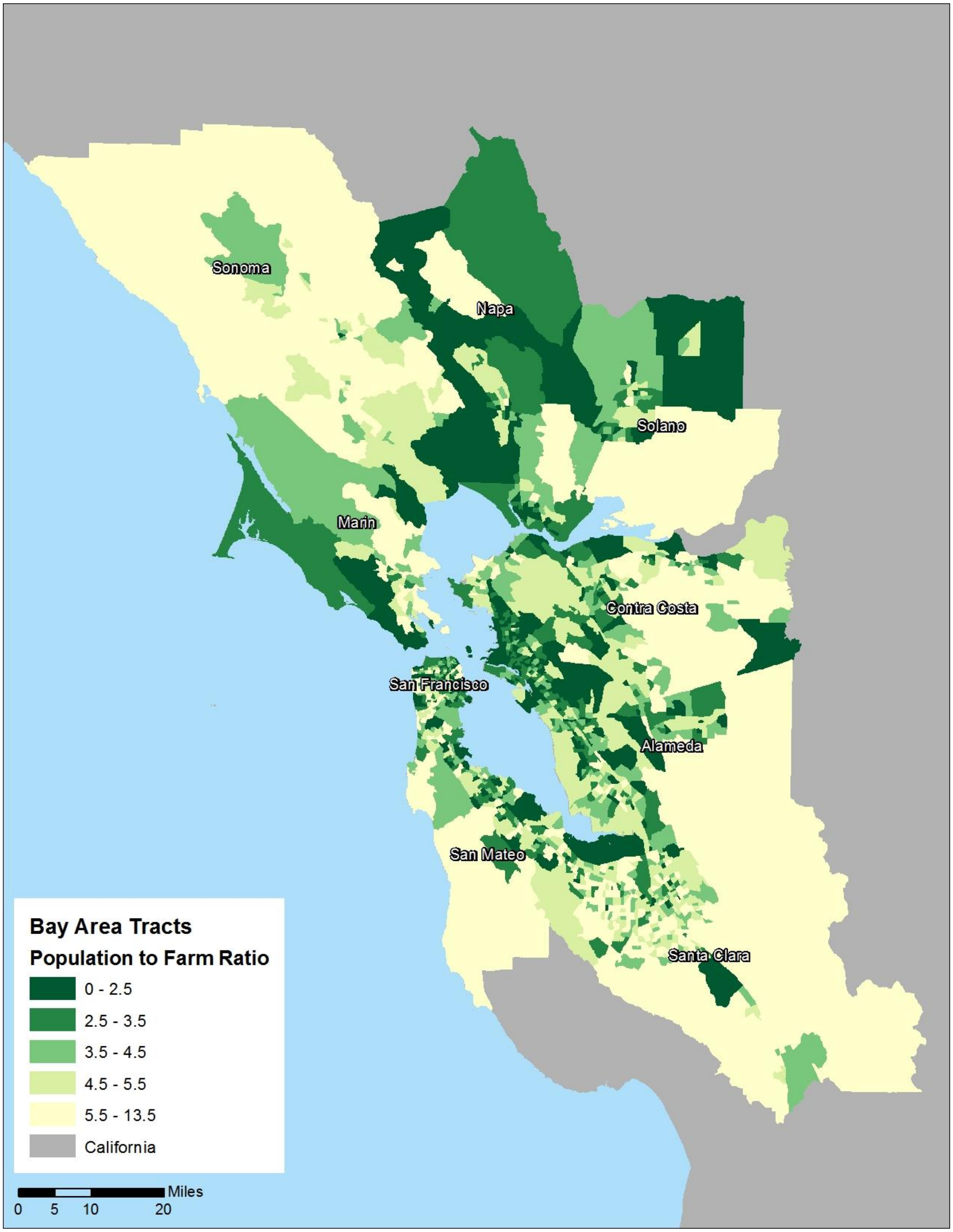
Map 5.1: The nine counties of the San Francisco Bay Area used as the study area



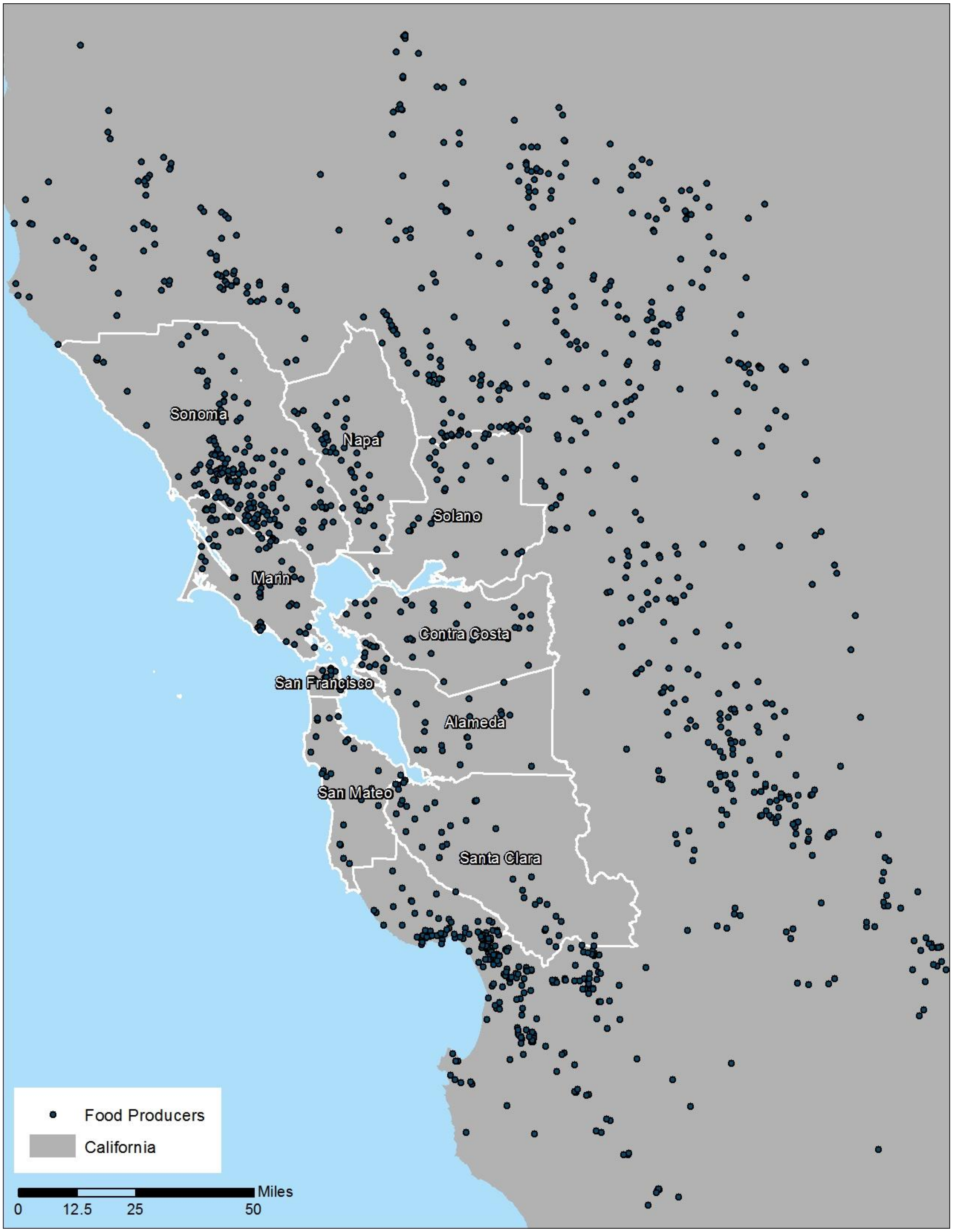
Map 5.2: Census Tract centroids within the study area



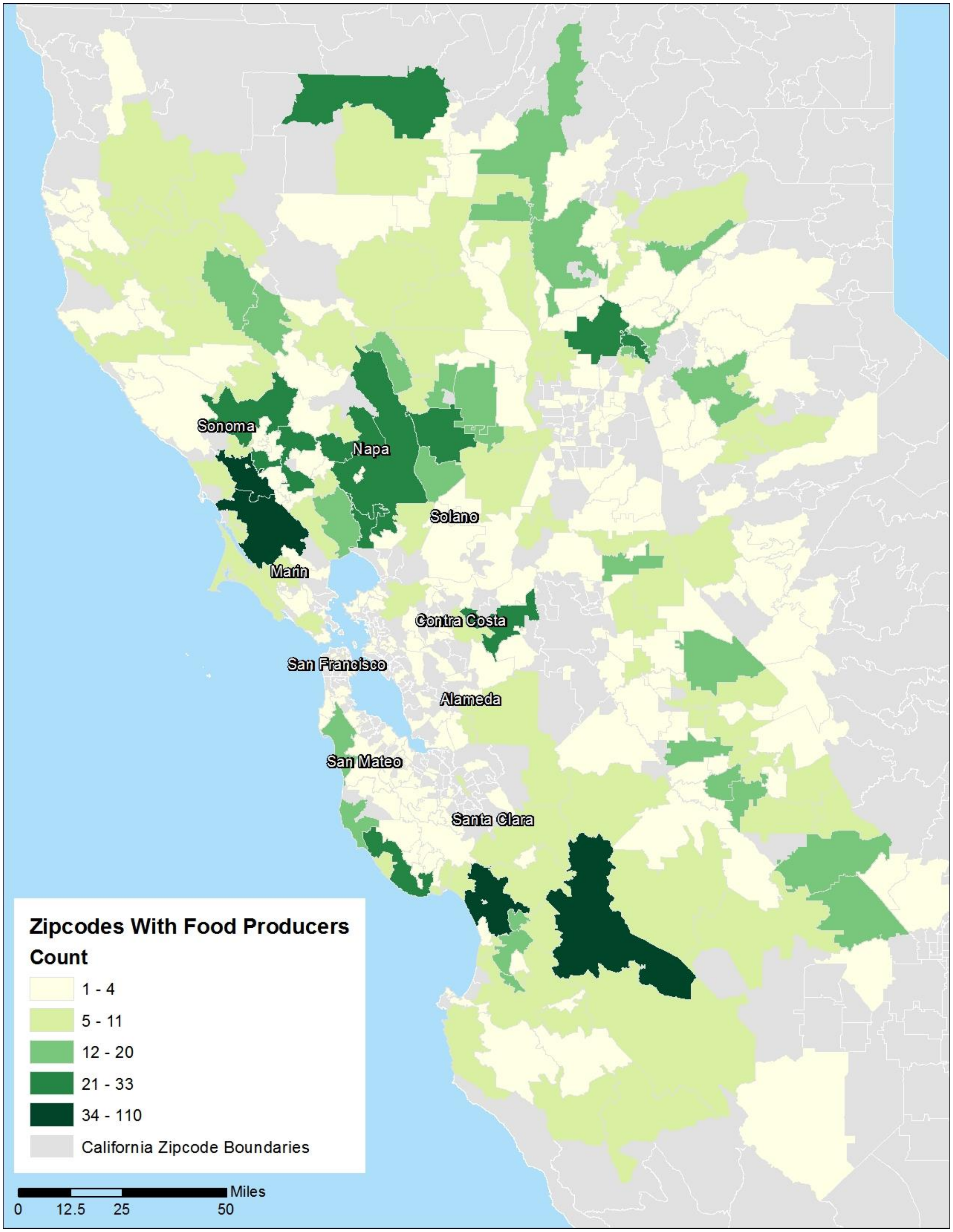
Map 5.3: The 250 lowest and highest producer counts within the 90 minute catchment of the census tract centroid



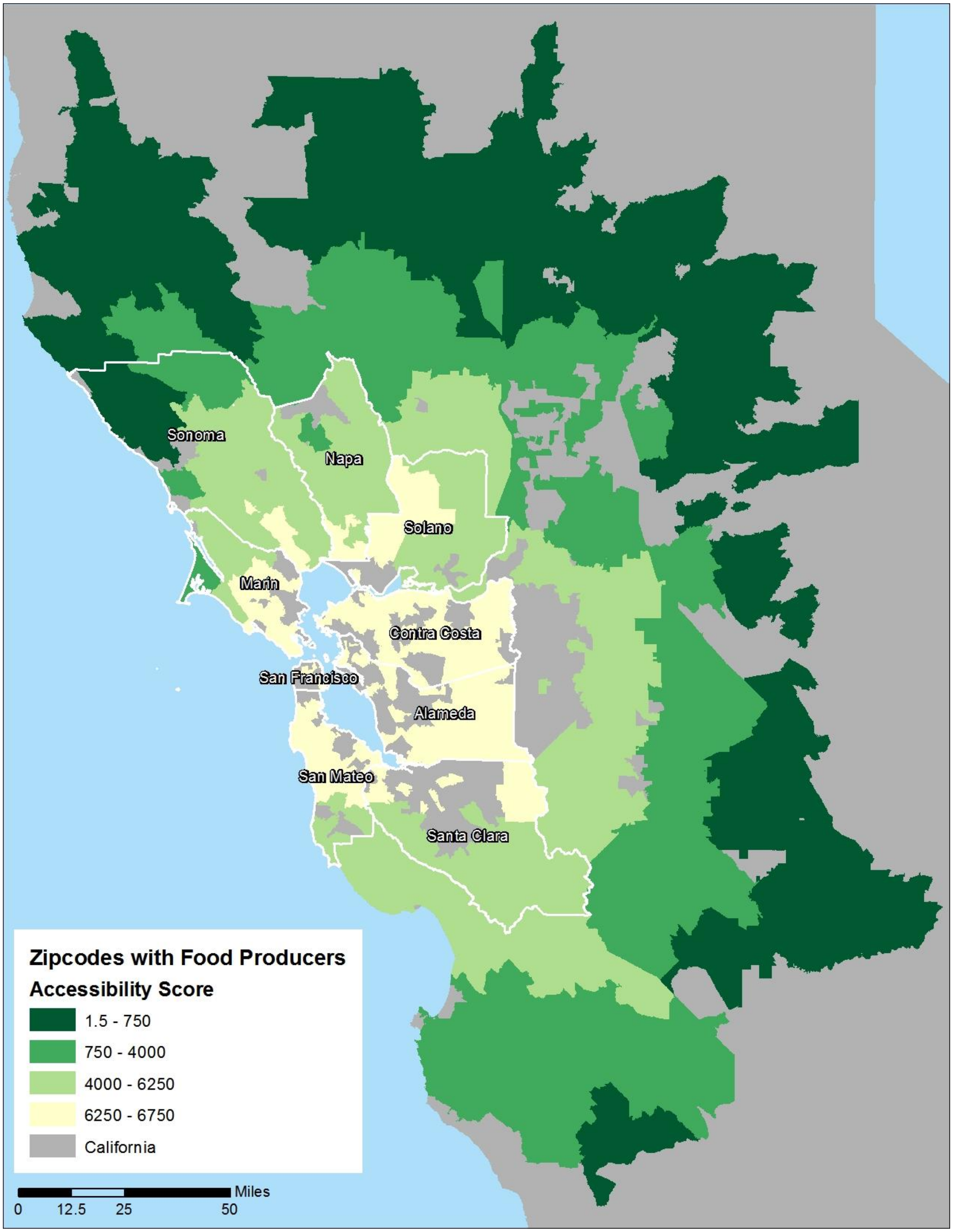
Map 5.4: Population to Farm Ratio visualized by census tract polygons



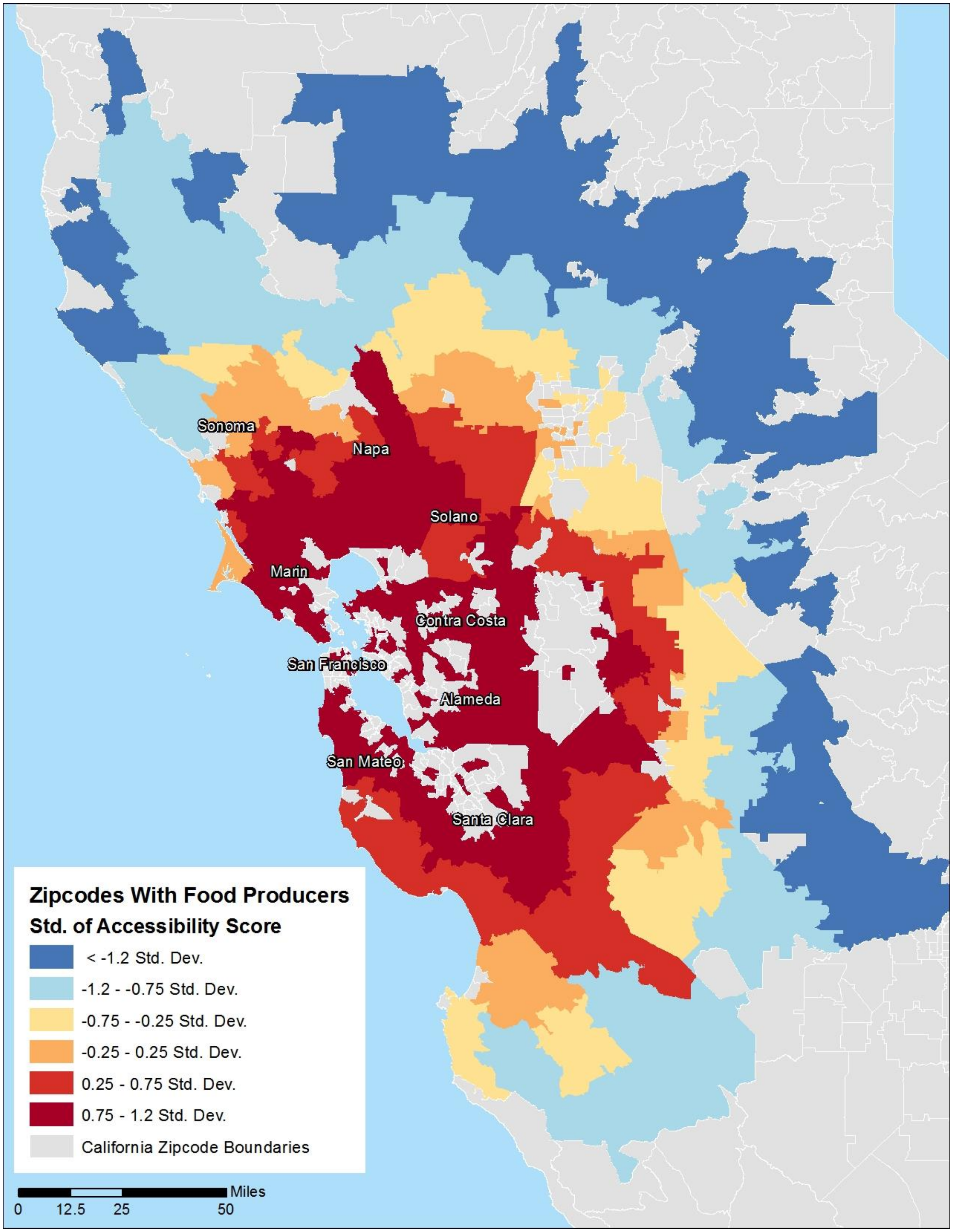
Map 5.5: Locations of Food Producers within 90 minutes of all census tract centroids in the study area



Map 5.6: Counts of food producers within a given zipcode



Map 5.7: Two Step Floating Catchment



Map 5.8: Accessibility score classified by standard deviations

6. DISCUSSION

Why is accessibility a valuable way to analyze a local foodshed? The bay area is densely populated and is surrounded by significant amount of farm land. Understanding where the greatest population pressure is being exerted, onto farmers, reveals the magnitude of demand and pressure placed upon food producers.

6.1 One Step Floating Catchment

The first step of the 2SFCA method demonstrates one side of the story, the consumer's perspective, of the food producers within ninety minutes of the centroid of the census tract that they reside in.

The percentage of Black residents in a census tract was shown to be a significant indicator of a difference between the amount of residents per farm. In this case, census tracts with lower percentages of Black residents had a higher population to farm ratio than tracts with a higher percent. This translates to the lower the percentage of Black residents in a tract the higher the amount of residents per farm. An explanation of this is black residents live in more accessible areas allowing for the greater use of major road systems. Also, they may live closer to higher concentration of food producers. Map 5.3 supports this assertion because the two hundred and fifty census tract centroids with highest farm counts within their service areas are located in Alameda and Contra Costa Counties. These counties are densely populated, nearest to the mean center of the entire bay area and have a higher percentage of Black residents than the other bay area counties. For the two hundred and fifty highest farm counts census tracts the mean Black resident count is 624. For the two hundred and fifty lowest the mean Black resident count is 95.

This is a very drastic difference that demonstrates, to a certain degree, the homogeneity of the bay area.

The percentage of Hispanic residents in a census tract was shown to be a significant indicator of a difference between the amount of residents per farm. Census tracts with lower percentages of Hispanic residents had a lower population to farm ratio than tracts with higher percentages. This finding shows that Hispanic residents may be living in less accessible areas and or further away from food producers. The distribution of Hispanic residents between census tracts is a factor to be considered. Again referring back to Map 5.3, for the two hundred and fifty highest farm counts census tracts the mean Hispanic resident count is 1,019. For the two hundred and fifty lowest the mean Hispanic resident count is 1,072. This difference is less drastic than the Black resident counts but is observable. What also must be taken into consideration are the percentages of the other races within these census tracts.

The Median Household Income of a census tract was also shown to be a significant indicator of a difference between the amount of residents per farm. Census tracts with higher Median Household Income had a higher population to farm ratio than tracts with lower income. For every 1000 residents in tracts above the median income, there are 224 farms but for every 1000 residents in tracts below the median income there are 242 farms. This is an 18 farm or 8% difference. An explanation for this is that higher income census tracts are located in more densely populated areas and or located further away from food producers and or located further away from major roads.

Figure 5.3 displays the results of a bivariate correlation using the population to food producer ratio variable in conjunction with percent White, percent Black, percent Asian, percent Hispanic and median household income. Correlation will not identify causal variables. However, it does show the relationship between the population to farm ratio and a given variable. Percent Asian was not found to have a significant correlation coefficient when compared to the population to food producer ratio. An explanation for this is that the Asian population of the bay area is grouped evenly throughout census tracts in areas with high population to farm ratios and areas of low population to farm ratios.

The first variable that displays significance is percent White of a census tract. The percentage of White residents in a given census tract is shown to have a positive significant relationship with its corresponding population to farm ratio. However, even though this result is statistically significant, in reality this variable does not show much of a relationship. Whether a census tract has a high or low percentage of white residents, this does not correspond to a high or low population to farm ratio.

The second variable that displays significance is percent Black of a census tract. The percentage of Black residents in a given census tract is shown to have a negative significant relationship with its corresponding population to farm ratio. This result supports the findings of Figure 5.2 and Map 5.3. In totality, a dramatic relationship is uncovered that sheds light onto the fabric of the bay area local foodshed. When the population to farm ratio decreases for a given census tract its corresponding percentage of Black residents increases.

The third variable that displays significance is percent Hispanic of a census tract. The percentage of Hispanic residents in a given census tract is shown to have a positive significant relationship with its corresponding population to farm ratio. This result supports the findings of Figure 5.2 and Map 5.3. Much like the percent Black findings this finding illustrates an important component of the local foodshed fabric of the bay area. When the population to farm ratio increases for a given census tract its corresponding percentage of Hispanic residents increases.

Lastly, percent median household income in a given census tract is shown to have a positive significant relationship with its corresponding population to farm ratio. When the population to farm ratio increases for a given census tract its corresponding percent median household income increases. This finding supports the results from Figure 5.2. An explanation for this is that higher income census tracts are located in more densely populated areas and or located further away from food producers and or located further away from major roads.

6.2 Two Step Floating Catchment

The food producer's perspective is an overlooked yet intrinsically vital aspect in fostering a more locally resilient food system. Their challenges of time and costs are directly transferable onto the consumer.

Food producers with the highest accessibility scores, produced from the 2SFCA method, implicitly have a competitive advantage in being able to market themselves to the greatest amount of people. The reasons for this are: proximity to major road, proximity to denser populations and the amount of farms.

The long history of urbanization and development coupled with the geographical restrictions provided by the bay and ocean create a unique scenario for food producers to have access to many people. However, land becomes increasingly more valuable the denser populations become. Unless a farm is situated on a land trust it is extremely difficult if not impossible for a farm to be developed in much of the bay area.

Map 5.7 and Map 5.8 shed light unto the reality that food producers experience in regards to accessibility to the populations of the bay area. The results are intuitive to interpret showing the zipcodes with greatest accessibility in the center with diminishing levels of accessibility the further away one gets. The food producers with the highest accessibility scores are located in areas of highest land development prices; these are the most urbanized areas. Because of this, it can be inferred that these producers are not large operations. Three areas stand out: south of Santa Clara county, north of Marin county and north of Solano county. Farms in these areas have a unique balance between land cost and accessibility to the most bay area residents. These areas strike a balance between population accessibility and land development cost.

CONCLUSION

This analysis demonstrates a methodology for analyzing the relationship between food producers and consumers. The findings provide a way to guide decisions that localities can make in order to strengthen the bay area local foodshed. One suggestion is to further investigate some of the surprising findings like whether lower income census tracts truly have greater access to local food producers. Another suggestion is for integrating food production into the urban fabric of the bay area. This can be done through a multitude of avenues including but not limited to, urban community gardens, roof top gardens, and land trusts.

Questions that should be further investigated are: Do East Bay (Alameda and Contra Costa County) residents eat more local food than other bay area residents? Specifically, are areas that are predominantly Black truly experiencing a greater level of local food access demonstrated by this analysis? Even though certain areas have greater spatial accessibility that does not always translate to direct access on the ground.

Another question warrants further investigated is: Do land prices influence the size and location of a farming operation? Intuitively, the answer should be yes. Showing this, through empirical analysis, may add another layer to the local foodshed fabric of the bay area.

The final question that would add more detail to the local foodshed fabric of the bay area is: What specific markets are food producers bringing food into? Each food producer would be connected to the market or markets that they have a relationship with. This would provide a robust analysis that would illustrate the reality that food producers face. However, this would require significant time, funding and man power in order to collect this level of data.

No study is without limitations. This thesis made certain distinctions between farms for instance nurseries and vineyards were excluded from this analysis. This thesis did not make distinctions between orchards, livestock, and mixed vegetable operations. Future research avenues can address specific types of food producers by using one type of operation at a time, then summing the accessibility scores produced from each 2SFCA. Another potential avenue of research is looking at the relationships that food producers have between each other. Collaboration may alleviate certain costs and also facilitate knowledge sharing.

American palates have become intensely diverse. These tastes require vast amounts of land and a multitude of food production practices. Taking ownership of the space that consumers and food producers share is a value that needs to occur in order to strengthen any local foodshed. Unveiling this complex relationship between food producers and consumers will allow for a more holistic understanding of how food flows. Much like a watershed catchment, local food accessibility catchments model the extent for which food flows from source to consumer. The corollaries between the foodshed and watershed are a major takeaway from this thesis. Both describe the flow of a resource, its need to be studied, and ultimately its need for protection.

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