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Food Security in Urban America: A model based on Minneapolis-St. Paul, Minnesota

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Senior Honors Thesis

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Abstract

Food security, through access and availability, has become a pressing issue in many fields of academia. Until the mid-1990s, research within the United States has been hampered by ill-defined concepts and a subsequent inability for social scientists to contribute to policy on the issues. My research attempts to contribute to the limited body of developed-world food security research by applying a Geographic Information Systems model to Minneapolis and St. Paul, predicting high risk of food insecurity in urban areas. Taking into account factors such as income, ethnicity, and family status, this model finds that it is not the central city areas that are most at risk, but rather the neighborhoods just inside the city boundaries.

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Chapter 1: Introduction

The field of food security is one that has been developing over the past thirty years, with much of that period dominated by work done in developing countries. In the United States, research on domestic food security has only recently been pursued, even lacking a measurable definition until the mid-1990s (Curtis and McClellan 1995). In addition to there being little work in the field, few people outside of academic and policy circles who work directly with the issue would even think that food insecurity and hunger would be present in the United States. Defined as "all people obtaining a culturally acceptable, nutritionally adequate diet, through non-emergency food sources at all times" (US House Select Committee on Hunger 1990, p. 4), food security certainly does not exist for all people in developed nations, and research into its causes and effects should be a priority for anyone who would like to see the eradication of poverty both domestically and internationally.

While it is a relatively new field, there has been plenty of time for various theories and critiques to develop and create a growing body of results. Theories include causes of insecurity, ranging from a simple lack of food to more complex critiques of the structure that causes individuals and households to be vulnerable to insecurity (e.g. Moseley and Logan 2005) and impacts of chronic insecurity, including the prevention of economic and social development (Jenkins and Scanlan 2001).

All of this work is pursued with the intention of somehow alleviating hunger and other social and economic costs of food insecurity. It is with that in mind that I am attempting to develop a model for predicting where the highest risk of urban food insecurity exists. Most research up to this point has focused on one of two issues: accessibility (or lack thereof) and demographics. Several scholars, including Guy (1983), Frazier, Margai, and Tettey-Fio (2003), and Clarke, Eyre, and Guy (2002), use various accessibility models to predict communities

within urban areas that have fewer opportunities to reach consumer goods. On the other side of the research, the US Department of Agriculture (USDA), has begun conducting compiling studies that correlate food insecurity status, as determined though the yearly Current Population Survey (CPS), with demographic variables such as race, household type, age, and income. As of yet, however, little, if any, research has attempted to combine these two parts of food insecurity work.

It is this void that I attempt to fill in, combining access modeling techniques with current demographic characteristics of food insecure populations. The food insecurity risk model will calculate demographic and accessibility risk separately, using resources available either through federal, county, and local governments or community business such as groceries. It will be designed to intentionally use data available to most government officials, academics, and the interested public, to allow for its application to many urban areas. By developing and applying this model to the greater urban area of Minneapolis and St. Paul, I hope to find a way to easily assess the current food security situation for various neighborhoods, both to influence policy and potential solutions and to provide a tool that can be used in other cities throughout the country.

The model cannot be created, though, until food insecurity and the concepts behind it are clearly understood. A review of previous research, both in developing and developed country contexts, will provide a theoretical background for the causes and predictors of food insecurity. Additionally, an analysis of accessibility measures is needed to decide what the best method is to use in an urban setting such as the Twin Cities. Once that is completed, the two sections of the model can be combined into an aggregate index of insecurity risk. Analyzing the results of the index, its strengths, and weaknesses can then lead to policy recommendations and areas of future research in the ongoing work of ending poverty and hunger.

Chapter 2: Food security: Theory and criticism

Food security is a topic that is not explicitly understood by all, but regardless of whether or not one studies it, everyone is affected by its presence or absence. Conceptualizations vary from the US House Select Committee on Hunger's definition of "all people obtaining a culturally acceptable, nutritionally adequate diet, through non-emergency food sources at all times" (1990, p. 4) to the World Food Summit declaration that "food security exists when all people, at all times, have physical and economic access to sufficient, safe, and nutritious food to meet their dietary needs and food preferences for an active and healthy lifestyle" (FAO 1996, p.1). Food security has also been explained through its antonym, as with the American Society for Nutritional Services, which states that "food insecurity exists whenever the availability of nutritionally adequate and safe foods or the ability to acquire acceptable foods in socially acceptable ways is limited or uncertain" (Quoted in Hamelin, Beaudry, and Habicht 2002, p. 119).

Other similar definitions exist, but no one is universally accepted, though, and subsequently, scholars and policy-makers argue about what is meant when referring to 'food security.' One dispute arises from the ambiguity of the definition with regards to the difference between food availability and food access. Sen (1981) was one of the first scholars to make this distinction, arguing that availability of food does not necessarily mean that a population will be able to afford or have access to those supplies. To distinguish between the two, food availability is often measured at the country level through mean daily per capita protein and calorie consumption (e.g. Jenkins and Scanlan 2001) or mean consumption expenditure per capita per day (e.g. Garrett and Ruel 1999). This measure does not reflect who the food is actually going to, or the access that individuals and households have to food. Some studies have tried to address this problem of availability not truly measuring access by measuring child hunger rates

through age-weight and age-height ratios (e.g. Jenkins and Scanlan; Garrett and Ruel 1999, respectively), but they are often only performed at a national scale, ignoring differential access within the country.

Another definitional dilemma within food security research and policy is the difference between food security and hunger. While many casual observers may equate the two, hunger is based on individual experience, regardless of societal conditions, while the concept of food security accounts for both community and individual resources. In addition, hunger is a physical condition with other causes, i.e. a consequence of food insecurity (Curtis and McClellan 1995).

Regardless of its conceptual problems, food insecurity (or the lack of food security) has many real and tangible effects. According to Jenkins and Scanlan, "People without secure access to food are unlikely to progress economically or to contribute indirectly to the welfare of other populations through economic trade, cultural exchange, or social interaction" (2001, p. 738). These results are not the immediate consequences of short-term conditions, but have long-term circumstances that lead to their appearance. Sen (1981) and Dreze and Sen (1989) have shown that resourceful households usually have enough food, even in relatively poor areas, and that "world hunger is generally not a question of sudden starvation but rather of chronic undernutrition that leaves populations vulnerable to disease and their members unable to lead active and productive lives" (Jenkins and Scanlan 2001, p. 738).

Along these lines, there have been many criticisms of current food security perspectives and policies. Moseley and Logan (2005) have summarized many of the opposition arguments, including post-modern perspectives on the definition of hunger. According to their work, when those in power, including donors, define food insecurity as a supply-side problem (i.e. lack of availability), they are able to ignore the structural problems that are preventing adequate access. By defining vulnerability to hunger as an outcome of food insecurity instead of as a cause,

organizations like the US Agency for International Development (USAID) can ignore structural problems associated with hunger, allowing agendas that perpetuate it to continue. Additionally, national food audits and food monitoring systems overlook local and household food security issues, ignoring the political economy of famine and poverty (Ibid.).

Another criticism of current research is the split between urban and rural food security. Often work in developing countries has concentrated on rural areas (e.g. Amarasinghe, Samad, and Anputhas 2005; Kerr 2005), while that in developed nations has focused on urban issues. The two bodies of research are similar in that the studies tend to concentrate in areas where the poorest populations live. There has been some research bridging the two fields, such as Garret and Ruel's (1999) study of urban and rural determinants of food security in Mozambique. They found that, while the magnitudes of determinants such as household income and food prices were different in rural and urban areas, their relationships to food security were the same. The only difference was that city residents were slightly more sensitive to changes in income, reflecting the safety net provided by the ability to grow one's own food in the countryside. With this finding in mind, it is possible to utilize previous research from both rural and urban case studies.

Regardless of the site, much research has been done to determine what resources contribute to food security, both at the household and community level. Individual resources include adequate personal income, access to transportation, and cooking and storage facilities (Curtis and McClellan 1995). In addition to personal capital, community assets are also important in assuring food security. Larger-scale factors include competitively priced food, nutritious, culturally acceptable food choices, and adequate local, conventional food sources (Ibid.). If any of these resources is missing, food security is at risk.

A determination of the factors that contribute to food security can then be used to develop a theoretical framework for its assessment. Several functions have emerged from this line of thought, including Blaylock and Blisard's (1995) food security production function:

$FS = f(X_{FS,C}, X_{FS,E,} Y)$, where

$X_{FS,C}$ is the human capital stock influencing food security, $X_{FS,E}$ is qualitative factors influencing food security, and Y is income. $X_{FS,C}$ is proxied by the respondent's age (older people tend to be more experienced and efficient in preparing meals and shopping), education level (indicates preparation skills, nutrition knowledge, and other efficiencies), participation in a food program (can provide nutritional training and assets), and household size. The latter two factors could be viewed as either positive or negative, depending on one's line of thought. For example households and individuals participating in food programs could be more secure because its use reduces the risk of hunger or less secure because it is more insecure households that utilize such programs (Nord, Andrews, and Carlson 2001). Household size can also be either a risk or benefit. Large households require more food, increasing the chances of food insecurity, while they are able to apply economies of scale and may provide more working members, decreasing the family's risk. $X_{FS,E}$ includes regional and urban location variables, accounting for food home production patterns, price variability, and customs and traditions particular to a certain location. Additional qualitative factors influencing food security are race and ethnicity variables, which capture cultural differences among groups. Y, measuring income and home ownership, reflect the resources available to acquire food.

A second function detailing the demand for calories (K_h) was developed by Garrett and Ruel (1999) in their study of food security in Mozambique. Caloric intake and its demand can be used as a proxy for food access by determining the amount of food that actually reaches a

population. This equation echoes Blaylock and Blisard's (1995) work while classifying the various factors slightly differently. On a household level the equation reads:

$K_h = f(P_h, A_h, Z_h)$, where

P_h is prices at each location, reflecting variability in local markets. A_h equals assets and income, including land and resources to grow food and assistance from formal and informal networks. Z_h are demographic characteristics and other exogenous factors that influence food security. Household demographic structure, educational levels of household members, and foods available by season are incorporated into Z_h.

These generalized models are useful for conceptualizing food security, but levels of food security are difficult to measure without empirical research. Until recently, food security was unable to be measured because no one had an adequate definition that could be universally used. While there is still much debate about the various ways of defining food security, creating a theoretical model has allowed researchers to begin to assess levels of insecurity in countries, cities, and neighborhoods.

Chapter 3: Food security in developing countries

The majority of food security research that has been done over the past thirty years has focused on the developing world, in particular rural areas. One example of this trend is the large body of work focusing on sub-Saharan Africa (e.g. Duncan 1998; Frayne 2005; Moseley and Logan 2005). Like Blaylock and Blisard (1995) and Garrett and Ruel (1999) for general food security patterns, there have been theoretical frameworks developed for factors affecting food security in less developed countries (LDCs).

Among these factors, six major issues are thought to possibly influence the prevalence of food insecurity in developing countries: modernization, economic dependence, urban bias, neo-Malthusian population pressure, ecological evolutionary processes, and militarism (Jenkins and Scanlan 2001). Modernization indicates the internal sources of economic development, allowing for a measure of how wealthy the country is. As with determinants of household food security, mentioned previously, income and assets affect a country's ability to acquire food resources as a whole. Some research has found that balanced economic growth "trickles down" to increase food security throughout the country (Ibid.), while others have shown that economic development produces a short-term decrease in equality (Arrow 1979; Letwin 1983).

A second factor influencing food security, economic dependence, shows the type of development that is taking place within a country. This development can be from a number of sources, including both internal and external investors. Proponents of dependency theory, however, believe that too much investment from abroad, particularly in primary industry, leads to a situation where the less developed country is prevented from progressing, due to restrictions placed upon it by the investing country or countries (Prebisch 1950). This dependency may create growth in the short-term, but is thought to cause a net decrease in a country's ability to sustain itself in the future. There is much argument about how the extent of dependence affects

a country's economy, and studies have presented evidence for both sides of the debate. Dixon and Boswell (1996) and Kentor (1998) have worked on empirical projects detailing the harm that can come from foreign investment through repatriation of profits and the discouragement of domestic investment. On the other hand, Jenkins and Scanlan (2001) have shown that foreign investment does help boost the economy, only to a lesser extent than domestic investment. Their work shows that a proper balance of both can help boost a country's economy, producing more income for its population and increasing food security. If this is the case, foreign investment does not cause a net decrease in social and physical conditions for the population, but is only relatively less beneficial to economic growth than domestic investment.

A third aspect of food security, urban bias, refers to the power that a developing country's urban elites often hold over the rural population. While rural groups may be large in number, they are often geographically dispersed and unable to organize effectively to improve their conditions. In addition to being unequal, the large influence that urbanites wield may also be inefficient by redirecting resources to urban projects that may not be as productive as the same investment in rural areas. Urban bias's influence on food security can be felt through the concentration of wealth in the hands of a few and the lack of funding for agricultural development that would increase the country's food supply.

Fourth, the idea of neo-Malthusian population pressure is thought to influence food security. Thomas Malthus, a late-18th century English philosopher, theorized that the human population was growing at such a rate that agricultural advancements and food production would not be able to keep pace, resulting in massive starvation, particularly of the lower-class (Malthus 1987). While his initial ideas were eventually dismissed on both empirical and moral grounds, proponents of his thoughts remain, positing that populations are outstripping the natural resources available to them. From this school comes the idea that agricultural density is

not able to keep up with high levels of population growth, leading to a decrease in the amount of available food and insecurity among vulnerable households.

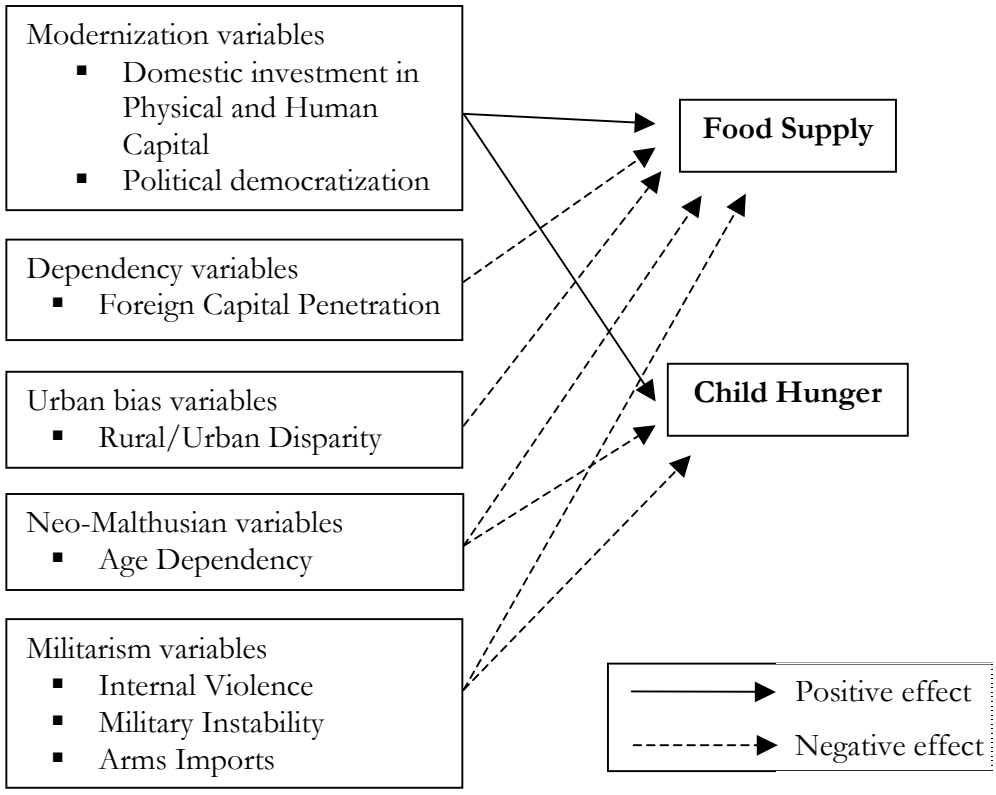
A fifth element possibly affecting food security is the level of ecological evolution, a movement in opposition to neo-Malthusianism. According to studies done by Crenshaw (1993) and Lenski, Lenski, and Nolan (1995), increasing agricultural density leads to innovation and the conditions necessary for industrialization, thus improving the welfare of the population. From this technocratic perspective, increased food production leads to decreased fertility and greater income equality (Jenkins and Scanlan 2001). These factors work together to raise both the amount of food available per capita and the average household's income.

Finally, militarism is argued to be responsible for some instances of food insecurity throughout the developing world as a result of "violent conflict, political repression, and structural inequality" (Ibid., p. 724). Contributing to militarism is the international arms trade, which can take funding away from other public programs designed to ensure food and education services. Internal conflicts can also disrupt food production and distribution, further affecting food security in various parts of a country.

Jenkins and Scanlan's (2001) study of food security in developing countries during the twenty year period between 1970 and 1990 found that one of these variables has a positive effect on the food supply and hunger rates, three had negative results, and the remaining two theories, agricultural density (ecological evolution) and economic dependence, did not produce significant change (Figure 1). Modernization, including domestic investment and political democratization, increased the chances of having a food secure population. Foreign investment also had a positive effect, although not to the same degree as domestic investment.

The three negative results were from urban bias, neo-Malthusian population pressures, and militarism. Urban bias was measured by a disparity index comprised of economic sectoral

disparity, agricultural employment, and development levels for urban and rural areas. The results indicated a strong negative effect on food security. The age dependency ratio, which in this case was the ratio of the population under the age of 15 to that over the age of 15, was used as a proxy for population pressure among developing countries. With this variable, a larger age dependency led to a greater risk of food insecurity, corroborating previous work by neo-Malthusian scholars. Militarism, violent conflict, and arms imports were also shown to be negatively correlated with food security through research conducted by Jenkins and Scanlan (2001) (Figure 1).



Adapted from Jenkins and Scanlan 2001

Figure 1 - Variables significantly affecting food security and child hunger in developing countries

Much of the research on food security in developing countries has taken approaches similar to that above, developing a theoretical framework for what might influence food security and empirically testing that hypothesis, but there have also been criticisms of the current method

for approaching food security. One such critique is Moseley and Logan's (2005) argument that, under the current paradigm, vulnerability is seen as an outcome of both household and national food insecurity, when it is actually the cause. Discussion of the political economy of food security allows for the examination of structural issues causing famine, hunger, and insecurity (e.g. Duffield 1990; Watts and Bohle 1993). In contrast, by approaching vulnerability as an outcome of insecurity, policy makers and administrators are able to maintain the *status quo* and allow for current food policy regimes and programs to continue.

Currently, food monitoring programs, designed to predict hunger and famine crises, "are built on the assumption that it is possible to identify vulnerable populations, monitor changing conditions, and deliver targeted food aid in the event of insurmountable production shortfalls" (Ibid., p. 135). From this perspective, food insecure populations are those vulnerable to varying conditions and in need of food aid. Such aid programs are designed to target the temporarily food insecure, as opposed to the chronically food insecure. Aiding the latter group would require examination of the political economy of food production and distribution, which few donors and governments are willing to do. By viewing vulnerability as a result rather than cause of food insecurity, the true causes of famine and hunger are entitlement failure and the exhaustion of buffers such as food stores, savings, and livestock. As a result, the need for examining structural failures is eliminated and current food policies that target these failures can continue.

Policies that have resulted from this vulnerability as outcome position include famine early warning systems currently used in Africa. Moseley and Logan (2005) provide a review of the four systems that are currently used by major aid organizations. The first is the food balance sheet, the second is the indicator-based approach, third is the modified income estimation, or maize equivalency approach, and last is the household food economy approach. The food

balance sheet, used by the United Nations Food and Agriculture Organization (FAO), calculates the national food needs by multiplying the population by a previously defined per capita grain need and comparing that amount to the sum of food production in the country, stocks, and net imports (Figure 2). A net positive amount of food supply is said to indicate adequate food security, while a negative balance signifies the opposite.

While this approach is widely accepted, there are several criticisms. First, the unit of analysis is the country as a whole, which ignores differences between rural and urban areas and disparities on the village or household level. Second, by equating food supply with food access this warning system is most emblematic of the supply-side focus mentioned before, preventing an examination of structural issues that might be causes food insecurity. It is commonly used and referred to when making food and agriculture policy, however, and its persistence can be explained by its technical simplicity and focus on inadequate supply as the cause of insecurity. Again, by implicating a lack of food availability as the problem, it is possible to ignore structural problems that lie at the heart of vulnerability and food insecurity.

Products	Domestic Supply					Domestic Utilization				Per capita supply			
	Prod	Impo	Stock	Exp	TOTAL	Feed	Seed	Waste	Food	Kg/ Yr.	Per day		
	1000 Metric tons										CAL No.	PRO Gr.	FAT Gr.
Cereals	3736	1310	0	46	5000	254	150	252	4343	132.1	1137	32.6	11.1
Wheat	247	1188	0	0	1435		12	10	1413	43.0	365	11.1	2.0

Source: FAOSTAT 2006

Figure 2 - Abridged food balance sheet for Sudan

The second type of famine early warning system, the indicator-based approach, is used predominately by USAID. Utilizing a finite number of indicators assumed to capture various aspects of vulnerability, this approach is able to measure the level of food security for populations in various locations. Indicators used in this model include vegetation indices, production estimates, food access, estimated through food and labor prices and local terms of

trade, and health conditions as measured by morbidity, mortality, and malnutrition. Unlike the food balance sheet, where famine is seen as a single catastrophic event due the lack of sufficient food supplies, the indicator-based approach views hunger as the culmination of a process with observable markers. These markers vary by place and time, but follow a progression that indicates the degree of vulnerability to famine. Using this rationale, the purpose of monitoring specific indicators is that some appear early enough in the progression to allow mitigating actions and relief efforts to occur.

While this method of famine prediction incorporates more factors than the food balance sheet, it still provokes several criticisms. First, there are methodological problems with the arbitrary weighting of variables in a composite index, like the indicator based approach. It is generally recommended that each item is weighted equally, except in consultation with experts in the field or policy makers who will be using the index (Booysen 2002). Weighting the indicators makes the final product more difficult to understand, particularly by such a large audience as the international food aid community. A second critique is that it is difficult to interpret the composite vulnerability index when studying it alongside other indices with differing weights and indicators. Third, the indicator-based approach may be good for comparative work, but it cannot assess the amount of food deficits that are present in a country or region. Its relative nature prevents some concrete policy actions, such as deciding the amount of food aid to send to a given country.

The third major famine early warning system is similar to the indicator-based approach, but involves converting food production, income, and transfer/entitlement data into a series of per capita maize equivalents. This number is calculated on a sub-national, communal area scale and compared to a standard of 250 kg of maize per capita per annum to determine the status of food supplies in the area. Unfortunately, this model is very data intensive and also heavily reliant

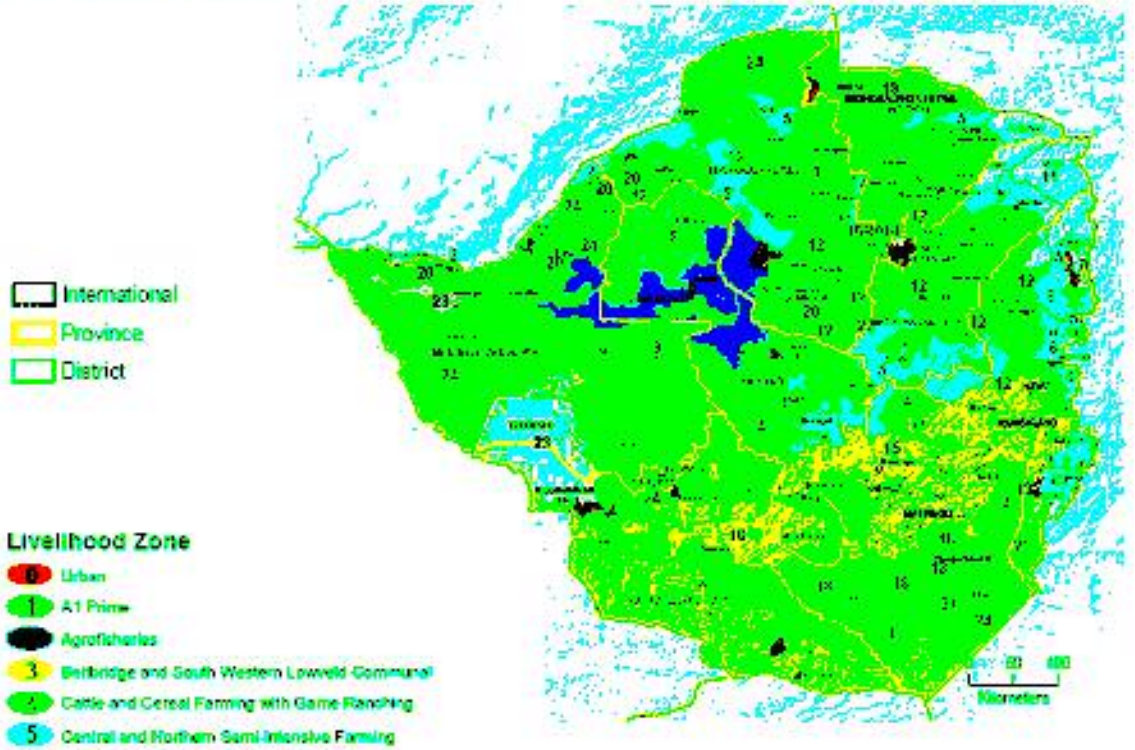
on the quality of data, which is often provided by the national government of the country being studied. In addition, the maize-equivalency approach assesses the condition of the average individual, overlooking possible disparities between populations.

The final early warning system used in sub-Saharan Africa is the household food economy approach used by Save the Children Fund UK. By understanding processes operating at the household level, the model attempts to understand aggregate need. To determine this need, the country in question is divided into zones where households have similar access to markets and strategies for obtaining food and income (Figure 3). Using indicator data, this model monitors food availability while attempting to understand the structural nature of food and income sources within the country. By using a scale that captures household differences within the country, this approach also captures differences between various groups in a society.

This model is different in that it suggests that underlying processes, along with environmental and economic changes, are the root causes of food insecurity. Unlike the previous three models, this approach allows for the examination of structural problems that prevent adequate food access to all populations of a country. Unfortunately, the end results of the household food economy model are still used to target food aid instead of address underlying conditions and vulnerability continues to be approached as a condition and result rather than a historical process. Additionally, current household food economy approaches are only focusing on rural areas, ignoring major vulnerability issues that have arisen in cities over the last twenty years.

These famine monitoring programs are put in place for use in the developing world, and there is no universal equivalent to measure food insecurity in more developed countries such as the United States and England. While most, if not all, people would say that famines are not a concern in developed counties, hunger certainly is. Prior to 1995, there was no adequate,

Rural Livelihood Zone Summaries



Source: FEWS NET 2005

pragmatic definition for hunger in the United States, so researchers had a difficult studying it and influencing policy to aid in its eradication. It is to this dilemma that this thesis now turns, to examine the body of research dedicated to food security in the developed world and factors that influence its presence or absence.

Chapter 4: Food security in developed countries

While the majority of research on food security has focused on poor populations living in rural areas of industrializing countries, there has been some work done on developed countries. Like the focus in developing countries, research in industrialized nations, particularly the United States and the United Kingdom, has focused on poor populations which tend to congregate in inner-city areas (Kaufman, MacDonald, Lutz, and Smallwood 1997). Because of the relative lack of research on domestic food insecurity, social scientists in the US have not been able to contribute to policy on the issue (Curtis and McClellan 1995). Until the mid-1990s, there was much disagreement about the extent of hunger in the US, as no one had created a standard measure (Fitchen 1988). Besides not having a standard measure for hunger, many people do not realize it is a problem in the US because there is little open begging (Curtis and McClellan 1995). Beginning in 1995, the Economic Research Service of the USDA conducted surveys to supplement the Current Population Survey (CPS) that was completed each year. This supplement explicitly measured the extent of food security and hunger in the households participating in the study through a series of questions such as "Was this statement often, sometimes, or never true for you in the last 12 months? 'We worried whether our food would run out before we got money to buy more' (USDA-FNS 1999, p.1). The survey was then used to present an outlook of the food security status in the United States. Figure 4 shows the temporal trends (1995-2004) found by this research.

While there may not have been a standard measure before the mid-1990s, there were two general definitions of hunger and implied food insecurity. The first is "the actual physiological effects of extended nutritional deprivation," (Blaylock and Blisard 1995, p. 961) while the second is the social and psychological definition, "The inability, even occasionally, to obtain adequate

food and nourishment" (Ibid. p. 961). The latter has been the main focus of US research, with little evidence of the former taking place except in extreme circumstances.

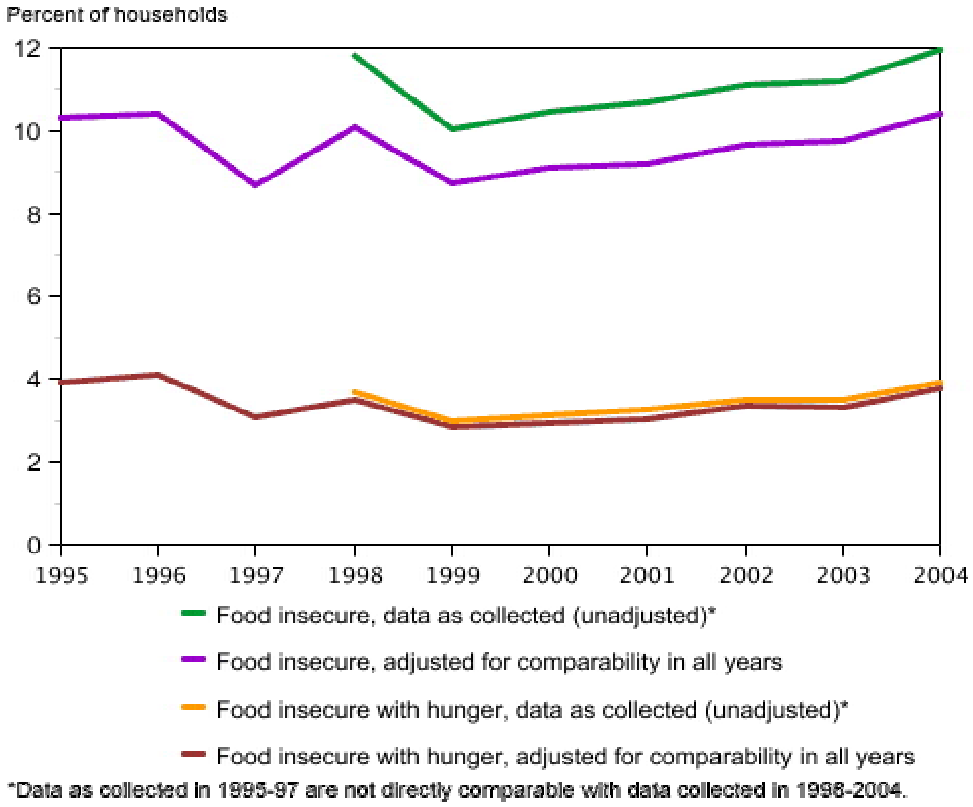


Figure 3 - Food insecurity and hunger in the US 1995-2004 *Source: USDA-ERS 2004*

Using the psychological and social definition to pursue research is not the only method of approaching the problem of hunger in the United States. Moseley and Logan's (2005) vulnerability approach, originally applied to developing countries, can also be used in this context. As mentioned before, this perspective necessitates viewing vulnerability as a cause rather than an effect of food insecurity, requiring one to examine preexisting structural problems. One example of structural and definitional problems that arises when this approach is taken is the concept of the official poverty line. Because the poverty level is based on the ability of a family to secure adequate food supplies, households in poverty are, by definition, at risk for hunger and food insecurity (Blaylock and Blisard 1995).

Other structural problems can be discovered by examining trends influencing food security over the decades. Tracing the rise of hunger in the 1980s, many analysts believe that economic and tax policies adopted during that period redistributed income from the poor and middle class to the wealthy (Curtis and McClellan 1995). Additionally, federal programs, including Temporary Assistance for Needy Families (TANF, formerly Aid to Families with Dependent Children), Women, Infants, and Children (WIC, a program targeted toward low-income, nutritionally at-risk groups), and food stamps have restricted eligibility and reduced budgets since the 1960s (Figure 5).

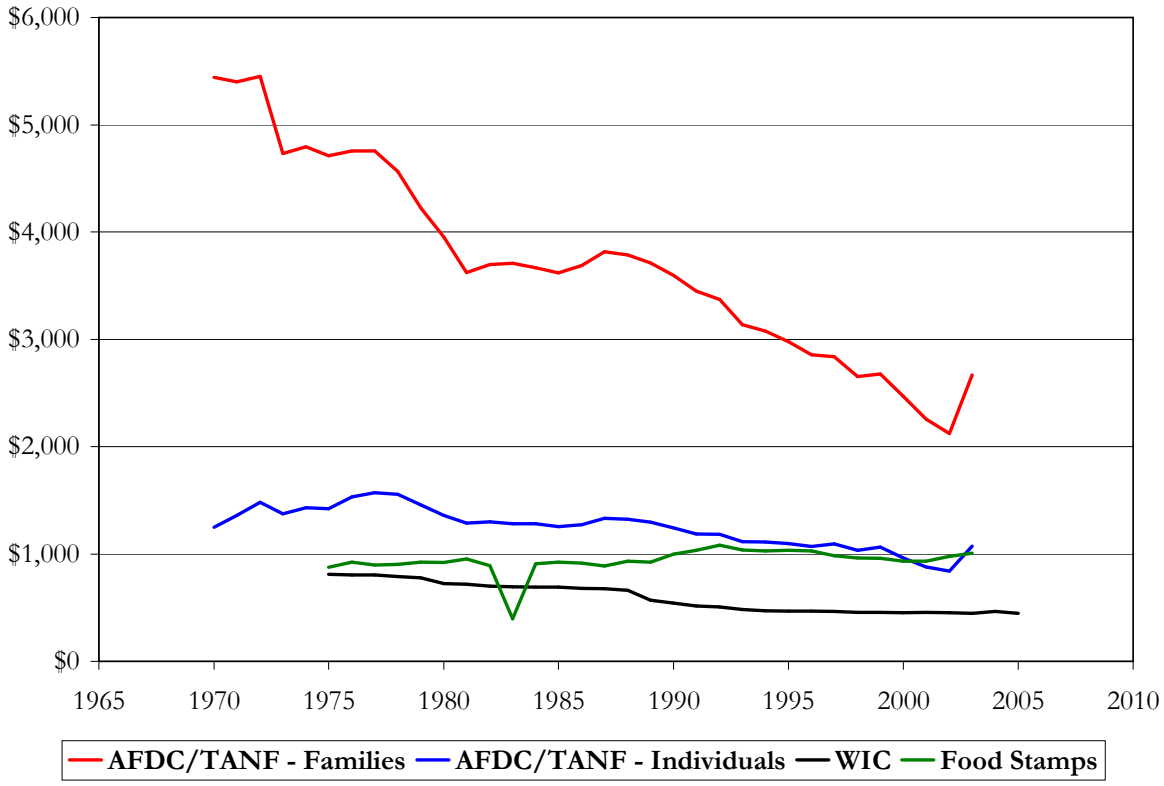


Figure 3 - Funding for selected federal food assistance programs (Allowance per household, 2005 dollars)

Source: USDA-FNS 2006; US Department of Health and Human Services 2004

Adding to difficulties presented by changes within the government, the grocery store industry has shifted its production and distribution patterns during the same time period, "leaving many 'inner cities' devoid of department stores and other important retail activities"

(Frazier et al. 2003, p. 213). During the late 1970s and early 1980s supermarkets moved from the central cities and low-income areas to the suburbs, reducing access to groceries for residents of those neighborhoods (Curtis and McClellan 1995). Suburban supermarkets also have the lowest prices and widest selection, but are generally unavailable to poor people, who tend to live in inner city and rural areas and have limited transportation options (Kaufman et al. 1997).

These industry trends are indicative of a larger shift in urban restructuring. Aided by post-World War II economic growth, higher disposable incomes, improved highways, and low land prices, higher-income families began to decentralize and suburbanize, with retail stores following shortly after (Frazier et al. 2003). Large retail stores, including groceries, initially resisted this movement, but eventually became the anchors of shopping centers, surrounded by small retailers. This suburban mall growth reached its peak in the 1990s, with current trends toward small strip malls reflecting a renewed focus on smaller demographics and specialty goods.

Groceries initially located near malls as the anchor store, although some became smaller "neighborhood" stores on the edge of the central city, serving both urban and suburban markets (Ibid.). As "megastores" developed, smaller retailers had to either upgrade or close, resulting in a drop in less profitable urban stores. Often these closures were the smaller corner groceries that had sustained a neighborhood for several generations. Since the suburban mall has begun to decline, however, larger chains, established during the growth of the suburbs, are beginning to move back into the inner city, with successful examples in Akron, Ohio and the Harlem neighborhood of Manhattan (Delaney 2002; Gomez 2004). These are the exceptions to the rule, however, and most low-income urban areas remain devoid of a low-cost grocery store, partially explaining why households in central cities were more likely to be food insecure than those in suburbs or other metro areas outside of the central city (Nord, Andrews, and Carlson 2001).

The above factors influencing food security and the availability of food sources are compounded by household variables that play a role in an individual's ability to acquire adequate resources. Demographically, several groups have been shown to be more susceptible to food insecurity in the United States. A study conducted in 2001 found that 10.7 percent of the nation's households experienced food insecurity in the previous 12 months. Households with more than one adult and no children and households with elderly persons were less likely to be food insecure, while low-income households, households with children headed by a single female, and Black and Hispanic households experienced food insecurity at a higher than average rate (Ibid.).

One reason that these demographic groups face higher rates of food insecurity is the obstacles they face. One such hurdle is the higher prices found in most inner city groceries (Curtis and McClellan 1995). In addition, food prices are up to 10% higher in small stores, which are often concentrated in central cities, than in chain stores (Kaufman et al. 1997). With a lack of large groceries in these areas, urban populations are often constrained to small independent stores with limited variety of food by type, brand, and size (Curtis and McClellan 1995). There is also evidence that inner city stores have lower quality food, particularly fresh food like produce, meat, and fish (Ibid.). These restrictions on price and quality exist partially because groceries in these areas have higher operating costs and cannot take advantage of economies of scale due to limited space (Kaufman et al. 1997).

Along with demographic groups that are at risk, another indicator of food security is the amount of money spent on groceries. Theoretically and logically, an increase in the amount money spent on food would increase the chances of an individual or household being food secure. This is not a perfect measure, however, as food spending does not take into account food from in-kind programs such as free and reduced price lunch, WIC, and other meal

programs. Another problem with this indicator is that it understates consumption in areas with relatively low prices and overstates consumption in areas with relatively high food prices. With these two caveats in mind, it is possible to get a general picture of how spending can affect food security status.

In terms of spending for different households, low-income families spend less on groceries than the national average, a statistic that can be attributed to shopping strategies such as buying in bulk, purchasing off-brand foods, and choosing lower-quality produce (Kaufman et al. 1997). While poor households spend less in absolute terms, their grocery spending is a higher proportion of their income compared to wealthier counterparts. Additionally, if a basket of equal or similar food was used, they would pay more, due to the higher prices in areas where low-income households tend to live. Two other reasons why the poor would pay more is that their shopping options are limited to smaller stores with higher prices and, when supermarket chains are present, the stores charge more than their suburban counterparts (Ibid.).

In an effort to mitigate the concerns about spending mentioned above and equate it with consumption, the Thrifty Food Plan (TFP) was developed by the USDA to serve as a national standard for nutritious, low-cost diet (Nord, Andrews, and Carlson 2001). The TFP is adjusted for household type, ranging from a single adult to a family of nine or more. In 2001, the average US household spent $37.50 per person per week, which was 32% more than the amount stated by the TFP guidelines for the household type (Ibid.). This disparity points to structural problems with the TFP program, indicating that it is not enough money to support an adequate diet. This difference becomes important when the uses of the TFP are taken into account, which include setting food stamp allotments (USDA-Center for Nutrition Policy and Promotion 1999). Structural problems are further evidenced by the fact that, on average, food secure households, as determined by the Food Security Supplement to the Current Population Survey,

spent 35% more on groceries than the TFP recommends, while food insecure households spent 2% more than the plan indicates they should (Nord, Andrews and Carlson 2001).

These problems are addressed in critiques of the USDA's program. First, the TFP does not account for higher grocery prices in central cities, regional price differences, or costs and difficulties of transportation faced by low-income households. Second, the plan assumes that there is adequate storage and cooking space for each household, as well as the time and skill needed to prepare meals (Curtis and McClellan 1995). Local studies may be conducted to adjust for cost of living in various regions and landscapes.

Another component contributing to food security for urban households is food assistance programs. There are two perspectives to take when considering such programs, one which proposes that households who utilize them are more food secure and another which posits that they are less food secure (Nord, Andrews, and Carlson 2001). The logic behind the former is that the use of food assistance programs reduces the risk of hunger for participating individuals and families. The latter supposes that use indicates insecurity because it is at-risk households that utilize the programs. In terms of federal assistance programs, over 50% of households receiving food stamps and 45% of households receiving free or reduced price lunches were determined to be food insecure (Ibid.). This finding can be used as evidence for either of the above schools of thought, leaving the discussion unresolved. In terms of state and local programs, food insecure households were 21 times more likely to use food pantries and 18 times more likely to use emergency kitchens than their secure counterparts. While this indicates that the majority of the users of these resources were food insecure, most food insecure households do not use them, indicating either unmet need or little knowledge about available programs for those groups (Ibid.).

Larger characteristics of food insecure households aside, the effects of insecurity are felt throughout the households experiencing it. Worries about the lack of food at the present and the future, as well as feelings of alienation from the rest of society, are pervasive. These feelings are compounded by a sense of powerlessness over the food situation, with insecure adults thinking that they are unable to escape the downhill spiral of insecurity and hunger. Problems also are present in the household dynamic, with socio-familial tensions, physical effects, and psychological issues arising from the family's insecure status (Hamelin, Beaudry, and Habicht, 2002).

The effects of food security and the demographics that feel them are only half of the equation when examining the nature of food insecurity in urban areas. The second part, which is more readily quantifiable than race and income issues, is calculated through various measures of accessibility. A family that has a relatively high income may not have easy access to groceries if they are limited in their transportation options or do not have any stores within a reasonable distance. Conversely, a household that may be thought of to be more at risk for food insecurity due to their demographic status may have unexpectedly high access through a corner grocery, improving their chances of obtaining food. Access can be calculated through a variety of methods, each of which has its advantages and drawbacks and should be examined before deciding which one best suits the situation.

Chapter 5: Access modeling

In general terms, accessibility can refer to anything from building and construction regulations to the design of cars and airplane seats. Geographically, it refers to "the inherent characteristic (or advantage) of a place with respect to overcoming some form of spatially operating source of friction (for example, time and/or distance)" (Ingram 1971, p. 101). Put more simply, it "measures the potential interaction between places," i.e. the attraction that one point places on another (Frazier et al. 2003, p. 217). With regard to retail activities, this attractiveness can be based on variables such as store size or population and can be measured by time, distance, or cost (Song 1996).

General accessibility can be broken down further into two distinct types. The first is relative accessibility, "the degree to which two places (or points) on the same surface are connected" (Ingram 1971, p. 101). The second is integral accessibility, the effort needed to overcome spatial separation between many places (Frazier et al. 2003). Each form has its own advantages and drawbacks and must be considered together for each particular point of interest. For example, relative accessibility can be used to compare the shortest distance needed to travel from a house or block group centroid to obtain some convenience good, such as gas, milk, or produce, while integral accessibility can aid in viewing systems as a whole, creating a larger picture of access for a particular community.

Regardless of what form of accessibility is used, a research project's purpose and design should be critically examined to determine what the type of accessibility measure to use for that particular question. Utilizing an inappropriate method can lead to problematic and inaccurate results. Most problems arise from accessibility measures' nature as a process versus outcome indicator (Guy 1983). Process indicators are measures of a supply in a system, and are the goal and end-product of modeling. Outcome indicators show actual use and level of satisfaction,

which is not easily measurable through theoretical modeling. Because of the lack of shopping behavior data available in many locations, outcome measures are not able to be used and process indicators are often substituted in their place. With the latter, behavior and decisions made by the shoppers are assumed and fixed, eliminating the need for such information.

Because of accessibility's nature as a process indicator, there are dangers associated with treating it as an indicator of equality (Frazier et al. 2003). For example, in a gravity model, the assignment of an "attractiveness" value based on size is not the equivalent of an individual's ability and cost to travel to that particular store. In other words, a store's size and attractiveness does not mean that all consumers can afford to reach it. Another problem that presents itself when determining the integral accessibility of a particular place develops from the averaging of distances from it to other points of interest. While this calculation is often done to allow comparison between places (Ingram 1971), can be erroneous due to the presence of outliers. These conditions aside, there are circumstances where accessibility can measure equality of opportunity, but not the ability of households to pay or their choices made under financial or time constraints (Frazier et al. 2003).

Calculations of equality of opportunity can be useful in administering, policy-making, and/or comparing various neighborhoods within the same urban area. To this end, empirical measures of accessibility have been developed and range from the simple to complex, with many methods in between. Perhaps the most easily understood is straight-line, or Euclidian, distance. Most often calculated using Pythagoras' theorem, straight line distance can either be relative, covering only two points, or integral, averaging the relative accessibilities of that point, as mentioned above (Frazier et al. 2003; Ingram 1971). When computing the integral accessibility, the sum is often normalized by the average distance of a block group (or another point of origin) to all stores within the entire system (Frazier et al. 2003). As discussed before, however, this

calculation can be deceptive by making block groups appear closer to the destination of interest, skewing accessibility findings.

Another relatively simple measure is rectangular distance, or the distance from the origin along a rectangular, right-angle pattern (e.g. a road system). This method may be more appropriate than straight line distances when the rectangular nature of the travel network causes significant differences from as-the-crow-flies distances (Ingram 1971). A third simple measure is time-cost distance, which determines either the potential time taken to travel a specific path or the equivalent in other monetary or non-monetary means.

Becoming more complex, there are two measures that use the above methods for determining access while taking into account considerations such as the type of good being bought. The first is the cumulative opportunities measure (CUMOPP) developed by Ingram (1971) and Guy (1983). CUMOPP calculates accessibility by counting the number of opportunities within a certain distance from home. This equation can be configured to either ignore or include the distances from the origin to each of the opportunities. Olsson (1965) has shown that some low-order functions are surrounded by areas where distance-decay is not measurable, while Guy (1983) argues that distance should be included to weight stores close to the origin. The nature of the good in question should be understood to know whether or not to include a weight factor in the accessibility measure. In most cases, a value around one-half mile is used as the maximum distance from the origin, reflecting the farthest an average person can be expected to walk and carry items (Guy 1983).

The second measure (SHORT) calculates the shortest distance to buy a certain number of goods that are deemed necessary on a regular basis, such as milk and bread (Ibid.). Unlike previous measures, with the shortest distance equation accessibility is understood to be a measure of retail goods and services, not shops themselves. To allow for comparison between

studies and account for the relative importance of some goods over others, the shortest distance is weighted by the mean cost of that good. After calculating the mean of all of the weighted distances, that amount is divided by total expenditure to form an index of access that can be transferred to other locations and studies. As with previous calculations, the characteristics of averaging should be taken into account and the data examined for outliers that might impact the results.

The above means of determining access can be made more accurate by the inclusion of several considerations regarding the shape of the accessibility function (Figures 6 and 7) (Ingram 1971). The first element is that the curve should be reasonably flat-topped in the region of origin. This indicates relatively easy access within a small radius of the point of origin. Second, the descent from the "plateau" should be smooth, showing a consistent application of the distance-decay theory. The only exception to this would be if there is some barrier that prevents access past a certain point, such as a bridgeless river or mountain range. The final element is that the curve should reach zero at infinity, signifying that no point is absolutely inaccessible. These three conditions point to the conclusion that a curvilinear function may be more appropriate than a linear one.

Two commonly used curvilinear functions are the reciprocal and negative exponential functions (Ingram 1971). The reciprocal function can be expressed as:

$a_{i,j} = 100 * d_{i,j}^{-k}$,

where *a* is access to opportunity *j* from origin *i*, $d_{i,j}$ equals the distance from origin *i* to opportunity *j*, and *k* is a constant that changes the rate of descent and position of the inflection point. One advantage of this equation over a linear one is that it approaches but does not reach zero, meeting the last of the three criteria mentioned above. Unfortunately, it does not have all

three elements of a good function, as it declines rapidly close to the origin, then levels out (See Figure 6).

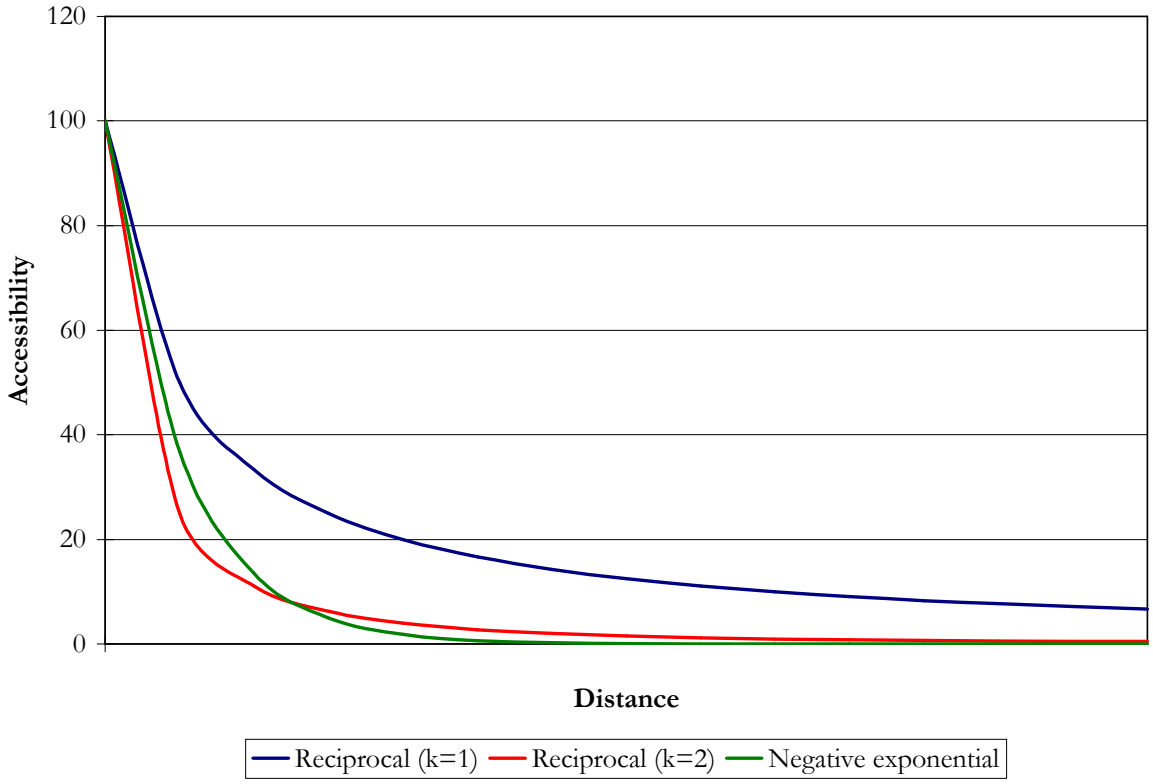


Figure 4 - Curvilinear accessibility functions

The second commonly used curvilinear equation is the negative exponential function, which is expressed as:

$a_{i,j} = 100 * e_{i,j}^{-d}$.

One of the characteristics of this equation is that it does not decline as rapidly as the reciprocal curve (Figure 6), placing more emphasis on accessibility over short distances. This emphasis is similar to the CUMOPP measure, but, unlike it, the negative exponential function includes opportunities farther from the origin. This curve has the same advantages and disadvantages as the reciprocal function, but it does not decline as rapidly as distance increases.

An additional measure of accessibility that includes more characteristics of the destination is the gravity function (GRAV). By taking the attractiveness of the opportunity into consideration, the utility that the consumer derives from that store is calculated. Most often, the size of the destination is used as a proxy for attraction. The equation for the gravity measure is:

$$A_i = \sum_j S_j \, d_{ij}^{b}$$

where S_j is the size of opportunity *j* and *b* is a constant set to reflect shopping behavior in the area of study, including the type of items desired by the consumer and the amount of travel time that is acceptable for particular goods (Huff 1963). In the lack of such information, *b* generally equals 1. Similar to the negative exponential function, GRAV does not decline very rapidly close to the origin, but it also does not incorporate a plateau there, either. These characteristics mean

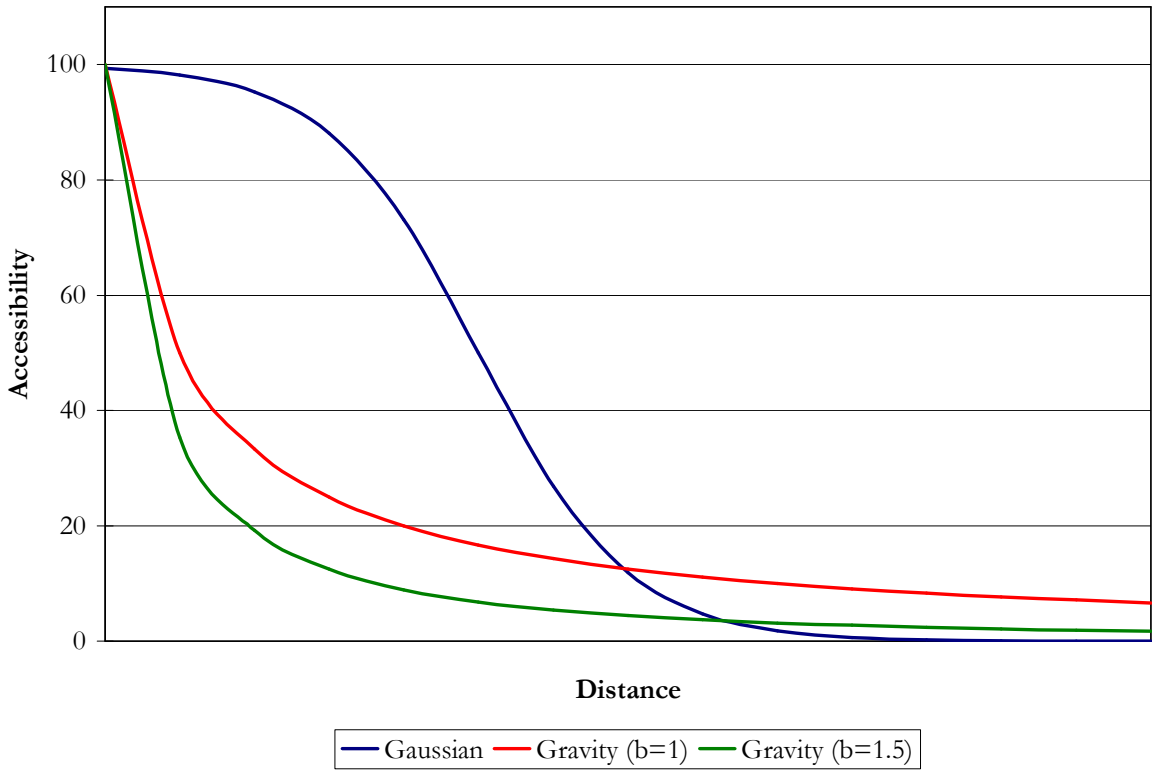


Figure 5 - GRAV and GAUSS accessibility functions

that the function does not meet all of the criteria for a good accessibility curve, although it is better than those mentioned previously.

A final measure of accessibility is the Gaussian function, which is thought to best satisfy the three qualifications mentioned above. Resulting from the idea that the gravity measure was unsuitable for measuring accessibility close to the origin (Guy 1983), the Gaussian measure declines gradually at first, then more steeply with increasing distance (Figure 7), resulting in a graph of accessibility against distance shaped as one-half of a bell curve. The equation for the Gaussian function is:

$$A_i = \sum S_j \exp\left[\frac{1}{2}\left(\frac{d_{ij}}{d_*}\right)\right]$$

where S_j is the size of opportunity j, d_{ij} is the distance between origin i and opportunity j, and d_* is the distance from origin i at which accessibility declines at the most rapid rate. For Guy's (1983) study of Reading, England, d_* was set at 0.6 kilometers and 1.5 kilometers, two values between the maximum walking distance and the distance easily traveled by public transit. Frazier et al. (2003) set d_* as one mile due to the automobile-oriented nature of the United States and the minimum radii of primary trade areas for grocery stores.

The above measures have been used in several studies of access in various locations. One such study was conducted by Guy (1983). Comparing SHORT, CUMOPP, GRAV and GAUSS equations, Guy found that the shortest distance (SHORT) measure and the gravity (GRAV) measure with high b values weigh opportunities closer to home more heavily, while the CUMOPP, GRAV with low b values, and GAUSS measures with low critical distances (d_*) weigh opportunities further from the origin more heavily. While socio-economic factors were not considered or correlated in this study, it does offer insight into the characters of the various

measures of accessibility and suggests that the nature of what is being studied should be understood before choosing a function to use.

A second study, conducted by Clarke et al. (2002) included a demand function in their equation of access, providing a more complete measure of the interaction between consumers and opportunities. The results demonstrated that urban concentrations near the edge of conurbations had the worst access, possibly due to their distance from both central-city stores and suburban chains.

Another study, of two counties in the eastern United States (Frazier et al. 2003), found that Guy's (1983) Gaussian measure was the most appropriate accessibility index when examining grocery stores. Their findings indicate that areas of minority concentration (AOMCs), where more than half of the population is non-white, had relatively poor access. In addition, differential access within AOMCs was found, with Hispanic concentrations having better access than Afro-American concentrations.

These previous studies use several methods of measuring accessibility and have demonstrated that the choice of index and parameters greatly affects the end values. Keeping with these findings, it is important that assumptions made through the choice of the index and parameters used should be clearly understood and stated. A thorough understanding of the study area, including its population characteristics, and the nature of consumer behavior with regards to food shopping will help in determining the best method for calculating accessibility.

Chapter 6: Methodology

Data—

The main data sets for this study came from three separate sources. For the accessibility model three pieces of information were needed, grocery store addresses, parcel information, and distance between origin and groceries. The addresses of grocery stores in the 7-county metro area were found in online yellow pages directories maintained by InfoUSA and Bell South. The parcel data, containing square foot data for the groceries, was provided by the Metropolitan Council, an administrative body overseeing some aspects of the governance of the 7-county area. The final data required to determine accessibility around the Twin Cities were origin points to determine distances to the groceries. These points were provided by finding the centroids of a block group sample, whose boundaries were taken from the Census 2000 files. The sample was taken systematically by selecting every third block group, in numerical order. This choice of methodology provided a distribution of points that corresponding with the population density of the 7-county area.

The data for the second half of the food insecurity model, demographics risk, were obtained from the 2000 Census's Summary File 3 data. This information was aggregated by tract level and expanded to the county level for summary statistics. The scale of the tract level was used for two reasons. The first is that its areas are small enough to identify various neighborhoods in the Twin Cities, and the second is that block group divisions were too small to indicate any regular patterns within the data.

Study area—

The study area is encompassed by the seven-county metro area of Minneapolis and St. Paul, Minnesota. The seven counties represented are Anoka, Carver, Dakota, Hennepin, Ramsey, Scott, and Washington. The larger region was selected because of the expansive urban

development of the Twin Cities, which has moved out of the of Ramsey and Hennepin counties with the growth of suburbs such as Chanhassen, Coon Rapids, and Eagan. As mentioned above, the grocery store industry has changed with the growth of these suburbs, causing food security throughout the region to change as well.

Demographically, the metro area has some characteristics that are higher and some lower than the national averages. With a population of slightly over 2.6 million, ranging from 70,000 in Carver County to 1.1 million in Hennepin, the region encompasses over half of the population of the state. Racially, the area is not as diverse as the nation as a whole, with 86.4% of the population identifying as White alone or in combination in the 2000 Census, compared to 77.1% for the entire the US. When broken down, the levels of Black and African-American and Hispanic members of the population follow this trend, with percentages of 6.9 and 3.6, respectively, compared to 12.9% and 12.5% for the nation as a whole (Figure 8). A further areal breakdown of the Hispanic population can be seen in Appendix A, Figure 16. The Asian population follows a different pattern, however, with 5.2% of the population identifying as such against an average of 4.2% for the entire country. This change is due to the large population of Hmong immigrants that have arrived in Minneapolis and St. Paul in the past several decades. The racial breakdowns for the seven counties and the metro region are displayed in Appendix A, Figures 18 and 19, showing increased diversity in the more heavily urbanized counties of Hennepin and Ramsey.

In terms of monetary resources, all seven counties have higher median household incomes than the country as a whole, ranging from $45,722 in Ramsey County to $66,612 in Scott County. Accordingly, the region has a lower percentage of people in poverty (6.9%) than the nation as a whole (12.4%), although there are substantial differences between the counties (Appendix A, Figure 17). The final demographic at a higher risk for food insecurity, single

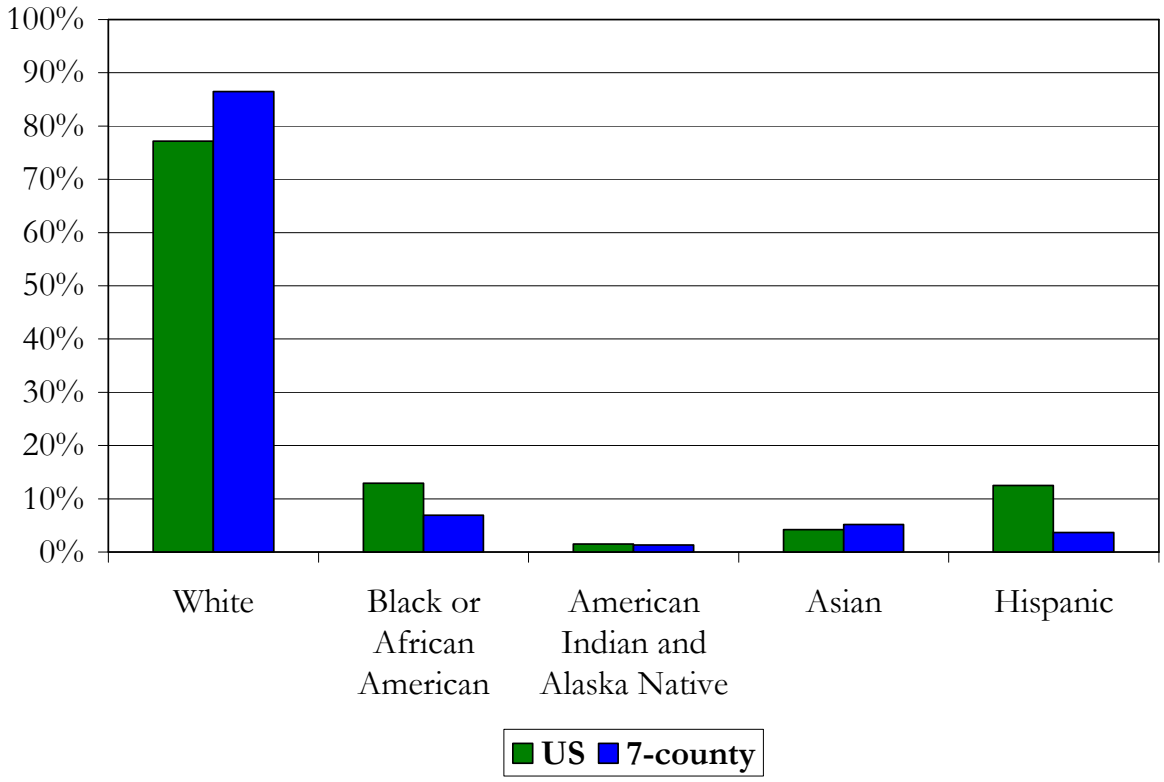


Figure 6 - Percent of population by race in US and 7-county area, 2000

Source: Bureau of Census 2000; Metro Council

female headed households, is lower in the metro area (9.5%) than for the entire country (12.2%). A county breakdown can be seen in Appendix A, Figure 20.

Procedures—

The two parts of the food insecurity risk model, demographic risk and accessibility, were calculated and combined using ESRI's ArcMap 9.1 software. The first and simpler half, the demographic model, was calculated through the creation of a demographic food insecurity risk index. The output of this index calculates the magnitude of three combined characteristics found to be positively correlated with food insecurity: poverty status, single female headed households, and minority status (Nord, Andrew, and Carlson 2001). Using data compiled at the tract level from the 2000 Census the percentage of the population falling into each of the three aforementioned groups was determined. Relative amounts in the form of percentages allows for

comparison between tracts, eliminating problems posed by varying tract populations. Each of the above variables was then converted to a five-category index, with one being the lowest percentage and five being the highest. The data were divided into categories using the natural breaks method, which helps to expose outliers, in this case at the high end. Separating the data with this method allows for the identification of the most vulnerable populations, enabling their needs to be addressed first. The three demographic groups were then combined into an additive index ranging from three to fifteen, where the larger numbers indicate a demographically higher risk of being food insecure. Using an additive index allows for the identification of the tracts that are most vulnerable, while not creating the extreme measures that would be the result of a multiplicative index.

Once the demographic model was obtained, the more complicated calculations required for the accessibility index were performed. Accessibility can be calculated between origin and destination zones, but this may not be the best method for determining access to retail opportunities in an urban area. As Guy (1983) expressed, zone-to-zone measurements can be too broad in areas where opportunities are spatially condensed and trips are often short and may not exit a zone. In addition, the spatial patterns and overlap of retail stores and residents prevents the formation of suitable zones. For these reasons, accessibility was calculated from a series of origin points, sampled from block group centroids in the metro area, and destination points in the form of geocoded grocery stores.

The groceries, obtained from the yellow pages, were geocoded to parcel information provided by the Metropolitan Council. The use of street address and zip code allowed for the majority of the stores to be matched with parcels, although there was a portion that had to be placed through other methods. The first recourse when there was not a match was to turn to additional information available in the parcel data. For example, Washington County listed the

name of the store under the "Landmark" heading, while other counties provided the name of the store's parent organization in the owner or taxpayer address. Another method to determine a grocery store's parcel was to eliminate all but a few options and examine aerial photography of the parcels, provided by Hennepin County and Google Earth. Often all but one of the parcels would either be open lots or parking areas, allowing the correct parcel to be selected by process of elimination. In the event that none of the above methods was able to determine the grocery's parcel field verification yielded the appropriate location and address.

Once the groceries were geocoded to the correct parcel the square footage of each store was matched by intersecting the parcel polygon layer with the grocery point layer. This operation resulted in the addition of the parcel attributes to the stores' data, creating one half of the accessibility equation in the form of the destination points and their size.

The final piece of information needed to calculate accessibility, the distance between the origin and destination points, was determined using Hawth's Analysis Tools, an ArcMap extension. Originally designed for ecological applications, Hawth's Tools include a function to determine the distance between points in two layers, in this instance between the centroid sample and the grocery locations. Once completed, the operation exported a data table with the origin, endpoint, and distance in the map's units. The maps of census tracts and groceries were created in UTM, Zone 15 format, so the distance was listed in meters. The distances were then recalculated to miles, to allow for comparison to other studies done in English units (e.g. Frazier et al. 2003). To simplify the accessibility calculations, a cutoff radius of one mile was established around the block group centroid sample, eliminating groceries outside of this area. The distance was chosen based on previous research that determined that one mile was the approximate minimum radius for grocery store trading area and was a distance slightly more than that which

is normal walked but less than that which is easily accessed through public transportation (Guy 1983, Frazier et al. 2003).

Accessibility was then calculated for the centroid sample using the Gaussian measure developed by Guy (1983). The equation can be written as:

$$A_i = \sum S_j \exp\left[\frac{1}{2}\left(\frac{d_{ij}}{d_*}\right)\right],$$

where d_* is set to one mile, following Frazier et al. (2003) study of urban areas in the eastern United States. Performing this calculation for the block group sample resulted in a series of accessibilities for points around the 7-county area. In order to determine access for the entire region, an interpolation function had to be conducted.

Another ArcMap extension, Spatial Analyst, was used to calculate the accessibility for the areas between the sampled block group centroids. The method used to interpolate the data, inverse distance weighted (IDW), was chosen based on its simplicity and availability in many GIS programs. IDW calculates unknown values by, as its name implies, weighting known values according to the distance they are from their respective points. By taking several points into consideration, this technique averages each weighted value and produces a range of interpolations for unknown areas (Mitas and Mitasova 1999). Limits of IDW include producing extreme values at the known points and ignoring shapes and values that might otherwise be implied by the data, but is readily available and understood by others who might hope to apply this model to different urban areas.

Once the accessibility output had been calculated, zonal analysis was conducted using Spatial Analyst, using census tracts as zones. The average accessibility value for each tract was calculated and the result was added as an attribute the tract database, allowing for comparison and compilation with the demographic model, also aggregated at the tract level. Like the

demographic index, the accessibility results were divided into fifteen categories, one being the most accessible and fifteen being the least. In the initial calculations accessibility increased as the values rose, but the reversal of this association is due to the inverse relationship between food insecurity and accessibility. For the first model, a larger percentage of demographic groups at risk for food insecurity led to a larger vulnerability and a larger index value. To correspond with this relationship, the accessibility index values had to be reversed, so that a lower accessibility (i.e. a higher risk of insecurity), was equated with a higher index value.

The final food insecurity risk model involved multiplying the two index values, demographic and accessibility, together. Creating a multiplicative index caused the tracts with both high demographic risk and low accessibility to be magnified. In this way, the areas at greatest risk for food insecurity were highlighted, while still indicating those with moderate or low risk. The final index was then mapped on the tract level, allowing for analysis of the results and possible causal factors behind the risk to be hypothesized.

Chapter 7: Results and Discussion

In order to understand the larger picture of the food insecurity risk index, its two components, demographic risk and accessibility, must first be examined. For the 7-county area as a whole, access was highest immediately in and around downtown Minneapolis, with semi-concentric rings spreading out from that focus (Figure 9). There were pockets of higher accessibility along the interstates, particularly I-94, I-35E, and I-494. This phenomenon can be explained by the large retailers' propensity to locate themselves close to major highways, for easy accessibility for their deliveries.

The demographic risk index yields a much less uniform distribution, but various tracts and neighborhoods do stand out (Figure 10)[1]. While there are areas of high risk throughout the 7-county metro area, the highest values are either in or around the cities of Minneapolis and St. Paul. This result is somewhat intuitive, as minority and poorer populations tend to live in the central city and first ring suburbs. The remaining middle levels of risk are found for tracts in the rural fringe that include towns such as Lakeville and Jordan. The lowest risk tracts are those which are mostly agricultural land with smaller towns, if any at all.

The calculations of the demographic risk index and the accessibility index individually led to interesting conclusions in their own right, but it is the combination of the two, the food insecurity risk index, that was the ultimate goal of this research. Unfortunately, merging the two parts resulted in an insecurity risk index that is jumbled, with no consistent patterns or grouped tracts with high risk except along I-94 in North Minneapolis (Figure 11). One reason for this inconclusive result may be that the assumptions that were made when developing the model, particularly the distance at which accessibility declines at the most rapid rate (d_*), most likely do not hold true for tracts outside of the urban areas and first ring suburbs. Due to the increased

[1] Maps of the individual demographics at risk for food insecurity can be found in Appendix B.

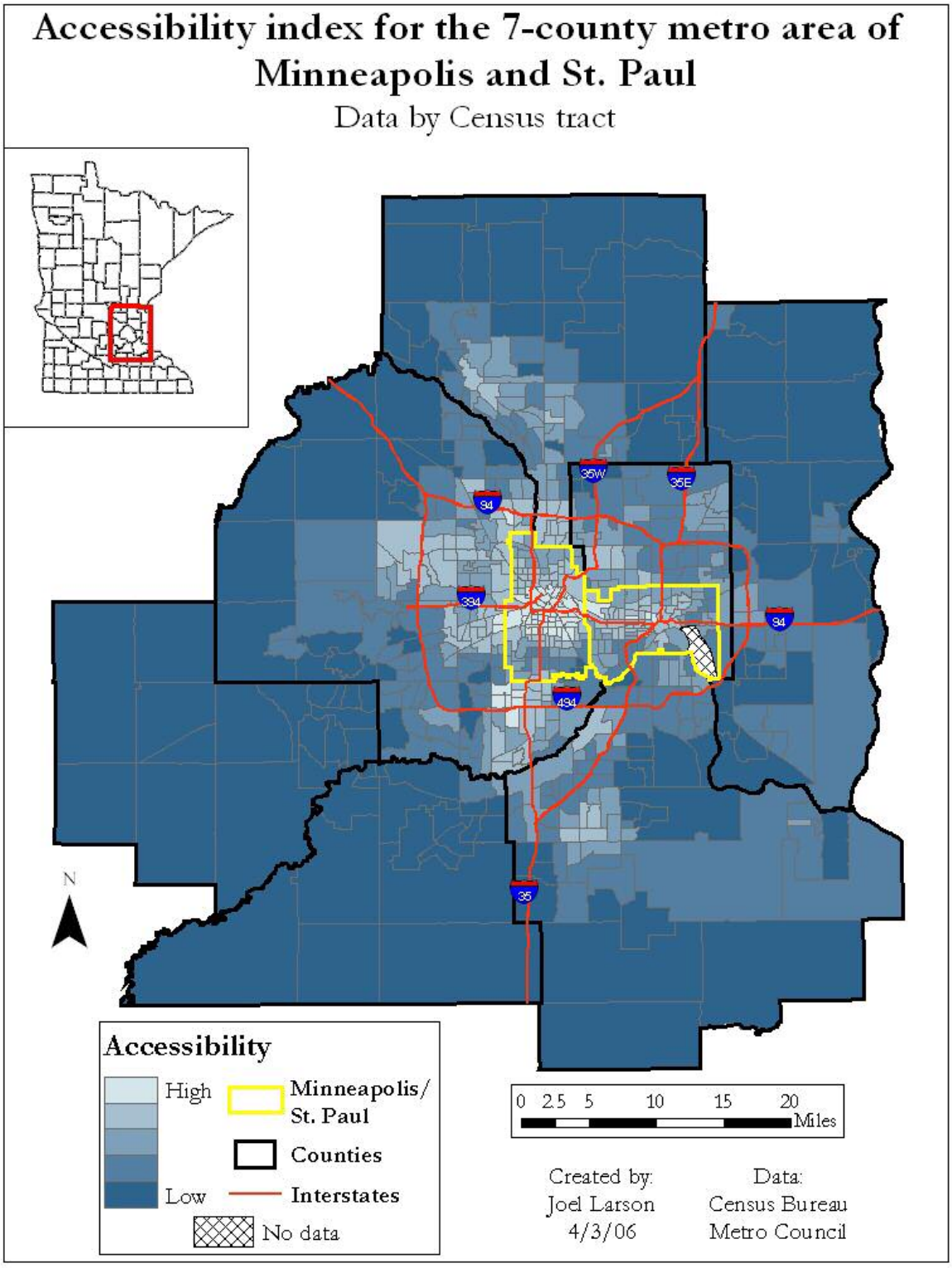


Figure 9 - Accessibility index for 7-county metro area

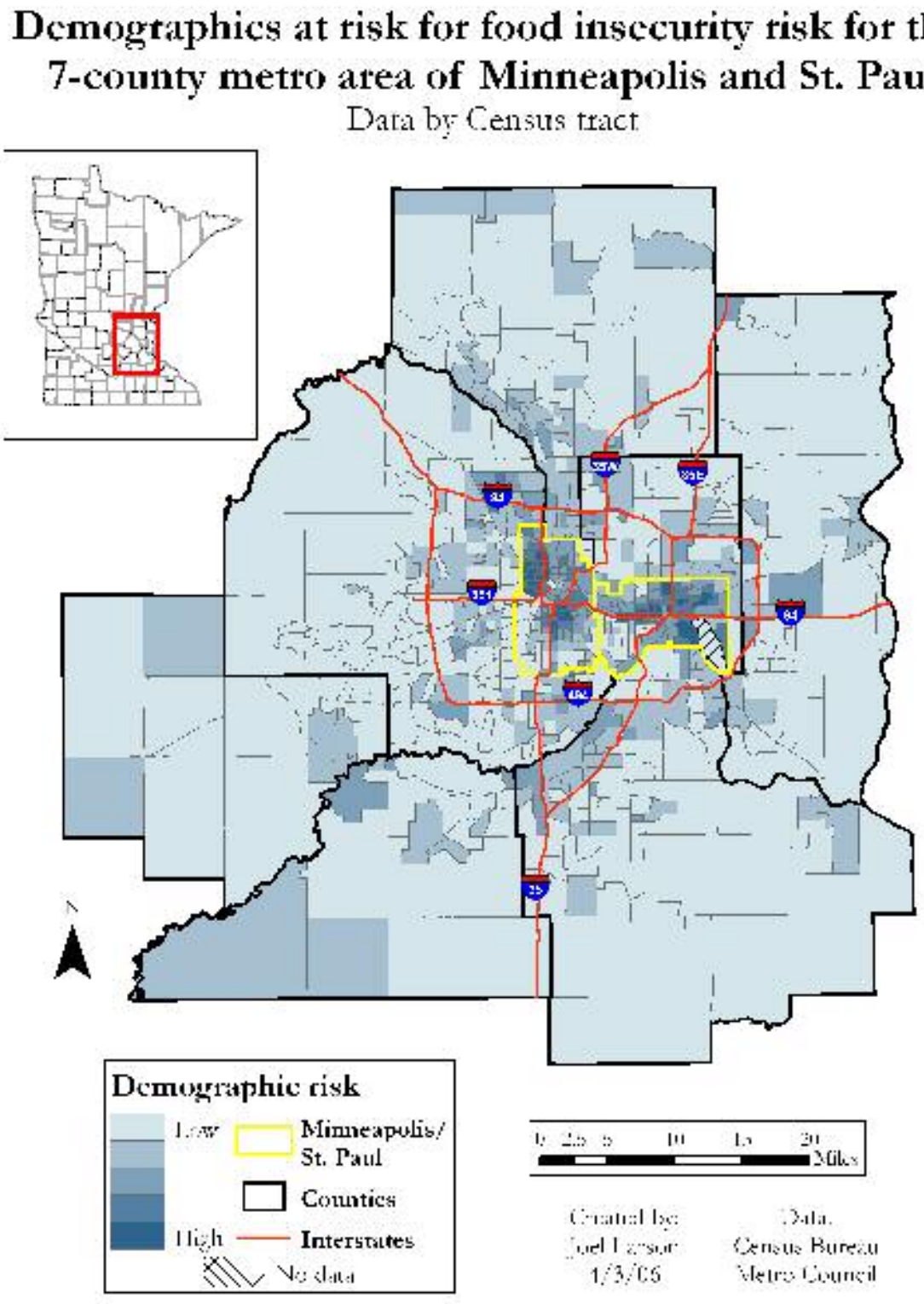


Figure 10 - Demographic risk for 7-county metro area

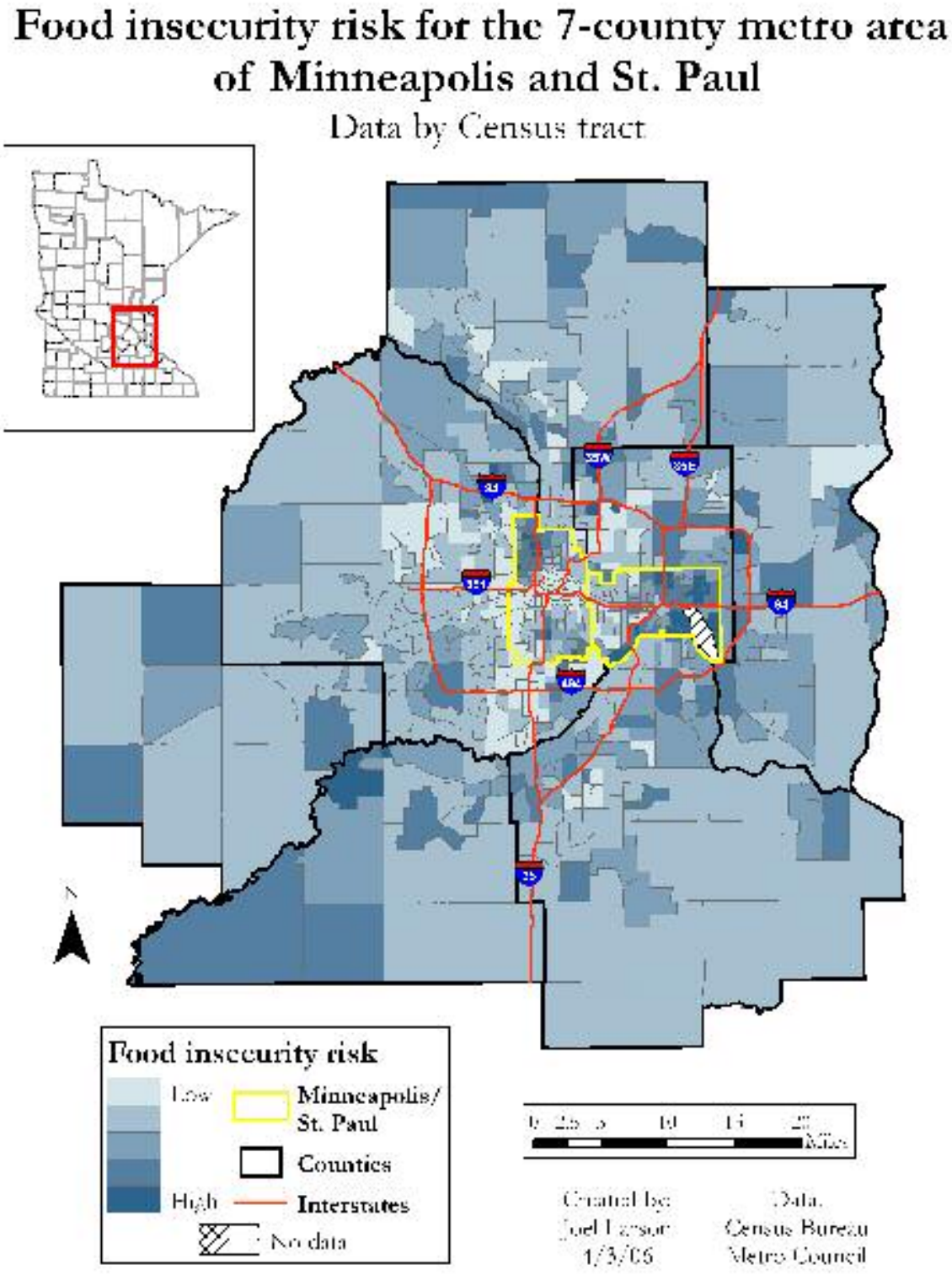


Figure 11 - Food security risk index for 7-county metro area

dependence on personal automobiles and subsequent drop in public transit routes and riders, d_*, which was set at one mile for the accessibility index, is not applicable in these tracts. In order to capture accurate accessibility measures, d_* would have to change, depending on variables such as car ownership and consumer behavior.

Due to the erratic nature of the accessibility function outside of predominantly urban areas, I chose to focus on the results for the cities of Minneapolis and St. Paul, where the patterns become clearer. Demographically, the areas of highest risk are in north, northeast, and near south Minneapolis, and tracts in the Hamline-Midway neighborhood of St. Paul and several tracts scattered outside of the downtown. Accessibility, as mentioned before, is greatest in and around downtown Minneapolis, with a branch extending east along University Avenue, to downtown St. Paul. Also of relatively high accessibility are the tracts directly south of downtown Minneapolis.

Combining the demographic risk and accessibility indices results in Figure 12, showing the cities of Minneapolis and St. Paul and indicating where the greatest levels of food insecurity risk are. Taking into account the relatively high accessibility in and around downtown Minneapolis and along University Avenue east to St. Paul, the highest areas of vulnerability were in north and south Minneapolis as well as tracts along the southern edge of St. Paul and several north and east of the downtown.

Several tracts that had high demographic risk had their composite vulnerability lowered due to their relatively high levels of access, such as those in downtown Minneapolis. Without examining the results of this model, intuition might lead one to the conclusion that the central city neighborhoods would have the highest risk for food insecurity, but this is not the case here, where the first ring neighborhoods surrounding the central business districts are the areas most at risk. Another reason for this result may be the increasing development drive in downtown

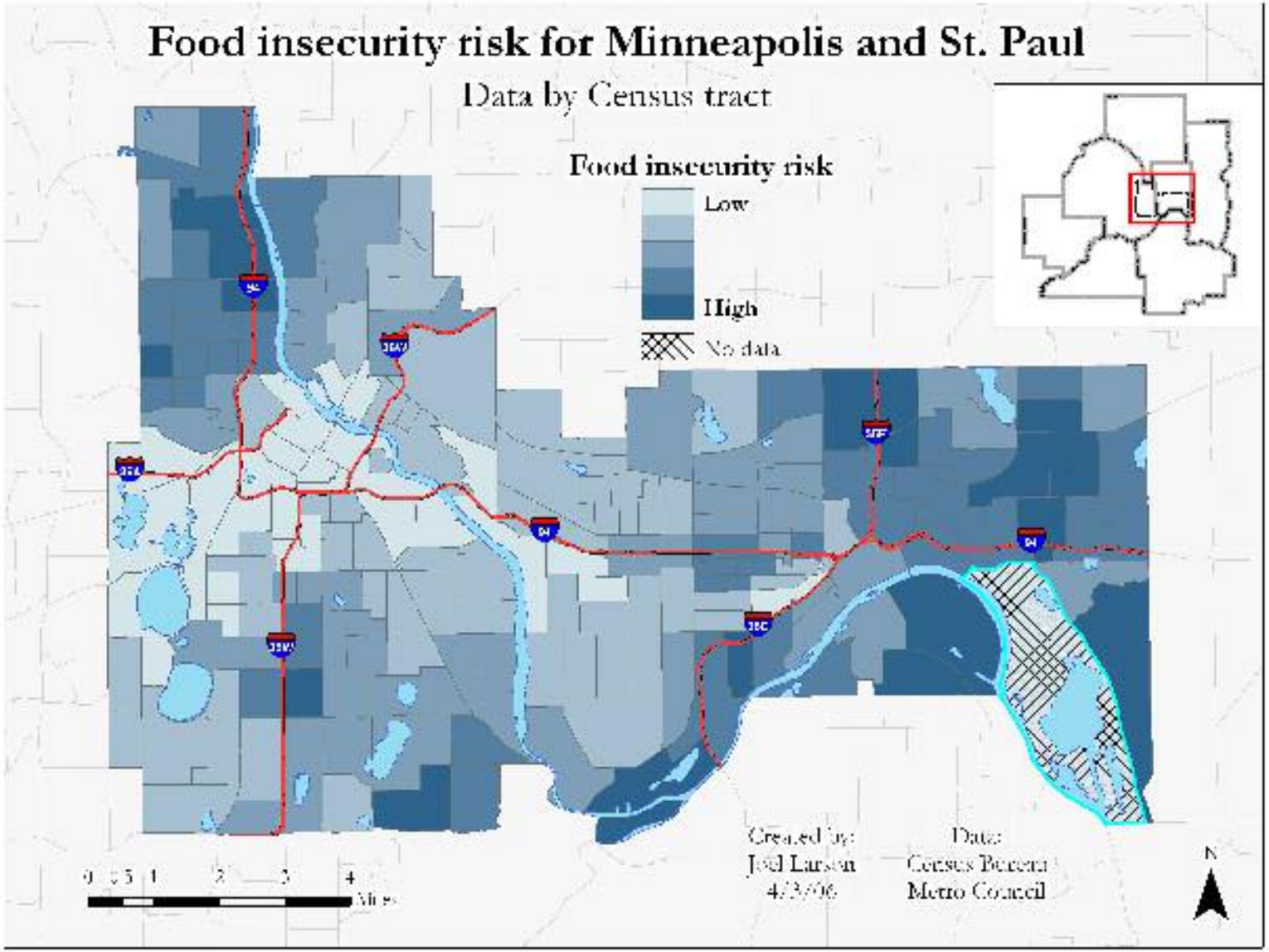


Figure 12 - Food insecurity risk for Minneapolis and St. Paul, MN

Minneapolis and St. Paul. Gentrification and condominium construction is on the rise, leading to a larger market for high-end grocery chains that might not have located in these neighborhoods previously.

More areas that have their composite risk reduced by high accessibility are the neighborhoods directly south of downtown Minneapolis. In these predominantly minority tracts there are high numbers of groceries able to serve the population, increasing their accessibility result (Figure 13). The tracts with few groceries easily stand out as having the highest risk, particularly in south Minneapolis and north and southeast St. Paul. These results, showing tracts at risk for food insecurity, can not only be used to more accurately distribute food aid programs, but also address problems that result from structural barriers preventing residents of these tracts from securing adequate food resources, such as providing incentives for groceries to move into areas lacking in retail opportunities through tax incentives or other subsidies.

The results of the food insecurity risk model are not immediately intuitive, but they can be explained through careful examination of the data that led up to the index. The downtown Minneapolis area has relatively high percentages of all three demographics at risk for food insecurity, but it is also densely populated. This large population leads to markets for groceries that have established themselves in those neighborhoods, increasing their accessibility.

In addition, many of the predominantly minority neighborhoods have significant numbers of ethnic groceries run by minority businessmen and women. The exception to this trend is the Afro-American dominated areas, particularly north and south Minneapolis. There are fewer groceries in these neighborhoods, and few local business owners opening new ones, so accessibility is not able to raise the aggregate insecurity risk like it does in other demographically vulnerable communities.

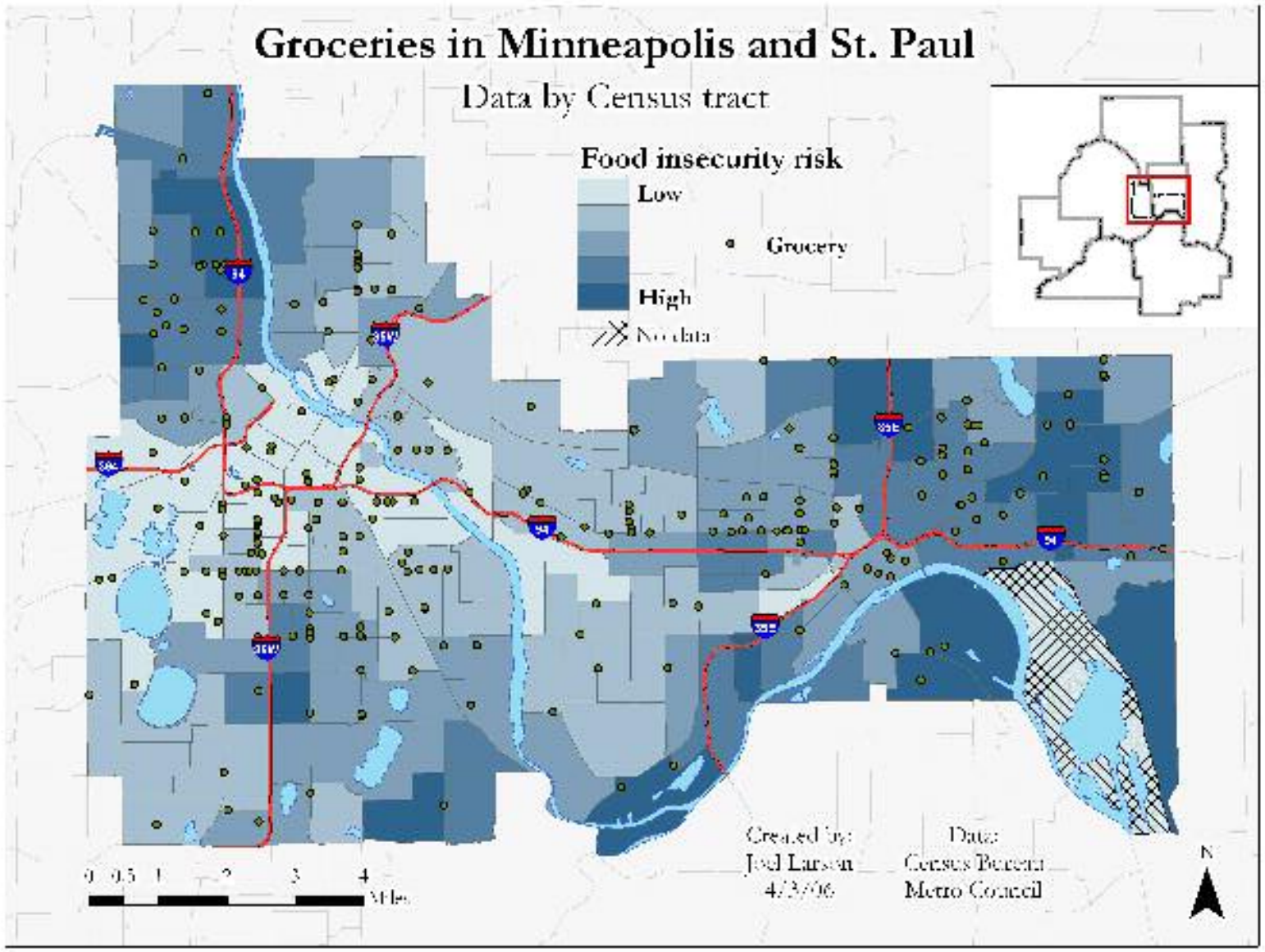
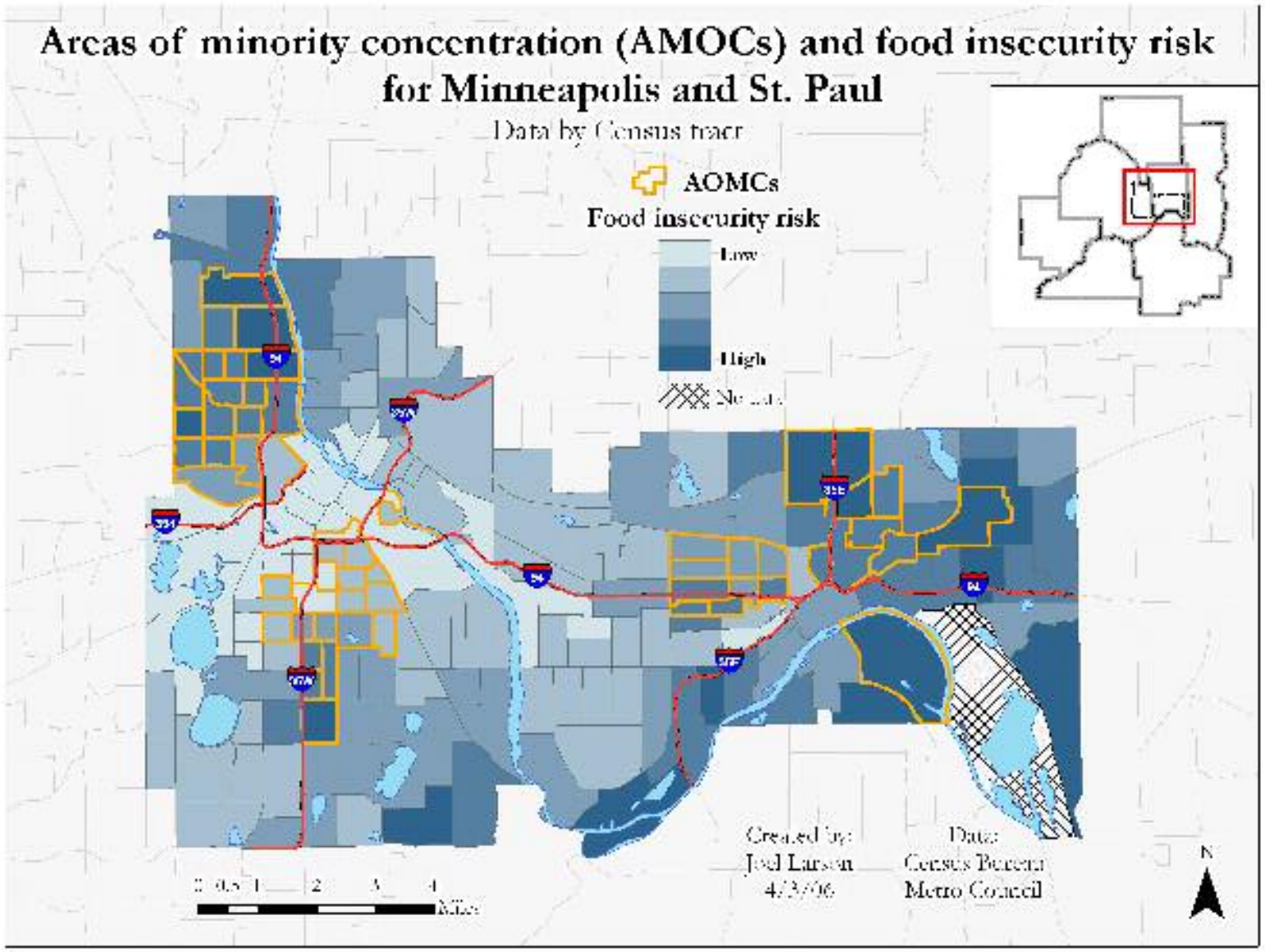


Figure 13 - Groceries and food security risk in Minneapolis and St. Paul, MN

Another way to analyze these results is to compare them to previous accessibility research. Frazier et al. (2003) found that areas of minority concentration (AOMCs), where more than fifty percent of the population was non-white, had lower accessibility than other communities. The food insecurity risk model produces results that are inconclusive in this regard, with some AOMCs that have a high risk for food insecurity and some that have a low risk (Figure 14). To compare these results with a larger scale (block groups), food insecurity risk was calculated for the city of St. Paul. Figure 15 shows findings, broken down by block group above and tract below, showing how both insecurity risk and AOMCs change when different scales and areal units are used. There are no major changes present, although a couple of block groups that were not in tracts designated as AOMCs do appear, in the southeast and southwest of the Cities. This is explainable through the averaging that takes place when information is aggregated to smaller scales. In taking the modifiable areal unit problem into account, therefore, one should realize that applying the aggregate outcome (i.e. food insecurity risk) to the individual would result in the ecological fallacy and the results will vary depending on what scale is used. With these considerations in mind, it is possible to develop areas of further research and policies for combating food insecurity in the future.


Areas of minority concentration (AMOCs) and food insecurity risk for Minneapolis and St. Paul
Data by Census tract
AOMCs
Food insecurity risk
Low
High
No data
Created by:
Joel Larson
4/3/06
Data:
Census Bureau
Metro Council
0 0.5 1 2 3 4
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Figur

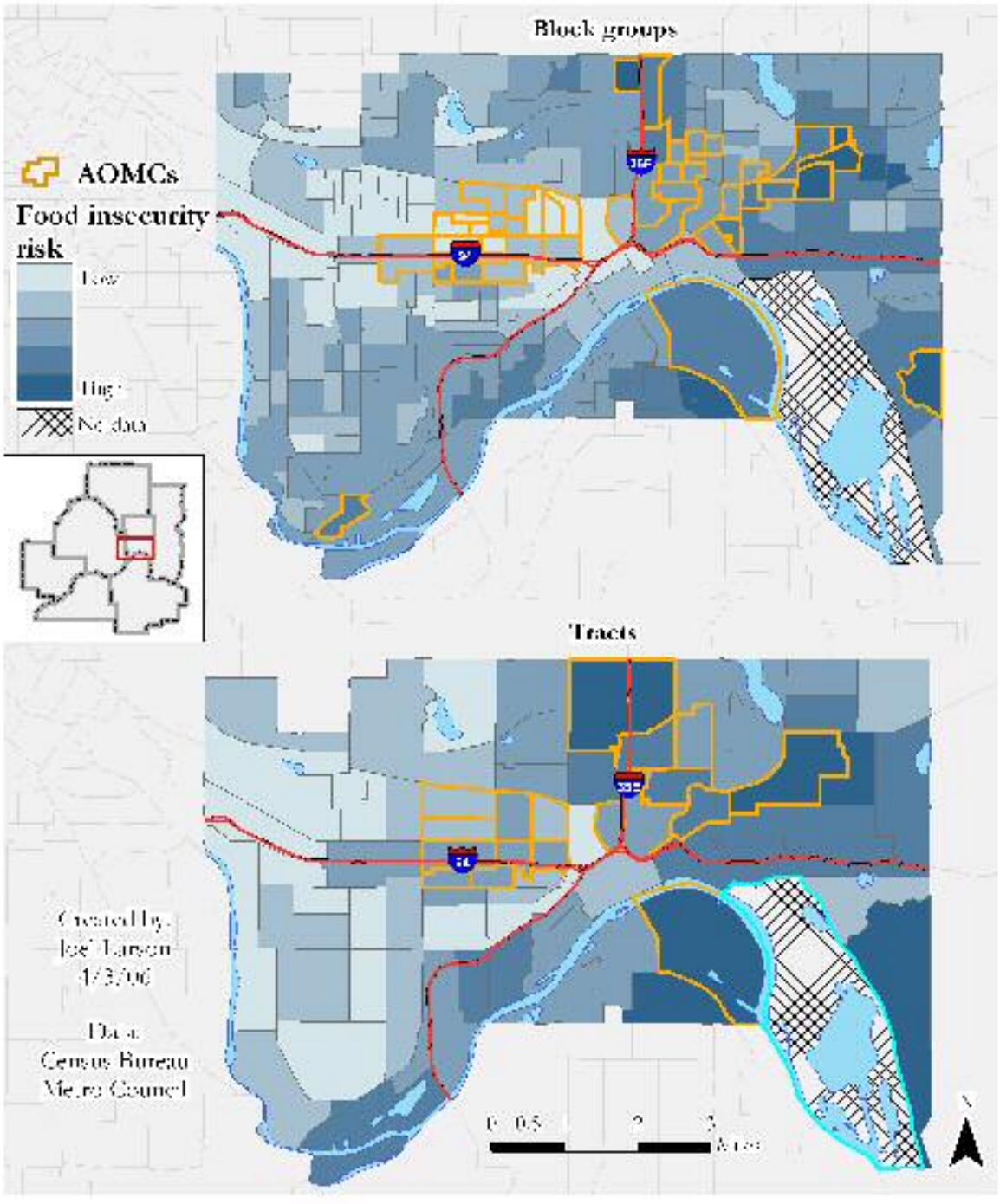

Figure 15 - Food insecurity risk and AOMCs by block group and Census tract

Chapter 8: Conclusion

This model is able to identify food insecurity risk in densely populated, predominately urban areas, becoming less accurate as the settlement patterns change to exurb and rural communities. While these results indicate that there is little risk in sparsely settled areas, it is not accurate to say that there is none. To find populations at risk for food insecurity, the model will need to be modified to account for the decrease in density and the change in shopper behavior, for example going to the grocery store only every two weeks instead of every few days, as an urban dweller might.

While it has the ability to be used to advance both theoretical and practical agendas, the model should not be utilized uncritically. One possible place for improvement in the work is the theoretical problems faced by equating access and the ability to obtain groceries. Even if there are grocery stores in a neighborhood, there are few ways to measure whether or not everyone in that area can afford to shop there. Incorporating demographic factors can help to solve this problem, but only indirectly through comparison of various groups found to be at risk for food insecurity. Another method that can be used to fill this gap is to perform a closer examination of retail outlets that are labeled as "groceries" in the Yellow Pages. Distinguishing between convenience stores, large chains, and high-end markets is important for both price and nutritional concerns.

A second problem that could be addressed in future research concerns methodology. Specifically, the quality of data for the grocery store square footage and the interpolation methods should be discussed. Many groceries, particularly smaller stores, are located in strip malls that occupy a single parcel. The parcel data only records the square footage for the entire complex and does not break the data down among individual shops. Because of this overestimation, stores that are located on such parcels have inflated attractiveness, leading to a

subsequent increase in the accessibility for any origin point that includes that grocery as a destination.

Another methodological assumption that should be examined is the choice of interpolation methods. This problem can be addressed by studying the results produced from other techniques, such as splining or kriging. Comparisons can be made between the various methods, resulting in a decision regarding the best one to use given the nature of the data and the subjects being studied.

Finally, at this point the food insecurity risk model can only be used for preliminary prediction, and has not been tested empirically. A detailed survey of the areas that are deemed as having the most risk should be performed, to determine how accurate the model is and provide a basis for the inherent relativity of the index. Testing this model will also allow it to be applied to other urban areas, although local patterns and results will vary and will have to be field verified on their own. Once these areas of future research are understood, it is possible to make some conclusions about the model and possible courses of action for further research and public policy.

First, while many families may be demographically at risk for food insecurity and reside in central cities, perhaps the first group to target would be those who live in neighborhoods outside of the downtown. While this model may not produce the same results in other metropolitan areas, it is the communities with little access to groceries *and* demographically at risk for food insecurity that should be the immediate targets of food aid policies. This aid should not only come in the form of food banks, shelters, and emergency pantries, but must include programs that work to change the structural problems behind each neighborhood's risk. For example, economic and zoning incentives can be put into place to encourage groceries to move into areas that previously only had easy access to high-priced convenience stores or no

groceries at all. If emergency measures are the only ones taken, the true issues behind food insecurity, including depressed income, inaccessibility to stores, and lack of adequate transportation options, will not be addressed and the residents' situation will not truly change (DeLind 1994; Poppendieck 1994).

A second place to address food inequality within urban areas is pricing and quality. One way to address this issue would be to survey stores and record prices for various items, although constructing an adequate basket of items that can be adequately transferred across many different sizes and types of groceries is difficult (Kaufman, et al. 1997). As many cities have large minority and immigrant groups, constructing a food basket that could be transferred between culture groups could prove to be pragmatically impossible, although surveying a sample of households and recording what they buy and at what prices might lead to conclusions about their shopping behavior and provide a basis for formulating a basket. Adding these considerations to the model will allow for more directed policies that would reduce and eventually eliminate food insecurity risk.

Some policies to address problems of high levels of food insecurity include:

- Construction of and aid to food banks and emergency kitchens, to meet the need of those faced with emergency food shortages
- Developing job-training and income support mechanisms for residents of high risk areas, to aid in long-term food accessibility
- Providing tax-based incentives for mid-sized groceries to move into areas lacking easy access to conventional food sources

While these recommendations are not the end-all solution that will eliminate food insecurity in the Twin Cities, they will provide a measure of support until more deep-seated structural inequalities, such as education and employment opportunities, can be addressed.

During the time that these policies are being applied in Minneapolis and St. Paul, the food insecurity risk model can be refined and applied to other urban areas, to determine if the findings from Minneapolis and St. Paul are similar elsewhere or if they are unique to this urban area. Using this framework would allow for a nationwide policy for improving food security, while allowing individual metro areas to cater programs and initiatives to their unique layout, market, and demographics.

In addition to policy initiatives, theoretical approaches can be changed by approaching food security from multiple perspectives. Previous research, particularly in developing countries, has traditionally focused a single cause of food insecurity, generally either accessibility or demographic risk. By combining these two approaches, the model developed in this paper attempts to bridge a gap that is created when these processes and indicators are studied individually. In doing so, the food insecurity risk model covers a wider variety of causes and attempts to address the many roots of vulnerability that exist in a complicated urban and social system. Broadening the scope of research and subsequent policy will allow for an increase in available funding as agencies are able to pool their funding and utilize larger governmental and private sector resources. At first, many people may think that food insecurity and hunger are only problems in less developed countries, but with education and training the problems within our own borders can be reduced, and hopefully, eventually eliminated.

Appendix A: Extended demographic figures

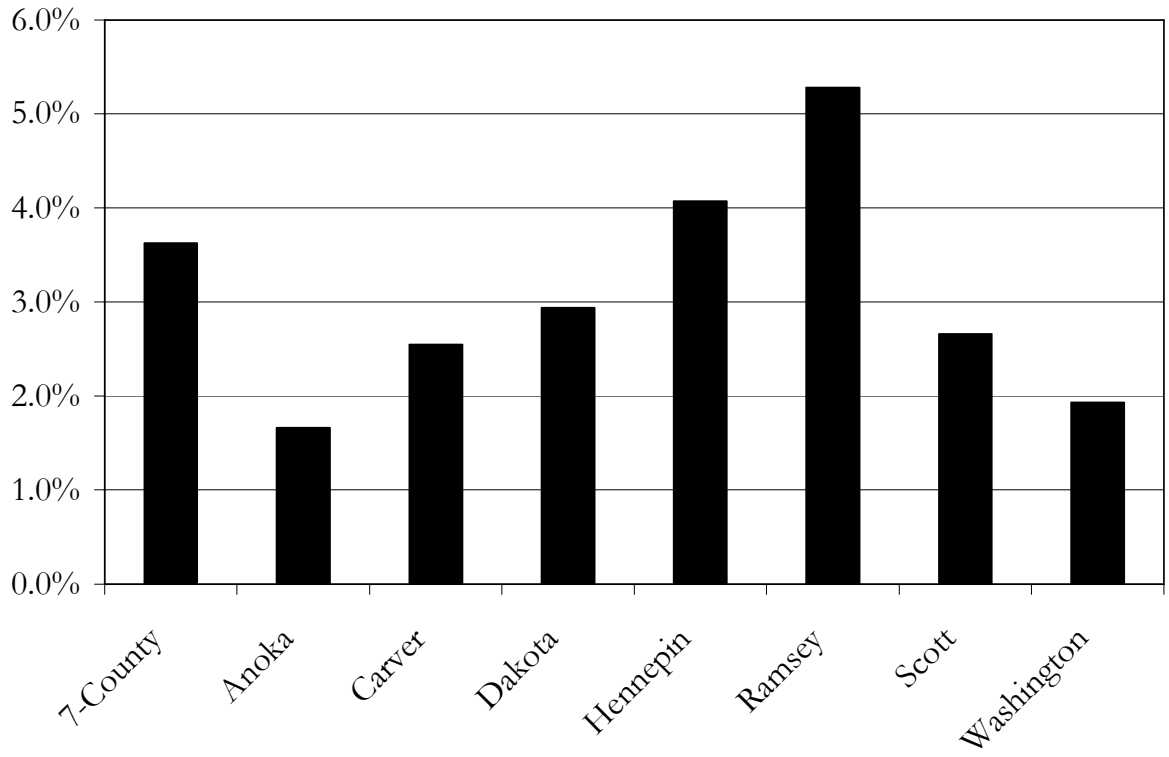

Figure 16 - Percent of population of Hispanic origin, 2000 *Source: Bureau of Census 2000*

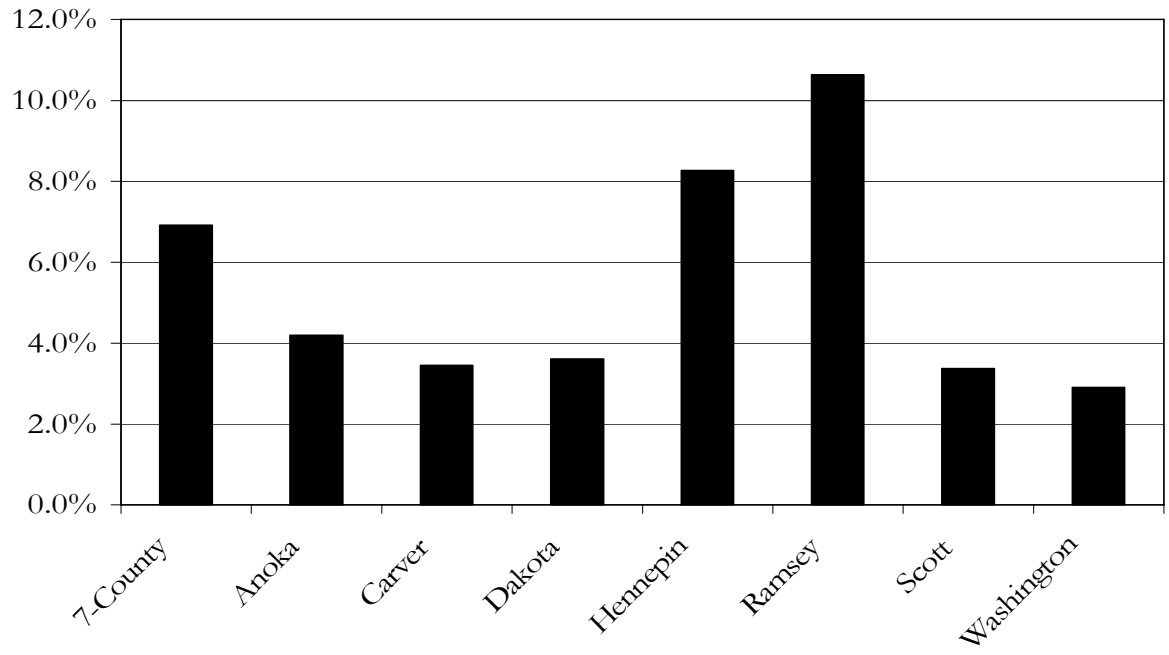

Figure 17 - Percent of population below poverty line, 1999 *Source: Bureau of Census 2000*

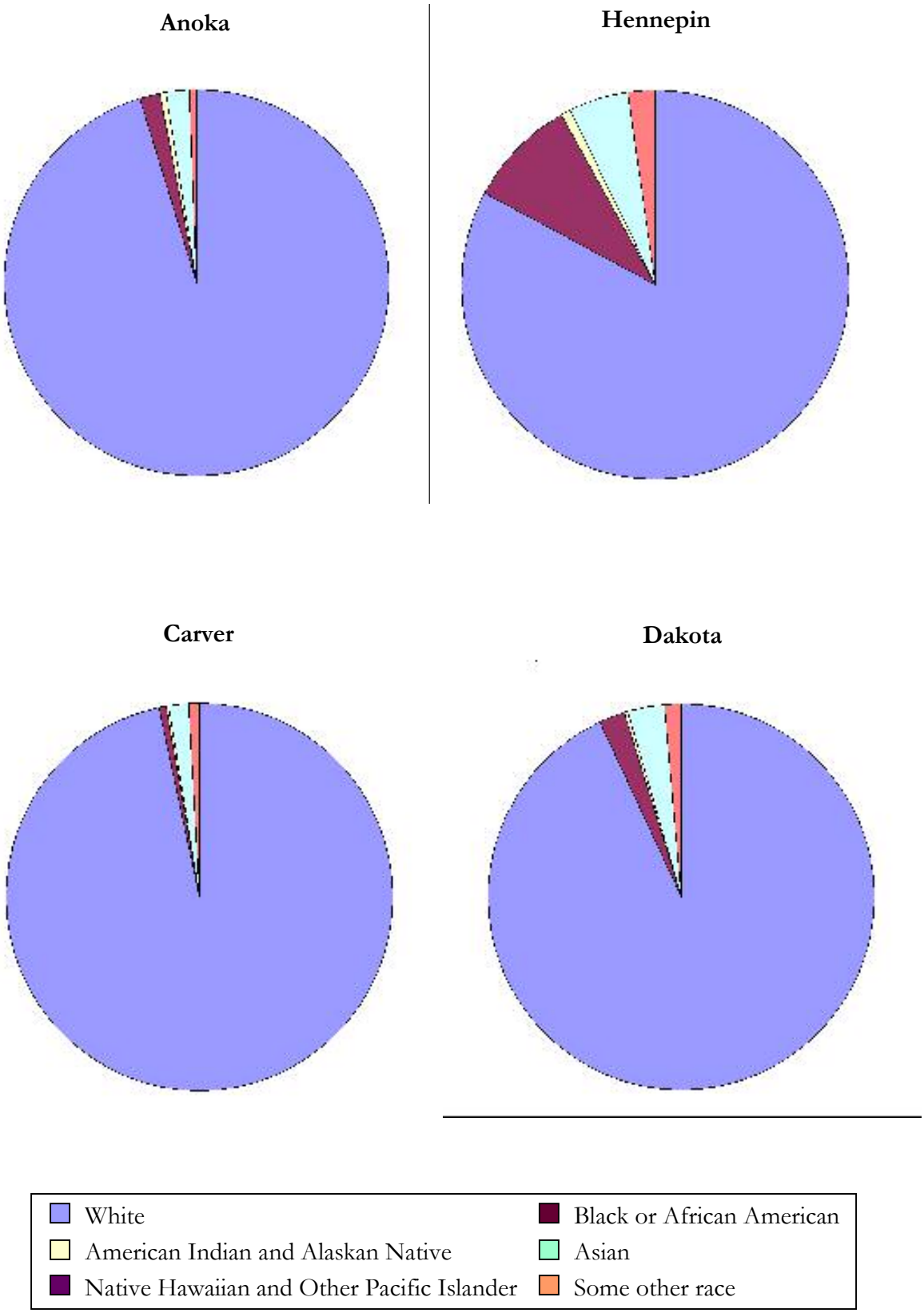

Figure 18 - Racial breakdown of 7-county area by percent, 2000 *Source: Bureau of Census 2000*

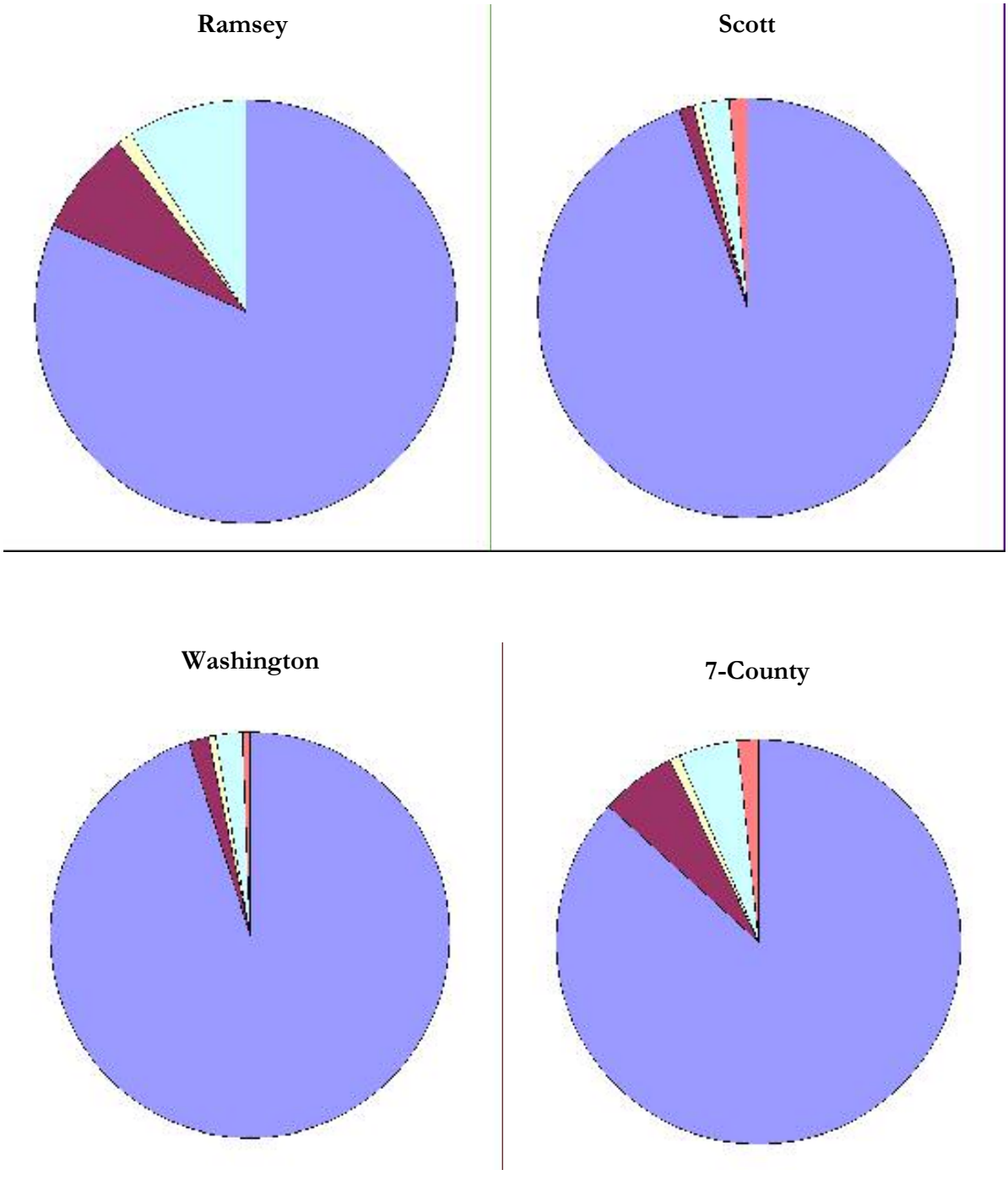

Figure 19 - Racial breakdown of 7-county area by percent, 2000 (cont.) *Source: Bureau of Census 2000*

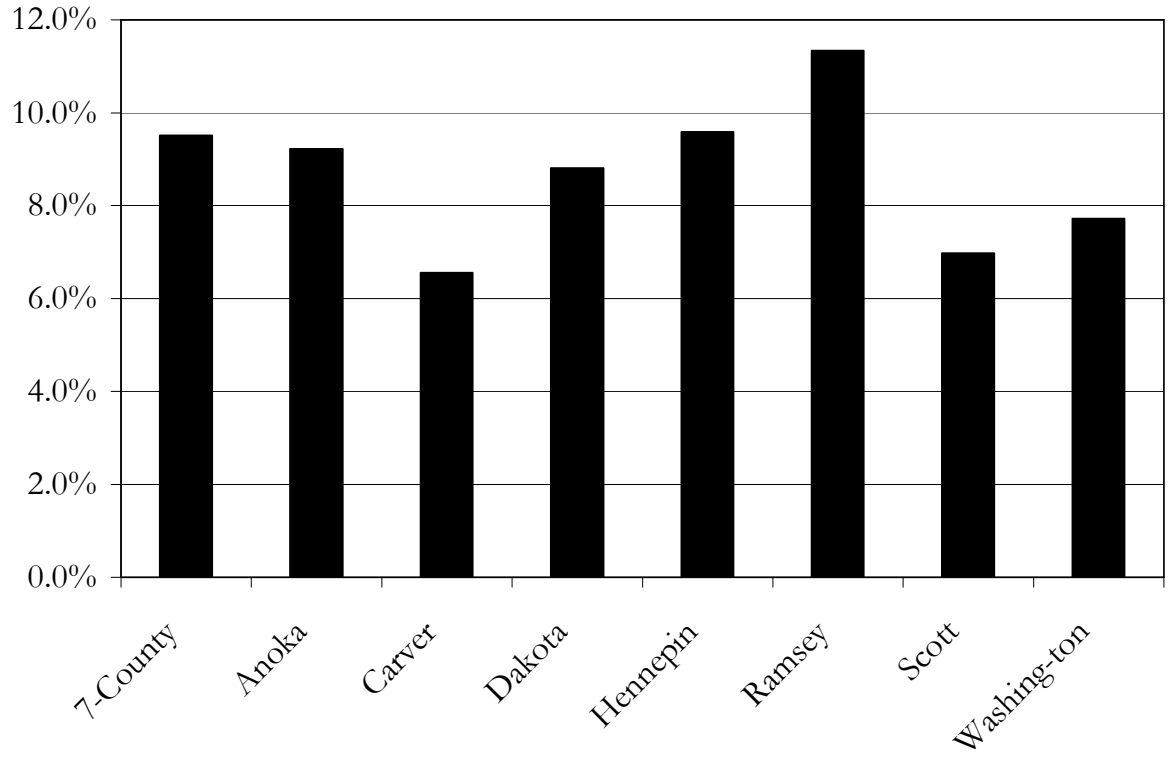

Figure 20 - Percent of 7-county households headed by single females, 2000 *Source: Bureau of Census 2000*

Appendix B: Demographic Maps – Minneapolis and St. Paul

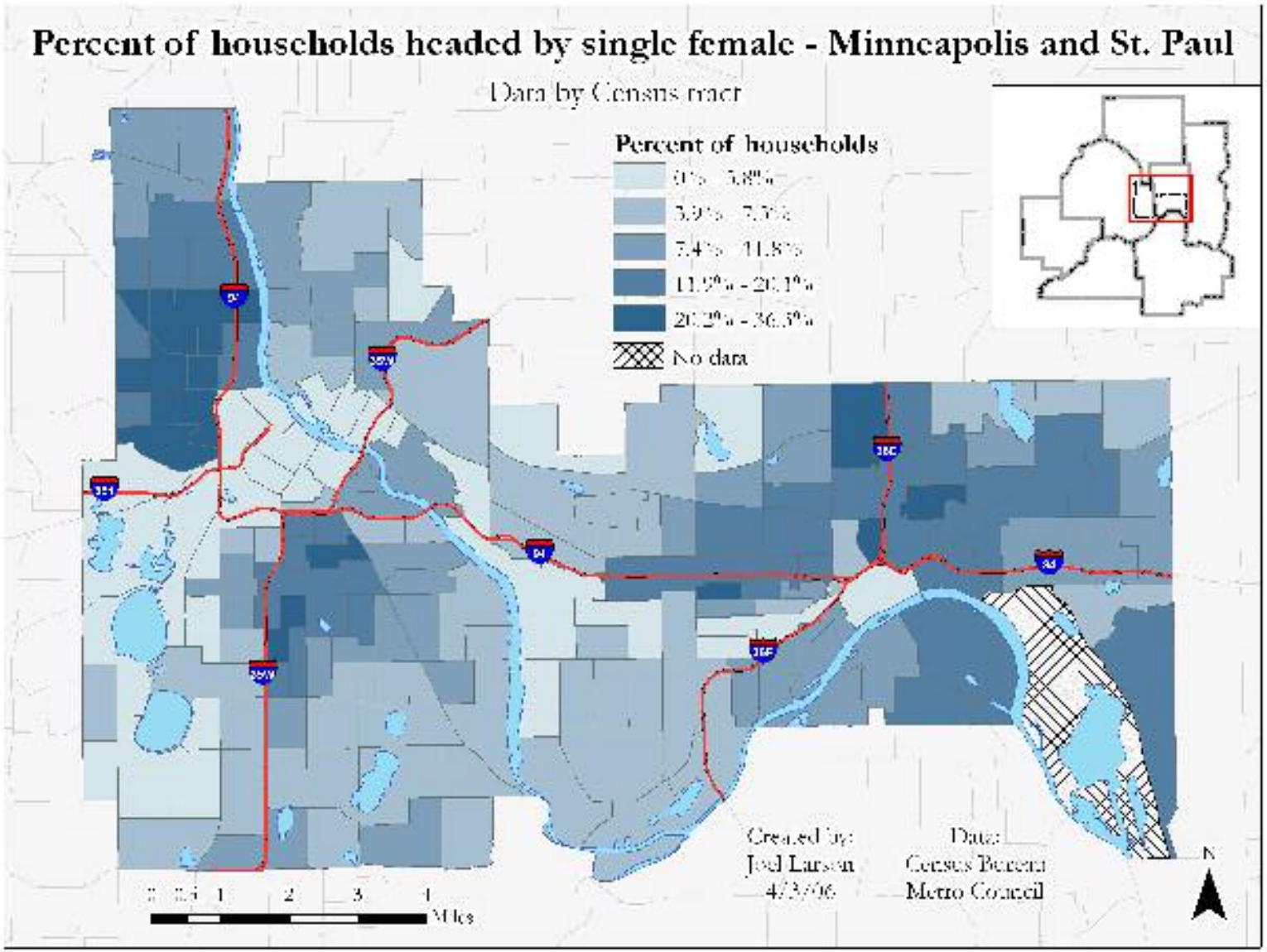

Figure 21 – Percent of households headed by a single female – Minneapolis and St. Paul, MN

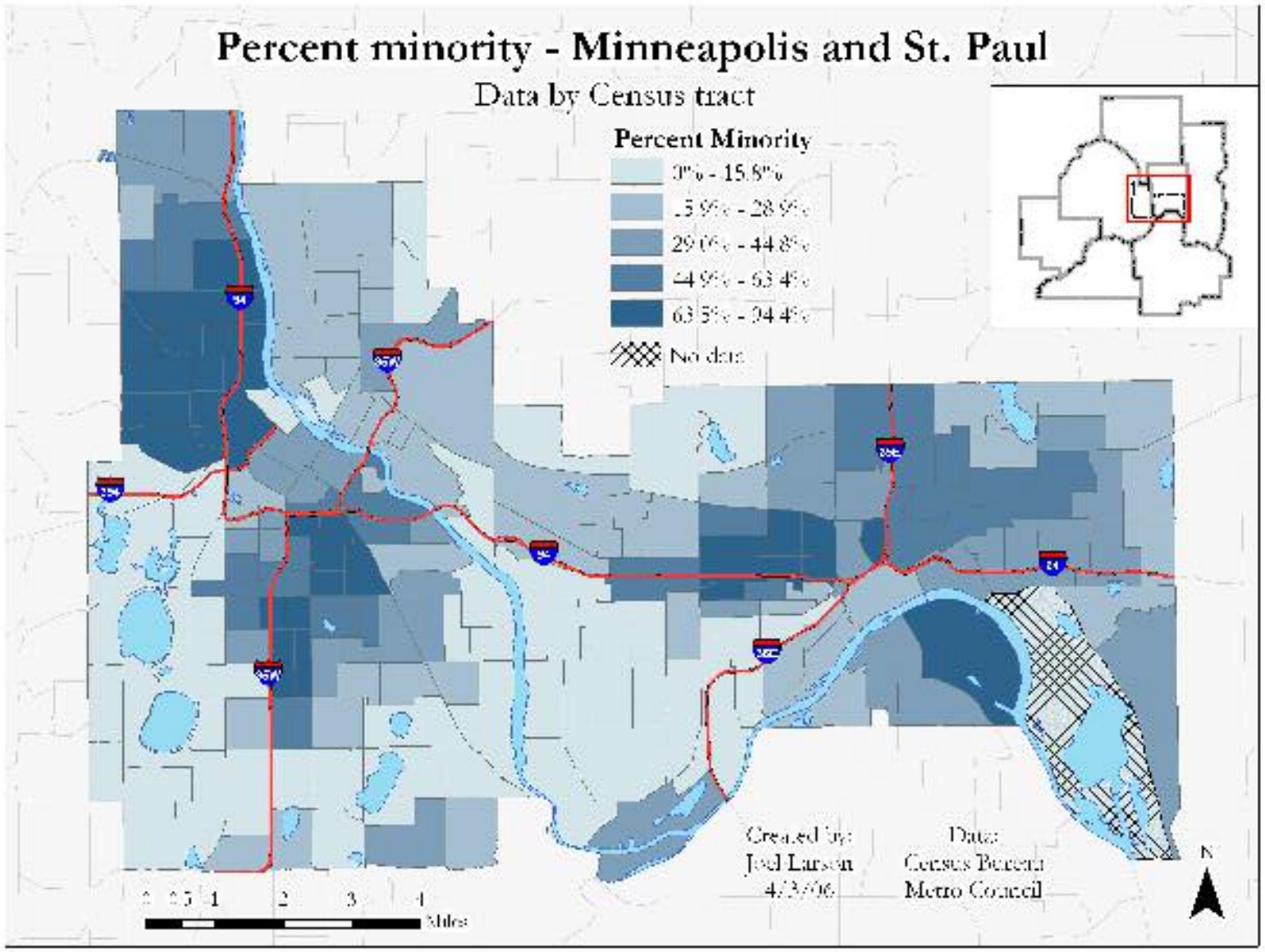

Figure 22 – Percent of minority residents – Minneapolis and St. Paul, MN

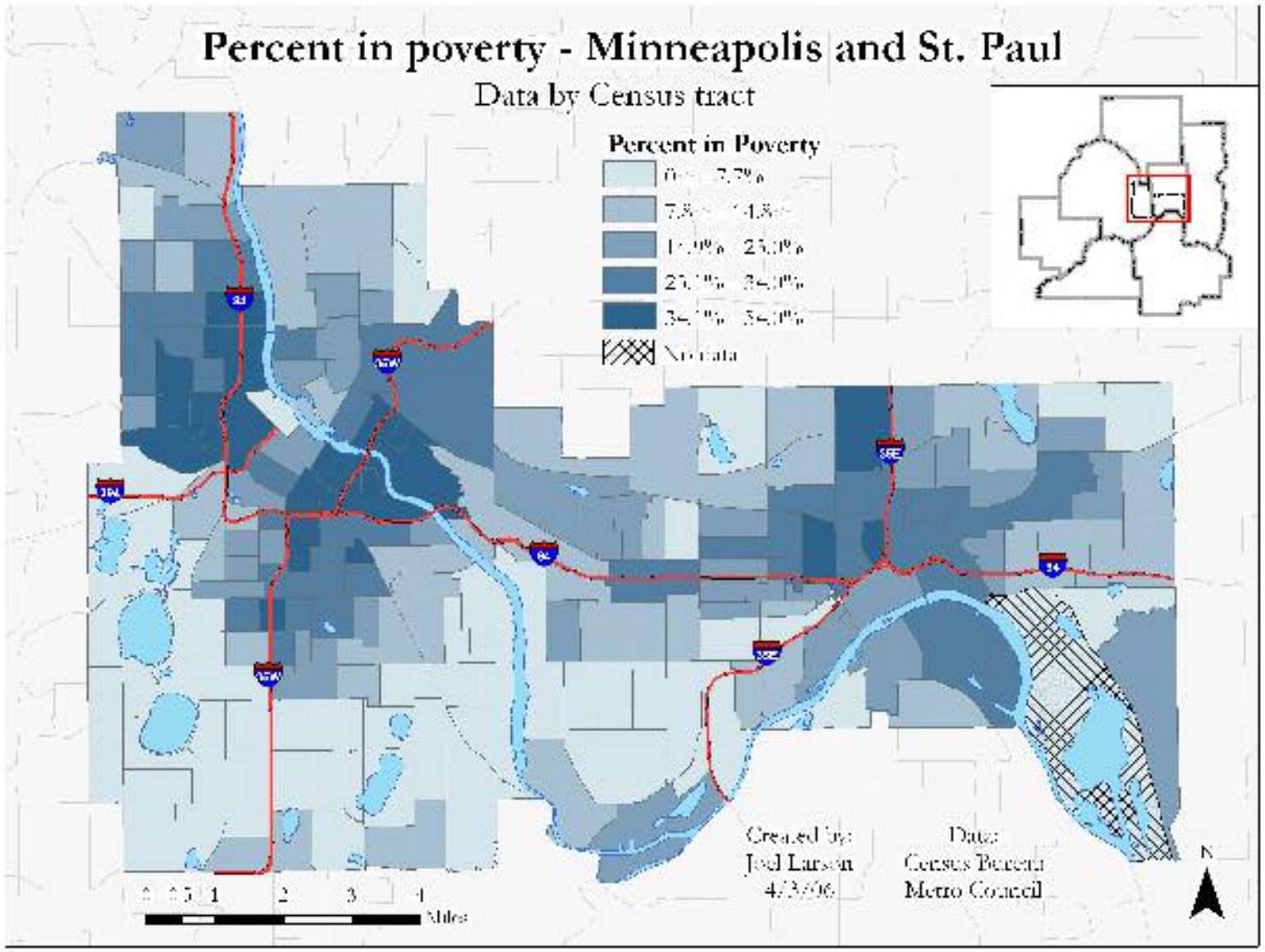

Figure 23 – Percent of residents in poverty – Minneapolis and St. Paul, MN

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