MARKET AREA MODELING AND NETWORK ANALYSIS OF AN AGRICULTURAL COOPERATIVE SYSTEM USING A GEOGRAPHIC INFORMATION SYSTEM

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INTRODUCTION

Introduction

Grain cooperation is an integral part of the American agricultural sector. A grain cooperative is simply a group of farmers working together to provide farm inputs and sell grain outputs for the best possible price. It is a type of 'economy of scale' in which a host of farm inputs such as seed, fertilizer, pesticides, herbicides, and fuel, to name just a few, are purchased in bulk by the cooperative to pass savings on to the individual member farmers. The same principle works in reverse for the grain output function of cooperation. Farmers sell their grain (e.g. corn, wheat, oats, grain sorghum, and soybeans) to the local cooperative elevator in hopes that collectively, a greater price per bushel will be paid by the end user for all of the cooperative's grain. Grain cooperatives are unique in the sense that few, if any other businesses provide goods or services to the customer (in the form of farm input sales), and then, in turn, buy goods from the same patrons (through the purchase of grain outputs).

Usually, a regional cooperative 'firm' exists which owns or manages several local cooperative 'locations'. Concurrently, however, there are usually several 'independent' grain cooperatives located across the agricultural landscape that are not owned by a larger regional cooperative firm and operate only for the benefit of the farmers in a given locale. Therefore, both 'independent cooperatives' and 'regional cooperative locations' exist, often side-by-side in an agricultural region, vying for that area's farm input and grain output business.

Grain cooperation is no different in southwestern Kansas. The only variations in the manner in which cooperatives function from region to region relate to the types of farm inputs required and the variety of outputs produced. For instance, the primary grain outputs in southwestern Kansas are corn, wheat, and grain sorghum. Considerable variation exists, however, in the spatial arrangement and operation of grain cooperatives and their associated market areas or 'drawsheds.' These drawsheds, which define the customer base (farmers), are not static across the landscape; rather, they contract and expand spatially depending upon the price and location of not just that individual 'elevator' (grain collection center), but all of the surrounding cooperative locations. Although privately owned farm input suppliers and elevators are not considered for this application to southwestern Kansas, delineating drawsheds on the agricultural landscape is further exacerbated when these non-cooperatives are considered. Grain cooperation and its spatial ramifications do not occur in isolation. Instead, each cooperative location in southwestern Kansas is competing with all neighboring locations for its customer base. Hence, the corresponding drawsheds are in a constant state of flux.

An understanding of the development of agricultural cooperation in the United States is necessary in order to demonstrate, through geotechniques, the impacts of marketing on agricultural geography from the perspective of grain cooperatives. Following is the statement of the problem and objectives of this study followed by a justification for this research in the realms of both agricultural geography and geotechniques along with the importance not only to cooperation across the country, but for other applications using similar techniques, as well. Next, a brief discussion of the growth of cooperation is outlined in the context of American society. Finally, the study area is defined and those characteristics of southwestern Kansas germane to agricultural cooperation are identified.

Statement of the Problem and Objectives

Despite the existence of agricultural grain cooperatives for nearly 140 years, little has been done in the way of studying their market/service areas. Most of the related literature focuses instead on retail store location and choice of suburban shopping centers (Brown 1992). The focus here is to model marketing and geography concepts using a geographic information system (GIS) to conceptualize the movement of grain outputs, farm (service/product) inputs, and market area fluctuation through a series of spatial database models for farm cooperatives using data from a seventeen county region of southwestern Kansas. The desired output is a set of models that capture both the market share for farm inputs (services) on a county level, as well as drawsheds of outputs (yields) for the three crops of corn, wheat, and grain sorghum based upon the historical production data of the study area. Once these drawsheds are established using Thiessen polygons, *ceteris paribus* assumptions are relaxed to see the effect the knowledge of economic distance (reflected in the pricing differentials of cost of transport and grain) plays on the expansion or contraction of each drawshed. Likewise, the effect distance to the regional grain terminal, located in Hutchinson, Kansas, plays on the bid price offered for grain by a cooperative is demonstrated using network analysis. Finally, the management of point-of-sales data for products and services offered by a cooperative are illustrated through a spatial database using fertilizer data from the region as a hypothetical example.

The purpose of this study is to combine marketing and GIS to model geographic concepts in an attempt to understand how all of the aforementioned factors work together to influence the respective outcome (drawshed, price, market area). Since the underlying goal is to educate for better comprehension, the impetus of this study lies in the conceptualization of geographic thought through the use of geotechniques, not on an empirical explanation of what is occurring in a given region--southwestern Kansas.

Several questions exist which these models seek to address.

1. How do the pricing differentials (related to distance/transportation costs and price) affect the contraction and expansion of crop drawsheds?
2. What impact does the distance from the regional grain terminal located in Hutchinson, Kansas have on the 'bid price' offered for grain by a local cooperative?
3. How can an individual cooperative utilize a spatial database to handle point of sales data for the farm inputs it provides?
4. What portion of the farm input market share (for fertilizer), portrayed at the county level, is captured by each respective cooperative?

I posit that the price offered for grain or charged for a farm input, the distance, and the competitiveness of the regional centers all play a significant role in determining the grain drawshed and product market share of a given cooperative.

Justification of Research

Addressing these questions serves two purposes. First, combining marketing and geography through a spatial database for the purpose of conceptual modeling lends insight into the market/service areas of agricultural cooperatives. More specifically, by conceptualizing various aspects of geographic thought using data from the southwest region of Kansas, the spatial efficiency of individual cooperatives are examined in an attempt to better understand how externalities such as price or distance impact crop drawsheds, prices offered for grain, or the portion of the service market share captured. Additionally, by educating ourselves and others on how these may interact in a given scenario to influence geographic space (reflected in movement of drawsheds, due to price and distance, or market shares), suggestions for the improvement of their spatial efficiency (by computing network costs to derive competitive bid prices that capture the grain market share necessary to maintain a profit) are made. This may have positive, pragmatic implications for grain cooperation throughout the country.

Second, this study serves a broader purpose by filling the agricultural market area void in the literature, forming a basis for the future use of spatial databases in modeling both marketing and geographic concepts. Although a plethora of research addresses both cooperatives or market analysis/store choice, no known study assesses the market/service areas for grain cooperatives. This study's aim, in part, is to make a contribution within the agricultural, marketing, and geographic communities.

Overview

The cooperative movement can be traced to England, where, in 1844, the Rochdale Society of Equitable Pioneers was founded by eight charter members. This was not the first attempt at cooperation in England; rather, it was the first successful one. Within the first decade following the founding of Rochdale, more than 130 cooperatives were operating in Northern England and Scotland (Alanne 1941). The Mayflower Compact of 1620, in which the Pilgrims joined together in a cooperative nature to advance mutually beneficial activities such as land clearing, home construction, and fence building, is often cited as the first example of American cooperation. It was not until after the Rochdale Society emerged in England, however, that the cooperative spirit branched out into other facets within society such as the urban, industrial, or even agricultural sectors (Abrahamsen 1976).

After the depression of 1857, the ideas of the Rochdale Society were first introduced in the United States by Horace Greeley via the *Self Help by the People,* which detailed the efforts by the founders at Rochdale. Following local interest, the first merchant cooperative on American soil was founded in late 1862 and later opened in Philadelphia as the Union Cooperative Association No.1 in 1864. Although it failed only two years later due to over-ambitious expansion, the popularization of cooperation through the Union Cooperative and the writings of its founder, Thomas Phillips, led to the establishment of nearly thirty grocery stores from Boston to San Francisco and gave the cooperative movement a foundation in the United States (Knapp 1969).

Agricultural Cooperation

Prior to the establishment of a merchant cooperative at Rochdale and its subsequent expansion in America, farmers within the newly independent United States began to organize cooperatives for the importation of purebred cattle as early as 1780. This led to community cattle drives to the East Coast, in addition to other agricultural functions like husking, threshing, and the production of cheese which was best facilitated through group cooperation. In 1810, the first commodity specific associations were established to manufacture cheese in Connecticut and New York. This was followed in 1820 by a cooperative for the slaughter of hogs by Ohio farmers and their subsequent transport to markets in Montreal. Concurrently, rural mutual fire insurance companies were organized in New England and quickly expanded, becoming the role models of American cooperation. Mormon settlers in Utah devised a highly successful irrigation cooperative in the 1840s in which users purchased water on the basis of the cost of providing the service. In the 1850s and early 1860s, farmers' clubs were established in Wisconsin, Illinois, and New York to purchase farm supplies and fertilizers. Finally, in 1857 the first cooperative grain elevator was organized in Madison, Wisconsin (Knapp 1969; Abrahamsen 1976).

Following these local cooperative efforts in the United States were two major agricultural movements which emerged after the Civil War. Both the National Grange and Farmers Alliance brought farm cooperation to the agricultural regions of the country. Founded in 1867, the National Grange organized over 20,000 granges with more than 540,000 members in the Midwest, New York, and California for the purpose of deriving a cost advantage for local farmers by purchasing large quantities of groceries, farm supplies, hardware, and farm machinery (Wiest 1923; Knapp 1969; Abrahamsen 1976) . After the heyday of the National Grange in the late 1870s and early 1880s and its subsequent demise in the early 1900s, the Farmers Alliance emerged and spread over the entire South by forwarding a similar agenda. Although both organizations died rather prematurely, they demonstrated the importance of, and advantages derived from, cooperation. These large scale movements of the late 1800s laid the foundation for more successful cooperatives of the 20th century such as the Farmer's Union (begun in Texas in 1902) and the Farm Bureau Federation of 1919 (Wiest 1923; Knapp 1969; Abrahamsen 1976).

Although agricultural cooperatives in the United States had been present for nearly 150 years, it was not until 1922 that they were officially sanctioned by federal legislation. The Capper-Volstead Act insured their continued importance in American Society. Subsequently, the Cooperative Marketing Act of 1926 created the Farmer Cooperative Service division within the U.S. Department of Agriculture, and the Agricultural Marketing Act of 1929 established the Federal Farm Board setting up a fund to make loans to agricultural cooperatives and aid in the stabilization of farm prices (Sapiro 1926; Legge 1929; Nourse 1940; Knapp 1973; Abrahamsen 1976). As a result of early successful attempts at cooperation, and federal legislation which facilitated their continued growth, agricultural cooperatives became firmly rooted in American society.

Study Area

Agricultural Cooperation and Southwestern Kansas

Grain cooperatives operating within the seventeen county region in extreme southwestern Kansas comprise the study area for this project (Figure 1). This region is roughly rectangular in shape and is composed of three adjacent counties in the north/south direction and six from east to west including Clark, Comanche, Edwards, Finney, Ford, Grant, Gray, Hamilton, Haskell, Hodgeman, Kearny, Kiowa, Meade, Morton, Seward, Stanton, and Stevens counties. Only those cooperatives within the

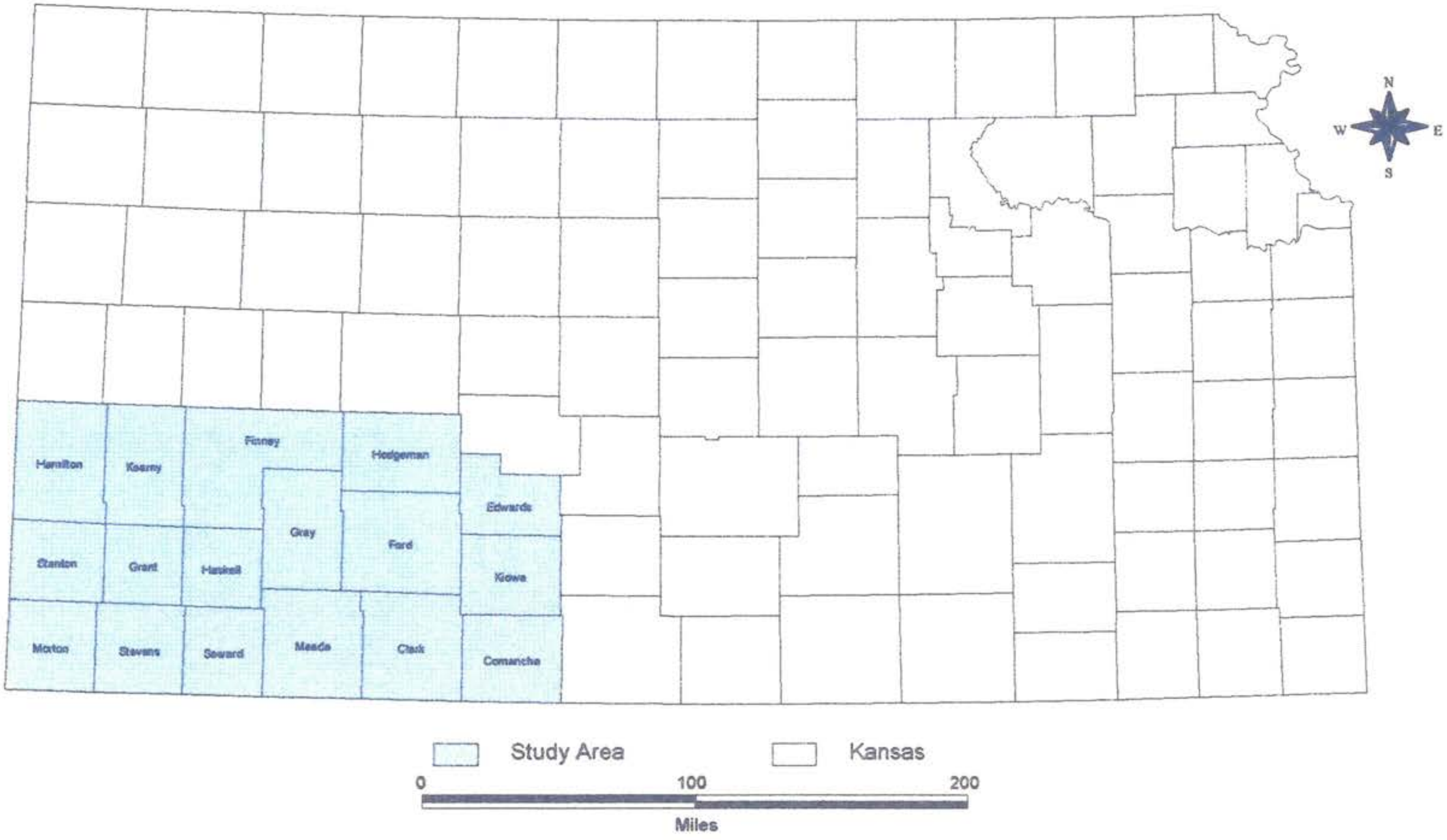


Figure 1: Seventeen County Study Area in Southwestern Kansas

study area that were operational in 1987, or subsidiaries of those from outside the region that have a branch located within the region, are considered.

Southwestern Kansas was chosen for this study for several reasons. First, the region has a uniformly geometric shape and is served by regional grain marketing centers from three different states: Kansas, Oklahoma, and Texas. Similarly, it is believed that regional activity within the study area comprises a good microcosm of cooperative activity. From an economic perspective, southwestern Kansas functions as an 'isotropic' plain. No major topographic barriers or large urban centers exist that might skew the transportation costs associated with the movement of grain. Conducting a conceptual study of agricultural cooperation in this area has implications that can be transferred to other cooperative regions, may depict the larger picture of cooperative activity in agricultural regions across America, or might even be appropriate for other spatial database modeling applications that utilize geographic concepts and techniques. Finally, this area and the 1987 season were selected because an earlier study using the same region provides a spatial data set of cooperative locations that is adopted for the conceptual modeling within this study. In the thesis, the spatial and temporal development of cooperatives in southwestern Kansas was assessed from 1902 until 1987.

Characteristics of Southwestern Kansas

In 1987, an estimated 2,475,000 people lived in Kansas, 128,600 of whom resided in the seventeen county study area. With an area of 14,007 square miles, the density of southwestern Kansas is just over 9 persons per square mile. Precipitation for the study area averages 18.56 inches over a thirty year period while the state mean is 26.95. Rainfall ranges from a low of 18.2 inches in the southwest corner of the region to a high of 29.5 inches at the northeast edge in Hodgeman county. The average July temperature for the study area is 77.2 degrees Fahrenheit with an annual mean of 55.5 degrees (*Kansas Statistical Abstract 1990-1991).*

Kansas' total net farm income for 1987 was 1.555 billion dollars. On an individual crop basis, Kansas ranked first in grain sorghum and wheat production for 1990 with 184.8 and 472 million bushels or 32.3 and 17.2 percent of the US supply respectively. Wheat production was up from 263.5 million bushels in 1987 while sorghum was down sharply from 273.75. Corn production in Kansas ranked 11th with 188.5 million bushels or 2.4 percent of all US production (*Kansas Statistical Abstract 1990-1991).*

Regionally, southwestern Kansas produced 32.3 percent (49.1 mil. bu.) of the state's corn in 1987, 18.4 percent (50.3 mil bu.) of the grain sorghum and 21.8 percent (79.9 mil. bu.) of all wheat (Kansas Department of Agriculture 1988). A total of 1.4 million tons of fertilizer were applied in Kansas during the 1987 growing season. Just over 20 percent, some 285,261 tons, was used in the southwestern Kansas study area.

Organization

This chapter has defined the scope and set the context for this study of agricultural cooperation within southwestern Kansas. The following chapters cover other pertinent aspects of this study's effort to conceptualize grain cooperation in southwestern Kansas and are organized as follows: Chapter Two explores related works in the literature dealing with agriculture, market areas, store choice/store location, gravity models, and spatial databases. Chapter Three covers the methods used in this study to collect, aggregate, manipulate, and analyze the data. Subsequently, the construction of drawsheds and market areas, along with the manner in which they are adjusted following the relaxation of *ceteris paribus* assumptions, is discussed. Finally, exit points for grain traveling to the regional terminals are defined in order to demonstrate the impacts of distance on bid prices using network analysis. Chapter Four is an in-depth analysis of a) the effects economic considerations (price and distance) have on the expansion or contraction of the local drawsheds and b) how distance to the regional grain terminals affects the bid price offered for grain at local elevators. Also discussed, from the perspective of farm inputs, is the manner in which point of sales data could be handled by individual cooperatives using a spatial database, and the service market share captured by each. Chapter Five begins with an evaluation of the appropriateness of using a spatial database as a medium for a study combining marketing and geography in the context of the specified goals outlined in the first chapter. The latter portion of Chapter Five is devoted to general concluding comments from this study, with areas for improvement and specific avenues for future research outlined.

CHAPTER 2

LITERATURE REVIEW

Introduction

In order to undertake a cross-disciplinary study of market share/area delineation and analysis of grain cooperatives, a review of both the agricultural and marketing geography literature is needed. This chapter identifies major relevant works on agricultural cooperatives, market area delineation and analysis, and the use of spatial databases as a medium for spatial interaction modeling. Related works on market area delineation and analysis are divided into several separate categories. The initial body of literature focuses on Reilly's Law and its major adaptations, followed by a look at the shape and size of market areas and their delineation. Next is a discussion of the development of the gravity models and their progression to current forms. A look at gravity models is further subdivided into Wilson's versus Huff's approaches. The remaining sections of this chapter explore the use of Thiessen polygons and their potential application for the construction of cooperative drawsheds, and the use of spatial databases for the modeling and management of this phenomenon.

Although various aspects of many of these works are applicable to the study of agricultural cooperatives or market areas, none of them deal specifically with a market area analysis of agricultural cooperatives. A basis for this study is found, however, in works from each of the respective subfields involved--agriculture, marketing, and geography.

Agricultural Cooperatives

Although grain cooperation began in the United States following the Civil War, much of the literature detailing this phenomenon was generated in the mid 20th century. Alanne (1941) outlined the origins of consumer cooperation in his *Fundamentals of Consumer Cooperation,* which saw seven revisions since the original in 1935. The founding principles of cooperation first established at Rochdale were discussed in the context of the aims and purposes for cooperation. Alanne noted the consumer (member) of a cooperative is motivated by: obtaining high quality products at reasonable prices, the eradication of corrupt business practices from trade, and the elimination of economic competition and waste from the distribution process. Alanne concluded with sections discussing differing types of cooperatives (consumer versus producer) and a comparative analysis of cooperatives and stock companies.

Knapp (1969, 1973) produced a two-volume history of the American cooperative system from 1620 through 1945. He addressed the earliest attempts at cooperation by the New England Pilgrims for settlement, its beginnings in agriculture by the Philadelphia Society in 1785, major grass-roots organizations such as The Grange and Farmers' Alliance of the 1870s and 1880s, as well as major pieces of federal legislation and institutions which fostered the development of cooperatives in America. Abrahamsen (1976) reviewed, in greater detail, the development of the cooperative and its role in

American society. Following his explanation of cooperative development and the historical account of its progression in the United States, Abrahamsen (1976) outlined growth strategies, taxation, finance, and management practices derived from cooperation.

The role and scope of agricultural cooperatives within the free market was the focus McBride (1986) took in his book, *Agricultural Cooperatives: Their Why and Their How.* Once the structure of agriculture was presented in the context of business, advantages derived from cooperation and the federal legislation that made it possible were outlined. The latter portion of his work was devoted to "how" cooperatives function in agriculture. Specifically addressed was the viability of farm cooperatives for solving basic problems in marketing, finance and taxation, suitable leadership within the cooperative for effective performance/service to the member, and how this is assessed.

Agricultural cooperatives' ability to compete with other investor-owned firms (IOF's) was the question raised in an article by Rhodes (1983). The author asserted the presence of relative advantages derived from cooperation which IOF's can not or will not provide. First, farm members viewed the organization as serving their particular interests, especially during the first two generations of cooperative organization. Likewise, members possessed a greater degree of confidence in their cooperative's efforts to not only continue its purchase of commodities such as grains or milk, but also to actively seek higher prices for their members' commodities. Finally, members were motivated by patronage dividends paid by cooperatives despite the fact they were often sporadic in nature and varied in magnitude. Rhodes (1983) concluded by noting through the use of a model that although cooperatives are special firms with certain relative advantages over IOF's, they still seek to maximize earnings (profits) within their respective markets.

The share of patronage refunds that agricultural cooperatives retain was the focus of a study by Knoeber and Baumer (1983). They constructed a model to ascertain how much of the members' refunds were retained for the purpose of raising equity. The model was then compared to the refund patterns of seventeen regional agricultural cooperatives and found to be consistent.

A more recent study by Rogers and Petraglia (1994) looked at the role of agricultural cooperatives in food manufacturing. Very large, capital intensive food processors have emerged in the United States as a result of the need for economies of scale to cut production costs and because of the vulnerability most farmers face due to the extreme bulk and perishability of their commodities. The net effect was the continued growth in market domination by the largest value-added firms, which have captured more than 70 percent of the market. Rogers and Petraglia (1994) demonstrated through the competitive yardstick effect that a greater presence by cooperatives in the food processing market reduced the price-cost margin of these value-added industries, thereby increasing the price for the individual member and/or lowering it for the end consumer.

Market Area Analysis

The relationship between individuals (potential customers) and a market/center was first recorded in Reilly's (1931) *The Law of Retail Gravitation.* Although he was not the father of the 'gravity model,' Reilly (1931) was the first to articulate the relationship between a market and consumers using a derived formula based primarily upon

Newtonian physics. Carey (1858) was actually credited with introducing the idea of human interaction being influenced by some sort of gravitational attraction. The first empirical study using Carey's (1858) conceptualization was undertaken by Ravenstein (1885) who looked at internal migration within the United Kingdom. Ravenstein (1885), however, did not specifically mention distance in his relationship. It was not until Young (1924) undertook a similar study in the United States that the distance component was incorporated.

Major Adaptations

One of the major initial innovations to follow *The Law of Retail Gravitation* was the reworking of Reilly's (1931) original formula by Converse (1949) to create the 'break-point,' identifying the location at which the influence (attraction) of two markets/centers is equal, and enabling a delineation of their respective market areas. Although Converse's (1949) article in the *Journal of Marketing* was credited with this break-through, he actually proposed it fourteen years earlier in *The Elements of Marketing* (Brown 1992). Converse's (1935, 1949) contribution to Reilly (1931) helped facilitate the study of trade area delineation and forms the basis for many techniques used today (Ghosh and McLafferty 1987).

Huff (1963, 1966) provided a second major adaptation of Reilly's (1931) original law. Although not the first to consider two or more competing markets or overlapping trade areas (Reilly actually proposed both himself in 1929 and 1931), Huff was the first to focus Reilly's Law on the choice of individual consumers and address attraction from the perspective of store specific applications, which inevitably changed the focus of the study of retail attraction (Brown 1992). According to Huff (1966), consumers selected from among several competing markets based upon the total 'utility' derived. A consumer's utility was determined by modeling all those forces that attract consumers to the market (such as relative size) and contrasting them with all deterrence factors (such as time/distance) which inhibited interaction. Huff (1966) forwarded the work of other scholars, such as Luce's (1959) choice axiom, in asserting the probabilistic 'revealed preference' approach to attraction. It is probabilistic in nature in that all competing centers have a calculated likelihood of being patronized that is directly related to their size, and inversely related to the distance from the consumer and the utility of all intervening markets (Brown 1992). Huff (1963) asserted that the probability of an individual patronizing a given market/center was equivalent to a ratio of a given market's utility compared to the total utility of all centers considered by the consumer. 'Revealed preference' referred to those stores that an individual actually patronized rather than their expressed preference (Berry and Parr 1988). Huff (1966) maintained that, from this information, the optimum store location could be derived. It is the development of research building upon Huff's (1963,1966) adaptation of Reilly's Law that is pertinent to the study of farm cooperatives in Kansas. By facilitating the study of individual cooperatives and their respective trade areas, recent models developed from Huff's (1966) are relevant in determining a cooperative's market share and total utility to the farmer via distance, price, and intervening opportunities.

Market Areas

Christaller (1966) asserted that the ideal shape of a market area was hexagonal since it is the only space filling object in which all sides are equidistant from the center and an even distance exists between all nodes of similar order. The ideal size of each hexagonal market area is contingent upon the 'order' of goods sold. Lower order goods--which are required more often by consumers (and often cheaper) and, therefore, more accessible to the consumer--commanded a smaller market area than goods of 'higher' order. Since the time of Christaller, scholars have noted many factors that alter both the shape and size of this idealized market area (Goldstucker *et al.* 1978).

Vaile *et al.* (1952) suggested that product differentiation, the range of choice in pricing, economies of scale, and the availability of adequate markets adjacent to the firm all contribute to the size and shape of the market area. Other physical (rivers, highways), physiological, and cultural (racial/ethnic) barriers exist that impact the size and shape of markets (Goldstucker *et al.* 1978). Applebaum and Cohen (1961) pointed to the existing competition, population density, accessibility to, and image of, the firm, income level of the consumer, and the availability of products versus the friction of traffic as crucial elements in determining market area size. They also suggested that market areas in suburban locations tend to be elliptical, with the longest axis moving away from the central business district (CBD) and elongated in the direction of consumer movement (along a highway). These market area boundaries were often found to be dynamic rather than static in nature with either seasonal changes (perhaps growing season of farmers in southwestern Kansas), weekly variations as Applebaum and Cohen (1961) noted exist with supermarkets, or as Peterson (1974) observed, throughout the day in the case of new shopping malls (Goldstucker *et al.* 1978).

Growth and Development of Gravity Models

Reilly's (1931) original attraction and deterrence variables were population and travel distance. Some of the early modifications to the gravity model focused on identifying more appropriate descriptors for attraction and deterrence. Voorhees (1957) replaced the population attraction attribute with floor space, while Lowry (1964) substituted total employees and Rhodes and Whitaker (1967) focused on the turnover of goods. Concurrently, road distance as the major deterrent was replaced with various indices such as Euclidean distance, travel time, and a congestion index (Gibson and Pullen 1972; Brunner and Mason 1968; Parry-Lewis and Traill 1968).

Further adjustments to the gravity model were made when Pacione (1974) adapted the attraction coefficient to account for the disproportionately larger options for shopping in larger urban areas relative to smaller cities. The friction of distance was also found to vary considerably among the lower and higher order goods, and as Mayo *et al.* (1988) noted, among differing socioeconomic groups as well as the particular retail activity being studied (Garrison 1956; Huff and Jenks 1968; Young 1975; Yuill 1967). As previously addressed, the continued adjustment of both the variables and parameters within Reilly's (1931) original gravity model altered the strict Newtonian gravity analogy and led to alternative approaches such as that proposed by Huff in 1966 (Brown 1992).

Operationalizing Huff's (1963, 1966) alternative approach to the gravity model required consumer survey information, data which in the early days of spatial interaction was not readily available. A deviation of this model, however, became popular which did not require extensive survey data (Brown 1992). Lakshmanan and Hansen (1965) developed an intraurban model for the Baltimore metropolitan area in an effort to project the potential of future shopping. A variable was devised to represent future retail expenditures in each of the residential zones within the Baltimore area. Each zones' projected expenditures were then allocated among the shopping centers within the

Baltimore region based upon the previously mentioned principles of spatial interaction/gravity models (Lakshmanan and Hansen 1965).

Lakshmanan and Hansen's (1965) model was an early example of a 'production-constrained' gravity model since allocation was limited to only the potential retail expenditures (Wilson 1971). Furthermore, this model denoted a transition between Huff's (1966) multiple center intraurban application of the gravity model (unconstrained) and the contrasting theoretical approach taken by Wilson (Brown 1992). Wilson (1967) demonstrated how the original gravity model can be derived by utilizing entropy maximization techniques from statistical mechanics rather than the traditional approach based upon Newtonian physics. Entropy maximizing forwarded by Wilson (1967) uses statistical averaging to support the assumption that the overall pattern of spatial interaction within a region is represented by all possible combinations of individual behavior. After considering all feasible combinations of interaction, Wilson's (1967) gravity model was determined by selecting the group with the highest probability (most likely). Wilson's (1967) entropy maximization, therefore, represents a significant contrast to Huff (1966) and early derivations of the gravity model in two important aspects. First, it is not based on Newtonian physics but on statistical analysis. Second, spatial interaction is analyzed in the aggregate, rather than on an individual basis (Brown 1992).

Advances to Early Innovations

Huff (1963, 1966) and Wilson (1967) began to challenge basic assumptions of gravity modeling, which, up to that time, was relatively simplistic in nature. Building upon the work of both Wilson and Huff, the 1970s and '80s saw the emergence of highly sophisticated spatial interaction models which left many scholars critical of their appropriateness (Sayer 1977). Several breakthroughs, however, occurred during this growth period of spatial interaction modeling in three separate areas which improved the ability to model consumer behavior. First, various theoretical shortcomings were rectified in the Wilsonian (aggregate) approach. Second, Huff's disaggregate methods, which as previously mentioned required extensive consumer information, led to the detailed analysis of consumer preference and store usage. Finally, various empirical applications led to the solution of some technical problems which improved the quality of spatial interaction modeling (Brown 1992).

Wilsonian Aggregate Approach

An increasing amount of literature began to demonstrate how the traditional gravity model was not dynamic in its ability to adapt to a variety of situations and applications (Parry-Lewis and Traill 1968; Jensen-Butler 1972), could not account for trips which originated from locations other than the residence, or the fact that many consumers are unable to select from a variety of market/store alternatives with varied distances and inventory sizes, and was not intended to depict multiple shopping purposes (O'Kelly 1981; Lord and Mesimer 1982). Many individuals are, to a large extent, limited in their store choice due to income, mobility, or overall socioeconomic status (Curry 1972; Kivell and Shaw 1980; Mayo *et al.* 1988).

Volumes of literature resulted, which addressed the traditional gravity model's lack of dynamism (see Brown 1992). Harris and Wilson (1978) looked at the effects of supply on the model by introducing an attribute to account for the cost of providing retail floorspace. Following their lead, more recent improvements incorporated both store size and location, multiple retail centers (malls), and pricing strategies, as well as multiple purpose shopping excursions (Jayet 1990; Williams and Kim 1990; Oppenheim 1990; Huriot *et al.* 1989; Mazurkiewicz 1985; Roy 1990). Further demonstrating the gravity model's dynamic capabilities were Wilson and Oulton (1983), who showed how the model's attraction and deterrence variables, when slightly altered, can have adverse effects on the entire spectrum of retail trade from small convenience stores to large supermarkets, while others looked at the effects of both highly concentrated and dispersed distributions of retail behavior (Fotheringham and Knudsen 1986).

Huff's Disaggregate Approach

Improvements of Huff's model of consumer preference focused on behavior and individual perception. The original utility attribute, which was defined merely by the store size and distance the consumer must travel, was replaced by the customer's image of the individual store (Stanley and Sewall 1976, 1978), entire shopping center (Spencer 1978; Nevin and Houston 1980), and one's perception to distance and that of alternative transportation methods (Cadwallader 1975; Mackay and Olshavsky 1975; Gautschi 1981; Bucklin and Gautschi 1983). As with earlier alterations to the original gravity model, Huff's model was also adapted for variations between different individuals and among various socioeconomic, ethnic, and minority groups (Hubbard 1979; Howell and Rogers 1983).

Another popular spin-off of the Huff model focused not on the perception and behavioral issues already addressed; rather, it centered on the competition aspect. Nakanishi and Cooper (1974) developed the use of the multiplicative competitive interaction model (MCI) to introduce both the subjective variables of the individual consumer and more objective attributes that depict the relative attraction to all competing stores. The MCI is not the only disaggregate adaptation of the original gravity model, but it is the dominant method. For a list of MCI applications or alternative disaggregate models see Brown (1992), Craig *et al.* (1984) or Wrigley and Dunn (1988).

The foregoing literature is beneficial in providing an understanding of major works in both the agricultural and market analysis fields. Not addressed in either, however, is the application of market area/share delineation and analysis techniques to agricultural cooperatives. However, previous studies may yield insights into suitable techniques for this study in southwestern Kansas which may, in turn, provide a basis for comparison across the United States, thereby, affording a better understanding of agricultural cooperation.

Technical Aspects

Brown (1992) noted the emergence of two categories of technical issues which resulted from gravity modeling during the advancement period beginning in the 1970s--specification and calibration problems. The former related to the study area and the model's structure. The latter addressed the fit of the model to a particular application and related data set (Brown 1992). One of the early problems encountered was that of improperly calibrated models in which the attraction variable skewed the output (Openshaw 1973). Batty and Mackie (1972) and Openshaw (1976) noted the difficulty of estimating the model's closeness-of-fit to the data set as a result of the inappropriateness of using ordinary least squares. Others pointed to the influence the spatial distribution and interrelationships of the origins and destinations play in determining the outcome of the calibration (Olsson 1970; Bucklin 1971; Ewing 1974). When both the attraction and deterrence variables are allowed to vary, finding a single, unique solution to the problem of calibration becomes increasingly difficult (Batty and Saether 1972; Curry 1972; Openshaw 1975). In short, the model's parameters are influenced by both the interaction between the origins and destinations, as well as the morphology of the landscape (Brown 1992).

Inherent in the specification problem is the closed system portrayed by the gravity model. Major assumptions to this closed system are the even distribution of population within a region and the ability to account for all expenditures (Brown 1992). As Curry (1972) noted, retailing is not a closed enterprise. Furthermore, population is not evenly distributed (Roberts 1971), and the result is a system that is not easily delineated (Davies 1977). Just as the spatial arrangement of the origins and destinations impact the calibration of the gravity model, specification and the output that results is influenced by both the size and shape of the zones comprising the study area (Davies 1970). Similar to other problems identified with gravity modeling, the literature became inundated with studies addressing the technical problems encountered. Although few issues were completely resolved, the discussion that resulted improved the performance of gravity modeling. For an extensive bibliography addressing the various technical problems, see Brown (1992).

Thiessen Polygons

The use of Thiessen (Voronoi) polygons in conjunction with gravity models is based upon the same principle as Converse's (1949) 'break point'. While the break point is the weighted midpoint at which a consumer exhibits the same probability of patronizing either market, Thiessen polygons are delineated by drawing perpendicular bisectors (true median location) to the line adjoining two centers. When the perpendicular bisectors of all competing centers are connected, the market area, *vis-à-vis* the Thiessen polygon, is demarcated. Therefore, each of the polygons around a market contain all locations that are closer to it than any competitor (Evans and Jones 1987). Similar to Reilly's original law and Converse's break point, Thiessen polygons are not commonly used to delineate market areas since consumers seldom patronize the closest center or remain within the corresponding market area. Instead, Thiessen polygons are more commonly used in applications dealing with the physical landscape such as geology (Evans and Jones 1987).

Most recent applications of Thiessen polygons, in the geographic realm, related to drainage networks, digital terrain models (DTMs), and the use of triangulated irregular networks (TINs) to estimate relief. Kalmar *et al.* (1995) utilized a DTM to construct Thiessen polygons for developing a three dimensional crustal model in order to approximate the volume of sediments within the Pannonian Basin in Hungary. Macedonio and Pareschi (1991) recorded the use of triangulation (based upon Thiessen polygons) to represent surface elevations, volumes, and the reconstruction of surface features by interpolating a plane through vertices with a known location and elevation (TINs).

Martin and Williams (1992) utilized Thiessen polygons to determine the accessibility to general practitioner (GPs) health care providers in the United Kingdom. Market areas were initially delineated between GPs using the 'nearest center' approach provided by the polygons. Probability functions which account for distance and size (consumer choice) were then combined with these polygons to enhance the accuracy of the market areas. The newly created polygons represented boundaries delineating equi-probability of patronizing a given GP. As the authors asserted, this technique is only appropriate when the probability of selecting a given center (GP) is greater than that of any other and their market areas do not overlap (Martin and Williams 1992).

Thiessen polygons are limited in their ability to delineate market shares, and therefore, are not extensively used in market area analysis (Martin and Williams 1992). The physical sciences are more appropriately explained using Thiessen polygons and most of the current literature relates to these applications. While these polygons may provide an initial delineation of cooperative service areas in southwestern Kansas, extensive use of the technique for this, or other market area analysis applications involving the human element, is arguably inappropriate.

GIS and Spatial Interaction/Analysis

Although the GIS literature does not abound with retail analysis applications, spatial interaction modeling of real-world scenarios has been facilitated by the advent of the spatial database. Spatially organized and digitally stored information on store locations, transportation networks, and voluminous consumer data have facilitated a resurgence in the use of gravity models (Brown 1992). At an increasing rate, retail managers are realizing the importance of spatially organized information as a key input to the decision-making process (Beaumont 1992).

Although GIS has been utilized for the traditional marketing question of where to locate a company, store, or branch office, it is increasingly being used for 'MaxiMarketing' or the maximizing of resources to reach the most customers who are likely to patronize a center leading to the greatest return on an investment (Rapp and Collins 1987). Through this approach, GIS plays an integral part in identifying the appropriate medium to reach the most desirable customers and in encouraging their continued patronage through maximum service. This type of 'target marketing' was the focus of King's (1991) article which incorporated information from a Buffalo, New York, bank into a GIS to assess its regional performance and improve its market share without additional expenditures.

The increased use of GIS technology in the area of spatial interaction/analysis has led to discussions of appropriate techniques. The use of GIS for retail/market analysis is largely under-represented. This is due to insufficient spatial analysis procedures in most GIS and statistical analysis software, not because of a lack of interest or ability on the part of analysts. Although many effective procedures for dealing with geographical data exist (ranging from points, lines and areas) most are not yet available for most GIS's (Openshaw 1992). The reason for this deficiency is twofold. Initially, most software developers have not seen a need to devote many resources to integrating spatial analysis methods. Second, even if they did, a lack of consensus exists as to what analytical tools are needed with most GIS packages (Openshaw 1992). The net effect is that while attempts have been made in the GIS literature to address the need for integrating GIS and spatial interaction/analysis procedures, most applications incorporate only a limited amount of analysis techniques (the true potential of a GIS), and opt instead to use it as a glorified computer mapping package (see King 1991).

Conclusion

Spatial interaction modeling and market analysis have progressed considerably since the work of Reilly, Huff, Converse, and Applebaum. Continued improvements in technology and a focus on more abstract theory with unrealistic assumptions brought spatial interaction models to the point of becoming almost unusable by non-specialists for practical applications. A resurgence in pragmatism, combined with the imperative by the private sector to combine spatial analysis techniques, has once again increased the potential for growth. Incorporating traditional spatial interaction and market analysis methods into a GIS is precisely what is needed for a market area model and network analysis of an agricultural cooperative system. The foundation has been laid. The next step is to identify the appropriate techniques and integrate them into models using a spatial database within a suitable study area.

CHAPTER 3

METHODOLOGY

Introduction

This chapter outlines the methods used to model geographic concepts from the integration of marketing and GIS to discern the impacts of economic distance and bid prices (at the regional grain terminal or local elevator) on grain drawsheds, local prices, or market areas. Techniques are organized chronologically from the initial identification of the needed attribute data and related sources, to database construction, manipulation of data, and the analysis of grain outputs and farm inputs. Finally, the method for creating the desired output from the database and presenting the findings is discussed.

Data Collection

Several types of data, both geographic and ancillary, are required to create this conceptual model and demonstrate how the aforementioned factors work in concert to influence agricultural cooperation. Initially, crop production data for the seventeen county region were acquired for the three crops of wheat, corn, and grain sorghum. Fertilizer data, also aggregated at the county level, were also obtained. All data were gathered for the 1987 growing season to correspond to cooperative locations and operations in the region as they existed at the time of the previous study.

To facilitate automation of this spatial database, various forms of geographic data, in both digital and tabular forms were collected for data input, merger and manipulation with the ancillary data, and analysis. Cooperative locations as they existed in 1987 were derived from an analog map of the study area. County boundaries for the study area from the *U.S. Census Bureau's* Topologically Integrated Geographic Encoding and Referencing System (TIGER) Line files were imported from an appropriate GIS format. Once the study area was delineated and the cooperative locations acquired, Wessex (Wessex Inc., 1994) data (enhanced TIGER files for 1992 updated from the 1990 Census) provided the highway and railroad networks for the study area.

Sources of Data

The primary data source for the tabular datasets is the *Kansas Department of Agriculture*. All crop yield data, aggregated on the county level for 1987, were obtained directly in database format. Fertilizer data for the same time period were derived from the department's Division of Inspections. Once all of the attribute data were acquired, they were imported into a spreadsheet, summed and aggregated to the county level using Federal Information Processing Standard (FIPS) Codes.

The spatial data were acquired digitally for ease of import into the spatial database. The study area's seventeen county region came from TIGER Line files. All highway and railroad networks were obtained from the Oklahoma State University Map Library's Wessex data at the county level. Finally, an analog map of agricultural cooperation location as it existed in southwestern Kansas in 1987 was acquired from an unpublished master's thesis by D.A. Waits, 1988.

Spatial Data Manipulation

Despite the existence of spatial data in digital format for portions of the study area, a significant amount of manipulation was necessary to produce a format conducive to the PC ARC/INFO and ArcView 3.0 environments. This manipulation was required to expedite the merger of the various levels of geographic data and the associated attribute information. The first step, however, was to ensure that all of the spatial data were automated to facilitate this required manipulation and enhancement. To accomplish this, the analog map of cooperative location, taken from the 1987 thesis, required digitizing.

Cooperative Location

The first step in the digitization process was to create a tic coverage of known geographic locations which would allow the newly digitized cooperative points coverage to be rectified into a known coordinate system and eventually registered with the coverage containing the boundaries of the study area. Sixty-seven cooperatives from the seventeen county region were digitized into the point coverage SWCOOPS1 using the tic coverage TICCOV as its boundaries and control points (see Appendix I). Following this automation step topology (spatial relationships) was created between these points, a feature that separates a true GIS from other spatial databases. Through another series of steps involving two additional coverages GEOREF and GEOLAT, the cooperative point coverage was transformed into one with real-world latitude/longitude coordinates. The lat./long coordinates from the file SWCOOPS.tic were then updated and both processes were saved in a newly transformed and rectified cooperative location ARC/INFO point coverage called SWCOOPS3.

Counties

A county level polygon coverage called KANSAS was created from an export file from another spatial database in which the study area was clipped from the entire state prior to creating a PC ARC/INFO coverage. Following the importation of KANSAS into the PC ARC/INFO planar enforcement (topological relationships) was created among the county polygon features. As a safety precaution, KANSAS was copied to a new coverage called KANSAS2. The arcs and labels from the surrounding area in this new were then renamed in ArcEdit. When this editing session was complete, topology was again recreated.

Since no geographic relationship had yet been established between the newly created cooperative point coverage and the study area county coverage, a topological overlay (hereafter referred to as 'overlay') of the two coverages, SWCOOPS3 and KANSAS2, was performed to create SWKAN7, a point coverage in which all of the county attributes are tied to the cooperatives. The ‘intersect’ option was used because it is the only PC ARC/INFO overlay that allows points to be overlaid with polygons in this manner to preserve the entire study area.

Once the two rectified coverages (a cooperative point layer and a county boundary polygon layer) were created with topology present, the ancillary attribute data could now be tied to the spatial data. Although this could be accomplished in PC ARC/INFO using the tables module by adding each item separately and then inputting records for each cooperative and county, a less tedious approach using ArcView was utilized. Each coverage was imported into ArcView 3.0 to create the five views comprising the project COOP.apr. The table for the KANSAS2 coverage was selected for editing and columns/fields were created in the database table for each of the attributes mentioned earlier: wheat, corn, grain sorghum, and fertilizer. The digital records were then 'cut' and ‘pasted’ from a spreadsheet into the ArcView 'fields.’ Likewise, items for the cooperative location and date of incorporation were added to the attribute table for the cooperative point coverage SWCOOPS3. Again, all attribute data were cut from a spreadsheet and pasted into the newly created item fields. The final step following the merger of the spatial and attribute data for both the cooperative and county coverages in ArcView was to once again overlay the coverages in PC ARC/INFO to combine all of the cooperative point and county polygon attributes into one point coverage containing both sets of data. The new coverage, SWKAN, was then renamed to replace the old SWKAN7 point coverage.

Highway and Railroad Coverages

As previously discussed, both the streets and railroad coverages were obtained from Wessex data. To produce the desired highway coverage, the county based line files required joining to create one contiguous topological coverage rather than seventeen separate ones. The seventeen separate county-level street coverages were ‘appended’ together producing one cohesive line coverage called SWSTR. Railroad networks for Kansas are only available for the entire state. A new rail coverage called SWRR was produced using the county coverage KANSAS2 to ‘clip’ the railroads for the study area from the entire state’s railroad coverage-RROAD. A final step was required for the highways coverage prior to importing it into the ArcView format. The TIGER Line street files contain all road networks from the state highways all the way down to unpaved secondary county roads. Roads are delineated by a CFCC code given to them by the

Census Bureau. Codes beginning with the numeral '4' (and some beginning with '3' within city limits) differentiate the state highways from county highways and secondary roads. These records in the SWSTR coverage were selected in ArcEdit and the rest deleted leaving only the state highways. To preserve the continuity of the entire highway network through city limits where the highways changed in name and code to city streets, arcs and nodes were manually entered. These edits were then saved and topology restored. Both coverages were then brought into ArcView as highway and railroad themes and added to the project called COOP.apr which already contained the cooperative and county layers.

Network Creation

Once the cooperative, highway, and railroad coverages were in a suitable ARC/INFO format, they could be manipulated to produce input network coverages for ArcView 3.0 in which nodes representing each cooperative exist along both the highway and rail transportation arteries. The creation of these meaningful highway and railroad networks was a two phase process. The first involved physically moving points on the cooperative coverage to line up with both the highways and rail networks to make the coverages appear correct when 'visually/graphically' overlaid on a display device. The second phase required altering the topological relationships among the three coverages to recognize each respective cooperative along both the highway and railroad arteries, thereby creating meaningful networks.

Phase one was accomplished in the PC ARC/INFO environment. First, a copy of the cooperative point coverage (SWKAN7) was created and selected for editing in the ArcEdit module. Using the highway coverage (HWYS) as a background, each cooperative was systematically moved onto the respective highway(s). Edits were saved and point topology in SWKAN7 was re-established.

A second step, which more accurately moves the cooperatives onto the transportation networks to graphically portray their intersection, was performed in the UNIX environment by making copies of all three coverages on the PC and transferring them to the workstation. Export files were first created for each coverage on the PC and moved to the UNIX through the RapidFiler program. Once on the UNIX platform, each coverage was imported: COOPS, HWYS, SWRAIL. A new point coverage named CPHWY was created in which the points in the cooperatives coverage were ‘snapped’ to the nearest node at the end of each highway arc. The process was repeated for the railroad coverage with SWRR as the resulting output point coverage. Both SWRR and CPHWY were then exported, transferred and re-imported onto the PC using the same process as before. Point topology for each coverage was then re-established.

Now that the cooperatives were more approximately moved and then snapped to the nearest node in the line coverages, the first phase of producing a 'visual overlay' of the cooperatives, rail, and highway networks was complete, and the second phase, building meaningful topological relationships among the coverages, could begin. To facilitate the creation of these topological relationships among the coverages, the copies of all three on the UNIX workstation were again utilized. This time, however, the cooperative location points were assigned a node in the respective highway or railroad coverage where a location exists by creating a topological relationship between the cooperative (point) and transportation artery (line) through a node attribute table (NAT). Using a copies of the CPHWY (point) coverage and the corrected HWYS (line) coverage, the procedure was performed and the resulting coverage re-named CH_NODE. The process required a tolerance to properly locate the cooperatives at the nearest node at the end of a line. Several attempts were made each with a different tolerance and coverage named incrementally until the correct node location existed. The resulting file was CH_NODE7 with a tolerance of 0.02 units. The same process was repeated on the cooperative point and railroad line coverages to produce CR_RR using the same tolerance. Once completed on the workstation, both coverages were exported, transferred to the PC, imported using the same naming conventions, and topologically reconstructed.

Drawsheds

Although ArcView 3.0 can handle the creation of grain drawsheds around the cooperative using a surface generated from the raster data model, and subsequently converted to a vector based shapefile, the UNIX 'Thiessen' command does the same using only the vector model. The same copy of the graphically correct cooperatives (SWKAN7 subsequently renamed to COOPS) was used as the basis for creating the Thiessen polygons. The resulting coverage, DRAWSHED, was transferred to the PC were topology was created. With the creation of the Thiessen polygons as a starting point for market area analysis and the rail and highway networks complete with NATs for topological relationships, the appropriate PC ARC/INFO coverages existed for importation into ArcView 3.0 and the analysis portion of this study.

Data Enhancement

Five coverages including: KANSAS2 (study area polygon), COOPS (cooperative points), CH_NODE7 (highway lines with cooperative nodes), CR_RR (railroad lines with cooperative nodes), and DRAWSHED (Thiessen polygons around cooperatives) were brought into ArcView 3.0 as themes, renamed, and converted to ArcView shape files (see Appendix II). These coverages, now ArcView shapefiles, and their related attributes created in PC ARC/INFO, form the basis for the themes, grids, and shapefiles, which provide the conceptualization of this network and market area analysis of grain cooperatives in southwestern Kansas.

The remaining portion of this methodology section, broadly titled 'Data Enhancement,' is further subdivided into the two phases of the analysis: 'grain outputs' and 'farm inputs.' The 'grain outputs' section is further categorized into the three desired functions of 'drawshed analysis,' 'simulation of pricing,' and 'network analysis.' The 'farm inputs' phase, likewise, breaks the discussion of data enhancement down into two over-riding topics, 'point of sales.' and 'market share analysis.' Within each of these five components of data analysis for both grain outputs and farm inputs, the appropriate 'views' created, together with the additional, themes, shapefiles, and grids which those views contain, are discussed.

Grain Outputs

Drawsheds

Once these five ARC/INFO coverages were imported into ArcView 3.0 as themes, and subsequently converted to shapefiles, a series of 'views' were constructed from them which contained the appropriate themes/shapefiles necessary for the two phased analysis: grain outputs and farm inputs. Initially, a view entitled 'Drawshed' was created with the COOP, SWKNSAS, and DRWSHD shapefiles added for the display of the shortest distance drawsheds (DRWSHD: Thiessen polygons), as well as the derivation of a weighted drawshed grid (raster based) surface to account for pricing and distance differentials once the *ceteris paribus* assumptions were relaxed.

In addition, a second drawshed was created around each location producing a raster derivation in the ArcView environment similar to the Thiessen polygons DRWSHD coverage which was created in PC ARC/INFO's vector format. After this grid (PRXDSHD) was created, it too was converted to a shapefile and added to the 'Drawshed' view.

After these initial shapefiles were added to ArcView, two additional steps were taken to accommodate the analysis of weighted drawsheds. First, as previously discussed, all three grain crop production items for wheat, corn, and grain sorghum were added to the polygon coverage in tables and an item titled 'cooperative,' showing the ownership of each individual location, was added to the COOPS coverage prior to overlaying them. Once in ArcView, grain totals by county were 'cut and pasted' from a spreadsheet into the appropriate columns, and cooperative names were manually entered.

The addition of the 'cooperative' item is significant in two ways. First, it connotes the fact that several 'individual' cooperative locations may actually function as a single entity in terms of the price paid for grain, distance traveled to a regional grain terminal, and service area supplied with farm inputs. Subsequently, the second role of the 'cooperative' item is a field on which to perform all of the proceeding market area analysis operations in ArcView. Unlike the PC environment, ArcView supports the creation of weighted cost surfaces, as well as allowing the analysis of either an entire 'area' of cooperation which occurs from the ownership of several member locations by a single cooperative, or an individual location. The addition of the 'cooperative' item allows for either of these contingencies.

This latter issue, the analysis of an entire area of cooperation centered around a cooperative and all of its member locations, was facilitated by once again employing the 'Assign Proximity' command. The preliminary step of creating the 'cooperative' item was required to insure that Thiessen areas were created among cooperatives rather than between the individual locations such as the DRAWSHED coverage produced in the UNIX ARC/INFO environment. The proximity was then calculated using the 'cooperative' item selected as the field on which to perform the analysis. ArcView created a raster rendition of the Thiessen polygon drawsheds, previously discussed, but one in which market areas under *ceteris paribus* assumptions for 32 cooperatives, rather than 67 individual locations, exist. The raster-based grid theme FRMDRWGD was saved, converted to the shapefile FRMDRWSD.shp, and both were added to the 'Drawshed' view as grid and feature themes respectively.

With the themes in their appropriate formats to produce the desired layouts, the only remaining task was to calculate the areas of the two drawshed themes. DRWSHD.shp was derived from the DRAWSHED coverage created in a vector format. ARC/INFO automatically calculates the area of a polygon feature and records it as the 'Area' item. Although this is in machine units, multiplying it by a scalar (3768.58) in ArcView produced the area in square miles which was 'calculated' and assigned to the 'Square Miles' field. Summing all of the drawshed areas and dividing by 67 produced the mean area which was placed in the 'Average' field. Subtracting the two fields yielded the extent each drawshed differed from the mean ('Difference' field) while the ordinal ranking of each was assigned to the 'Rank' field. The same process was repeated with the FRMDRWSD.shp attribute table with one notable exception. Drawsheds for each cooperative were created using ArcView's raster based Spatial Analyst. Since the area is not computed in the attribute table, the total number of pixels from the FRMDRWGD grid theme in each drawshed were divided by a scalar (264.698) to convert the grid area to square miles. The grid theme was joined to the shapefile and the area records were transferred.

Simulation of Pricing

Three of the original shapefiles, KANSAS2.shp, COOP.shp, and DRWSHD.shp, along with the cooperative level drawshed files of FRMDRWGD and FRMDRWSD.shp were copied into a new view entitled 'Pricing Simulation.' Following the alteration of the tables associated with their related shapefiles, the view was in the appropriate format to demonstrate how distance to a regional grain terminal affects the price of grain offered at each location (creation of a cost surface) and the manner in which market areas (grain drawsheds) grow or decline when the bid price a location offers is increased, thereby enticing customers of neighboring locations and encroaching upon the neighboring location's market area.

Since the procedure which performs these two operations is not included in ArcView's analysis options, a script using ArcView's Avenue was written. Once the appropriate themes and grids are declared, the syntax for the Avenue script request is, "CostDistance (costGrid, directionFN, allocationFN, maxDistance)" where the CostDistance command returns a costGrid from an input source grid and produces optional files for the appropriate direction (directionFN) and route (allocationFN) to take to return to the original source grid (in this case a cooperative location point). The required arguments for this request are both a source and cost grid-SRCGRID and CSTGRID.

CSTGRID was derived from the COOPS point theme by calculating a proximity grid based upon the ‘impedance.’ 'Impedance' is a new field created in the COOPS table which considers the range of prices offered for wheat and their variability from east to west due to distance. In general, the farther west the cooperative (all individual locations with similar owners), the lower the price it can afford to pay for wheat to offset the increased cost of transportation through the eastern exit point to the regional grain terminal in Hutchinson, Kansas. The impedance value is based upon ‘costs,’ derived for each location and standardized by cooperative, from the network analysis portion of this study and is subsequently discussed in that section. Once created, this grid was converted to a shapefile with the same name, CSTGRID.shp. To ensure that the CostDistance script calculated weighted distances for each cooperative rather than the individual elevator locations comprising them, the 'impedance' value was calculated for each cooperative based upon the median price (derived from the distance to the eastern exit point) for all of a firm's locations.

SRCGRID is a raster representation of the cooperatives in which a pixel containing a cooperative is given a value of '0' (zero) indicating a source location. All other cells are assigned a value of 'No Data'. SRCGRID was created by converting the COOPS point theme to a grid. Subsequently, a shape file was also created for the source grid with the same name, SRCGRID.shp and added to the 'Drawshed' view. Although the script request operates on the grid themes, the shapefiles were still created and added to the view for display purposes, and, in the case of an error, could be re-converted back to grids to be used for analysis as necessary.

An ArcView Avenue script, 'Whtdist2.ave', was then created with the previously mentioned CostDistance command with SRCGRID and CSTGRID used for the arguments. Optional names for the direction and allocation file names were called 'AlnGrd' and 'DrGrd', respectively. Once the script was compiled and run, the resulting cost grid was arbitrarily given the name PGRID8 by ArcView. This grid was saved as WHTCSTGRD, as well as converted to a shapefile with the same name and '.shp' extension. This final grid theme and corresponding shapefile represents the weighted cost distance by cooperative, using wheat as an example, for grain leaving the study area via the Hutchinson exit point.

The latter portion of this pricing simulation, demonstrating the growth and decline of the drawsheds from individual locations due to fluctuations in the bid price, is accomplished by using the same WHTCSTGRD grid theme to delineate adjoining market areas. Standard deviations in one-half unit increments were used to portray the weighted costs zones circumscribing each location. Demarcating neighboring drawsheds was accomplished by creating a new polygon feature theme entitled WHTD_DSD.shp. For illustrative purposes, the extreme southwestern corner of the study area in the vicinity of Dermot and including all adjoining locations in the six counties of Stanton, Grant, Morton, Stevens, Haskell, and Seward were chosen. WHTD_DSD.shp was selected for editing with the WHTCSTGRD and DRWSHD themes displayed in the background. Drawsheds weighted on the bid price offered for wheat were created by manually demarcating between those areas where the same colored cost zone of neighboring locations intersected. A total of fourteen weighted drawsheds were produced, one for each location, and edits to the WHTD_DSD.shp shapefile were saved.

By selecting the attribute table to the WHTD_DSD.shp shapefile, fields were added to compute the area of the newly created weighted market areas. Since the ‘shape’ item is the only one that exists when a new feature theme is created, an ‘ID,’ ‘Location,’ ‘Weighted_area,’ ‘Thiessen_area,’ ‘Change_area’ and ‘Bid Price’ item were all added. Locations names for each were manually. Once a common field existed, the table was merged with first the DRWSHD and then the COOP.shp attribute tables to calculate the ‘Thiessen_area’ and ‘Bid Price’ respectively. ‘Weighted_area’ was calculated by first converting WHTD_DSD.shp to a grid, dividing by the same scalar (264.698) used in the original FRMDRWSD.shp (see discussion in ‘Drawshed’ section) attribute table, joining the attribute tables, and ‘calculating’ the field values. All joins were removed and the attribute table was saved.

Network Analysis

The third and final phase of the ‘grain outputs’ portion of the analysis uses ArcView 3.0's network analysis capabilities to discern the impacts that the distance to the regional grain terminal located in Hutchinson, Kansas, has on the 'bid price' offered for grain. Similar to the 'Pricing Simulation' phase of the analysis, wheat prices are again used to illustrate the conceptual relationship between grain prices and the distance to the 'exit points', as well as the highway networks. Although any grain price for both the railroads and highways networks could be utilized for analysis, wheat prices were used for consistency throughout all of the analyses while the highways theme provided a more complete network, connecting all but two of the locations within the study area.

A separate view entitled ‘Network Analysis’ was created for this phase of the analysis. All of the five original PC ARC/INFO coverages, now shapefiles, were added as themes to the ‘Network Analysis’ view, with the exception of the drawsheds. Additionally, a new point theme called EXITS.shp was created from the two locations selected as exit points from the study area and saved as a shapefile. The first point, located on U.S. Highway 50, along the eastern edge of the region demarcated the exit through which all grain in the area was 'forced' to pass when traveling to Hutchinson, while a second point, on State Highway 1, in the southeast corner was similarly established for grain destined for both Enid, Oklahoma, and Forth Worth, Texas.

In order to demonstrate how GIS can be incorporated into the network analysis function of route construction, the highway theme was selected as the transportation artery to be analyzed using the Hutchinson exit point. Using the highways theme and the Network Analyst, the distance between each ‘facility’ (all 65 locations on the highway network) and the ‘event’ (Hutchinson exit) was computed. The resulting shapefile, HWYEXT.shp, contains the appropriate highway route and associated ‘cost’ from each cooperative location to the Hutchinson exit point. The shapefile was added to the ‘Network Analysis’ view as the HUTCHHWYRTS theme. In order to portray the relationship among these different ‘costs’ associated with traveling via highway to the Hutchinson exit, a second operation was performed to created an isodapane map of equal cost areas. This function was likewise performed on the HIGHWAYS theme using the Network Analyst to create a ‘service area’ around the Hutchinson exit in twenty mile increments. The resulting surface was saved as HTCHSRFC.shp and also added to the view as the HUTCHHWYAREA theme.

Finally, to produce the desired impedances or costs necessary for the pricing simulation portion of the analysis (previously discussed), the costs of traveling from the Hutchinson exit to each cooperative, the 'T_cost' (renamed Impedance) field in both the HTCHSRFC.shp and HWYEXT.shp shapefile attribute tables, was manipulated and added to the attribute table for the 'Cooperatives' theme (COOP.shp). To standardize these costs, which are represented as real numbers corresponding to the distance, and allow them to be utilized by the Spatial Analyst (which only performs functions on integer values) multiplication was used. This was done to the 'Impedance' field in the COOP.shp shapefile's table after it was merged with the HTCHSRFC.shp table. The 'T_cost' field was multiplied by 1000 to produce a temporary impedance for each cooperative. A final impedance for each cooperative was derived by visually overlaying the firm (cooperative) drawshed grid theme (FRMDRWGRD) and the Hutchinson highway feature theme and examining the 'Cooperatives' theme's attribute table. Since all cooperatives generally 'bid' for grain at the same price, each location, no matter what its distance to the exit, must be the same for a given cooperative. In those cases where a cooperative's drawshed overlapped two or more isodapanes on the surface theme, the final impedance was determined by the following criteria. First, if only one elevator location from a given cooperative's drawshed was located in a different 'cost zone', it was given the same impedance as the other locations within the cooperative. If, however, several elevator locations were located in various 'cost zones' then the COOP.shp attribute table was queried on wheat production to determine in which zone the majority of grain was produced and all locations within that cooperative were assigned this final 'impedance' value in the COOP.shp shapefile's attribute table.

Another field, 'Transport Cost,' was added to both the HTCHSRFC.shp and HWYEXT.shp shapefiles' attribute tables and calculated by dividing the 'T-cost' (Impedance) field by 10 to derive a dollar cost for traversing each isodapane or 16 mile highway segment with each bushel of wheat. The price each location can offer for wheat within the same isodapanes or along the same segments was calculated by subtracting the 'Transport Cost' field from the price paid per bushel of wheat at the Hutchinson exit (four dollars). This item was added as 'Wheat Price' in the attribute tables for both the HTCHSRFC.shp and HWYEXT.shp shapefiles. Since all three of the attribute tables, HTCHSRFC.shp, HWYEXT.shp, and COOP.shp, were now ready for analysis, all of the joins between the tables were removed and the edits were saved.

Farm Inputs

While the 'grain output' portion of the analysis is concerned with cooperation operating at the macro scale within the study area, the 'farm inputs' phase employs similar geographic techniques to demonstrate economic activity at the smaller, micro scale. The 'point of sales' component illustrates how an individual cooperative could utilize a spatial database to handle the sale of the products and services that it provides. Another portion of the 'farm inputs' phase of analysis, 'market share', uses the same methods to examine how a firm can determine and portray the portion of the market-at the county level-the corporation captures for an individual product, service, or grain crop. The methods used to demonstrate each using a spatial database are subsequently discussed.

Point of Sales

Meade County, Kansas, was selected for this micro scale conceptualization of sales data for individual customers using actual fertilizer totals sold in the county for illustration. A new view, 'Point of Sales' was created with the standard shapefiles of: COOP.shp, HIGHWAY.shp, and SWKNSAS.shp, added as feature themes. Additional data for Meade county, which included all roads, cities, and the county boundary, were derived from *the U.S. Census Bureau's* TIGER Line files. A final set of layers containing township and range sections using the Public Land Survey System (PLSS) Grid and hydrography was obtained from the *United States Geological Survey's* Digital Line Graphs (DLG's) (United States Geological Survey 1995). Each of these four layers, available as a PC ARC/INFO coverage, was imported to ArcView's 'Point of Sales' view, converted to a shapefile, added as a feature theme, and saved (see Appendix II).

A new point theme, 'Customers' was created for Meade cooperative's customers. Names, address locations and sales information were arbitrarily created. Actual fertilizer totals for the county were used. It is assumed that since the Meade cooperative drawshed occupies roughly 34.6 percent of the area in Meade county, despite the existence of three other cooperatives, it captured approximately that same portion of the county's total cooperative fertilizer sales in 1987. Once the spatial database of customer information was manually digitized in ArcView and tabular data entered, it was saved as the CSTMRS.shp shapefile and added to the view as the 'Customers' feature theme.

Two queries were performed on the customer and cooperative data to create the appropriate map layouts (see Chapter 4). Initially, the table for the 'Cooperatives' theme was selected and queried for the Meade location. Then, by highlighting the 'Customers' theme and choosing 'Select By Theme,' all customers that 'are within a distance of' 10 miles of the 'Cooperatives' theme were identified. Since Meade is the only location selected in the 'Cooperatives' theme, the 10 mile threshold applied only to it. The resulting table and view were saved to a layout and the selections were cleared for the next query. Again, the table for the 'Customers' theme was selected and queried for all customers with total fertilizer sales exceeding 300 tons. The selected records in the table and customer locations on the map were saved to a second layout.

Market Share

The second portion of the 'farm inputs' phase of analysis and final component of this study demonstrates the ability of a spatial database to graphically portray the portion of the farm inputs market share that a corporate firm (several individual cooperatives) captures in each county of the study area. The eight locations in the Garden City Cooperative Equity Exchange are used to illustrate the percentage of fertilizer sales captured by the firm in every county.

To accomplish this, the COOP.shp, SWKNSAS.shp, and FRMDRWSD.shp shapefiles were added to a new view-'Market Share'. The 'Cooperatives' theme's attribute table was then queried for all locations belonging to the Garden City Cooperative Equity Exchange cooperative. Once all eight locations were highlighted, 'Find Distance' was selected to compute a grid surface of distances to the entire cooperative. A new temporary grid was produced that was renamed GC_GRID. Distances were displayed using one-half standard deviation intervals ranging from -2.0 to 3.0. Since a grid cannot be converted directly to a shapefile to maintain any sort of thematic classes, a new shapefile-GC_GRID.shp-was created. All four classes from -2.0

standard deviations down to the mean were manually digitized in the GC_GRID.shp shapefile using GC_GRID as a base map.

Using a form of inverse distance weighting, each of the four zones (eleven miles in width) was assigned a percentage of a location's market share that the Garden City firm would expect to capture based on the square of the distance. Therefore, the innermost zone, containing only Garden City's elevator locations, were assigned values of 100 corresponding to the percent the cooperative expects to capture of each location's fertilizer sales. The next concentric ring eleven miles away received a value of 82.6 percent connoting the portion of any location's market Garden City expected to capture. The third and fourth zones were given values of 20.6 and 9.2 percent respectively. Each was recorded in a new attribute field-'Gc_Idw'.

GC_GRID.shp's attribute table was then joined to that of the cooperatives (COOP.shp) to merge the 'Gc_Idw' field with each respective location's data. Using the COOP.shp attribute table, a new field (CP_Cnty) was created and given a value representing the number of elevator locations in each county. Another field, 'Cnty_MSh', was added to record the final cooperative fertilizer market share captured by the GCCEE in each of the seventeen counties. This proportion was calculated by first selecting all elevator locations in a given county, summing the 'Gc_Idw' field (the amount each location is influenced), and dividing by the 'CP_Cnty' attribute (or total number of cooperatives in the respective county). Counties exceeding the mean standard distance of GC_GRID were given values of zero; Garden City does not expect to capture any portion of a cooperative location's market share in these counties. All edits were saved in the COOP.shp attribute table and the same field, 'CP_Cnty', was added to the county theme, 'SW Kansas' (SWKNSAS.shp). County percentages were then manually entered for each of the seventeen counties. Once saved, the county theme's legend was selected for editing. A graduated color scheme classified on the county market share item (Cnty_MSh) categorized by quintiles (five equal assignment classes) was chosen for display purposes.

Data Output

Once each of the five views was created and the desired analysis performed, an appropriate output format was needed. To accomplish this, ArcView 3.0's 'layouts' were used. Each view was arranged in a series of layouts with supporting legend, text, scale, and any additional graphics such as tables were added. A total of fourteen layouts were created for the five views: three for 'Drawshed,' (one of which was the study area) three for 'Pricing Simulation,' two for both 'Network Analysis' and 'Point of Sales,' and four were created for 'Market Share.' To expedite the printing process, print files were saved and utilized for outputting each newly derived map. The naming convention for each corresponded to the order in which a layout was created from within a respective view (e.g. 1A, 1B and 2A, 2B, 2C, are the first two and three layouts respectively from the 'Drawshed' and 'Pricing Simulation' views) followed by the '.eps' extension.

Conclusion

The methodology incorporated here combines established techniques utilized in marketing, economic geography and geographic information systems, with available computer hardware / software. To accomplish the creation of drawsheds, networks, point of sales data and market shares, various spreadsheets and spatial databases provided an efficient means of aggregating and maintaining attribute data and the acquisition, manipulation, and analysis of spatial datasets. Ancillary data collected from the *Kansas Department of Agriculture,* were acquired or entered into a spreadsheet and aggregated to the county or cooperative level. Spatial data from the *U.S. Census Bureau's* TIGER Line files, *United States Geological Survey's* DLG's, Wessex data, or digitized files were created or manipulated in the ARC/INFO format and brought into ArcView 3.0 for analysis. Once both the spatial and ancillary data were merged and the respective analyses performed, ArcView also provided the means to create and output the resulting maps of drawsheds, pricing simulations, network analysis, point of sales and market shares. The following chapter is devoted to the application of this methodology for the merging of geographic techniques and geomarketing concepts to demonstrate, for a better understanding, how grain outputs and farm inputs for agricultural cooperatives can be analyzed using the previously discussed spatial databases.

CHAPTER 4

ANALYSIS AND RESULTS

Introduction

The appropriate methods for this conceptualization of geographic thought which incorporate marketing and GIS through the use of geotechniques has been outlined. In this chapter, the goal is to educate for a greater understanding by analyzing the results of those methods in the context of grain outputs and farm inputs. What follows is an analytical discussion of the resulting spatial database products that were produced. Real-world historical agricultural data for southwestern Kansas and various geomarketing concepts were combined for the purpose of demonstrating the spatial database models' ability to conceptualize the movement of grain outputs, farm inputs, and market area fluctuations. To facilitate the discussion, this chapter is subdivided into the five components, similar to the methodological section, which comprise the two phases of this study–grain outputs and farm inputs. In the grain outputs phase, the results of the drawshed, pricing simulation, and network analysis components are explored, while the point of sales and market share analyses are looked at from the farm inputs phase.

Grain Outputs

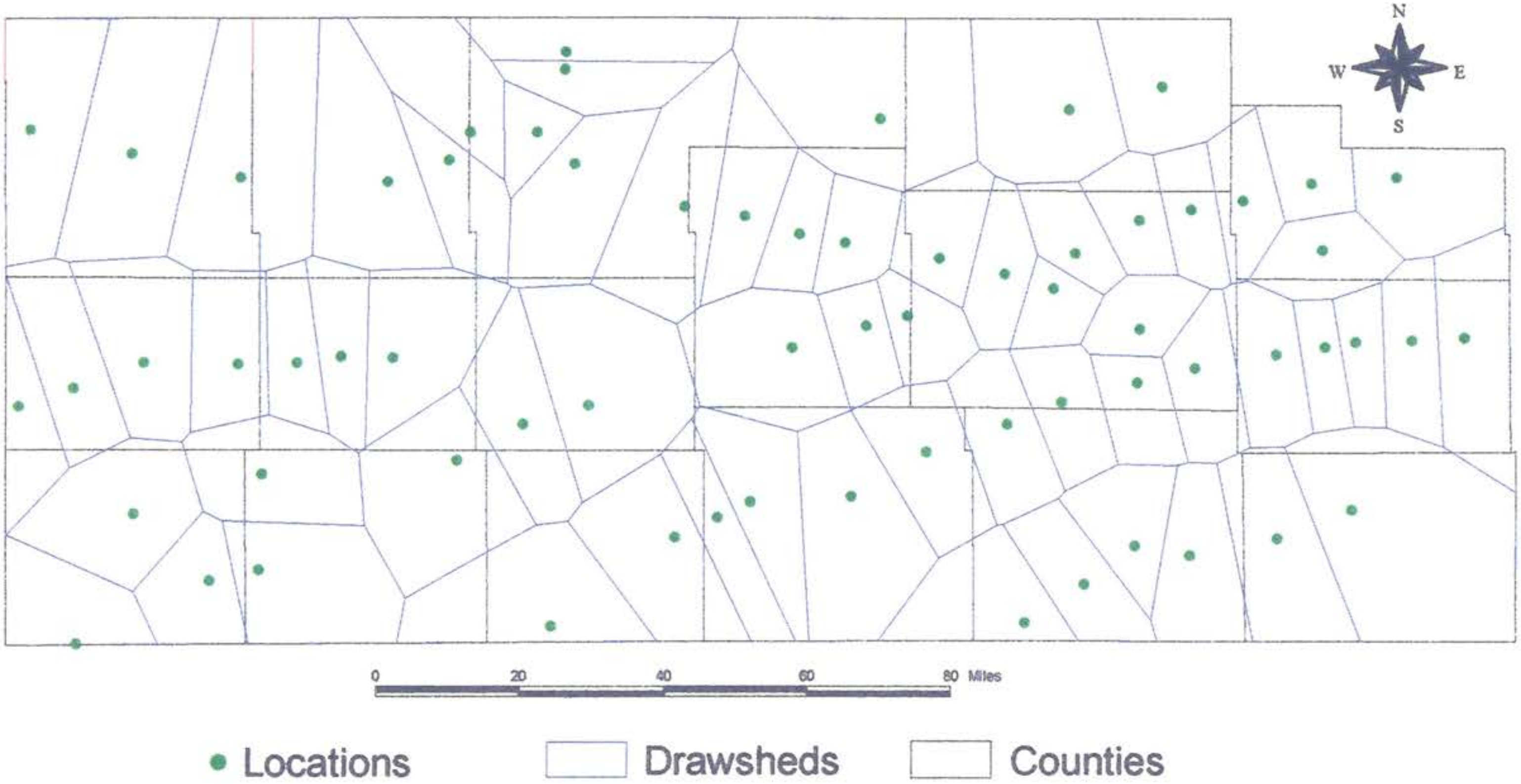
Drawsheds

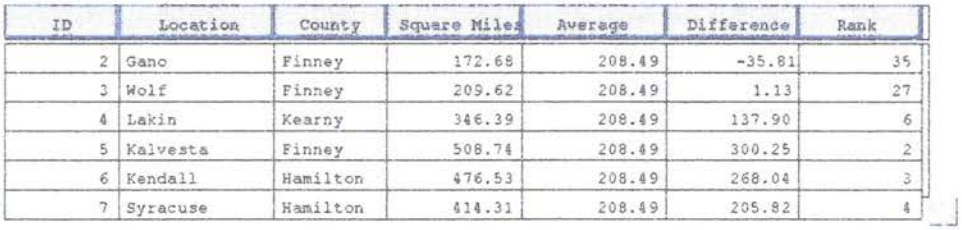
Two layouts for the 'Drawsheds' view were created for the purpose of portraying the market shares for both the individual locations and the entire cooperative firm. This view and the corresponding layouts depict the respective market shares under *ceteris paribus* assumptions using Thiessen polygons. That is, they portray the market share each cooperative or individual location would capture if all other considerations were equal.

As Evans and Jones (1987) noted, Thiessen polygons are primarily used for natural resource applications such as portraying drainage networks (where gravity forces water to behave in a 'predicable' manner) and rarely used for socio-economic studies since humans seldom behave in this manner. The rationale for using Thiessen polygons for market area analysis stems from the work of Martin and Williams (1992) and Openshaw (1992). Martin and Williams (1992) point out that although Thiessen polygons can be used for market share analysis, they are limited in their ability to delineate these areas. However, Openshaw (1992) asserted that their use as a basis from which to compare human activity is appropriate. Therefore, the delineation of agricultural grain drawsheds using Thiessen polygons under *ceteris paribus* assumptions is an acceptable basis from which to make comparisons. This view and related layouts form the basis for the subsequent contrasting of these market areas once these assumptions are relaxed to accommodate the grain 'bid' price and distance to the exit point for the regional grain terminal.

In the first layout (Figure 2), Thiessen polygons portraying the market share for individual locations (green dots) are portrayed in blue. The associated table identifies each location, its corresponding county and the total area (in square miles) each drawshed covers. All 67 locations averaged nearly 208.5 square miles. The 'Difference' field shows how each location differed in total area from the mean, while the final column gives an ordinal ranking to the drawshed's area.

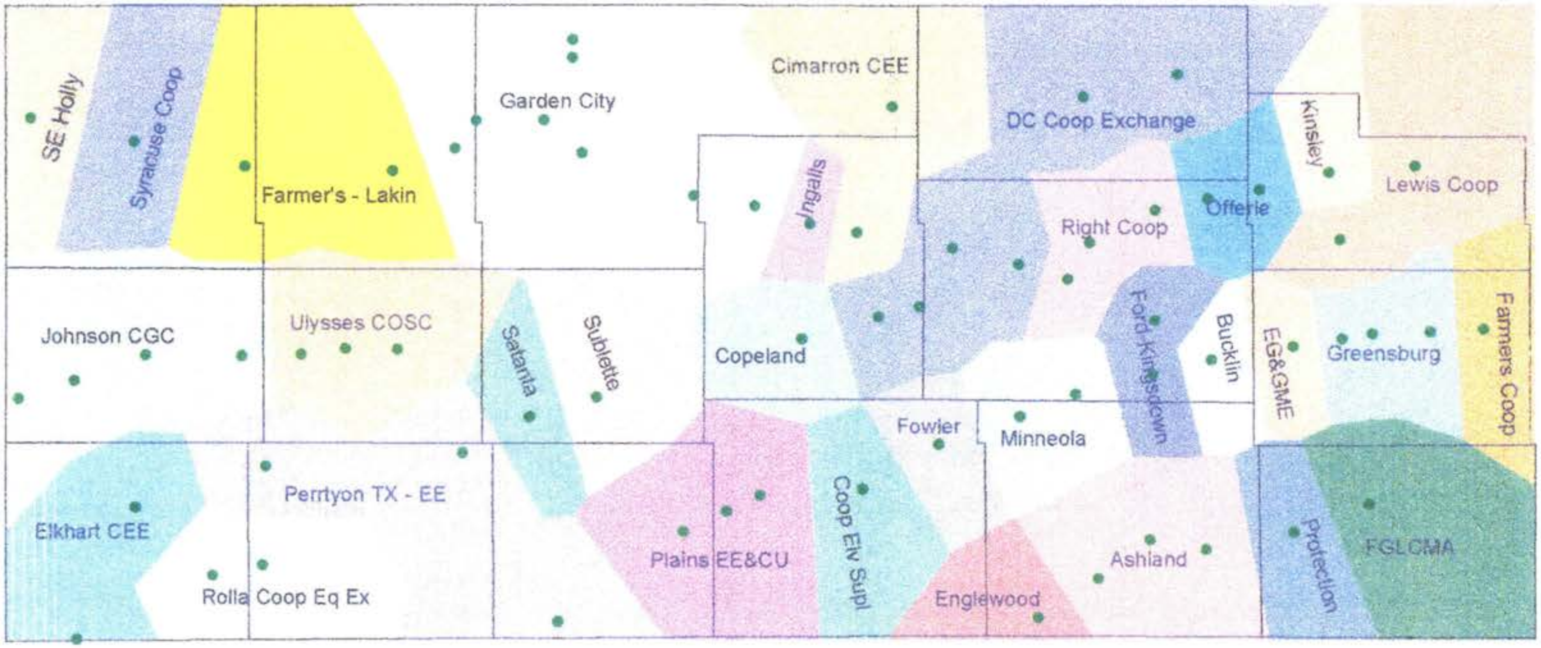
Drawsheds for all locations within a given cooperative are depicted in Figure 3. Once again, individual locations are represented by green dots, but the colored market areas correspond to all locations within a cooperative. Although they were created using different techniques, the cooperative drawsheds in Figure 3 are conceptually similar to grouping all of the Thiessen polygons from Figure 2 according to all member locations of the same cooperative. Farmer's Cooperative-Lakin is highlighted in yellow on both the map and corresponding attribute table. Similar to the table for each location in Figure 2, each cooperative's area is depicted in square miles and its variation from the mean size of approximately 456 mi^2 is indicated in the difference field. Finally, the cooperative's drawshed size relative to the mean for all 32 is given in the rank column. Farmer's Cooperative-Lakin covers an area of approximately 826 mi^2, is nearly 370 mi^2 larger than the average, and has the fourth largest overall drawshed in the region. The Garden City Cooperative Equity Exchange is the largest cooperative containing eight individual locations stretching nearly 1510 mi^2. Ingalls Cooperative, located in north central Gray county in deep purple, is the smallest cooperative covering only 106 mi^2; an area 350 mi^2 smaller than study area's mean.

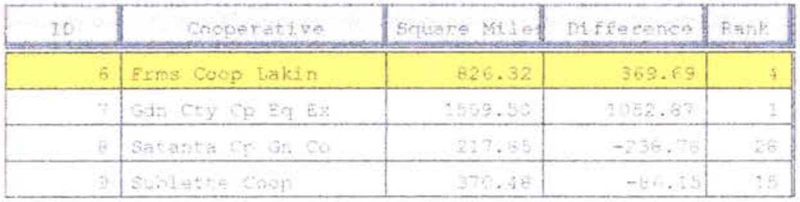




ID	Location	County	Square Miles	Average	Difference	Rank
2	Gano	Finney	172.68	208.49	-35.81	35
3	Wolf	Finney	209.62	208.49	1.13	27
4	Lakin	Kearny	346.39	208.49	137.90	6
5	Kalvesta	Finney	508.74	208.49	300.25	2
6	Kendall	Hamilton	476.53	208.49	268.04	3
7	Syracuse	Hamilton	414.31	208.49	205.82	4

Figure 2: Thiessen Polygon Drawsheds by Location





ID	Cooperative	Square Miles	Difference	Rank
6	Frms Coop Lakin	826.32	369.69	4
7	Gdn Cty Cp Eq Ex	1509.50	1052.87	1
8	Satanta Cp Gn Co	217.85	-238.78	28
9	Sublette Coop	370.48	-86.15	15

Figure 3: Thiessen Polgyon Drawsheds by Cooperative

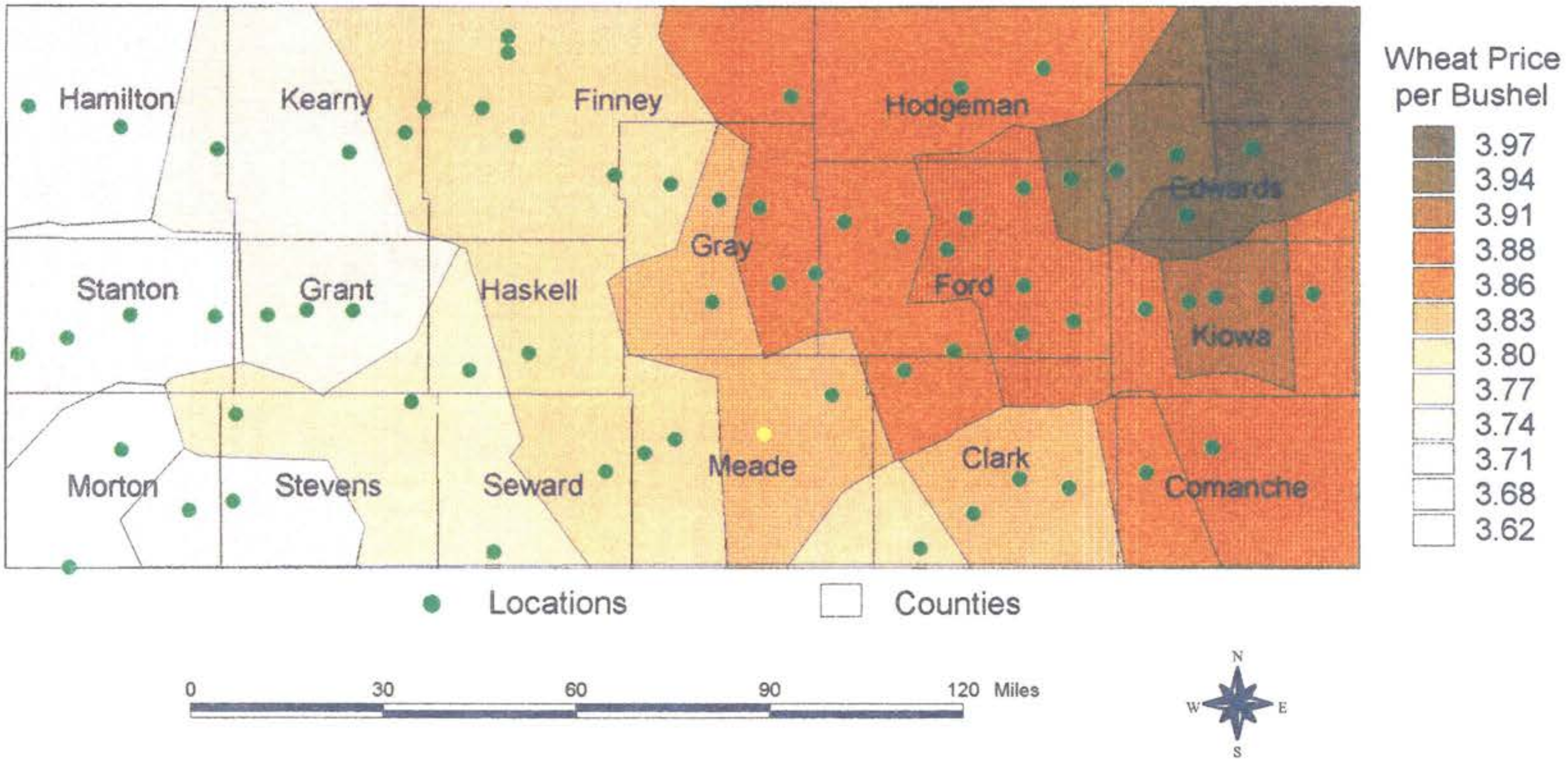
Thiessen polygons, although limited in their ability to delineate market areas, are an appropriate basis for comparing human activity once other factors are introduced (Martin and Williams 1987; Openshaw 1992). Thiessen polygon grain drawsheds under *ceteris paribus* assumptions form the basis for comparison once transportation costs related to distance and the bid price offered for grain are introduced. However, no proven methods currently exist in the literature to derive this relationship for grain cooperation and compare it to the Thiessen drawsheds. It is in the following two sections that transportation cost and bid price are incorporated into a spatial database for the purpose of developing this framework.

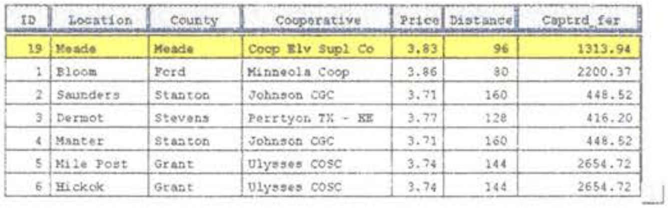
Pricing Simulation

The second component to the grain output phase of the analysis relaxes the *ceteris paribus* assumptions (cost and distance) to demonstrate how the distance between the study area's exit points to the regional grain terminals and the cooperatives impacts the bid price offered for grain. Many factors, including personal preference which is difficult to quantify, have been noted to affect the size of market areas (Vaile *et al.* 1952; Goldstucker *et al.* 1978). However, this friction of movement, related to the cost of moving over a given transportation network, was identified by Applebaum and Cohen (1961) as one of the most critical components for determining market area size.

To derive this relationship between transportation cost, bid price, and market areas for grain cooperation, highway routes and the Hutchinson exit were utilized to calculate the network distance between individual locations and the exit point. Once a highway distance was derived, each location was assigned to a particular zone, based on twenty mile increments, corresponding to the highway distance to the exit. All locations from an individual cooperative, however, are assumed to offer the same bid price for grain regardless of how its distance to the exit might differ from all other locations within the same cooperative. In order to ascertain the cooperative's bid price, all individual locations within the cooperative were compared, based upon the zone of equi-distance in which they were located. Naturally, if all locations were in the same zone, the cooperative's bid price corresponded to that zones distance. In a few instances, however, one or more locations were located in separate zones. In these cases, either the price was averaged based upon the two distance zones (if the cooperative contains only two locations), or the cooperative maintained the price corresponding to the zone with the locations that occurred most frequently (mode values).

Once each cooperative was assigned to an isodapane, the wheat price per bushel for each was computed. The bid price for grain was assumed to be $4.00 per bushel at the Hutchinson exit along the east edge of Edwards county. A further assumption was that the price was assumed to drop approximately three cents per bushel for every zone of equi-distance crossed (Figure 4). Since the actual wheat price values are calculated from a highway distance impedance (16 mile increments), and not the actual zone of equi-distance, the prices do not always decline in three cent increments due to rounding. The color corresponding to the wheat price represents the projected bid price offered at each location within the similarly colored area. In other words, the colors represent the true isodapanes based on all locations of the same cooperative and all locations of similar distance offering the same bid price.





ID	Location	County	Cooperative	Price	Distance	Captrd fer
19	Meade	Meade	Coop Elv Supl Co	3.83	96	1313.94
1	Bloom	Ford	Minneola Coop	3.86	80	2200.37
2	Saunders	Stanton	Johnson CGC	3.71	160	448.52
3	Dermot	Stevens	Perrtyon TX - KE	3.77	128	416.20
4	Manter	Stanton	Johnson CGC	3.71	160	448.52
5	Mile Post	Grant	Ulysses COSC	3.74	144	2654.72
6	Hickok	Grant	Ulysses COSC	3.74	144	2654.72

Figure 4: Distance to Hutchinson Exit Reflected in Wheat Price

Meade is highlighted to illustrate how the wheat price was derived. First, Meade is the only location within the Cooperative Elevator Supply Company Cooperative. Meade fell within the equi-distance zone corresponding to 96 highway miles to the Hutchinson exit (Distance field). This was the sixth zone from the exit, and it carried an impedance just under 18 cents per bushel to overcome the cost of transporting the wheat to the exit point. The bid price that Meade can offer and still maintain a profit is $3.83 for every bushel of wheat. The highway distance to the exit and corresponding bid price each location can offer and still maintain a profit is given in Table 1. All 67 locations, their county of origin and cooperative, are listed with the corresponding wheat price and highway distance.

The costs and associated prices in Figure 4 form the basis for the cost surface (COSTGRID) that was created as an input for the Avenue request (COSTDISTANCE) to create weighted drawsheds for each location. Figure 5, entitled 'Weighted Impedance Areas,' is the resulting grid produced from the Avenue script. Zones were constructed around each cooperative corresponding to the impedance each was assigned on the input COSTGRID. The higher the price a location can offer for grain, the lower the impedance of traveling across it and the larger the corresponding zone. Adjacent firms with the greatest contrast in bid price exhibit the starkest contrast in the areal extent of their zones.

Rather than portraying these zones using the bid price or a transportation cost, standard deviations from -1.5 to 3.0 in one-half increments were utilized. The use of standard distances in proximity mapping was outlined by Berry (1993) as means for comparing coverages with varying proximity distances or measuring scales. This provides a sense of 'nearness' regardless of the magnitude of the data or variable used to

ID	Location	County	Cooperative	Price	Distance
33	Acres	Clark	Ashland Coop Ex	3.83	96
55	Ashland	Clark	Ashland Coop Ex	3.83	96
31	Bellefont	Ford	Offerle Cp Gr Sp	3.94	32
41	Big Bow	Stanton	Johnson CGC	3.71	160
1	Bloom	Ford	Minneola Coop	3.86	80
62	Brenham	Kiowa	Greensburg FGSC	3.91	48
32	Bucklin	Ford	Bucklin Coop Ex	3.88	64
51	Center View	Edwards	Lewis Coop Ex	3.97	16
45	Charleston	Gray	Gdn Cty Cp Eq Ex	3.80	112
48	Cimarron	Gray	Cimarron CEE	3.86	80
57	Coldwater	Comanche	FGLCMA	3.88	64
43	Coolidge	Hamilton	SE CO Cp Holly	3.68	176
50	Copeland	Gray	Copeland CEE	3.83	96
65	Deerfield	Kearny	Gdn Cty Cp Eq Ex	3.80	112
3	Dermot	Stevens	Perrtyon TX - EE	3.77	128
22	Dodge City	Ford	DC Coop Exchange	3.86	80
37	Elkhart	Morton	Elkhart CEE	3.62	209
54	Englewood	Clark	Englewood Cp Ex	3.80	112
25	Ensign	Gray	DC Coop Exchange	3.86	80
35	Feterita	Stevens	Rolla Coop Eq Ex	3.71	160
59	Ford	Ford	Ford-Kingsdown	3.88	64
20	Fowler	Meade	Fowler Eqty Exch	3.83	96
12	Gano	Finney	Gdn Cty Cp Eq Ex	3.80	112
10	Garden City	Finney	Gdn Cty Cp Eq Ex	3.80	112
61	Greensburg	Kiowa	Greensburg FGSC	3.91	48
26	Haggard	Gray	DC Coop Exchange	3.86	80
28	Hanston	Hodgeman	DC Coop Exchange	3.86	80
63	Haviland	Kiowa	Farmers Coop Co	3.88	64
6	Hickok	Grant	Ulysses COSC	3.74	144
18	Hobart	Meade	Plains EE&CU	3.80	112
23	Howell	Ford	DC Coop Exchange	3.86	80
47	Ingalls	Gray	Ingalls Coop	3.83	96
27	Jetmore	Hodgeman	DC Coop Exchange	3.86	80
42	Johnson	Stanton	Johnson CGC	3.71	160
64	Joy	Kiowa	Greensburg FGSC	3.91	48
49	Kalvesta	Finney	Cimarron CEE	3.86	80
44	Kendall	Hamilton	Frms Coop Lakin	3.74	144
58	Kingsdown	Ford	Ford-Kingsdown	3.88	64
52	Kinsley	Edwards	Kinsley Coop Ex	3.94	32
16	Kismet	Seward	Plains EE&CU	3.80	112
8	Lakin	Kearny	Frms Coop Lakin	3.74	144
53	Lewis	Edwards	Lewis Coop Ex	3.97	16
15	Liberal	Seward	Perrtyon TX - EE	3.77	128
9	Lowe	Finney	Gdn Cty Cp Eq Ex	3.80	112
4	Manter	Stanton	Johnson CGC	3.71	160
19	Meade	Meade	Coop Elv Supl Co	3.83	96
5	Mile Post	Grant	Ulysses COSC	3.74	144
21	Minneola	Clark	Minneola Coop	3.86	80
67	Moscow	Stevens	Perrtyon TX - EE	3.77	128
60	Mullinville	Kiowa	EG&GME	3.88	64
29	Offerle	Edwards	Offerle Cp Gr Sp	3.94	32
46	Pierceville	Finney	Gdn Cty Cp Eq Ex	3.80	112
17	Plains	Meade	Plains EE&CU	3.80	112
34	Protection	Comanche	Protection Cp Sp	3.86	80
39	Richfield	Morton	Elkhart CEE	3.62	209
38	Rolla	Morton	Rolla Coop Eq Ex	3.71	160
13	Satanta	Haskell	Satanta Cp Gn Co	3.77	128
2	Saunders	Stanton	Johnson CGC	3.71	160
56	Sitka	Clark	Ashland Coop Ex	3.83	96
30	Spearville	Ford	Right Coop Assoc	3.88	64
14	Sublette	Haskell	Sublette Coop	3.80	112
7	Syracuse	Hamilton	Syracuse Cp Ex	3.68	176
11	Tennis	Finney	Gdn Cty Cp Eq Ex	3.80	112
40	Ulysses	Grant	Ulysses COSC	3.74	144
66	Wilroads	Ford	Right Coop Assoc	3.88	64
36	Wolf	Finney	Gdn Cty Cp Eq Ex	3.80	112
24	Wright	Ford	Right Coop Assoc	3.88	64

Table 1: Distance to Hutchinson Exit Reflected in Wheat Price

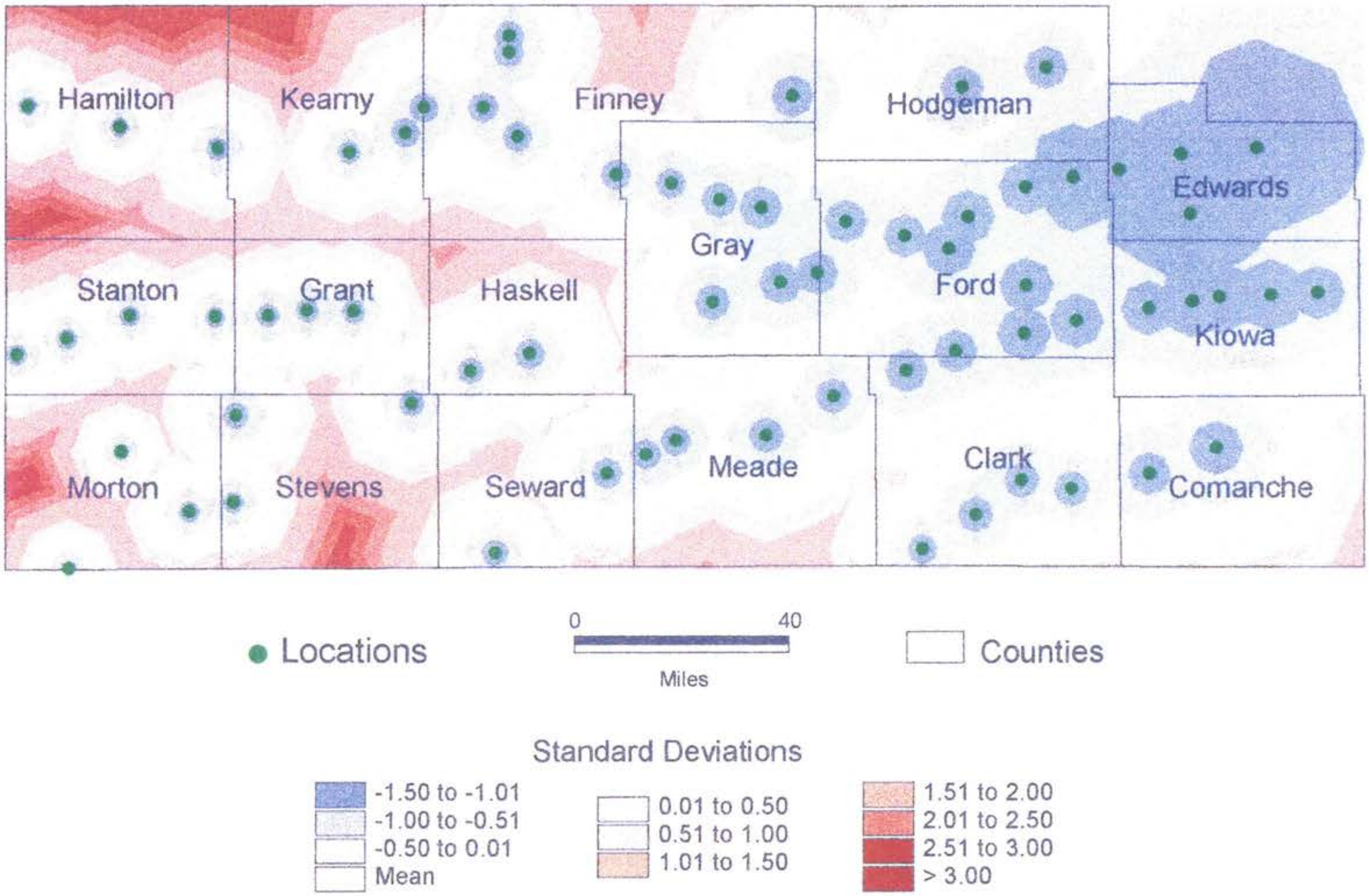


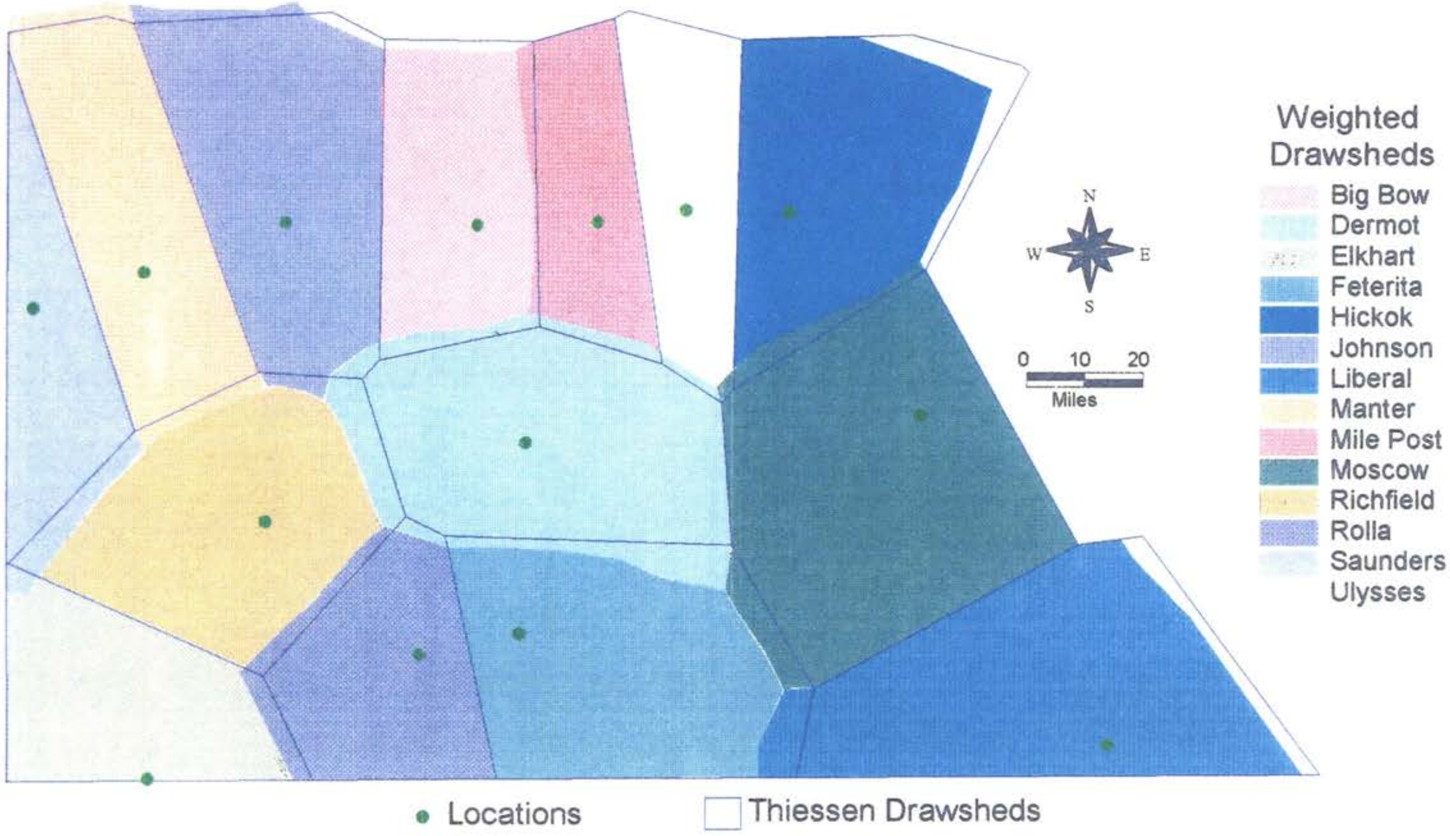
Figure 5: Weighted Impedance Areas for Cooperative Locations

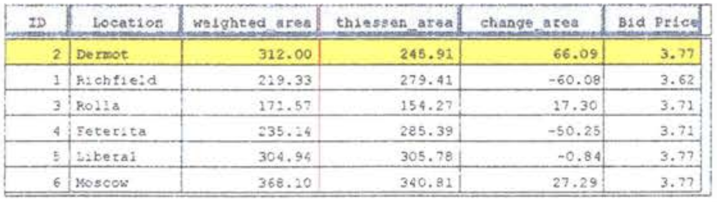
portray proximity (Berry 1993). Depicting impedance areas around cooperative locations in this manner allows for comparison regardless of the scale of measurement or distance variable used.

The point at which similarly shaded zones for adjacent locations overlap represents the boundary between the two location's market areas or grain drawshed. Market areas for Dermot and the surrounding locations were constructed by demarcating the boundaries between these zones (Figure 6). Shaded areas represent the market area for a given location weighted using the bid price for wheat, while the dark blue lines delineate Thiessen polygon drawsheds under the previously mentioned *ceteris paribus* assumptions.

Figure 6 demonstrates how market areas in the Dermot area grow or decline as one location changes its bid price for grain. Dermot, located in the center in teal, has raised its bid price for wheat. As a result, Dermot's drawshed grows, enticing customers located on the boundaries of adjacent market areas and encroaching on the drawsheds of other elevator locations. Dermot's market area expands past the dark blue Thiessen polygon and into those of all other locations offering a lower bid price. In contrast, Richfield's (dark brown adjacent to Dermot) market share is encroached upon by all other locations since its bid price of $3.62 for wheat is the lowest in the area. The boundary between Dermot and Moscow's market areas does not change from that of the Thiessen polygon since both locations are offering $3.77 for each bushel of wheat.

From the table we see that Dermot's drawshed encroaches on nearly all of the other location's market areas as those customers near the Thiessen polygon borders are enticed into Dermot's market area due to the increased bid price. Under *ceteris paribus*





ID	Location	weighted_area	thiessen_area	change_area	Bid Price
2	Dermot	312.00	245.91	66.09	3.77
1	Richfield	219.33	279.41	-60.08	3.62
3	Rolla	171.57	154.27	17.30	3.71
4	Feterita	235.14	285.39	-50.25	3.71
5	Liberal	304.94	305.78	-0.84	3.77
6	Moscow	368.10	340.81	27.29	3.77

Figure 6: Dermot and Surrounding Market Areas Weighted by Bid Price

assumptions Dermot's market area is over 245 mi^2. By increasing the bid price offered for grain, however, the market area encroached on neighboring locations, growing by over 66 mi^2 to a total of 312. Conversely, Richfield lost customers to neighboring locations due to a decline in its market area by 60 mi^2 reflecting its bid price of $3.62 per bushel of wheat. At first glance, this decline may not seem significant, but when the original Thiessen area, covering more than 279 mi^2, is considered, Richfield's total loss in market area exceeds 21 percent of the original Thiessen drawshed. Price is often the pivotal factor in determining the success of a cooperative, and using a spatial database to apply the appropriate geomarketing techniques to set the bid price could be the difference between a healthy profit and insolvency.

As previously mentioned, Thiessen polygons are an appropriate technique to delineate market areas when used as a basis for comparison (Martin and Williams 1992). They are, however, not suited for modeling these drawsheds when other factors, such as transportation cost due to distance or bid price, are introduced (Openshaw 1992). Although the inappropriateness of applying Thiessen polygons to model these other facets is noted throughout the literature, alternative methods that account for these other factors are not discussed. A spatial database that utilizes both network and spatial analysis capabilities was used to capture these fluctuations in bid price related to distance to create a framework for comparison with the Thiessen drawsheds. What resulted is a method for deriving the effects of bid price and distance on grain drawsheds, a basis for comparing these to drawsheds under *ceteris paribus* assumptions, and a better understanding of how these facets impact the growth or decline of agricultural grain drawsheds.

Network Analysis

As discussed in the 'simulation of pricing' component, friction of movement related to transportation cost is often a pivotal factor in delineating market areas (Applebaum and Cohen 1961). To create the formerly mentioned relationship between grain market areas weighted by bid price and distance requires a derivation of transportation costs from each cooperative location to the exit. Using the Network Analyst, both the routes and areas of equal cost to the exit points were determined. For analytical purposes, highway routes and the Hutchinson exit were used (Figure 7). The ability exists within the database, however, to calculate this relationship for all three grain crops across either the highway or railroad networks to any of the three regional grain terminals.

An impedance for each 16 mile section of highway was computed in ArcView and converted into a cost of almost 3 cents (rounded) in the attribute table and accompany legend. Each segment depicted on the map corresponds to the cost of traversing across it to the Hutchinson exit with one bushel of wheat. By identifying the appropriate network adjacent to each location, the cost to the elevator per unit is determined. The maximum cost to transport a bushel of wheat from the extreme southwest corner of the study area to the Hutchinson exit is 38 cents.

ArcView's Network Analyst also delineated areas of equal distance from the Hutchinson exit in increments of 20 miles. The same impedances for each zone of equi-distance were computed by ArcView and added to the table. Using the calculated highway costs from Figure 7 as a basis, an isodapane map of equal price per bushel was

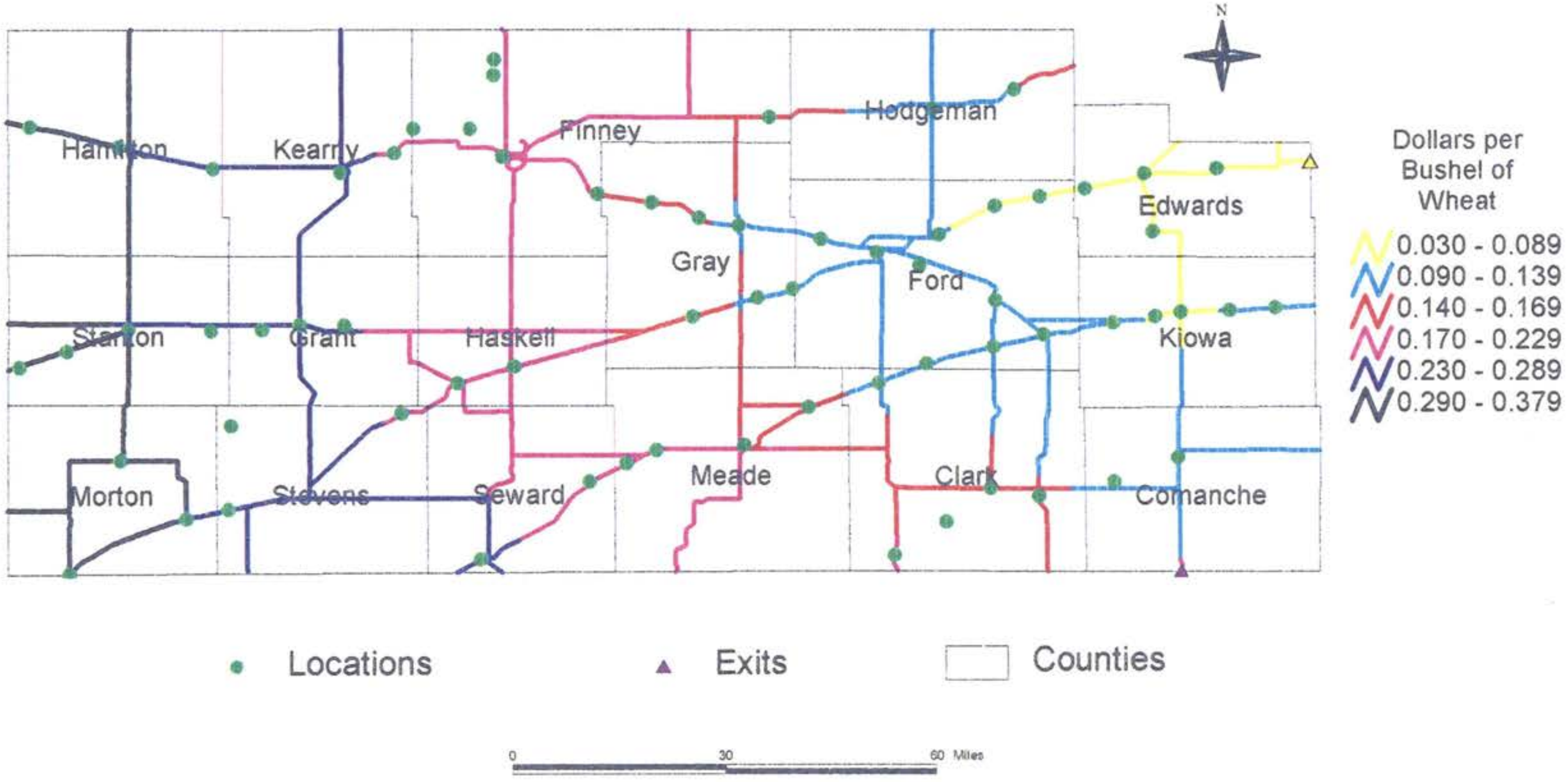
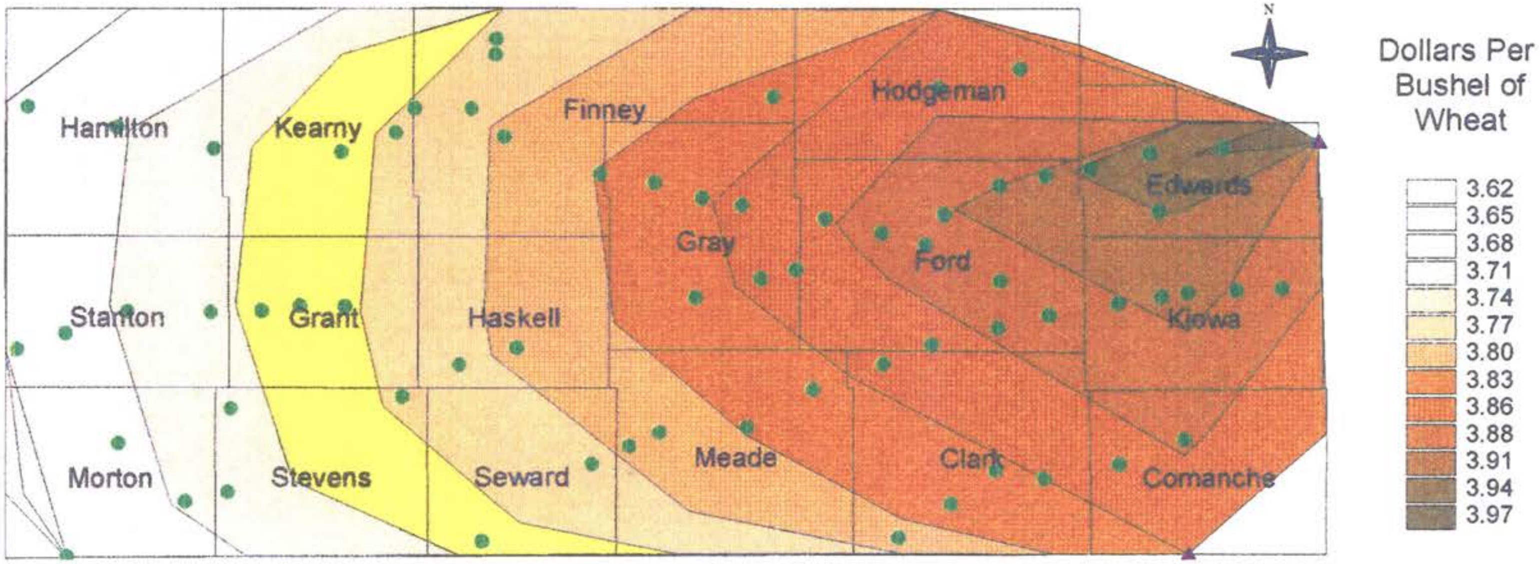
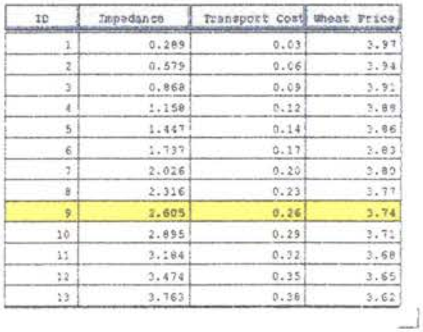


Figure 7: Routes Of Equal Transport Cost to Hutchinson Exit

created for all locations. When holding all other considerations constant but allowing distance to vary, all locations within an isodapane, regardless of cooperative affiliation, offer the same price for wheat (Figure 8). This differs from the 'pricing simulation' component which notes that the final wheat price actually varies by both distance (transport cost) and cooperative affiliation. Based solely on the transport cost of wheat (determined by distance), all elevator locations, regardless of cooperative affiliation, within the selected isodapane (highlighted in yellow) incur a transport cost of 26 cents per bushel. If these locations sold their wheat for $4.00 per bushel at the Hutchinson exit, they can offer $3.74 for every bushel and still maintain the same profit margin.

As the previous sections demonstrate, the profitability of a given location based solely on distance can be offset by subsidizing the price of an individual location from the rest of the cooperative, or affected by a location's (such as Dermot's) desire to expand its market area and corresponding volume of grain (drawshed). However, when these considerations are held constant, the distance across a network (and associated transport costs per unit incurred) constitute the main determinants in deriving the bid price for grain. This relationship, between the highway distance and wheat price, is obtained by overlaying the themes in the spatial database corresponding to Figures 7 and 8. In Figure 7, the cost of traversing any given segment of highway is derived and calculated for each individual elevator location along the network. What the 'routes' map fails to consider are all elevator locations, or potential sites, that do not currently exist, or may not be constructed, on the highway network. The 'isodapane' map in Figure 8 accounts for prices at all of the current or potential locations in an area that do not lie on the highway network but would have grain from the region moved across it to the exit point.





ID	Impedance	Transport Cost	Wheat Price
1	0.289	0.03	3.97
2	0.579	0.06	3.94
3	0.868	0.09	3.91
4	1.158	0.12	3.89
5	1.447	0.14	3.86
6	1.737	0.17	3.83
7	2.026	0.20	3.80
8	2.316	0.23	3.77
9	2.605	0.26	3.74
10	2.895	0.29	3.71
11	3.184	0.32	3.68
12	3.474	0.35	3.65
13	3.763	0.38	3.62

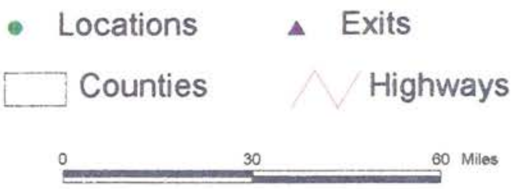


Figure 8: Isodapanes of Wheat Price from Hutchinson Exit

Therefore, Figure 7 derives prices based upon the impedance of traversing a network to the exit while Figure 8 considers the friction of moving from within the area, to the highway network, and over to the Hutchinson exit.

The use of network analysis in this manner for grain cooperation is significant for several reasons. First, it provides a way for cooperative locations to compute the distance to regional grain terminals and calculate more accurate transportation costs rather than relying on simple Euclidean distances. Second, and more important, using network analysis to compute more accurate transportation costs allows for a more precise derivation of the relationship between distance, transportation costs and the setting of bid prices. This process, up until now, has largely been based upon previous bid prices, what is occurring at neighboring locations, or pure conjecture.

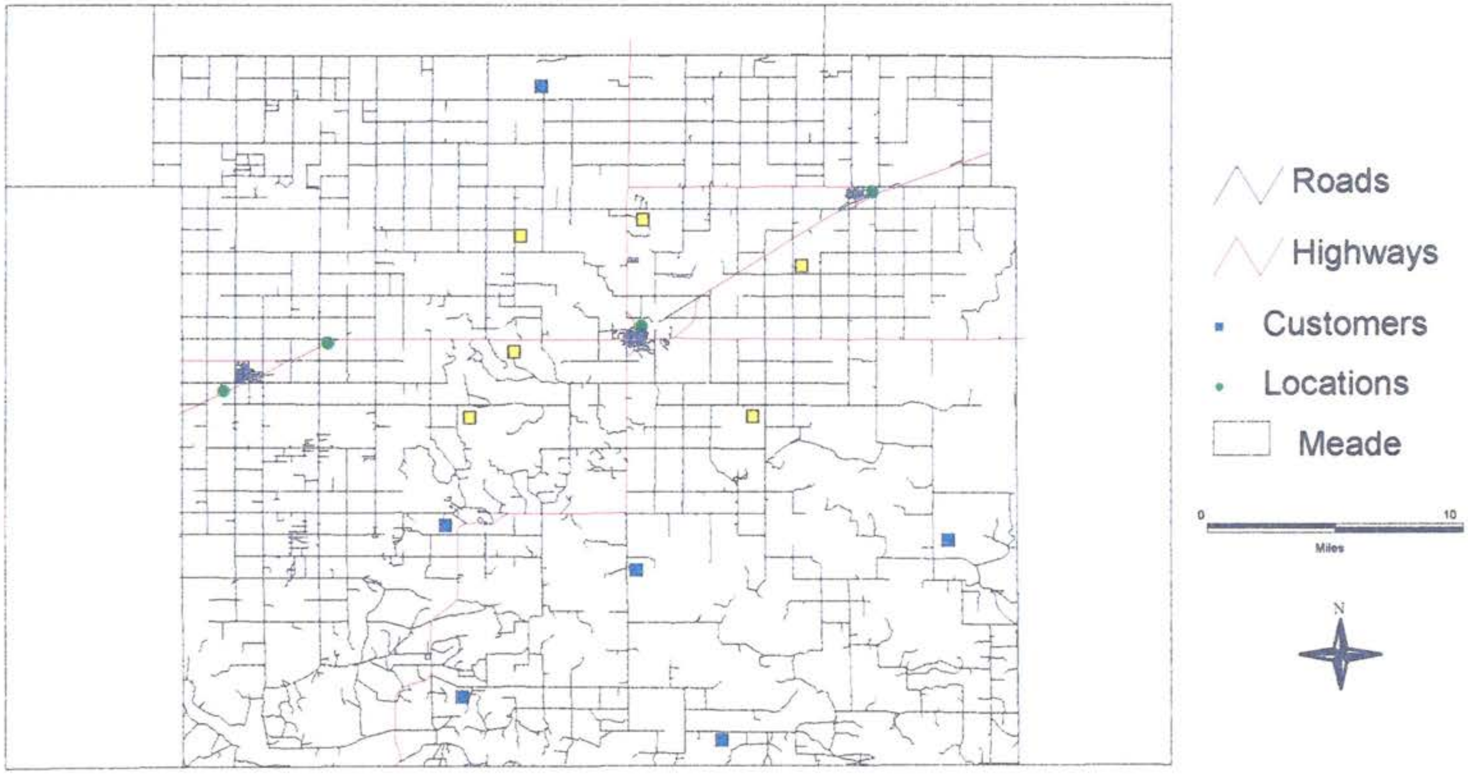
Farm Inputs

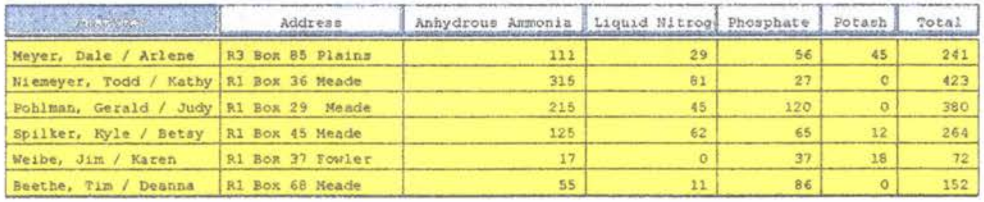
The preceding procedures and analyses are based solely on the grain output (buying) function associated with agricultural cooperation. What follows, in this second phase of the analysis, are the 'point of sales' and 'market share' components. Each deals with the farm inputs (service) provided by a cooperative to their individual customers and the corresponding service areas that result. 'Point of sales' is a micro scale look at how a spatial database can be used to maintain, analyze, and portray customer data for an individual location. 'Market share' is a macro scale look at the portion of each county's market share captured by a single cooperative–Garden City. Both use fertilizer data for illustrative purposes. Each demonstrates the advances in the analytical power of spatial databases for making these types of decisions that, up until recently, have been missing in both the software and literature (Openshaw 1992; Brown 1992).

Point of Sales

Meade cooperative, located in the heart of Meade county, provides a micro level example of the power of spatial databases in handling customer information. A table with related attribute fields was created with a record for each customer's sales information (hypothetical). The map of the area and a selected group of Meade patrons are depicted in Figure 9. A spatial query was performed on all customers of Meade to identify those within a distance of ten miles from the individual cooperative location. The location of these patrons are automatically highlighted on the view, as well as within the related attribute table. Only those six patrons which are within this threshold distance are selected and displayed in the table. Those customer locations that remain in blue lie outside of this buffered distance from the Meade location. This type of analysis may be useful to a cooperative location for determining the maximum distance of a servicing territory for a commodity or service or for determining delivery rates.

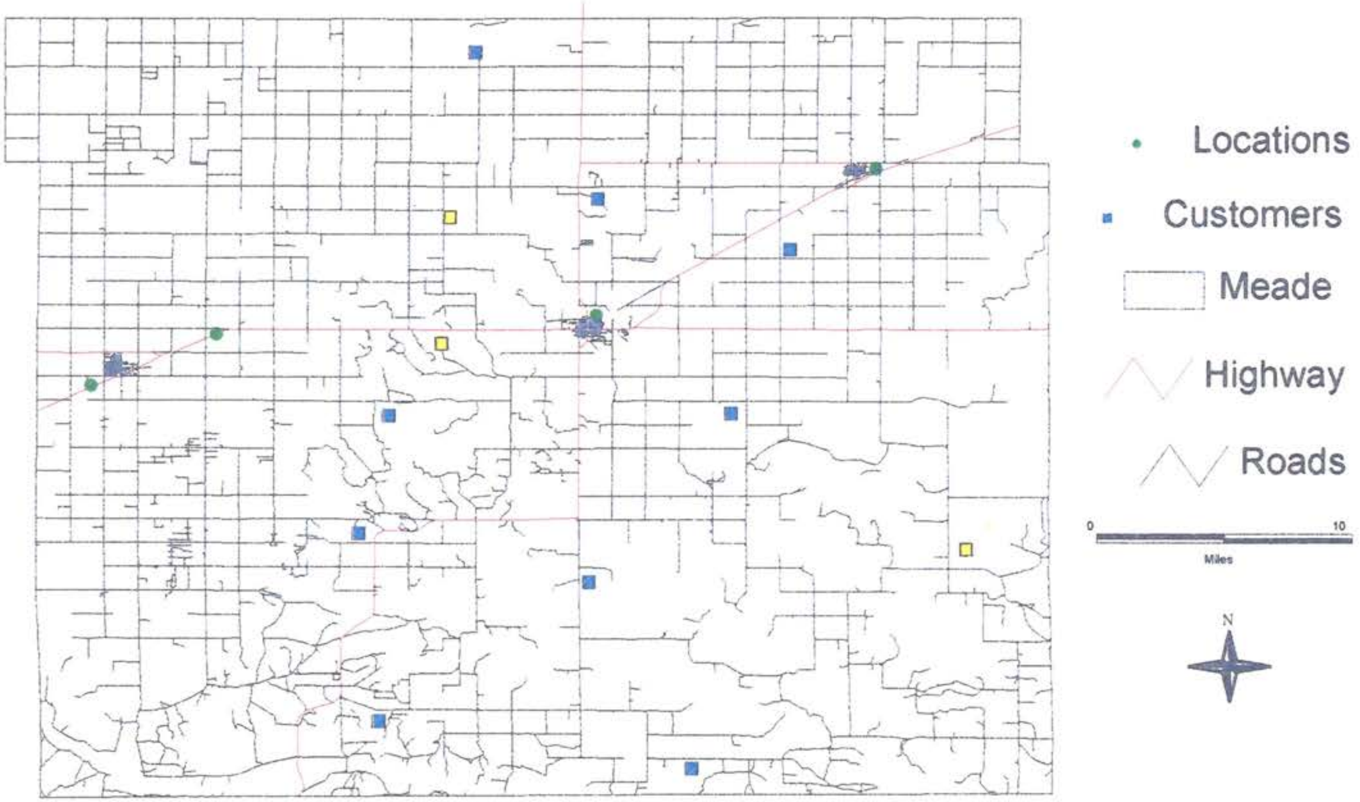
Another instance that illustrates the significant advances in the analytical power of spatial databases to analyze customer data is portrayed in Figure 10. A spatial query is once again performed using the patrons. This time, however, Meade wants to identify those customers with total fertilizer sales greater than 300 tons. Once again, only those patrons who meet this criteria are selected on the map and within the attribute table. Both the customer location and related sales information, ranging from their address and every type of fertilizer purchase they have made in addition to the total, are displayed.





[illegible]	Address	Anhydrous Ammonia	Liquid Nitrog	Phosphate	Potash	Total
Meyer, Dale / Arlene	R3 Box 85 Plains	111	29	56	45	241
Niemeyer, Todd / Kathy	R1 Box 36 Meade	315	81	27	0	423
Pohlman, Gerald / Judy	R1 Box 29 Meade	215	45	120	0	380
Spilker, Kyle / Betsy	R1 Box 45 Meade	125	62	65	12	264
Weibe, Jim / Karen	R1 Box 37 Fowler	17	0	37	18	72
Beethe, Tim / Deanna	R1 Box 68 Meade	55	11	86	0	152

Figure 9: Customers Within Ten Miles of Meade Cooperative



Customer	Address	Anhydrous Ammonia	Liquid Nitrog	Phosphate	Potash	Total
Pohlman, Gerald / Judy	R1 Box 29 Meade	215	45	120	0	380
Niemeyer, Todd / Kathy	R1 Box 36 Meade	315	81	27	0	423
Niemeyer, Lavern / Joan	R2 Box 204 Fowler	212	61	32	4	309
Spilker, Kyle / Betsy	R1 Box 45 Meade	125	62	65	12	264
Meyer, Dale / Arlene	R3 Box 85 Plains	111	29	56	45	241

Figure 10: Fertilizer Customers of Meade Cooperative with Sales Greater than 300 Tons

Spatially organized and automated information is becoming a key input into the decision-making process of many commercial and retail activities (Brown 1992; Beaumont 1992). The use of a spatial database to capture, store, manipulate, and query grain cooperative customer data is a significant departure from traditional analog records or even database management systems. Although database management systems are a marked improvement from traditional record keeping, they lack the spatial component that Beaumont (1992) and others have noted is necessary to analyze customer information geographically. Queries could be performed to identify customers with a threshold of fertilizer sales, but the spatial aspects of where they live in relationship to the cooperative location or what route is best suited for delivery are not possible in a database management system. Furthermore, identifying customers within a given distance along a network of a cooperative location and graphically portraying them is feasible only with a spatial database.

These type of analyses requiring a spatial database can be used to replace tabular files or traditional database management systems by identifying the geographic location of preferred farm input customers for target marketing, or identifying those patrons who may be in need of additional farm inputs. King (1991) used a similar approach for target marketing bank patrons in New York. Going a step beyond the current systems, spatial databases can use this aspatial data for decision making by capturing new geographic relationships that were unmeasured previously (Openshaw 1992). Once these customers have been queried from the database and visually portrayed in relationship to the cooperative location, a routing scheme to deliver products in the most efficient order or lowest cost across the highway network can be derived. Conversely, more accurate delivery charges for all customers served by a location can be produced when transportation costs across a road network are used rather than simple Euclidean distance.

Market Share

The final component of this conceptual analysis involves an assessment of a cooperative's market share for a particular commodity. Garden City Cooperative Equity Exchange (GCCEE), which contains eight individual locations, was selected to illustrate the portion of the market share of total fertilizer sales this cooperative captures from each county within the study area. The cooperative is centrally located along the upper edge of Figure 11 and portrayed in light brown. To determine the impact GCCEE has on every other county's market share in the study area, distance was first calculated from all eight of the locations. Using the 'Find Distance' command, the distance, using standard deviations, from the entire cooperative was calculated by creating a grid based buffer out towards the edges of the study area (Figure 12). Each zone represents an area of equi-distance from the cooperative. Similar to the weighted impedance map, standard distances are again used for the market share analysis, rather than a specific distance variable or measurement scale, to facilitate comparison (Berry 1993).

The next step is to determine the area of influence from the map of standard distances. The maximum extent of Garden City's impact on fertilizer sales was assumed to be the mean standard distance from one of the eight locations. All cooperative sales greater than the mean are not influenced by Garden City's sales while all those within this threshold have a portion of their fertilizer market share captured by the GCCEE. Since the area of influence is arguably a function of distance, the portion of the market share

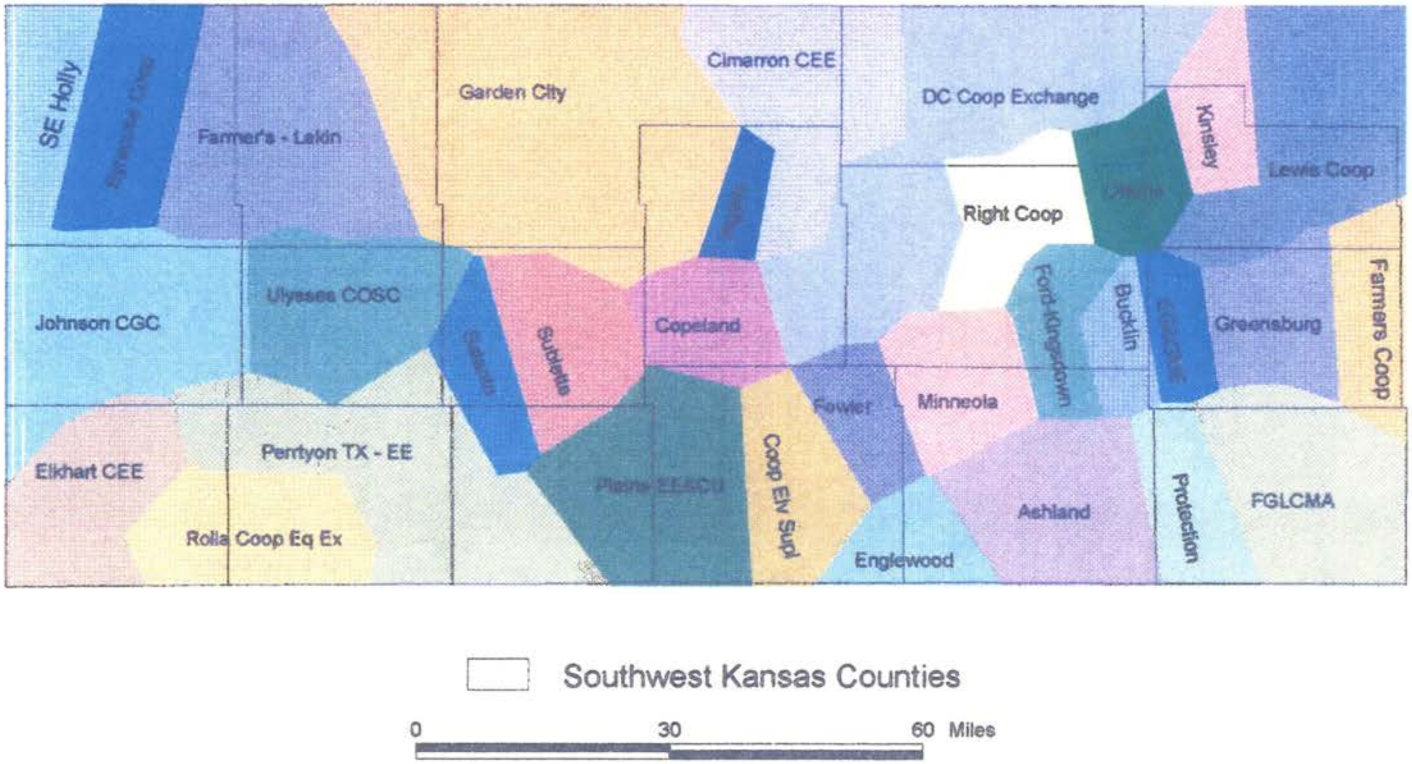


Figure 11: Cooperatives in Southwestern Kansas, 1987

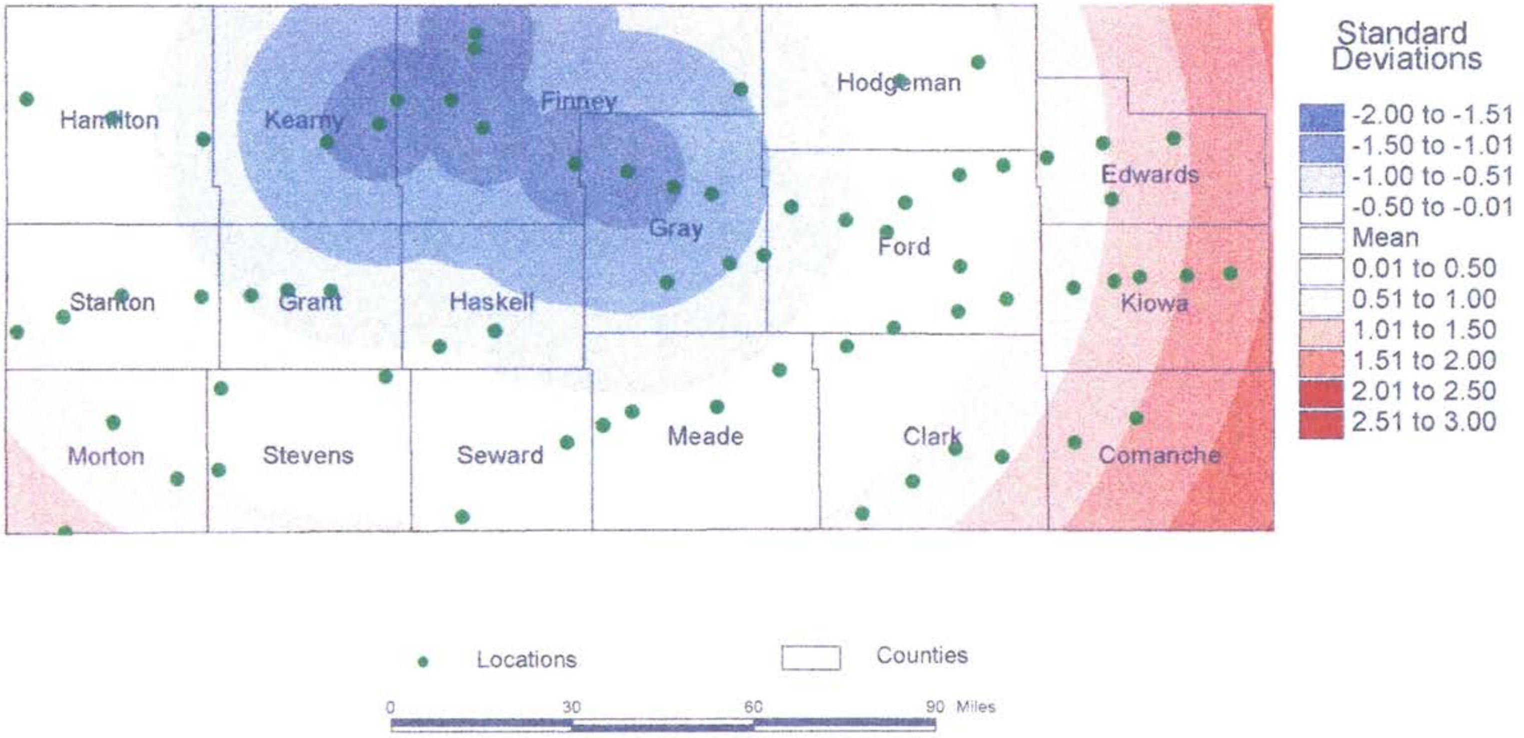


Figure 12: Standard Distance From Garden City Cooperative Locations

captured diminishes as the customer's distance to one of Garden City's locations increases. This decline is also believed to be non-linear, exhibiting a type of distance-decay effect that decreases at an increasing rate. Reilly's (1931) gravity model exhibits a similar relationship between travel distance to a center and attraction. As distance from a population center increases, attraction decreases, (often at an increasing rate). For these reasons, a form of inverse distance weighting (IDW) was selected as a means to compute the impact Garden City has on the market share of all other locations.

Four zones of equi-distance remain when only those within the mean standard distance are considered (Figure 13). The inner most zone directly surrounding the Garden City locations (approximately 11 miles in width) is the distance in which all locations will have 100 percent of their fertilizer sales captured by the Garden City cooperative. That is, all locations within this zone belong to the GCCEE. To calculate the impact on locations in each consecutive zone, a type of IDW is used. Each consecutive zone is roughly 11 miles in width making the second (red-ish brown) 11 miles farther from the first, the third 22 miles, and the fourth (light bright) 33 miles away from the zone housing the GCCEE locations. The area of influence within each zone was computed by dividing 1 by the squared distance each zone is from the first and multiplying by a scalar of 10,000 to derive a percentage of influence. Therefore, all locations within the innermost zone have 100 percent of their market share captured by the GCCEE. Locations in the second zone have 82.6 percent captured, the third 20.6, and in the final zone, 9.2 percent of the market share is lost. Each individual cooperative location within 22 to 33 miles of the original GCCEE area will have just over 9 percent of its fertilizer sales captured by one of the GCCEE locations.

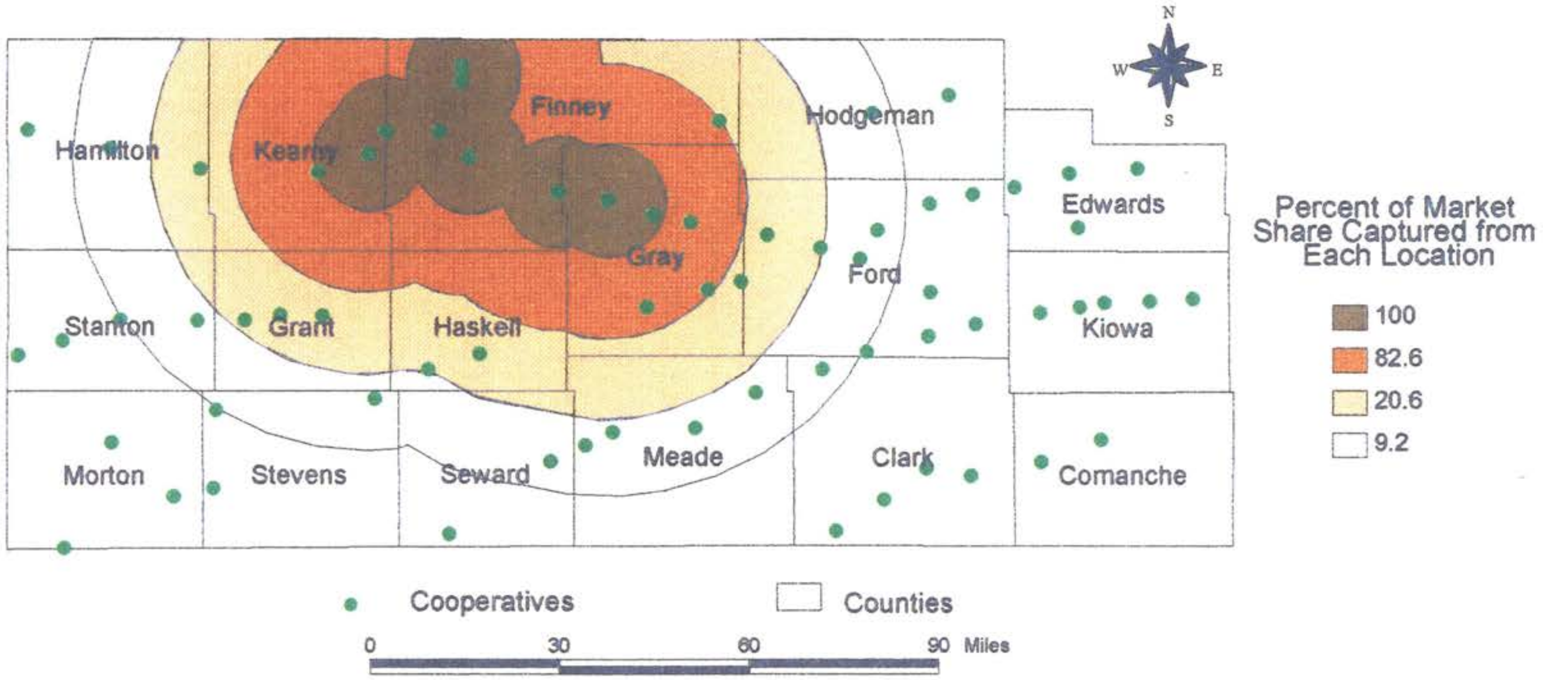
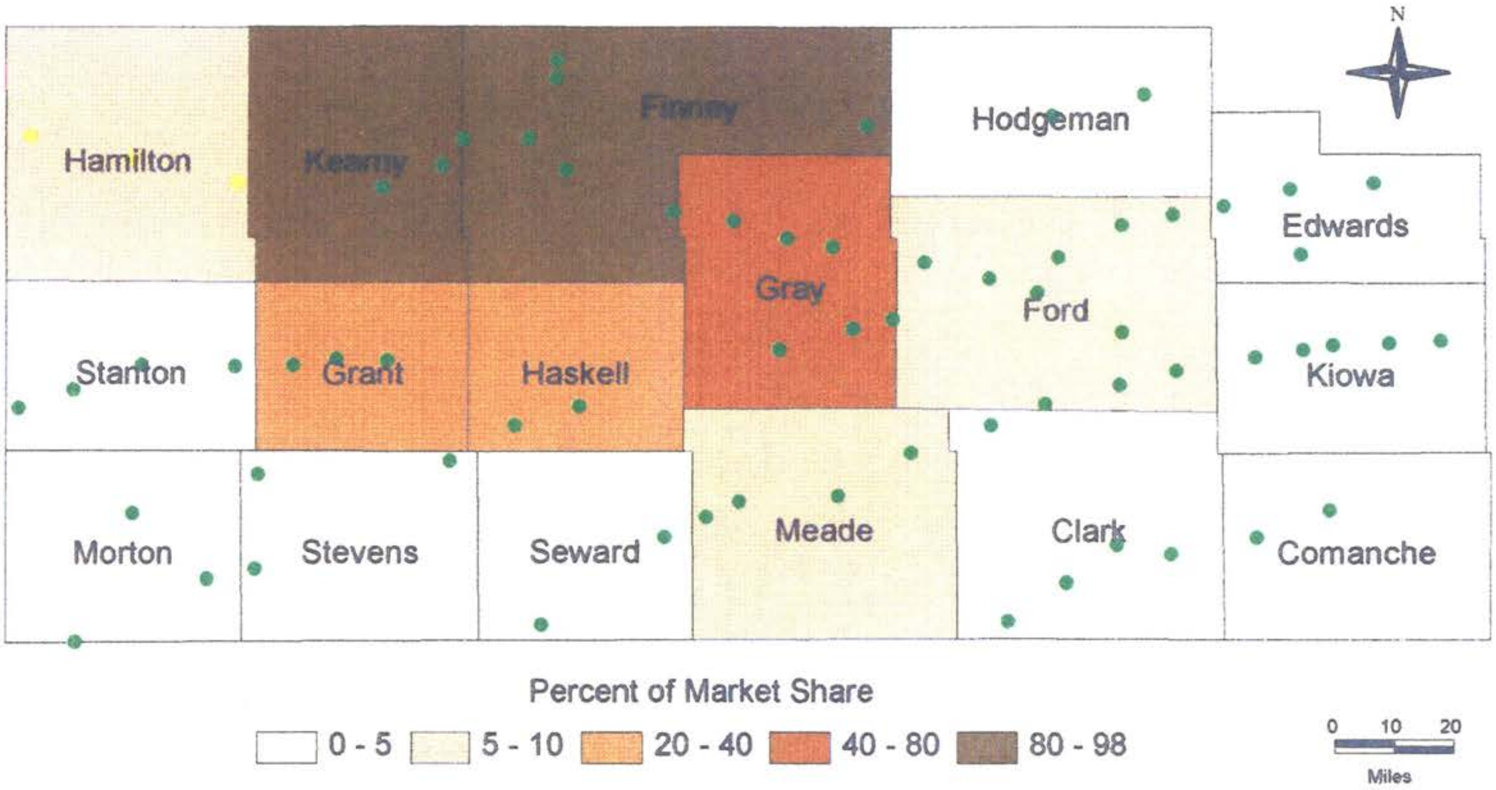


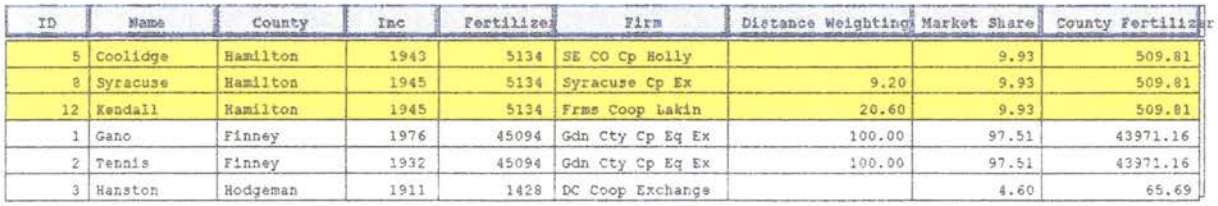
Figure 13: Garden City Cooperative's Area of Influence

Using the areas of influence from Figure 13, a new field in the attribute table is created called 'weighted distance' and assigned a percentage corresponding to the market share captured by the GCCEE. All locations outside the previously specified threshold distance are a given a 'null' value representing the GCCEE's lack of impact on their fertilizer sales. The final step is to compute the portion of the county market shares that is captured by GCCEE. To achieve this, the weighted percentages for all locations within the same county are summed and divided by the total number of locations within that particular county.

In Figure 14, the three locations within Hamilton county and their corresponding records in the attribute table have been selected for illustration. The location at Kendall is closest to the GCCEE and lies within the 20.6 percent zone (See Figure 13). Syracuse is located in the outer most zone of influence where only 9.2 percent of its fertilizer sales are capture by Garden City. Coolidge, however, lies outside of the area of influence and does not have any portion of its fertilizer market captured by the GCCEE. To ascertain the entire fertilizer market share captured by the GCCEE in Hamilton county the three 'distance weighting' values from Figure 13 are summed (29.8) and divided by the total number of locations within the county (3) to produce the market share captured by Garden City (9.93). Based upon this method, Garden City Cooperative Equity Exchange can expect to capture just under 10 percent, or approximately 510 tons, of Hamilton County's 5134 tons of total fertilizer sales.

Looking at the market share from a broader perspective, the GCCEE will capture nearly 98 percent of Finney County's, which is home to the cooperative, and 91 percent of Kearny county's sales directly to the west. Over three-fourths of Gray County's





ID	Name	County	Inc	Fertilize	Firm	Distance Weighting	Market Share	County Fertiliz r
5	Coolidge	Hamilton	1943	5134	SE CO Cp Holly		9.93	509.81
8	Syracuse	Hamilton	1945	5134	Syracuse Cp Ex	9.20	9.93	509.81
12	Kendall	Hamilton	1945	5134	Frms Coop Lakin	20.60	9.93	509.81
1	Gano	Finney	1976	45094	Gdn Cty Cp Eq Ex	100.00	97.51	43971.16
2	Tennis	Finney	1932	45094	Gdn Cty Cp Eq Ex	100.00	97.51	43971.16
3	Hanston	Hodgeman	1911	1428	DC Coop Exchange		4.60	65.69

Figure 14: Projected Fertilizer Sales for Garden City Cooperative Equity Exchange

fertilizer sales will go to Garden City while Grant and Haskell will contribute only one-fifth of their total sales. The second tier of non-contiguous counties, however, exhibit a rapid decline in the percent of their market share going to Garden City due to the rapid diminishing of the GCCEE's influence on those locations as a result of the distance decay factor and the increasing number of locations which are outside of the GCCEE's area of influence (See Figure 13). Because of the distance decay factor, those counties that are not adjacent to Finney, or whose locations are great distances from the GCCEE, yield little to no fertilizer sales for the cooperative. Therefore, the fringe counties of Edwards, Kiowa, Comanche, and Morton, as expected, have no portion of their market shares going to the GCCEE.

The ability to determine the current market share for a commodity is an important function not only for agricultural cooperation, but for virtually every other retail activity. GIS can play a critical role in assessing regional performance and improving market share, often with no additional costs incurred (King 1991). Farm input sales data are routinely kept by each cooperative. For statistical purposes, however, this information is aggregated on the county level when published by the USDA to prevent cooperatives and individual locations from determining the volume of commodities sold by competitors. Therefore, at present, cooperatives are only able to thematically map the sale of farm inputs from their own locations, or possibly as a percentage of total county sales. While traditional cartographic techniques could be employed to visually portray sales for a given cooperative, a spatial database, with the ability to capture new geographic relationships, is required to analyze this data spatially in the context of all cooperative sales. The use of a spatial database to analyze geographic relationships allows the cooperative to compute an area of influence based upon the relationship between its known sales in the region and the county totals. Once this proportion is acquired and properly weighted to account for the diminishing effects of geographic distance, the projected market share at the county level can be determined that a cooperative expects to capture from the locations of all other cooperative competitors. This process, as Openshaw (1992) noted, has traditionally been lacking in the analytical capabilities of spatial databases, and, as a result, has previously not been possible.

Conclusion

Interpreting the layouts produced from the five components of this conceptualization of geographic principles via a spatial database yielded some valuable insight into their applicability to the grain output and farm input phases of agricultural cooperation. Beginning with drawsheds for both individual locations and entire cooperatives under *ceteris paribus* assumptions provided a basis for comparison once transport costs and distance are considered. Once impedances (transport costs) along the highway networks and isodapanes were created using the Network Analyst, a 'friction layer' of costs was constructed forming the basis for the simulation of wheat pricing for each location. A market share increase captured by a location that raises its bid price to encroach on neighboring drawsheds and cause their decline is developed for agricultural grain cooperation using the Dermot example. This is done by relaxing the assumption that price decreases uniformly with distance from the exit. The use of Thiessen polygons as a basis for comparing market areas already exists in the literature. What is lacking is a method for capturing the fluctuations in the bid price for grain due to transportation cost and distance to compare to these drawsheds under *ceteris paribus* assumptions. The approach taken to develop the weighted drawsheds around Dermot may fill this void.

Shifting to the farm input function of a cooperative, Meade provided a relevant setting to demonstrate the power of a spatial database and its ability to analyze customer data to improve a cooperative's marketing and service functions beyond the level of current database management systems and thematic mapping methods that currently exist. Finally, these techniques are relevant for tracking the progress of a cooperative's regional sales efforts by capturing and modeling new geographic relationships between the diminishing effects of distance and total sales for both individual locations and entire counties, as the Garden City Cooperative Equity Exchange's market share example depicts. Not only are these geomarketing techniques, when combined with a spatial database, appropriate for the analysis of local sales and service to the individual customer, but they can be applied at the macro level to demonstrate how a cooperative performs against others in an entire region. Regardless of the function, whether it relates to the grain output or farm input activities, the use of a spatial database to illustrate geographic concepts as they relate to these aspects provides a marked improvement over current techniques used in agricultural cooperation.

CHAPTER 5

SUMMARY AND CONCLUSIONS

Introduction

A spatial database is a useful tool for integrating geographic thought and marketing principles for the purpose of demonstrating conceptually the major grain output and farm input functions involved in agricultural cooperation. Applying the appropriate concepts in the two spatial database environments made it possible to: 1) derive the relationship between pricing differentials related to cost and distance and compare this with Thiessen polygon drawsheds under *ceteris paribus* assumptions to determine how these aspects impact the expansion and contraction of agricultural grain drawsheds, 2) route grain across the transportation network to a regional grain terminal and calculate the appropriate impedances and corresponding bid prices, 3) better manage point of sales data by creating new relationships among cooperative locations, their customer data and the geographic space that separates them, and 4) compute and portray an entire cooperative's market area more effectively than simple thematic mapping. It is in this chapter that the results of this conceptualization are summarized, and avenues for future studies outlined. To facilitate the discussion, major findings are once again subdivided into the two phases of this analysis: grain outputs and farm inputs.

Summation of Results

Grain Outputs

Drawsheds

The creation of *ceteris paribus* drawsheds for individual locations is, as Martin and Williams (1992) pointed out, an acceptable method for delineating market shares as an initial basis for comparison. Openshaw (1992) further noted that this procedure is an appropriate spatial analysis method for comparison when used with a GIS. Therefore, Thiessen polygons were used for delineating grain drawsheds under 'idealized' conditions to contrast changes that resulted once the bid price was altered.

The creation of these drawsheds for individual locations is handled within the vector data model by constructing Thiessen polygons around each point. Creating similar market areas around an entire cooperative, however, is inherently a problem best dealt with in the raster environment. Using a 'hybrid' GIS, which incorporates much of the functionality of both the vector and raster data models, the creation of drawsheds for cooperatives was fairly straightforward. All of a cooperative's locations were selected (in effect grouping them) for analysis and a raster surface created around each that, when vectorized as a shapefile, functioned as *ceteris paribus* drawsheds for all 32 cooperatives. As both Martin and Williams (1987) and Openshaw (1992) discussed, the use of Thiessen polygons provided a useful framework to compare these drawsheds once a suitable methodology was found for capturing the impacts of the fluctuations in bid price and distance on grain cooperation.

Pricing Simulation

Many factors, often too numerous or difficult to quantify, contribute to the size of market areas (Vaile *et al.* 1952; Goldstucker *et al.* 1978). One of the biggest impacts, however, and among the easiest to quantify, is the friction of overcoming distance related to transportation cost (Applebaum and Cohen 1961). A spatial database has demonstrated its importance in producing these relationships (Beaumont 1992). The use of GIS to model these question of spatial interaction has been lacking in recent years in the literature (Brown 1992). This was due, in large part, to the absence of spatial analysis methods in most spatial databases (Openshaw 1992).

Under the pricing simulation component, the relationship between transportation cost, bid price, and drawsheds for grain cooperation, was produced using suitable spatial databases with the appropriate spatial analysis functionality. This required both the network and spatial analysis capabilities of GIS to capture these fluctuations in bid price as they relate to distance. This relationship, which until now was determined largely by Euclidean distance, neighboring locations, or pure speculation, provided a framework for comparison with the Thiessen polygons to better understand how these factors impact the expansion or contraction of drawsheds. The integration of GIS and spatial analysis procedures were not only impractical until recently, due to improper analytical capabilities of software (as Openshaw (1992) noted), but were also missing from the literature because many applications failed to use what analytical power existed (King 1991). This void in the literature, mentioned by Brown (1992), may be filled, in part, by this study's use of a spatial database to capture the fluctuations in bid price and distance to portray the growth or decline of agricultural grain drawsheds.

Network Analysis

As Applebaum and Cohen (1991) noted, transportation costs associated with distance are among the most important aspects for determining fluctuations in market share. Spatially organized transportation data, when combined with GIS for this type of gravity modeling involving grain drawsheds, is crucial to the commercial decision making process (Brown 1992; Beaumont 1992). Using the versatility of a 'hybrid' GIS, the friction of traversing a network with wheat was derived. The relationship between the friction of distance and transportation cost was then determined to: 1) calculate the bid price for wheat at a location (point) or over an entire service area (isodapanes), 2) spread the impedances through the use of a friction layer (raster), and 3) aggregate them as a single, weighted drawshed around each location (vectorized polygons).

The use of network analysis in this manner, as Beaumont (1992) noted, is the key to the decision-making process of agricultural grain cooperation for a number of reasons. First, it provides an alternative method to Euclidean distance that more accurately calculates transportation costs by computing the distances between each location and the regional grain terminal. Second, and more significant, the use of transportation costs derived from network analysis more precisely captures the relationship between the fluctuation of these transportation costs due to distance and grain bid prices. Perhaps the most critical of all grain cooperative decisions, the setting of bid prices has largely been based upon other less accurate methods including speculation. The methods incorporated in the grain outputs component of this study provide an alternative to this procedure or what currently exists in the literature.

Farm Inputs

Point of Sales

The growing analytical power of spatial databases was further demonstrated in the 'point of sales' component. Spatial queries were performed on customer data to graphically identify customers, and their relational attribute data, that were within a given range of the Meade location or that purchased a certain threshold of total fertilizer. While sales information could have been queried in a database management system, equating that information with a spatial location and graphically portraying it could only be done using a spatial database. The buffer operation, however, is unique only to spatial databases. Spatial relationships must be established between two themes that otherwise do not share common geography. The fact that certain customers patronize a given cooperative location requires the computation of relationships between these two otherwise incongruent themes. The result is a conceptually simple, yet logistically complicated, buffer around a cooperative location to identify customers within a ten mile radius (for example).

Using GIS to capture, store, manipulate, analyze, and display customer data is a significant departure from tabular records and even automated database management systems. While records can currently be queried using a database, they are not tied to a geographical location and are, therefore, unusable for computing any type of spatial relationship. GIS can not only be used for target marketing certain customers, as King (1991) noted, but can take this aspatial data one step further by tying it to geography. A spatial database is a significant departure from current customer data management systems and thematic mapping packages because GIS enhances the decision making process by creating new spatial relationships that previously did not exist.

Market Share

The final component of this conceptual analysis provided yet another example of the need that Openshaw (1992) notes exists, for increased analytical power using both the vector and raster data models in demonstrating geographic principles. Much like Reilly's (1931) original gravity model, a cooperative's influence on the market shares of neighboring locations is primarily a function of distance. The use of traditional thematic or computer mapping techniques is ineffective for capturing these diminishing effects of distance on competitor locations. GIS provides an acceptable medium for assessing regional performance and improving the market share captured, often without incurring additional costs (King 1991).

The nature of the collection and aggregation of farm input sales data requires cooperatives to portray it, often thematically, on the county level. Currently, cooperatives are only able to map sales from their own locations or as percentages of the county total, with little indication of the impact they are having on competitors. GIS will allow cooperatives to go beyond the traditional mapping of farm input data and compute the new geographic relationships required to assess their sales in relationship to competitors. This is facilitated through the creation of a new spatial association, using a 'hybrid' raster surface, between a cooperative and its area of influence related to competing locations. Once this new spatial association is determined and properly weighted to factor in the diminishing effects of distance, the projected county-level market share can be determined that a cooperative expects to capture from all competitor locations. This type of spatial analysis functionality is what Openshaw (1992) and Brown (1992) noted is missing from many spatial databases and, therefore, the current literature. Combining the spatial analysis techniques for analyzing cooperative market shares and a GIS with the appropriate spatial analysis capabilities from this study will not only improve upon existing methods for cooperative market share analysis but may also fill part of this void in the literature.

Conclusion

The use of a spatial database to merge marketing and geographic concepts can be an invaluable tool in agricultural grain cooperative decision making. Combining the previously discussed spatial analysis techniques with the increased analytical power of modern spatial databases has advanced our understanding of economic considerations relating to the bid price paid for grain, distance to the regional grain terminals reflected in transportation cost, and market areas of grain cooperatives. A spatial database was necessary to bring the geography and ancillary data of many varied, and often unrelated, themes together into one system for the purpose of educating ourselves and others on how they work together to influence agricultural cooperation.

Avenues for Future Studies

Additional work involving the integration of a spatial database to geographic concepts and techniques could take several avenues. First, the impact of economic distance and bid price could be assessed from the perspective of one of the other two regional grain terminals located in Forth Worth, Texas, or Enid, Oklahoma. Similarly, another grain output (such as corn or grain sorghum) or perhaps a farm input (like diesel oil or anhydrous ammonia) might be employed to portray bid prices and the subsequent expansion and contraction of drawsheds or market areas. Additionally, now that the foundation has been laid, a more in depth, micro level analysis of an individual agricultural cooperative could be performed in an attempt to model existing activity. Conversely, a more macro level approach might be useful in demonstrating the interrelationships of the larger grain terminals on a regional (such as Hutchinson, Fort Worth, and Enid) or national scale.

A second approach might be the merger of the same concepts within the context of a spatial database to model an entirely different type of commercial activity. If the techniques used in this study successfully demonstrated, conceptually, the influence concepts from several disciplines including geography have on agricultural cooperation, does the same relationship exist with wholesale and retail trade or the service industries? If so, can these sectors be modeled in such a way to explain existing activity, or perhaps even to predict future developments?

The methodology outlined in this conceptual model, which uses a spatial database to better comprehend the influence on agricultural cooperation, will be instrumental for many applications. It can be utilized for a micro level assessment of an individual cooperative, a macro scale analysis of agricultural activity on a regional or national basis, a look at farm inputs or another regional grain terminal, or the introduction into an entirely different sector of the economy. Regardless of the course taken, when combined with the appropriate geotechniques, the utility of a spatial database is virtually limitless.

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APPENDICES

APPENDIX I

Spatial Data Manipulation

Cooperative Location

Coverage	Description
SWCOOPS1	67 cooperative locations digitized in ArcEdit as points
TICCOV	tic coverage used for control points of study area
GEOREF / GEOLAT	created to rectify SWCOOPS1 using 'create' and 'transform'
SWCOOPS3	67 cooperative locations updated to lat./long. coordinates

Counties

Coverage	Description
KANSAS	study area 'clipped' from entire state as polygons
KANSAS2	study area with planar enforcement created using 'build'
SWKAN7	overlay of SWCOOPS (point) and KANSAS2 (polygon) using the 'Intersect' option
SWKAN	overlay of SWCOOPS3 (point) and KANSAS2 (polygon) using the 'Intersect' option with added attribute data from both the counties and locations renamed to SWKAN7

Transportation Networks

Coverage	Description
SWSTR	street arcs for all 17 counties 'appended' together and sorted by CFCC code leaving the highways
RROAD	State of Kansas railroad networks
SWRR	study area railroad networks 'clipped' from RROAD using KANSAS2 and the 'line' option
SWKAN7 (new copy)	elevator locations manually moved onto the highway network in ArcEdit
COOPS	SWKAN7 imported into the UNIX environment
HWYS	SWSTR imported into the UNIX environment
SWRAIL	SWRR imported into the UNIX environment

CPHWY	moving the nodes corresponding to the elevator point locations in COOPS to the closest node along the highway arcs in HWYS using 'snapcover' and the 'point' and 'arc' options and a snap tolerance of 0.03 units
SWRR	moving the nodes corresponding to the elevator point locations in COOPS to the closest node along the railroad arcs in SWRAIL using 'snapcover' and the 'point' and 'arc' options and a snap tolerance of 0.03 units
CH_NODE	topologically assigning a node (NAT) corresponding to the elevator point locations in COOPS to a node along the highway arcs in HWYS using the 'pointnode' command with a specified tolerance of 0.02 units
CR_RR	topologically assigning a node (NAT) corresponding to the elevator point locations in COOPS to a node along the railroad arcs in SWRAIL using the 'pointnode' command with a specified tolerance of 0.02 units

Drawsheds

Coverage	Description
DRAWSHED	Thiessen polygons created around the COOPS point coverage using the UNIX 'Thiessen' command

APPENDIX II

Data Enhancement

ArcView Project

Shapefile	Description
SWKANSAS.shp	ARC/INFO study area polygon coverage KANSAS2 converted to an ArcView shapefile in the COOPS.apr project
COOPS.shp	ARC/INFO cooperative location point coverage COOPS converted to an ArcView shapefile in the COOPS.apr project
HIGHWAY.shp	ARC/INFO highway arc coverage CH_NODE(7) converted to an ArcView shapefile in the COOPS.apr project
RAILROAD.shp	ARC/INFO railroad arc coverage CR_RR converted to an ArcView shapefile in the COOPS.apr project
DRWSHD.shp	ARC/INFO drawshed polygon coverage DRAWSHED converted to an ArcView shapefile in the COOPS.apr project

Drawsheds

Shapefile / Grid	Description
PRXDSHD	grid of Thiessen polygons around each location using ArcView's 'Assign Proximity' command
FRMDRWGD	grid of Thiessen polygons around all 32 cooperatives created in ArcView using the 'Assign Proximity' command
FRMDRWSD.shp	shapefile created by converting the grid file FRMDRWGD

Simulation of Pricing

Shapefile / Grid	Description
CSTGRID	COOPS point theme converted to a grid based upon the transportation 'impedance' field using ArcView's 'Assign Proximity' command used as input for Avenue request 'CostDistance'
CSTGRID.shp	shapefile created by converting the grid file CSTGRID
SRCGRID	grid created from COOPS, cooperative locations point theme, used as input for Avenue request 'CostDistance'
SRCGRID.shp	shapefile created by converting the grid file SRCGRID

PGRID8	temporary grid created from the 'CostDistance' request that was renamed to WHTCSTGRD
WHTCSTGRD	weighted cost grid for wheat price around each cooperative location produced form the 'CostDistance' request using SRCGRID and CSTGRID as objects
WHTCSTGRD.shp	shapefile created by converting the grid file WHTCSTGRD
WHTD_DSD.shp	polygon feature theme created by manually digitizing grain drawshed polygons around Dermot from the grid WHTCSTGRD

Network Analysis

Shapefile / Grid	Description
EXITS.shp	points theme of the highway exits to the regional grain terminals
HWYEXT.shp	highway routes from the Hutchinson exit to each cooperative location created from the 'Find Closest Facility' command
HTCHSRFC.shp	isodapanes of equal transport cost to Hutchinson exit created from the 'Find Service Area' command using 20 mile increments ranging from 0 to 260

Point of Sales

Shapefile / Grid	Description
MD_RDS.shp	line theme of all roads for Meade County
MD_CTYS.shp	line theme of all cities for Meade County
MD_STRMS.shp	line theme of hydrography for Meade County
MD_SECT.shp	polygon theme of the PLSS Grid for Meade County
MD_CNTY.shp	polygon theme of the Meade County boundary
CSTMRS.shp	point theme of fertilizer customers for the Meade location

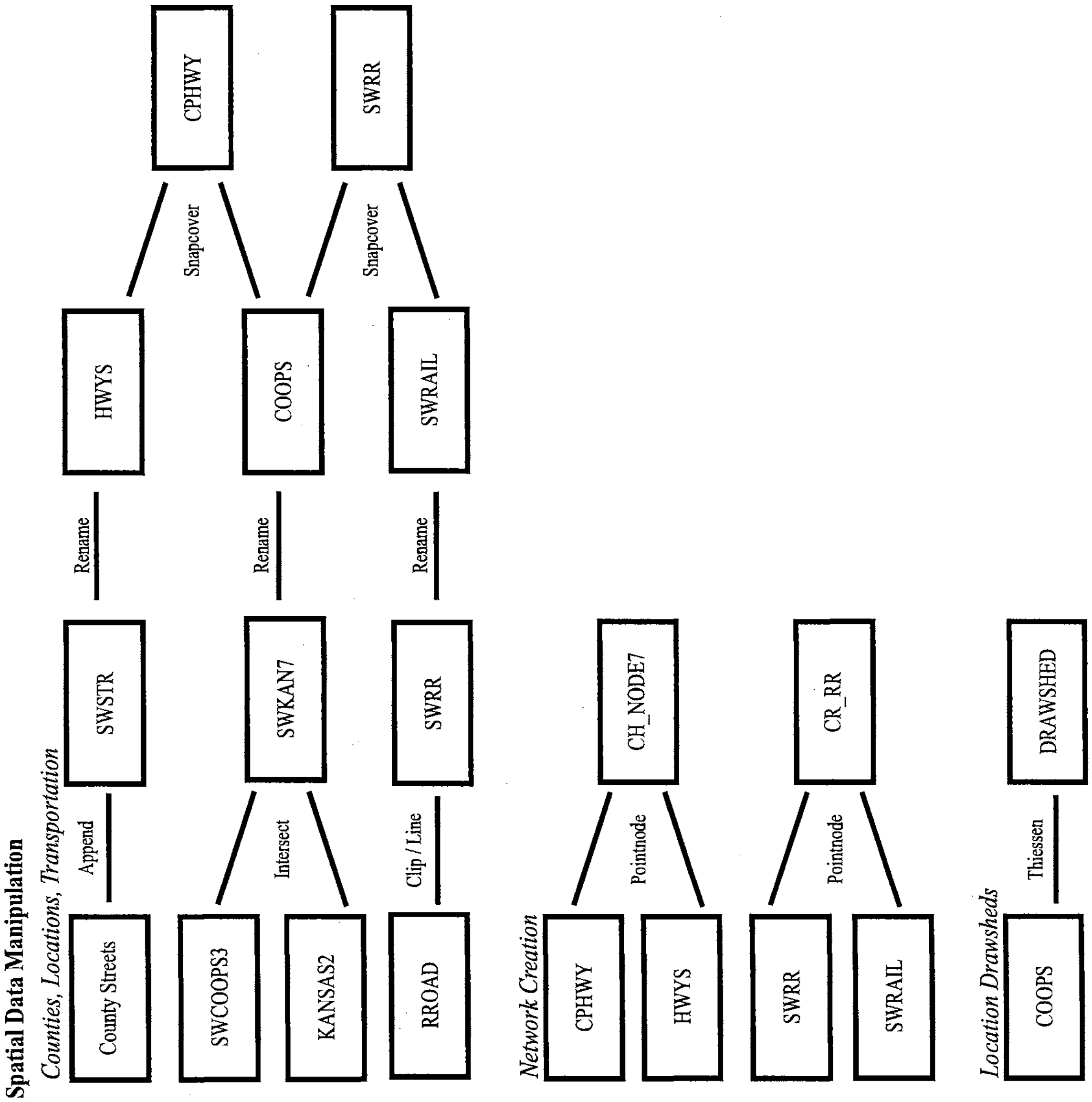
Market Share

Shapefile / Grid	Description
GC_GRID	grid theme produced by computing the distance from the 8 GCCEE locations using the 'Find Distance' command
GC_GRID.shp	shapefile created by converting the grid file GC_GRID

APPENDIX III.a

Flowchart of ARC/INFO Operations

The following flowcharts are graphical representations of the steps outlined in the methodology from Chapter 3. Each series of GIS operations and the resulting themes, grids, or coverages, follow the discussion in the text. Operations are organized according to the software used, ARC/INFO and ArcView, data manipulation and enhancement headings and by subheadings corresponding to the appropriate component in both the grain output and farm input phases of the analysis.

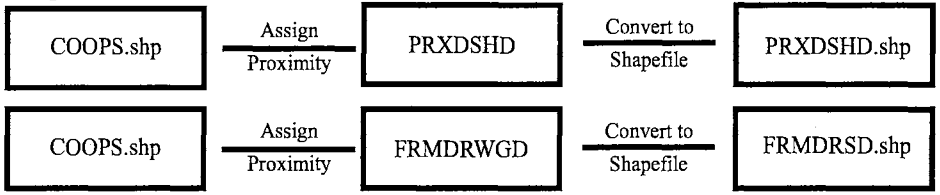


APPENDIX III.b

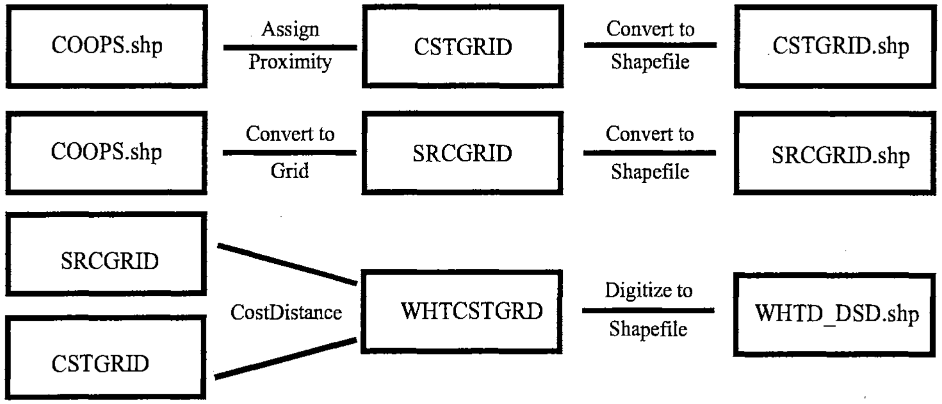
Flowchart of ArcView Operations

Data Enhancement

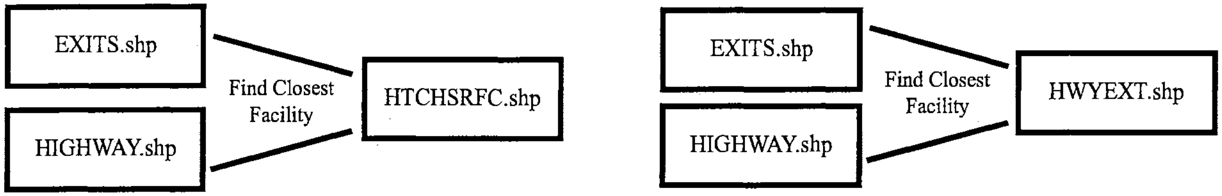
Cooperative Drawsheds



Pricing Simulation



Network Analysis



Market Share

VITA

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Education: Graduated from Tri County High School, DeWitt, Nebraska in May 1988; received Bachelor of Science and Master of Arts degree in Geography from Northwest Missouri State University and Kansas State University in 1992 and 1994, respectively. Completed the requirements for the Doctor of Education degree with a major in Geography at Oklahoma State University in May, 1997.

Experience: Employed by the Department of Geography at Northwest Missouri State University as an undergraduate teaching assistant from the fall of 1991 to the spring of 1992; employed by the Department of Geography at Kansas State University from 1992 through 1994 and by Oklahoma State University from 1994 to the present as a graduate teaching assistant.

Professional Memberships: Association of American Geographers, Gamma Theta Upsilon, Phi Kappa Phi, Pi Sigma Alpha.