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Measuring urban commercial land value impacts of access management applications

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Measuring urban commercial land value impacts of access management applications

by

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David Plazak
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This is to certify that the master's thesis of
Jamie L. Luedtke
has met the thesis requirements of Iowa State University

.gnatures have been redacted for privacy

To Dad, because he was always right.

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ABSTRACT

The safety benefits of access management, the controlling of access points on roadways, have been proven and have been well documented in past research. However, there is limited research on the economic impacts of access management, and most existing research is qualitative. Further quantitative research is needed because commercial business owners believing that direct and complete access to their land is an integral part of sales do not always accept access management practices. However, using sales data as an economic indicator in analysis presents problems, for sales data cannot be gathered per land parcel. Commercial land values are useful in this regard.

This research measures the urban commercial land value impacts of access management applications in Des Moines, Iowa through a regression model. The regression model is based on the hedonic property value model, a regression model measuring relationships between non-market variables and property values. The regression model used in this study measures relationships between commercial land values per square foot to parcel square footage, average annual daily traffic (AADT) counts, and scaled access control for each study parcel.

The results of the study regression model found that both parcel square footage and AADT have negative relationships to commercial land values, while access control has virtually no influence on commercial land values. This finding could help demonstrate to business owners that access control should not negatively impact their land values, and be one step to further access management acceptance in the business community.

CHAPTER ONE - INTRODUCTION

Benefits of Access Management

The practice of controlling access points on roadways, known as access management, has been proven to reduce traffic conflicts, preserve roadway functional classification, and improve roadway safety. Safety impacts of access management strategies have been well documented, however, the economic impacts of access management, although previously researched, are less understood. Past research on the economic impacts of access management techniques have used qualitative measures of study that may not accurately represent how access control affects business owners. A quantitative approach to this research is proposed to explore the economic impact of access management on businesses surrounding an access-controlled corridor. The most logical indicator of business vitality is sales data. However, sales data are proprietary and difficult to obtain for individual parcels. For this reason, an alternative indicator was studied to determine the economic impacts of access management techniques.

Land Values as an Economic Indicator

One economic indicator that may be measured quantitatively is commercial land values. Commercial land values are influenced by a number of factors such as location, socio-economic characteristics of the surrounding area, etc. This research hypothesizes that commercial land values are influenced by roadway characteristics such as access control. Using land values instead of property values as an economic indicator has benefits as well. Property values are the sum of land values and structural values per parcel, and including structural values as an economic indicator could lead to problems due to frequent structural value changes from building updates.

Need for Research

Although the safety benefits of access management have been demonstrated in past research, commercial property owners have expressed concerns about the practice out of fear that limiting access points to businesses may deter customers desiring direct and complete roadway access. If research could determine quantitatively that access management techniques do not negatively impact commercial land values, more business owners may be tolerant of access management techniques in new or existing site designs. As found in previous research, measures of customer satisfaction could determine this, as could an inventory of business sales. However, this past research has all used qualitative data, since most related quantitative data, such as sales data, is not available publicly per individual land parcel.

Project Definition and Objectives

This research will determine the commercial land value impacts of access management techniques within the city of Des Moines in Polk County, Iowa, through analysis of parcel land values with and without controlled access. This study presents both descriptive statistics to show overall land value change and inferential statistics to that demonstrate the strength of the relationship between access control and land value, as well as other variables. The analysis was completed using two computer programs: a geographic information system (GIS) to create data sets, project maps, and process descriptive statistics, and a statistical program to process inferential statistics. The hedonic property value model (*1*), a regression model used in other types of research but not yet access management research, are introduced as a tool to find the true non-market impacts of access management on commercial land values. The regression model contains other variables that could explain variation in land values, and will test those variables' relationships with commercial land value as well. Analyzing and comparing the results of the regression models with descriptive statistics of relevant data sets provides insight on access management's and other variables' influences on commercial land values.

Hypothesis

Land valuation is a balance of many unique factors, and these factors do not influence land values similarly. A parcel's roadway access could influence commercial land valuation to varying degrees. In hopes that minimal negative commercial land valuation change may create less opposition to the practice of access management among commercial property owners, the hypothesis for this research is that access management techniques will have minimal or no negative impacts on land values in Des Moines, Iowa.

Thesis Organization

This thesis is divided into seven chapters: Introduction, Access Management, Property Values and Transportation Improvements, General Methodology, Descriptive Statistics, Inferential Statistics, and Conclusions. Chapter One, Introduction, has determined a need for this research, defined the research project, and created a hypothesis. Chapter Two, Access Management, and Chapter Three, Property Values and Transportation Improvements, are both a review of prior literature relating to this research topic. Thus far, the economic impacts of access management have not been studied through a regression model, so the literature review focuses on general concepts and findings of overall access management research, as well as research trends relating property values and transportation improvements. Chapter Four, General Methodology, outlines the methodology for analyzing related data in study areas, as well as for creating the regression model. Chapter Five, Descriptive Statistics, provides a thorough view of study corridors used for this research, including breakdowns of relevant corridor and land parcel data. Chapter Six, Inferential Statistics, describes the creation of the hedonic property value model, or regression model, and provides results. Chapter Seven, Conclusions, studies the research results found from descriptive and inferential statistics in previous chapters to conclude, accept or reject the research hypothesis, and make recommendations for future research.

CHAPTER TWO - ACCESS MANAGEMENT

Access Management Overview

The practice of managing access points on roadways is twofold; access management manages access to land development while simultaneously preserving traffic flow on roadway networks (2). The primary benefit of managing access is reduced vehicle conflicts demonstrated through research results. Access management begins with access classification systems, and then concentrates on both access spacing and access design in order to create more efficient and safe roads.

Access Classification

The practice of access management should begin with an analysis of network access classifications. Generally, road classification systems have four types of roadways:

- Interstate roads
- Arterials
- Collectors
- Local roads

(3 - *Michigan Access Management Guidebook: 2001*)

These four roadway types reflect differing proportions of mobility and property access, and differ by varying levels of traffic volumes, trip speeds, and travel distance (2). The four types of roadways make up a complete road network, and this functional classification reflects land uses and densities in urban and rural areas.

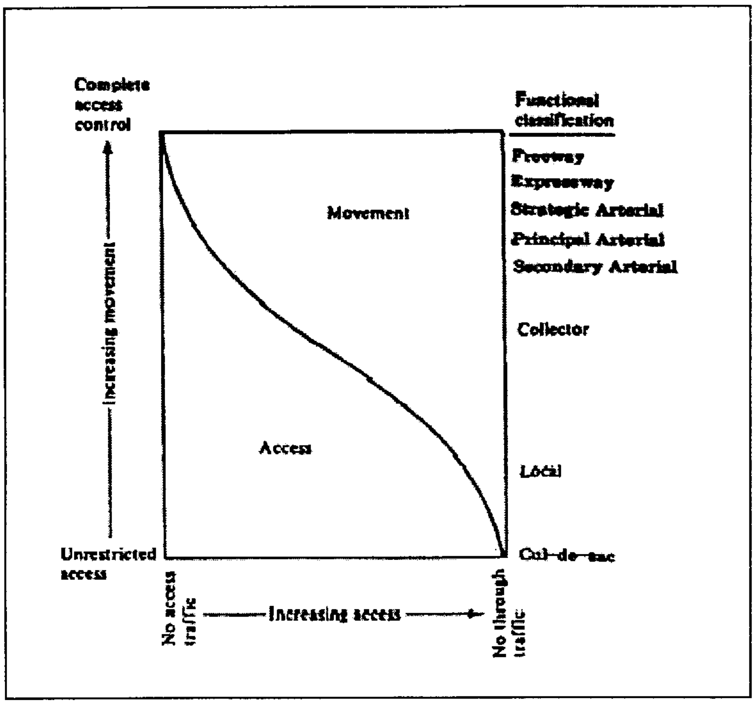

Figure 2-1. Mobility versus access: Roadway functional classification

(Source: Koepke and Levinson, NCRHP 348, Access Management for Activity Centers)

Access Spacing

To preserve roadway functional classification, the management of access also depends on three components of highways and activity centers as specified by Koepke and Levinson (2). The first element regards the access level allowed for each roadway type as defined by the functional classification of roads. The second component involves site planning and geometric design standards of adjacent land parcels. The final portion considers access spacing criteria for each roadway type. Access spacing preserves the functional classification of roadways by allowing for land parcel access while maintaining traffic flow. The spacing of access points is determined through access spacing guidelines, which differ among the varied roadway access classifications. The access types generally managed through access spacing guidelines include grade-separated interchanges, signalized and nonsignalized intersections, unsignalized driveways, and median openings (2). Access spacing guidelines are tailored to each access type, but should reflect the following factors:

1. Permitted access varies by access class, facility type, road speeds, and density of land development.
2. Access spacing guidelines do not have to conform to existing access practices.
3. Access spacing guidelines should be applied to new development and to significant changes in existing developments.
4. Permitted deviations from the guidelines should vary with access level or functional classification of roadway.
5. Traffic signal spacings for driveways and at-grade intersections should be related to speed; higher speeds should indicate greater spacings.
6. Signal spacing guidelines should detail both intersecting public streets and access drives.
7. Locations for signalized at-grade intersections should be located first so that unsignalized intersections and driveways may be selected based on the signalized intersections
8. Grade separations may be needed at system interchanges, where major roads intersect.
9. Reasonable alternative access points need to be considered, but access problems should not be transferred to another point in the system.
10. Direct access to land parcels that do not follow the spacing guidelines may be needed if no reasonable alternative access is found.

--Source: Koepke and Levinson, NCHRP 348, 1992

Access spacing uses each roadway's access classification to create guidelines for spacing to be used by both new and existing land developments. These guidelines will create roadway corridors that are planned based upon major signalized intersections and grade separations; lower degrees of access points, such as unsignalized intersections and driveways, are planned in relation to these larger access points. Access spacing guidelines strive to create safer roadways, and are tailored by access classifications, land developments, and other unique aspects of an area.

Access Design

Access design is another step required for access management. Access classification created the background to produce access spacing guidelines, and these guidelines will determine the access design needed to complete corridor management. Techniques to manage access are applied to roadways and driveways as well as land developments. In this, access design involves not only roadways and access points themselves, but activity center sites (2). All three of these aspects must be considered in order to fully mitigate, rather than reassign, access problems on a corridor.

Some major types of design used in access management include interchanges, frontage roads, intersections, driveways, and raised medians. These design types may be implemented into new development, or may be used to retrofit roadway corridors to control land parcel access points. Again, these designs must be considered for a corridor after access classification and spacing guidelines have been created; if access classifications and spacing guidelines are used to implement access designs, roadways will manage access more effectively.

Separated-grade interchanges are primarily used at either large activity centers to create access from highways where it would not be practical for an at-grade intersection, or to separate traffic from major arterial roadways (2). Frontage roads are service roads off arterial streets that cut off arterial street access to land development by providing access only from the frontage road. The selective placement of frontage roads can increase access to land development while reducing access points on an arterial roadway (2). However, the arterial road access to frontage roads must be defined in access spacing guidelines so that new access problems are not created. Both signalized and unsignalized intersections may have a place within a managed corridor, but their main access problem is that of left turning movements. Left turning vehicles not only must cross into oncoming vehicles' paths, but these vehicles can cause queues at intersections while yielding to oncoming traffic. To remedy this problem, left-turn lanes can be constructed to store left-turning vehicles while leaving the other lanes for through traffic. In addition, left turns may be completely prohibited on certain roadways, most likely during peak-hour traffic, to avoid queues and possible crashes (2). Medians also help to control turning movements into driveways by separating traffic flows and restricting left turning movements fully.

Direct access to land development has been strictly controlled to this point through access classification and access spacing guidelines. However, if a driveway is desired after these processes, driveway locations should be assessed based on the amount of right-of-way allotted for access purposes, the directions of the approaching traffic, the locations of existing access points, queue patterns that occur along the roadway, nearby traffic signal timing requirements, and existing driveway locations (2).

Researched Safety Impacts of Access Management

Access management not only preserves traffic flow on roadway networks, it also reduces potential driver conflict, creating safer roads. A major study conducted by Gluck, Levinson, and Stover (*4*) reveals the true safety impacts of access management techniques by focusing on the impacts of more than 100 specific access management techniques. The following safety impacts of access management were found:

1. Closer spacing of traffic signals decreases levels of safety and traffic operations.
2. Crash rates increase as unsignalized access density (access points per mile) increase.
3. The number of impacted through traveling vehicles traveling in the curb (right) lane increases as high-volume driveways are spaced closer together.
4. Traffic safety and operations improve when corner clearance is increased.
5. The installation of two-way left turn lanes (TWLTL) and raised medians provide traffic safety and operations benefits as turning movements are restricted.
6. Adding left-turn lanes improve traffic safety and roadway capacity by removing turning traffic from the through vehicle lanes.
7. When indirect left turns or U-turns are used as an alternative to direct left turns, traffic safety, roadway capacity, and travel time benefits are seen.
8. Access spacing on arterial roadways near interchanges may not be adequate for left-turning movements
9. Frontage roads along freeways could reduce arterial left turn lanes and provide access to land development.

   -- Source: Gluck, Levinson, and Stover, NCHRP 420, 1999

Access classification, spacing guidelines, and design have been proven to work together to create safer and more efficient transportation systems. While access management has been documented to increase safety on roadways, other types of impacts have not been researched as thoroughly as safety impacts of access management. Economic impacts of access management techniques have been researched to a much lesser extent, but the research performed provides a good base for further research on the topic.

Researched Economic Impacts of Access Management

Past access management research has centered on the safety benefits of the practice- however, there has been limited research on the economic impacts of access management. Most economic studies of access management have focused on medians and how left turn restrictions could impact business activity (5).

Because access management can restrict direct access to commercial land parcels, the issue of business impacts of access management needs to be studied. The potential economic impacts of access management on nearby businesses have been previously researched, using different methods to determine if businesses suffer negative effects from losing direct access to their properties. However, economic impacts are difficult to measure quantitatively in this situation, for many researchers may do not have access to individual businesses' sales data. If this data were available, researchers could compare sales before and after access management treatments have been applied to determine the impacts of the access control on sales and consumer tastes. Though this obstacle of unavailable data persists, the economic impacts of access management treatments have been researched through business and customer perception surveys, and comparison of business vitality among different roadway corridors (*6*).

To discover if access management treatments have minimal overall effects on business vitality, the states of Kansas, Texas, Iowa, and Florida conducted studies on the economic impacts of access management techniques in the United States (6). Each state conducted different studies, but each provided strong evidence that access management techniques do not have significant negative economic impacts. The Kansas Department of Transportation studied businesses that filed lawsuits claiming their businesses were negatively impacted by a variety of access management treatments. The Texas Department of Transportation studied the economic impacts of restricting left turns by installing raised medians. In lieu of sales data, the researchers personally interviewed business owners, and found that owner perception of business change due to the access management treatment was generally more negative than the actual business change. The state of Iowa used secondary data, interviews, and field investigations to determine access management treatments' effects on business vitality. The study found that corridors with completed access management projects reported higher overall sales than their surrounding communities. The state of Florida performed two studies on the economic impacts of median reconstruction projects; again, these studies showed that business owner perception of business vitality after treatments was more negative than the actual economic conditions.

The practice of access management is proven to be beneficial from a safety standpoint, but this fact alone does not sustain support from commercial landowners to control parcel access points to major roadways. Reduced crashes benefit motorists, but business owners are uncertain about the practice's influence on sales and other economic indicators. Chapter Three provides an introduction to such an economic indicator used for this study, land values. Because access management could be considered an improvement to transportation systems, the next chapter also reviews past research to find connections between value and transportation improvements.

CHAPTER THREE – PROPERTY VALUE AND TRANSPORTATION IMPROVEMENTS

Property Value

Value, as a term, has a distinct meaning. Value, unlike the terms price, market, and cost, represents the monetary worth of property, goods, or services to buyers and sellers at a certain point in time (7). This paper reviews literature on property values; although the item being valued, property, is not disputed, the type of value measured is of importance. There are generally five types of value: market, use, investment, going-concern, insurable, and assessed value. The type of value that would best measure access management's impact on property values is assessed value. Assessed value applies ad valorem taxes to property's value, and reports property's value as reported by tax rolls.

Property value is a combination of value of the land parcel and the structures that occupy it. Property's value is created through individual preferences in a market that form a relationship between an individual and the property. However, these relationships are quite intricate, and values may fluctuate along with individual preferences (7). Four factors constitute the supply and demand of a property, and also create the property's value to an individual: scarcity, desire, effective purchasing power, and utility (7). Scarcity is the present or forecasted supply of the property in relation to the demand for the property. Desire is measured by property users' aspiration for the property to meet their needs. Purchasing power represents the ability of one potential buyer within the market to pay for the property. The factor of utility, however, can be directly related to properties' access. Utility represents the ability to satisfy user needs. Owners or renters of property must receive some level of benefit from the property in order for it to have value, and this benefit can be translated into a property's cash value (7). Utility's effect on property value varies due to unique property amenities, which could include property access.

This research used land value as an economic indicator of access management techniques. Land values were used rather than property values because property values include structural values, which experience more change than land values due to building construction, remodeling, and general improvements. The constant structural value changes in a data set would not only be difficult to track, but nearly impossible to control for. Land values are generally more stable, and therefore will be used as an economic indicator rather than property values.

The valuation process of assessing a property's value generally combines one to three types of data analysis: cost, sales comparison, and income valuation (7). The cost approach of property assessment adds the estimated land value to the current cost of creating a replacement and then subtracts the amount of depreciation. The cost approach is useful when valuing new property improvements or properties that are not involved in many transactions. The sales comparison approach of property assessment compares one property against others to find similarities by comparing items such as real property rights conveyed, financing terms, sale conditions, market conditions, location, physical characteristics, economic characteristics, use, and non-realty components of value. After these aspects are compared among properties, appraisers or assessors can compare them to result in an overall assessment of a property's value. This method is best used when a group of similar properties are sold in the same market. The income capitalization method of property valuation combines a property's income and its resale value into a summed value. Either of two formulas can be used for this process, but these formulas require much market research to determine the supply and demand relationships of the market. All three of these property valuation methods require a final step in order to assess a property's true value. The results of the valuation methods must yield a dollar range of the appraised property value; therefore, the appraiser or assessor must compare the results of the three methods to determine a reasonable dollar range for the property's appraised value (*7*).

Land use planners see land as having four functions that measure community change: land as functional space for varied uses, land as a location for activity centers, land as a commodity to develop, and land as an aesthetic resource (*8*). These functions support different types of land uses. For example, some urban land uses that draw on various aspects of these land use functions include residential, industrial, and commercial land uses. Commercial land uses are of great importance to access management, for the impacts of restricting access to commercial parcels could be detrimental to sales by deterring potentially large traffic volumes that may be generated by the commercial land use. Commercial land uses generally include uses such as manufacturing; wholesaling and distribution; headquarters, developmental research, and back office activities; non-local government activities; and higher education (*8*). These land uses can be encompassed into activity centers, which can include employment areas and commercial centers. Out of these two activity centers, commercial centers are the most responsive to access changes. This is because employment centers present a reason (a job) and a destination (place of employment) for people to access those land parcels, but commercial centers may not always be the original destination of drivers. Some commercial centers by their nature specifically create trips, while others attract drive-by traffic (*9*). Conversely, some commercial centers may not appeal to people driving by for certain undesirable characteristics. Directness of access to the commercial center could be a factor determining if people will patronize businesses located there.

Alonso's land-rent theory provides additional insight into the value of accessibility on land values and rents. The land-rent theory shows the relationship of land values to land prices in the city (*10*). Alonso creates his theory assuming the city is on a featureless plain where all land is of equal quality, and that buyers and sellers have perfect knowledge of the market, where the sellers seek to maximize revenue and the buyers seek to maximize satisfaction. In his land-rent model, Alonso uses price, site size, and the concept of the featureless plain in order to control for site features that may alter land values (*10*). In addition to this, he uses a "bid rent curve," a formula to determine land rent that includes the following variables on each site: number of units produced, price per unit, cost of production, and the cost of transportation for each product unit. In this, the value of transportation in land rents is apparent; however, the value of direct accessibility to land parcels from the roadway is not. Alonso determines the value of land parcels' accessibility by connecting his study to that of Robert M. Haig (1926), where it was found that "rent appears as the charge which the owner of a relatively accessible site can impose because of the saving in transport costs which the use of his site makes possible" (*10*). Therefore, Haig determines that as site accessibility increases, allowable rent for the site may also increase due to the amenity of decreased travel times. Alonso, in turn, determined in his bid rent model that costs of transportation are directly connected to sites' access to the transportation system.

Transportation Improvements and Property Values

Alonso's connections between site accessibility and land rents provided a background for a new realm of research to determine links between transportation and property values. Although previous research has not explored how access management techniques impact commercial property values, much research has examined the connection between transportation improvements and property values. Because access management improvements are a type of transportation improvement, this research is important to relate to the study of property value impacts of access management techniques.

The first generation of highway studies to measure the connection between transportation and land values only used test and control site property values to determine changes in land value after transportation improvements (*11*). This method assumes that all land value changes are attributed to the transportation improvement, and does not take into account other possible contributing factors. The next wave of studies featured other methods of comparing transportation improvements and property values that studied many simultaneous factors of property value change, such as distance or travel time from a transportation facility (*11*). These methods have all emphasized a relationship between transportation and land use, and depending on the comparison method used, most studies have shown a relationship between transportation facilities and land value. Different methods of determining these property value impacts have historically resulted in varied results.

The fluctuation of results when determining relationships between transportation facilities and land values is likely due to the many factors that make up land values (11 - Ryan 1999). As stated previously, many factors contribute to land values, and accessibility to land parcels is only one factor. Accounting for these individual factors can make the transportation facility and land value connection even clearer. The second generation of highway studies to evaluate the connection between transportation and property values uses multiple variables to determine property value impacts of transportation improvements. This type of analysis also measures property value change, but considers property value factors other than transportation. One method of evaluating the influence of separate factors on land values involves the hedonic property value model, discussed in the next section.

Some second generation studies evaluating the connection between transportation improvements and property values yield a strong relationship. Knapp, Hopkins, and Pant used a multivariable approach to analyzing real estate transactions, land values, building permits, and current development to find that land values increase the nearer they are located to light rail stations studied in Portland, Oregon (*12*). Another such analysis by Nelson in Atlanta, Georgia created a model to estimate the associate between rail transit stations and nearby commercial property values based on transit station proximity to the commercial land parcels and the existence of policies encouraging economic development in the region. Both these studies use multivariable methods to determine property value change based upon unique regional characteristics.

Although all past research measuring the relationships between property values and transportation improvements have not made the same conclusions, later versions of the research accounting for multiple variables of property value change have made similar conclusions. Because of this, a model containing multiple explanatory variables seems appropriate to measure the land value impacts of access management. Chapter Four will detail the methodology used for this research, combining both descriptive and inferential statistics.

CHAPTER FOUR – METHODOLOGY

This chapter provides an overview of the methodology and data collection techniques used in this research. The major components of this chapter include a review of the problem statement, an introduction to the methods used in this research, data collection, and an introduction to descriptive and inferential statistical methods for this study.

The methodology of this research involved four major tasks, the problem statement and hypothesis, data collection, descriptive statistics, and inferential statistics. The problem statement, hypothesis, and data collection techniques used are outlined in this chapter. The methods used to create descriptive and inferential statistics are briefly outlined in this chapter, but explained in more detail in Chapters Five and Six.

Problem Statement and Hypothesis Review

As previously stated, the safety benefits of access management techniques have been proven through past research. Notably, the practice of access management reduces vehicle conflicts on roadways by reducing or restricting turning movements. While the safety benefits of access management have been proven, there may be constraints on the application of the practice. Commercial business owners are especially wary of reducing or restricting access to land parcels, fearing a negative economic impact. The economic impacts of access management have been previously studied through business surveys, but never fully studied using quantitative measures; certain quantitative measures such as sales data are generally unavailable for such a study. Therefore, selecting a suitable economic indicator in lieu of sales data is necessary for this type of study. If it could be found access management techniques do not have a negative impact on the economic indicator through quantitative measures, this finding may alleviate business owners' fears of reducing or restricting land parcel access.

Land value is an economic indicator that may be used to measure the commercial land value impacts of access management techniques; this data can be more easily acquired than sales data, and land data does not include the frequent adjustments that property value experiences when structures are updated. However, land valuation is a balance of many unique factors, and these factors do not influence land values similarly. A parcel's roadway access could influence commercial land valuation to varying degrees. Again, in hopes that minimal negative commercial land valuation change may create higher favor for the practice of access management among commercial property owners, the hypothesis for this research is that access management techniques will have minimal negative impacts on land values in Des Moines, Iowa. The statistical methods used show if land value impacts exist, as well as the severity of the impacts.

Introduction to Methods Used

This study used both descriptive and inferential statistics to measure commercial land value changes and to what degree certain factors influence this change. The use of both types of statistics in this study will help to overcome the problem of a smaller data set by providing more in-depth analysis of the dataset prior to model fitting. Descriptive statistics provide an overview of a sample dataset, but while these statistics are necessary to understand how parcels on various roadways differ from one another, they do not provide a full analysis of why these commercial parcels' land values differ based on parcel characteristics. Multivariate regression was used to analyze how these land values are influenced by parcel characteristics by determining the strength of the relationship between each characteristic to parcel land values. The "hedonic property value model" is a method used in past research to define the strength of relationships between property value and its determinants. It is simply a multivariate regression model with property values as the dependent variable, and non-market factors as explanatory variables (*13*). Principles from the hedonic property value model, such as the use of non-market explanatory variables, will be used to create the regression model for this study. For this study, the characteristics used were related to non-market influences on land value as well as parcel access control. The combination of descriptive and inferential statistics provided a comprehensive view of commercial land values as related to access control in Polk County. Chapters Five and Six outline the exact methods used in both descriptive and inferential statistics used in this study.

ArcView and ArcGIS, two geographic information systems (GIS), were used in this process to create descriptive statistics and create maps. An innate benefit of using GIS over traditional mapping techniques is the ability to integrate data into the maps. This allows for a much "smarter" map; this allows for data analysis to occur within the program, and for results to be displayed graphically in map form.

SPSS Statistical Software was used to create the hedonic property value model, or more simply, to create a regression model detailing the relationship between commercial land values and explanatory variables chosen for this research.

Data Collection

Polk County is home to Iowa's state capitol of Des Moines, the largest metropolitan area in Iowa. Major cities in Polk County include the cities of Des Moines, 2000 population 198,682; Ankeny, 2000 population 27,117; West Des Moines, 2000 population 46,403; Clive, 2000 population 12,855; and Urbandale, 2000 population 29,072 (*14*). These cities have all experienced great increases in population over the last ten years, and combined, continue to be the fastest-growing region of Iowa. Figure 4-1 shows Polk County and its cities.

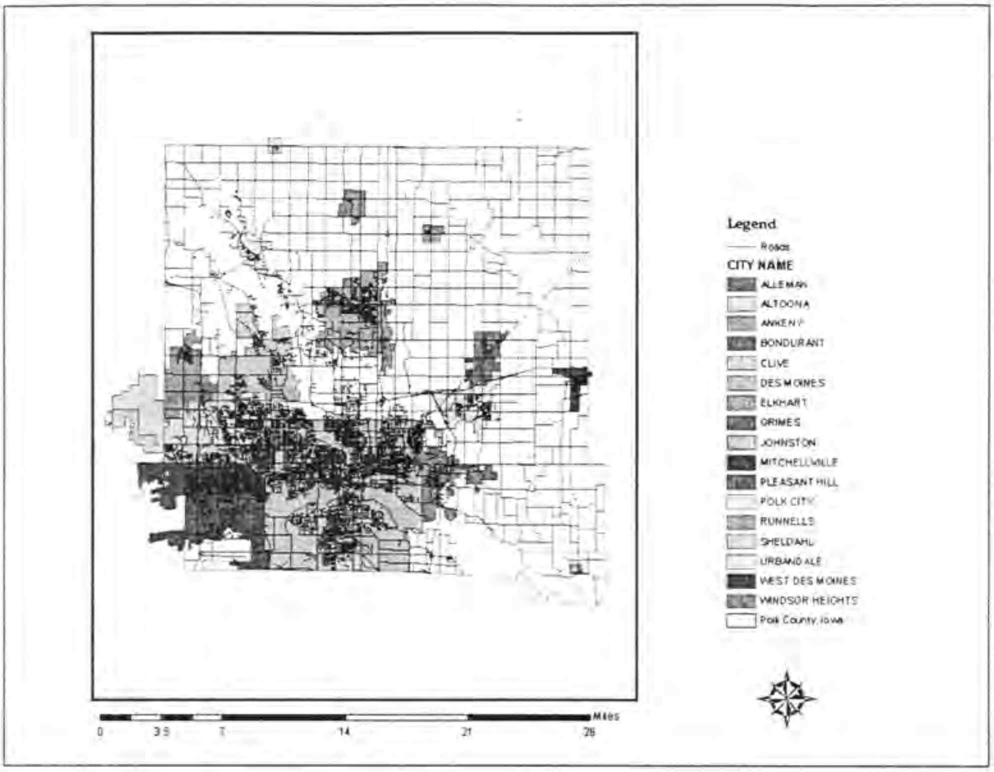

Figure 4-1. Polk County, Iowa

The Polk County Assessor's Office was an invaluable resource for this research. The Assessor has current property value data in digital GIS format, ready for use in many GIS applications, which eased the process of data collection and mapping (*15*). The assessor's data was helpful in selecting study corridors through mapping areas preliminarily selected for study through windshield surveys. The Assessor's office also keeps limited records of property values from previous years.

Although these values are not in digital format, these figures can be added to existing databases.

In addition to the Polk County Assessor's office, some geospatial data from the Iowa DOT was used (*16*). This supplementary data included county, city, and roadway data, as well as additional roadway database information (such as traffic counts) needed for analysis. In addition, infrared aerial photographs from an Iowa State University GIS data server were used (*17*) to aid in assessing access control on study corridors.

Preliminary study corridors

Once background geospatial data (such as roadway, city, and county information) was collected for Polk County, the project area needed to be more specifically defined to be able to select roadway corridors for study. The first step necessary to selecting study corridors was to perform windshield surveys of urban arterial corridors with primarily commercial adjacent land uses in Polk County. The windshield surveys were used to determine roadway segments with these characteristics, and were also used to analyze access control techniques. In addition to windshield surveys, aerial photographs from the Polk County Assessor's website were used to clarify access control on the first group of corridors selected for study (*15*).

Location largely influences property value; to control for location effects in the hedonic model, the final study corridors were chosen by pairing the selected corridors together by location, one access controlled corridor to one non-controlled corridor. The remaining corridors selected through the windshield survey that did not match to another corridor were excluded from the sample. The corridors chosen for study had to meet certain assumptions in order to control the sample for land value variations. All corridors had to be urban arterials, either access controlled or not managed at all, with primarily commercial adjacent land uses. The study corridor selection was controlled so that roughly half the corridors have raised medians, so that roughly half the study parcels were located on a stretch of roadway with a raised median.

The resulting preliminary list of seven study corridors included arterial corridors in the cities of Des Moines and Ankeny, Iowa. Specifically, this list included the Des Moines corridors of Southeast 14th Street, Army Post Road, Euclid Avenue, 63rd Avenue, and Grand Avenue, and the Ankeny corridors of 1st Street and Delaware Avenue. Table 4-1 contains information on the preliminary study corridors, while Figure 4-2 depicts the corridors' locations in Polk County.

Table 4-1. Preliminary study corridor information

Road Name	City	Classification	Access Control
1st Street	Ankeny	Minor Arterial	Low
Delaware Avenue	Ankeny	Collector	High
Army Post Road	Des Moines	Minor Arterial	Mixed
SE 14th Street/U.S. 69	Des Moines	Principal Arterial	High
Grand Avenue	Des Moines	Minor Arterial	Low
63rd Street/IA 28	Des Moines/Clive	Principal Arterial	High
Euclid Avenue/U.S. 6	Des Moines	Principal Arterial	Mixed

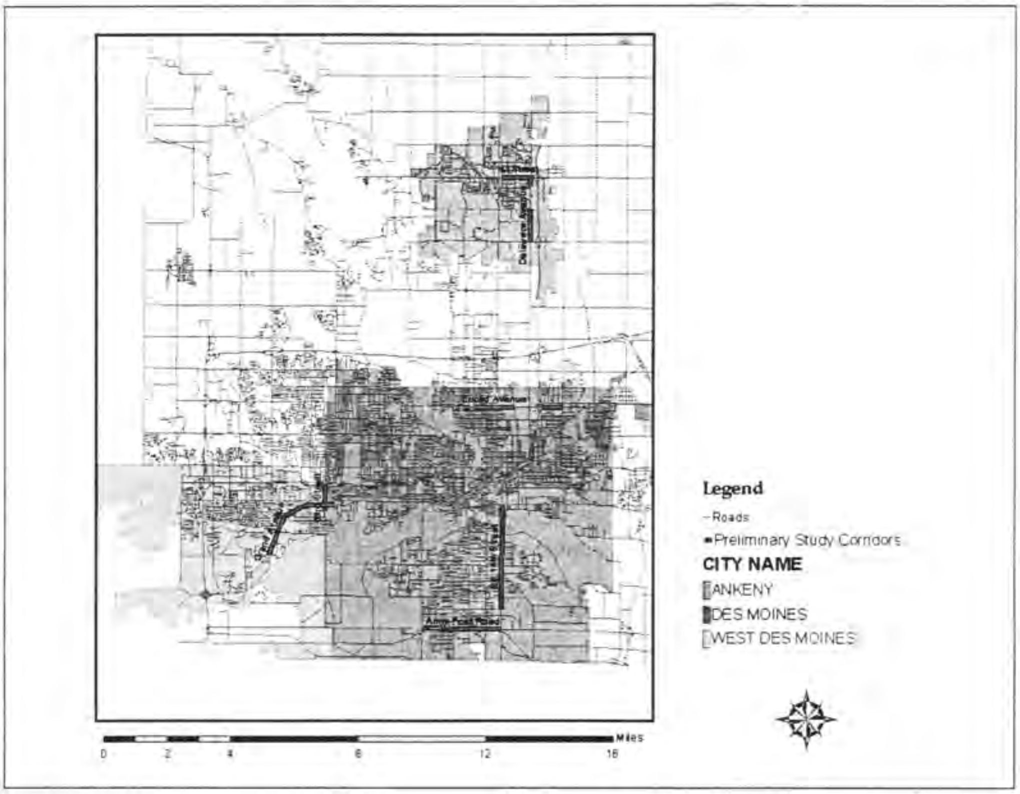

Figure 4-2. Preliminary study corridors

The study corridors used in this research were urban arterial roadways, since these roads serve major activity centers, while enabling motorists to access land parcels. All seven corridors best suited for this study were either principal or minor arterial roadways, except for Delaware Avenue in Ankeny, which was classified as a collector but functions as an arterial roadway due to the high level of commercial activity that has developed on the corridor in recent years.

After preliminary study corridors were chosen based on field reviews, the seven corridors were then reduced to five due to lack of data; the Polk County Assessor did not keep all older records of land values, and this reduced the viable dataset. The final study corridors, all located in the city of Des Moines, were Southeast 14th Street (1.988 miles), Army Post Road (0.876 miles), Euclid Avenue

(1.392 miles), Grand Avenue (0.286 miles), and 63rd Street (0.187 miles). Figure 4-3 later in this chapter shows the location of the study corridors within the city of Des Moines. The Polk County Assessor's Office supplied all land parcel data for this study. The current land use information was available in GIS format, while the varied years of historic data were only available on scanned property value cards, when available. While the selection of preliminary study corridors proved to be relatively straightforward, the data sample was drastically restricted by the availability of "historic" land values. For this study, "historic" land values refers to land values from a date before raised medians were installed on either SE 14th Street or 63rd Street, the study's access controlled corridors. Southeast 14th Street's raised medians were constructed in two phases; Phase I of the median construction (Army Post Road to Park Avenue) took place in 1984, while Phase II of the median construction (Park Avenue to the Des Moines River) occurred in 1985 (*18*). The raised median installation on 63rd Avenue was completed in 1991 (*19*). In order to keep the dataset consistent, the historic dates of land values used for the study corridors that were not access controlled were from the same range of dates used for the access controlled corridors. For example, the historic land values for Army Post Road centered around 1984 and 1985, for these were the years raised medians were constructed on Southeast 14th Street, the nearest study corridor.

Euclid Avenue was originally included in this study because it had both access controlled and un-controlled road segments. However, the access controlled segments of this road could not be used for analysis because raised medians here were constructed in 1958, and historic land values were not available for before that date (*20*). Similarly portions of Grand Avenue and Army Post Road were also removed from the study; small areas of commercial parcels here had raised medians and were to be treated as access controlled land parcels, but the dates of median construction, 1969 and 1976, respectively, hampered historic land value data collection efforts (*20*).

The originally included corridors in Ankeny, 1st Street and Delaware Avenue, were excluded from the sample at this point. Delaware Avenue is a newly developed portion of Ankeny; its medians were constructed in 1998, when most development had yet to take place. Because many portions of that study area were not yet developed or subdivided to its current configuration until after medians were built, any historic land values collected for Delaware land parcels would not adequately reflect trends along the corridor. To this end, Delaware Avenue was excluded from the study. However, after Delaware Avenue was reconstructed with raised medians, it was quickly developed to become a large commercial node in Ankeny. 1st Street, being the only other Ankeny corridor remaining in the study, was excluded at this point as well, to counteract any discrepancies that may result from location effects on land value.

Because the availability of older land value data is severely limited in Polk County, study parcels that did not have historic land value data for before the dates of median installation on the access controlled corridors had to be excluded from the study. Because of this, the study was limited to selected parcels on the access controlled corridors of Southeast 14th Street and 63rd Street (a total of 51 parcels) and the not access controlled corridors of Army Post Road, Grand Avenue, and Euclid Avenue (a total of 53 parcels.)

Final study corridors

The final five study corridors, Southeast 14th Street, 63rd Street, Army Post Road, Euclid Avenue, and Grand Avenue, are all located within the city of Des Moines. Figure 4-3 shows the placements of the corridors within the city. From this, it is apparent that the corridors are located all over the city (but all are located outside the downtown core), from Southeast 14th Street and Army Post Road in the east, Euclid Avenue in the north, and 63rd Street and Grand Avenue in the west. Although the corridors should have been controlled for location effects on land value, the ensuing regression analysis in Chapter Six discusses whether the obvious grouping of study corridors in certain sectors of Des Moines could cause problems in the sample dataset.

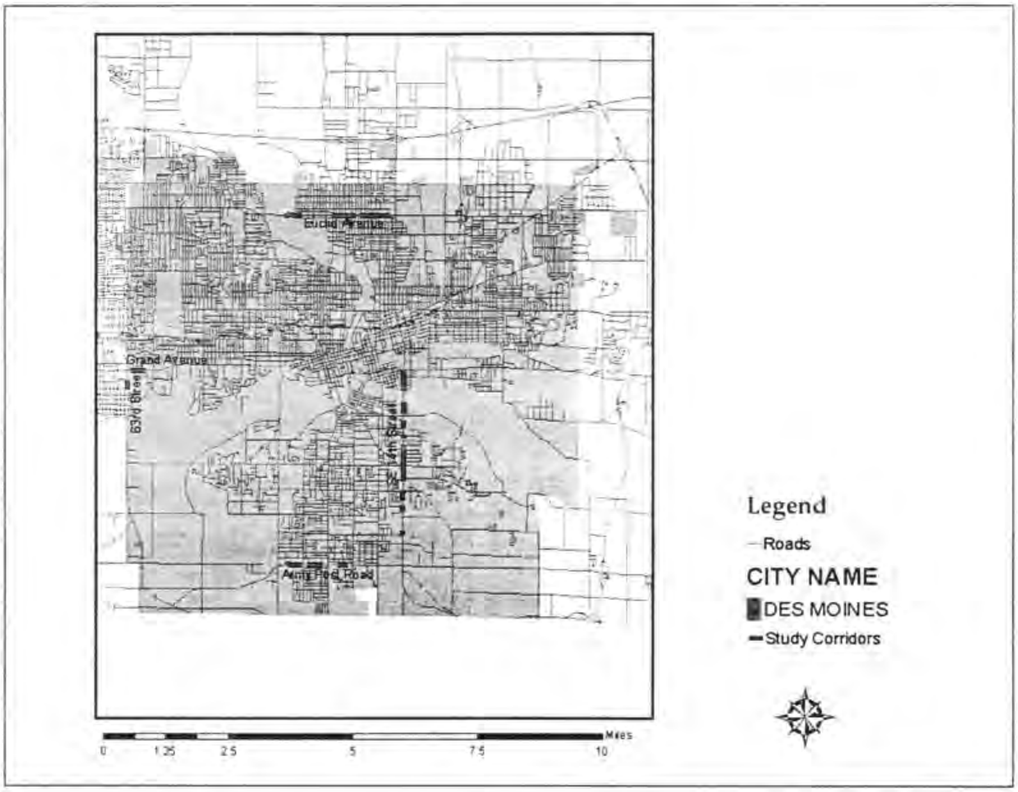

Figure 4-3. Final study corridors

Study parcel selection

The spatial and tabular land parcel data collected for the study corridors was cut down by hundreds of study parcels due to lack of historic land value data, but more parcels needed to be removed from the study for various other reasons. Vacant or semi-improved land parcels were removed from the study because the parcels did not have currently operating businesses on them. Also, land parcels with low or high-density residential, or light or heavy industrial uses were removed, even if the parcel was classified as commercial; these parcels were not representative of the commercial land parcel sample collected.

In addition to these parcel removals, some parcels on Euclid Avenue were removed because they were built as a traditional neighborhood center, with mixed land uses and buildings set closely together with no driveways or parking lots. These select parcels do not reflect the layouts of the other study parcels, for the other parcels had some sort of parking area or a driveway; because these Euclid parcels were not representative of the sample, they were removed.

After the remaining study parcels were screened for other possible irregularities, approximately 104 parcels remained for study. Figures 4-4 through 4-7 display study parcels' locations on each study corridor. In all figures showing 63rd Street and Grand Avenue together in this study, 63rd Street is the north-south road, while Grand Avenue is the east-west road.

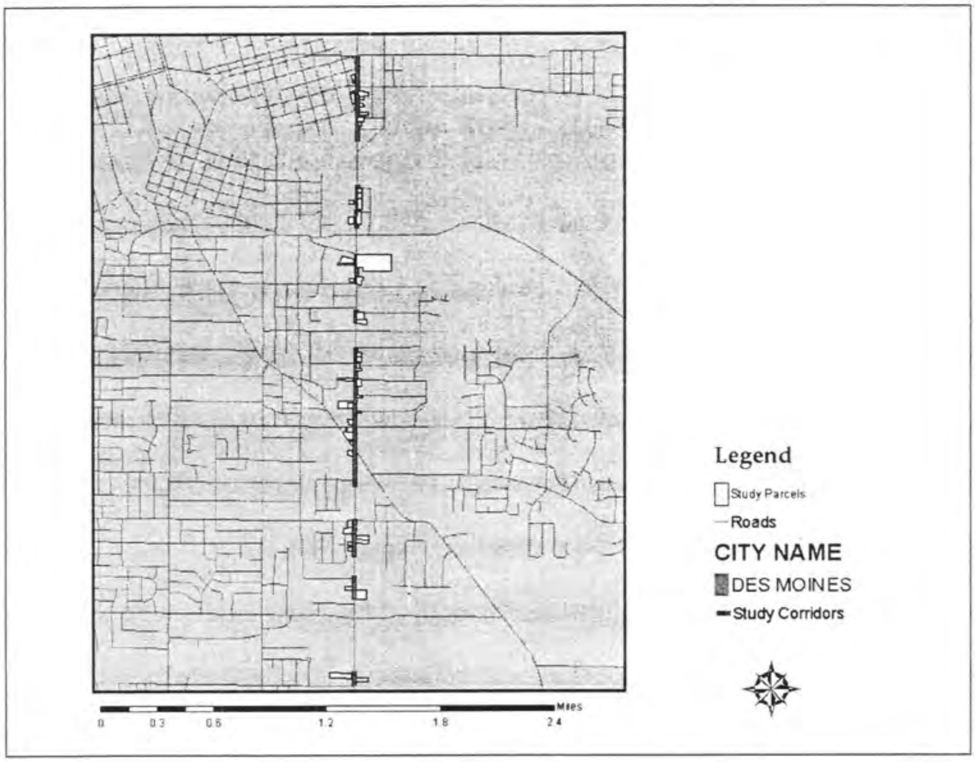

Figure 4-4. Southeast 14th Street study parcels

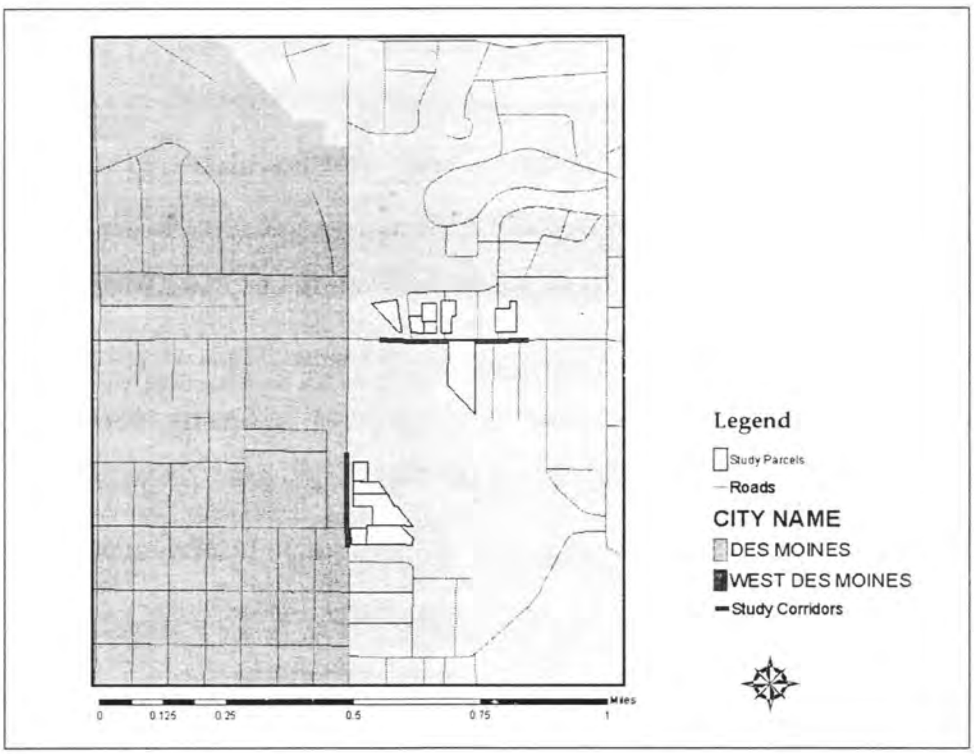

Figure 4-5. 63rd Street and Grand Avenue study parcels

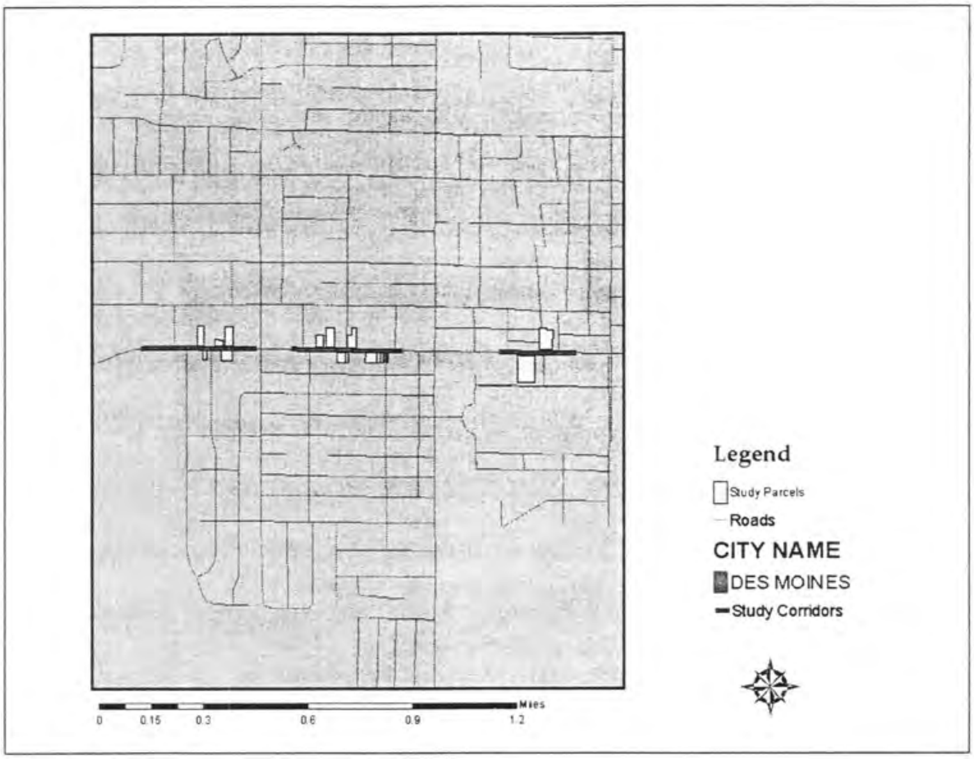

Figure 4-6. Army Post Road study parcels

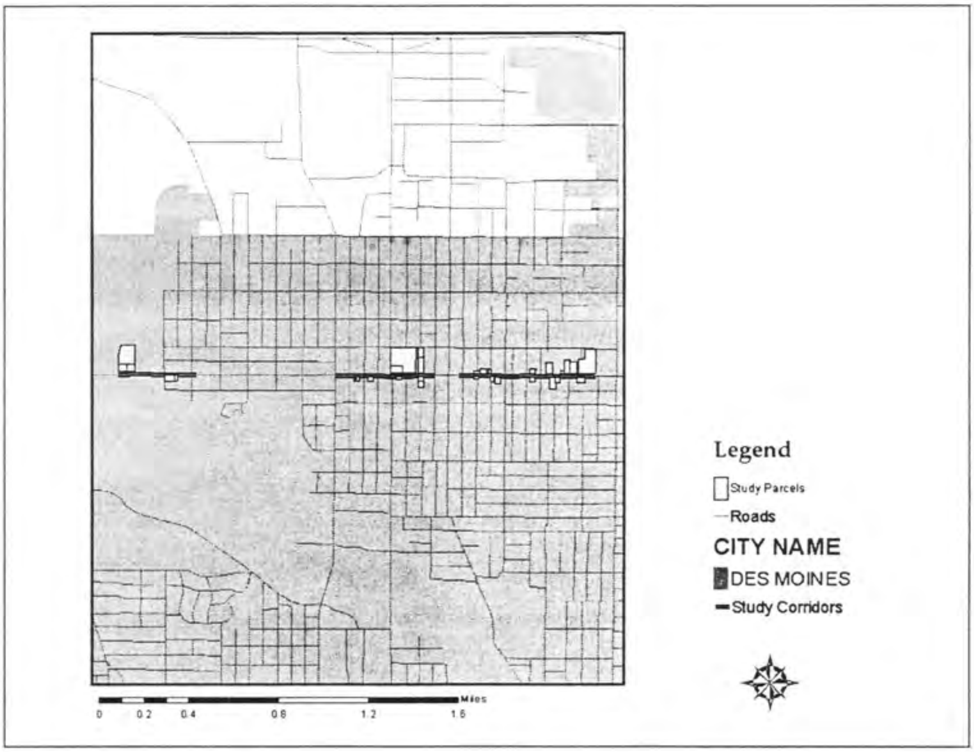

Figure 4-7. Euclid Avenue study parcels

Descriptive Statistics

The purpose of including descriptive statistics in this study was to examine the dataset for outliers, data trends, and other possible irregularities that may skew the regression model. Chapter Five will further explain and outline the descriptive statistics of the data used in this study, including current and historic land values, average value per square foot, land use, average parcel square footage, AADT, and measures of access control.

Inferential Statistics

The inferential statistics for this research were a multivariate regression model based on the principles of the hedonic property value model. Multivariate regression examines the strength of the relationships between a factor and its determinants. For this study, the multivariate regression models created measure the strength of the relationships between commercial land values and later-defined explanatory variables that will include a scaled value describing access management techniques per land parcel. There were two regression models created for this analysis; in order to analyze land value change before and after access management improvements, one regression model had a dependent variable of current land value per square foot, and the other had a dependent variable of historic land value per square foot. The historic dates used for this study refer to dates before raised medians were installed on either Southeast 14th Street or 63rd Street, the study's access controlled corridors. This section briefly explains methods used to develop the regression model, as well as the variables used within it. Chapter Six will further explain the inferential statistics used in this study.

To yield an accurate assessment in the regression model, the model must be constructed using all available data that could be relevant to land value change or access management's influence on land value change. Research in hedonic property value models state that all variables within this type of model must be non-market variables, or must not include indicators such as sales, for hedonic price characteristics do not identify demand or supply (*1*). Land parcel value change is likely to be dependent upon certain characteristics of each land parcel, the roadways on which they are located, and the area of study; the variables chosen for the regression model should reflect these ideas. From this, the variables chosen for inclusion into the regression model were parcel square footage, average annual daily traffic counts, and the level of access control for each land parcel. These three variables are projected to have an influence on land value change, but location is another influential factor that needs to be controlled for in the model.

Parcel square footage

The square footage of each study corridor is a notable variable to control for in the regression model for two reasons. First, parcel square footage is included as an explanatory variable because it may have an influential impact on commercial land values. Then, parcel square footage must be controlled for in the dependent variable, land value. If the dependent variable remains as overall parcel land value, the resulting regression model will show the relationship between land value and size of parcel; in other words, that larger parcels are generally worth more than smaller parcels due to size differences. However, controlling for square footage in the dependent variable will show the strength of the relationship between land values per square foot and overall parcel square footage, a more meaningful evaluation. Therefore, dividing parcel land values by their respective square footage resulted in a better dependent variable for this model.

Average annual daily traffic

Annual average daily traffic counts (AADT) were another potentially influential explanatory variable for this study. AADT is used in transportation studies to measure the existing demand for service on study roads (*21*). The corridors' AADT counts should be within the same general range, for all the study corridors are arterial roadways. Because of similar AADT ranges and similar roadway configurations, AADT was determined to be a rough measure of congestion on study corridors; as AADT increases on study corridors, congestion could increase as well. However, higher roadway volumes could increase roadway exposure for commercial businesses; if more drivers can see a business, there is a possibility that more could patronize the business. The regression model evaluated whether AADT variations have a significant influence on land values. Because this study is simultaneously measuring land value change before and after access changes, it is assumed that while AADT likely increased over time, it increased proportionately among the study corridors.

Access control variables

The level of access control on the study corridors was a very important measure to include in this regression model, for the purpose of the model is to determine how access control is correlated to land values. To include access control in the model, it must become a quantifiable measure; therefore, an access scale was created evaluating driveway density, medians and two-way left turning lanes, and other measures of access control. The value given to each access level will be the value used in the hedonic model. The access scale has a total value of 15 points, awarded in three categories: driveway spacing, median type, and other factors. Because this study is simultaneously studying how land value changed after access control change, the access control data used for the historic land value regression model reflected access control before raised medians were installed on any study corridors. Table 4-2 below provides an overview of the access scale scoring used for this research.

Table 4-2. Access scale overview

Type of Access Control	Points Awarded
Driveway Spacing	
Both driveways on a parcel spaced at least 300-500 ft from next	5
One driveway on a parcel spaced at least 300-500 ft from next	3
No driveways on a parcel spaced at least 300-500 ft from next	0
Median Type	
Raised median with breaks 1/4 or more miles apart	
Raised median with breaks for left turns 1/4 mile apart	5
Painted median (no two-way left turning lane)	4
Two-way left turning lanes (3 or 5 lane roadways)	3
Undivided roadway (2 or 4 lane roadways)	2
Other Factors	1
Right turning lanes on roadway adjacent to land parcel	
Right turning lanes	1
No right turning lanes	0
Frontage roads adjacent to land parcel	
Frontage roads	1
No frontage roads	0
Good internal circulation on land parcel	
Good internal circulation	1
No good internal circulation	0
Shared driveways	
Shared driveways	1
No shared driveways	0
Formality of driveways	
Formal driveways	1
Lack of formalized driveways	0

Driveway spacing

Unsignalized driveways are common occurrences on urban roadways; these driveways are numerous especially in commercial areas, where they provide direct access to commercial land parcels from roadways. When the numbers of these driveways along a corridor go unchecked, however, it can result in safety problems caused by frequent turning movements. The safety problems caused by unsignalized driveways can affect all levels of urban density.

The creation of guidelines for the spacing of unsignalized driveways is necessary for safety reasons, but too stringent guidelines could impede economic development; a balance must be found where driveway spacing does not contribute to excessive safety problems but can still encourage healthy development (2). Previous research has determined guidelines for unsignalized driveway spacing through the factors of roadway posted speed, roadway access level, and the size of the travel generator (or the density of the activity center). These guidelines for urban arterial roadways can be used to measure this study's driveway spacing in order to create a scale, as part of the model's access scale. Because all the study corridors are or function as arterial roadways, these corridors should have similarly-spaced driveways; driveway spacing for major arterial roadways should be from 300 to 500 feet apart, and driveway spacing for minor arterial roadways should be from 100 to 300 feet apart (2).

From this, a driveway spacing portion of the access scale can be developed based on driveway spacing on each land parcel; if each parcel meets recommended driveway spacing guidelines by its functional classification or does not have driveways, it can be awarded five points, if it meets recommended driveway spacing guidelines on one side of the driveway it can be awarded three points, and if it does not meet guidelines, it is awarded no points. In this method, spacing is measured between each driveway on each parcel to the nearest driveway or roadway intersection to determine its driveway spacing scoring. If a parcel had a driveway off a side road other than the study corridor, such as if the parcel access was located around the corner from the study corridor, the parcel was counted to have no driveways on the study corridor.

Median type

Different median types and two-way left turn lanes will control access to land parcels in different ways. The medians and left turning lanes on the study corridors will be awarded points on the access scale by the level of access control they provide. Raised medians provide the most access control on the corridors, followed by painted medians, and then two-way left turn lanes. Undivided roadways do not provide any access control. Therefore, parcels are awarded points for median types as such:

5 points = Raised median with breaks 1/4 or more miles apart

4 points = Raised median with breaks for left turns 1/4 mile apart

3 points = Painted median (no two-way left turning lane)

2 points = Two-way left turning lanes (3 or 5 lane roadways)

1 point = Undivided roadway (2 or 4 lane roadways)

Because all the study parcels used in this study were fully developed during both the historic and current years of study in this analysis, it was assumed that the only access change during the study years was raised median installations on Southeast 14th Street and 63rd Street.

Other factors

Other factors which comprise the level of access control on the study corridors include right turning lanes, frontage roads, good internal circulation, shared driveways, and the formality of driveways. The presence of these factors will result in one point for each factor on the access scale. Right turning lanes provide storage for right turning traffic while preserving the flow of traffic on roadways. Frontage roads provide indirect access to land parcels while reducing the number of access points on the main roadway. Also, in this study, if a parcel on the study corridor does not have access from the corridor but on another road, it is a condition similar to a frontage road situation. Good internal circulation on land parcels is also another important factor of access management. Good internal circulation for this study was interpreted as clear paths for vehicles to travel within each parcel to reduce vehicular conflicts by separating and channelizing traffic to separate activity centers on each parcel. For example, a "big box" store with a large parking lot that does not funnel traffic directly to parcel activity centers and does not mitigate vehicular conflicts does not have good internal circulation. Measuring the number of shared driveways on study corridors was another important measure of other factors in access control; a shared driveway was counted if it has a driveway on the study corridor that also serves as a direct access to another parcel. If a short expanse of roadway that is not a through road serves as the driveway access, it can also be a shared driveway if it meets the previous stipulation. The formality of driveways was the final factor in access control measured in the regression model. This measure separated channelized, formal entrances from wide, unspecific land parcel entrances. Altogether, these five "other factors" in access control, right turning lanes, frontage roads, good internal circulation, shared driveways, and the formality of driveways, completed the access control scale for the regression model.

Location

Location is another important issue in land value, but rather than quantify this factor, it has been controlled for in the regression model through certain methods of corridor selection, as described previously. However, the study corridors are quite different economically; the northern and eastern Des Moines corridors, Euclid Avenue, Southeast 14th Street, and Army Post Road, represent older sections of the city, while the western corridors of 63rd Street and Grand Avenue are located in a younger section of the city that not only looks differently, but has different types of land uses than the northern and eastern corridors. In addition to controlling for location through the corridor selection process, it was a notable factor to watch during the regression model development; as noted in Chapter Six, there were two runs of the regression model sets: the first set represented all five study corridors, one model with historic land values as the dependent variable, the other with current land values; the second set represented only the northern and eastern corridors from older sections of Des Moines, one model with historic land values as the dependent variable, the other with current land values. Determining how the different data sets affect the regression models is pertinent for finding the best model fit to the data.

Chapter Five describes the dataset used for the inferential statistics created in Chapter Six. Evaluating the trends of the data set are essential to creating and understanding regression models, as well as to establish a sense of corridor character, found through traffic, land parcel, roadway, and area characteristics. Chapter Six outlines the process to create the regression model with commercial land values per square foot as the dependent variable and parcel square footage, AADT, and access control as explanatory variables, all while controlling for location both by corridor selection and analyzing model outputs for irregularities.

Irregularities in the regression model could suggest lack of conformance to multiple linear regression assumptions.

CHAPTER FIVE – DESCRIPTIVE STATISTICS

This chapter provides a background of the sample data used to develop the regression model through descriptive statistics. Descriptive statistics detail the sample dataset, display the characteristics of each sample parcel, and show overall data trends on parcels among sample roadway corridors. This chapter will first describe the process used to deflate historic land values using the GDP deflator, then detail different measures of collected study data in order to produce a vivid description of the datasets employed in the regression model detailed in Chapter Six. The types of statistics detailed in this chapter detail land parcel data, land use data, and explanatory variables data.

The descriptive statistics study in this research also includes a before and after analysis of land values and access control to determine if parcels with access upgrades had significant differences in change as compared to parcels where no access upgrade occurred. The "historic" land values needed to be adjusted to the year 2002, the year of the "after" data collection, in order to make accurate comparisons of land value change.

Because the land values being compared for this study are from different years, the values needed to be brought to a constant year to control for inflation in order to be effectively analyzed. Inflation occurs when the average level of prices in an economy rises, and conversely, deflation occurs when this average level of price declines (22). An alternative view of deflation is that it removes the effects of price changes upon current values (23). Price indices can perform this function in practice.

There are different types of indices that can account for deflation and inflation. However, land is economically viewed as an investment, which removes the use of the standard inflation accounting device, the Consumer Price Index (CPI), from this study. The method chosen for this study was the Gross Domestic Product (GDP) deflator. The CPI is best suited for use with commodities, while the GDP may be used for investments such as land (*22*). The GDP Deflator deflates the value of the nation's Gross Domestic Product, the measured market value of all goods produced in an economy in one year (*22*). The GDP Deflator is created using many different types of indices, including the Consumer Price Index (CPI). The GDP is created by combining four types of spending: consumption expenditure, investment expenditure, government expenditure, and net-export expenditure (*24*).

To account for the effects of inflation when comparing parcel land values before and after the construction of raised medians on the study corridors, the GDP inflation index was calculated and applied to the historic land values on the study parcels. These inflation-adjusted values were used as the historic land values in the regression model.

Parcel Land Value Statistics

As stated in Chapter Four, the study dataset includes 51 access-controlled land parcels and 53 un-controlled parcels. The study parcels were reduced from a much larger dataset due to lack of availability of "historic" parcel data. The historic dates used for this study refer to dates before raised medians were installed on either Southeast 14th Street or 63rd Street, the study's access controlled corridors. As stated previously, Southeast 14th Street's raised medians were constructed in two phases during 1984 and 1985, while the raised median installation on 63rd Avenue was completed in 1991.

The range of years for historic values collected from the Polk County Assessor's Office are seen in Table 5-1 along with the number of parcels used for each study year. Most study parcels are located in the eastern section of Des Moines, where raised medians on Southeast 14th Street were constructed in 1984-85; therefore, as seen in the table, many historic land values were collected between the years of 1981-1983.

Table 5-1. Years of historic land values data collection

Year	Number of Parcels
1975	1
1981	33
1982	11
1983	10
1984	6
1985	5
1986	6
1987	5
1988	4
1989	14
1990	8
1991	1

The process to deflate the historic land values using the GDP deflator was described in Chapter Four, and the average historic land values for each study corridor are found in Table 5-2 below. These values are not adjusted for parcel size, these averages are simply for overall parcel value; therefore, corridors with larger parcels may have higher averages than corridors with smaller land parcels. Table 5-2 shows that Grand Avenue has the highest average historic land values, and Southeast 14th Street has the lowest average historic land values. Figures A-1 through A-5 in Appendix A show the range of individual historic land parcel values on each study corridor.

Table 5-2. Average historic land values per parcel by corridor

	Average Value
SE 14th Street	$53,932.61
63rd Street	$99,114.80
Army Post Road	$111,949.69
Euclid Avenue	$119,771.23
Grand Avenue	$219,996.57

The figures above show the range of historic land values for each study corridor. The trends for average current (2002) land values, shown in Table 5-3 below, are different from those of the historic land values. While the corridor with the highest average current land values was again Grand Avenue, and the corridor with the lowest average current land values was again Southeast 14th Street, this dataset seems to be grouped by location. Grand Avenue and 63rd Street, the western corridors located in a more-recently developed section of Des Moines, had higher average current land values than the northern and eastern corridors in older sections of the city. Again, these values do not reflect differences among parcel sizes, rather only the differences in overall parcel land values; an in-depth look at differences both in parcel square footage and value per square foot on these corridors could explain the land value differences. These statistics will be analyzed later in this chapter for comparison purposes. From an average land value standpoint, land value changes on these corridors do not appear to be influenced by the existence of raised medians. Also, from comparing historic to current land value trends, Southeast 14th Street, Army Post Road, and Euclid Avenue have experienced declines in average land values, while 63rd Street and Grand Avenue have experienced increases in average land values. For a more in-depth look, Figures A-6 through A-10 in Appendix A show the range of individual current land parcel values on each study corridor.

Table 5-3. Average current land values per parcel by corridor

Corridor	Average Value (in dollars)
SE 14th Street	$53,214.13
63rd Street	$113,868.00
Army Post Road	$75,392.50
Euclid Avenue	$113,442.67
Grand Avenue	$249,581.43

Determining average value per square foot trends for both historic and current land values may be a better factor to compare study corridor trends, for this factor controls for different parcel sizes. Table 5-4 below displays the average value per square foot for each study corridor, and this table reveals that corridor rankings for average land values per square foot do not match corridor rankings for average land value in Table 5-3 above. While Southeast 14th Street has both the lowest average land value and the lowest average land value per square foot, Army Post Road has the second lowest average land value, and 63rd Street (which has the second highest average land value) has the second lowest average land value per square foot. These differences reveal that parcel square footage is a factor in overall parcel land value that needs to be controlled for in a regression model, for overall parcel land value statistics on the study corridors do not mirror corridor trends in land value per square foot. Because of this, it is necessary to not only control for parcel square footage as an explanatory variable in the regression model, but the dependent variable, land values, should be controlled for square footage as well- making the dependent variable land value per square foot achieves this.

Table 5-4. Average historic land value per square foot by corridor

Corridor	Average Value per Square Foot (in dollars)
SE 14th Street	$2.15
63rd Street	$2.18
Army Post Road	$3.64
Euclid Avenue	$3.83
Grand Avenue	$4.02

Table 5-4 lists average value per square foot for average GDP-adjusted historic land values. Again, because these values have been broken down to square feet, the effects of parcel size have been controlled. The study corridors show that the corridors that received raised medians after these values were recorded (Southeast 14th Street and 63rd Street) have less value per square foot than the corridors that never received a raised median. Historic land value per square foot by parcel may be seen in Figures A-11 through A-15 in Appendix A.

Table 5-5. Average current land value per square foot by corridor

Corridor	Average Value
SE 14th Street	$1.93
63rd Street	$2.25
Army Post Road	$2.82
Euclid Avenue	$3.37
Grand Avenue	$4.21

Table 5-5 displays the average current land values per square foot per study corridor. The corridors of Southeast 14th Street and 63rd Street (which at this time have raised medians) both continue to report the lowest average value per square foot, even with the access control treatments. However, as this research strives to prove, there may be no relationship between access control and land value at all, so this occurrence may be circumstantial or due to other reasons. Current land value per square foot by parcel may be seen in Figures A-16 through A-20 in Appendix A.

Table 5-6. Change in average values per square foot

Corridor	Value Change
SE 14th Street	-$0.22
63rd Street	$0.08
Army Post Road	-$0.82
Euclid Avenue	-$0.46
Grand Avenue	$0.19

Table 5-6 shows the changes in average land value per square foot between the two study times for each study corridor. These statistics show little difference between study corridors with or without raised medians; both types of corridors experienced increases and decreases in average land value over time. However, the only corridors that experienced a positive change in average value over time were the western corridors of 63rd Street and Grand Avenue. Generally, the west side of Des Moines has been acknowledged to contain higher income consumers, as well has having a higher growth rate, than other sections of the city.

Land Use Statistics

The types of land uses on the study corridors are quite varied. Analyzing the predominant land use type on each corridor may demonstrate major land use differences among the corridors that could cause discrepancies in the dataset during the regression model creation.

Table 5-7. Land use on all corridors by parcel

Land Uses	Parcels
Auto Dealer	11
Auto Service	10
Bank	1
Car Wash	3
Child Care	1
Convenience Store	3
Fast Food Restaurant	8
Grocery Store	1
Hotel/Motel	2
Medical Office	4
Mini Warehouse	1
Office	13
Office/Apt	2
Office/Residential	1
Office/Retail	4
Office/Warehouse	2
Regional Shopping Center	2
Restaurant/Tavern	5
Retail	16
Retail/Warehouse	2
Service/Repair	8
Vet Clinic	1
Warehouse	3

Table 5-7 displays land uses for all corridors included in this study. Although a wide range of land uses are present, the most prevalent uses are auto dealers, auto service, fast food restaurants, offices, retail, and service and repair uses. Determining what land uses are found on individual corridors will not only establish a feel for the corridor's roadside environment, but will also help to distinguish land value differences among study corridors. Land use not included in the regression model for this study, but it represents an important aspect of land value, for different groups of land uses can create different levels of desirability, etc.

Tables 5-8 through 5-12 display the varied land uses found on each study corridor. In addition, Figures A-21 through A-25 in Appendix A show the locations of various land uses on the study corridors.

Table 5-8. Southeast 14th Street land uses

Land Uses	Parcels
Auto Dealer	9
Auto Service	6
Bank	0
Car Wash	1
Child Care	0
Convenience Store	0
Fast Food Restaurant	1
Grocery Store	0
Hotel/Motel	2
Medical Office	0
Mini Warehouse	0
Office	3
Office/Apt	1
Office/Residential	0
Office/Retail	2
Office/Warehouse	1
Regional Shopping Center	0
Restaurant/Tavern	1
Retail	9
Retail/Warehouse	2
Service/Repair	4
Vet Clinic	1
Warehouse	3

From Table 5-8, it is apparent the Southeast 14th Street corridor contains mainly auto dealerships (9 parcels), auto service locations (6 parcels), and general retail (9 parcels). Other popular land uses along this corridor include offices, service or repair shops, and warehouses. From this information, this corridor is centered about the buying and repairing of durable goods.

Table 5-9. 63rd Street land uses

Land Uses	Parcels
Auto Dealer	0
Auto Service	0
Bank	0
Car Wash	0
Child Care	0
Convenience Store	1
Fast Food Restaurant	1
Grocery Store	0
Hotel/Motel	0
Medical Office	0
Mini Warehouse	1
Office	0
Office/Apt	0
Office/Residential	0
Office/Retail	1
Office/Warehouse	0
Regional Shopping Center	0
Restaurant/Tavern	0
Retail	1
Retail/Warehouse	0
Service/Repair	0
Vet Clinic	0
Warehouse	0

Table 5-10. Grand Avenue land uses

Land Uses	Parcels
Auto Dealer	0
Auto Service	0
Bank	0
Car Wash	1
Child Care	0
Convenience Store	0
Fast Food Restaurant	2
Grocery Store	0
Hotel/Motel	0
Medical Office	0
Mini Warehouse	0
Office	3
Office/Apt	0
Office/Residential	0
Office/Retail	0
Office/Warehouse	0
Regional Shopping Center	0
Restaurant/Tavern	0
Retail	1
Retail/Warehouse	0
Service/Repair	0
Vet Clinic	0
Warehouse	0

The study corridor for 63rd Street does not include many parcels, but the few land uses that are found here are focused on fast food restaurants and car washes. Table 5-9 shows that the land uses found on the 63rd Street corridor include a convenience store, a fast food restaurant, a mini warehouse, an office and retail mixed parcel, and a retail parcel. 63rd Street is clearly a consumer services-driven corridor, in contrast to the automobile-focused Southeast 14th Street corridor. The Grand Avenue study corridor does not contain many parcels, but this short corridor shows a service-based environment with uses such as fast food restaurants, an office, a retail shop, and a car wash.

Table 5-11. Army Post Road land uses

Land Uses	Parcels
Auto Dealer	2
Auto Service	1
Bank	0
Car Wash	0
Child Care	0
Convenience Store	0
Fast Food Restaurant	2
Grocery Store	0
Hotel/Motel	0
Medical Office	1
Mini Warehouse	0
Office	3
Office/Apt	0
Office/Residential	0
Office/Retail	1
Office/Warehouse	0
Regional Shopping Center	1
Restaurant/Tavern	0
Retail	3
Retail/Warehouse	0
Service/Repair	2
Vet Clinic	0
Warehouse	0

Army Post Road has a wide variety of land uses, but yet shows groups of offices, retail, and service or repair shops. These land uses mesh well with the durable goods and repair-based land uses of Southeast 14th Street; Army Post Road continues the trends of durable goods service and repair, retail, and office uses as seen on the nearby corridor of Southeast 14th Street.

Table 5-12. Euclid Avenue land uses

Land Uses	Parcels
Auto Dealer	0
Auto Service	3
Bank	1
Car Wash	1
Child Care	1
Convenience Store	2
Fast Food Restaurant	2
Grocery Store	1
Hotel/Motel	0
Medical Office	3
Mini Warehouse	0
Office	4
Office/Apt	1
Office/Residential	1
Office/Retail	0
Office/Warehouse	1
Regional Shopping Center	1
Restaurant/Tavern	4
Retail	2
Retail/Warehouse	0
Service/Repair	2
Vet Clinic	0
Warehouse	0

The Euclid Avenue study corridor displays a variety of land uses, from auto-based to personal types of land uses. Table 5-12 shows a well-rounded distribution of land uses on Euclid Avenue, from durable goods services to personal services such as retail, restaurant, office, and other related uses. This corridor, which is in the northern, older portion of Des Moines, reflects a mixture of the land use trends seen on the durable goods-focused eastern corridors of Southeast 14th Street and Army Post Road and the human services-focused western corridors of 63rd Street and Grand Avenue.

Explanatory Variables Statistics

As described in Chapter Four, the regression model used for this study includes three explanatory variables: square footage, AADT, and access control. These explanatory variables will be used in creating the regression model in Chapter Six. Examining trends in these datasets in addition to analyzing their relationships with land value can help to explain the finished regression model later in Chapter Six.

Square footage

Controlling for parcel square footage when looking at the determinants of land value is essential, for larger parcels generally are valued higher than smaller parcels. As found previously in this chapter, land values varied by land parcel size, and parcel square footage were a factor in overall land value. Table 5-13 below shows average parcel square footage per study corridor. From this table, it is apparent that the western study corridors of 63rd Street and Grand Avenue have the highest average parcel square footage. 63rd Street and Grand Avenue also were both earlier found to have the highest average land values per parcel out of the study corridors, but this relationship dropped out when studying the average land value per square foot on these corridors.

Table 5-13. Average parcel square footage per corridor

Corridor	Average Square Footage
SE 14th Street	35,788
63rd Street	60,470
Army Post Road	27,685
Euclid Avenue	42,980
Grand Avenue	56,406

Average annual daily traffic

Annual average daily traffic counts (AADT) are also included in this study as a possibly being related to land value on the study corridors. Although all the study corridors are either principal or minor arterial roadways, and as such, should all be within a similar range of traffic volumes, the corridors do have unique traffic volumes within the arterial roadway traffic counts range for Des Moines. The differences in AADT among the study corridors could be used as a rough measure of congestion if the regression model supports this (in Chapter Six). Urban arterial roadways carry a large percentage of traffic, and very large AADT could indicate congested conditions. As seen in Table 5-14, the SE 14th Street corridor has the highest AADT, ranging from 28,500 to 34,300 vehicles per day. Grand Avenue, however, has the lowest AADT of the study corridors, ranging from 11,700 to 18,400 vehicles per day. However, Grand Avenue has a parallel interstate to its north, which reduces traffic volumes on Grand. These AADT trends follow the average value per square foot trends seen earlier in the chapter. As AADT increases, value per square foot decreases, and vice versa. At this point, it seems that AADT has an inverse relationship to land value per square foot; if AADT could ultimately be used as a measure of congestion, this means that land value per square foot decreases as roadway congestion increases.

Table 5-14. AADT range by corridor

Corridor	AADT Range
SE 14th Street	28500 – 34300
63rd Street	19100
Army Post Road	22300 - 24600
Euclid Avenue	20900 - 22200
Grand Avenue	11700 - 18400

Access control

Access control was converted to a quantitative variable for use in the regression model by creating an "access scale" that measured various ways to control turning movements on study corridors. The access scale was developed so that a maximum of 15 points could be awarded for maximum access control per land parcel. The variables used in the scale included driveway spacing at a maximum of five points, median type at a maximum of five points, and other related factors (right turning lanes, frontage roads, good internal circulation, shared driveways, and the formality of driveways) for one point each. Historic access control scores were used for the historic land value regression model, while current access control scores were used for the current land value regression model. There were no raised medians on any study corridors during the historic dates of data collection, the only assumed access control change during the years of study.

Driveway spacing accounts for five points on the overall access scale. All five points were given to driveways meeting spacing requirements (as detailed in Chapter Four), three points were given to driveways meeting spacing requirements on one side of the driveway, and no points were given to driveways not meeting spacing requirements. Table 5-15 below displays the driveway spacing scoring distribution by each study corridor. From this, it is apparent that the study corridors with raised medians, Southeast 14^{th} Street and 63^{rd} Street, have the most undesirable driveway spacing; Southeast 14^{th} Street has 41 parcels that do not meet driveway spacing requirements, and all five parcels on 63^{rd} Street do not meet spacing requirements. Army Post Road has the most parcels receiving five points for driveway spacing, and this corridor had no parcels that did not meet driveway spacing requirements.

Table 5-15. Driveway spacing scoring distribution by parcel

Corridor	0	3	5
SE 14th Street	41	3	2
63rd Street	5	0	0
Army Post Road	0	6	10
Euclid Avenue	27	0	3
Grand Avenue	3	2	2
All Corridors	76	11	17

Median type accounts for five points on the overall access scale; as described in Chapter Four, the median type scoring was awarded as follows:

5 points = Raised median with breaks 1/4 or more miles apart

4 points = Raised median with breaks for left turns 1/4 mile apart

3 points = Painted median (no two-way left turning lane)

2 points = Two-way left turning lanes (3 or 5 lane roadways)

1 point = Undivided roadway (2 or 4 lane roadways)

Table 5-16 below shows the distribution of current median type scoring by land parcel. There are 53 land parcels that are not access controlled and 51 access controlled parcels. Out of the 53 parcels that are not access controlled, 46 are located on an undivided roadway with no access control, and 7 are on roadways with two-way left turn lanes (TWLTL). Out of the 51 access controlled parcels, 47 have raised medians with frequent left turn breaks, and only 4 parcels have raised medians with less frequent left turn breaks. Therefore, although there are 51 access controlled parcels, these parcels did not receive the highest scoring possible for median type. Adding this scenario to the poor driveway spacing scoring resulting on this study's access managed corridors shows that while the access managed corridors have better access control than their non-managed counterparts, this study's access managed corridors are not optimally controlled. More desirable access managed study corridors would have better driveway spacing and fewer breaks in raised medians.

As stated previously, the assumed only access control change over the study years was the installation of raised medians on Southeast 14th Street and 63rd Street. Therefore, the historic land value regression model's median type scoring had the 51 parcels currently with raised medians as undivided roadways in the historic regression model.

Table 5-16. Median type by parcel

Median Type	Number of Parcels
None/Undivided Roadway	46
Two-Way Left Turn Lanes	7
Painted Median	0
Raised Median, left turn breaks 1/4 mi apart or less	47
Raised Median, left turn breaks more than 1/4 mi apart	4

Shared driveways, or driveways serving more than one land parcel, are another measured of access control used in this study. Table 5-17 below shows the distribution of shared driveways per study corridor. The trends of shared driveways do not seem to be influenced by either the installation of a raised median on a corridor or location of the corridor within Des Moines.

Table 5-17. Shared driveways

Corridor	Shared Driveways	Non-Shared Driveways
SE 14th Street	10	36
63rd Street	4	1
Army Post Road	5	11
Euclid Avenue	12	18
Grand Avenue	2	5
All Corridors	33	71

The formality of driveways on the study corridors, or distinguishing channelized, defined driveways from wide, unspecific driveways, may be related to location, as well as other factors. Figures 5-1 and 5-2 are examples of a channelized driveway and an unspecific driveway, respectively. As shown in Tables 5-17 and 5-18, most land parcels on the western and northern study corridors had shared driveways, and most parcels on the eastern study corridors did not have formal driveways. However, the formality of driveways may be due to many other factors, such as land uses, parcel square footage, land value, and more.

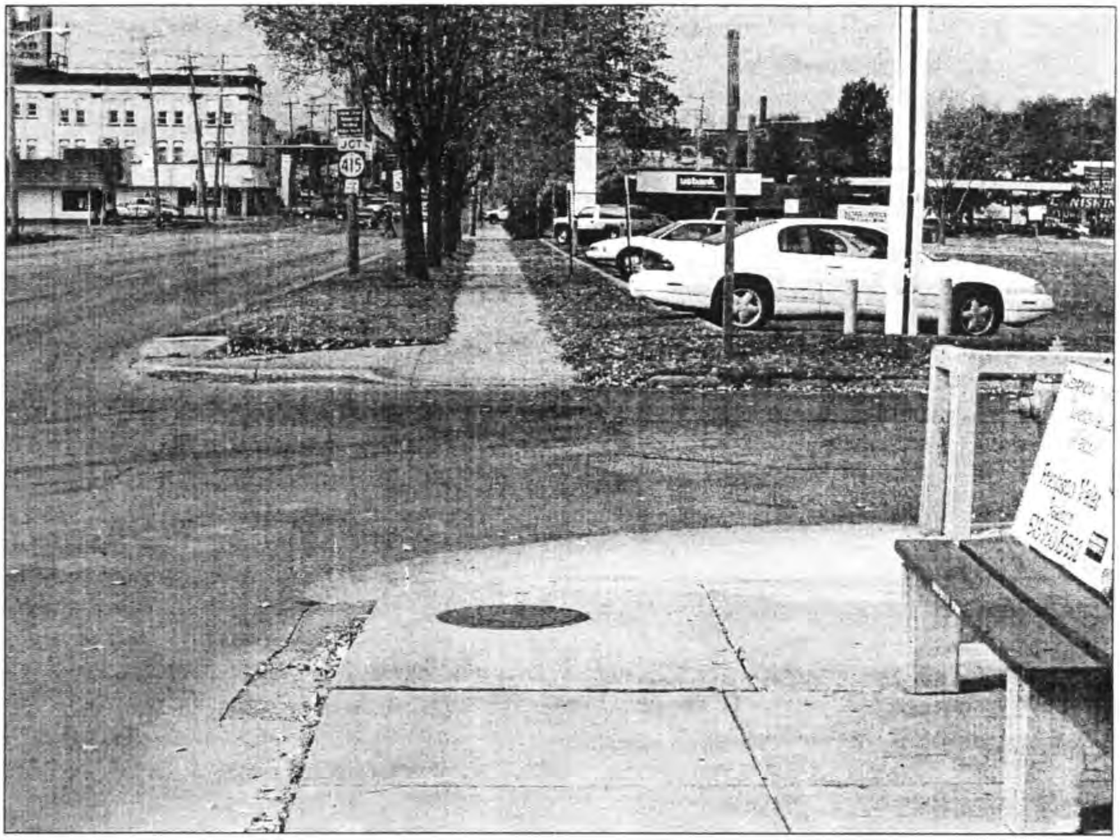

Figure 5-1. Example of a formal, channelized driveway

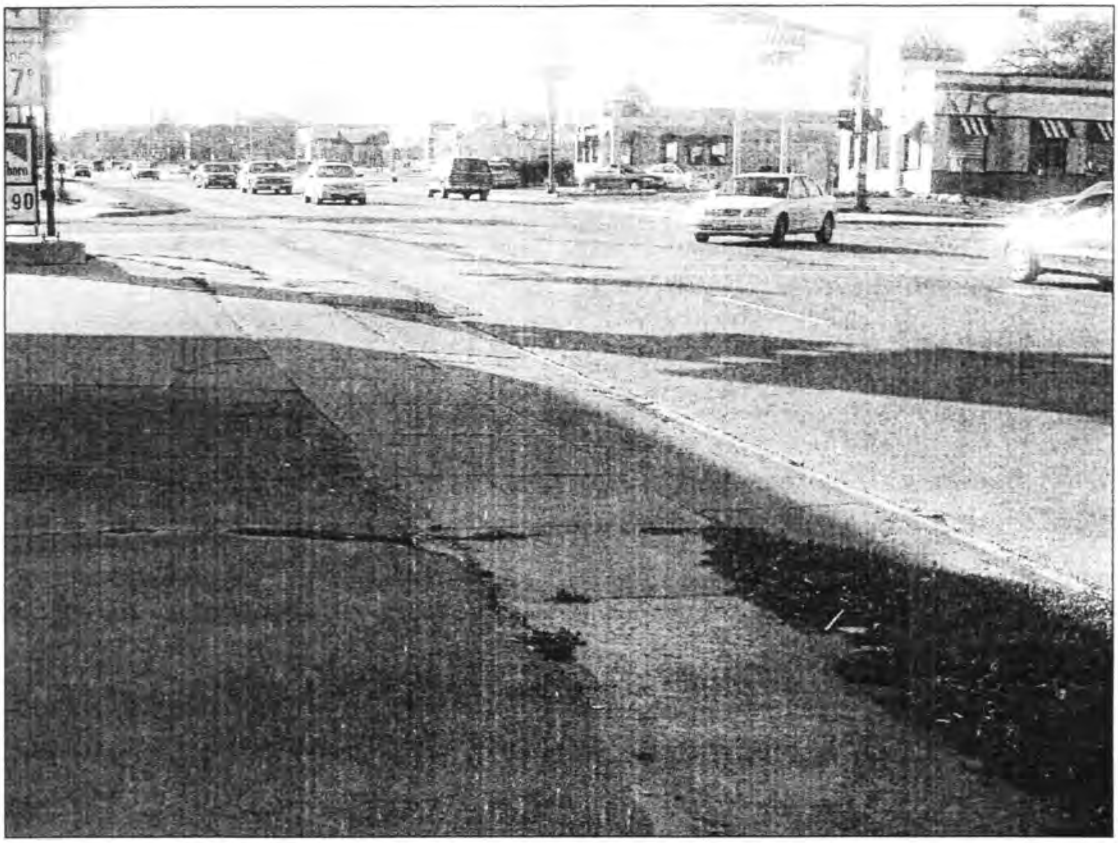

Figure 5-2. Example of an informal driveway

Table 5-18. Formal driveways

Corridor	Not Formal	Formal
SE 14th Street	28	18
63rd Street	0	5
Army Post Road	13	3
Euclid Avenue	8	22
Grand Avenue	2	5
All Corridors	51	53

Right turning lanes provide traffic storage and allow traffic flow on roadways to continue without waiting for turning vehicles. There were not many study parcels accessed by right-turning lanes, as seen in Table 5-19; only Southeast 14th Street had right turning lanes.

Table 5-19. Right turning lanes

Corridor	Right Turn Lanes
SE 14th Street	2
63rd Street	0
Army Post Road	0
Euclid Avenue	0
Grand Avenue	0
All Corridors	2

The study dataset did not include any land parcels located on frontage roads, so no parcel received points for this in the access scale. Good internal circulation for this study was interpreted as clear paths for vehicles to travel within each parcel to reduce vehicular conflicts by separating and channelizing traffic to separate activity centers on each parcel. Table 5-20 below shows the distribution of good internal circulation scoring per parcel by corridor. From this, it is apparent that the corridors with raised medians do not share good internal circulation trends; rather, it seems the newer-developed sections of the study area had better internal circulation. Most parcels on the newer-developed corridors of 63rd Street and Grand Avenue had good internal circulation, while most parcels on the corridors in the older sections of the city did not have good internal circulation.

Table 5-20. Good internal circulation

Corridor	Good Internal Circulation	Not Good Internal Circulation
SE 14th Street	8	38
63rd Street	5	0
Army Post Road	3	13
Euclid Avenue	13	17
Grand Avenue	5	2
All Corridors	34	70

Table 5-21 below displays the resulting most frequently occurring access control scores per study corridor, out of 15 possible points. Again, the only corridors that have different access scores from the historic to the current dataset were Southeast 14th Street and 63rd Street. From the table, it is apparent the corridors with raised medians, Southeast 14th Street and 63rd Street, may not necessarily have the highest overall access control scores. Army Post Road actually has higher most frequently occurring access control scores than Southeast 14th Street, which could be attributed to Southeast 14th Street's many driveways, of which many are not formal or not adequately spaced.

Table 5-21. Most frequently occurring access control scores

Corridor	Historic Access Scale Scores	Current Access Scale Scores
SE 14th Street	0 to 1	4 to 5
63rd Street	2 to 3	6 to 7
Army Post Road	5 to 6	5 to 6
Euclid Avenue	1 to 2	1 to 2
Grand Avenue	Variable: 3-9	Variable: 3-9

Determining how each explanatory variable relates to the other is important to begin to assess possible conditions for multicollinearity in the regression model, a circumstance where explanatory variables are redundant and may not be needed once other variables are added to the regression model (25). While this condition should be analyzed during the stepwise regression model creation, looking at the explanatory variables' trends over each of the study corridors may provide some indication of relationships among the variables. Figure 5-3 below graphs the average access scale score per corridor, the average square footage per corridor divided by 10,000 (to create a comparable index), and the average AADT per corridor divided by 10,000. This figure shows no apparent relationships among variable trends, for no trend line mirrors another.

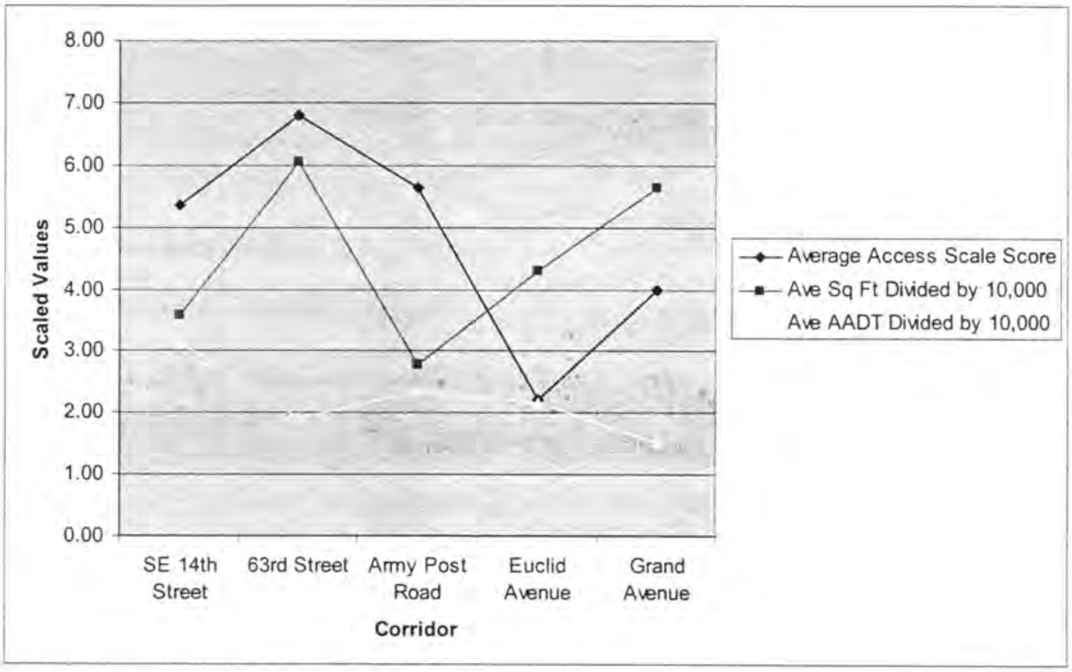

Figure 5-3. Comparison of explanatory variables

This chapter described data trends in each dataset employed in the upcoming regression analysis in Chapter Six. Land value data trends show the variability in the regression models' dependent variables. Average land value per overall parcel by corridor showed that the western corridors had the highest average land values, but these western corridors also had the highest average square footage per parcel. Controlling land value for square footage, or making the dependent variable commercial land value per square foot, showed that the access managed corridors had lower average commercial land values per square foot, but this could be circumstantial. Explanatory variable data trends were not very different between access managed and non-managed corridors, but trends were noticeably different between the western corridors from the northern and eastern corridors. Comparing explanatory data trends to land value trends, it was found that the dependent variable, land value per square foot, has an inverse relationship to AADT; as AADT increases, land value per square foot in the study dataset decreases. This occurrence could possibly support using AADT in this study as a measure of congestion, but needs to be further studied through the regression model developed in Chapter Six.

CHAPTER SIX – INFERENTIAL STATISTICS

Introduction to Regression Models

Regression models have three purposes: to determine if an association exists between two variables, to analyze the strength of that relationship, and to investigate the form of that relationship (*25*). Multivariate regression is regression with more than one explanatory variable; it can analyze partial relationships between two variables while controlling for other variables in the model. Multivariate regression can incorporate more than one explanatory variable, so it is be useful for land value models; since land value is dependent upon more than one factor, it is crucial to account for all these factors in regression models seeking to relate land value to its determinants.

This chapter will outline the process used to create two stepwise regression models to describe the relationships between historic or current commercial land value and parcel square footage, average annual daily traffic counts, and access control. The chapter will begin with an overview of regression, then detail variables used, basic methodology used, model assumptions and hypothesis, regression model outputs, regression diagnostics, and interpreting the results of regression models creation.

Regression Model Sets Overview

The sets of regression models used for this study were projected to have three explanatory variables. In accordance with previous hedonic models, the regression model may not include any market-related factors, such as sales. The projected explanatory variables are parcel square footage, average annual daily traffic (AADT) counts, and access control, described previously in Chapter Four. The first two explanatory variables are quantitative and can easily be used in the regression models. Access control, however, is a qualitative measure, and has been quantified for use in the regression model through the development of an access scale measuring many types of access control per land parcel.

The regression models were created using stepwise regression, which is a modified version of the forward selection method of regression model creation. Stepwise regression begins with no explanatory (x) variables and then adds them one at a time. Stepwise regression then drops explanatory variables from the model if they lose their significance as other variables are added (*25*).

The inferential statistics portion of this research was conducted in SPSS using data created or analyzed first in ArcView. In the process of conducting the inferential statistics, ArcView was used to quantify factors for the regression model, as well as to collect roadway and economic attributes necessary for the analysis. SPSS was only used in this research to set up, run, and analyze the regression model after the databases were completed in ArcView.

Dependent Variable – Commercial Land Value per Square Foot

The dependent variable used for all regression models in this research was commercial land value per square foot, the indicator used here to measure economic impacts of access management techniques. Two types of commercial land value were collected for the regression models. Current commercial land values were collected for study parcels, as well as the "historic" land values (from before raised medians were constructed on study corridors with raised medians) described previously. To fully analyze the dataset in the regression models, the data were split into two groups for two regression models, one for current land values as the dependent variable and another for historic land values as the dependent variable.

Simply using overall land value for each parcel may lead to incorrect regression results. Parcel square footage is also strongly linked to land value in the sense that larger land parcels are generally valued at higher prices due to their size. Using overall parcel land value as the dependent variable in a regression model would skew the results, for the model would be accounting for the large impact of square footage on land value. A dependent variable such as land value per square foot should remedy this problem, for the obvious value differences from larger to smaller land parcels will be controlled for. Even if square footage is included as an explanatory variable, the regression model measures how land value per square foot is related to overall parcel square footage; in other words, the model will measure how value per square foot changes as overall square footage changes.

Explanatory Variables

The explanatory variables in the regression models were used to explain variation in the commercial land value datasets. These variables included parcel square footage, annual average daily traffic counts, and access control. Because the type of regression model used is a stepwise regression model, the explanatory variables were removed from the model as their significance dropped out, leaving a model with only significant relationships to commercial land values per square foot.

Parcel square footage

Parcel square footage needed to be accounted for in the regression model, for larger parcels of land should have higher value. Square footage was tracked in the regression model in two ways. First, the independent variable of commercial land value was found per square foot to control for land value fluctuations due to parcel size. Then, the explanatory variable of parcel square footage was used in the regression model to determine the strength of the relationship between land value per square foot and parcel size. The range of square footage is important to note; as seen in Chapter 5, 63rd Street and Grand Avenue have the largest average parcel size by far, then followed by the smaller average parcel sizes of Euclid Avenue, SE 14th Street, and Army Post Road. The square footage factor in the regression model was transformed to make error terms more normal. Using square footage alone as an explanatory variable lead to poor residual versus explanatory variable plots, and using the logarithm of square footage instead made errors more normal.

Average annual daily traffic

Annual average daily traffic was another important factor to measure in the regression model. Because all corridors used in this study are either principal or minor arterial roadways, the AADT range among them is similar due to similar functional classifications. Because of this, AADT could also be viewed as a rough measure of congestion on the corridors; the arterial roadways all have high AADT counts, and the variation in AADT could describe possible congestion levels on these roadways. As seen in Chapter 5, AADT trends are opposite to parcel square footage trends: SE 14th Street has the highest AADT, followed by Army Post Road.

Access control

The level of access control on the study corridors is a very important measure to include in the regression models, for the purpose of the model was to determine how access control is correlated to land values. To include access control in the model, it must become a quantifiable measure; therefore, an access scale was created evaluating driveway density, medians and two-way left turning lanes, and other measures of access control. The value given to each access level was the value used in the hedonic model. As seen in Table 4-1 (in Chapter 4), the access scale has a total value of 15 points, awarded in three categories: driveway spacing, median type, and other factors including right turning lanes, frontage roads, good internal circulation, shared driveways, and the formality of driveways. The presence of these factors resulted in one point for each factor on the access scale.

Location Influences on Data

Location is another important issue in land value, but rather than quantify this factor, it was controlled for in the regression model through certain methods of corridor selection. The corridors chosen for study had to meet certain assumptions in order to control the sample for land value variations. All corridors were urban arterials, either access controlled or not managed at all, with primarily commercial adjacent land uses. The first step necessary to selecting study corridors was to perform windshield surveys of urban arterial corridors with primarily commercial adjacent land uses in Polk County. The windshield surveys were used to determine roadway segments with these characteristics, and were also used to analyze access control techniques. In addition to windshield surveys, aerial photographs from the Polk County Assessor's website were used to clarify access control on the first group of corridors selected for study (*15*).

Another important issue in fitting a model to this data was to ensure the study corridors had similar characteristics. However, trends in parcel square footage, AADT, and access control differ among the study corridors. As seen in Chapter Five, the corridors on the north and east sides of Des Moines, Euclid, SE 14th, and Army Post, the older portions of the city, have similar data trends, while the corridors on the west side of the city, 63rd and Grand, the more newly developed portions of the city, have similar data trends. Of course, these two groups of data trends are slightly different, and this may have an impact on the regression model. Testing regression models to determine how location affects model fit was important for this research. To determine if datasets were skewed by location effects, two regression model sets were created; the first regression model set contained data from all five study corridors, and the second regression model set contained data only from Southeast 14th Street, Army Post Road, and Euclid Avenue, excluding the western corridors of 63rd Street and Grand Avenue. Each regression model set contained two regression models, one for historic land value per square foot, and one for current land value per square foot. These two regression model sets were compared to see which set fit the data better, and if there was a location effect on the data used.

Model Methodology

As previously detailed, two regression models were created to examine commercial land value change as access control changes. One regression model used historic commercial land value per square foot as a dependent variable, while the other used current commercial land value per square foot. Also, the possible effects of location on the datasets was analyzed by creating two regression model sets; one model set used data from all five study corridors, while the other model set only used data from Southeast 14th Street, Army Post Road, and Euclid Avenue, excluding the western corridors. Each model set contained the two regression models for historic or current land value data.

Model assumptions and hypothesis

The basic linear regression model is as follows:

$$Y_i = B_o + B_1X_{1i} + e_i$$

The dependent variable Y is a function of a constant term B_0 and a constant B_1 times the independent variable X_1 plus a disturbance term.

Each linear regression model has assumptions that must be met. If assumptions are not completely satisfied, other actions should be taken, such as alternative modeling. The multiple regression assumptions include:

1. *Continuous dependent variable Y*: Regression assumes that the response variable is continuous and its value may be any within a certain range of values.
2. *Linear-in-parameters relationship between Y and X*: Regression assumes that the form of the model is inherently linear, or forms a linear relationship between the dependent variable (Y) and the independent variables (X).
3. *Observations independently and randomly selected*: Regression requires that data observations be independent and randomly selected, but this requirement can be relaxed if other actions are taken.
4. *Uncertain relationship between variables*: Regression requires the addition of a disturbance term to the model (seen as the net effect of model uncertainty).
5. *Disturbance term independent of X and expected value zero*: Regression requires that disturbance terms are independent and random across observations.
6. *Disturbance terms not autocorrelated*: Regression requires that disturbance terms are not autocorrelated across observations.
7. *Regressors and disturbances uncorrelated*: Regression requires that regressors be not correlated with the disturbance term.

8. *Disturbances approximately normally distributed*: Regression requires that disturbances be approximately normally distributed to make correct inferences about the model.
--Washington, et al. Statistical and Econometric Methods for Transportation Data Analysis, 2003

The hypothesis for this research was that access control does not have a significant impact on commercial land values (measured as commercial land values per square foot). Regression model hypotheses include a null hypothesis and an alternative hypothesis. The null hypothesis is directly tested through the regression model, and the alternative hypothesis contradicts this hypothesis.

The null hypothesis states that the mean of the response variables does not depend on the values of the explanatory variables

$$H_o: B_1 = B_2 = B_3 = 0$$

The alternative hypothesis (or research hypothesis) states that at least one explanatory variable is related to the response variable when controlling for the other explanatory variables.

$$H_a: \text{At least one } B_i \neq 0$$

To determine if corridor location has an effect on the regression model, two regression model sets were created; the first model set used a dataset of all five study corridors, and the second model set used a dataset of only the northern and eastern corridors, excluding 63rd Street and Grand Avenue.

Stepwise Regression Outputs

The regression analysis showed that the regression model set for all study corridors did not fit the dataset as well as the regression model set excluding the western study corridors. This result showed differences in land value trends between the newer western and older northern and eastern sections of Des Moines, which should be studied through further research. Because of this, the better-fitting three-corridor regression model set was used for the final analysis in this research. In addition, there were similar trends between the historic and current regression models in both regression model sets, which could mean there was little or no land value change due to access change.

The regression model output tables shown in this section are only for the second regression model set using data from only the northern and eastern study corridors because this model set was found to have better-fitting models. To show differences between the two regression model sets, the five-corridor regression model outputs are located in Appendix B, and referenced throughout this chapter. This section details the various outputs of both stepwise regression models sets used in this research. First, data will be tested for linearity, and then regression outputs will be discussed, including multiple correlation, model summary, regression coefficients, excluded variables, and residual analysis.

Plotting data points in a scatterplot reveals linear or nonlinear relationships in the data; if the data points follow a relatively linear progression (even with some outliers), a linear regression model may be used (*25*). A scatterplot matrix is especially useful when many explanatory variables are included in a model, for a matrix displays all scatterplots for all possible pairings of explanatory variables. Figure 6-1 shows a scatterplot matrix of the three explanatory variables included in the historic land value regression model with the three study corridors. Figure 6-2 shows a scatterplot matrix of the three explanatory variables included in the current land value regression model for the three study corridors.

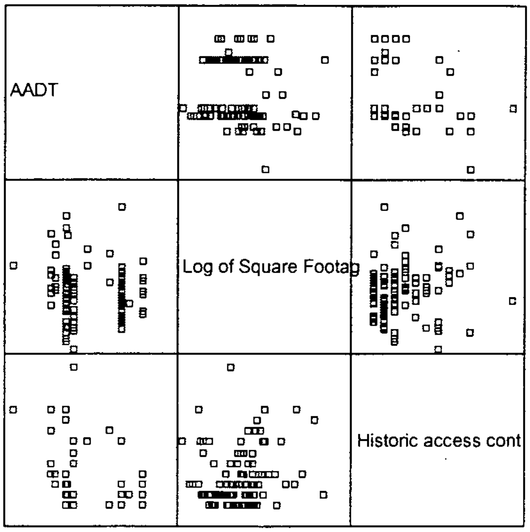

Figure 6-1. Scatterplot matrix of historic land value explanatory variables, three study corridors

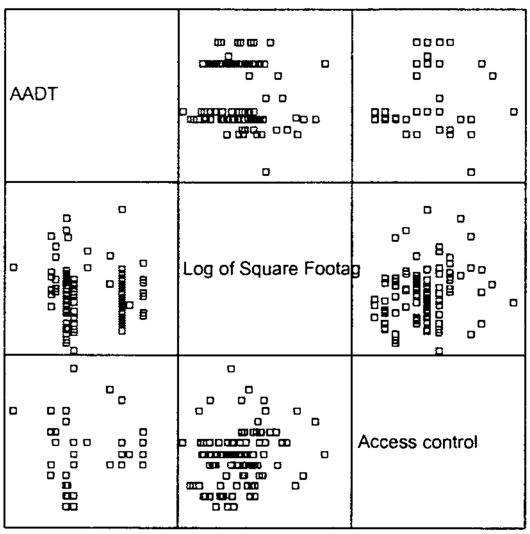

Figure 6-2. Scatterplot of current land value explanatory variables, three study corridors

Both scatterplots show similar results; the scatterplot matrices reveal linear relationships among all explanatory variables, and therefore a linear regression model is appropriate. In each individual scatterplot, data points are clustered or follow some sort of progression, with the exception of a few outliers.

Multiple correlation describes the strength of bivariate relationships, and is the Pearson correlation between observed and predicted values in a model (*25*). The Pearson correlation is denoted by R in multiple regression. R always falls between 0 and 1, and correlations closer to 1 yield better prediction values, or the relationship between the two variables is stronger (*25*). The multiple correlations between each variable are seen in Tables 6-1 and 6-2 below. The correlations between variables are slightly different for both models. The independent variables of AADT and the log of square footage are weakly or moderately inversely related to land value per square foot. The independent variable of historic access control has a weak inverse relationship to historic land value per square foot, and the variable of access control has a weak positive relationship to current land value per square foot. However, correlations alone do not prove if relationships between variables are significant- this is found in the Significance row in Tables 6-1 and 6-2, but will be discussed later in this chapter.

Table 6-1. Multiple correlations: Historic land values

Correlations

		Historic value per square foot	AADT	Log of Square Footage	Historic access control
Pearson Correlation	Historic value per square foot	1.000	-.330	-.278	.126
	AADT	-.330	1.000	-.068	-.457
	Log of Square Footage	-.278	-.068	1.000	.159
	Historic access control	.126	-.457	.159	1.000
Sig. (1-tailed)	Historic value per square foot	.	.000	.002	.101
	AADT	.000	.	.247	.000
	Log of Square Footage	.002	.247	.	.054
	Historic access control	.101	.000	.054	.
N	Historic value per square foot	104	104	104	104
	AADT	104	104	104	104
	Log of Square Footage	104	104	104	104
	Historic access control	104	104	104	104

Table 6-2. Multiple correlations: Current land values

Correlations

		Current value per square foot	AADT	Log of Square Footage	Access control
Pearson Correlation	Current value per square foot	1.000	-.566	-.238	-.261
	AADT	-.566	1.000	-.068	.202
	Log of Square Footage	-.238	-.068	1.000	.208
	Access control	-.261	.202	.208	1.000
Sig. (1-tailed)	Current value per square foot	.	.000	.008	.004
	AADT	.000	.	.247	.020
	Log of Square Footage	.008	.247	.	.017
	Access control	.004	.020	.017	.
N	Current value per square foot	104	104	104	104
	AADT	104	104	104	104
	Log of Square Footage	104	104	104	104
	Access control	104	104	104	104

Tables 6-3 and 6-4 provide a summary of the regression models for the five-corridor model set. The summary includes multiple correlation (R), used again to describe how well a regression model predicts data. The coefficient of multiple determination (R^2) is the proportion of total variation in Y that is explained by simultaneous predictive power of all explanatory variables through the multiple regression model (25), and is also in these tables. The coefficient of multiple determination shows how well each model predicts values- the higher the percentage, the better the model predicts. The F statistic helps to determine if the null hypothesis is true; the higher the F statistic, the more evidence exists against H_o (25).

Tables 6-3 and 6-4 may be compared to the model summary tables of the five-corridor regression model, Tables B-3 and B-4 in the appendix. The model summary tables were not used as the indicator of which regression model was the best fit for the data; the five corridor historic data model (R = .450) fit the data better than the three corridor historic data model (R = .446), and the three corridor current data model (R = .630) fit the data better than the five corridor current data model (R = .625). Multiple correlation alone is not sufficient to determine model quality, but multiple correlation showed that the two model sets fit the data similarly, but the three corridor regression model set fit data slightly better (26). The model sets were also chosen later in this chapter based on significance testing and residual plots.

The coefficients of multiple determination for the two model sets follow the same trend as the correlation; the three-corridor regression model set has higher R^2 values than the models in the five corridor set, and therefore has a higher reduction in errors (or predict values better) than the five corridor regression models.

Table 6-3. Model summary: Historic land values

Model Summary[c]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.330[a]	.109	.100	1.81990	.109	12.452	1	102	.001
2	.446[b]	.199	.183	1.73371	.090	11.393	1	101	.001

a. Predictors: (Constant), AADT

b. Predictors: (Constant), AADT, Log of Square Footage

c. Dependent Variable: Historic value per square foot

Table 6-4. Model summary: Current land values

Model Summary[c]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.566[a]	.320	.314	.95440	.320	48.108	1	102	.000
2	.630[b]	.397	.385	.90347	.077	12.823	1	101	.001

a. Predictors: (Constant), AADT

b. Predictors: (Constant), AADT, Log of Square Footage

c. Dependent Variable: Current value per square foot

Tables 6-5 and 6-6 show the coefficients for each regression model in the five-corridor set. This table can be used to develop the finalized regression models (using model 2 in these tables, including AADT and log of square footage as independent variables) for each time period, which are:

$E(Y) = 12.792 - 0.000116X_1 - 1.517X_2$

Where: $E(Y)$ = Historic land value per square foot

12.792 is the constant term

X_1 = AADT

X_2 = log of square footage

$E(Y) = 9.482 - 0.00012X_1 - 0.839X_2$

Where: $E(Y)$ = Current land value per square foot

9.482 is the constant term

X_1 = AADT

X_2 = log of square footage

The predictor of AADT was found to have an inverse relationship with land value per square foot, and the predictor of the log of square footage also had an inverse relationship with the dependent variable. Tables 6-5 and 6-6 also include test statistic (t) information as well as each variable's significance in the model. Model 2 in these tables show that AADT and the log of square footage are significant at the .000 and .001 levels, respectively, for the historic values model, and .000 for both variables in the current values model. Tables 6-5 and 6-6 may be compared to Tables B-5 and B-6 in Appendix B.

The stepwise regression process removed predictors that were not significant, and this model did not find access control as a significant explanatory variable at the .05 level of significance in either regression model. Tables 6-7 and 6-8 list the statistics of the excluded variable of access control for both the historic and current land value models. However, significance levels are crucial to results at this juncture; according to Tables 6-7 and 6-8, the historic model's access control significance level was .178, and that of the current model was .250. Comparing these significance levels with those in future studies could reveals similar trends in the relationship between access control and land value. In addition, choosing a level of significance is important to overall results, especially if a variable's significance level is close to the alpha level of significance.

Table 6-5. Regression coefficients: Historic land values

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients			95% Confidence Interval for B		Correlations			Collinearity Statistics	
		B	Std. Error	Beta	t	Sig.	Lower Bound	Upper Bound	Zero-order	Partial	Part	Tolerance	VIF
1	(Constant)	5.947	.856		6.947	.000	4.249	7.645					
	AADT	-1.16E-04	.000	-.330	-3.529	.001	.000	.000	-.330	-.330	-.330	1.000	1.000
2	(Constant)	12.792	2.186		5.853	.000	8.456	17.128					
	AADT	-1.23E-04	.000	-.350	-3.924	.000	.000	000	-.330	-.364	-.349	.995	1.005
	Log of Square Footage	-1.517	.449	-.301	-3.375	.001	-2.409	-.625	-.278	-.318	-.301	.995	1.005

a. Dependent Variable: Historic value per square foot

Table 6-6. Regression coefficients: Current land values

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients			95% Confidence Interval for B		Correlations			Collinearity Statistics	
		B	Std. Error	Beta	t	Sig.	Lower Bound	Upper Bound	Zero-order	Partial	Part	Tolerance	VIF
1	(Constant)	5.698	.449		12.692	.000	4.808	6.589					
	AADT	-1.20E-04	.000	-.566	-6.936	.000	.000	.000	-.566	-.566	-.566	1.000	1.000
2	(Constant)	9.482	1.139		8.325	.000	7.223	11.742					
	AADT	-1.24E-04	.000	-.585	-7.553	.000	.000	.000	-.566	-.601	-.584	.995	1.005
	Log of Square Footage	-.839	.234	-.277	-3.581	.001	-1.303	-.374	-.238	-.336	-.277	.995	1.005

a. Dependent Variable: Current value per square foot

Table 6-7. Excluded variables: Historic land values

Excluded Variables[c]

Model		Beta In	t	Sig.	Partial Correlation	Collinearity Statistics		
						Tolerance	VIF	Minimum Tolerance
1	Log of Square Footage	-.301[a]	-3.375	.001	-.318	.995	1.005	.995
	Historic access control	-.031[a]	-.293	.770	-.029	.791	1.264	.791
2	Historic access control	.018[b]	.178	.859	.018	.775	1.291	.775

a. Predictors in the Model: (Constant), AADT

b. Predictors in the Model: (Constant), AADT, Log of Square Footage

c. Dependent Variable: Historic value per square foot

Table 6-8. Excluded variables: Current land values

Excluded Variables[c]

Model		Beta In	t	Sig.	Partial Correlation	Collinearity Statistics		
						Tolerance	VIF	Minimum Tolerance
1	Log of Square Footage	-.277[a]	-3.581	.001	-.336	.995	1.005	.995
	Access control	-.153[a]	-1.857	.066	-.182	.959	1.042	.959
2	Access control	-.094[b]	-1.157	.250	-.115	.910	1.099	.910

a. Predictors in the Model: (Constant), AADT

b. Predictors in the Model: (Constant), AADT, Log of Square Footage

c. Dependent Variable: Current value per square foot

Regression Diagnostics

Regression diagnostics are used to determine if a model fits the data correctly. In particular, regression diagnostics determine if model assumptions are violated, and also find which observations are influential in affecting the model (*25*). The assumptions in inference statistics are tested by regression diagnostics. These assumptions may be violated but not grossly violated for a successful model:

- The true regression function has the form used in the model (linear, non-linear, etc)
- The conditional distribution of Y is normal
- The conditional distribution of Y has constant standard deviation throughout the range of values of explanatory variables (homoscedasity)
- The observations on Y are statistically independent, such as in random sampling

--Washington, et al. Statistical and Econometric Methods for Transportation Data Analysis, 2003

Residual versus explanatory variables plots are used to determine model normality (*25*). Originally, a stepwise regression model was created by entering AADT, square footage, and access control as variables- this model yielded residual versus explanatory variable plots that indicated possible regression model violation. To remedy this, the square footage variable was transformed by using the log of square footage as a variable, which made error terms more normal.

The method used to check for model assumption violations is plotting residuals against explanatory variables. Figures 6-3 and 6-4 show the residual versus explanatory variable plots for the three-corridor model set. Figures B-3 and B-4 in Appendix B show the residual versus explanatory variable plots for the five corridor model set, and comparing the plots from the two sets shows that with the exception of a large outlier in the historic value regression models in both model sets, both model sets appear to not violate model assumptions.

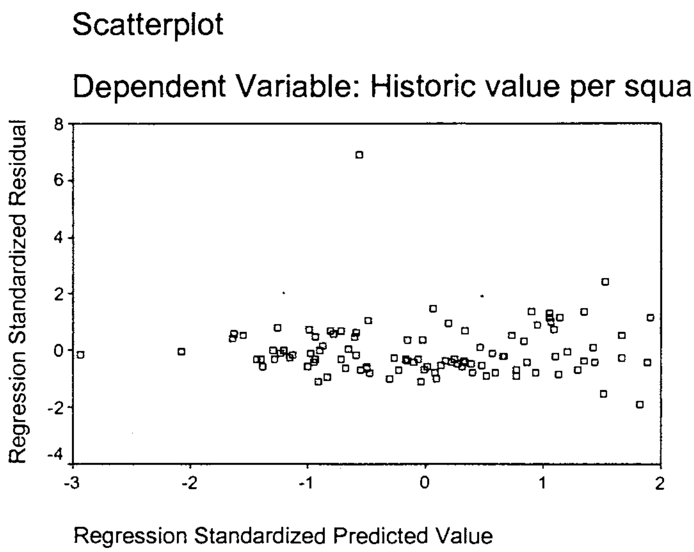

Figure 6-3. Residual analysis: Historic land values

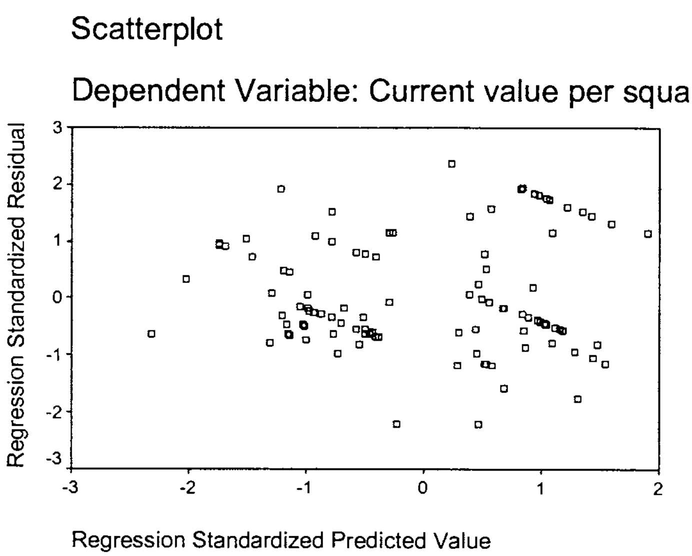

Figure 6-4. Residual analysis: Current land values

Interpreting the Regression Model Sets

The resulting regression model set found to be the best fit for the Des Moines data (the three corridor model set) does contain some irregularities that should be addressed through additional analysis. First, the log of square footage was found to be inversely related to commercial land value, which means that as parcels increase in size, their value per square foot (not overall value) decreases. Second, AADT was also inversely related to commercial land value, which contradicts conventional thought on commercial properties that increased exposure (or traffic volumes) to a property could result in more economic prosperity.

The regression model found that the log of square footage is inversely related to land values per square foot. To further analyze the possible impacts of land use on square footage, the 15 parcels with the highest square footage in the dataset were analyzed against the 15 parcels with the lowest square footage in the dataset. First, the two groups of land parcels were analyzed by value per square foot; the smallest parcels had mean values per square foot of $3.94 (historic values) and $3.00 (current values), while the largest parcels had mean values per square foot of $2.84 (historic values) and $2.14 (current values). This finding is consistent with that of the regression model- as square footage increases, value per square foot decreases. However, comparing these trends to other factors on the land parcels could better explain the value variations by square foot. Comparing land use types on these two groups of land parcels could account for some of the land value variations by square footage. The most frequently occurring land uses on the largest land parcels included regional shopping centers, auto service, auto dealer, and retail. Conversely, the most frequently occurring land uses on the smallest land parcels included service and repair shops, offices, medical offices, and retail.

The regression model also found that AADT is inversely related to land values per square foot. AADT could possibly be treated as a measure of congestion in the model because all corridors were arterial multilane roadways; the corridors should have similar traffic counts (within a large range as compared to other roadway functional classifications). If AADT was much higher on one corridor than another, it could be an indication of congestion. Or, perhaps AADT is not actually measuring congestion in this study at all. It is plausible to think that as congestion increases, land value decreases; however, this goes against traditional business thought that as traffic (or exposure to businesses) increases, economic prosperity should increase. Although sales were not measured in this study, and no conclusive evidence shows that sales decrease as AADT increases, commercial land values as an economic indicator did decrease as AADT increases. Future research should be performed to determine the extent of the relationships among AADT, congestion, and access control.

Because the three corridor regression model set was found to fit the data better than the model set using all five study corridors, it was determined that location was not adequately controlled for during corridor and parcel selection. While the explanatory variables of square footage and AADT had inverse relationships to land values in the model, access control was not found to be a significant influence on commercial land values, and was removed from the regression model. Because one of the three possible explanatory variables was found not significant, the statistical null hypothesis can be rejected. This regression model fits the research hypothesis; in this study, commercial land values were not adversely impacted by access management techniques, because access control is not a significant predictor of commercial land values. Chapter Seven will further discuss the findings of this research, as well as detail needs for further research.

CHAPTER SEVEN - CONCLUSIONS

This research has investigated the relationship between access control and commercial land values in Des Moines, Iowa, and has found correlations between commercial land values and the variables of AADT and square footage. This chapter concludes the research by relating research results to the research hypothesis.

The introduction and the access management overview chapters outlined the safety benefits of practicing access management. Access management reduces crashes by reducing vehicle conflicts caused by turning movements, but the economic impacts of the practice have not been quantitatively studied in past research. Studying the economic impacts of access management techniques could lead to evidence that access management techniques do not negatively influence economic factors on a corridor. Such findings would be beneficial to overall access management research, standards, and implementation. While the safety benefits of the practice have been documented, some business owners believe their business could be negatively impacted if access is restricted or removed. While studying sales data per individual land parcel is improbable due to lack of data, land values were instead used as an economic indicator.

The hypothesis for this research was that access management techniques would have minimal negative impacts on land values in Des Moines, Iowa. If this hypothesis is not rejected, it may create higher favor, or at least acceptance, for the practice of access management among commercial property owners.

Conclusions: Inferential Statistics

It was found that location slightly influenced the Des Moines dataset used for this research. Past research has found interesting land value differences between western Des Moines and the rest of the city; therefore, this factor was also studied in this research. For instance, a literature review from the Center for Transportation Research and Education cites many pieces of research that have found rapid growth to the north and west in most central Iowa cities (27). The three-study corridor stepwise regression models created in Chapter Six found that access control is not a significant factor on commercial land values in Des Moines. However, the models did find that both AADT and the log of square footage had inverse relationships with commercial land values in Des Moines.

Conclusions: Descriptive Statistics

Descriptive statistics were used in this study to explore the inferential statistical findings and further investigate the datasets. Tables 7-1 and 7-2 below compare the averages of the variables entered into the regression model- AADT, square footage, access scale, and the dependent variables of historic and current land value per square foot.

Table 7-1. Descriptive statistics comparison

Corridor	AADT	Ave. Square Footage	Ave. Access Scale Score
SE 14th Street	28500 – 34300	35,788	5.35
63rd Street	19100	60,470	6.8
Army Post Road	22300 - 24600	27,685	5.63
Euclid Avenue	20900 - 22200	42,980	2.2
Grand Avenue	11700 - 18400	56,406	4

Table 7-2. Descriptive statistics comparison

Corridor	Ave. Current Land Value per Sq Ft	Ave. Historic Land Value per Sq Ft
SE 14th Street	$1.93	$2.15
63rd Street	$2.25	$2.18
Army Post Road	$2.82	$3.64
Euclid Avenue	$3.37	$3.83
Grand Avenue	$4.21	$4.02

This study found that although corridors with raised medians could be considered access managed, evaluating the same corridor using an access scale with many determinants of access control could find a corridor with raised medians to be "less" access controlled than a corridor with no medians. A prime example in this research is the comparison of Southeast 14th Street and Army Post Road. Southeast 14th Street has raised medians, but these medians have frequent breaks, and the corridor has many driveways spaced closely together. Army Post Road does not have raised medians (except at major intersections, not included in this study), but has better driveway spacing practices. Using the access scale derived in this research, it was found that Army Post Road (with no raised median) was actually considered to be a higher access managed road than Southeast 14th (with a raised median). Descriptive statistics alone may indicate that commercial land value trends are lower on corridors with raised medians, the access scale variable clearly indicated access control levels on each corridor beyond raised medians.

The regression model can be further analyzed by examining variable relationships in Tables 7-1 and 7-2. 63rd Street had the highest average access scale score of the study corridors. 63rd Street also had the second-lowest AADT, the highest average square footage, and the second lowest average historic and current land values per square foot. Conversely, Euclid Avenue had the lowest average access scale score of the study corridors. Euclid Avenue also had the third highest AADT, the third average square footage, and second highest average historic and current land values per square foot. These two examples do follow the relationships established by the regression model; access control on a corridor does not seem to fluctuate with the other variables, but AADT and square footage do seem to have varied relationships with land value.

Reject or Accept Hypothesis

The inferential statistics used for this research found that access control was not a significant influence on commercial property values in Des Moines, Iowa. The hypothesis for this research was that commercial property values in Des Moines were not negatively impacted by access management techniques, and these research findings support that hypothesis.

Need for Future Research

There is currently little quantitative research on the economic impacts of access management practices. This research conveys the need for further research on the economic impacts of access management, similar research using more case studies and more varied datasets, and more research on the determinants of commercial land value.

One important finding of this research is the need to reproduce this study or perform similar studies in different cities. Different cities or areas of the world may have different commercial property value determinants, and although access control was not shown as a significant determinant of commercial property values in Des Moines, findings may not be the same elsewhere. Additionally, there should be further study on corridors designed to be access managed. The "access managed" corridors used in this study (during corridor selection) had raised medians, but the driveway spacing on one of the corridors did not meet access spacing guidelines. Therefore, some corridors without medians actually scored higher than corridors with medians on the access control scale.

Similarly, future studies should be tested on corridors with more consistent access management techniques. This research was limited because the "access managed" corridors used for this study had raised medians, but many of these medians had frequent breaks for turning traffic, as well as uncontrolled numbers of driveways. It would be valuable to see how access influences land values on a more consistently access managed roadway. Performing this study on more access managed corridors (or that consistently control the number and locations of driveways, as well as having raised medians and other access control methods) may provide more conclusive results. Also, comparing regression model significance levels among different locations with different characteristics may prove beneficial to study overall trends.

Also, there is a need to further study the impacts of traffic counts and/or congestion on commercial land values. Although increased numbers of traffic driving past commercial land parcels could increase customer exposure to businesses, over-saturated roadways could lead to congestion. Higher levels of congestion could make the roadway less desirable to travel unless people have a destination on the roadway or cannot avoid it in their travel path. If reduced numbers of people use the corridor for through travel, or on the way to another destination, the higher exposure to businesses will not matter; most people using the corridor will already have a destination on the corridor, and increasing business exposure may not increase sales.

Further research on the relationship between access management and commercial property values would be valuable by expanding current literature on the economic impacts of access management, and also as a tool for local access management implementation. If there was evidence that access management was not found to influence property values, transportation officials could have an easier time implementing access control on local roadways. Access management has been proven to reduce crashes due to turning movements, but showing business owners that access control should not negatively impact their land values could be one step to further access management acceptance in the business community.

APPENDIX A – DESCRIPTIVE STATISTICS

This appendix contains maps of land use and land value data outlined in Chapter Five, and is intended for use as a companion to that chapter.

GDP-Adjusted Historic Land Value Trends

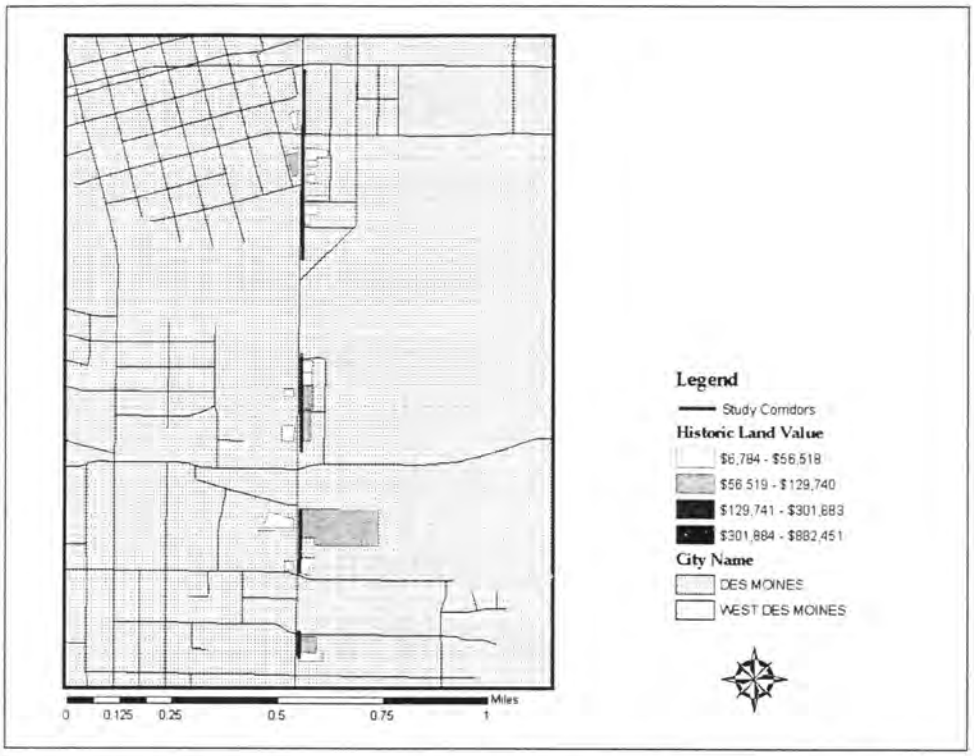

Figure A-1. Historic parcel values: North half, Southeast 14th Street

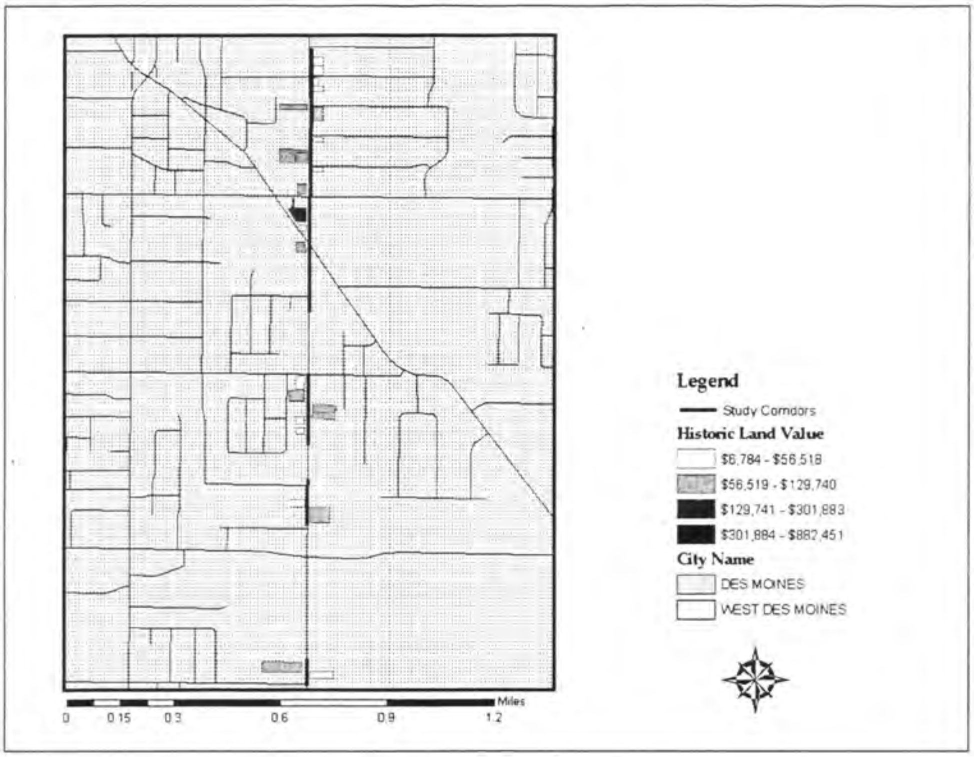

Figure A-2. Historic parcel values: South half, Southeast 14th Street

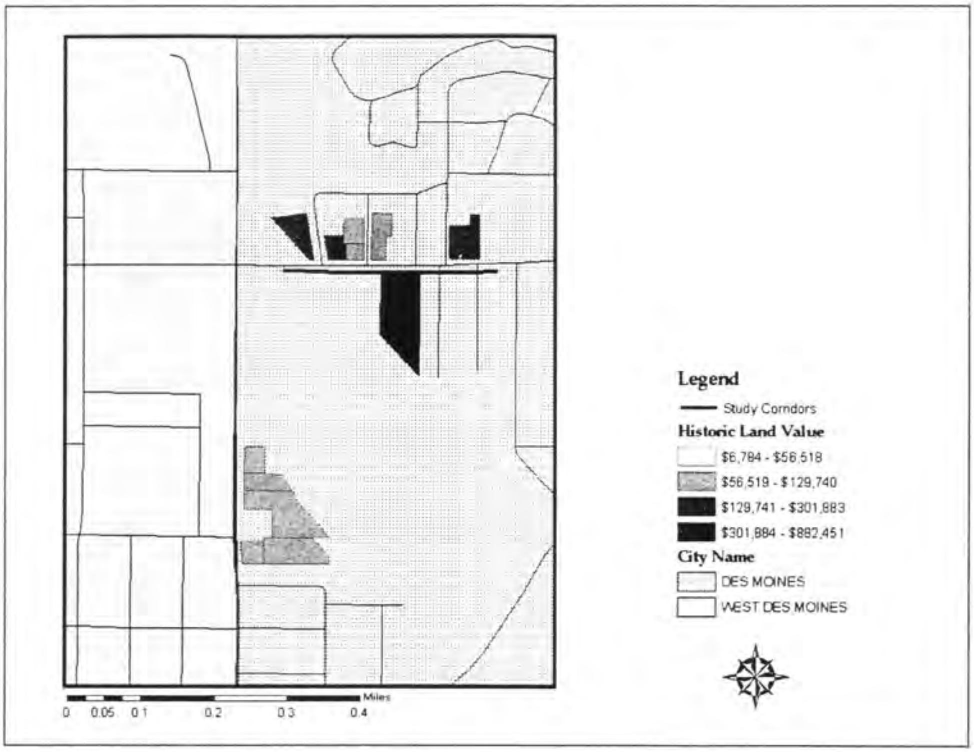

Figure A-3. Historic parcel values: 63rd Street and Grand Avenue

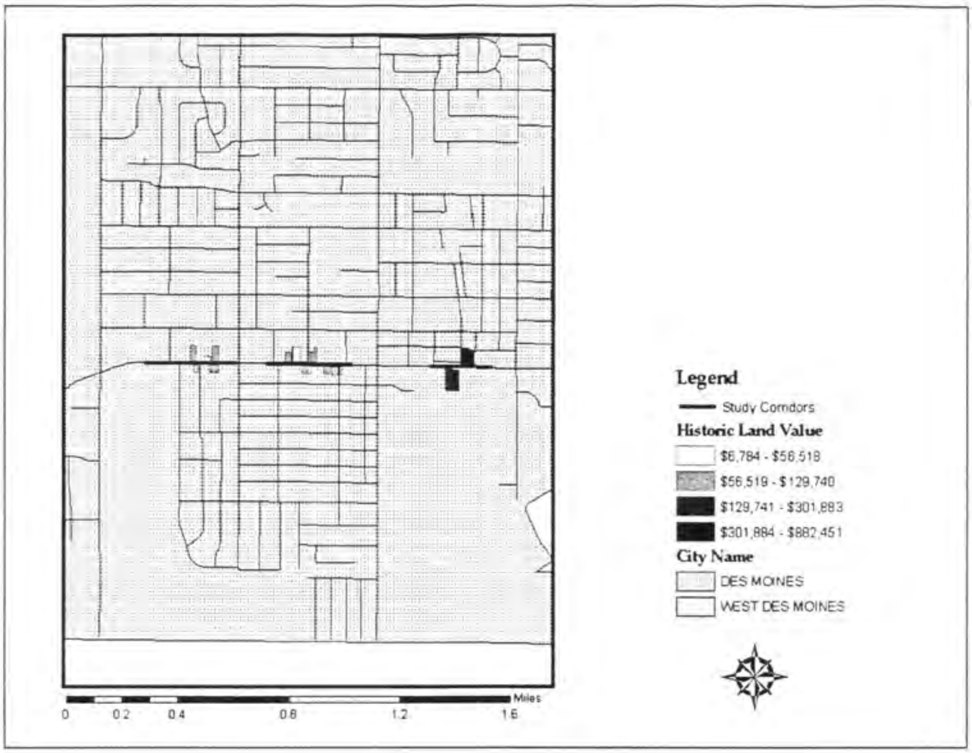

Figure A-4. Historic parcel values: Army Post Road

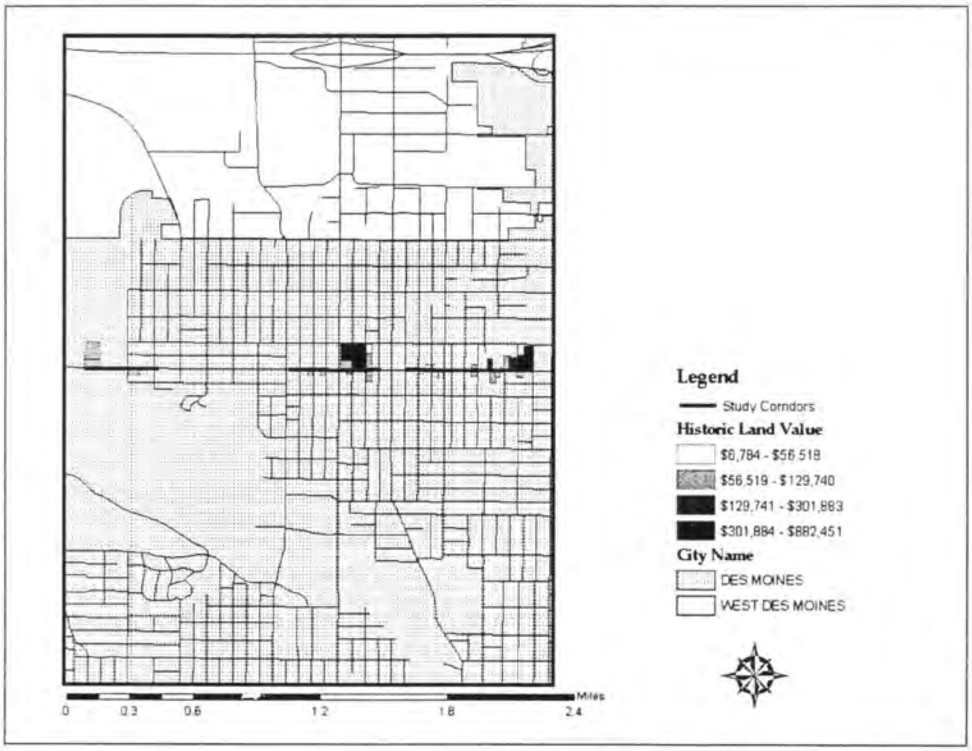

Figure A-5. Historic parcel values: Euclid Avenue

Current Land Value Trends

Figure A-6. Current land parcel values: North half, Southeast 14th Street

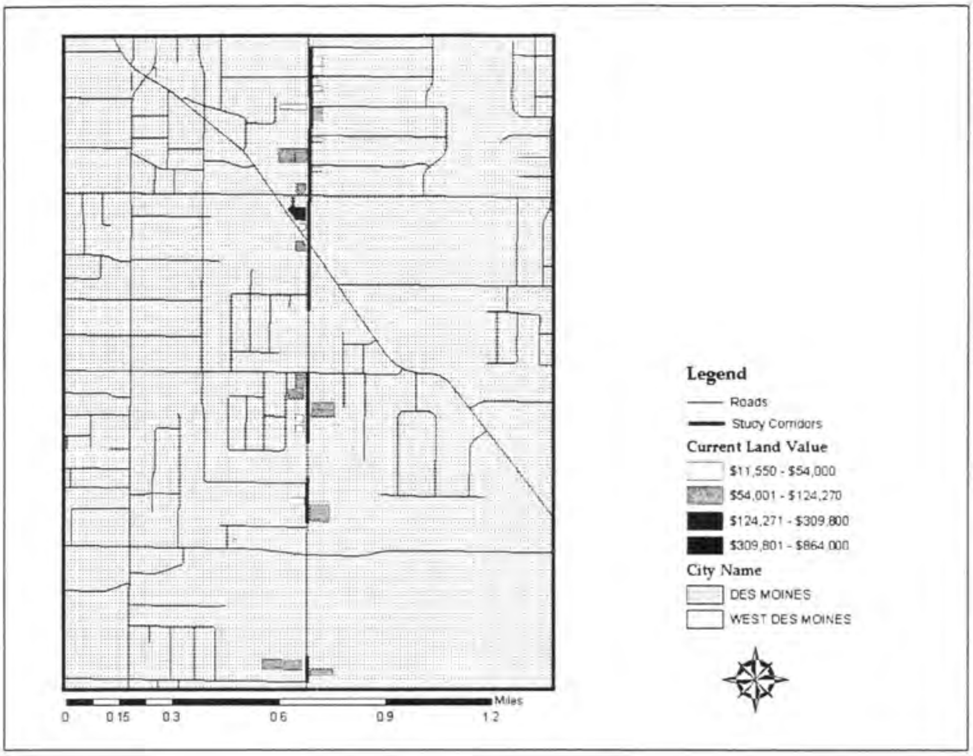

Figure A-7. Current land parcel values: South half, Southeast 14th Street

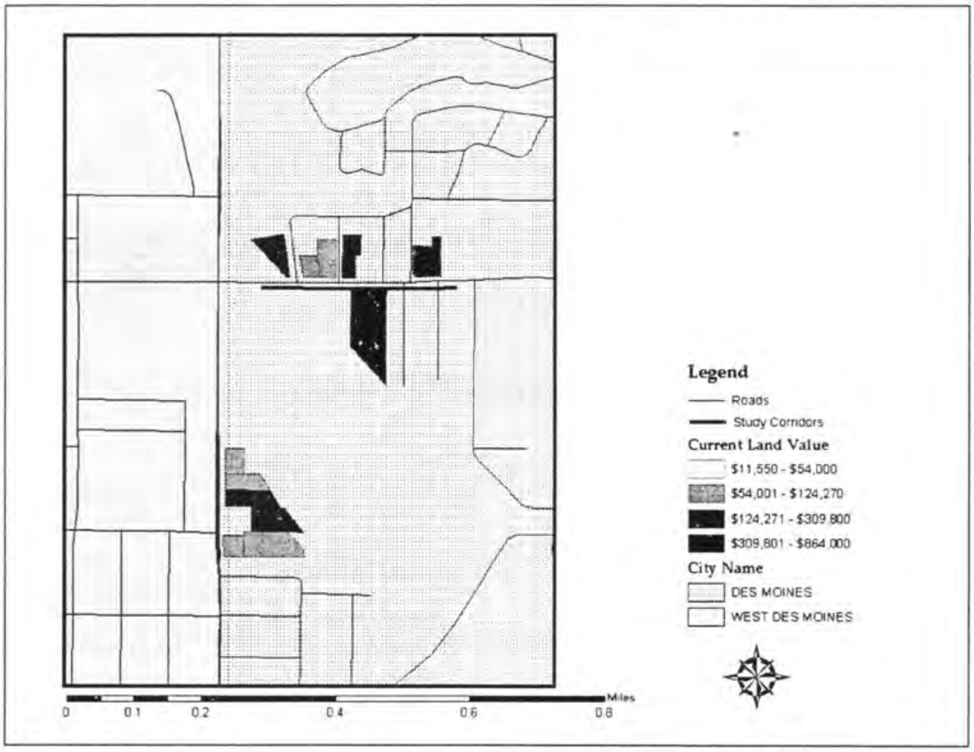

Figure A-8. Current land parcel values: 63rd Street and Grand Avenue

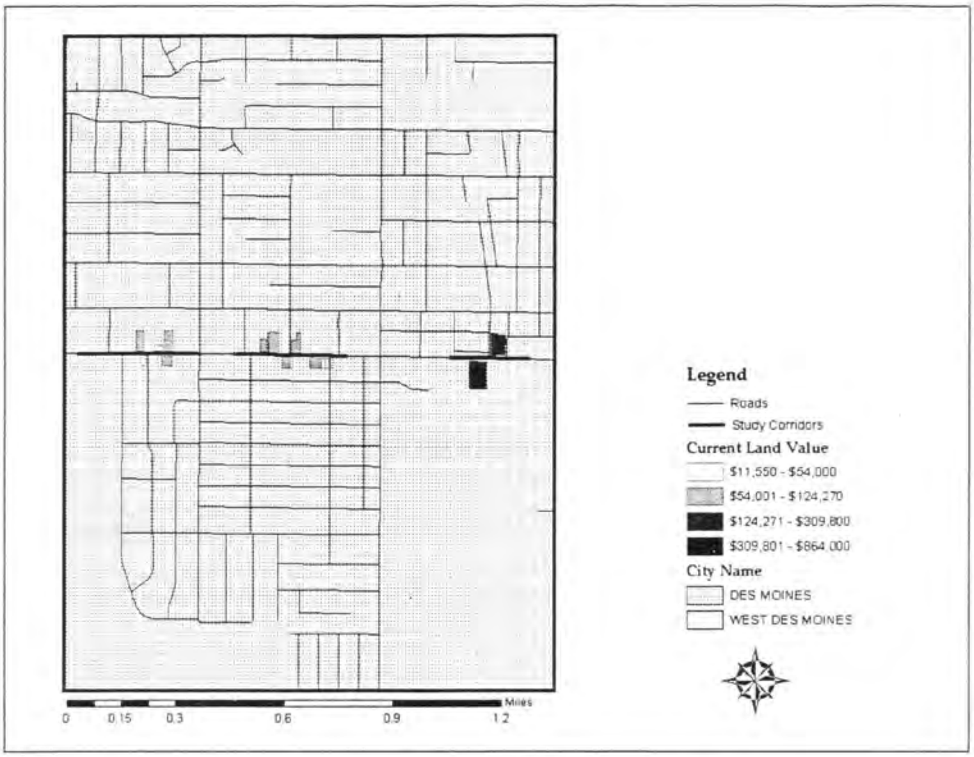

Figure A-9. Current land parcel values: Army Post Road

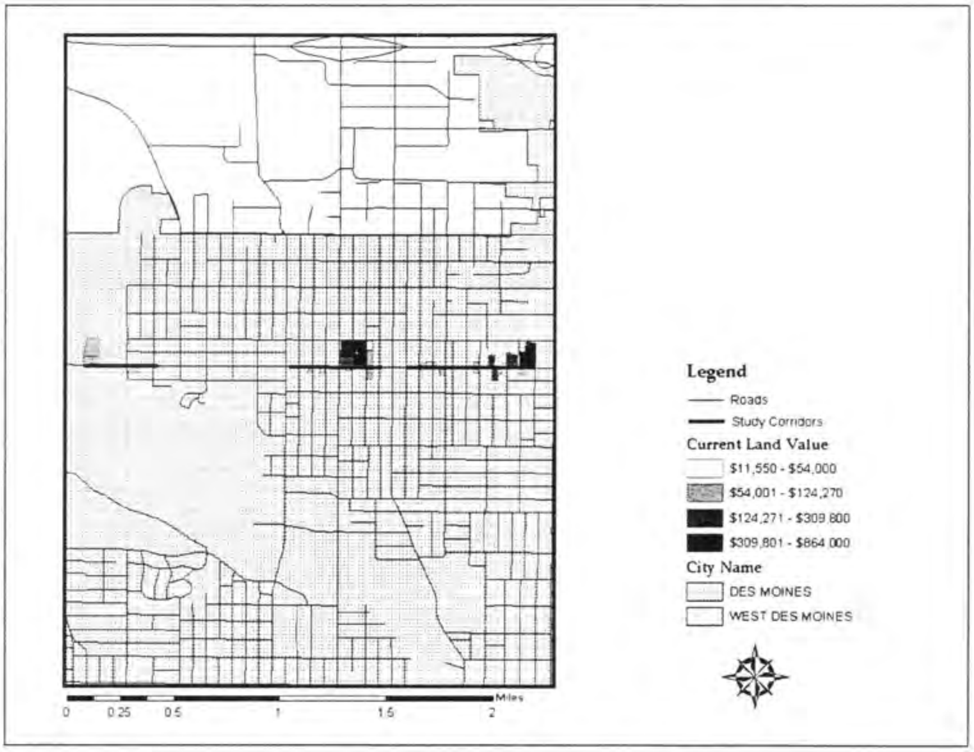

Figure A-10. Current land parcel values: Euclid Avenue

Historic Land Value per Square Foot Trends

Figure A-11. Historic land value per square foot: North half, Southeast 14th Street

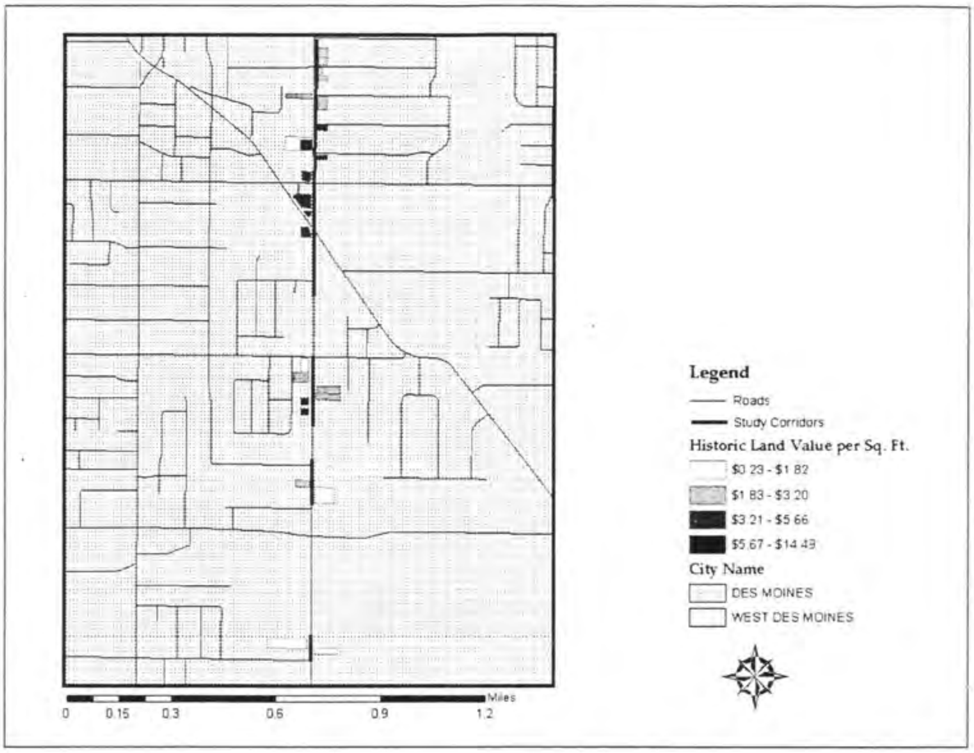

Figure A-12. Historic land value per square foot: South half, Southeast 14th Street

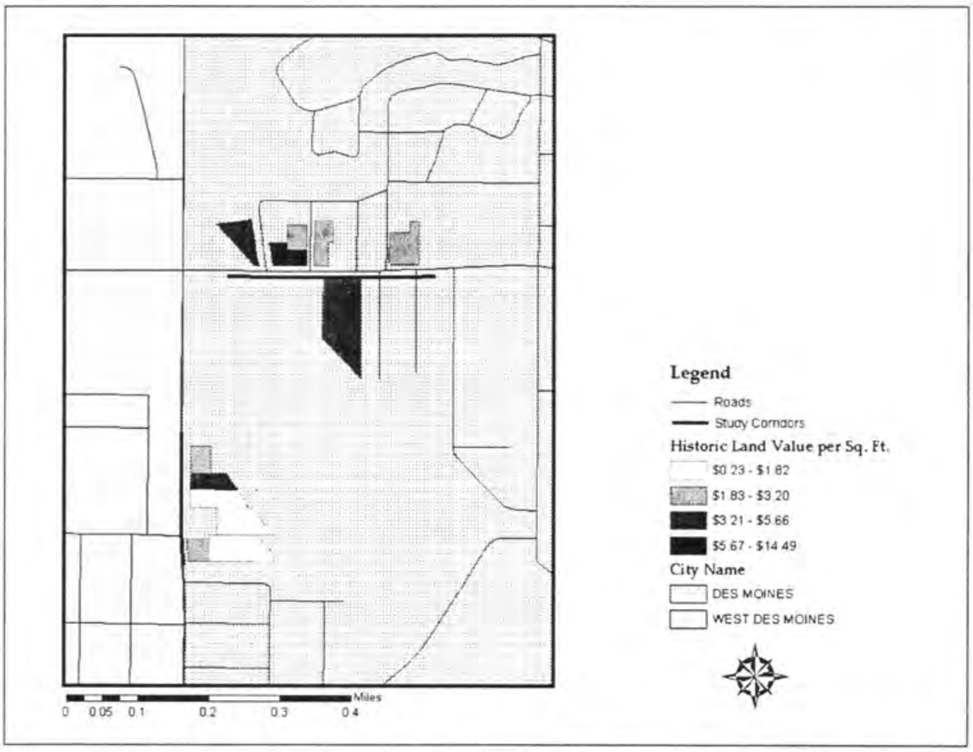

Figure A-13. Historic land value per square foot: 63rd Street and Grand Avenue

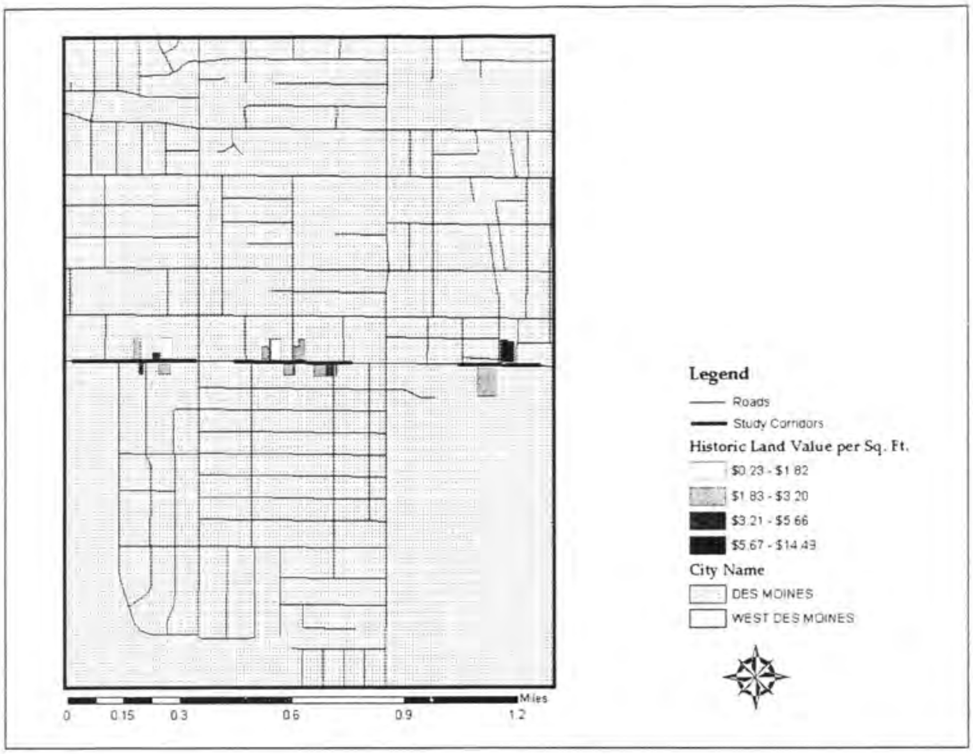

Figure A-14. Historic land value per square foot: Army Post Road

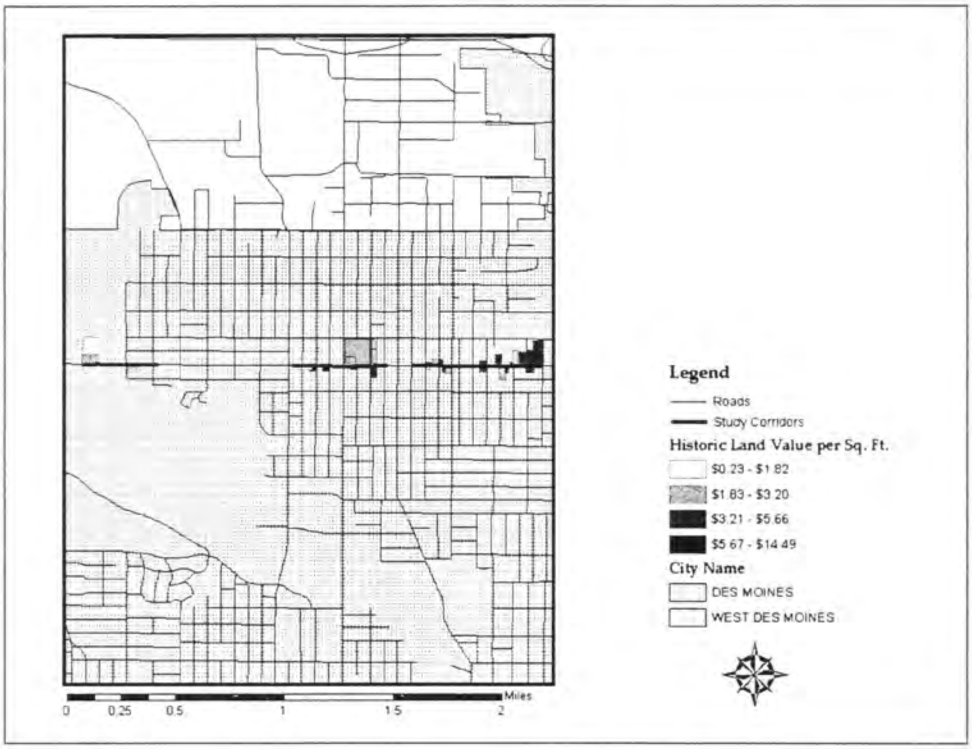

Figure A-15. Historic land value per square foot: Euclid Avenue

Current Land Value per Square Foot Trends

Figure A-16. Current land value per square foot: North half, Southeast 14th Street

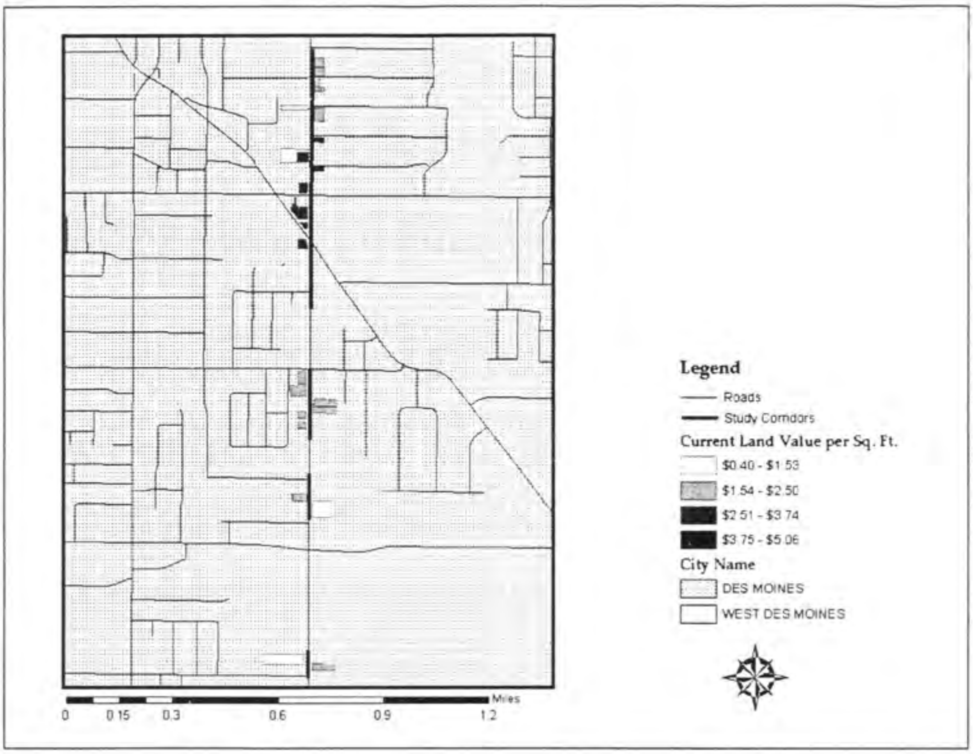

Figure A-17. Current land value per square foot: South half, Southeast 14th Street

Figure A-18. Current land value per square foot: 63rd Street and Grand Avenue

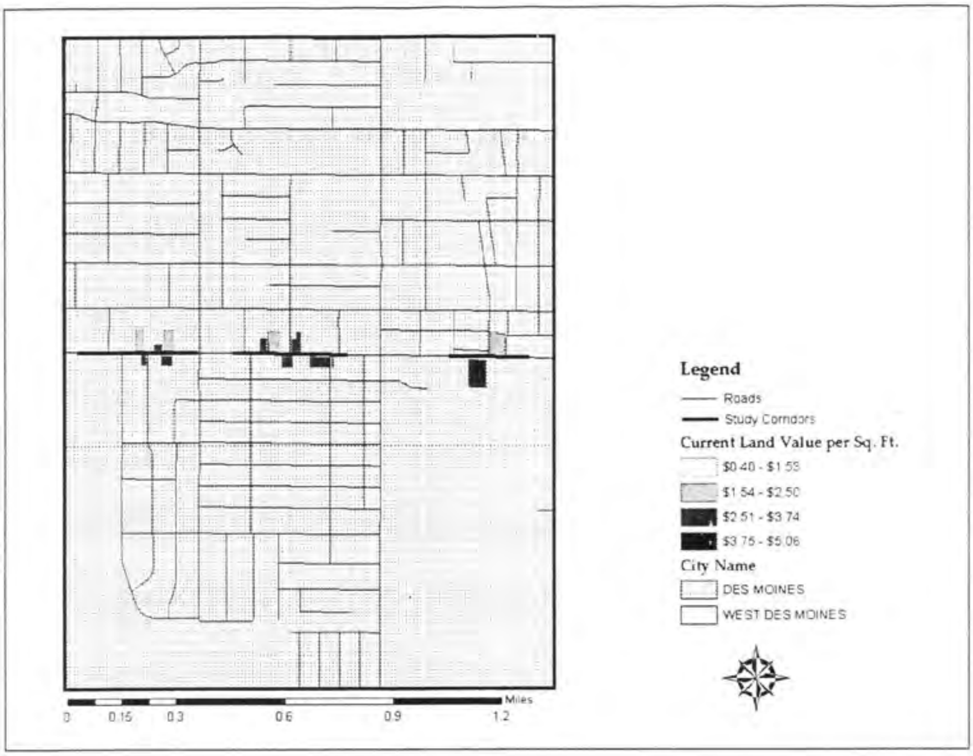

Figure A-19. Current land value per square foot: Army Post Road

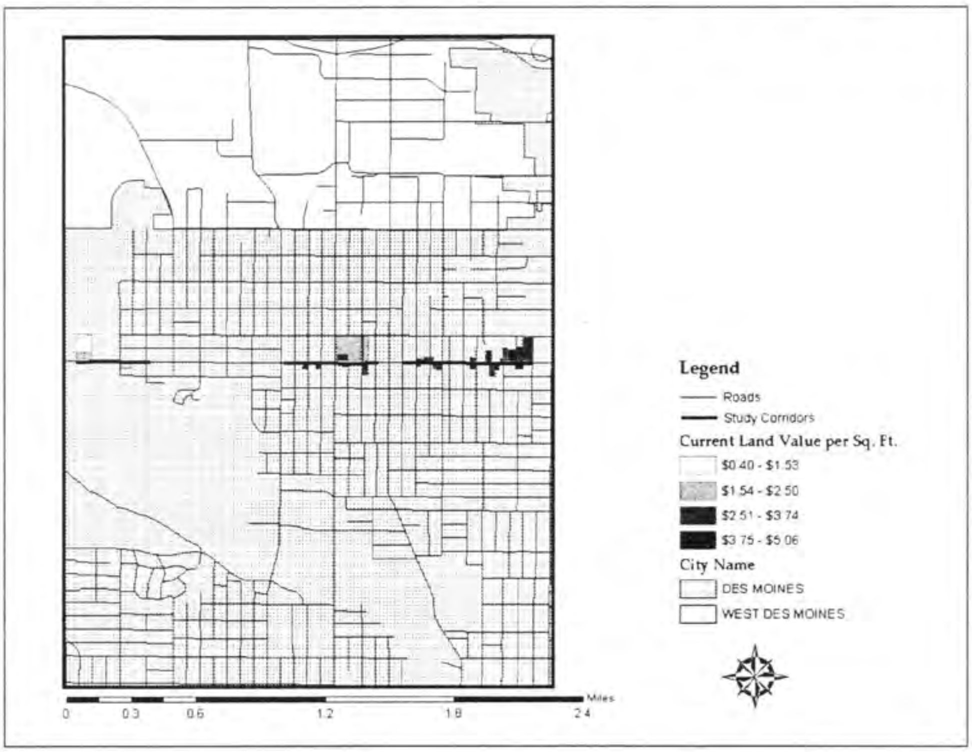

Figure A-20. Current land value per square foot: Euclid Avenue

Land Use Variations

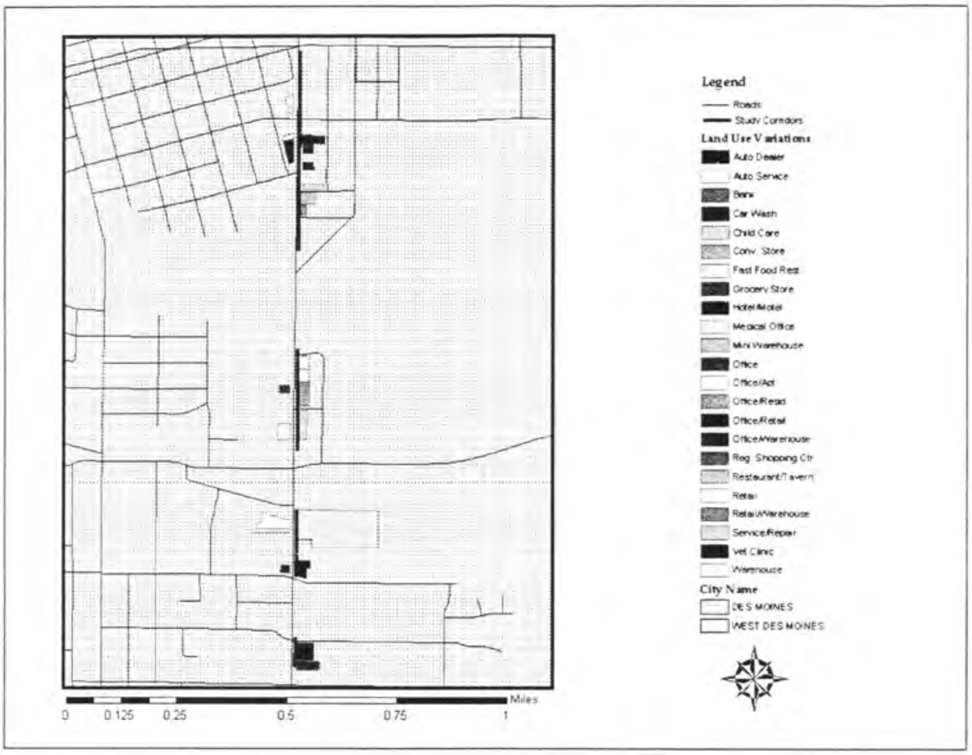

Figure A-21. Land use variations: North half, Southeast 14th Street

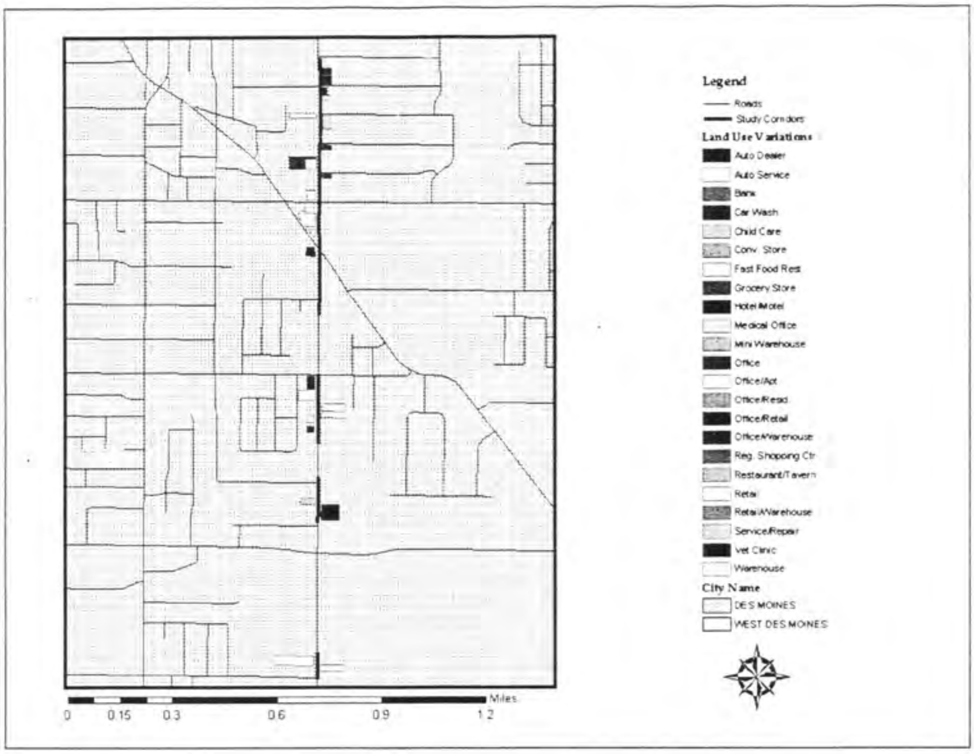

Figure A-22. Land use variations: South half, Southeast 14th Street

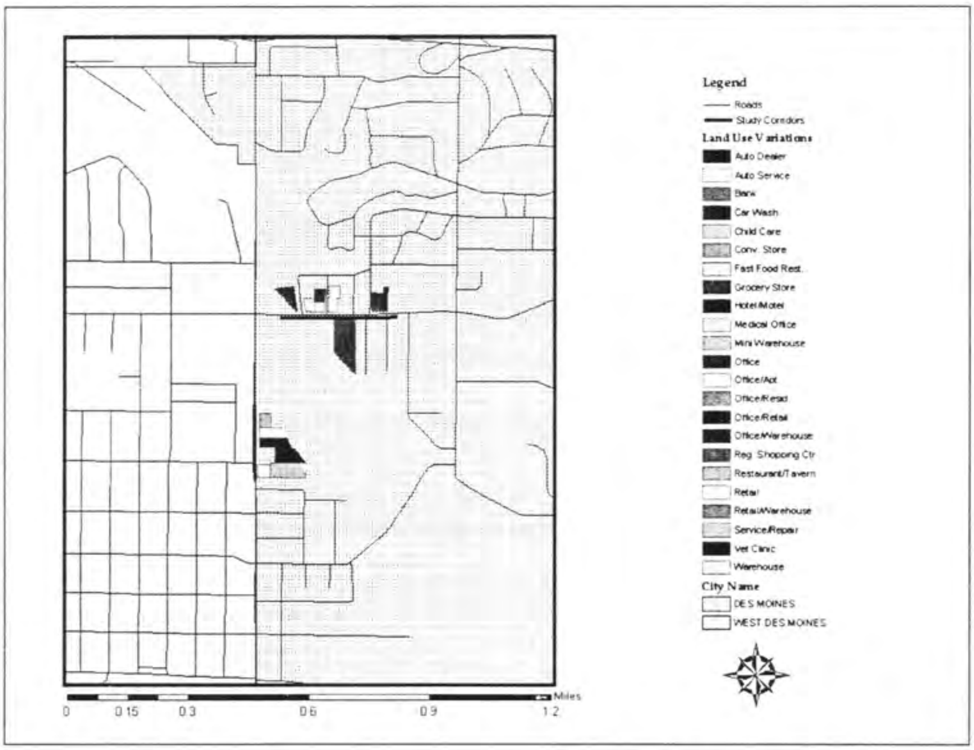

Figure A-23. Land use variations: 63rd Street and Grand Avenue

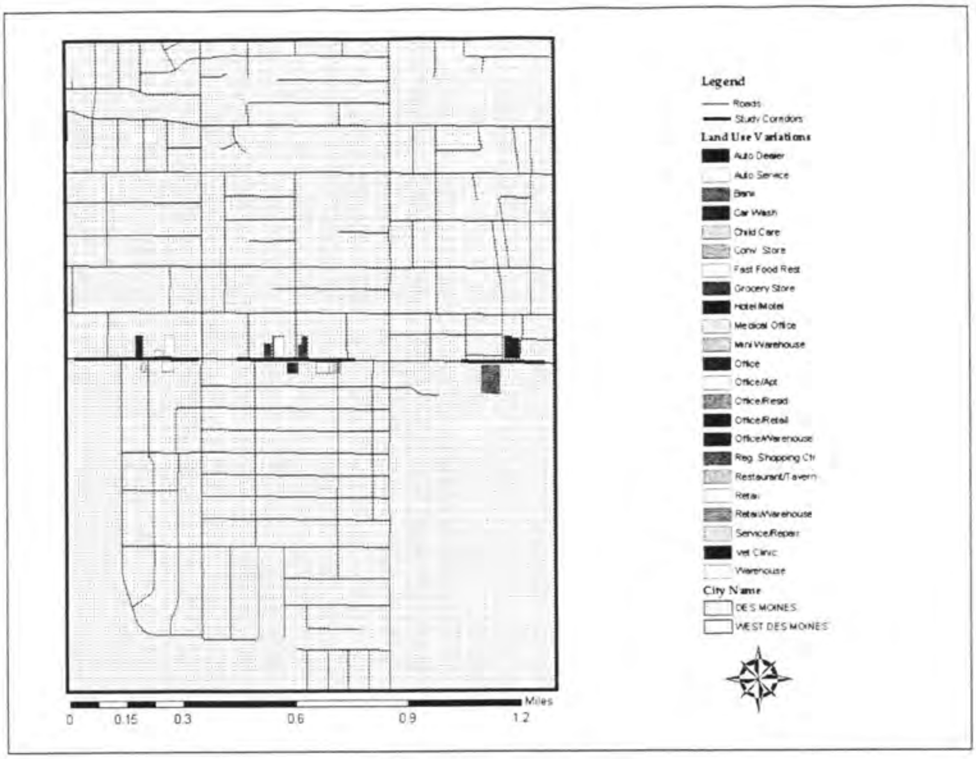

Figure A-24. Land use variations: Army Post Road

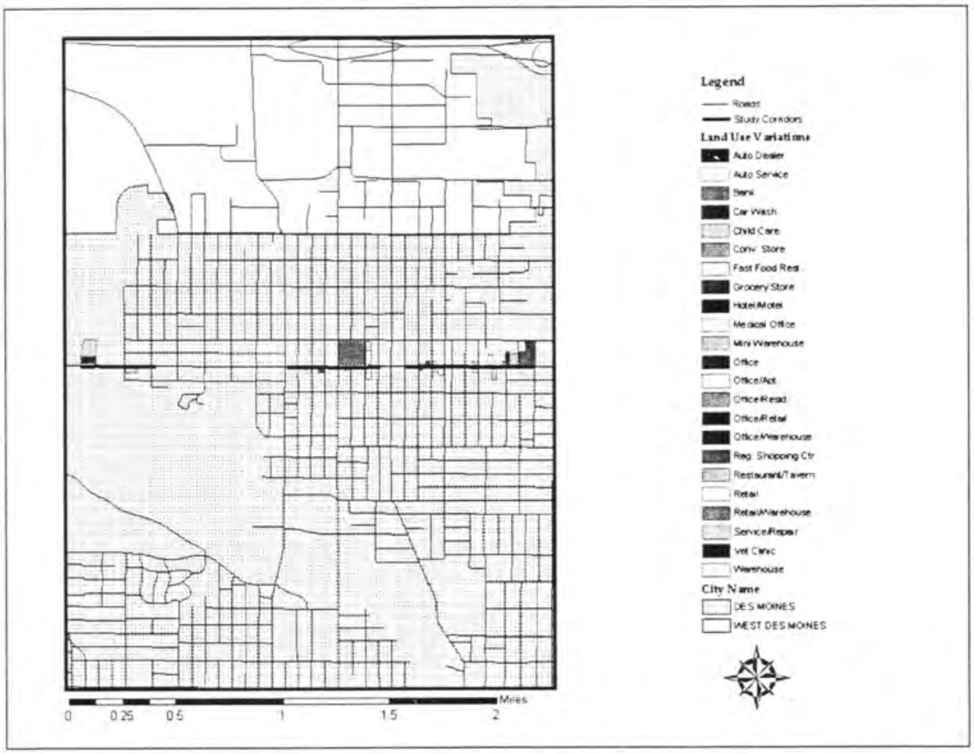

Figure A-25. Land use variations: Euclid Avenue

APPENDIX B – INFERENTIAL STATISTICS

In Chapter Six, the process to create two regression model sets to measure land value differences due to location was outlined. One model set used data from all five Des Moines study corridors (Southeast 14th Street, 63rd Street, Army Post Road, Euclid Avenue, and Grand Avenue) to historic and current commercial land value per square foot. The second model set used data from three northern or eastern Des Moines study corridors (Southeast 14th Street, Army Post Road, and Euclid Avenue) to historic and current commercial land value per square foot.

Regression analysis showed that the model set excluding the western study corridors had regression models that fit the data better than the model set with all five study corridors. Because of this, the regression model set with three study corridors were shown as the final regression model set in Chapter Six. This appendix is meant to serve as a reference to Chapter Six, showing the differences between the two model sets and why the three-corridor model set was chosen.

This appendix shows tables identical to those in Chapter Six, only the tables from the five study corridor regression model set are shown here to show differences between them. These differences have been referenced to this appendix from Chapter Six for comparison ease.

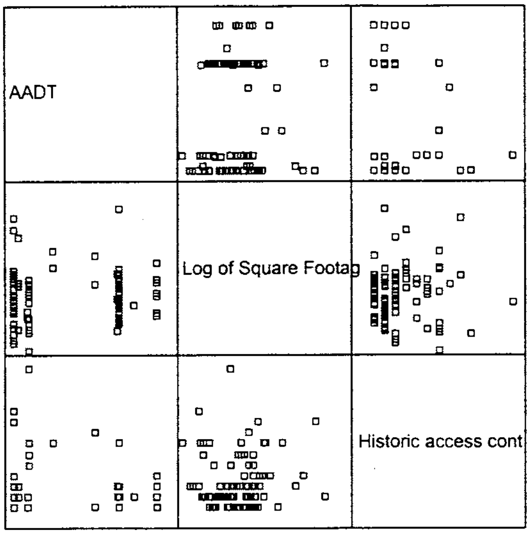

Figure B-1. Scatterplot matrix of historic land value explanatory variables

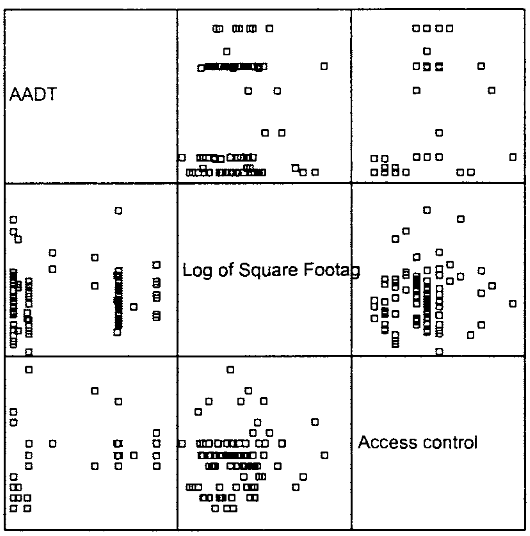

Figure B-2. Scatterplot matrix of historic land value explanatory variables

Table B-1. Multiple correlations: Historic land values

Correlations

		Historic value per square foot	AADT	Log of Square Footage	Historic access control
Pearson Correlation	Historic value per square foot	1.000	-.368	-.285	.113
	AADT	-.368	1.000	.073	-.376
	Log of Square Footage	-.285	.073	1.000	.061
	Historic access control	.113	-.376	.061	1.000
Sig. (1-tailed)	Historic value per square foot	.	.000	.003	.141
	AADT	.000	.	.246	.000
	Log of Square Footage	.003	.246	.	.280
	Historic access control	.141	.000	.280	.
N	Historic value per square foot	92	92	92	92
	AADT	92	92	92	92
	Log of Square Footage	92	92	92	92
	Historic access control	92	92	92	92

Table B-2. Multiple correlations: Current land values

Correlations

		Current value per square foot	AADT	Log of Square Footage	Access control
Pearson Correlation	Current value per square foot	1.000	-.555	-.327	-.378
	AADT	-.555	1.000	.073	.417
	Log of Square Footage	-.327	.073	1.000	.114
	Access control	-.378	.417	.114	1.000
Sig. (1-tailed)	Current value per square foot	.	.000	.001	.000
	AADT	.000	.	.246	.000
	Log of Square Footage	.001	.246	.	.139
	Access control	.000	.000	.139	.
N	Current value per square foot	92	92	92	92
	AADT	92	92	92	92
	Log of Square Footage	92	92	92	92
	Access control	92	92	92	92

Table B-3. Model summary: Historic land values

Model Summary[c]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics: R Square Change	F Change	df1	df2	Sig. F Change
1	.368[a]	.136	.126	1.82338	.136	14.117	1	90	.000
2	.450[b]	.202	.185	1.76128	.067	7.459	1	89	.008

a. Predictors: (Constant), AADT

b. Predictors: (Constant), AADT, Log of Square Footage

c. Dependent Variable: Historic value per square foot

Table B-4. Model summary: Current land values

Model Summary[c]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics: R Square Change	F Change	df1	df2	Sig. F Change
1	.555[a]	.308	.300	.91634	.308	40.038	1	90	.000
2	.625[b]	.391	.377	.86467	.083	12.078	1	89	.001

a. Predictors: (Constant), AADT

b. Predictors: (Constant), AADT, Log of Square Footage

c. Dependent Variable: Current value per square foot

Table B-5. Regression coefficients: Historic land values

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients			95% Confidence Interval for B		Correlations			Collinearity Statistics	
		B	Std. Error	Beta	t	Sig	Lower Bound	Upper Bound	Zero-order	Partial	Part	Tolerance	VIF
1	(Constant)	6.743	1.025		6.579	.000	4 707	8 779					
	AADT	-1.43E-04	.000	-.368	-3.757	000	.000	.000	-.368	-.368	-.368	1.000	1.000
2	(Constant)	12.386	2.291		5.406	.000	7 833	16.938					
	AADT	-1.36E-04	000	-.349	-3.681	.000	000	.000	-.368	-.364	-.348	.995	1.005
	Log of Square Footage	-1.340	.490	-.259	-2.731	.008	-2 314	-.365	-.285	-.278	-.259	995	1.005

a. Dependent Variable: Historic value per square foot

Table B-6. Regression coefficients: Current land values

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients			95% Confidence Interval for B		Correlations			Collinearity Statistics	
		B	Std. Error	Beta	t	Sig	Lower Bound	Upper Bound	Zero-order	Partial	Part	Tolerance	VIF
1	(Constant)	5.758	.515		11.180	.000	4 735	6 782					
	AADT	-1.21E-04	.000	-.555	-6 328	000	000	.000	-.555	-.555	-.555	1 000	1 000
2	(Constant)	9.283	1.125		8.254	.000	7 049	11 518					
	AADT	-1.17E-04	.000	-.534	-6 436	.000	000	.000	-.555	-.564	-.533	.995	1 005
	Log of Square Footage	-.837	.241	-.288	-3 475	.001	-1 315	-.358	-.327	-.346	-.288	995	1 005

a. Dependent Variable: Current value per square foot

Table B-7. Excluded variables: Historic land values

Excluded Variables[c]

Model		Beta In	t	Sig.	Partial Correlation	Collinearity Statistics Tolerance	VIF	Minimum Tolerance
1	Log of Square Footage	-.259[a]	-2.731	.008	-.278	.995	1.005	.995
	Historic access control	-.029[a]	-.274	.784	-.029	.859	1.164	.859
2	Historic access control	-.002[b]	-.024	.981	-.003	.851	1.175	.850

a. Predictors in the Model: (Constant), AADT

b. Predictors in the Model: (Constant), AADT, Log of Square Footage

c. Dependent Variable: Historic value per square foot

Table B-8. Excluded variables: Current land values

Excluded Variables[c]

Model		Beta In	t	Sig.	Partial Correlation	Collinearity Statistics Tolerance	VIF	Minimum Tolerance
1	Log of Square Footage	-.288[a]	-3.475	.001	-.346	.995	1.005	.995
	Access control	-.178[a]	-1.865	.065	-.194	.826	1.211	.826
2	Access control	-.150[b]	-1.651	.102	-.173	.819	1.221	.819

a. Predictors in the Model: (Constant), AADT

b. Predictors in the Model: (Constant), AADT, Log of Square Footage

c. Dependent Variable: Current value per square foot

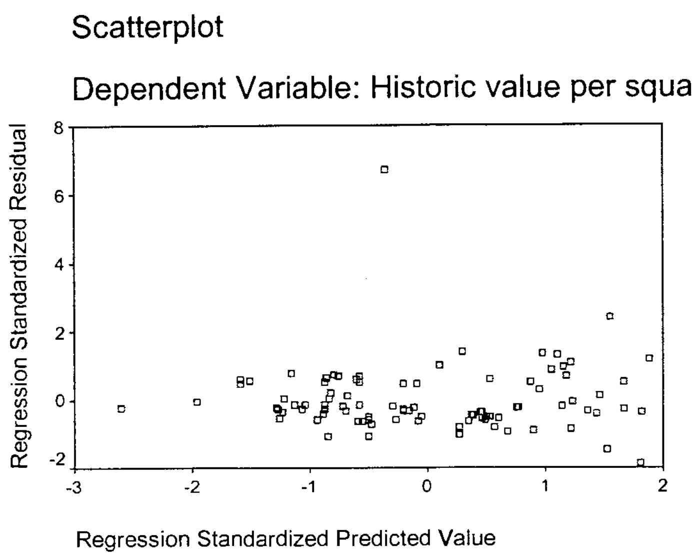

Figure B-3. Residual analysis: Historic land values

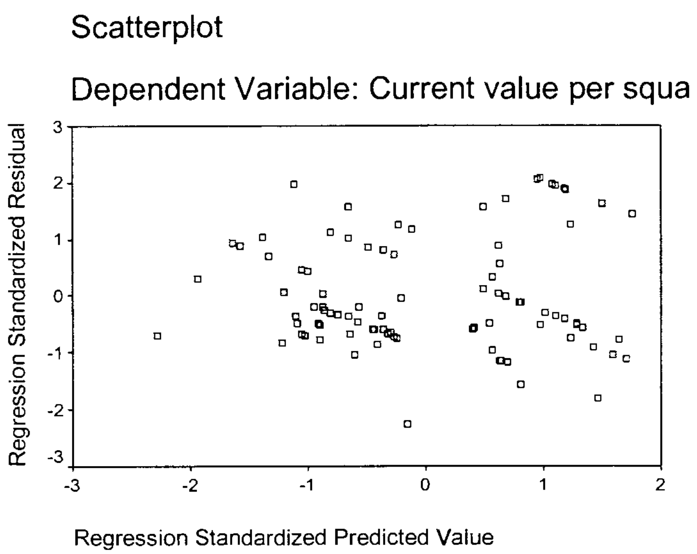

Figure B-4. Residual analysis: Current land values

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