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# The Proximate Principle of Parks and Greenways: An Hedonic Analysis for Cary, North Carolina

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To the Graduate School:

This thesis entitled "The Proximate Principle of Parks and Greenways: An Hedonic Analysis for Cary, North Carolina" and written by Paul D. Stockwell is presented to the Graduate School of Clemson University. I recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of City and Regional Planning.

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# THE PROXIMATE PRINCIPLE OF PARKS AND GREENWAYS:

# AN HEDONIC ANALYSIS

# FOR CARY, NORTH CAROLINA

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A Thesis

Presented to

the Graduate School of

Clemson University

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In Partial Fulfillment

of the Requirements for the Degree

Master of City and Regional Planning

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by

Paul D. Stockwell

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# ABSTRACT

This thesis uses multiple regression analysis in the determination of a hedonic model that explains the contribution to single-family residential parcel values due to identified community amenities for the jurisdiction of Cary, North Carolina. Bond Park, the primary metropolitan park, was determined to have a total predicted capitalization into the observed set of single-family parcels of $312,932,266. Community parks and schools were also found to have predicted total aggregate contributions to proximate properties of $3,123,758 and $7,251,977, respectively, to single-family parcel values. The capitalization of value into proximate parcel values was found to decrease at an increasing rate with distance from Bond Park. The predicted capitalization due to community parks and schools, however, was found to decrease at a decreasing rate with distance from the amenity.

ACKNOWLEDGEMENTS

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# CHAPTER I

# INTRODUCTION

One could make a persuasive argument that the allocation of public monies and resources is the primary function of government as well as the source of conflict between political parties and interest groups. Although this notion may not be absolute, the allocation of public monies and resources is one of, if not the most, important functions of government. When officials make decisions in the allocation of public monies or other general policy initiatives, provision of justification for such decisions will bring credibility to those officials with decision-making capacity.

Whenever public monies are expended for projects, scrutiny will undoubtedly arise from many corners including private developers, non-profit groups, and the general public. In order for such projects to gain acceptance among these parties, tangible benefits must be shown to exude from such provision. In addition, these parties are undoubtedly also interested in the costs of such an investment. Understanding of such benefits and costs can aid policy makers in the decision making process as to what investments do indeed provide benefits for residents and the community as a whole. Many of these benefits at the local level can be observed through residential land values.

For over 150 years there has been an interest in how proximity to parks or other open spaces contribute to the value of residences in the area of the amenity. It is obvious that parks provide many aesthetic as well as recreational benefits for the users of the park. Communities and councils, however, do not always come to realize that the provision of particular amenities such as parks or greenways often prove beneficial not only to the residents of the community but to the financial well-being of the government tax base as well. The positive benefit derived from these amenities has been coined the proximate principle. Although the city government can derive financial benefits from such investments, the primary recipients of these benefits are the owners of proximate residences who see increases in their housing value. This thesis will attempt to address questions arising from the expenditure of public monies for community amenities, specifically parks and greenways.

## Research Questions and Hypothesis

What are the benefits that derive to residents and the community as a whole from provision of public amenities? How much do the values of proximate properties increase as a result to amenities such as parks and greenways? What is the spatially allocated aggregate benefit of the increase in land values due to these public investments? Are there other immeasurable benefits that should be taken into account in making public investment decisions?

The aforementioned questions lead to one overarching hypothesis as the focus of this thesis, "There will be a significant effect on residential land values due to proximate community amenities." Thus the final research question asks: Do the monetary benefits derived from amenities such as parks and greenways alone justify the expenditure of public monies for such projects?

## Objectives

The research questions will be explored through the development of an hedonic pricing model. The model will use multivariable regression to test the statistical significance of a set of independent variables that are hypothesized to have an effect on the value of properties. Factors influencing property values that are included in the hedonic model include structural attributes, neighborhood attributes, community attributes, and locational and environmental attributes.

More importantly, however, the coefficients of the model help determine a quantifiable benefit that each variable contributes to the value of residential parcels. The contributions of the proximate values due to the public amenities are then aggregated to find a total derived benefit for the analysis area.

## Overview of Thesis

Chapter I provided an introduction to the thesis including some research questions and objectives for the study. Chapter II presents a review of literature related to the historic background of the proximate principle of parks and open space. Following this historical overview a review of the current issues and studies with a focus on those that use hedonic pricing models to determine the valuation of amenities is presented. Chapter III presents the analysis methodology and the theoretical model used in the study. Chapter IV discusses the data used and the analysis area. Chapter V provides the results of the empirical analysis. Finally, Chapter VI provides the conclusions and implications for the analysis as well as opportunities for expansions and further study.

# CHAPTER II

# LITERATURE REVIEW

The concept of parks and open spaces contributing to residential land values has been in existence for at least 150 years (Crompton 2004). This review will begin exploring the historical background of the proximate principle. Hedonic models and methods are then reviewed focusing on hedonic pricing studies of environmental amenities such as parks and greenways. Finally, various current fiscal impact methods are explored.

## Historical Background

### Early History and Studies

The proximate principle emerged in England where development projects began to establish parks as a benefit to local landowners. The first of these projects was Regent's Park which was established in 1811 initially as a private real estate venture, but eventually was opened to the public (Crompton 2004). The project including the surrounding residences proved to be successful as a real estate venture while it was also found that the value of the proximate housing came in large part due to the amenity value of Regent's Park (Chadwick 1966).

Another project that brought to light the public benefits of parks came in the Prince's Park project (Crompton 2004). The park was constructed in 1842 and 1843 in Liverpool. Again, this project demonstrated how the construction of the park was used as a means to raise the selling price of surrounding residential properties and therefore the profit for private land developers (Ibid).

Birkenhead Park further illustrated the principle that the increased value created by the existence of a park could be captured to finance the expense of the park itself (Crompton 2004). "Birkenhead Park was a self-financing venture employing the simple device of surrounding the park with plots for single houses and terraces, and selling them at an enhanced value because of their relationship with the park. The profit from this paid for the park (Smith 1983)." In addition, the profit generated from the sale of these plots would have also provided enough revenue to pay for the maintenance and future development in the park as well (Crompton 2004).

The agent by whom the proximate principle traversed the Atlantic to the United States was by none other than Frederick Law Olmstead (Ibid). Olmstead visited Birkenhead Park and impressed by what he saw brought the ideas back to the United States in the implementation of New York City's Central Park. Olmstead used his knowledge gained from Birkenhead to convince key decision-makers of how the park would ultimately be self-financed (Ibid). In 1856, the New York City Comptroller even wrote, "The increase in taxes by reason of the enhancement of values attributable to the park would afford more than sufficient means for the interest incurred for its purchase and improvement without any increase in the general rate of taxation (Metropolitan Conference of City and State Park Authorities 1926).

Olmstead also documented the earliest relationship between public parks and real estate values (Fox 1990). According to Olmstead's documentation, Central Park began generating revenue when it was only half complete (Ibid). Olmstead argued that the properties in the wards surrounding Central Park in 1873 appraised for over four times the value than the appraised values of properties elsewhere in the city. This generated an increase in property tax revenues exceeding the cost of land and improvements in the amount of 4.4 million dollars over a twenty year period (Ibid).

Olmstead and his partner Calvert Vaux also designed and built Prospect Park in Brooklyn (Crompton 2004). Stimulation of real estate investment in the surrounding area was one of the primary purposes of the plan (Lewis 1923). They planned to use the Birkenhead model to recoup the park's costs (Chadwick 1966). The proximate principle came to be understood and widely used as a justification for public park projects.

Examples of utilization of the proximate principle in this period range far and wide across the country. Some of these positive increases to residential values were recorded by the Boston Park Commission in 1874 (Wilson 1989) and 1900 (Board of Parks Exposition Managers 1900). In addition, in Madison, Wisconsin a citizens committee concluded that parks have increased the value of proximate properties from ten to fifteen percent and taxable revenues are meeting expenses. (Nolen 1913). Similar results were observed in Hartford and Kansas City as well (Ibid).

In 1924, a professor of landscape architecture at Harvard University observed in his studies that "After the park is established the land abutting it is increased in value, which value comes back to the city in increased taxes: and in addition to this localized increase in values on account of the visible and obvious advantages which accrue to the abutting property, there will also be a general rise in value because the park has raised the tone of the city as a whole (Weir 1928)."

price modeling, some of these shortcomings could be accounted for. Although these hedonic pricing methods became popular, some studies still utilized other methods successfully to observe the proximate impact of parks such as control group methods.

## Later History and Studies

The early studies acted as the foundation for further studies later in the century. One of the first sophisticated analytical approaches was undertaken in 1939 (Ibid). Herrick asserted that his study, "made it possible to compute the probable future average real estate and land values for the city of Washington with any assumed acreage of parks and density of population, and so to determine whether the probable increase in values justified the expenditure necessary to procure any park lands (Herrick 1939)." This was accomplished using multiple regression analysis to isolate other contributing factors such as park acreage and population density.

A few recent studies rather than using statistical techniques opted to utilize a more traditional scientific approach for observation. This approach employs experimental and control areas to attempt to account for the variation of multiple factors. A 1961 study conducted by the Caro Foundation of two parks in Oakland found a positive impact due to the two parks (Wonder 1965). Assessed values were used to compare properties near the parks to those of a control group with similar characteristics (Ibid).

Another study similar to that of the Caro study was undertaken in 2003 on five parks in New York City (Ernest 2003). The study rather than using assessed valuations compared property sales transactions in Park Impact Areas (PIA's), located 1 to 2 blocks immediately adjacent to the park, to those in Control Areas (CA's), the next 3 to 4 blocks beyond the PIA's (Ibid). The study concluded that, "Single family turnover rate was generally lower near well improved parks as compared to adjoining ones. Quality parks serve to stabilize local communities and are a catalyst for the redevelopment of adjacent real estate (Ibid)."

Although studies waned from the latter 1930s onward, widespread studies began reemerging in the 1970s and '80s when more sophisticated analytical tools became more widespread and usable (Crompton 2004). The decline in studies largely was due to the realization that the earlier studies did not take into account other factors that could influence the value of property over time. Among these factors included structural attributes, neighborhood attributes, community attributes, locational attributes, environmental attributes, and time-related attributes (Ibid). Analytical tools such as GIS and statistical application software made studies which took more of these attributes into account more feasible to undertake.

Most recent studies have largely utilized the approach first presented by Herrick in 1939. With the advent of GIS and statistical computing applications, analysts have been able to undertake computations of large-scale datasets with relative ease compared to before the existence of such technology. This approach using multiple regression analysis to identify and isolate the contribution to property value among various factors has come to be known as the hedonic pricing method.

A 1972 analysis of seven neighborhoods in Philadelphia indicated a positive impact on properties surrounding three parks, three schools, and a school-park combination (Lyon 1972). In addition, the notion of a "net effects" curve was also tested indicating that the highest attained property values proximate to a junior high school with an athletic field actually occurred 600 to 800 feet from the site (Ibid). This brings credence to the idea that heavily traversed public facilities while having a positive impact on neighboring properties, being far enough away to diminish noise and light pollution will attribute even greater incremental values to properties.

A 1974 study of Pennypack Park in Philadelphia indicated that an increase in property values of nearly $3.4 million was attributable to the park (Hammer 1974). The authors used regression analysis here as well indicating that existence of the park accounted for 33 percent of land value of properties 40 feet from the park (Ibid). The effect of greenbelts on properties was also explored in areas of Boulder, Colorado (Correll 1978). This study found that properties adjacent to the greenbelt were 32 percent greater value than those 3,200 feet away (Ibid). Variables used in the regression analysis for the Boulder study included the following: walking distance in feet to greenbelt, age of each house, number of rooms in each house, lot size, distance to city center, and distance to nearest major shopping center (Ibid).

In addition to numerous studies of parks in general there have also been some studies trying to determine the impact of various park design features and use qualities on neighboring properties. A study of parks in Spokane, Washington indicates a proximate property value continuum along active and passive recreation areas (Sainsbury 1964). The more active in use a park's recreation area is, the less it contributes to incremental increases in the values of proximate properties.

A 1973 study indicated the varying effects of different types of open space on property values. The types of open space used in the study included: public open space with recreational facilities, public open space without recreational facilities, private open space, and institutional open space (Coughlin 1973). The study found that public open space with facilities was important to rental blocks but not homeowner blocks, open space with no facilities was important to both homeowner and rental blocks, while private and institutional open space was significant only for homeowner blocks (Ibid). Therefore, while type of facility is important in determining incremental values to neighboring properties other neighborhood characteristics can aid in identifying what facilities would ultimately be most beneficial for the existing neighborhood.

Many studies of parks have been undertaken in the past thirty years. Most of the studies show a positive impact on surrounding properties. Communities around the country have begun to undertake such studies themselves as justification for their programs. Generally, the effect of parks in non-urban settings, however, has had less of an effect due to the already prevalent existence of open space in rural areas (Crompton 2004).

This history of the proximate principal informs of the emergence and resurgence of the principal in empirical findings and studies and the positive conclusions attributable to the existence of parks. Many of these studies have laid the foundation for study of current cases and analyses of many differing contributing factors to the value of property. Some of these attribute studies will be explored further with a focus on greenways and open space as well as the techniques used in these hedonic pricing studies.

# Hedonic Pricing Models and Methods

The prevalence of hedonic pricing emerged as technological capabilities such as statistical computing programs in addition to Geographic Information Systems enabled researchers to undertake the modeling process much more efficiently. A review of some of the current research as well as the methods employed by them will aid in understanding the nature of hedonic pricing studies. First, a brief overview of the various types of studies undertaken will be explored. A closer look at the methods undertaken in studies pertaining to environmental amenities, open space, and greenways will give a greater understanding of hedonic pricing as a research tool. In addition, the role of GIS in preparing many of these studies will be explored.

## Diversity of Hedonic Pricing Studies

Hedonic pricing studies have been used to explore the significance of many topics pertaining to property valuation. These models have ranged from the effect of water (Leggett 2000) and air quality (Hanson 2000) on property values to the determination of the effect of zoning on residential property values (Jud 1980). Other studies have estimated the value of environmental amenities such as having lakefront property (Colwell 2005) or landscaped lots (Mukherjee 1992). The significance of housing being located at the urban-rural fringe in effecting value has also been explored using hedonic pricing methods (Fakruddin 2004 and Shonkwiler 1986). Some more interesting studies have included research pertaining to the effect on property value of disamenities including hog operations (Palmquist 1997), an earthquake, (Beron 1997), airport noise (Uyeno 1993). As can be observed hedonic price models cover a wide array of topics, however a closer look at the methods used in environmental amenities, open space and greenway models is warranted.

Environmental Amenities and Open Space

Several studies provide a good foundation for how to isolate the effect of the variables of interest. Among these are studies by Cheshire (1995), Taylor (2000), Irwin (2002), and Geoghegan (2001). These studies focus on the effects of open space and environmental amenities on property values (or rents in the case of Taylor).

Cheshire and Sheppard in their study focused their attention on providing locational characteristics into their model (1995). They assert that locational attributes and the parcel area are necessary in the determination of a land rent surface. Such a locational determination could be ascertained using a variable such as distance from town center. Through the use of this distance variable in conjunction with a direction variable, a land rent surface was created. Other variables taken into account in the model included bedrooms, water closets, terrace, off street parking, garage, central heat, floors, plot width, square footage, area of land associated with structure, school districts, street quality, business route, blue collar neighborhood, ethnicity, altitude, proximity to industrial land, new construction, accessible open space, and inaccessible open space. These variables indicate the care to include structural, neighborhood, locational, and amenity attributes in the model to account for the various factors affecting the price of land.

Taylor and Smith (2000) explored how environmental amenities can act as a mechanism by which firms including developers, real-estate agents, hotel industry, etc. can exert market power due to a type of product-differentiation. They assert that the existence of environmental amenities such as beaches or proximity to large unique parks create a market that can not easily be replaced by substitute goods. Firms therefore take advantage of the inelastic nature of these goods to raise prices and achieve greater profits than could be achieved in a competitive market with substitute goods. Estimates were taken from hedonic price models using house rents as the dependent variable. Also included in this model as independent variables were number of bedrooms, baths, central air, dishwasher, washer, microwave, television, phone, carpeting, observation deck, deck, walkway, fireplace, jacuzzi, screened porch, single house, number of stories, ocean view, ocean front, ocean side, road-side, located in northern towns of study area. As can be observed from the variables provided here the rental market highly depends upon the structural attributes and features of the rental property while location and environmental amenities also exerted significant influence.

Irwin's study found that permanent open space had a premium compared to agricultural or forested land that could be developed later (2002). Irwin utilized variables in the model designed to capture the specific spillover effects of differing types neighboring development to the value of properties. Included in these variables were the proportions of neighboring lands that were specific types of land uses such as low density, medium and high density residential land, as well as commercial and industrial land uses. In addition, locational variables were also included such as distances to Washington and Baltimore as well as neighborhood demographic attributes such as median household income, population density, and percentage of neighborhood population that was African American. Of course structural characteristics such as dwelling unit grade (quality), baths, age of house, and lot size among others were included as variables in the model. Here again we find variables spanning structural, locational, and neighborhood characteristics.

Geoghegan (2001) identified a premium for "permanent" open space in Howard County, Maryland compared to open space that was "developable." In her research dummy variables were used to identify the quality of the house: fair, average, good, very good. In addition the year built, lot size, square feet in house, and the number of stories for each house was also included. Distance variables were also included for DC, Baltimore, and the nearest town as well as neighborhood characteristics such as percent in block group with Bachelor's, population density, and median income. Variables for "developable" and "permanent" open space were included in the form of the percent of land within a 1,600 meter buffer of properties. Here as in other studies, some variables attempted to account for variation in property value due to structural, neighborhood, locational, and environmental attributes. She found that "permanent" open space contributed over three times more value to properties than open space classified as "developable".

Greenways

The literature relating to greenways specifically is far sparser than that pertaining to parks and open space in general. Much of the research pertaining to greenway trails used surveys to determine residents' perception of effect on properties' land values. These methods often do not reflect the actual effect of properties' value in the market due to these amenities. Therefore more studies using methods such as hedonic pricing could provide more convincing evidence of the actual proximate impact that these greenways have on the market value of properties.

A survey of residents of households located near greenways in Cary, North Carolina questioned residents on their perceptions regarding the greenways. The survey yielded a response rate of 75% (Crompton 2004). This survey indicated that 55% of respondents believed that the greenways contributed to an enhanced resale value of their homes (Ibid). While only 3% perceived the greenway to have a negative effect on property values 42% believed it to have no effect (Ibid).

A study undertaken in 1999 of the Indianapolis Greenways System found a premium of 14% on the average property within a half-mile zone of the Monan Trail, a primary regional recreation artery (Ibid). This study used sales transactions of residential property as the dependent variable in an hedonic price model. A second model was undertaken for secondary trails which were corridors of the larger Monan Trail greenway (Ibid). From these models, one can conclude the differential property value impacts due to the varying quality and expanse of the greenways. In addition, use of sales transaction information acts as a reference of real market transfers and real market valuation of existing properties as compared to perceived valuations of residents in surveys.

GIS and Property Valuation

Geographic Information Systems have greatly enhanced the efficiency and capabilities by which spatial analysis and representation can occur. In order to even acquire data on many of the variables used in the hedonic pricing model GIS must be used. The capability of providing a database with large amounts of spatial information is useful to the researcher curious of the effects that location and spatial characteristics contribute to market transactions. Thus the use of GIS to obtain information in property valuation and assessment has become commonplace over the past ten years.

Geographic Information Systems can be used in environmental economics in the controlling of spatial dependence in models that could previously not be controlled (Bateman 2002). Such features of spatial dependence may include proximity to features or locations and characteristics of neighboring uses. In addition, GIS could also be used to include visibility and views in hedonic property valuation models (Paterson 2002).

GIS aids in identifying and storing structural, neighborhood, accessibility, and environmental variables (Lake 1999). Using GIS, models could also be used to create spatial representation of areas according to visual character, development opportunities, or other suitability measures (Ibid). These evaluations could then be included in hedonic pricing models by incorporating the resulting categories by the use of dummy variables as a means to find significance and magnitude to property value contribution.

GIS can be extremely useful in commercial and retail planning as well in determining areas with greater sales and market potential (Thrall 1998). This capability will inevitably aid in further studies of hedonic pricing studies of retail and other commercial locations due to their spatial characteristics. In all cases, GIS enables a timelier and more efficient evaluation process as well as adding processes to studies that previously could not be achieved.

CHAPTER III

# ANALYSIS METHODOLOGY AND THEORETICAL MODEL

The methodology for carrying out this research project consisted of gathering existing data, preparation of data for analysis using GIS and other database tools, analysis of data using hedonic price modeling, interpretation of model results, and using the results from the model to calculate net benefits of amenities to the analysis area. Finally conclusions and perspectives of the results can be obtained. Figure 1 shows the process by which analysis and determination of the benefit of analyzed amenities will be achieved.

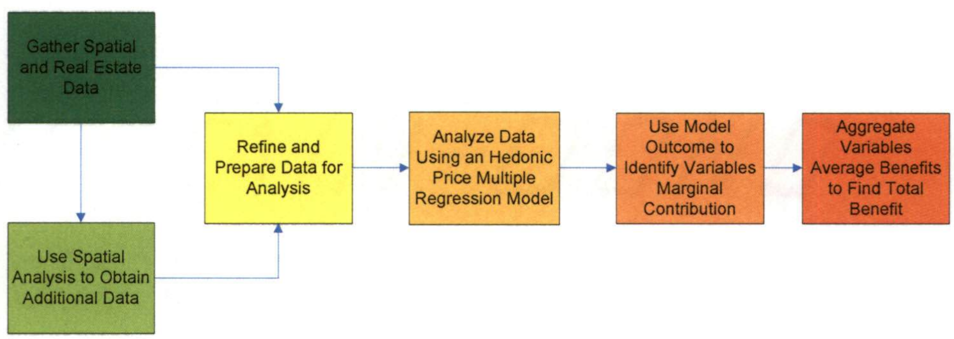



Figure 1. Hedonic Benefit Analysis Process

## Data Gathering and Preparation

The information and data necessary for this research study was primarily obtained via the internet available for download from the Wake County website. Real estate data was acquired in relation to the four attribute areas of property characteristics: structural attributes, locational attributes, neighborhood attributes, and environmental attributes. Time-related attributes such as year built were also obtained and acted as a basis for analysis as well.

Creation, preparation, and refinement of much of this data will take place utilizing Geographic Information Systems. Much of the spatial vector and raster data for analysis in GIS was acquired from the Wake County GIS. Census information also was utilized primarily in obtaining neighborhood characteristic attributes.

Data will be identified and some data will be created using existing spatial data and information. GIS will enable analysis of spatial characteristics including proximity to amenities and defining of other locational variables that will ultimately be analyzed using an hedonic regression model. Utilization of GIS also occurred in the modification of previously existing data such as identification and display of census information.

## Theoretical Hedonic Price Model

Analysis and interpretation of the data will take place through the use of an hedonic pricing model. Hedonic pricing attempts to identify the inherent attributes in properties that contribute to their value. The theoretical model flows from the notion that the price of a parcel derives from the consumer's utility for each individual characteristic in a parcel's bundle of characteristics. Therefore the rent for a given parcel is a function of an individual's perceived or hidden rent for each individual characteristic that comprises the parcel's bundle of goods.

This bid-rent relationship can be shown in the following functional form:

$$R = r(s, n, l, c)$$

Where in this model ***R*** is the rent associated with the bundle of characteristics, ***r*** is the rent associated with an individual characteristic within the bundle, ***s*** represents a set of structural attributes for the existing housing structure(s), ***n*** is a set of neighborhood characteristics such as median age, educational achievement, etc., ***l*** is a set of locational attributes identifying the parcels location in relation to important places such as downtown or the airport, while ***c*** represents the identified community amenities. It is important to remember that the function can contain positive as well as negative rents for individual characteristics within the bundle.

This theoretical model can be expanded into an empirical model by distributing the *r* throughout the function. The ***r*** in effect becomes the $\beta$ coefficients in the empirical model. This is accomplished by creation of a function where a single dependent variable's quantification, in this case a parcel's real sale value is dependent upon a set of identified independent variables. The model is typical of a multiple regression model. The model will take the form of an equation whereas:

$$R = \alpha + \beta_{1S}(S_{1S})\ldots\beta_{kS}(S_{kS}) + \beta_{1N}(N_{1N})\ldots\beta_{kN}(N_{kN}) + \beta_{1L}(L_{1L})\ldots\beta_{kL}(L_{kL}) + \beta_{C}(C) + \epsilon$$

Where **R** acts as the dependent variable of real sale value, $\alpha$ is the constant and intercept of the function and $\beta_n$ are the coefficients of the independent variables in each set of characteristics. In addition, **S** acts as a set of independent variables for the structural attributes of the housing structure(s) on the parcels, **N** acts as a set of independent variables for the neighborhood characteristics such as median age, educational achievement, etc., **L** acts as a set of locational variables, and **C** is the community amenity independent variable. **€** acts as an error term that identifies the variation in the dependent variable that can not be identified using the included independent variables as well as error in existing data gathering and specification.

Interpretation of the model can take place once it has been created. Identification of the variables that have statistical significance will undoubtedly give insight to which variables exert a significant influence on existing property values. To do this a two-tailed statistical hypothesis test will be undertaken for each variable. If a statistically significant relationship exists between the independent and dependent variables, then we fail to reject the null hypothesis that the independent variable included in the model does not exert a significant influence on the dependent variable.

In addition to finding statistical relationships between the independent variables and the dependent variable, the model can be used to obtain independent variable contributions, or rents, to the dependent variable using the coefficients. The coefficients multiplied by an existing variable will yield the marginal contribution to the existing property value resulting from a small change in the given unit of the independent variable. This relationship can be identified as follows *ceteris paribus*, holding all else constant:

$$\beta x_i = R / K x_i$$

Where $\boldsymbol{\beta}\mathbf{x_i}$ acts as the rent an individual must pay in order to acquire an additional unit of characteristic $\mathbf{x_i}$, $\mathbf{Rx_i}$ represents rent for the bundle of characteristics, and $\mathbf{Kx_i}$ represents the units of variable $\mathbf{x_i}$ desired for evaluation. As a result, $\boldsymbol{\beta}\mathbf{x_i}$ multiplied by $\mathbf{Kx_i}$ yields the incremental bid-rent increase in **R** due to the contribution of characteristic $\mathbf{x_i}$.

The marginal contribution can be found for any given observation or all observations *ceteris paribus*. Then, finding these contributions, they may be summed to obtain the total contribution for a characteristic in the analysis area. This will prove useful in finding the benefit derived from community amenities such as parks. The next chapter provides a description of the data used in the analysis as well as an overview of the analysis areas.

# CHAPTER IV

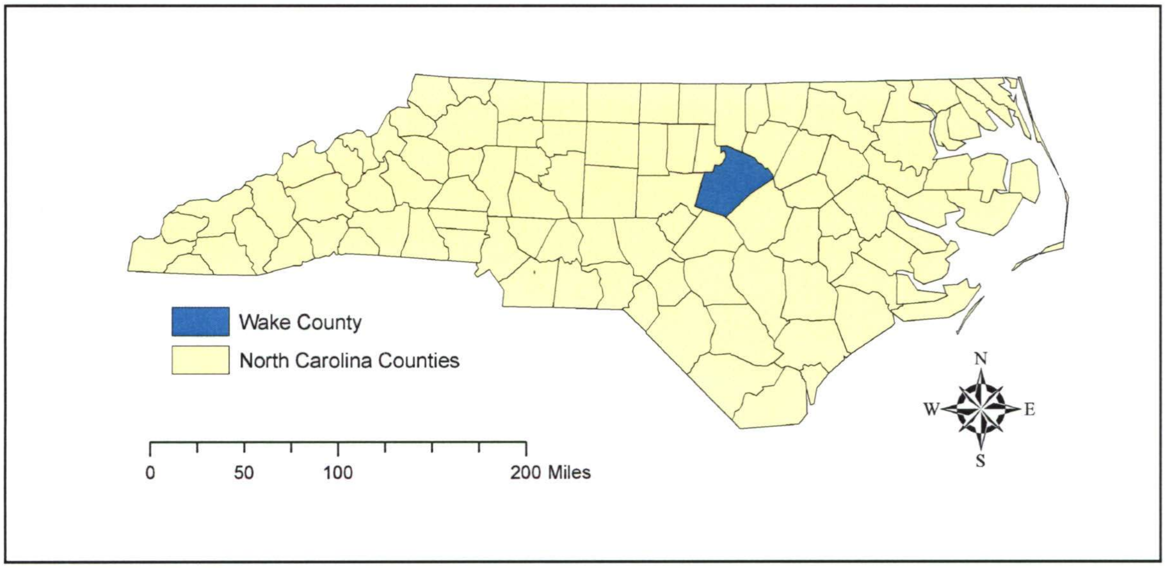
# DESCRIPTION OF ANALYSIS AREA AND DATA

In order for a an hedonic study to be successful, a comprehensive set of data must be obtained and carefully refined without altering the fundamental base of information that the existing data set presents. This chapter will describe the area for which the hedonic analyses took place in addition to the data sources, procedures for data creation and GIS utilization, and a description of the qualitative assumptions and descriptive specifications for the data used in the models.

## Analysis Area Description

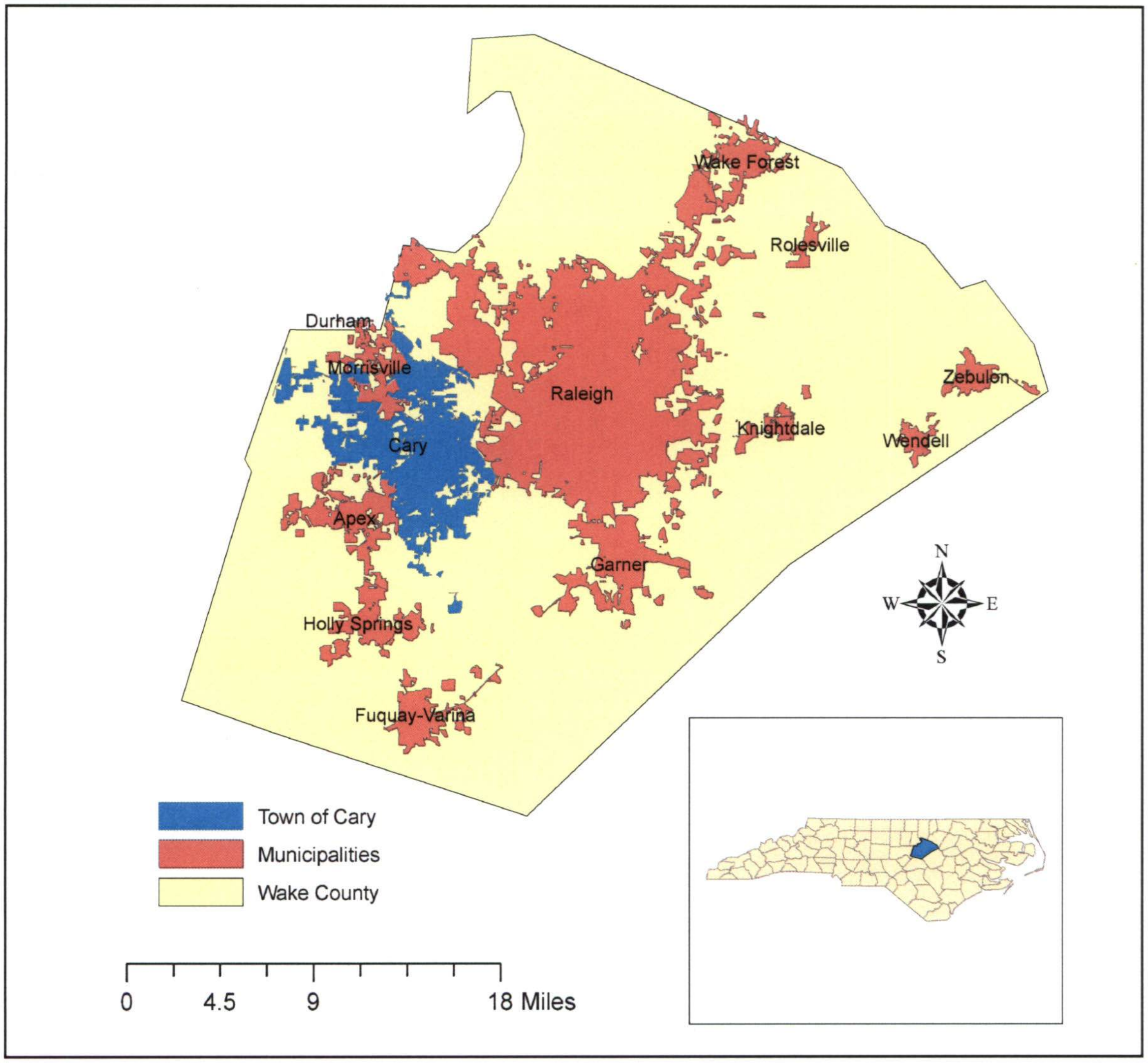
The study area used spatial data obtained primarily covering the jurisdictional limits of the Town of Cary, North Carolina. The Town of Cary is the primary suburban community of Raleigh, both of which are located in Wake County. Wake County is one of North Carolina's largest located in the lower Piedmont region of the state (Map 1). In addition to Raleigh and Cary, Wake County also contains the municipalities of Garner, Apex, Holly Springs, Wake Forest, Zebulon, Fuquay-Varina, Morrisville, Knightdale, Wendell and Rolesville (Map 2). Wake County is located along Interstate 40 which is the primary East-West interstate highway through the state of North Carolina. The region has demonstrated an increasing rate of growth over the past ten to twenty year period. This growth is in large part due the success of

Research Triangle Park and the numerous technology based companies locating in the area.




Map 1. Location of Wake County

Wake County's 2004 population was just over 700,000 while its area is 847 square miles giving it an overall population density of 826 persons per square mile. Although the largest city in the county is Raleigh with a 2004 population of 317,651 Cary is the second largest municipality in the county at 101,265 in 2004. Table 1 highlights important demographic, social, and geographic comparisons between Wake County, Raleigh, and Cary according to the 2000 Census. As the comparison shows, the Town of Cary has a more affluent population than that compared to the county or Raleigh. Cary's minority population, renter occupied housing, and poverty rate are all significantly below those of the county and Raleigh. In addition, Cary's population has a significantly higher education level and median household income than the surrounding areas while the median value of a single-family home is significantly higher as well.




Map 2. Wake County Municipalities

Table 1. Study Area Comparison

| | Wake County | Raleigh | Cary |
|---|---|---|---|
| Total Population | 627,846 | 276,093 | 94,536 |
| Area (square miles) | 847 | 115 | 43.65 |
| Population Density | 741.26 | 2,409.2 | 2165.6 |
| Median Age | 32.9 | 30.9 | 33.7 |
| Percent Minority Population | 27.6 | 36.7 | 17.8 |
| Percent Vacant Housing | 6.5 | 6.7 | 5.3 |
| Percent Renter Occupied Housing | 34.1 | 48.4 | 27.2 |
| Percent Bachelor's Degree or Higher | 43.9 | 44.9 | 60.7 |
| Median Household Income | 54,988 | 46,612 | 75,122 |
| Percent Individuals Below Poverty | 12.4 | 11.5 | 3.4 |
| Median Value Single-family Home | 162,900 | 156,000 | 196,700 |

The Town of Cary and the entire Raleigh metropolitan area has been experiencing significant growth within the past decade. Cary's 1990 population was 43,858 indicating a growth rate of 131 percent over the period the period from 1990 to 2004. Even the City of Raleigh has demonstrated a 57 percent growth rate over the same period when many other city populations across the country have declined in population. Much of this growth rate is largely due to the location and growth of technology companies in the area. For example, Cary is home to SAS, a statistical software company, which has experienced tremendous growth which in turn has contributed to the growth of Cary along with other technology-based countries in Research Triangle Park such as IBM.

The Town of Cary provides many amenities attractive to young families with professional parents who work in the area. The Raleigh-Durham International Airport is less than three miles from north Cary while Cary is also positioned in easy commuting distance from either Research Triangle Park or downtown Raleigh. There is a quality school system as well as Cary Academy which is private. In addition, Cary offers quality community amenities which are the focus of this study. These community amenities have been divided into four categories for the purpose of this study: 1) Bond Park, the primary metropolitan park, 2) a set of secondary community parks of significant size, 3) existing schools and associated recreational space, and 4) existing greenways within Cary.

## Data Sources

The data used for this study was primarily obtained from two sources and then compiled and modified in a usable format for the study. Much of the spatial data including shapefiles and their attributes were obtained through the Wake County GIS department. Additional attribute information was obtained through the Wake County tax assessor's department. ESRI also acted as a source for Census shapefiles and attributes used in the study.

The Wake County GIS website provided the bulk of the spatial information Data downloaded included point locations for libraries, schools, fire departments, etc., roads, voting districts, municipalities, tax parcels, centerlines, parks and open space, landmarks, hydrography, existing subdivisions, etc. Attribute information for tax parcels that came along with the shapefiles included owners' names and addresses, the deeded acreage, the deed date, the assessed building value, the assessed land value, the heated square footage of the parcel, available utilities, whether there is extra territorial jurisdiction and its jurisdiction, and its zoning. In addition, the attribute information included the year that the structure was built, the total sale price for the parcel, the sale date, the type and use of the parcel, the structures building style, the parcels land classification, and total structures on the parcel.

In addition to the information obtained through the GIS department, the tax assessor's department provided more attributes through an Access database. Data included in this database included the parcels planning jurisdiction, township, fire district, zoning, special districts, billing class, land class, utilities, story height, design style, foundation or basement, exterior wall type, heating type, assessment grade, air type, bathrooms, built-ins such as fireplaces, elevators, or sprinkler systems, the parcels' city, and type and use. Much of this information acted as the basis for analysis in the determination of a bundle of characteristics determining the value of a parcel.

United States Census 2000 information was used to acquire additional demographic characteristics of the block groups in which the tax parcels are within. Attributes from the block groups included characteristics such as population, households, retired population, working population, education levels, age distributions, median household income, occupied and vacant housing units, renter occupied housing, and racial demographics. Much of this information was used as neighborhood characteristics in the hedonic price studies.

## Data Construction Procedures

In addition to acquiring data from existing sources, other data needed to be created using the spatial analysis capabilities of GIS. In addition, GIS capabilities were utilized for the display of much of the attribute information for a basic spatial understanding while undertaking the hedonic analyses. The constructed data then was added to the already existing attribute data to create the full data set.

GIS aided in the construction of the locational attributes. These locational attributes primarily included parcels' distances from identified landmarks and community amenities. Identified landmarks included Raleigh-Durham International Airport, downtown Cary, and downtown Raleigh. Identified community amenities included Bond Park, four community parks, schools, and greenways.

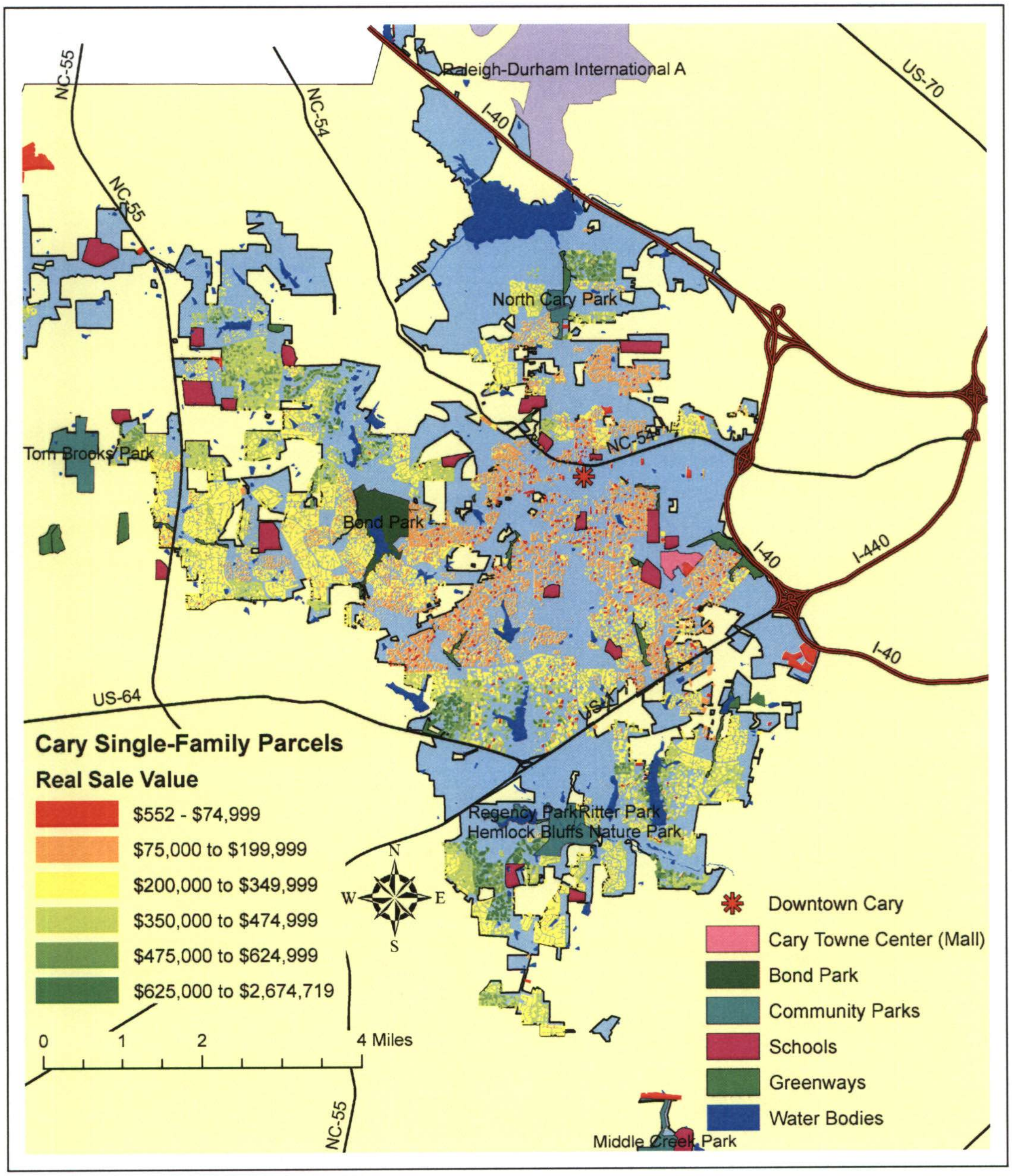
In order to acquire data in a usable format, several procedures were undertaken using raster to obtain vector attribute information. The spatial analyst tool for Euclidian Distance was used in order to obtain the proximity to landmarks. The output for this tool, however, is in raster format that does not contain attribute information. In order to incorporate the raster information into a vector attribute table the Zonal Statistics tool was used for each landmark to find the mean proximity from the specified landmark or community amenity for each tax parcel in vector attribute format. The vector output could then be joined to the existing tax parcel attribute information.

In addition to the construction of data, GIS was also useful in putting data together in a usable format for analysis. The primary case in point was combining tax parcel and block group information since they are different geographical units. This was accomplished by using the Union tool to create a single attribute table with the characteristics of the existing tax parcel information in conjunction with the demographic characteristics of the parcel's respective block group.

## Data Specifications and Characteristics

Although most of the data used in this study was readily available for access, the format for many of the variables had to be modified in order for the information to be used in analysis. Much of this modification included excluding observations that were clearly invalid or had "null" or "0" entries. Other specifications included, modifying qualitative variables into quantitative form.

The first and most important data set to insure accuracy and conformability was that of the dependent variable in the hedonic price model. The existing data included total assessed value for the tax parcels as well as total sale value and sale date. I decided to adjust the total sale value according to the February 2006 Consumer Price Index. In order to do this, I adjusted using the average CPI for each year of a sale as to simplify calculations. After this adjustment took place it was clear that this adjusted sale value would be a more accurate depiction of actual market value than the assessed values. As there were inevitably invalid entries, any "null" or "0" entries were excluded from the data set. Map 3 displays the inflation adjusted sale value for single-family residential parcels in Cary.




Map 3. Real Sale Value for Cary Single-Family Parcels

The set of independent variables similarly had to be modified in order to have a contiguous data set without errors. Here again any invalid entries were eliminated from the data set. For example all "null" and "0" values were eliminated from most of the data set. The exception was creation of a dummy variable for the exterior of the structure. If the exterior was brick or stone a value of "1" was inputted in the data set otherwise all other value were coded "0". The only other modification to the data set involved a qualitative assumption involving the sale date of the parcels. All parcels sold before 1990 were eliminated from the data set as measure to attempt to control for the drastic changes in real estate prices not captured by adjusting using the Consumer Price Index. The Appendix contains maps showing the spatial distribution of all the independent variables used in the model.

# CHAPTER V

# EMPIRICAL ANALYSIS AND RESULTS

## Introduction

Since the objective of this analysis is to determine the contribution to residential parcel values by chosen community amenities, the majority of the text will focus on these independent variables of the models. In addition, the objective of this study is not to find a single working model for all of Cary, but to determine the actual benefit derived from community amenities. Since the method used to determine contribution will be multiple regression modeling, different observation sets were chosen for each community amenity studied. The observation sets were chosen based on the following two assumptions:

1) The chosen community amenities only have a significant effect within a given impact area or proximate distance from the amenity; additional observations will disproportionately reduce the significance of the community amenity for the observations within the impact area.

2) The community amenities are spatially allocated as to minimize overlapping of amenity impact areas reducing the possibility for significance of simultaneous amenities for a given observation and thus omitted variable bias.

As a result five different observation sets were chosen resulting in five models for four different community amenities: Bond Park, community parks, schools, and greenways. The analysis and results of the hedonic models for each of these chosen amenities will be explored in turn.

## Variables

The hedonic models developed for each community amenity utilized typical hedonic variables including structural (S), neighborhood (N), and locational (L) variables in addition to the chosen community variable (C). Table 2 presents the variables, their respective type vector, and the models in which they were used.

Table 2. Independent Variables of Models

| | S | N | L | C | MODELS |
|---|---|---|---|---|---|
| Year Structure was Built | X | | | | 1, 2, 3, 4, 5 |
| Heated Area of Structure (Sq. Feet) | X | | | | 1, 2, 3, 4, 5 |
| Brick or Stone Exterior (1,0) | X | | | | 1, 2, 3, 4, 5 |
| Assessment Grade | X | | | | 1, 2, 3, 4, 5 |
| Parcel Acreage | X | | | | 1, 2, 3, 4, 5 |
| Percent Population with Bachelor's in Block Group | | X | | | 1, 2, 3, 4, 5 |
| Median Age of Population in Block Group | | X | | | 1, 2, 3, 4, 5 |
| Percent Occupied Housing Rented | | X | | | 1, 2, 3, 4, 5 |
| Median Household Income in Block Group | | X | | | 2 |
| Households per Square Mile | | X | | | 1, 2, 3, 4, 5 |
| Distance to Downtown Cary (Feet) | | | X | | 1, 2, 3, 4, 5 |
| Distance to Downtown Raleigh (Feet) | | | X | | 1, 2, 3, 4, 5 |
| Distance to Raleigh Durham International Airport (Feet) | | | X | | 1, 2, 3, 4, 5 |
| Distance to Cary Towne Center (Feet) | | | X | | 1, 2, 3, 4, 5 |
| Distance to Park (Feet) | | | | X | 1 |
| Distance to Park Squared (Feet) | | | | X | 1 |
| Distance to Community Parks (Feet) | | | | X | 2 |
| Distance to Community Parks Squared (Feet) | | | | X | 2 |
| Distance to Schools (Feet) | | | | X | 3 |
| Distance to Schools Squared (Feet) | | | | X | 3 |
| Distance to Greenways (Feet) | | | | X | 4 |
| Within 115 Feet of Greenway (1,0) | | | | X | 5 |

The structural variables in the model attempt to capture the physical characteristics of the housing structure and the parcel. One would expect that the newer a housing structure is, the greater its value would be, therefore the year the structure was built was included as a variable. Included as a variable for size of the structure was the heated area of the house by square feet. A greater area in square feet would result in a higher sale price for the parcel. As a measure for the value for the type of exterior wall, a brick or stone exterior variable would indicate the value for having a brick or stone house as opposed to not having one. The assessment grade was included as a proxy measure to capture the overall quality of the parcel; a higher grade would indicate an overall higher quality thus greater value for the parcel. The final structural variable of parcel acreage was used to determine the value of having a greater parcel area.

The neighborhood variables included in the models portray the social and demographic characteristics at a neighborhood level. Census Block Group level data was used to show these neighborhood attributes. A neighborhood with a higher education level should show greater increases in parcel values than those with a lower education level. Value changes occurring due to the median age of the neighborhood could be viewed two different ways. Typically an increase in age would mean, higher incomes and thus higher parcel values. Alternatively, however, an increase in the median age could mean an increase in retirement population or those residents still living in their older homes thus decreasing the value of the parcel. In addition, retirees do not require houses large enough for children and thus a reduction in median age likely indicates an increase in the school age population.

Additional neighborhood variables used in the models included the percent of occupied housing rented, the median household income, and households per square mile. Since homeowners are typically seen as being more responsible and tied to the community, an increase in rented housing should decrease a neighborhood's parcel values. In a community such as Cary, however, with many young technologically savvy residents, an increase in rental availability may indicate a demand for quality temporary housing for some of these residents just moving into the community. Clearly, a higher median household income for the neighborhood would indicate higher overall parcel values, but this would largely be indicated in many of the other attributes already included in the models thus resulting in covariance among this and other independent variables. In addition, residents typically prefer a lower household density for their neighborhood; therefore a neighborhood with a lower household density would tend to see a premium in their parcel sale values over a neighborhood with a higher household density.

The locational variables are included as a determination of how a parcels location in relation to other locations that may have an affect on a parcel's value. A closer proximity to downtown Cary may indicate an increase in a parcel's value for being closer to downtown amenities. Alternatively, however, there are not many amenities in downtown Cary. In addition, a parcel's distance from downtown Raleigh would indicate a premium if it decreased the commute time of the parcel's working resident. The primary work location of many Cary residents, however, may be in Research Triangle Park or elsewhere therefore reducing the significance of being closer to downtown Raleigh.

Distance from Raleigh Durham International Airport may also affect a parcel's value in addition to distance from Cary Towne Center, the mall in Cary. Distance from the airport again could have conflicting qualities. A closer proximity would mean easier access to flights in a timely manner for residents who travel for business. However, being too close to the airport may decrease a parcel's value as a result of the airport noise pollution. Similarly, proximity to a mall may increase a parcel's value due to residents who perceive decreased travel time as convenient; since the mall is located in a commercial area, however, with traffic, lights, and noise, proximate parcel values are likely to decrease.

Using travel time instead of Euclidian distance may give a more accurate depiction of actual benefits accruing to parcels due to the convenience of getting to these locations. Distance on the other hand may tend to capture the negative externalities of being directly closer in distance to these locations. In order to try to minimize counteracting effects with the primary community amenity variables of interest, nonlinear functional forms were chosen to show the rate of change in value with distance from the amenity of interest. The following sections will discuss the models' results according to the community amenity of interest.

## Bond Park

The Town of Cary's largest and most utilized park is Bond Park. With over 300 acres, the park also is located on a small lake that undoubtedly acts as a contributing factor to proximate residential land values. The park contains a community center, senior center, amphitheater, playground, picnic shelters, and boat rental among many other amenities. The prominence of Bond Park as a community amenity is apparent. As a result of the park's prominence the observation set, or alternatively the park's assumed impact area, parcels within 3 miles or 15,840 feet from the park were chosen.

In order to realize the nonlinear nature of the park's contribution over distance, a square term was added to the multivariable regression model. Table 3 presents the Model 1 variables, their coefficients, and their significance at the 95 percent and 90 percent confidence level. The Appendix includes a complete table of statistical regression results.

Table 3. Model 1 Coefficients and Significance

| | *Coefficients* | *t Stat* | *95% Sig.* | *90% Sig.* |
|---|---|---|---|---|
| Intercept | -745,237.26492 | -5.44357 | yes | yes |
| YEAR_BUILT | 393.02177 | 5.944616 | yes | yes |
| HEATED_ARE | 64.27920 | 74.72984 | yes | yes |
| ACRES | 41,010.69578 | 14.6333 | yes | yes |
| PERCENT_BA | -291.53485 | -3.90835 | yes | yes |
| BRICK_STON | 10,138.28474 | 6.182926 | yes | yes |
| MED_AGE | 936.58314 | 5.165655 | yes | yes |
| PER_RENT | 314.34459 | 6.672228 | yes | yes |
| HH_SQ_MI | -5.47118 | -3.66429 | yes | yes |
| GRADE | 2,563.47899 | 82.09603 | yes | yes |
| PARK_DIST | -0.50393 | -1.18897 | no | no |
| PARK_DIST_SQ | -0.00011 | -4.14882 | yes | yes |
| DWNTN_CARY | 1.03150 | 1.856701 | no | yes |
| DWNTN_RAL_ | -7.68585 | -12.1211 | yes | yes |
| AIRPORT_DI | 1.11816 | 4.634499 | yes | yes |
| MALL_DIST | 7.52794 | 9.389424 | yes | yes |

Derived from the regression output the following hedonic model is generated.

Model 1

*R* = -745,237.26492 + 393.02177*(YEAR_BUILT)* + 64.27920*(HEATED_ARE)* + 41,010.69578*(ACRES)* - 291.53485*(PERCENT_BA)* + 10,138.28474*(BRICK_STON)* + 936.58314*(MED_AGE)* + 314.34459*(PER_RENT)* -5.47118*(HH_SQ_MI)* + 2,563.47899*(GRADE)* -0.50393*(PARK_DIST)* -0.00011*(PARK_DIST_SQ)* + 1.03150*(DWNTN_CARY)* - 7.68585*(DWNTN_RAL_)* + 1.11816*(AIRPORT_DI)* + 7.52794*(MALL_DIST)*[1]

From observing the statistical significance of each of the variables the model shows success explaining the variation of the dependent variable real sale value. According to the R squared for the model of .82, the models independent variables successfully explain eighty two percent of the variation in the adjusted sale values of homes.

Most of the variables coefficients make logical sense. An older house will lower the value of a house compared to a newer one. Larger houses are more expensive than smaller ones. A house with a brick or stone exterior is more expensive than one that does not have a brick or stone exterior. A high assessment grade adds a premium to the house as well as if the house is located in a neighborhood with a higher median age. There were a couple of interesting outcomes, however. A higher education rate in the block group lowered a parcel's sale value. In addition, as the percentage of occupied housing rented increases, then the predicted parcel value increases as well. The locational variables indicated that distance proximity to both downtown Cary and the Raleigh-Durham International Airport has a negative effect on residential property values while parcels closer to downtown Raleigh see a higher premium in their sale prices.

[1] Models 2 through 5 are constructed in the same manner.

The variables of interest, however, were those of "park distance" and "park distance squared." The coefficients of these two variables aided in the determination of the benefits that the single-family parcels received for being a specified distance from Bond Park. Since the coefficients are negative, multiplying the coefficients by the distance or distance squared values and adding the two products together yields the individual parcel's loss in value for being a specified distance from the park. This finding does not produce, however, the contribution the park makes to the identified parcel. In order to find this, the change in value due to distance must be determined *ceteris paribus*, holding all other variables constant. To do this, the means of all the other variables were used to determine the mean value of a parcel at no distance from the park, then finding the parcel values with a successive increase in distance from Bond Park. Figure 2 shows this change in mean parcel values.

These change in values does not show the monetary amount to which Bond Park contributes to each observed parcel. In order to acquire a predicted estimate of this contribution, the previous assumption of the park's impact area was maintained; any parcels greater than three miles from Bond Park has no capitalization into its sale value due to the presence of Bond Park. This may or may not be the case, but this assumption will result in a conservative estimate of the park's contribution to proximate parcel values. Therefore in order to get these contributions the values from Figure 2 were subtracted by the mean value of a parcel at three miles distance from the park. The resulting contributions according to increasing distance from Bond Park are shown in Figure 3.

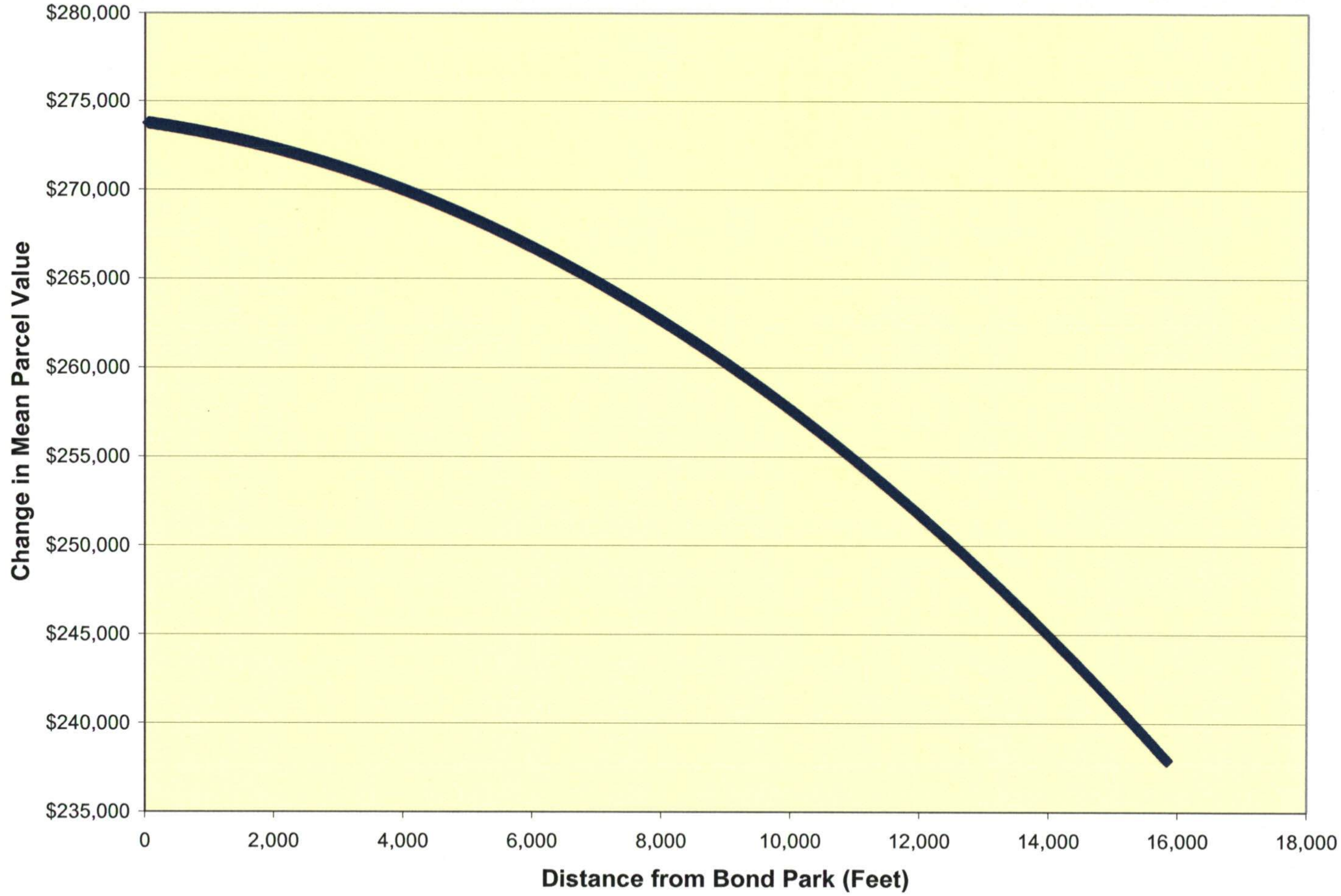



Figure 2. Predicted Change in Mean Single-Family Parcel Value with Distance from Bond Park

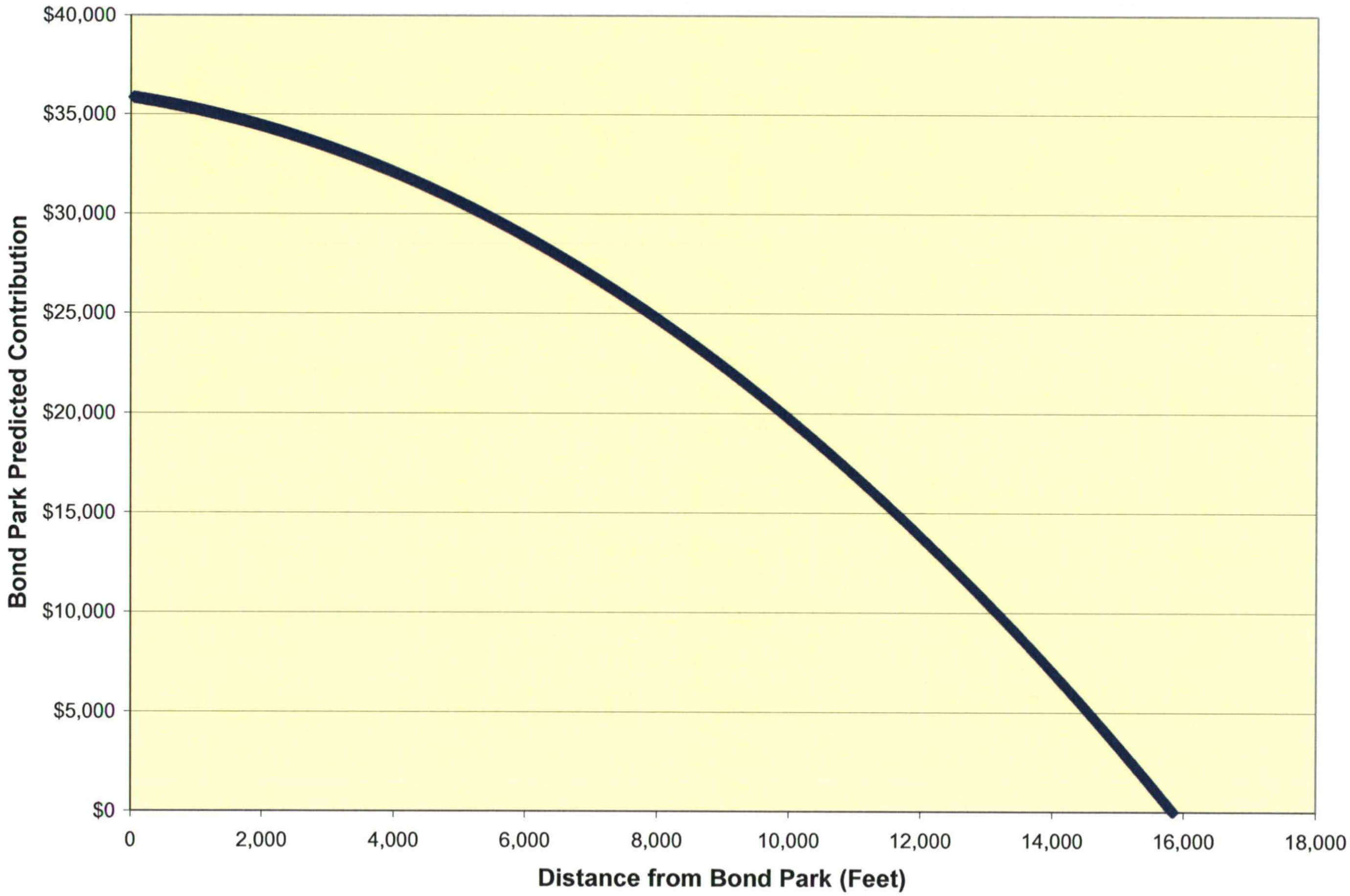
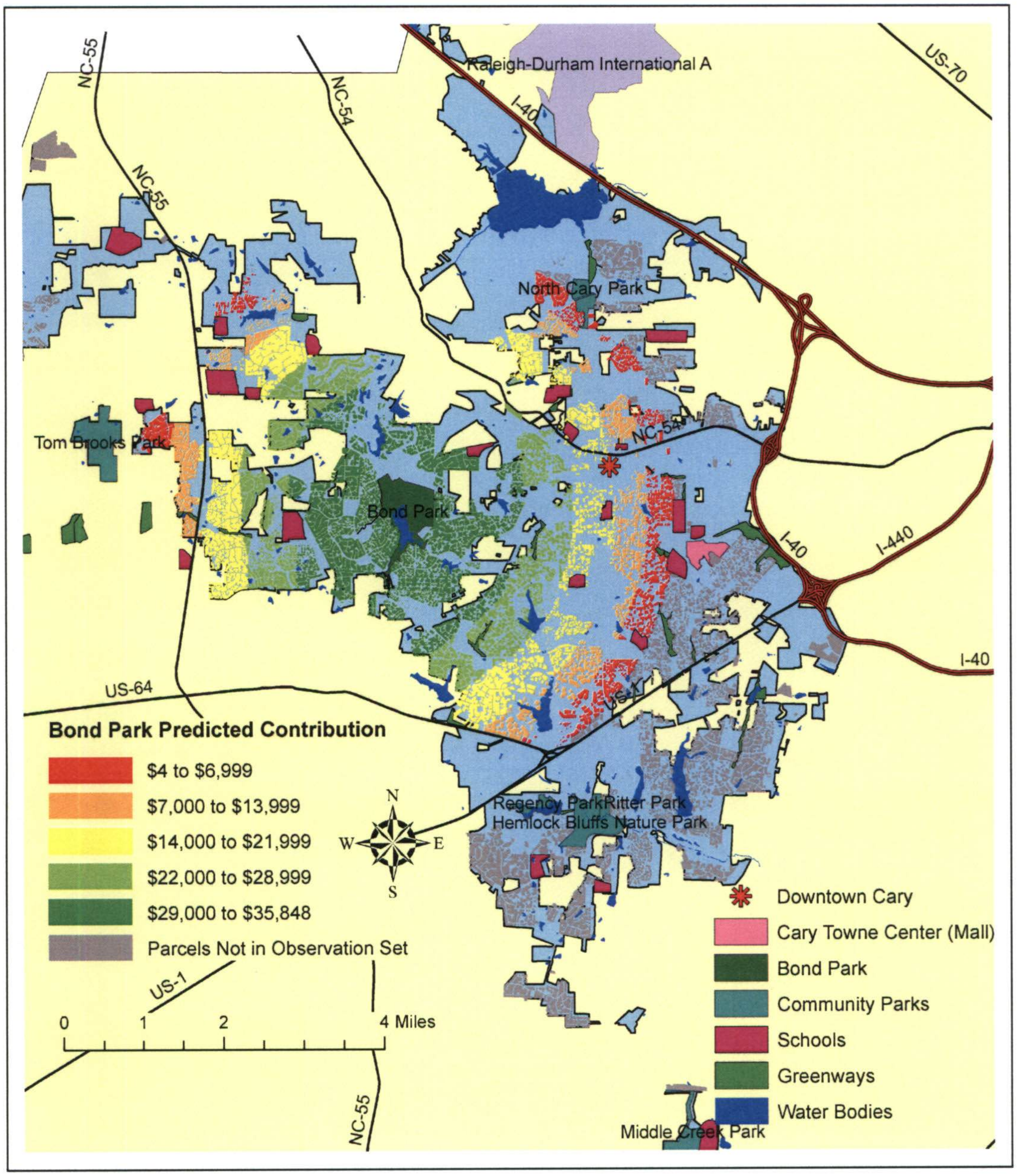



Figure 3. Bond Park Predicted Contribution to Single-Family Parcel Values

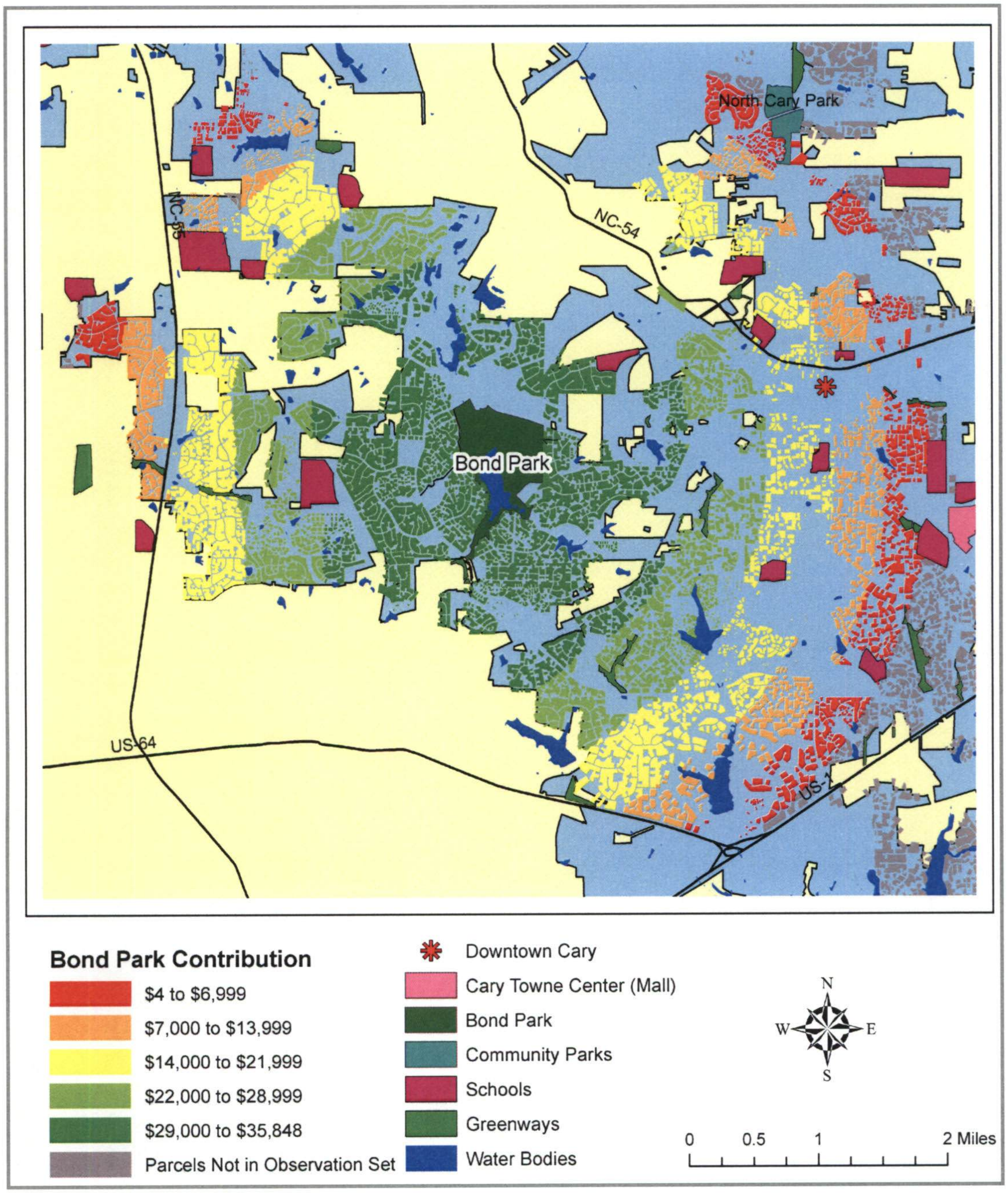
In order to display this monetary contribution spatially, the contribution values were aligned with their respective Real Estate Identification (REID) numbers. These numbers could then be joined with the corresponding REID numbers in the attributes of a GIS parcel shapefile. The breaks in the groups were then made accordingly to accurately depict the functional form of the contribution graph. Maps 4 and 5 display this spatial distribution of Bond Park's contribution among the parcels in the observation set.

Both Figures 2 and 3 and Maps 4 and 5 demonstrate that the contribution to a parcel's value from Bond Park has a diminishing marginal effect with an increased distance from the park. Therefore the contribution due to the park decreases at an increasing rate with distance from the park. In other words, a small change in distance has a greater effect on contribution for those parcels further away from the park than those that are closer. This is inevitably in large part due to the value of being within a viewshed of the lake as well as the positive effect of being within close walking distance to the park.

Since the aim of this project is to identify the monetary benefits that result by the public provision of community amenities, finding the predicted aggregate total benefit will prove useful in the determination of the park's value to the community. Aggregating the predicted contribution values for all parcels within the observation set will provide a total capitalization value due to provision of the park that is captured in residential single-family parcel values. This analysis found a predicted total capitalization of $312,932,266. Of course the Town of Cary will see some fiscal benefits as well resulting due to the incremental increase in total taxes captured due to the existence of the park and its amenities.




Map 4. Bond Park's Contribution to Single-Family Parcel's Value




Map 5. Bond Park Predicted Contribution to Single-Family Parcel Values

Community Parks

Cary's community parks act as a complement to the primary facilities located at Bond Park. These parks are much smaller than Bond Park, but still have quality amenities such as playgrounds, walking trails, and picnic areas. Regency Park has a quality amphitheater at which frequent musical performances occur on the weekends. Tom Brooks Park contains four lighted baseball fields, two soccer fields, and two basketball courts along with playgrounds, picnic shelters and restrooms. Similarly North Cary Park contains basketball courts, sand volleyball courts, a soccer field, a playground, walking trails, and picnic areas. Hemlock Bluffs Nature Park has about 3 miles of nature trails. From these descriptions, the category for these smaller community parks largely consists of "active" as opposed to "passive" uses.

Single-family parcels within one and a half miles were chosen as the observation set for these community parks. A greater distance than that would be assumed to have little or no significant effect on property values. In addition, in order to determine a nonlinear relationship between the parks' contribution to residential values and distance from the park a squared term was included in Model 2. Table 4 shows the model's variables, coefficients, t statistic and significance. As with Model 1 the R squared for this model explains a significant portion of the variation in the dependent variable. With an R squared of .84, the independent variables in the model explain 84 percent of the variation in the adjusted sale price of the single-family residential parcels in the observation set of 6,861 parcels. Full regression results are located in the Appendix.

Table 4. Model 2 Coefficients and Significance

| | *Coefficients* | *t Stat* | *95% Sig.* | *90% Sig.* |
|---|---|---|---|---|
| Intercept | -550328.6175 | -2.005881616 | yes | yes |
| YEAR_BUILT | 55.97294219 | 0.404865754 | no | no |
| HEATED_ARE | 70.80148457 | 53.45303589 | yes | yes |
| ACRES | 31586.20866 | 7.212700505 | yes | yes |
| PERCENT_BA | 59.26754471 | 0.288764285 | no | no |
| BRICK_STON | 2433.864078 | 0.928685113 | no | yes |
| MED_AGE | 1633.795459 | 4.227287182 | yes | yes |
| PER_RENT | 799.8994278 | 5.958221134 | yes | yes |
| HH_SQ_MI | -3.985553001 | -1.497520397 | no | no |
| MED_HH_INC | 0.776625538 | 7.271307318 | yes | yes |
| GRADE | 2711.467661 | 64.78470193 | yes | yes |
| COMM_PARKS | -1.973202455 | -1.26088688 | no | no |
| COMM_PARKS_SQ | 0.000237481 | 1.313226263 | no | no |
| DWNTN_CARY | -3.289917124 | -3.757660542 | yes | yes |
| DWNTN_RAL_ | 0.354006606 | 0.870754615 | no | no |
| AIRPORT_DI | 0.976957207 | 3.32636522 | yes | yes |
| MALL_DIST | 1.981205705 | 1.892569974 | no | yes |

As with Model 1 most of the coefficients in the model make sense. Here again, however, it is interesting to note that as the percentage of occupied housing rented in a neighborhood increases, so does the value of the observation. In addition, it is interesting to note that both the airport and mall have significant levels of influence at ninety-five and ninety percent respectively. The model indicates that with every foot closer to Cary Towne Center a parcel loses $1.98 in value. While a closer distance to downtown Cary increases a parcel's value by $3.29 per foot, distance to downtown Raleigh was found to be insignificant in this observation set of 6,861 single-family residential parcels.

Analyzing the coefficients for community parks will prove useful in the determination of the parks' contribution to surrounding single-family residential land values. By multiplying the coefficients of the variables by an observation and then summing the products we obtain a contribution value for that given observation. In the case of this model, the result would be negative values indicating a loss for being a specified distance away from a park. Here as with Model 1, in order to find the monetary value contribution for being a specific distance from the amenity, the value change *ceteris paribus* is required. This analysis utilized the means for each of the independent variables in the model and then determined the change in total parcel value for a change in distance from the park.

The resulting graph, however, would indicate an increasing value with distance from the park after a specified distance. Since this portion of the model does not make intuitive economic sense, only the portion showing a declining total parcel value with distance from the graph is displayed in Figure 4. In order to determine the point where there is no significant contribution to parcel values due to community parks, the first derivative of the park and park squared variables were found subsequently solving for distance ($d$):

$$R = \alpha + -1.973202455(d) + 0.000237481(d^2)$$

$$(dy/dx)\, R = (dy/dx)\; [\alpha + -1.973202455(d) + 0.000237481(d^2)]$$

$$0 = -1.973202455 + 2*(0.000237481)\, d$$

$$1.973202455 = 2*(0.000237481)\, d$$

$$d = 4{,}154.435$$

Therefore the distance beyond which there is no significant contribution due to community parks is 4,154 feet. As a result, the change in parcel value resulting from the park will occur from adjacent to the park to about three quarters of a mile away beyond which there is no significant contribution. Figure 4 demonstrates this change in parcel value.

In order to obtain the actual contributions for each parcel located a specified distance away from a community park. The total mean parcel values obtained for the observations were subtracted by the total mean parcel value of a parcel at a distance of 4,154 feet from the park. The results give the actual predicted contributions to each parcel in the observation set at a specified distance from a community park. Figure 5 shows the predicted monetary contributions to single-family residential parcel values to proximate properties of community parks.

As with Model 1, the resulting predicted contributions can be displayed spatially using GIS. The REID numbers were matched with existing parcels to display the contributions to proximate parcels resulting from proximity to a community park. Map 6 displays these contributions parcel values due to community parks, while Maps 7 and 8 provide a closer look at the contributions due to Regency, Ritter, and Hemlock Bluffs and North Cary Park respectively.

The graphs demonstrate that the contribution due to community parks is diminishing with distance from the park. Furthermore, however, the graphs indicate that the change in mean parcel value or contribution decreases at a decreasing rate. Therefore, that parcels further away from the amenity get a much smaller benefit for a small change in distance than those parcels that are closer in proximity from the park. This is reflected in both the graphs and maps.

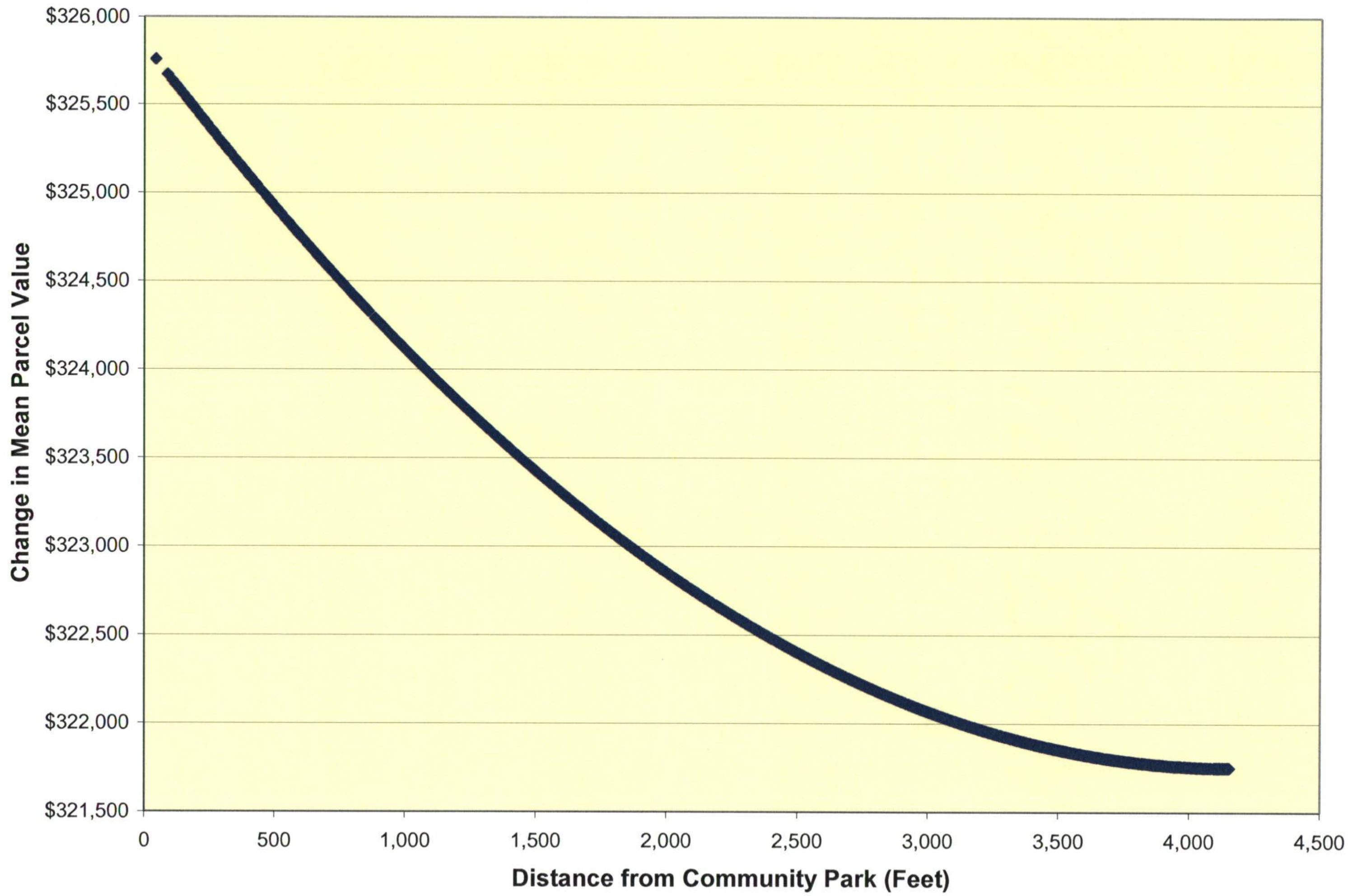



Figure 4. Change in Mean Single-Family Parcel Value with Distance from Community Park

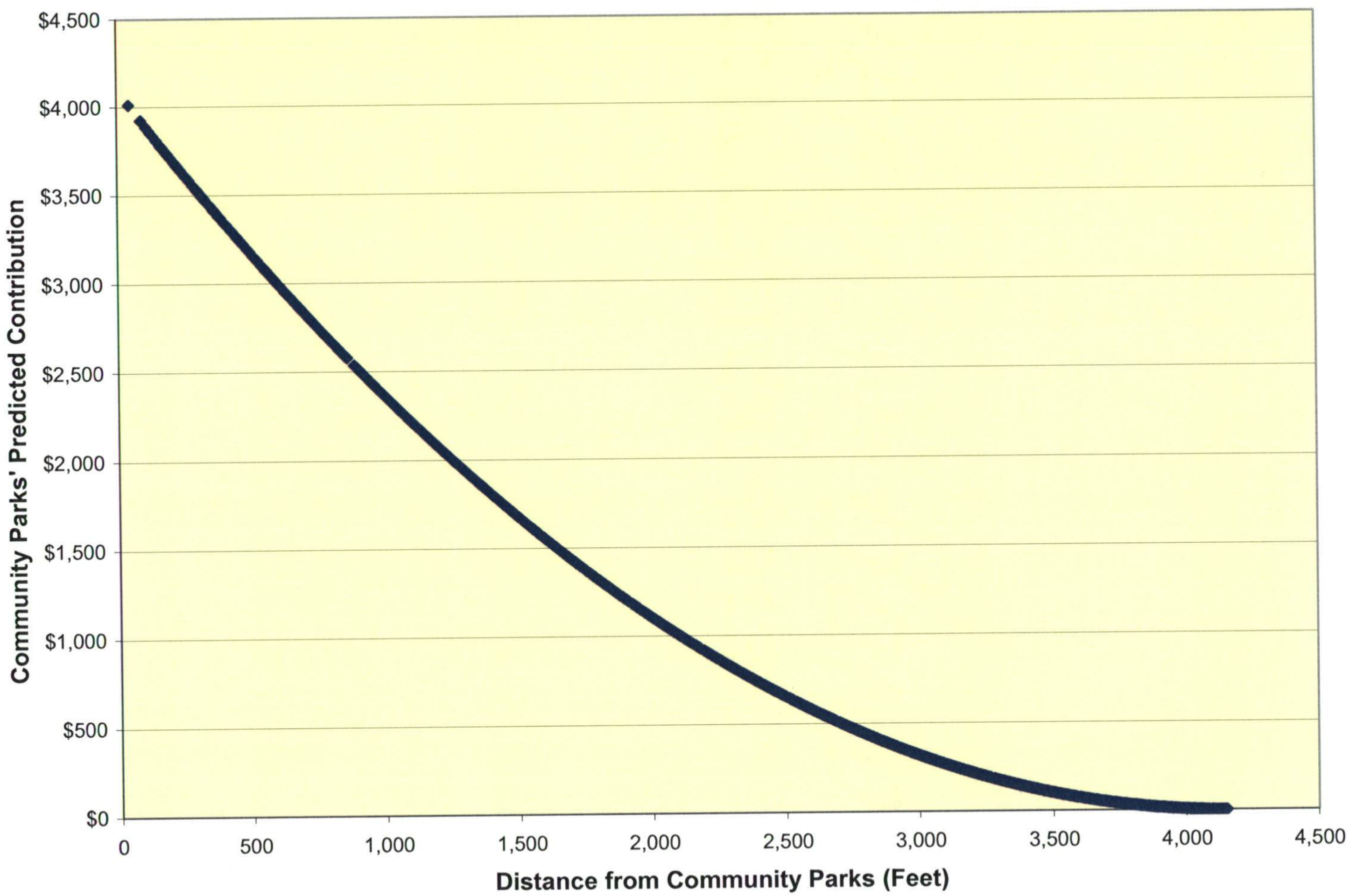
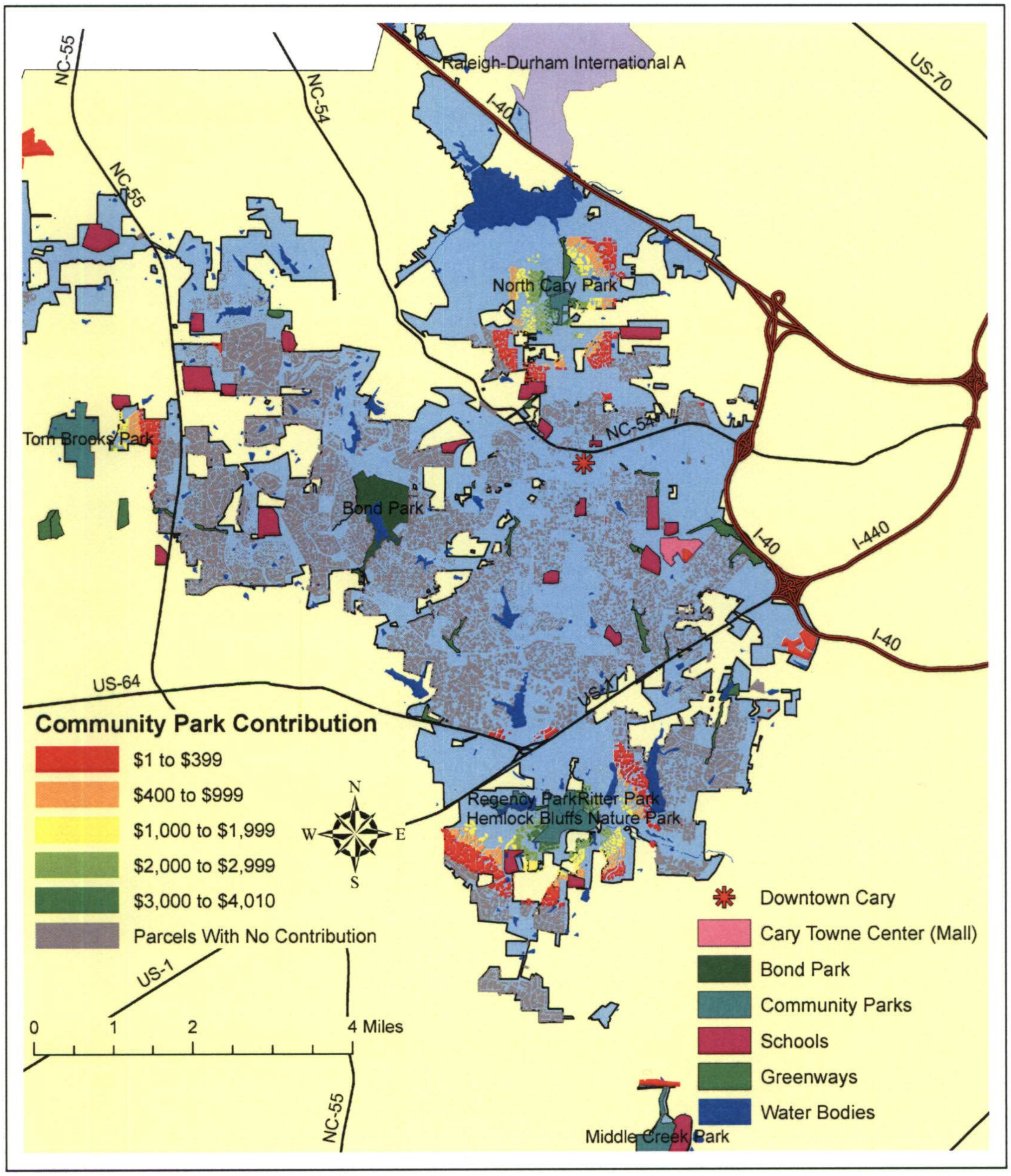
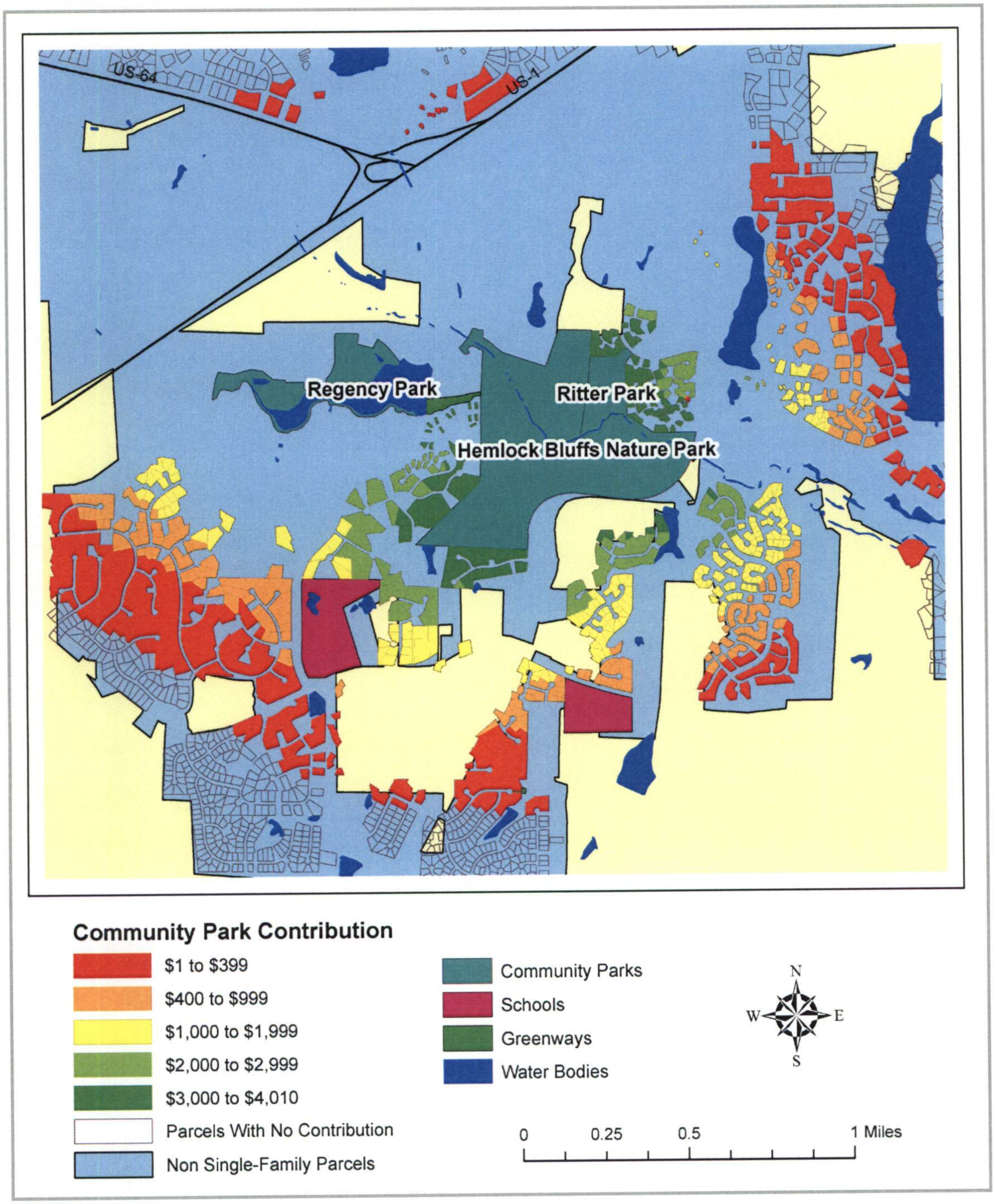


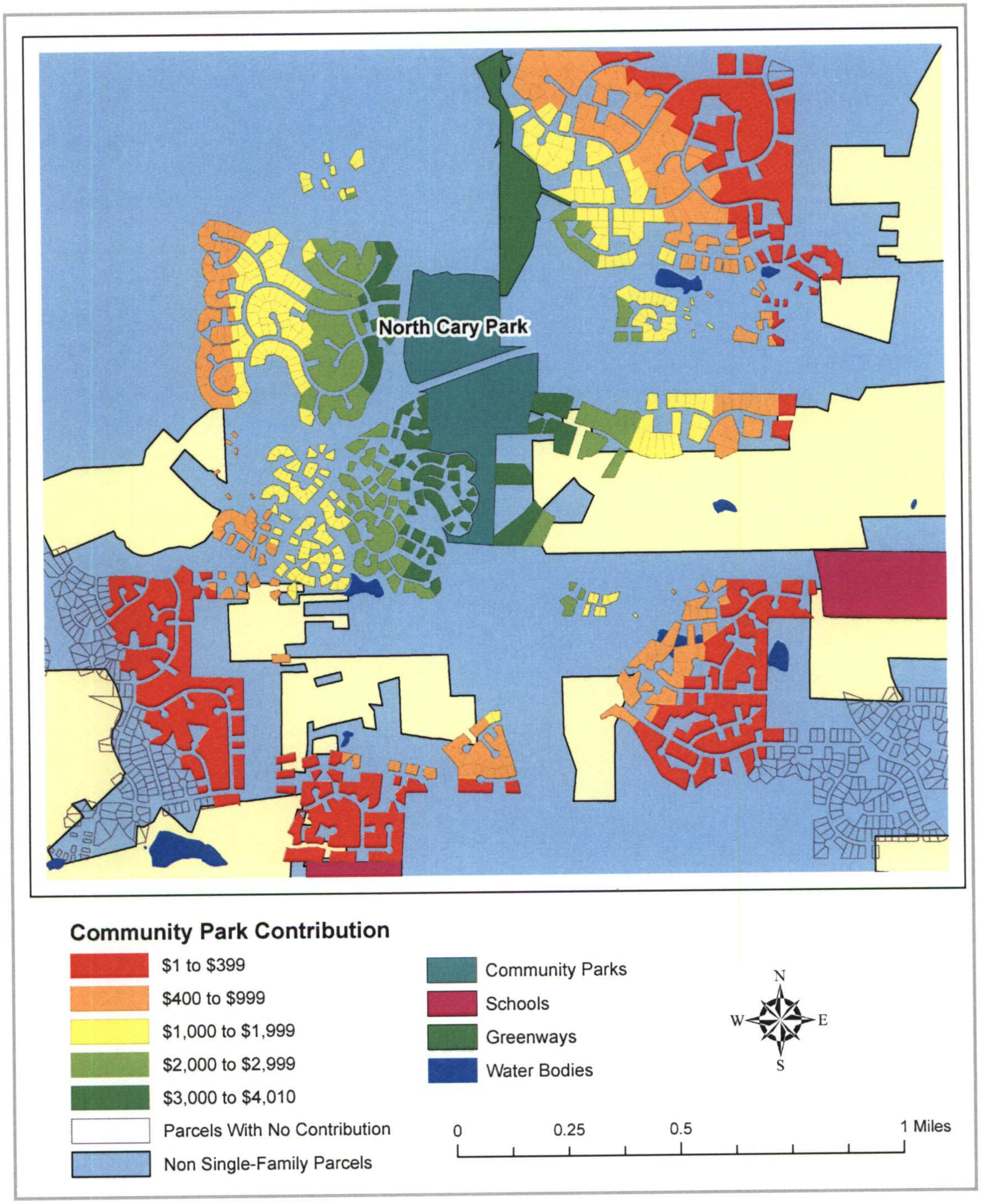

Figure 5. Community Parks' Predicted Contribution to Single-Family Parcel Value




Map 6. Community Parks' Contribution to Single-Family Parcel Values




Map 7. Regency, Ritter, and Hemlock Bluffs Contribution to Single-Family Parcel Values




Map 8. North Cary Park Contribution to Single-Family Parcel Values

The resulting distance decay function makes logical sense, as these are primarily an "active" as opposed to "passive" form of park. The benefit derived proximity to these parks, although, present does not nearly match the contribution due to the much larger Bond Park. Athletic fields create traffic and noise as well as music events at an amphitheater. Lights from ball fields act as a disturbance as well. It is important to note, however, that even with these negative side effects, these parks do not have an adverse effect on proximate property values. As a result of the "active" characteristics of these parks, property values do not capture large benefits resulting in proximity. A willingness to pay survey of the users, however, would provide a picture of what benefit derives from the actual users of these facilities and not just proximate properties that see both these positive and negative characteristics.

Here again an aggregation of benefits over all the parcels in the observation set yields a total capitalization benefit to proximate parcels occurring due to the provision of these amenities. Summing the individual predicted benefits according to the parcels' distance from the park results in predicted total aggregate benefit of $3,123,758 for the provision of these community parks. The realized capital from these community parks is much less than that of the contribution realized in land values from Bond Park.

## Schools

Schools often provide benefits such as athletic fields or other facilities. In addition, being within a short walking distance from schools can cut down on parents' time taking them or picking them up from school or other extracurricular activities. With these uses in mind an observation set of parcels within one mile distance from the schools was chosen resulting in 14,934 observations. Table 5 shows the independent variables, their coefficients, t statistics, and significance for Model 3. The R squared for the model indicates that the independent variables explain almost 86 percent of the variation in the dependent variable of adjusted sale value.

Table 5. Model 3 Coefficients and Significance

| | *Coefficients* | *t Stat* | *95% Sig.* | *90% Sig.* |
|---|---|---|---|---|
| Intercept | -1307777.668 | -10.9482 | yes | yes |
| YEAR_BUILT | 534.5493035 | 8.901933 | yes | yes |
| HEATED_ARE | 64.77353979 | 82.16522 | yes | yes |
| ACRES | 30411.12903 | 12.51201 | yes | yes |
| PERCENT_BA | -84.61563732 | -1.51684 | no | no |
| BRICK_STON | 11808.68568 | 8.262367 | yes | yes |
| MED_AGE | -113.4577082 | -0.79231 | no | no |
| PER_RENT | 208.1295948 | 5.129965 | yes | yes |
| HH_SQ_MI | -7.389794521 | -5.74676 | yes | yes |
| GRADE | 2651.302748 | 98.87661 | yes | yes |
| SCHOOLS_DI | -4.077348044 | -3.10566 | yes | yes |
| SCHOOLS_DI_SQ | 0.000850102 | 3.639123 | yes | yes |
| DWNTN_CARY | -0.631950031 | -2.43575 | yes | yes |
| DWNTN_RAL_ | -0.143247002 | -0.82697 | no | no |
| AIRPORT_DI | 0.298276724 | 2.67261 | yes | yes |
| MALL_DIST | 0.712295464 | 2.283721 | yes | yes |

Most of the coefficients in this model are both statistically significant and intuitive. A house one year newer than another house will have a premium of $534. One additional square foot of structure area contributes $64 to a parcel's value. A one acre increase in parcel size will result in an increase in sale price of $30,411. A brick or stone exterior will put a premium of $11,808 on a house. It is interesting to note, however, although the median age and percent Bachelor's variables are insignificant the coefficients indicate that an increase in either of the variables would result in a decrease in sale value of the parcel. In addition, once again the percent of occupied housing rented variable is positive indicating that a greater rental rate would improve a parcel's value.

Model 3 also indicates a statistical significance for both the school and school squared variables. As with Models 2 and 3, the contributions due to schools were found in a similar manner. First, the value change *ceteris paribus* for distance from schools was obtained using the means of the independent variables in the model. As with community parks the model would indicate an increasing value with distance at a specified distance from the school. Since this does not make sense economically, we assume that there is no significant contribution beyond that specified distance. As with Model 2, to find this distance we find the first derivative of the model and then solving for distance (*d*):

$$R = \alpha + -4.077348044(d) + 0.000850102(d^2)$$

$$(dy/dx)\, R = (dy/dx)\ [\alpha + -4.077348044(d) + 0.000850102(d^2)]$$

$$0 = -4.077348044 + 2*(0.000850102)\, d$$

$$4.077348044 = 2*(0.000850102)\, d$$

$$d = 2{,}398.153$$

Thus the distance beyond which there is no significant contribution due to proximity to schools is 2,398 feet or about one half mile. Figure 6 shows the change in mean parcel value with distance from a school. Subtracting the mean parcel value at 2,398 feet from a school from each of the mean parcel values in the observation set according to distance from the school would yield the contribution due to proximity to a school. Figure 7 graphically demonstrates the predicted contribution to proximate parcels to a school.

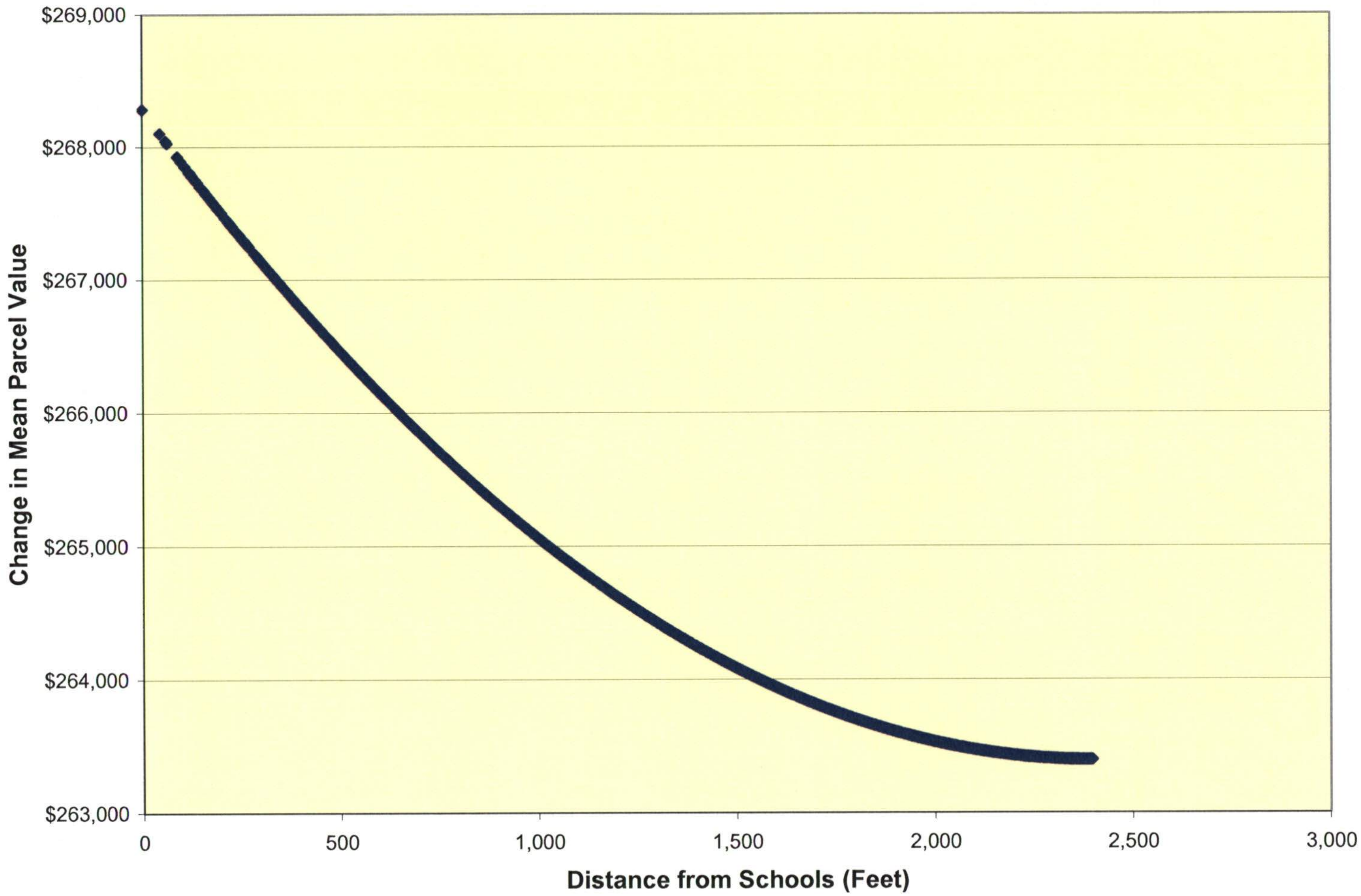



Figure 6. Change in Mean Parcel Value with Distance from School

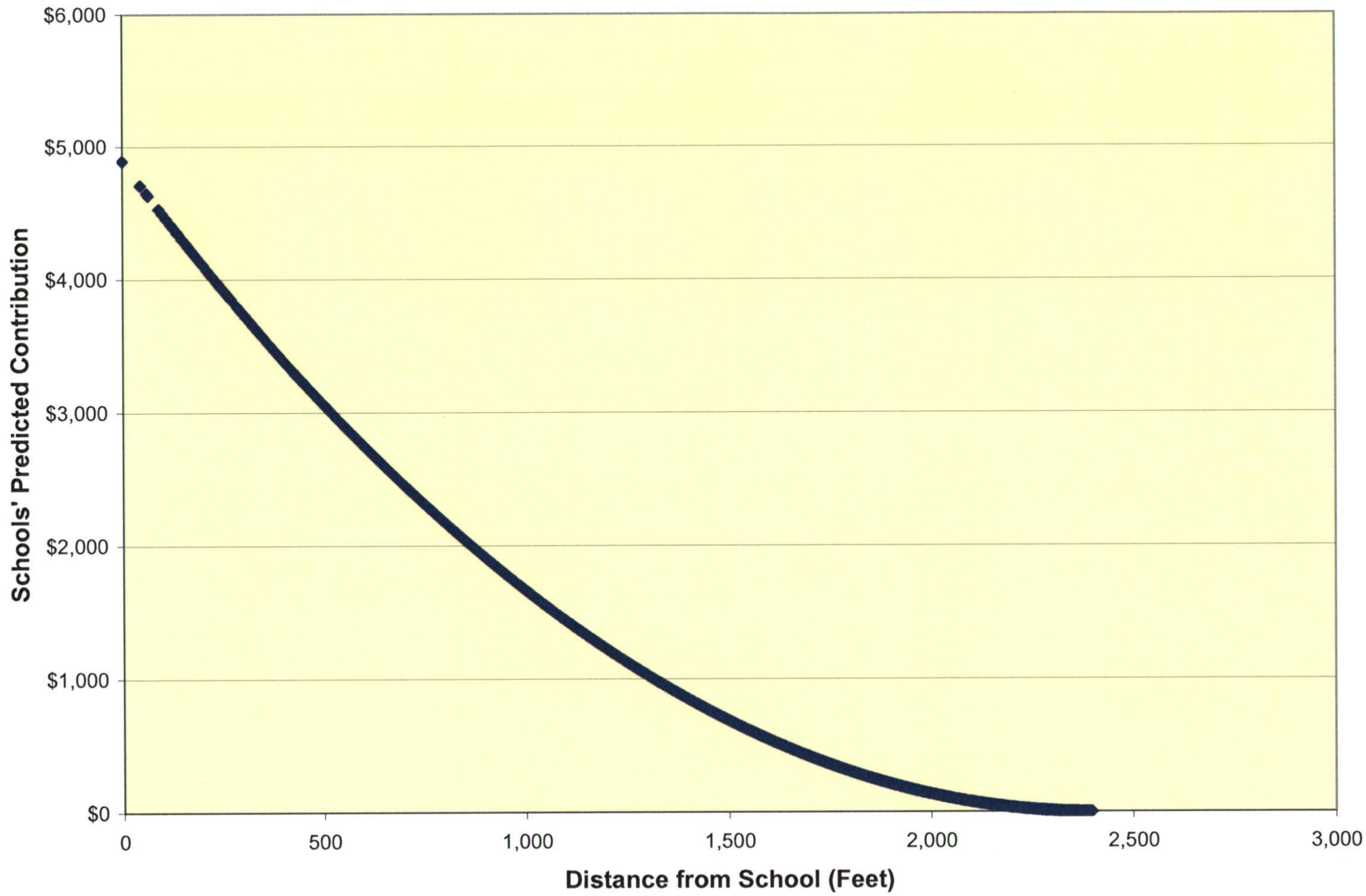
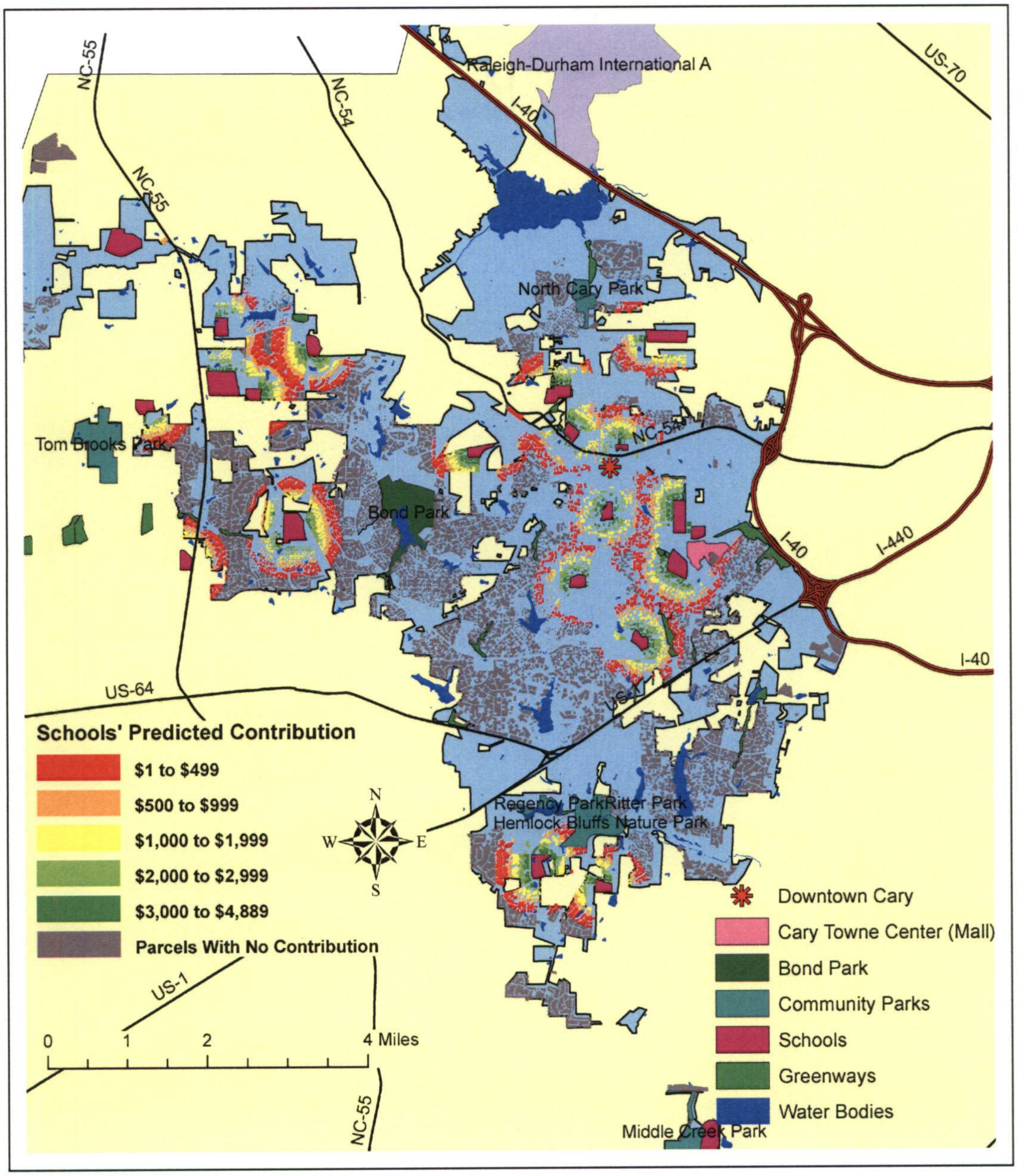



Figure 7. Schools' Predicted Contribution to Parcel Values

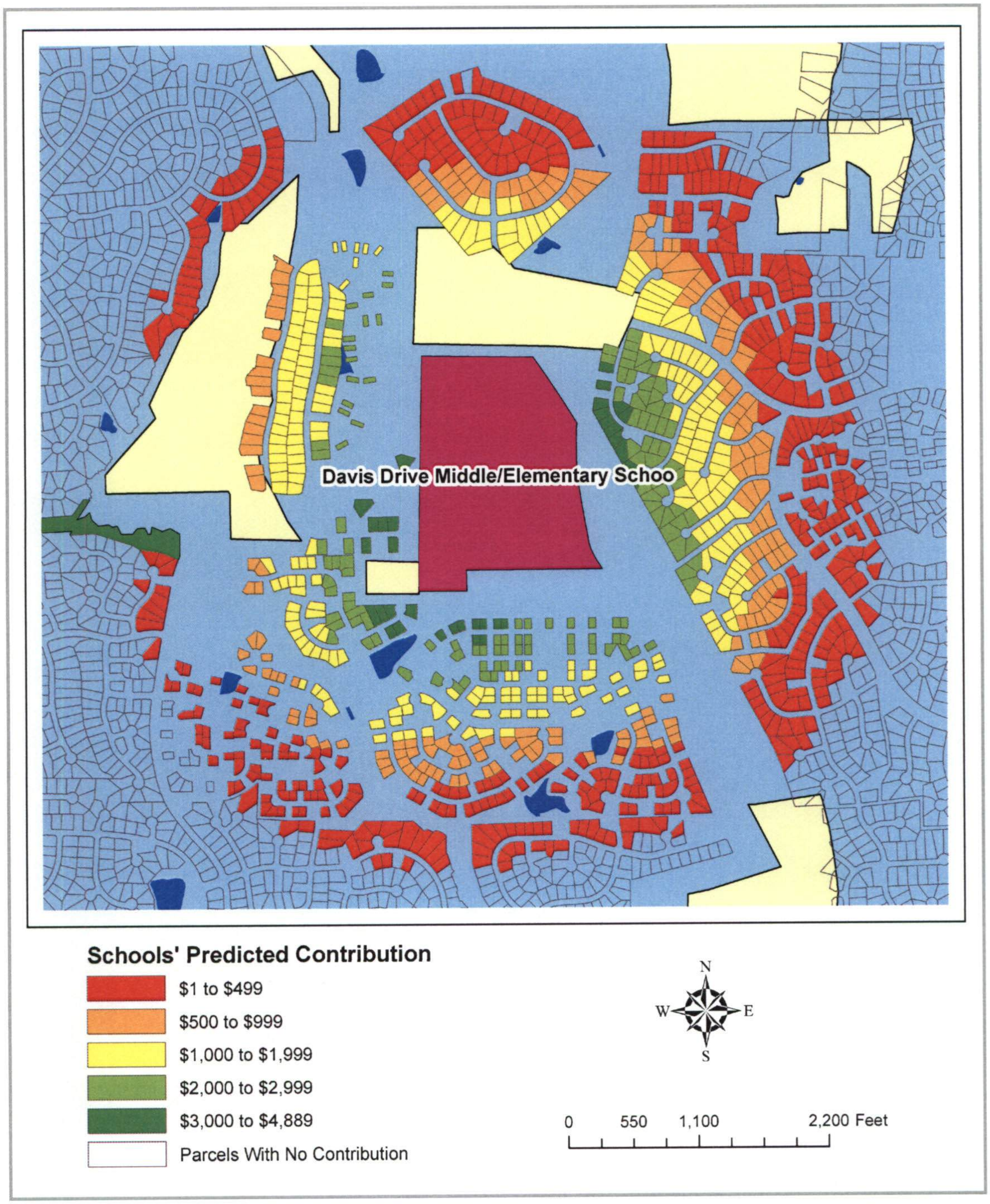
As with community parks, the function for schools indicates that there is a diminishing marginal rate of return for proximity to a school. As a result, a small change in a parcel's distance closer to the school yields a greater change in contribution than a similar change in distance farther from the school. The distance of a half mile beyond which contributions are insignificant is less than that of both Bond Park and community parks. This would make sense due to the fact that many elementary school children will not be walking to school greater than a half mile away from their home.

Here again as with Models 1 and 2, a spatial display of these contributions was obtained through GIS using the Real Estate Identification numbers. Map 9 shows the spatial distribution of the contribution to proximate single-family parcels for all schools in Cary. Map 10 displays a closer look at the contribution to surrounding parcels of Davis Drive Elementary and Middle schools.

As with the previous two models the total benefit capitalized into land values can be found by summing the predicted contributions of each observation. The total aggregate contribution of school proximity is $7,251,977. This number is greater than that of community parks due to the greater number observations as a result of the number of existing schools within Cary. This aggregate total still does not come close to match the capitalization in value due to the presence of Bond Park as a community amenity.  These figures, however, do not capture the primary benefits of schools, only the benefits of being within a proximate distance of a school.




Map 9. Schools' Contribution to Single-Family Parcel Values




Map 10. Schools' Contribution to Single-Family Parcel Values (Example)

## Greenways

Cary's Greenways provide multiple biking, walking, or jogging opportunities. Most all of the greenways are paved and run along stream basins, floodplains, and utility easements. These amenities provide for increased recreational opportunities for those within proximate distance from these greenways. Since greenways will most likely have an effect on those parcels directly proximate to properties an observation set was chosen with those parcels within 115 feet of a greenway resulting in a set of 145 observations. Table 6 shows the variables, coefficients, t statistics, and significance for Model 4. With an R squared of .87 the model explains eighty-seven percent of the variation of the dependent variable.

Table 6. Model 4 Coefficients and Significance

| | *Coefficients* | *t Stat* | *95% Sig.* | *90% Sig.* |
|---|---|---|---|---|
| Intercept | 1344724.129 | 0.850554 | no | no |
| YEAR_BUILT | -667.0980255 | -0.83517 | no | no |
| HEATED_ARE | 56.205342 | 9.808994 | yes | yes |
| ACRES | 8238.106564 | 0.264394 | no | no |
| PERCENT_BA | -256.6977015 | -0.51415 | no | no |
| BRICK_STON | -23888.52204 | -1.88357 | no | yes |
| MED_AGE | -370.3209327 | -0.14014 | no | no |
| PER_RENT | -1176.558093 | -2.27621 | yes | yes |
| HH_SQ_MI | -21.42036409 | -1.25913 | no | no |
| GRADE | 2534.061476 | 8.347482 | yes | yes |
| GREENWAY_D | -166.2737693 | -1.3675 | no | no |
| DWNTN_CARY | -0.93295193 | -0.46202 | no | no |
| DWNTN_RAL_ | -3.175124288 | -1.84529 | no | no |
| AIRPORT_DI | -0.615735415 | -0.37905 | no | no |
| MALL_DIST | 3.55902364 | 1.208909 | no | no |

As a result of so few observations in the data set few of the variables proved to show statistical significance. The only statistically significant variables for this model were the heated square footage, percent occupied housing rented, and the structure assessment grade. All other variables including the greenway distance variable were statistically insignificant. The coefficient did indicate, however, a contribution of $166 for every foot closer in proximity to a greenway.

Due to the many variables statistical insignificance in Model 4 an additional model was developed in an effort to determine the significance of greenways on proximate property values. This model included the entire modified observation set of 20,194 single-family residential parcels. A dummy variable was created for greenway proximity where "1" indicated a parcel within 115 feet of a greenway while a "0" indicated a parcel outside that range. Table 7 indicates the variables, coefficients, t statistics, and significances for Model 5.

Table 7. Model 5 Coefficients and Significance

| | *Coefficients* | *t Stat* | *95% Sig.* | *90% Sig.* |
|---|---|---|---|---|
| Intercept | -1696425.424 | 0.850554376 | no | no |
| YEAR_BUILT | 691.9035611 | -0.835169333 | no | no |
| HEATED_ARE | 63.77877319 | 9.808994413 | yes | yes |
| ACRES | 57589.27451 | 0.264394143 | no | no |
| PERCENT_BA | 247.4154728 | -0.514146436 | no | no |
| BRICK_STON | 8529.126192 | -1.883570733 | no | yes |
| MED_AGE | 390.6805542 | -0.14014444 | no | no |
| PER_RENT | 266.3517137 | -2.276210422 | yes | yes |
| HH_SQ_MI | -5.919576553 | -1.259128445 | no | no |
| GRADE | 2623.863582 | 8.347482182 | yes | yes |
| GREENWAY_D | -3249.843459 | -1.36750411 | no | no |
| DWNTN_CARY | -0.509493041 | -0.462024393 | no | no |
| DWNTN_RAL_ | 0.664064544 | -1.845285268 | no | yes |
| AIRPORT_DI | 0.382340545 | -0.379050928 | no | no |
| MALL_DIST | -0.404637768 | 1.208908813 | no | no |

The resulting significance indicates many more significant variables than those in Model 4. However, the coefficient for the greenway dummy variable indicates a large negative coefficient. This coefficient indicates that a house within 115 feet from a greenway has a negative premium of $3,250 compared to parcels not within that 115 ft. range. This seems to indicate that the greenways have a negative effect on proximate properties. Here again, however, this variable is statistically insignificant.

From both these models little can be gleaned as to the actual contribution, positive or negative that greenways have on proximate property values in Cary. These statistics may be an indication that there are counteracting positive and negative effects of greenways. These characteristics include the quality of land on which the greenways are built (i.e. floodplain, easement, etc.) and the recreational availability as well. It could very well be the case that proximity to greenways has a negative effect on property values but not due to the greenways themselves but due to other negative characteristics of the land. In addition, greenways may actually contribute positively to proximate property values cutting the losses due to the other negative characteristics of the land. With the models in this study, however, these assumptions can not be proven to be accurate or not.

# CHAPTER VI

# CONCLUSIONS, IMPLICATIONS, AND FUTURE RESEARCH

## Conclusions and Implications

This thesis determined the parcel value contributions that occur as a result of proximity to certain public amenities including a large metropolitan park, community parks, schools, and greenways. The findings indicate that each amenity contributes to proximate parcels differently as a result of their type of use. The findings indicate that larger parks with more passive and aesthetic uses have a significantly greater contribution to proximate parcels than smaller parks or schools with primarily more active uses.

The contributory effects of these amenities are probably best indicated through their total aggregate contributions to parcels within the observation sets. The aggregate contribution due to Bond Park is a predicted $312,932,266. Community parks and schools total aggregate contributions to surrounding single-family parcel values were significantly less at $3,123,758 and $7,251,977 respectively. Greenways were found to have no significant effect on property values and their contribution was indeterminate as well. Therefore, the greatest overall monetary benefit accrued to proximate parcels as a result of the major metropolitan park and its included amenities.

These conclusions have implications in both the government and household sectors. Households would benefit from knowing how amenities affect their property values. Governments could benefit by assessing property with accurate contributions die to amenities. In addition, decision-makers and policy-makers often times want to know the resulting implications of a given action or decision to expand existing or provide new facilities and amenities. The results of this study give a notion as to what benefits accrue and where they accrue due to the provision of certain amenities.

## Perspective of Results

Although the results of this thesis indicate some contribution to proximate parcels they must be taken in perspective of all other existing factors and conditions. Other monetary and non-monetary benefits of such provision should not be ignored by decision-makers. For example, the increased value to proximate properties not including the incremental increase in tax revenue is still a significant quantifiable benefit to residents. However, other benefits must be considered as well when making policy decisions. These benefits undoubtedly will include environmental, quality of life, and non-resident and tourist benefits.

Other costs may also exist, besides capital and operating costs of the parks that should be taken into consideration when determining costs versus benefits. These include the opportunity costs of park provision as opposed to alternative development. All in all the methodology of evaluation used in this thesis, although useful in identification of potential benefits to the fiscal budget of a jurisdiction, should be used by policy-makers in perspective of all existing factors and conditions within a local jurisdiction.

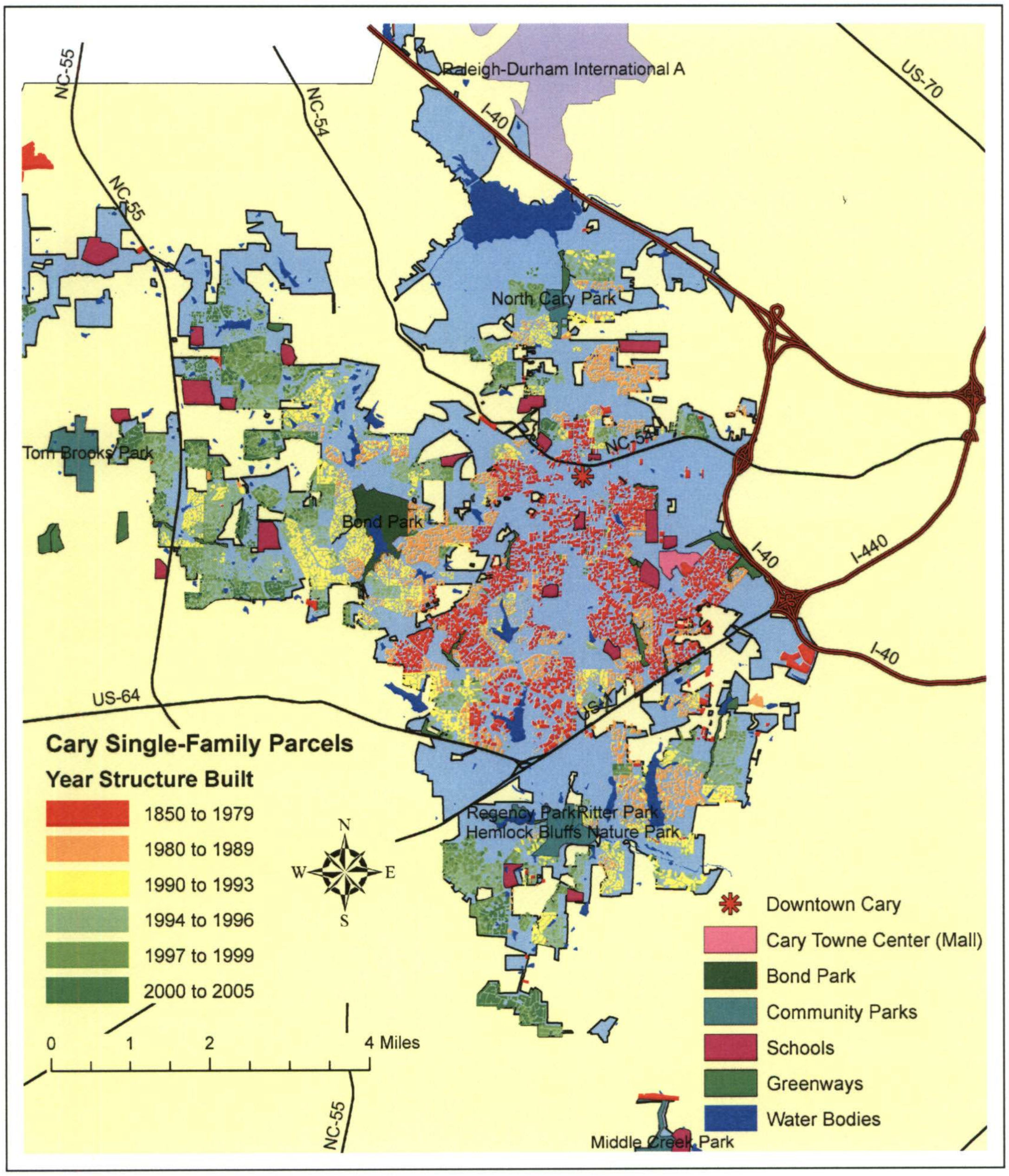
## Future Research

This research can be expanded in many ways through the development of additional research questions and application of the existing work by an existing government or appraisers. Following are additional research questions that may be addressed as well as applications for local government use.

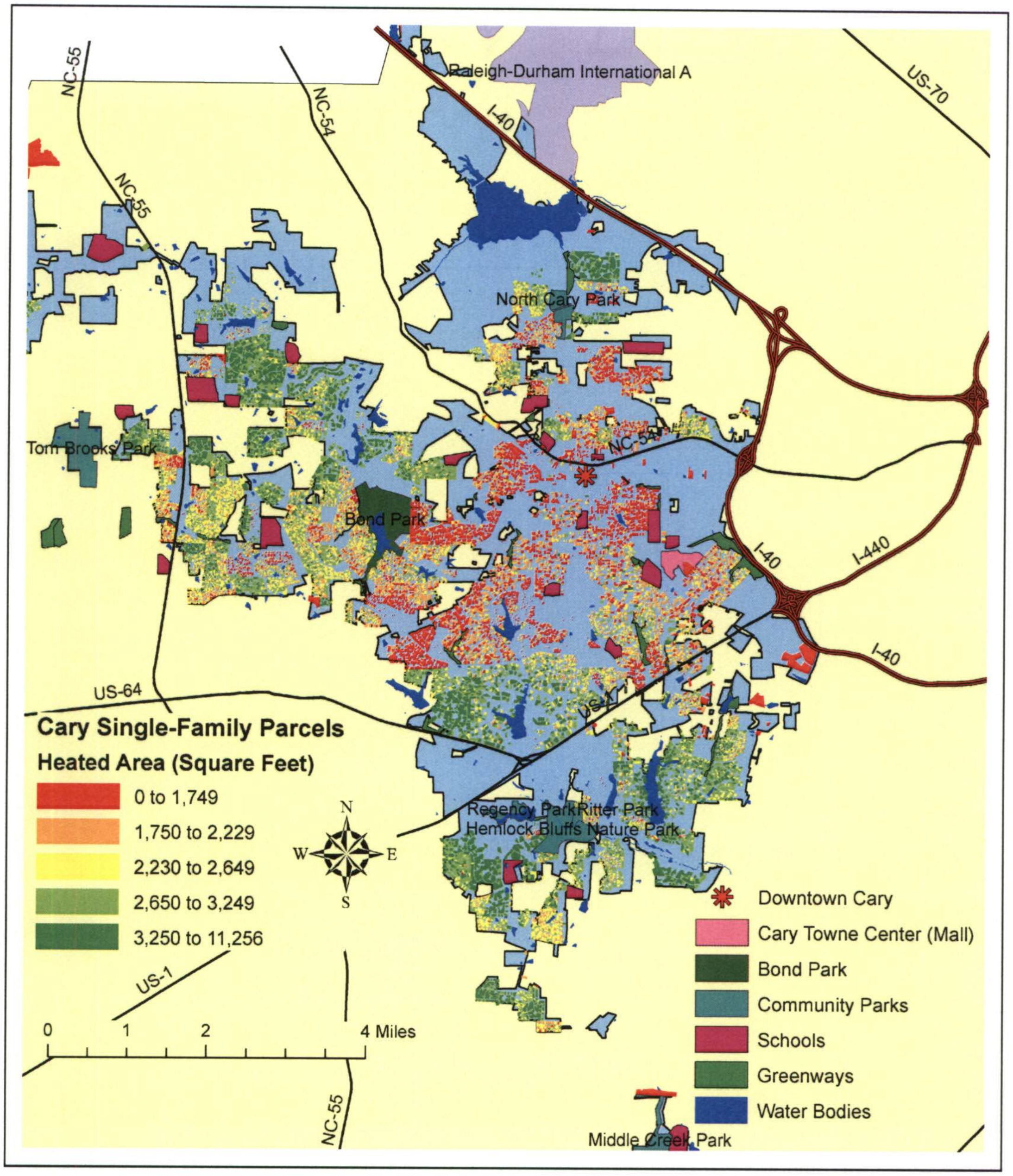
What are the costs incurred to residents and the community as a whole because of the public investment in parks, open space, and greenways? What opportunity costs exist in the development of these parks and greenways? In other words, what benefits could have been derived if the land were developed in another use? What mechanisms are available for municipalities and counties to recover the development costs of these investments?

The results of this study indicate local government officials can use this contribution information in determining the assessed values of properties. Maps 4 through 10 indicate display of specific contribution values for specific parcels due to the studied amenities. This will result inevitably in an incremental capture of revenue to the local jurisdiction due to the provision of this amenity. From the incremental increase in land value resulting from the provision of the park or other amenity, the increase in the tax base could be derived. A discounted revenue stream could then be constructed to determine the incremental tax flows. It could therefore be determined whether such an investment would be fiscally beneficial, as well as the pay-off time-frame, for the jurisdiction by comparing such increases in the tax base to the initial capital and ongoing operating costs of the amenities.

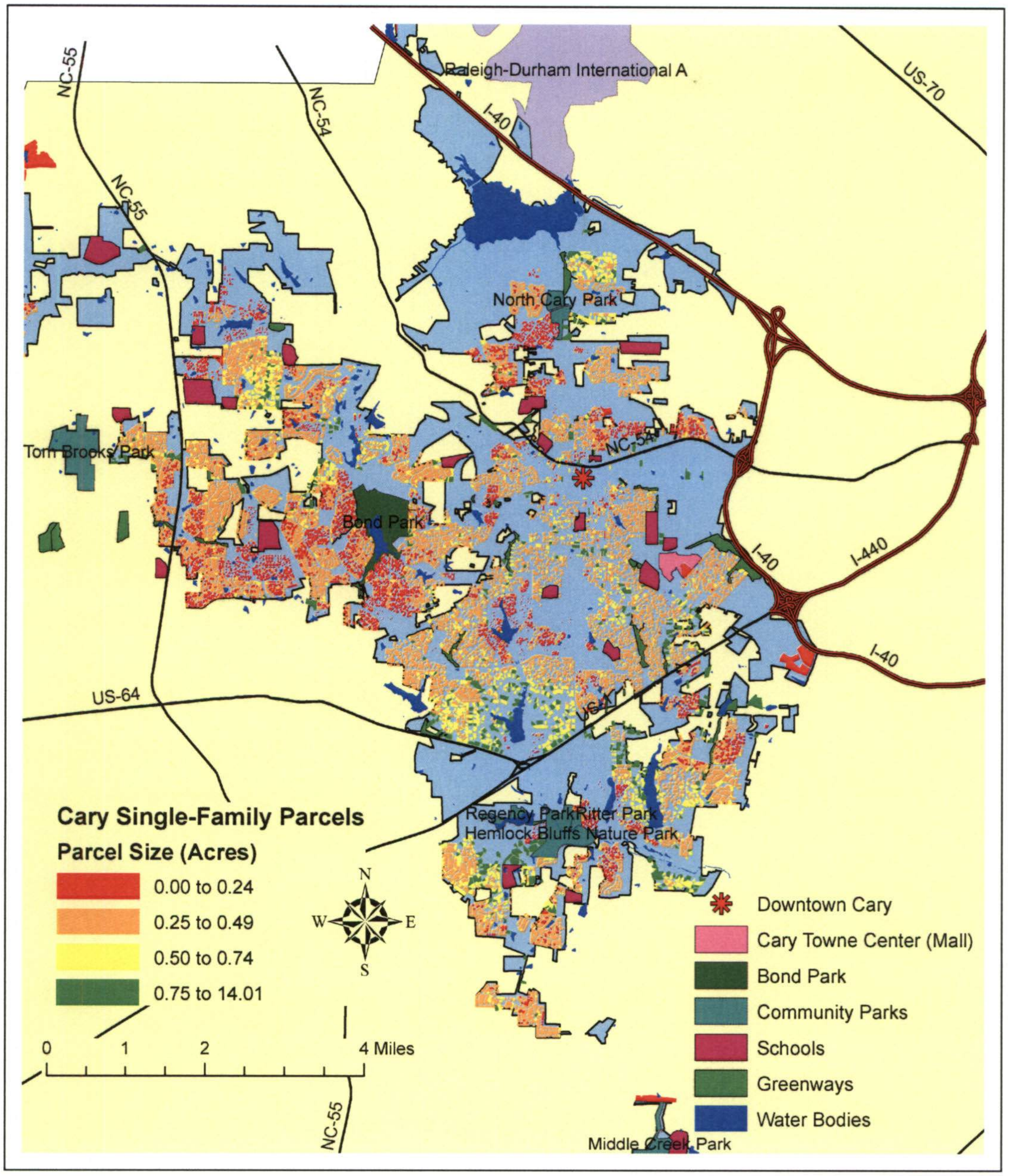
# APPENDIX



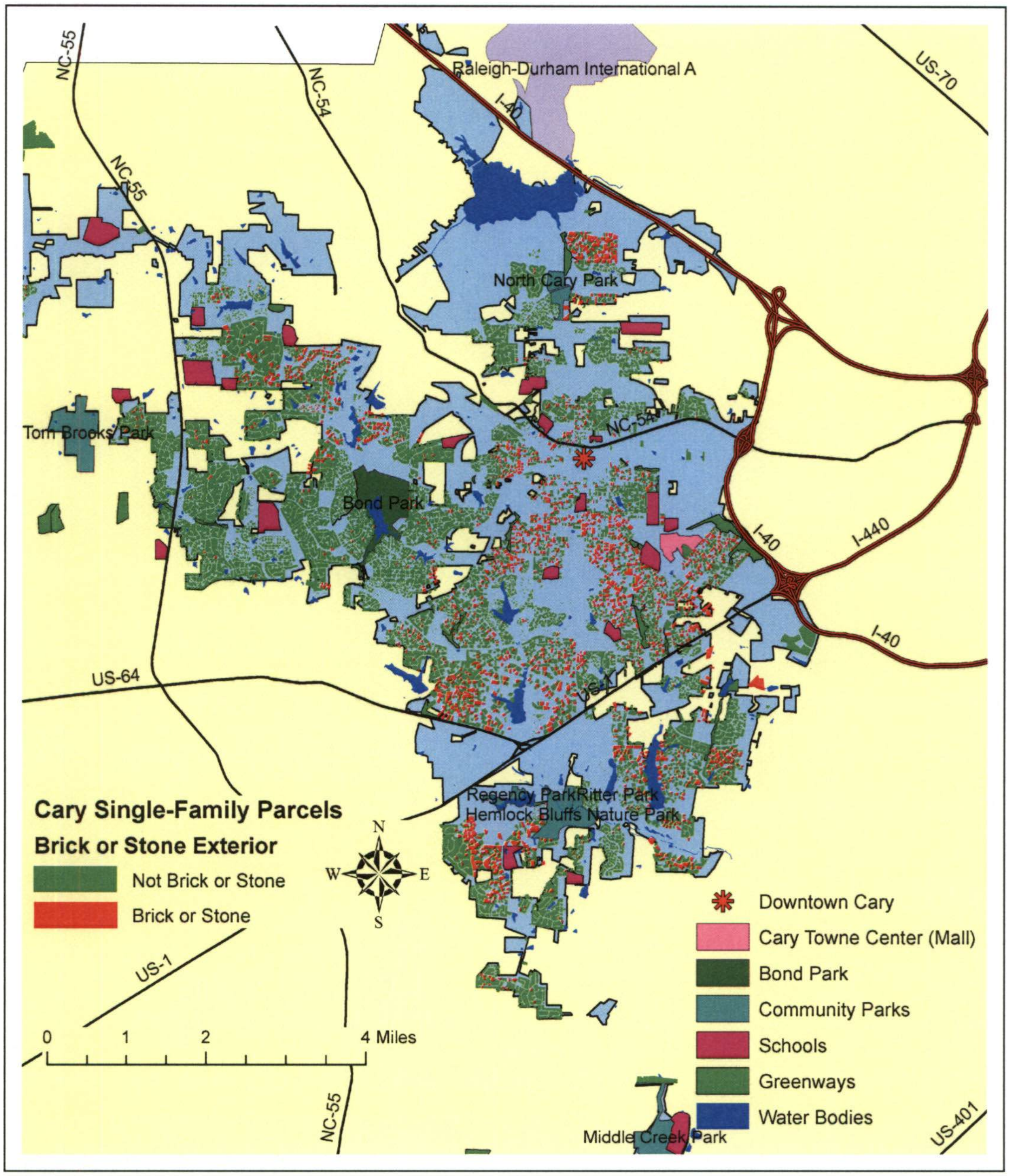

Map A-1. Year Structure Built for Cary Single-Family Parcels



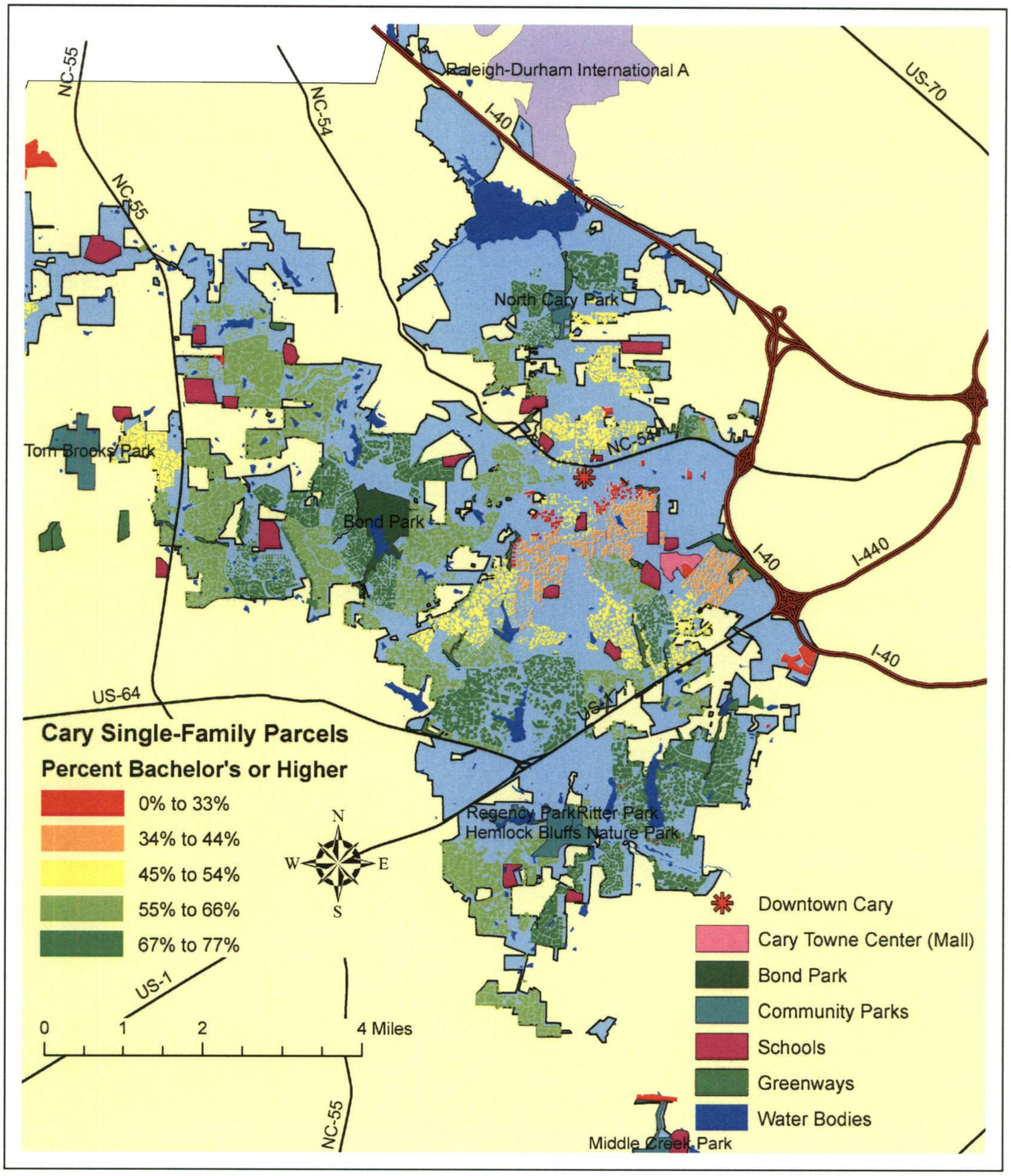

Map A-2. Heated Area of Structure for Cary Single-Family Parcels



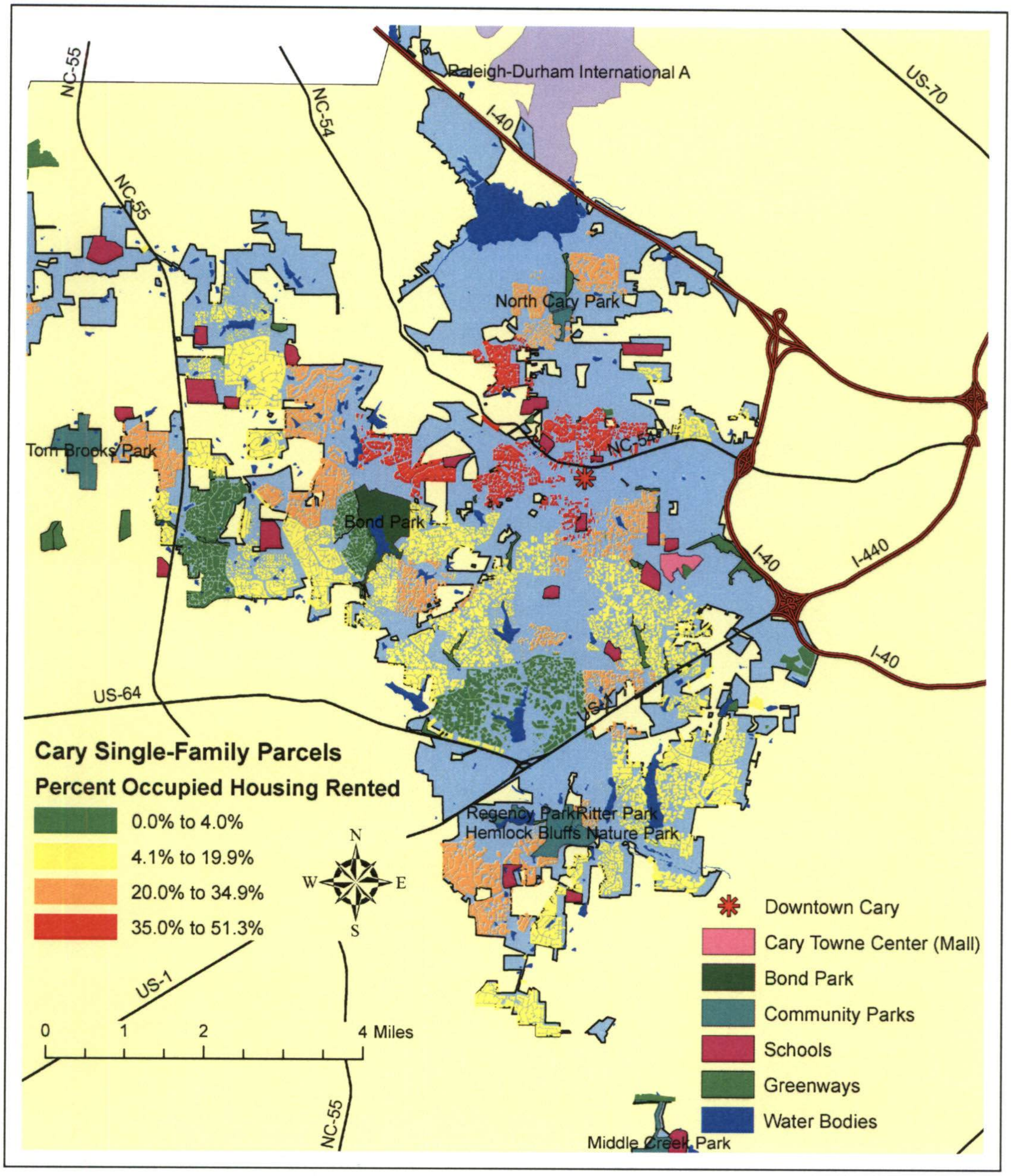

Map A-3. Single-Family Parcel Size (Acres)



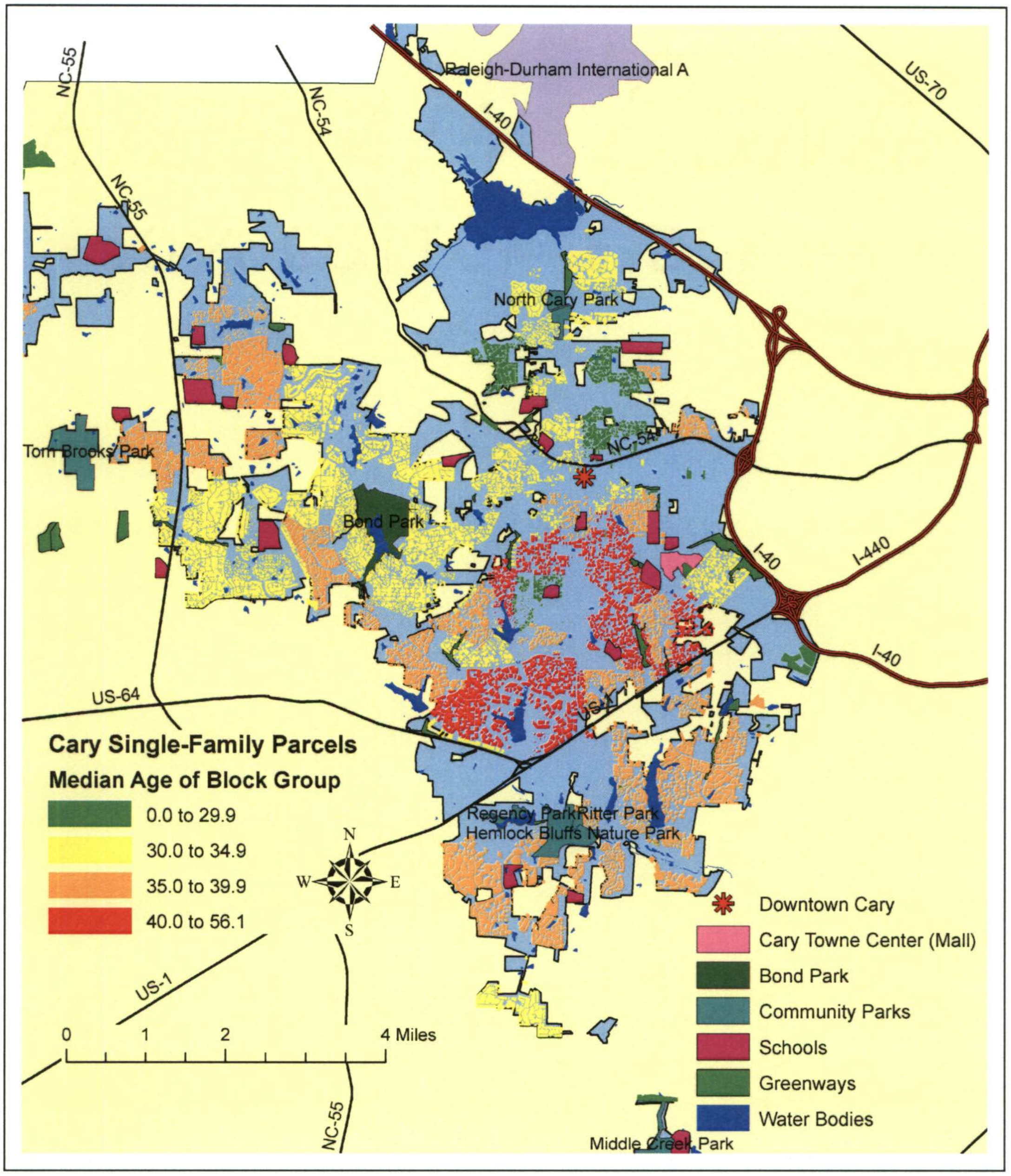

Map A-4. Brick or Stone Exteriors for Cary Single-Family Parcels



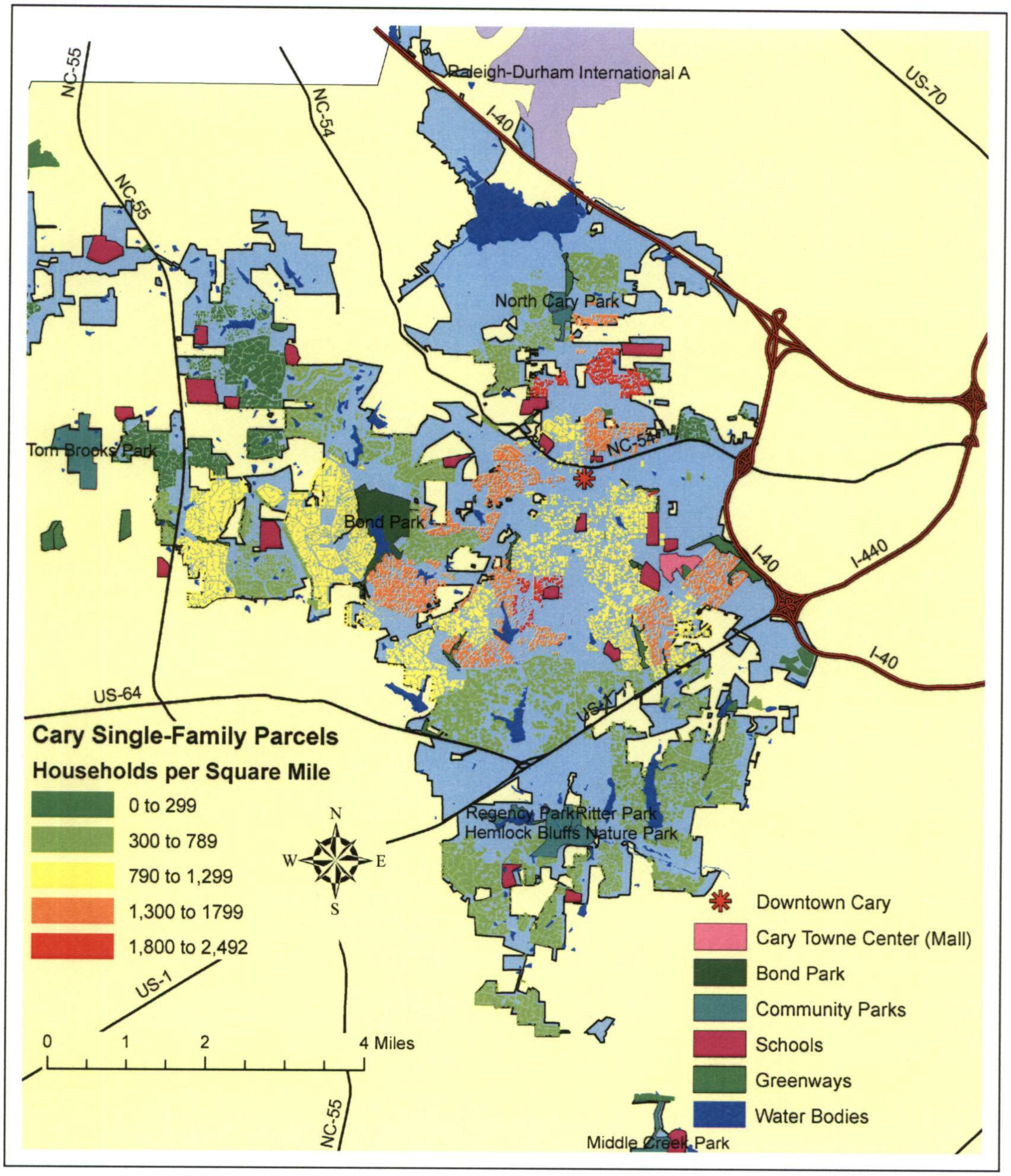

Map A-5. Percent Bachelor's Degree or Higher in Block Group



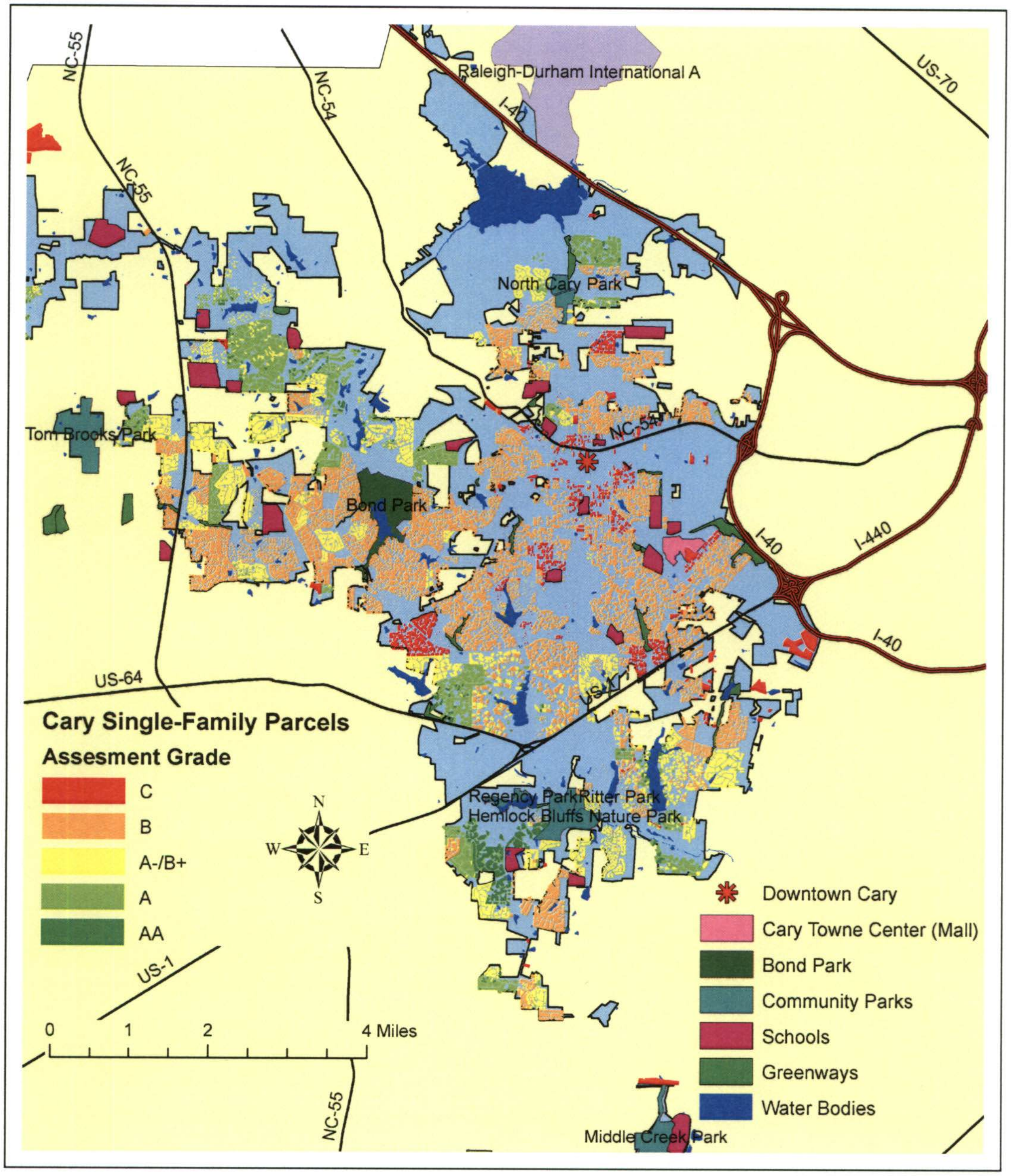

Map A-6. Percent of Occupied Housing Rented in Block Group



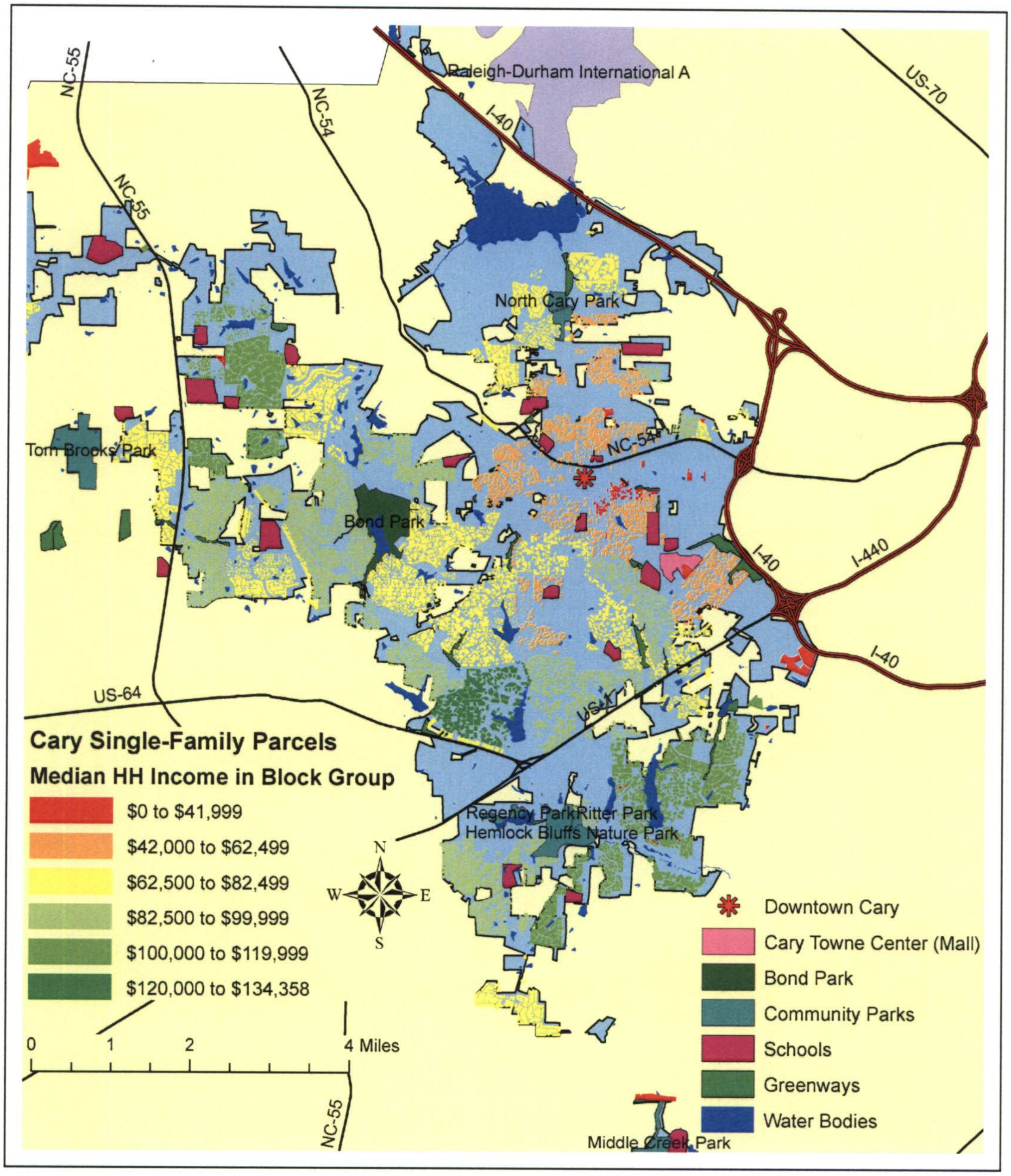

Map A-7. Median Age of Population in Block Group



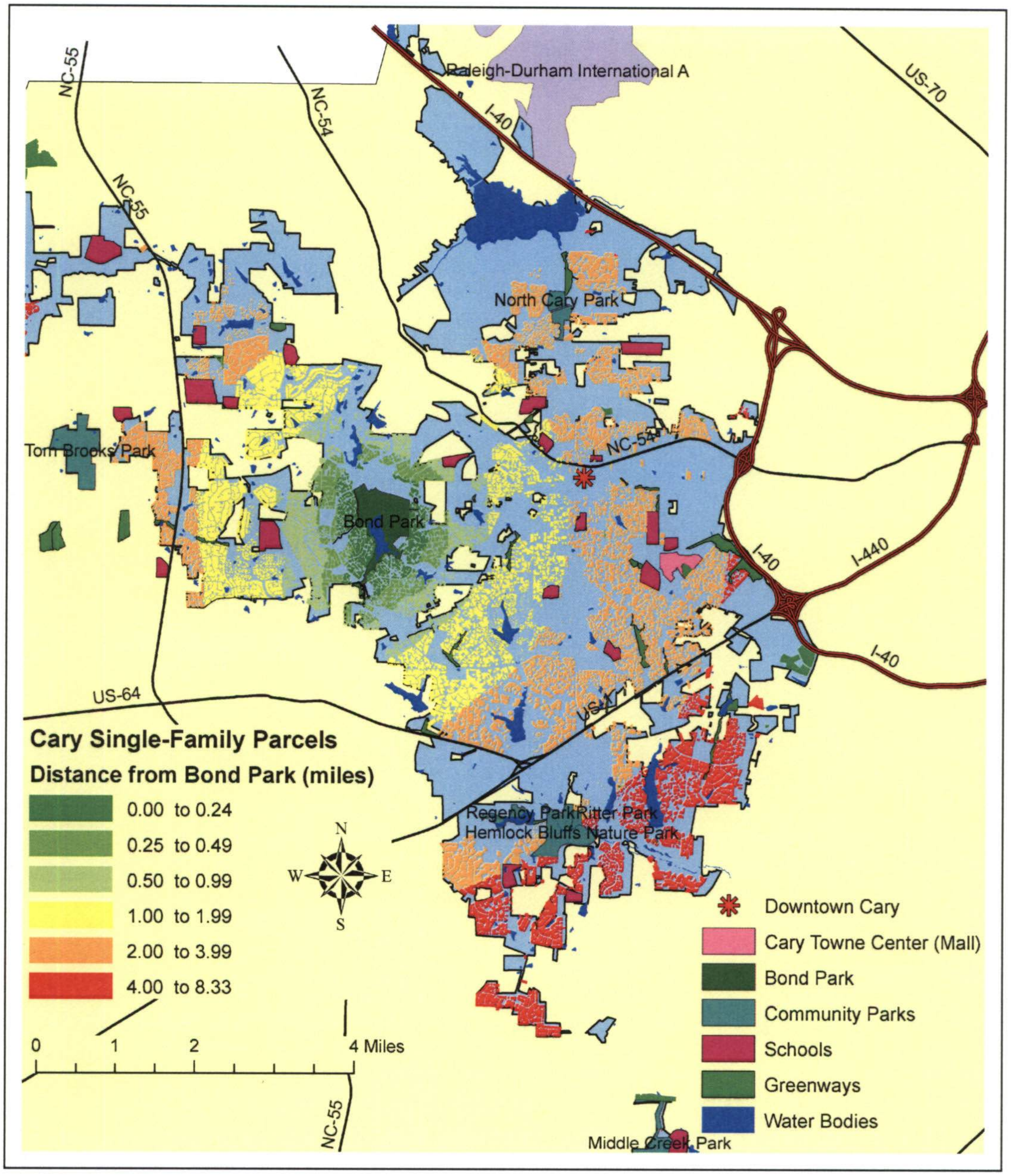

Map A-8. Households per Square Mile in Block Group



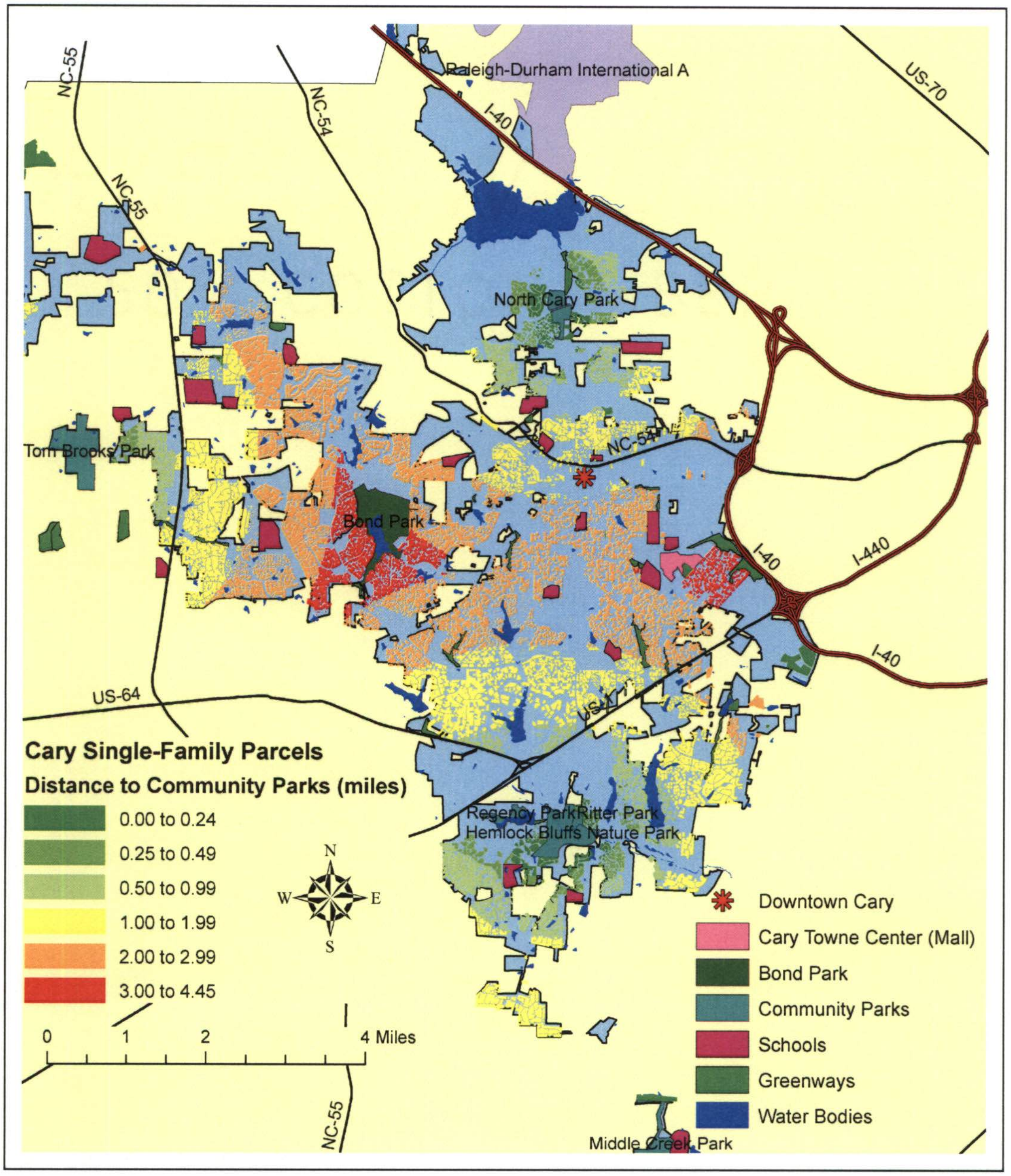

Map A-9. Assessment Grade for Cary Single-Family Parcels



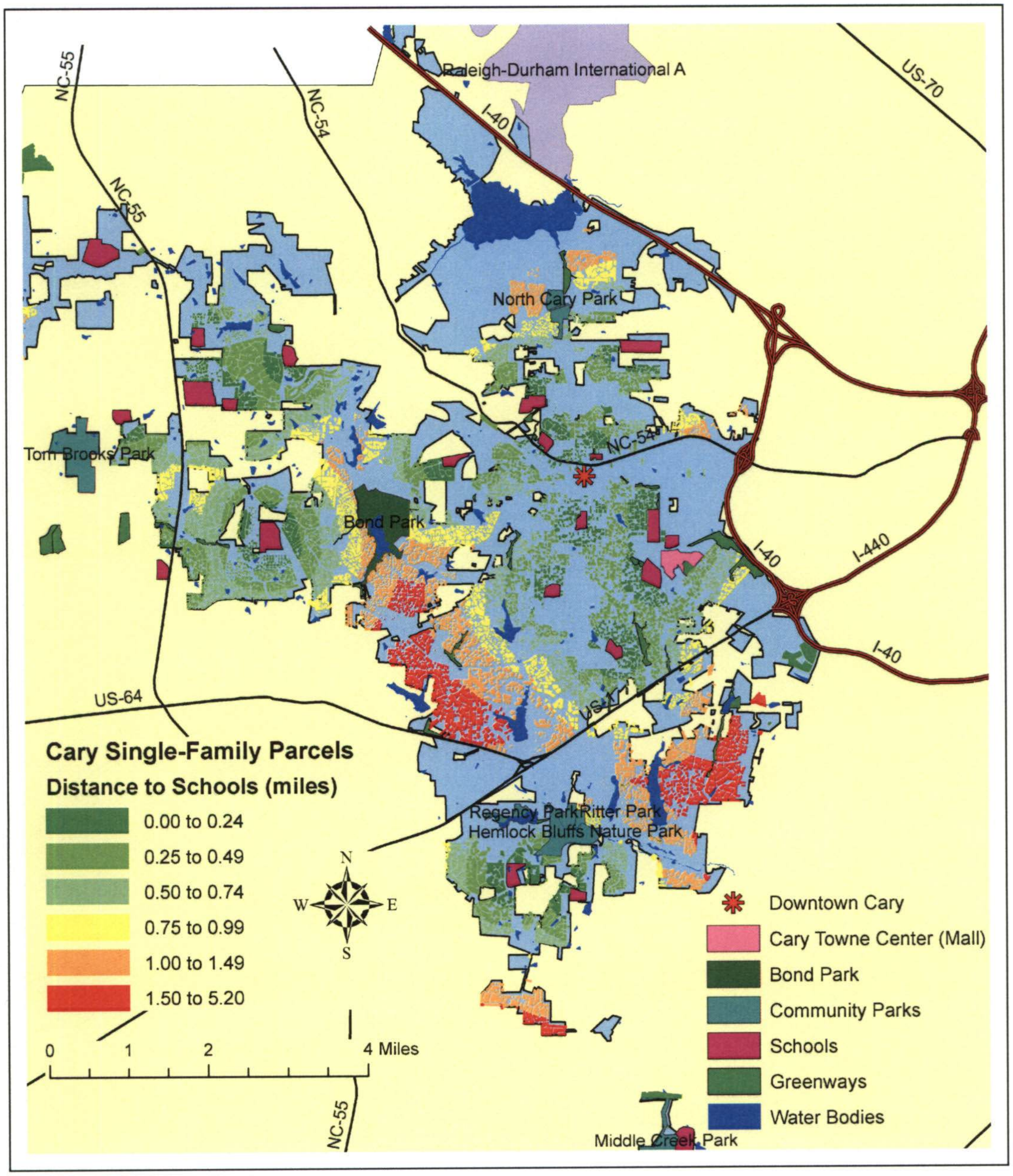

Map A-10. Median Household Income in Block Group



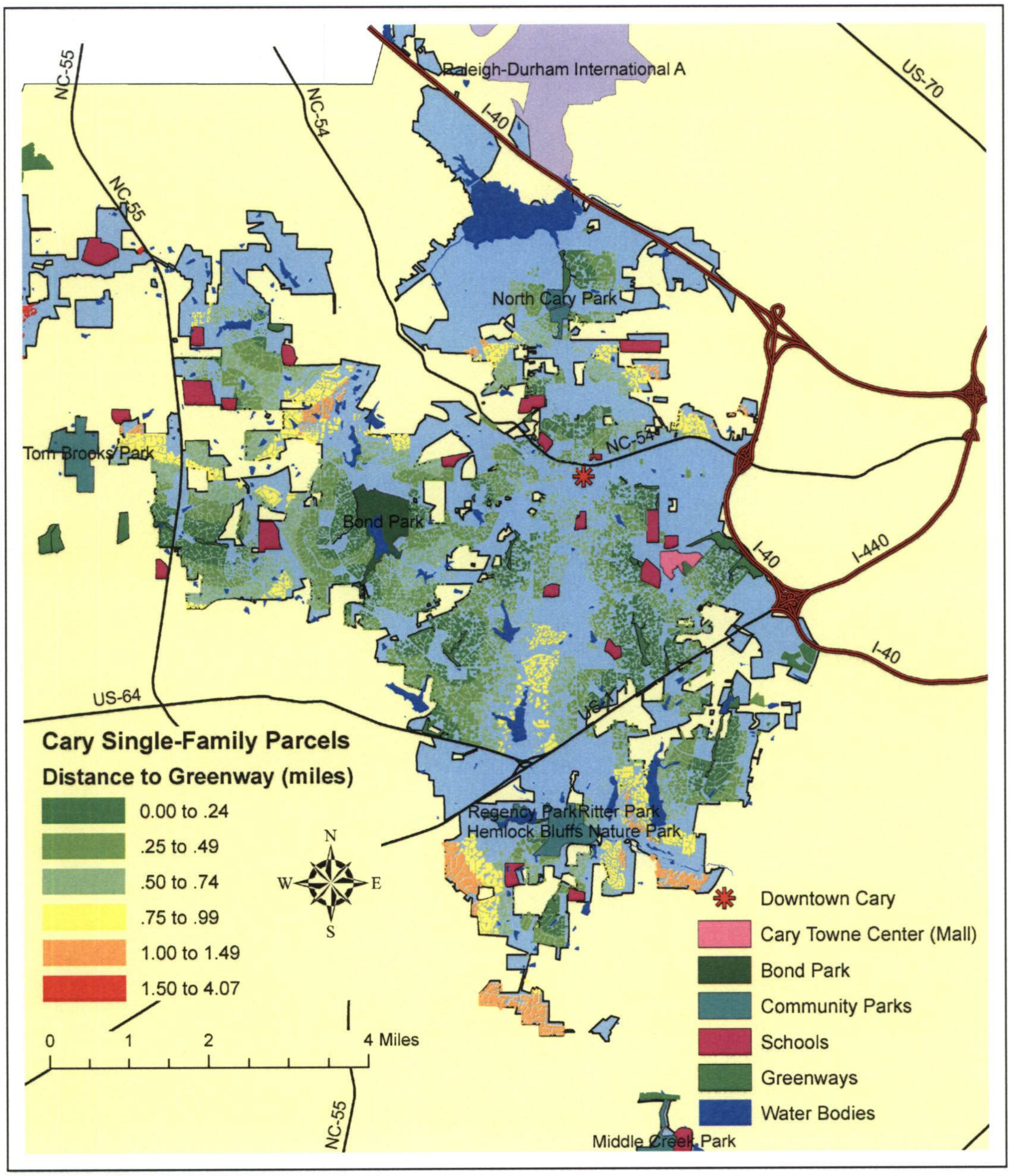

Map A-11. Distance to Bond Park in miles for Cary Single-Family Parcels



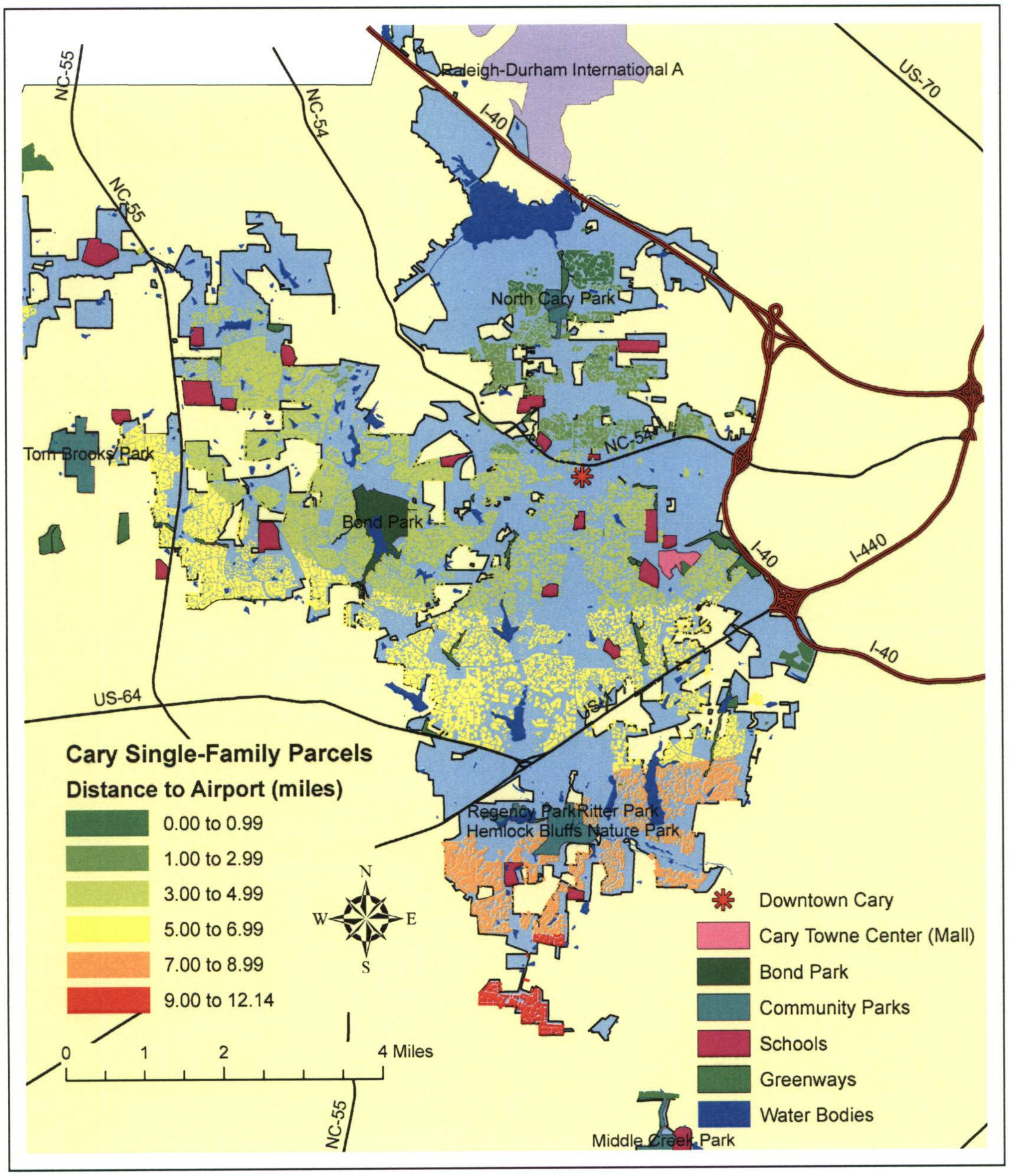

Map A-12. Distance to Community Parks in miles for Cary Single-Family Parcels



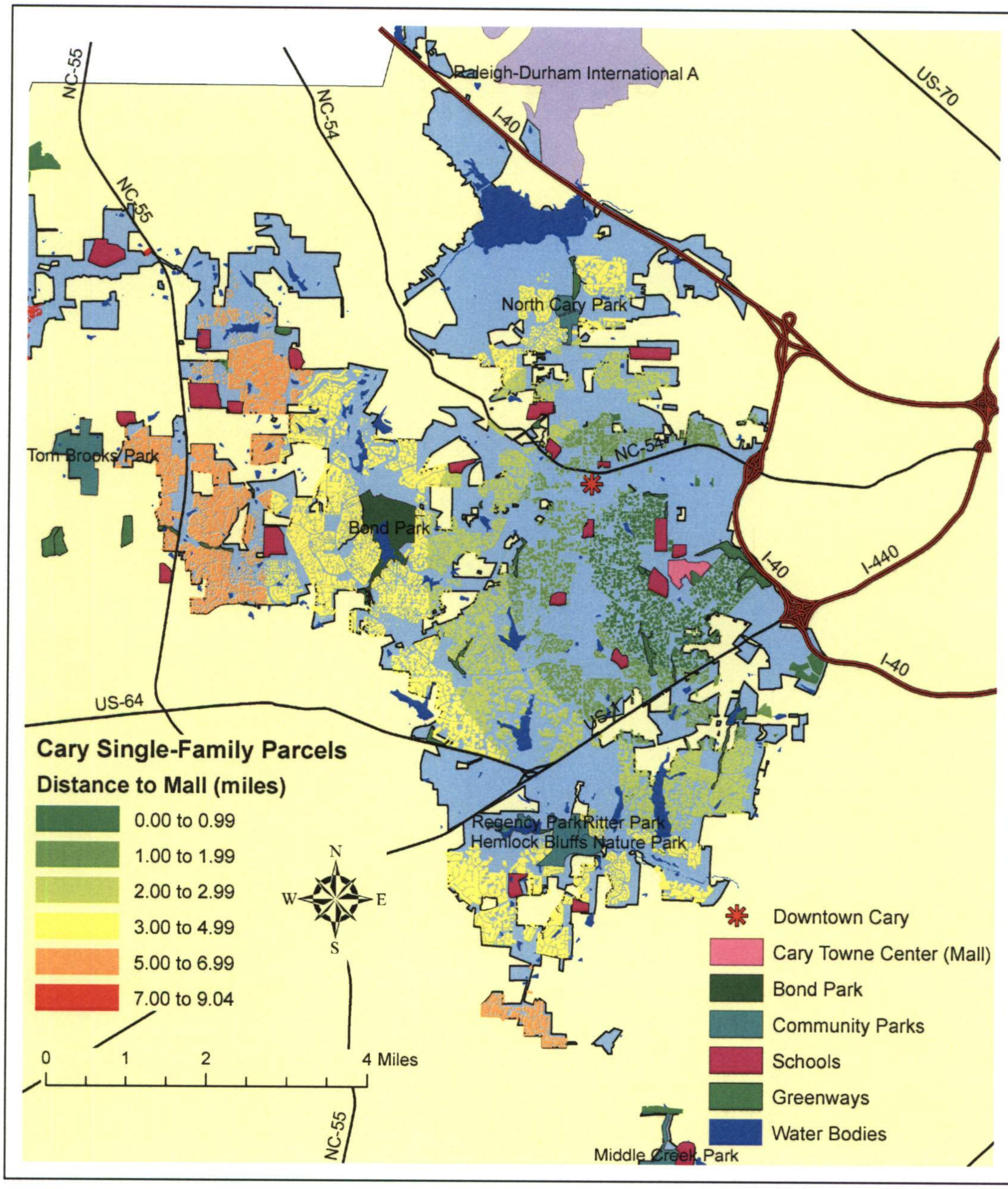

Map A-13. Distance to Schools in miles for Cary Single-Family Parcels



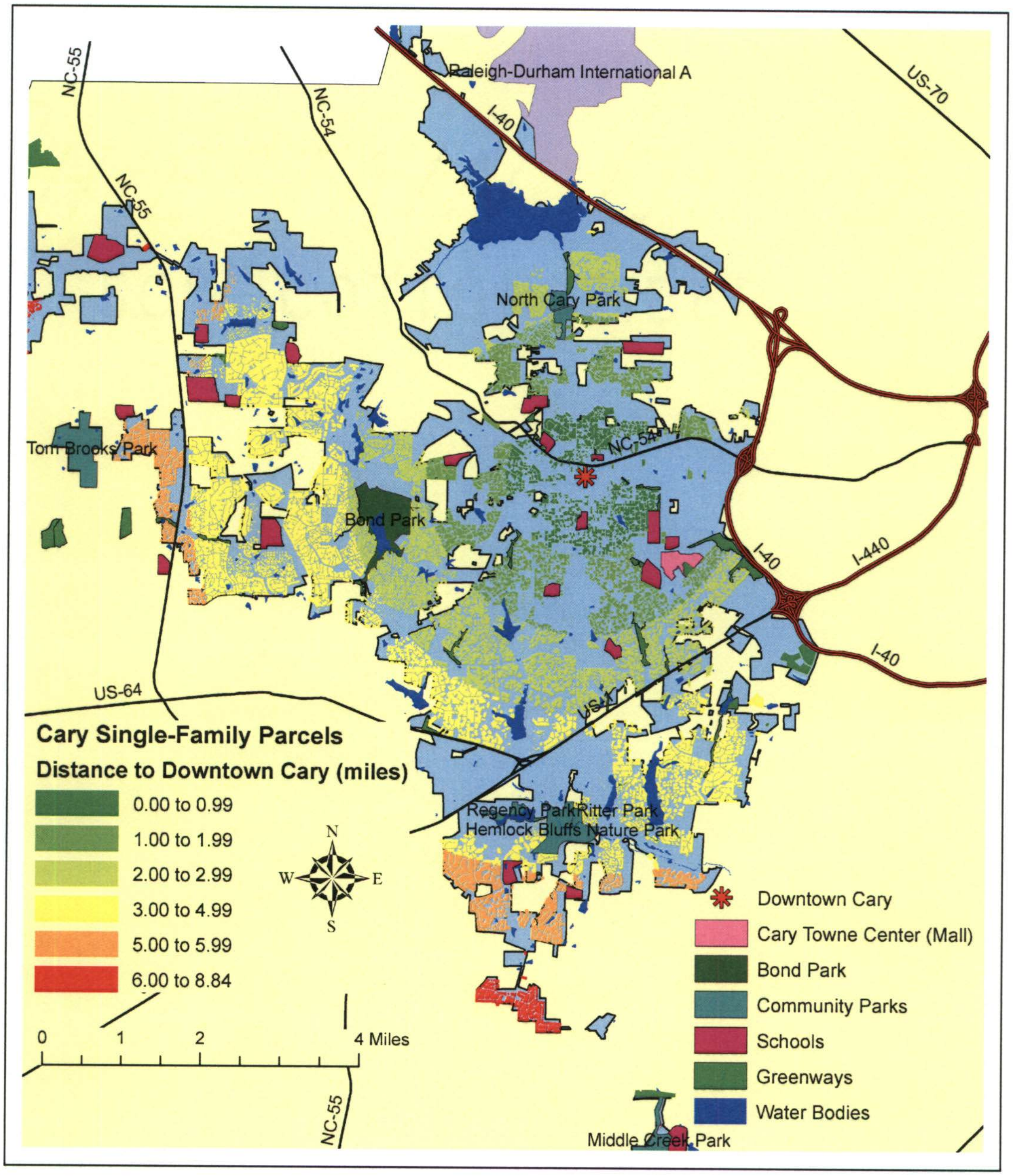

Map A-14: Distance to Greenways in miles for Cary Single-Family Parcels



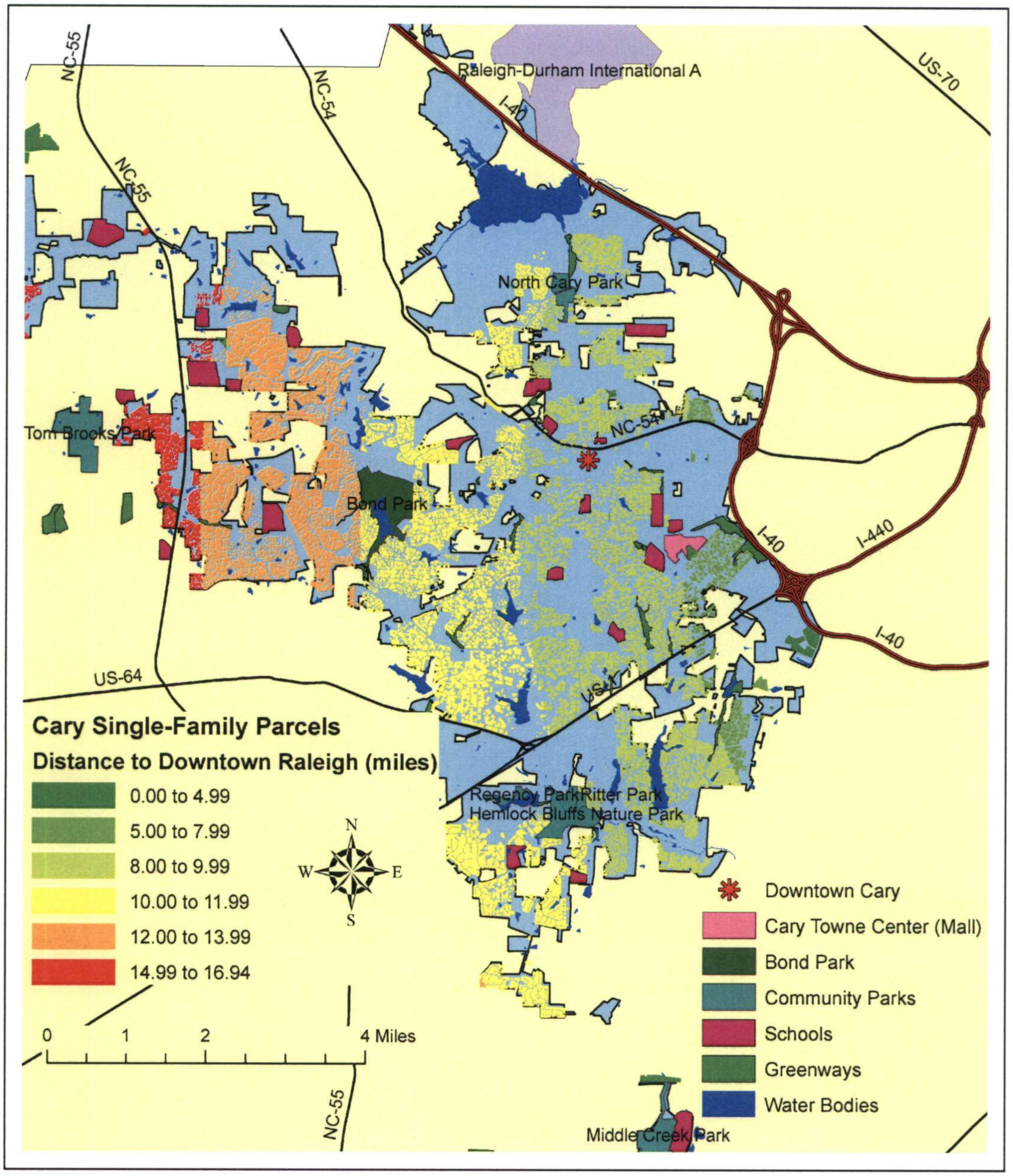

Map A-15. Distance to Airport in miles for Cary Single-Family Parcels




Map A-16. Distance to Mall in miles for Cary Single-Family Parcels




Map A-17. Distance to Downtown Cary in miles for Cary Single-Family Parcels




Map A-18. Distance to Downtown Raleigh in miles for Cary Single-Family Parcels

Table A-1. Model 1 Regression Output

| *Regression Statistics* | |
|---|---|
| Multiple R | 0.905267544 |
| R Square | 0.819509327 |
| Adjusted R Square | 0.819318116 |
| Standard Error | 52036.21522 |
| Observations | 14175 |

ANOVA

| | *df* | *SS* | *MS* | *F* | *Significance F* |
|---|---|---|---|---|---|
| Regression | 15 | 1.74078E+14 | 1.16052E+13 | 4285.884457 | 0 |
| Residual | 14159 | 3.83393E+13 | 2707767695 | | |
| Total | 14174 | 2.12417E+14 | | | |

| | *Coefficients* | *Standard Error* | *t Stat* | *P-value* | *Lower 95%* | *Upper 95%* |
|---|---|---|---|---|---|---|
| Intercept | -745237.2649 | 136902.3803 | -5.443566893 | 5.30937E-08 | -1013583.931 | -476890.5985 |
| YEAR_BUILT | 393.0217736 | 66.11390566 | 5.944615882 | 2.83623E-09 | 263.4298253 | 522.6137219 |
| HEATED_ARE | 64.27919521 | 0.860154359 | 74.72983718 | 0 | 62.59317957 | 65.96521086 |
| ACRES | 41010.69578 | 2802.559101 | 14.63330274 | 3.86759E-48 | 35517.31144 | 46504.08012 |
| PERCENT_BA | -291.5348493 | 74.59284135 | -3.908348899 | 9.33617E-05 | -437.7466265 | -145.3230722 |
| BRICK_STON | 10138.28474 | 1639.722787 | 6.182926055 | 6.46522E-10 | 6924.212477 | 13352.35701 |
| MED_AGE | 936.5831438 | 181.3096544 | 5.165655115 | 2.42851E-07 | 581.1923811 | 1291.973907 |
| PER_RENT | 314.3445947 | 47.11238692 | 6.67222816 | 2.61308E-11 | 221.9981216 | 406.6910678 |
| HH_SQ_MI | -5.47117807 | 1.493106953 | -3.664290798 | 0.00024893 | -8.397864025 | -2.544492116 |
| GRADE | 2563.47899 | 31.22536914 | 82.09603474 | 0 | 2502.273161 | 2624.684819 |
| PARK_DIST | -0.503933818 | 0.423840671 | -1.188969942 | 0.234471435 | -1.334717264 | 0.326849627 |
| PARK_DIST_SQ | -0.000111167 | 2.67949E-05 | -4.148824909 | 3.36138E-05 | -0.000163689 | -5.86458E-05 |
| DWNTN_CARY | 1.031496471 | 0.55555332 | 1.856701118 | 0.063374434 | -0.057461086 | 2.120454027 |
| DWNTN_RAL_ | -7.685854463 | 0.634087261 | -12.12113055 | 1.19798E-33 | -8.928748868 | -6.442960057 |
| AIRPORT_DI | 1.118158609 | 0.241268495 | 4.63449905 | 3.60995E-06 | 0.645240635 | 1.591076582 |
| MALL_DIST | 7.527938156 | 0.801746573 | 9.389423556 | 6.93785E-21 | 5.956409454 | 9.099466859 |

Table A-2. Model 2 Regression Output

| *Regression Statistics* | |
|---|---|
| Multiple R | 0.917768413 |
| R Square | 0.842298861 |
| Adjusted R Square | 0.841930185 |
| Standard Error | 61759.66811 |
| Observations | 6861 |

ANOVA

| | *df* | *SS* | *MS* | *F* | *Significance F* |
|---|---|---|---|---|---|
| Regression | 16 | 1.39428E+14 | 8.71428E+12 | 2284.659067 | 0 |
| Residual | 6844 | 2.61048E+13 | 3814256606 | | |
| Total | 6860 | 1.65533E+14 | | | |

| | *Coefficients* | *Standard Error* | *t Stat* | *P-value* | *Lower 95%* | *Upper 95%* |
|---|---|---|---|---|---|---|
| Intercept | -550328.6175 | 274357.476 | -2.005881616 | 0.044908155 | -1088154.489 | -12502.74609 |
| YEAR_BUILT | 55.97294219 | 138.2506218 | 0.404865754 | 0.685588846 | -215.0412188 | 326.9871031 |
| HEATED_ARE | 70.80148457 | 1.324554974 | 53.45303589 | 0 | 68.2049454 | 73.39802374 |
| ACRES | 31586.20866 | 4379.24861 | 7.212700505 | 6.07504E-13 | 23001.52114 | 40170.89617 |
| PERCENT_BA | 59.26754471 | 205.2454125 | 0.288764285 | 0.772770511 | -343.0772153 | 461.6123047 |
| BRICK_STON | 2433.864078 | 2620.763535 | 0.928685113 | 0.35308505 | -2703.646487 | 7571.374644 |
| MED_AGE | 1633.795459 | 386.4879269 | 4.227287182 | 2.39602E-05 | 876.1590752 | 2391.431843 |
| PER_RENT | 799.8994278 | 134.251383 | 5.958221134 | 2.67653E-09 | 536.7250171 | 1063.073839 |
| HH_SQ_MI | -3.985553001 | 2.661434868 | -1.497520397 | 0.134304018 | -9.202792013 | 1.231686012 |
| MED_HH_INC | 0.776625538 | 0.106806865 | 7.271307318 | 3.95601E-13 | 0.567250908 | 0.986000169 |
| GRADE | 2711.467661 | 41.85351757 | 64.78470193 | 0 | 2629.421766 | 2793.513555 |
| COMM_PARKS | -1.973202455 | 1.564932181 | -1.26088688 | 0.207392587 | -5.040955615 | 1.094550705 |
| COMM_PARKS_SQ | 0.000237481 | 0.000180838 | 1.313226263 | 0.189150742 | -0.000117018 | 0.00059198 |
| DWNTN_CARY | -3.289917124 | 0.875522706 | -3.757660542 | 0.000172935 | -5.006213574 | -1.573620674 |
| DWNTN_RAL_ | 0.354006606 | 0.406551513 | 0.870754615 | 0.383918692 | -0.442960639 | 1.150973851 |
| AIRPORT_DI | 0.976957207 | 0.293701125 | 3.32636522 | 0.000884501 | 0.401211775 | 1.552702638 |
| MALL_DIST | 1.981205705 | 1.046833529 | 1.892569974 | 0.058457227 | -0.07091317 | 4.033324579 |

Table A-3. Model 3 Regression Output

| *Regression Statistics* | |
|---|---|
| Multiple R | 0.925404876 |
| R Square | 0.856374185 |
| Adjusted R Square | 0.85622977 |
| Standard Error | 49267.53746 |
| Observations | 14934 |

ANOVA

| | *df* | *SS* | *MS* | *F* | *Significance F* |
|---|---|---|---|---|---|
| Regression | 15 | 2.15905E+14 | 1.43937E+13 | 5929.941449 | 0 |
| Residual | 14918 | 3.62103E+13 | 2427290247 | | |
| Total | 14933 | 2.52116E+14 | | | |

| | *Coefficients* | *Standard Error* | *t Stat* | *P-value* | *Lower 95%* | *Upper 95%* |
|---|---|---|---|---|---|---|
| Intercept | -1307777.668 | 119451.0927 | -10.94822692 | 8.6441E-28 | -1541916.498 | -1073638.839 |
| YEAR_BUILT | 534.5493035 | 60.04867487 | 8.901933384 | 6.11108E-19 | 416.846517 | 652.25209 |
| HEATED_ARE | 64.77353979 | 0.788332792 | 82.16522319 | 0 | 63.22831059 | 66.318769 |
| ACRES | 30411.12903 | 2430.554095 | 12.51201489 | 9.69976E-36 | 25646.94413 | 35175.31392 |
| PERCENT_BA | -84.61563732 | 55.78429188 | -1.516836272 | 0.129329216 | -193.9597088 | 24.72843414 |
| BRICK_STON | 11808.68568 | 1429.21347 | 8.262366632 | 1.54727E-16 | 9007.251542 | 14610.11982 |
| MED_AGE | -113.4577082 | 143.1988783 | -0.792308638 | 0.428193335 | -394.1451179 | 167.2297014 |
| PER_RENT | 208.1295948 | 40.57135185 | 5.129964501 | 2.93431E-07 | 128.6047564 | 287.6544331 |
| HH_SQ_MI | -7.389794521 | 1.285905829 | -5.74676182 | 9.27455E-09 | -9.910328064 | -4.869260978 |
| GRADE | 2651.302748 | 26.81425511 | 98.87661386 | 0 | 2598.743511 | 2703.861986 |
| SCHOOLS_DI | -4.077348044 | 1.312875434 | -3.105662532 | 0.001902091 | -6.650745328 | -1.503950759 |
| SCHOOLS_DI_SQ | 0.000850102 | 0.000233601 | 3.639123081 | 0.000274492 | 0.000392216 | 0.001307988 |
| DWNTN_CARY | -0.631950031 | 0.259447997 | -2.435748356 | 0.014872645 | -1.140500007 | -0.123400055 |
| DWNTN_RAL_ | -0.143247002 | 0.173219689 | -0.826967203 | 0.408268878 | -0.482778891 | 0.196284888 |
| AIRPORT_DI | 0.298276724 | 0.111605023 | 2.672610208 | 0.007534548 | 0.079517156 | 0.517036293 |
| MALL_DIST | 0.712295464 | 0.311901326 | 2.28372054 | 0.022401948 | 0.100930513 | 1.323660415 |

Table A-4. Model 4 Regression Output

| *Regression Statistics* | |
|---|---|
| Multiple R | 0.93541776 |
| R Square | 0.875006386 |
| Adjusted R Square | 0.861545535 |
| Standard Error | 32870.57535 |
| Observations | 145 |

ANOVA

| | *df* | *SS* | *MS* | *F* | *Significance F* |
|---|---|---|---|---|---|
| Regression | 14 | 9.83289E+11 | 70234957667 | 65.0037952 | 1.29253E-51 |
| Residual | 130 | 1.40462E+11 | 1080474724 | | |
| Total | 144 | 1.12375E+12 | | | |

| | *Coefficients* | *Standard Error* | *t Stat* | *P-value* | *Lower 95%* | *Upper 95%* |
|---|---|---|---|---|---|---|
| Intercept | 1344724.129 | 1580997.25 | 0.850554376 | 0.396580814 | -1783089.808 | 4472538.066 |
| YEAR_BUILT | -667.0980255 | 798.7578073 | -0.835169333 | 0.405154628 | -2247.344798 | 913.1487475 |
| HEATED_ARE | 56.205342 | 5.72998002 | 9.808994413 | 2.44167E-17 | 44.86926196 | 67.54142203 |
| ACRES | 8238.106564 | 31158.43067 | 0.264394143 | 0.791894931 | -53405.12128 | 69881.33441 |
| PERCENT_BA | -256.6977015 | 499.2696312 | -0.514146436 | 0.608022506 | -1244.442943 | 731.0475403 |
| BRICK_STON | -23888.52204 | 12682.57232 | -1.883570733 | 0.061856933 | -48979.47426 | 1202.430179 |
| MED_AGE | -370.3209327 | 2642.4233 | -0.14014444 | 0.888762773 | -5598.03934 | 4857.397475 |
| PER_RENT | -1176.558093 | 516.8933775 | -2.276210422 | 0.024468536 | -2199.169809 | -153.9463772 |
| HH_SQ_MI | -21.42036409 | 17.01205637 | -1.259128445 | 0.21024013 | -55.07668261 | 12.23595444 |
| GRADE | 2534.061476 | 303.5719539 | 8.347482182 | 8.9395E-14 | 1933.480679 | 3134.642273 |
| GREENWAY_D | -166.2737693 | 121.5892282 | -1.36750411 | 0.173826959 | -406.8235127 | 74.27597401 |
| DWNTN_CARY | -0.93295193 | 2.019269858 | -0.462024393 | 0.644836103 | -4.927835795 | 3.061931934 |
| DWNTN_RAL_ | -3.175124288 | 1.720668529 | -1.845285268 | 0.067271505 | -6.579261143 | 0.229012568 |
| AIRPORT_DI | -0.615735415 | 1.624413422 | -0.379050928 | 0.705268441 | -3.829443054 | 2.597972225 |
| MALL_DIST | 3.55902364 | 2.94399677 | 1.208908813 | 0.228892052 | -2.265321803 | 9.383369084 |

Table A-5. Model 5 Regression Output

| *Regression Statistics* | |
|---|---|
| Multiple R | 0.915901246 |
| R Square | 0.838875092 |
| Adjusted R Square | 0.838763305 |
| Standard Error | 54284.50409 |
| Observations | 20194 |

ANOVA

| | *df* | *SS* | *MS* | *F* | *Significance F* |
|---|---|---|---|---|---|
| Regression | 14 | 3.09589E+14 | 2.21135E+13 | 7504.231496 | 0 |
| Residual | 20179 | 5.94636E+13 | 2946807385 | | |
| Total | 20193 | 3.69053E+14 | | | |

| | *Coefficients* | *Standard Error* | *t Stat* | *P-value* | *Lower 95%* | *Upper 95%* |
|---|---|---|---|---|---|---|
| Intercept | -1696425.424 | 118759.7777 | -14.28451162 | 4.58532E-46 | -1929204.267 | -1463646.582 |
| YEAR_BUILT | 691.9035611 | 59.56578585 | 11.61578835 | 4.30294E-31 | 575.1497664 | 808.6573558 |
| HEATED_ARE | 63.77877319 | 0.708568848 | 90.01069321 | 0 | 62.3899205 | 65.16762588 |
| ACRES | 57589.27451 | 1977.582167 | 29.12105271 | 1.1532E-182 | 53713.05229 | 61465.49672 |
| PERCENT_BA | 247.4154728 | 52.20675146 | 4.739147062 | 2.16082E-06 | 145.0859852 | 349.7449604 |
| BRICK_STON | 8529.126192 | 1325.81925 | 6.433098775 | 1.27836E-10 | 5930.412412 | 11127.83997 |
| MED_AGE | 390.6805542 | 144.3682115 | 2.706139739 | 0.00681276 | 107.7070941 | 673.6540143 |
| PER_RENT | 266.3517137 | 39.56725277 | 6.73162009 | 1.72292E-11 | 188.7966736 | 343.9067537 |
| HH_SQ_MI | -5.919576553 | 1.263977447 | -4.683292862 | 2.84141E-06 | -8.397075359 | -3.442077748 |
| GRADE | 2623.863582 | 24.37211467 | 107.6584292 | 0 | 2576.092251 | 2671.634913 |
| GREENWAY_D | -3249.843459 | 2124.8802 | -1.529424322 | 0.126174962 | -7414.781824 | 915.0949047 |
| DWNTN_CARY | -0.509493041 | 0.263335613 | -1.934766952 | 0.053032851 | -1.025652303 | 0.006666221 |
| DWNTN_RAL_ | 0.664064544 | 0.149063566 | 4.45490849 | 8.438E-06 | 0.371887807 | 0.956241281 |
| AIRPORT_DI | 0.382340545 | 0.106162246 | 3.601473773 | 0.000317178 | 0.174253891 | 0.5904272 |
| MALL_DIST | -0.404637768 | 0.306738547 | -1.319161779 | 0.187130001 | -1.005870319 | 0.196594783 |

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