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Reservoir Sedimentation and Property Values

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RESERVOIR SEDIMENTATION AND PROPERTY VALUES: A HEDONIC VALUATION FOR WATERFRONT PROPERTIES ALONG LAKE GREENWOOD, SOUTH CAROLINA

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by
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ABSTRACT

This thesis uses multiple regression analysis in the determination of two hedonic models to explain the impact that sedimentation and algal bloom events may have on property values along Lake Greenwood, SC. Utilizing different independent variables, the hedonic equations reflect the market value and the sales price of the selected lakeside properties. With an average 4.6 percent of the original lake area lost to accreted sediment, the models show a $7,800 to nearly $10,000 average loss in property value or an estimated $5 to $6 million in value lost within the study area. Properties sold within a two-year period following the major algal bloom event that occurred in 1999 are found to have sold for approximately $22,000 less than they would have during any other period. This equates to a loss of over $1.6 million among the parcels sold during this period.

DEDICATION

This thesis is dedicated to my family and friends, whose never-ending support has helped me every step of the way. In particular, I would like to dedicate this to my Mom and the other special women in my life: Erin, Brandy, and Sadie. Thanks for all your love.

ACKNOWLEDGMENTS

I would like to take this opportunity to thank those who have aided me in my efforts in this project and completion of my degree. I would like to thank the members of my committee including my advisor Dr. Jim London, Professor Stephen Sperry, and Dr. Caitlin Dykman for their interest and guidance in this project. I would also like to thank everyone involved with North Wind Inc. (formerly Pinnacle Consulting Group), the Saluda-Reedy Watershed Consortium, and the Greenwood County GIS Department. The help and data resources obtained from these entities were vital in the creation of the hedonic models.

Finally, I want to express my gratitude to all the faculty of the City and Regional Planning Department who have given me a greater perspective on public policy and planning implications.

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CHAPTER I

INTRODUCTION

Sedimentation, from runoff and erosion, is a major water quality issue for many lakes and reservoirs. Upstream sediment flows are accelerated significantly beyond natural conditions due to unsuitable agricultural practices in some areas and the rapid conversion of rural lands into urban and suburban land uses in other areas. The rivers and streams deposit their sediment loads in the calmer waters of the lakes and reservoirs, where sediment accumulation can have negative impacts on the functions of these water bodies. Infilling with sediment can result in a decrease of water storage capacity and may result in an increase in water treatment costs or a decrease in electrical production capability. Shallower waters also may lead to a decrease in the recreational value of a lake and the loss of lake access for parts of the upper reaches and coves of a lake. Sedimentation also can result in the loss of natural lakebed habitat and can carry pollutants and nutrients along with it, which may act as catalysts for eutrophication. The effects of sedimentation delivered from upstream regions can have severe economic costs for downstream residents and may result in a decrease of property values for lakefront properties and those properties adjacent to the lake.

To evaluate this issue, this thesis will create a hedonic model that can be used to test the correlation between sedimentation and property value. A hedonic model will be formulated based on previous studies that have attempted to show the effects of water quality on property values. The hedonic model then will be customized so that it can be used to analyze the impact that sedimentation and algal bloom events may have on lakeside property values. To test this model, an analysis will be made for properties surrounding Lake Greenwood, a local example of a reservoir that has been dramatically affected by sediment in its upper reaches. Established in 1940, Lake Greenwood has been impacted by poor soil conservation practices from agriculture in the 1940's and 1950's, and the rapid conversion of these lands to urban and suburban land uses in more recent years. Analysis of sediment accretion in Lake Greenwood from a previous report by the Saluda Reedy Watershed Consortium [SRWC] (2004) has shown that, "approximately 307 acres of water area have disappeared due to sediment accumulation". This accumulation equates to "over two billion gallons of water storage volume lost", causing many areas of the lake to become "progressively more shallow". Traveling along with the sediment, nutrients have accumulated within Lake Greenwood and have caused several algal bloom events, the largest of which occurred in 1999 (SRWC 2004).

Although there are many water quality impacts linked with sediment loading, these impacts seldom have market values associated with them. However, it is often assumed that losses caused by water quality impacts will be capitalized into individual property values. A hedonic model can estimate the property owner's willingness to pay for a house in an area with lower accumulations of sediment and a lower likelihood of algal bloom events.

Research Questions

- Utilizing a hedonic model, does runoff containing sediment and nutrients from upstream sources affect the value of lakefront properties?
- Will the model show a decrease in property values for parcels purchased after the algal bloom event of 1999?

A hedonic model will be used to capture and estimate the monetized loss caused by sedimentation as the reservoir begins to infill and show signs of eutrophication. This model will attempt to use objective measurements of sediment accretion within the lake and variable denoting properties sold within a period following the 1999 algal bloom. These questions seek to gauge whether a monetary value can be estimated to show the costs of sedimentation on downstream reservoirs; so that a future cost-benefit analysis of erosion and sediment control regulations and stormwater management practices can include this monetized variable as part of the existing costs associated with the non-market environmental amenity- runoff. This methodology leads to the final research question: Can a monetary value be estimated (using a hedonic model) for the losses incurred by lakeside property owners due to the effects of sedimentation and algal bloom events?

Objectives

The objective of this research effort is to evaluate the potential losses in property value from sedimentation. Specific objectives include:

1. Determining the effect of gradual sediment infill on lakeside property values.
2. Determining the effect of major events, such as reported algal blooms, on lakeside property values.

Overview of Thesis

Chapter I introduced the thesis including the research questions and objectives. Chapter II presents a review of the literature related to sedimentation of reservoirs and the use of hedonic pricing models to evaluate water quality. The chapter gives an overview to the problems associated with sedimentation and nutrient loading, answers to its potential root cause, and its effect on the advanced eutrophication of reservoirs. The chapter also discusses the hedonic pricing model and its history in evaluating water quality effects on property values and evaluates the methodology and common findings of these studies. Chapter III defines the study area and reviews previous relevant studies of the area. The chapter also describes the data gathering process and sources of that data. Chapter IV describes the methodology of the thesis. The steps include the preparation of the data, the defining of the variables, and the formation of the hedonic models. Chapter V explains the results and relevance of these findings.

CHAPTER II

LITERATURE REVIEW

The literature review will show that runoff caused by upstream land uses can expedite the process of eutrophication within both lakes and reservoirs. An examination of this limnological process will help refine the differences between lakes and reservoirs and explain why reservoirs tend to be more susceptible to sedimentation. Further, to calculate the costs created by sedimentation and its associated effects on water quality, a hedonic model will be employed. To establish this model, the concept of a hedonic valuation will be assessed along with a discussion of its wide-ranging applications for monetizing non-market goods. A review of previous water quality based hedonic studies will follow. This hedonic literature will be assessed chronologically to show the progression from study to study. Additionally, along with the findings for each study, the variables utilized within each of the hedonic equations will be reviewed to help formulate a methodology for this thesis

Sedimentation of Reservoirs

Reservoirs are constructed for a particular purpose, usually water supply storage, water supply for industries, flood control, power generation, or as often is the case for many of these purposes. Reservoirs also can present the same benefits as a natural lake such as recreation, aesthetics, and habitat. The watershed of a reservoir plays a crucial role in the health and longevity of the reservoir. Many lakes and reservoirs throughout the country have been degraded by pollution, sedimentation, and nutrient loading. Many of the point sources of pollution currently are being regulated, but non-point sources have begun to threaten reservoirs with sediment and nutrients. Runoff from urban areas, agriculture, and silviculture can prompt advanced eutrophication within lakes and reservoirs that can lead to algal blooms, high growth rates of aquatic vegetation, low levels of dissolved oxygen, and the decimation of the eco-system within the water body (Marsh 2005). Many reservoirs that were created for water supply or power generation have begun to become non-operational because of the loss in storage volume from sedimentation.

Lakes and Reservoirs

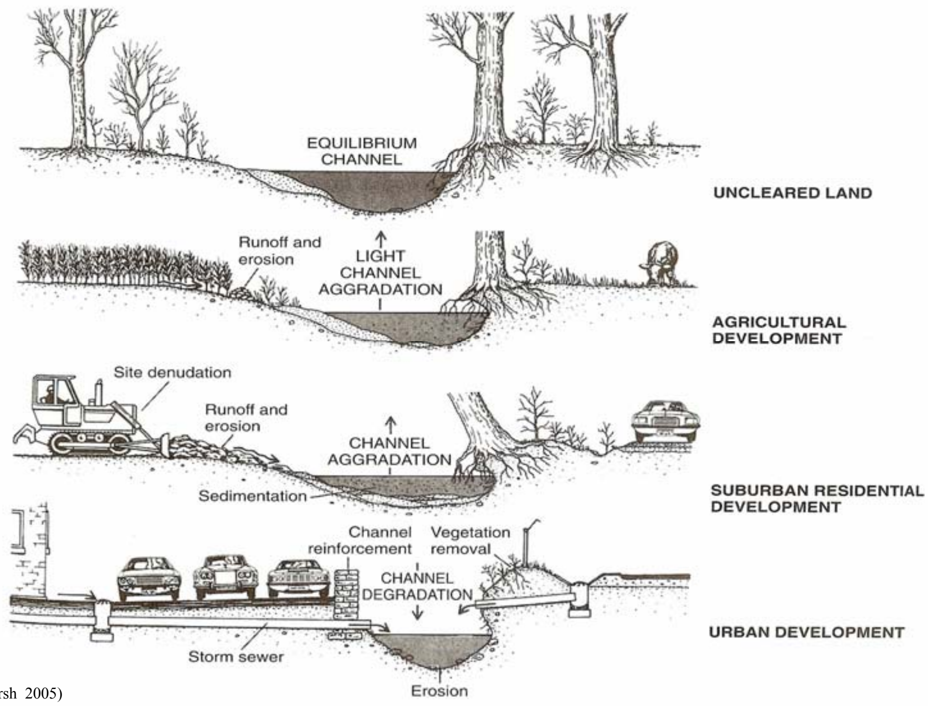
Within the continental United States, over 100,000 lakes exceed 100 acres in size (Davenport 2004). These lakes and reservoirs constitute a significant multifunctional amenity for nearby residents. With nine out of ten Americans living within a 50 mile proximity to a lake (Holdren 1997), most citizens can enjoy both the active and passive recreation opportunities or just admire the visual aesthetics that these lakes offer. Lakes and reservoirs often function as the local water supply or serve local industry needs. Reservoirs, established as artificial lakes, also may be designed for power creation or flood control. Often, lakes and reservoirs are magnets for economic development, attracting residents with the visual and recreational amenities while supporting industry by providing a constant supply of energy and water. These water bodies also provide critical habitat for fish and local flora and fauna, which attracts nature lovers, anglers, and those who want to live near a piece of nature. “When all else is equal, the price of a home, located within 300 feet of a body of water, will show an increase of up to 27.8 percent” (National Association of Home Builders [NAHB] 1993).

The main difference between lakes and reservoirs is that reservoirs are much younger than lakes but age much faster. This distinction is due to the acceleration of the eutrophication process from runoff and nutrient loading. The amplification of this aging process is in part related to the distinct differences between natural lakes and reservoirs. A lake will typically be centrally located within a watershed where it will receive flow from smaller tributaries; whereas, a reservoir will generally be located towards the end of a large watershed and receive flows from major rivers (Jørgensen 2005). Although lakes have a longer residence time that can lead to the accumulation of pollutants, the smaller size of their watershed allows them to be more easily managed (Randolph 2004). On the other hand, reservoirs have a shorter residence time but a much larger watershed which can be more difficult to control (Randolph 2004). The consequences of a larger watershed to water body ratio, as is the case for most reservoirs, are higher pollutant loads and significant sedimentation problems (Straškraba 2004).

Runoff, Sedimentation, and Nutrient Loading

Reservoirs are exposed to more sedimentation and nutrient loading because they are located closer to population centers (Straškraba 2004) and as a result may be more susceptible to runoff from poorly managed land uses within the watershed. This human induced runoff leads to, what both John Randolph

(2004) and William M. Marsh (2005) refer to as, "cultural eutrophication". Cultural eutrophication is perpetuated in part by poor erosion and sediment control practices and inadequate stormwater management along the stream and river channels that feed into a reservoir. The effect of different land uses on these channels can be seen in Figure 1 below.



Source: (Marsh 2005)

Figure 1: Channel Degradation and Land Use

The figure above shows the effect of land clearing, deforestation, and the addition of impervious surfaces on runoff and ultimately towards the degradation of the channel itself. When a watershed becomes heavily urbanized, it can more than double the drainage density (Marsh 2005). The addition of impervious surface and the channeling of stormwater through storm drains, functions to convey the precipitation into the stream as fast as possible. The resulting effect is depicted in the hydrograph shown in Figure 2 below. A hydrograph curve represents the flow discharge level of a stream or river over time.

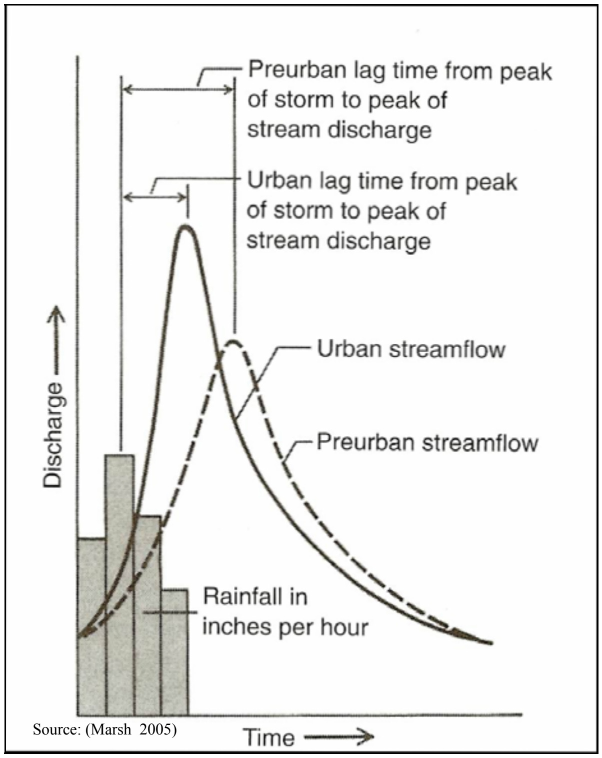
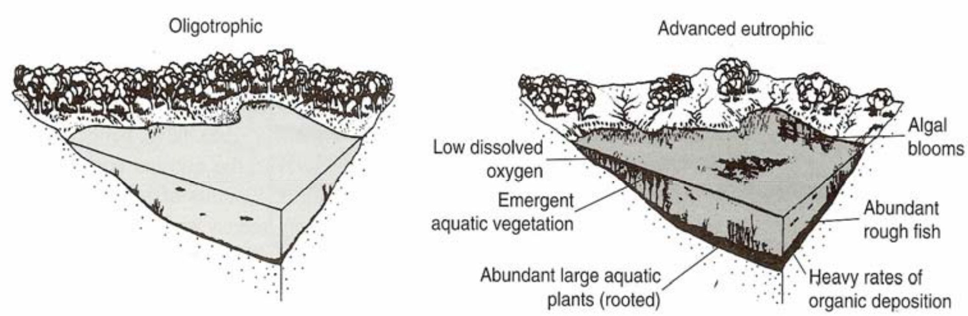


Figure 2: Urbanization Hydrograph

The hydrograph shows that urbanization has caused the flow to be magnified in intensity and created a shortened lag between the time of the precipitation event and the point of peak flow. Essentially, the decrease in infiltration and increase in both overland flow and piped conveyance has created large discharge events that will occur more frequently (Marsh 2005). Not only does this magnified surge create a greater potential for flooding events downstream, it also generates flows that scour the channel bed and cause even greater sedimentation downstream. "Most sediment carried by a stream is moved by high flows" (Leopold, 1968). Carried along with this sediment, travel nutrients such as phosphorous and nitrates, pathogens such as E. Coli and fecal coliform, organic matter such as biochemical oxidative demand (BOD) and dissolved oxygen, toxic pollutants such as hydrocarbons and phenols, and heavy metals and salts (Haested et al. 2003).

Eutrophication and Algal Blooms

The urban runoff pollutants can accumulate within lakes and reservoirs causing cultural eutrophication. The "sediments fill up lake bottoms, nutrients contribute to growth of algae and other undesirable vegetation, and organics consume dissolved oxygen" (Randolph 2004). In a natural state, most inland waters have a low level of phosphorous, because it is retained by the soil (Marsh 2005). Therefore, when sediment is flushed downstream into a reservoir, the phosphorous, which has been transported attached to the sediment, begins to become soluble causing accelerated rates of algae and vegetative growth (Phillips 2005). Nitrogen on the other hand, "tends to be highly mobile in the soil and subsoil" (Marsh 2005) and often permeates into the groundwater, which provides it with another avenue of transport into water bodies in addition to suspension within runoff. Nitrogen accumulates in higher concentrations so that the addition of phosphorous creates a heavy nutrient load that can cause an increase in biological activity, which leads to a buildup of organic deposits and a decreased level of dissolved oxygen. Oftentimes these conditions will produce algal blooms, which can be exacerbated by the level of sediment accumulation. Algal blooms may appear as green or red scum on the surface of the water. In areas where sediment has created shallow lakebeds, biological activity is further heightened by increases in water temperatures and light penetration to the lake bottom. Eventually this plant matter dies and "microbial decomposition will increase the biological oxygen demand (BOD)" (McKinney & Schoch 2003). "When BOD levels are higher than the local dissolved oxygen content in the water, there is not enough oxygen left for other organisms, such as fish, causing them to die" (McKinney & Schoch 2003). The eutrophication process can be seen below in Figure 3.



Source: (Marsh 2005)

Figure 3: Lake or Reservoir Eutrophication

Marsh (2005) describes further alterations that can occur in the aquatic environment such as "increased rate of basin in-filling by dead organic matter; decreased water clarity; shift in fish species to rougher types such as carp; decline in aesthetic quality; increased cost of water treatment by municipalities and industry; and a decline in recreational value."

<u>Capacity Loss and Sediment Management</u>

Eutrophication also can diminish many of the benefits from which reservoirs were initially built, such as recreation, fishing, and, the aesthetic value to lakeside residents and other lake users and visitors. However, the biggest decimator of reservoir value occurs when sediment begins to infill the basin. This sedimentation can reduce or impede the functions of water supply, electricity production, flood control, and recreation; not to mention destroy fish habitat and potentially change the whole eco-system. Eventually the reservoir will have to be abandoned. In the United States, "more than 3000 such dams… have been retired" (Marsh 2005). Worldwide, "the replacement value for storage capacity lost due to siltation is moderately estimated at $6 billion a year" (Mahmood 1987). The processes of sediment management can prolong the life of a reservoir. "Sediment management methods include: (1) reduction of sediment yield by measures in the catchment area (soil conservation measures, etc…); (2) sediment routing through construction of off-stream reservoirs, construction of sediment exclusion structures, and by sediment passing through the reservoir (sluicing); (3) sediment flushing, by increasing flow velocities within the reservoir to flush sediment downstream; and (4) sediment removal by mechanical or hydraulic dredging" (Palmieri et al. 2001). Many of these sediment management techniques can be cost prohibitive or environmentally harmful. A more sustainable means of management can be found in De Janvry et al. (1995) analysis of watershed management, which found that soil erosion control is desirable from the perspective of upstream users, because it "increases the life-span of the downstream reservoir by 23 years and raises the net present value of the dam for future generations". De Janvry et al. (1995) consider reservoirs to be nonrenewable resources, short of continuous dredging. In this vein, it is important that society begin to evaluate the cost and benefits of these aging reservoirs. To reap the most benefit from these large capital projects, methods should be taken to prolong the health and viability of the reservoirs. Appropriate management of the watershed is the "best way to guard good water" (Straškraba 2005), through prevention of pollutants, such as metals and toxins, and erosion management to prevent sedimentation and nutrient loading. To compare the costs and benefits of a watershed management program, values that explain the costs of non-management should be compared to the actual costs of management.

Hedonic Valuation

A growing need for valuation of environmental resources and the potential losses incurred from the degradation of water and air quality leads to the increased utilization of techniques that attempt to assess non-market values. Attempts to evaluate environmental resources include contingent valuation, travel cost method, and hedonic pricing. In cases where an environmental change or condition will affect property values, a hedonic model can give insights into environmental values. The formulation of hedonic prices has been carried out to evaluate the costs and benefits of environmental amenities, disamenities, and externalities. Hedonic evaluation has had proven success dealing with water quality issues; however, there has been a relatively low number of water quality hedonic studies published over the last few decades (Leggett 2000). A review of this body of work will help establish the methodology for this thesis.

Cost-Benefit Analysis

The realm of environmental economics has grown along with the increased use of benefit-cost analysis within public policy decision making. The National Environmental Policy Act (NEPA) of 1969 required the creation of Environmental Impact Statements (EIS) for all government projects. Cost-benefit analysis techniques were vital in the creation of the EIS reports. Since that time, Presidents Carter, Reagan, Bush Sr., and Clinton have all expanded the process of economic review to cover major environmental, health, and safety regulations (Portney 2000), and many state governments have included cost-benefit analysis as part of their evaluative process for state projects and regulations. "When used to select publicly funded projects and set regulations, (cost-benefit) analysis has a role in the public sector similar to that of profit analysis for private firms." (Easter, Becker, & Archibald 1999)

The analysis is performed by evaluating the potential benefits of a project and comparing this valuation to the estimated costs of the project. Unfortunately, natural resources and environmental effects seldom have attached monetary values. For this reason, economic methods must be employed to analyze these values. Values for recreational resources often are calculated through the application of the travel cost method, which relates travel and recreational related expenditures to the value placed on these amenities (Sexton et al. 1999). One of the more commonly used methods to ascertain non-market values is contingent valuation (CV), which uses survey methods to discover people's value for a resource by their willingness to pay (WTP) for that resource or their willingness to accept (WTA) for a reduction or removal of that resource (Markandya & Richardson 1992). By employing personal interviews, telephone interviews, or mail surveys, respondents are asked questions designed to elicit the monetary value they would place on certain environmental goods (Bishop & Welsh 1999).

Diverging from the calculations of hypothetical willingness to pay, hedonic price theory attempts to discover what people did pay for a resource or what amount of payment they declined because of a reduction or removal of that resource. Generally, these hedonic models look at land, property values, and environmental impacts to try to reveal preferences. Either of these techniques can produce values for non-market items to be utilized within a cost-benefit analysis in order to evaluate projects, regulations, or the lack thereof.

Hedonic Models

The effect of an environmental resource on property values is best analyzed using a hedonic model. Hedonic models are based on the notion that homebuyers purchase a home based on a set of attributes: the housing characteristics, its neighborhood or location, and characteristics of its environment. For example, the housing characteristics include: number of bedrooms, number of bathrooms, square footage, the construction year, and lot acreage; the neighborhood attributes could include location to nearest urban area, school quality, tax rate, median income, etc…; and the environmental characteristics could include air or water quality, distance to parks, or distance to a nuisance or disamenity. All of these characteristics are assumed to have their own implicit price. Once these characteristics or others are chosen to represent the attribute bundle associated with the properties in question, the characteristics can be regressed on the value of the homes, and one can extract the contribution of the environmental characteristic to the prices of these homes (Boyle & Kiel 2001). The large purchase price of a home and the bundle of attributes associated with the purchase, establish "housing markets (as) one of the few places where environmental quality is traded" (Palmquist et al. 1997).

A typical hedonic regression equation (Kiel 2006) is:

$$P_i = \beta_0 + \beta_1 H_i + \beta_2 N_i + \beta_3 ENV_i + \varepsilon_i ,$$

Where P_i is the sale price of the *i*th house, H_i represents the housing characteristics for the *i*th house, N_i represents neighborhood or location attributes of the *i*th house, ENV_i represents the environmental characteristic in question for the *i*th house, and ε_i is the margin of error. B_0 represents the intercept of the line and, 'in a linear hedonic equation such as this, the coefficients ($\beta_{1\text{-}3}$) for each variable, estimated by an ordinary least squares (OLS) analysis, will represent the marginal price of that good' (Kiel 2006).

Hedonic market theory generally is credited to Sherwin Rosen's (1974) essay on modeling implicit markets. Since then, hedonic pricing techniques have been used to estimate the implicit prices of a variety of environmental goods. Hedonic models have been used extensively to estimate the relationship between housing prices and air pollution (too many to list here) and a little more sparingly to find values for other non-market disamenities such as proximity to hog farms (Palmquist et al.1997), earthquake risk perception (Brookshire et al. 1998), and airport noise (Uyeno 1993). The value of certain amenities has been tested as well, such as distance to open space (Geoghegan 2001), ocean view (Benson et al. 1998), and urban forest amenities (Tyrvainen & Miettinen 2000). Related to lake and reservoir values, Brown and Pollakowski (1997) found that distance away from waterfront reduces the price of a house, and Seiler, Bond, and Seiler (2001) found that a positive relationship exists between views of Lake Erie and the values of homes. Another waterfront study performed along the boundary of Lake Michigan found that prices were not set proportionately to the width of lake frontage (Colwell & Dehring 2005). These studies imply that a waterfront variable should be employed within the model for this thesis and that a variable representing width of lake frontage may not be statistically significant if used within the model. A review of previous water quality based hedonic studies will provide support for other characteristics that are relevant as attributes for lakeside developments.

Water Quality Studies

The first study, David (1968), looked at properties located around artificial lakes in Wisconsin and the lakes' perceived water quality rating: poor, moderate, or good, based on the opinions of government officials familiar with water quality issues (Krysel 2003). This subjective measure of water quality proved to have a significant affect on the dependent variable, which was the weighted sum of land values around the lakes from 1952, 1957, and 1962 (Boyle & Kiel 2001).

Epp and Al-Ani (1979) picked up from where David left off and utilized both a subjective measure of water quality, utilizing public records and phone interviews to gauge public opinion, and objective measures from recorded pH readings in Pennsylvania streams. The authors utilized a much more complete model, using actual sale prices deflated to the base year for their dependent variable. The independent variables were very limited for housing characteristics, including only age of house, lot size, and number of rooms; but very complete for neighborhood characteristics, looking at flood hazard, potential employment (based off of a gravity model), per pupil expenditures for local schools. The results showed that both subjective and objective measures of water quality had an effect on property values. The model was then estimated with the data split based on clean stream areas and already impacted stream areas. The results show that pH level increases have a stronger negative effect on property values when the stream is clean but very little effect when the stream is already polluted. This result suggests that although the effect on housing prices can be analyzed using objective measurements, subjective observations may provide a more accurate indicator, as individuals within the housing market appear to react to what is readily observable, in this case the change from a healthy stream to an unhealthy stream versus the continual degradation of an already unhealthy stream.

Feenberg and Mills in 1980 looked at 13 water quality variables within a model for the Boston area, and found that oil and turbidity showed the strongest correlation (Michael, Boyle, & Bouchard 1996). It is not surprising that the water quality variables that showed the strongest correlation were those that were most easily observable.

Young and Teti in 1984 looked at homes adjacent to St. Albans Bay on Lake Champlain in northern Vermont and "found that degraded water quality significantly depressed property prices around the bay relative to properties outside of the bay area" (Michael, Boyle, & Bouchard 1996). The dependent variable was formulated from sale prices; the independent variables included housing variables such as: frontage, square footage, and quality of construction; and the environmental measurement consisted of a subjective rating of water quality made by local officials (Boyle & Kiel 2001).

The Brashares study in 1985 looked at 78 different lakes in southeast Michigan and considered eight different measures of water quality and found turbidity and fecal coliform to be correlated with property prices (Michael, Boyle, & Bouchard 1996). It is likely that the turbidity was perceived visibly by the property owner or buyer and interpreted as evidence of low water quality. The levels of fecal coliform were regularly monitored and reported to the potential buyers by the state Board of Health (Michael, Boyle, & Bouchard 1996). Again, a case for subjective measurements based on observation and knowledge over objective readings of water quality in regards to their effect on property values.

Steinnes (1992) looked at leased lots along 53 lakes in Minnesota. For the dependent variable, he chose to look only at land values, using appraisal data from the Minnesota Department of Natural Resources for the empty lots. Steinnes (1992) felt that land values are what is actually affected by water quality and that housing characteristics may actually "diminish the explanatory power of the water quality variables" since bigger houses of more value may actually be built in areas with high quality water. Steinnes (1992) found that water clarity had a significant impact on land values, with results indicating that each additional foot of clarity would raise the value of a lot by $206. However, the water clarity measures were affected by the tannic acid present in some lakes, causing the water to have a darker color. Even though the true quality of the lakes was good, property values were affected by the perceived, subjective measure of water quality. It is also important to point out that Steinnes attempted to use other variables such as lake size, lake depth, and accessibility only to find that there was no correlation. Again, Steinnes was only looking at land values, and these dropped variables would seem to have more effect on a residential property and may not be incorporated into the price of the land until it is developed residential.

Mendelsohn et al. looked at PCB pollution in the New Bedford, Massachusetts Harbor, using change in real house pricing from 1969-1988 (Boyle & Kiel 2001). By using change in prices over time, they stepped away from the cross-sectional approach that had been used more generally up to this point. The authors established dummy variables for sales after the pollution event and dummy variables for locations near PCB contaminated sites, and found a decrease in property values ranging from $7,000 to $10,000 for affected properties (Boyle & Kiel 2001). Although this time around there was actual water quality problems, the property values were not affected until awareness of the problem was elevated (Kashian 2005) through public notice of the contamination.

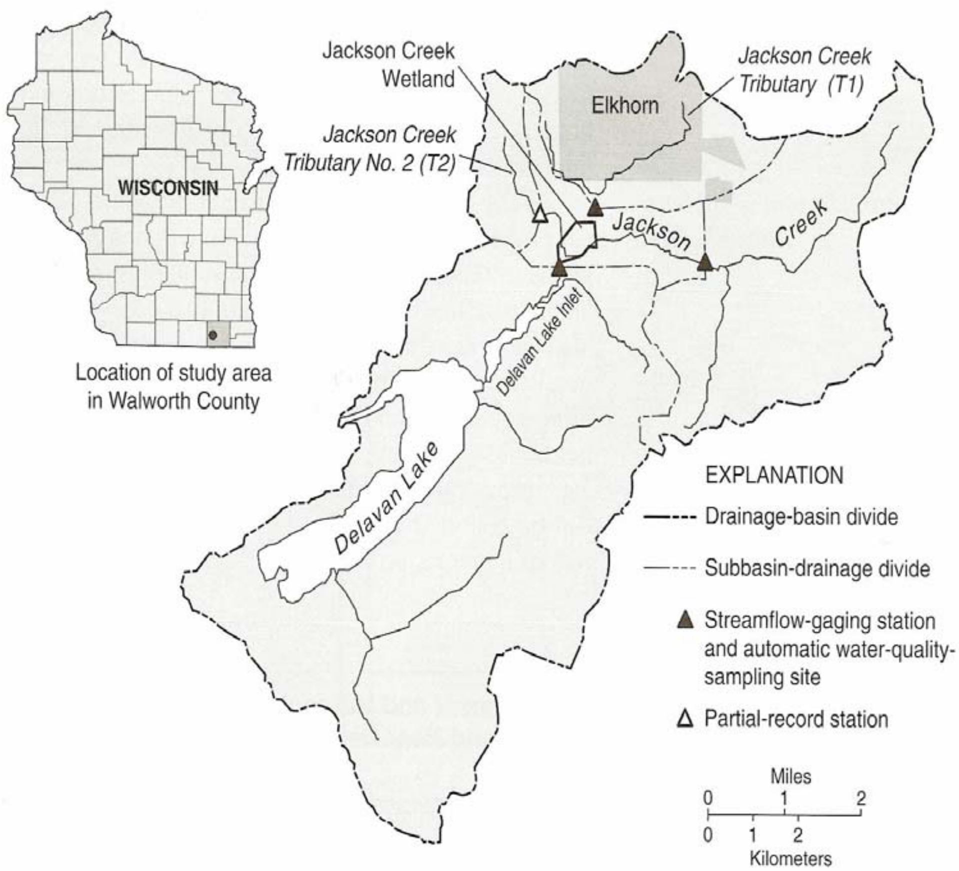
Michael, Boyle, and Bouchard (1996) looked at secchi disk data that provided a measure of water clarity for thirty-four Maine lakes. These secchi disc readings give a measure of water clarity. The authors wanted to show the effect eutrophication was having on Maine lakes. They chose water clarity because although objective it was readily observable by the public. Their dependent variable was taken from property records for sales occurring between 1990 and 1994. They looked only at single-family residential homes and calculated price per foot of lake frontage. For housing characteristics, the study looked at number of stories, square footage, heating system information, and whether or not the house had a fireplace, deck, basement, full bath, septic system, or a garage. For neighborhood characteristics, the study looked at whether or not the house was located on a public road, looked at density around the property, the tax rate, distance to the largest city in the area, and size of the lake. The results of the study show that water clarity significantly affects property prices, ranging from $11 to $200 per foot of lake frontage.

Poor, Boyle, Taylor, & Bouchard (2001) pick up where Michael, Boyle, and Bouchard (1996) left off, utilizing a similar data set but adding in survey data of resident's subjective measurement of water quality. The units of the subjective (survey) measurement were set to match the units for the objective (secchi disc) measurements. The study results showed that the objective measure was statistically superior to the subjective measures, mostly because those surveyed tended to underestimate water clarity. They conclude however, that this result may not prove true if the public did not have a sensory awareness of the disamenity.

Leggett and Bockstael (2000) looked at house sales from 1993 to 1997 along the western shore of the Chesapeake Bay in Anne Arundel County, Maryland. Their environmental variable was median fecal coliform concentration at the nearest monitoring station. Some independent variables include assessed value of structure, acres, distance to major cities, and percentage of commuters. Also in an effort to avoid “omitted variable bias”, other variables are added that give distance from other “emitter effects” such as nearest industrial NPDES site and nearest sewage treatment plant. The results of the study show an effect on property values caused by the fecal coliform bacteria concentrations. The county operates a hotline during the summer months advising potential swimmers of the levels of fecal coliform counts, thereby a mechanism exists to advice the market participants about the water quality condition. Leggett and Bockstael do not use data for nitrogen, phosphorous, or dissolved oxygen, because changes in these measures are invisible to the homeowner. In as much that nutrients, such as nitrogen and phosphorous, “have several sources in common (with fecal coliform), and because inlets and streams that are poorly flushed will tend to concentrate both pollutant types”, the results for fecal coliform concentrations may similarly apply to nutrients.

Krysel et al. (2003) looked at 37 lakes in the Mississippi Headwaters Region in Minnesota. Sales prices were used from 1996 – 2001 and once again the environmental variable used, was secchi disk readings. Most of the same independent variables were used except for the addition of a site quality rating that was created through site visits. These site visits were possible because no more than 50 parcels were selected along each lake. The findings showed that water clarity did have an affect on property values.

The Kashian et al. (2005) study looked at Delavan Lake, Wisconsin, which had undergone a $7 million lake rehabilitation project that began in 1989 and ran into 1993. The rehabilitation included draining the lake and "eliminating undesirable fish species, algal, and nutrients that were contributing to the eutrophication problem" (Kashian et al. 2005). The Jackson Creek Wetland was expanded to 95 acres to help reduce sediment and nutrient inflow to the lake (Elder & Goddard 2005). A picture of this project can be seen in Figure 4 below.

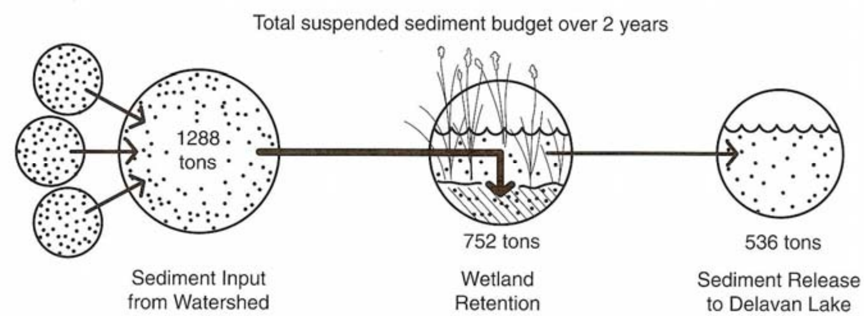


Delavan Lake, its watershed, and the Jackson Creek Wetland.

Source: (Elder & Goddard 2005)

Figure 4: Delevan Lake Rehabilitation Project

A study of the wetland area showed that it had a 58 percent retention efficiency for sediments but a low and variable retention rate for nutrients (Elder & Goddard 2005). Apparently, during certain seasonal events the phosphorous was actually being released from the sediment and being transported downstream, leaving the bulk of the sediment behind as the nutrients traveled into the lake (Elder & Goddard 2005). A depiction of the wetlands retention of sediment can be seen in Figure 5 below.



Source: (Elder & Goddard 2005)

Figure 5: Sediment Capture- Jackson Creek Wetland

This rehabilitation project greatly enhanced the water quality of Delevan Lake. Kashian (2005) created a hedonic model to evaluate the effect of these changes, and utilized assessed values for a selection of properties on Delevan Lake, two other lakes, and a nearby town. Instead of a cross-sectional approach, property values were gathered for the years 1987, 1995, and 2003. The environmental variable was taken from secchi-disc readings and the rest of the model included the typical housing and neighborhood characteristics. The Kashian (2005) study found that values around the rehabilitated Delevan Lake increased 354 percent compared to a 222 percent increase for properties at nearby lakes. The Elder and Goddard (2005) study showed that even though sediment was being retained in the wetlands and the eutrophication process had been temporarily cleaned up, the nutrients were still being released into the lake. Comparing this study to the Kashian study opens up the notion that nutrient levels themselves may not be adequate to affect property values if there were no perceivable eutrophication effects or if the sediment that generally accompanies these nutrients was held at bay. Based on this assumption, one could derive that the decrease in sedimentation within the lake may have been just as responsible for increased property values at Delevan Lake as the higher secchi-disk readings.

Synthesis of Water Quality Studies

The general finding from these previous studies is that environmental variables can have an affect on property values, but the variable likely will have to be obvious or noticeable to the homeowner. Objective measurements of these environmental variables will work and have been shown by Poor, Boyle, Taylor, & Bouchard (2001) to be statistically stronger than the subjective measurements; however, a mechanism needs to be in place to inform the homeowners of this variable if it is not readily observable, such as education programs or public health advisories.

Many of the housing characteristics were the same from model to model and consisted mainly of the fundamental attributes of the house. In many ways the models may have overcompensated for the housing characteristics, including many variables that likely duplicate each other and may even be highly correlated, creating a problem with multicollinearity (Kiel 2006). This problem should best be solved by avoiding redundancies within the model.

The problem of multicollinearity also can occur within the neighborhood characteristics and the environmental variables as well. Redundancy should be avoided within these sections of the model as well but not at the cost of omitting an important variable that could lead to a biased estimate of the environmental variable (Leggett 2000). To avoid this omitted variable bias within the environmental variable of the hedonic equation, Leggett (2000) added variables to calculate distance from local emitters, such as a NPDES permit sites.

The Kashian (2005) study was unique in that it reviewed the potential for changes within the values of lakefront properties over time due to a massive rehabilitation project. Unfortunately, by only evaluating one objective environmental variable, it is hard to distinguish whether the perceived value is truly associated with the improvement in water clarity as measured by secchi-disc readings or a factor of omitted variable bias.

The ideas and findings discovered within this review of hedonic water quality studies will play a fundamental role in formulating a hedonic model for this study. Further analysis of these studies will be included throughout the formation of the methodology of this thesis as this body of work represents the framework from which this study is based.

CHAPTER III

STUDY AREA AND DATA SOURCES

Can a monetary value be estimated (using a hedonic model) for the losses incurred by lakeside property owners due to the effects of sedimentation and algal bloom events? To answer that research question, a hedonic model will be created to analyze the effects of these observable environmental variables on properties along Lake Greenwood, in South Carolina. The study area lends itself to this sort of investigation because of the growing database of information accumulated for Lake Greenwood and its watershed, the Saluda- Reedy Watershed. Following a major algal bloom occurring in 1999, a group of stakeholders including non-profits, academics, private consultants, and philanthropic organizations organized the Saluda- Reedy Watershed Consortium (SRWC) in an effort to create, "a foundation of sound science on which to build a broad array of policy and outreach efforts." (SRWC 2007) Furthermore, Greenwood County, which borders the entire western side of the lake, holds ownership of Lake Greenwood. As a result, the County has accumulated an extensive data set for the lake and its surrounding properties. The data acquired from the SRWC and Greenwood County was essential to the formation of the hedonic model used in this analysis.

The Study Area

Lake Greenwood is a major impoundment receiving water from the Saluda- Reedy watershed, which can be seen in the figure below.

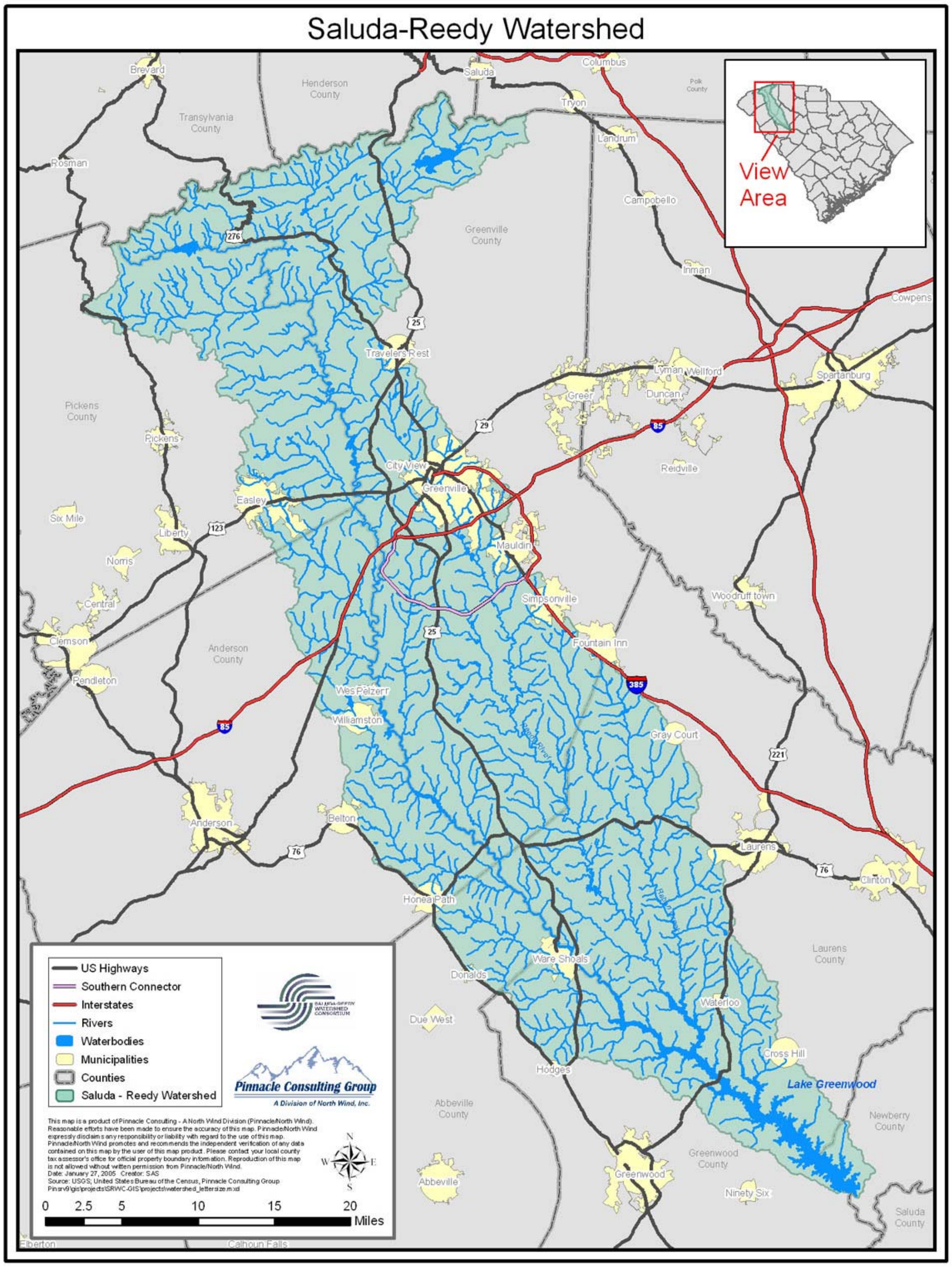


Figure 6: Saluda-Reedy Watershed Map

The Saluda-Reedy Watershed consists of 1,165 square miles, which includes much of the rapidly growing urban Greenville area. Lake Greenwood, seen in the southeast corner of the figure above, is an 11,400-acre reservoir constructed in 1941. It plays an important role as an economic and recreational asset to the region and is utilized by surrounding counties for both water storage and power generation. Located at the end of the watershed, both the Reedy and Saluda Rivers lead into the lake and represent the major source of inflow into the lake. The Saluda River has a flow of 976 cubic feet per second (cfs), which is nearly three times the 352 cfs flow of the Reedy River. Water quality problems have been documented for both rivers.

A study conducted by Clemson University's Institute of Environmental Toxicology monitored sampling stations located near the points of confluence for each river as they enter the lake. The study found that the Reedy River had higher concentrations of the nutrients phosphorous and nitrogen as compared to the Saluda River. The higher level of nutrients was most likely due to, "more point-source discharges, such as wastewater treatment facilities, along its course." (SRWC 2006) However, when flow rates were taken into consideration, the study found the total load levels of these nutrients to be nearly identical for each river. The loading of total suspended solids (TSS), i.e. sediment, was significantly higher within the Saluda River, most likely due to a larger watershed and the effect of non-point sources such as agriculture (SRWC 2006). However, both rivers are contributors to sedimentation within the reservoir.

The sediment accumulation within Lake Greenwood has been calculated for some sections of the lake near the confluences of the Saluda and Reedy rivers. The Saluda- Reedy Watershed Consortium (2004) has shown that, "over two billion gallons of water storage volume has been lost" from just the upper portions of the lake. An "average of 16.6 cubic yards of sediment is delivered to the lake for every acre of land (in the applicable portion of the watershed)", causing many areas of the lake to become "progressively more shallow" (SRWC 2004). These calculations were produced using two methods of sediment estimation. Initially, a sediment report from the United States Department of Agriculture- Natural Resources Conservation Service (USDA-NRCS 2002) calculated sediment in sections of the lake using measurements taken during a field survey. The measurements were made using a range pole that was first lowered to probe for the water depth and then pushed through the sediments down to the residual soils that make up the original lake bottom. A GPS unit recorded the position, and later the location and measurement data was examined to create cross-sections that were then used to calculate the estimated cubic yards of sediment that have filled in the selected study areas of the lake. Further analysis was made for these sections within a SRWC report (SRWC 2004) as ArcGIS was utilized to calculate the areas of accreted sediment. This analysis was made measuring the difference between the original 440' elevation line, which represents the original extent of the lake, against current lake levels as shown from aerial photographs. The areas of vegetated bottomlands that were located within the original 440' line were measured to show that, "approximately 307 acres of water area has disappeared due to sediment accumulation." Combining the two sets of data, the SRWC was able to estimate that the, "total volume of sediment delivered to the uppermost portion of the lake is about 11 million cubic yards." (SRWC 2004).

Lake Greenwood has also experienced several algal bloom events over the last couple of decades, with a major event occurring in 1999 (SRWC 2004). The

1999 event occurred mostly in the upper reaches of the lake near the confluences of both the Saluda and Reedy Rivers. It is in this upper section of the reservoir that the majority of the sediment infilling has occurred (SRWC 2004). The algal bloom event of 1999 was so bad as to hinder most recreational activity throughout these portions of the lake while it was being treated with algaecide. The photographs below (SRWC 2004) show both the sedimentation in the upper reaches of the watershed (Photograph 1) and the algae growth that occurred during the algal bloom of 1999 (Photograph 2).

Photograph 1: Sediment in Lake Greenwood **Photograph 2: Algal Bloom in 1999**

The study area, Lake Greenwood, has issues that are of interest for answering the research question posed in this study. The high levels of sediment accumulation provide a unique opportunity to test a hedonic model using sediment as an environmental variable. Sediment accumulation, particularly accreted sediment, is readily observable and thanks to the SRWC has been reported to the surrounding public. The major algal bloom event of 1999 was also readily observable and broadly reported throughout the local media during that period of occurrence in the late summer 1999. This algal bloom event then also provides a unique test of the hedonic model to see the effects eutrophication, as perpetuated by sediment and nutrient loading, may have on property values.

Data Gathering

As mentioned previously, a wealth of information has been created for Lake Greenwood and its watershed because of the growing interest by concerned stakeholders and the management interests of Greenwood County. Data was obtained for this project from North Wind Inc., a local environmental consulting firm (formerly called Pinnacle Consulting Group) that has contributed greatly to the Saluda-Reedy Watershed Consortium (SRWC). Data was obtained pertaining to the report on sedimentation within Lake Greenwood. This data included the original USDA- NRCS data points defining the sediment within the lake as well as the data used by North Wind for their evaluation of the accreted sediment. North Wind, Inc. also provided a bathymetry model representing the current lake bottom and data showing the location of NPDES permit sites around the lake. Perhaps most importantly for this project, North Wind, Inc. made available hard copy survey maps that show the original 440’ line, representing the original extent of the lake.

Information from the Greenwood GIS department was vital for the creation of variables for the hedonic model. The Greenwood County database provided some detailed information of parcels along the Greenwood County, SC side of the lake, which equates to the entire western side of the lake from its confluence with the Saluda River to its end at the Buzzards Roost Dam. However, complete parcel data on the Laurens County side of the lake is incomplete, so only the parcels on the Greenwood side of the lake shall be considered within this analysis. Fortunately, the study area includes both the upper Saluda River arm of the lake, where many sediment problems have occurred, and areas farther down the lake that have not had as many sedimentation issues.

The analysis for this thesis will focus on homes within 1000 feet of Lake Greenwood along the Greenwood County side of the lake. Homes with incomplete data will be dropped from the study. The remaining properties will be selected as the study group; the study group can be seen in Figure 7 below.

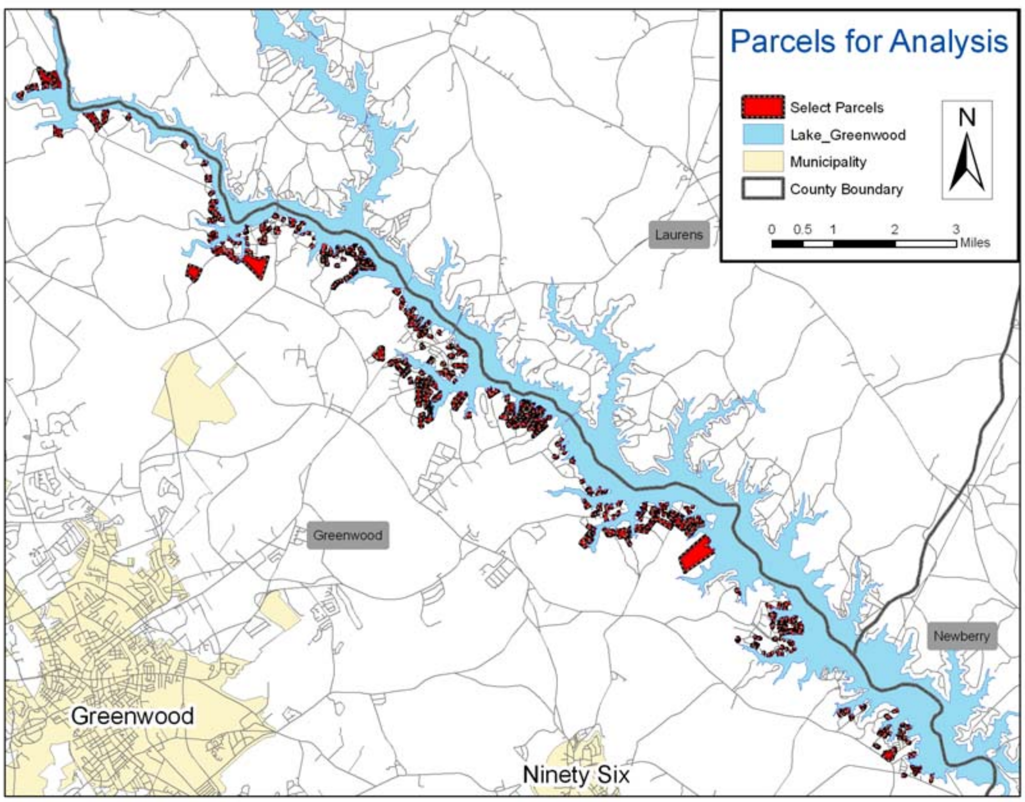


Figure 7: Study Area Map

The housing characteristics from the parcel data will be used and include: number of bedrooms, number of bathrooms, square footage, basement square footage, unfinished basement square footage, year built, and acreage of parcel. The parcel data includes an appraised market value. The actually sale price and sale date have been obtained from the GIS Department as well as the Tax Assessor's office. The housing data also included a record of previous net property taxes and the tax district that the property was located.

The Greenwood County GIS Department hah also provided a geo-referenced survey map of the original 440' line as well as a critical habitat layer that showed the habitats present around the edge of the lake. The polygon representing the lake boundary itself was obtained from Greenwood County and was created from 1992 aerial photogrammetry with a plus or minus 5-foot horizontal accuracy. Also critical to the model, the Greenwood County GIS database included commercial, industrial, golf course, and mobile home park locations within the study area, as well as municipal and county boundaries.

Data was compiled from the South Carolina Department of Natural Resources (SCDNR), in particular, the 2006 Orthophotos for the surrounding region. These adjusted aerial photographs were taken some time between January 1 and March 7. All other data used for this thesis was created using spatial analysis techniques within ArcGIS.

CHAPTER IV

METHODOLOGY

After defining the study area and gathering existing data describing Lake Greenwood and surrounding properties, a review of the hedonic model will help identify relevant data that can be utilized as attributes to help explain the dependent variable. Other data will be created, prepared, and refined using ArcGIS and other database tools. Finally, a methodology will be created to establish the different models in order to analyze the effects that sedimentation and the 1999 algal bloom event may have had on property values around the lake.

Preparing the Data

A typical hedonic regression equation (Kiel 2006) is:

$P_i = \beta_0 + \beta_1 H_i + \beta_2 N_i + \beta_3 ENV_i + \varepsilon_i$,

Where P is the dependent variable and the independent variables consist of (H) housing attributes, (N) neighborhood or location attributes, and (ENV) the environmental attributes including the environmental variable in question. In this study, the dependent variable is either the sale price or the appraised market value for homes within 1000 feet of the western side of Lake Greenwood. The sale price was adjusted to 2006 dollars based on the consumer price index for the southeast region and the listed sale date for each house. The independent variables representing attributes considered important by those in the housing market are obtained from or created by further analysis of the gathered data.

Housing Attributes

Many of the housing attributes are already available from the Greenwood County database and are left as is, such as number of bedrooms, square footage, basement square footage, unfinished basement square footage, and lot size (in acres). Other data categories are included within the Greenwood County dataset, but must be modified to fit the model. Number of bathrooms and number of half bathrooms are consolidated, with each half bathroom being added to the number of bathrooms as .5. Thereby a house with two bathrooms and one half bathroom is listed as having 2.5 bathrooms. Combining these two data sets is done to help minimize the total number of variables. The year the house was built is used to calculate the age of the house with 2006 being the base year. Therefore, if a house was listed as being built in 1996 it is classified as ten years old within the age category. The construction date for the house was used again to create a comparison with the purchase date information in order to analyze properties that were sold without a house present. Other data is created solely through analysis. Within ArcGIS, the parcels are analyzed along with the Orthophoto aerial imagery. Total lake frontage for each lot is measured to the nearest meter and a dummy variable is established for each house with a dock. All the houses that appear to have a dock or pier from inspection of the aerial photography are listed with a one in the Dock column. All the properties utilized within this study were chosen because they were within a 1000 feet of the lake. Further analysis is done looking at lake front properties and properties within a certain proximity to the lake. Properties within 300 feet of the lake are tagged within the 300_feet category. This distance is established based on findings from the National Association of Home Builders (NAHB 1993) that stated that properties within 300 feet of a lake would show an increase up to 27.8 percent.

Neighborhood Attributes

The neighborhood or location attributes are mostly created by performing a spatial analysis on the existing data. Variables were created for both potentially positive and potentially negative locational attributes. Beginning with the positive attributes, the houses are tagged if they are located within a neighborhood near one of the two golf courses on the Greenwood side of the lake: Stoney Point or The Patriot. Secondly, houses are tagged if they were within a half mile of Greenwood State Park. Greenwood State Park is a 914-acre park located on Lake Greenwood that provides camping, fishing, boating, and hiking. Thirdly, the distance from a property to the nearest grocery store was marked to the nearest whole mile. In previous hedonic studies, properties are often evaluated based on their proximity to the nearest major city. Within the study area used for this thesis, the properties were found to be generally the same approximate distance from the city of Greenwood, so the nearest grocery stores were used to evaluate distance to the nearest commercial entities. The potential negative attribute was based on proximity to mobile home parks, tagging all properties within 500 feet. Proximity to industrial sites was also considered for analysis, but there were only a couple industries within the study area, and both were covered by the NPDES permit category included within the environmental attributes. The neighborhood characteristics for the properties within this thesis were found to be homogenous in regards to other potential attributes, such as nearby land use or potential employment models. The area spans three different school systems, but there seemed to be very little difference among their academic achievement records. A figure showing the spatial relationships of the neighborhood attributes is shown in Figure 8 below.

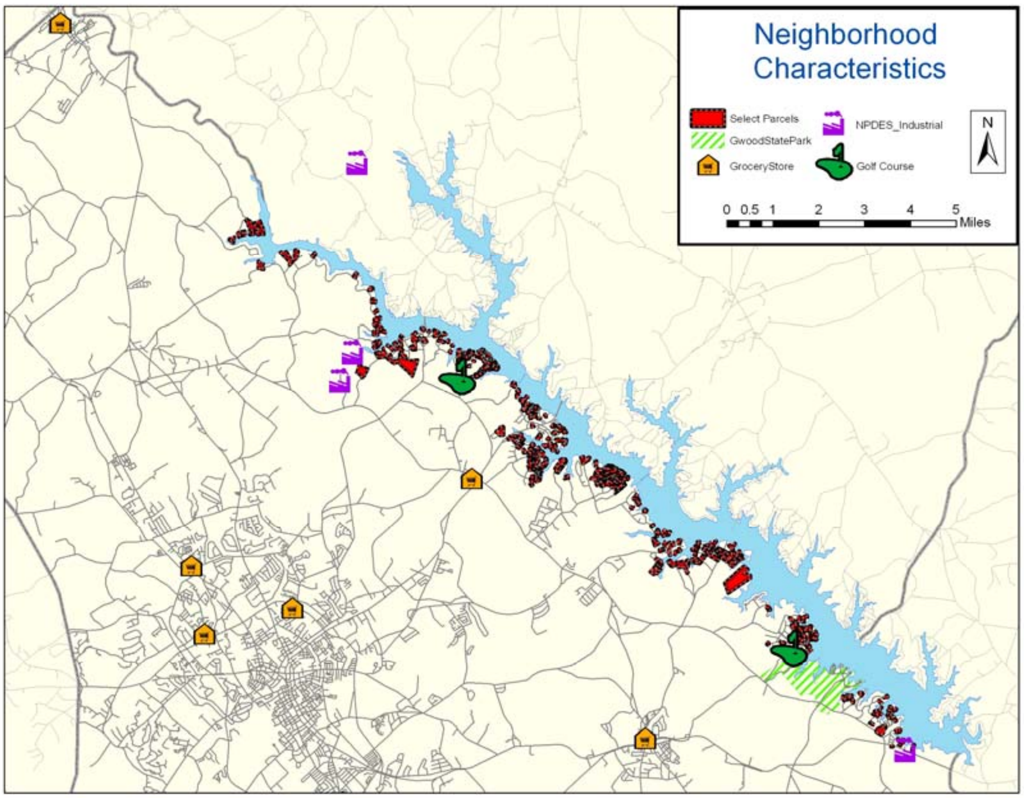


Figure 8: Neighborhood or Locational Attributes

Environmental Attributes

The main environmental variables relate to sediment and the 1999 algal bloom event. However, in order to avoid the possibility of an emitted variable bias, it is necessary to account for other pollutant sources that may be observable by those within the housing market. The proximity around an industrial NPDES permitted site is considered by establishing a dummy variable for homes within a mile of these sites as shown in Figure 8 above. The National Pollutant Discharge Elimination Service (NPDES) is a permitting program for anyone who is discharging waste or wastewater into surface waters. The permits impose effluent limits that are created to protect the environment, however they sites are still emitters and may still have an effect on property values nearby. The focus for this proximity measurement in this study was on industrial NPDES sites, ignoring the water treatment plant and homeowners association owned sites.

Attempts were made to model sediment loads for the lake following the two-method approach as found in the SRWC report (2004) on sediment within the upper reaches of Lake Greenwood. This two-method approach evaluated sediment loads within the lake, which had changed the contours of the lake bottom, and accreted sediment that had filled in sections of the lake, thereby reducing water surface area. The USDA- NRCS field data points, used to evaluate sediment within the lake, were only taken within the upper portions of the lake. A current bathymetrical model obtained from North Wind, Inc. would show the level of the current sediment deposits, but it must be compared with the original contours of the lake. Unfortunately, a topographic map of the area before impoundment is not available at any scale that would allow for this sort of investigation. The USGS quad maps dated before the 1930's impoundment were produced with 50-foot contours and would be of little use in creating contours for a lake whose deepest depth is 69.5 feet with an average depth of 21.8 feet (SCDHEC 2004). Unable to calculate underwater sediment deposits for the entire lake, this thesis will focus on the second method of sediment measurement and attempt to calculate the accreted sediment throughout the entire lake.

To calculate the areas of accreted sediment, a map showing the original 440’ line, representing the original extent of the lake, and a map of the current lake extent must be used to observe the noticeable areas of change that represent the infill of sediment. The 440’ line was established within a 1981 Duke Power survey map that was received as a hard copy from North Wind Inc., scanned, and geo-referenced within ArcGIS to best approximate how the map would fit spatially with the rest of the data. A copy of the same map already geo-referenced was obtained from the Greenwood County GIS department and was used alongside with the one geo-referenced for this study. The geo-referencing process is very subjective and oftentimes a map may line up perfectly in one section but still be slightly askew in another. Utilizing both maps to approximate the 440’ line was done to improve the accuracy this analysis. The 1981 Duke Power survey map depicts the original 440’ line as surveyed in the 1938 Greenwood County Municipal Power Plant atlas maps. The 1981 map also depicts corrections for some areas of the lake wrongly surveyed in the original maps. The current lake extent is approximated using the Lake Greenwood polygon, which was calculated using 1992 aerial imagery. Areas around the lake where the current lake polygon is distinctly different from the 440’ line were categorized as accreted sediment. It should be noted that the current lake level is actually set at 439’ feet; however, at the scale that this analysis is performed, it is unlikely that this would have contributed to any major errors in the approximations of sediment. Additional analysis is performed using the 2006 Orthophoto aerial images. The aerial images cannot be used to estimate the current extent of the lake because the images were taken during the late winter to early spring of 2006. The lake is lowered every winter, is gradually allowed to refill, and may not have been completely full at the time of the images. However, the imagery was used to identify additional areas of accreted sediment based on the presence of vegetation, which will only be present in areas that are normally above the water level. Polygons were created within ArcGIS that correspond to the areas of accreted sediment as evaluated from the methods stated above. Figure 9 below shows the geo-referenced survey map, the lake polygon, and the accreted sediment areas.

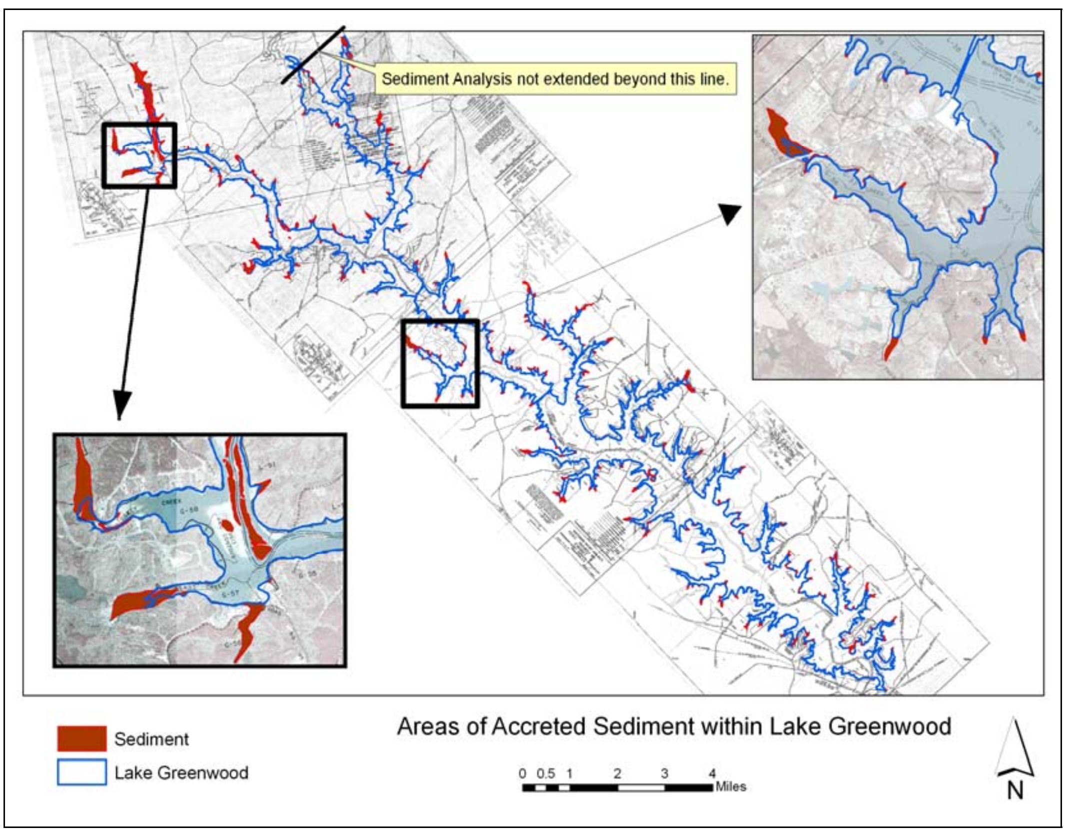


Figure 9: Sediment Calculations

To relate the accreted sediment data to the homes within the study area, segments are established to help approximate the area of influence, i.e. the area around a home where observed sedimentation would influence the value. The areas of accreted sediment are analyzed to determine their acreage and their location with respect to the pre-determined segments of the lake. Calculations are made to determine the percentage of the lake surface area that has been filled with accreted sediment within the property's area of influence, defined as the three closest segments: the immediate segment that the property borders, the segment upstream, and the segment downstream. These calculations are shown in Appendix A. The map shown in Figure 10 below classifies the segments based on their level of sedimentation.

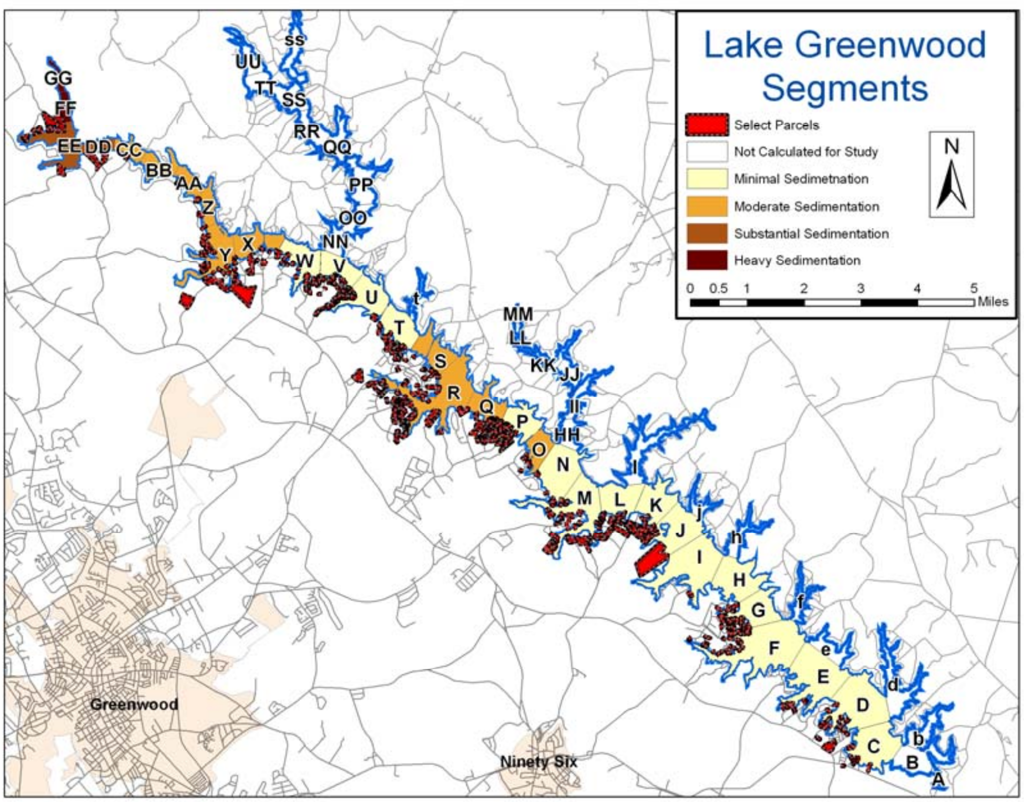


Figure 10: Designated Lake Segments

The effect of the 1999 algal bloom will be analyzed with a dummy variable that denotes houses sold in the two years following the event. It is thought that the algal bloom may have affected the housing market through the media coverage and public attention that the event obtained. It is suspected that properties sold in the years immediately following (July 1999 thru July 2001) may have been sold at a decreased value compared to normal sale prices for the properties surrounding the lake. It is likely that the effects of this algal bloom event would continue to affect property values until some unspecified period of time when it would fade out of the public consciousness. However, the algal bloom variable established here is only attempting to capture a snapshot of this relationship between an algal bloom event and a potential downturn in property values. The environmental attributes will be included along with the housing and neighborhood attributes in order to approximate the effects they may have on property values when all other variables are held constant.

The Variables

There will be two independent variables evaluated for this project: the appraised market value and the sale price. The county tax assessor established the market values with the majority of the assessments having been performed in 2001. The sale prices of the properties have been converted into 2006 dollars utilizing the Consumer Price Index (CPI) for the Southeast region. Both independent variables have been transformed into units of a thousand dollars (i.e. a $200,000 home is listed as 200.000). Table 1 below shows the two dependent variables and their column headings.

Table 1: Dependent Variables

Property Values	
Market Value [2001] ($1,000)	MarketTH
Sale Price [in 2006 dollars] ($1,000)	CPI_SaleTH

A list of all the independent variables that have been prepared for use within the hedonic model can be seen in Table 2 below. The table also lists the abbreviated column headings for each of these variables. Information describing the preparation of these variables can be found in the sections above, separated by attribute type (as they are below).

Table 2: Independent Variables

Housing Attributes	
Square Footage	SqFt
Finished Basement Square Footage	FinBsmtSqF
Unfinished Basement Square Footage	UnfinBsmtS
Bedrooms	Bedrooms
Bathrooms+Half Bathrooms	Bathrooms
Age of Structure	Age
Dock or Pier	Dock
Length of Lake Frontage (meters)	WF_Length
Waterfront	WF
Within 300' of the Lake	300_feet
Parcel Acreage	Acres
Neighborhood Attributes	
Golf Course Access	GolfCourse
Proximity to Grocery Store (miles)	Grocery_St
Within a 1/2 mile of G'wood State Park	StatePark
Within 500 feet of a Mobile Home Park	MblHome
Environmental Attributes	
Within a 1 mile of industrial NPDES site	NPDES
% of Surrounding Lake Area filled with Sediment	Sediment
Houses sold between July '99 and Jul '01	AlgalBloom

The Models

In order to make the best use of the data gathered for this project, two separate models will be established, so that both dependent variables can be utilized. A "market value" model (MV-model) will be able to use the entire database of selected properties (632 properties). It also has the advantage of having the dependent variable already listed in common dollars. However, the market value is somewhat subjective, based on the assessor's analysis of surrounding property values. A "sales price" model (SP-model) uses a dependent variable that provides the actual value of the properties as derived from the last market transaction. The sales price model also has the advantage of being able to analyze differences in property valuation over time, which will be beneficial in trying to pinpoint the effects of the algal bloom event. All the sales price data must be converted to common dollars, in this case 2006 dollars. The data set is cut to 558 properties due to missing or transfer only sales, such as a property passed on to a relative for a $1. The missing or transfer only sales represent 74 of the original 632 properties listed in the database or nearly 12 percent. Both models have an appropriate amount of data to predict the effects of our environmental variables on the value of properties around Lake Greenwood.

MV-model

The MV-model utilizes the market value as the independent variable and incorporates all the housing, neighborhood, and environmental attributes, except for the algal bloom variable, which will only be utilized within the SP-Model. The variables used in the model can be seen below in Table 3 along with their descriptive statistics, which include: minimum or maximum value, mean value, the standard deviation, and the count or number of properties with a value for that variable. The model will be expected to show that there is relationship between accreted sediment and property values within the Lake Greenwood study area.

Table 3: MV-model Variables and Descriptive Statistics

Market Value	Min	Max	Mean	Std. Dev.	Count
MarketTH	6.200	671.000	224.703	114.709	632
SqFt	425.00	5553.00	2206.94	835.88	632
FinBsmtSqF	0.00	2416.00	258.97	532.02	142
UnfinBsmtS	0.00	2810.00	183.36	444.13	140
Bedrooms	1.00	6.00	3.06	0.81	632
Bathrooms	1.00	5.50	2.45	0.79	632
Age	0.00	76.00	13.79	14.47	632
Dock	0.00	1.00	0.54	0.50	340
WF_Length	0.00	755.00	31.37	48.22	417
WF	0.00	1.00	0.66	0.02	417
300_feet	0.00	1.00	0.77	0.42	487
Acres	0.02	94.61	1.44	4.68	632
GolfCourse	0.00	1.00	0.29	0.45	184
Grocery_St	2.00	7.00	3.86	1.23	632
StatePark	0.00	1.00	0.09	0.28	54
NPDES	0.00	1.00	0.11	0.31	68
Sediment	0.464	22.792	2.509	3.391	632

<u>SP-model</u>

The SP-model utilizes the market value as the independent variable and incorporates all the housing, neighborhood, and environmental attributes developed for this thesis including the Algal Bloom variable. The variables used in the model can be seen below along with their descriptive statistics in Table 4.

Table 4: SP-model Variables and Descriptive Statistics

Sale Price	Min	Max	Mean	Std. Dev.	Count
CPI_SaleTH	7.35	875.00	185.60	143.52	558
SqFt	0.00	4736.00	1229.73	1140.37	338
FinBsmtSqF	0.00	2224.00	131.91	399.80	65
UnfinBsmtS	0.00	2674.00	69.44	278.40	54
Bedrooms	0.00	5.00	1.81	1.57	338
Bathrooms	0.00	4.50	1.39	1.25	338
Age	0.00	76.00	10.58	14.59	338
Dock	0.00	1.00	0.54	0.50	302
WF_Length	0.00	600.00	29.11	37.81	367
WF	0.00	1.00	0.66	0.02	367
300_feet	0.00	1.00	0.77	0.42	428
Acres	0.02	17.68	1.13	1.70	558
GolfCourse	0.00	1.00	0.32	0.47	176
Grocery_St	2.00	7.00	3.87	1.23	558
StatePark	0.00	1.00	0.09	0.29	51
NPDES	0.00	1.00	0.11	0.31	60
AlgalBloom	0.00	1.00	0.13	0.34	75
Sediment	0.46	22.79	2.48	3.49	558

Many of the properties were sold before the house was built on the property, thereby distinguishing the need to use housing characteristics to explain the sales price. For these 220 properties the housing characteristics were adjusted to zero to more accurately represent the condition of the property when it was purchased. The model will test the hypothesis that there is relationship between accreted sediment and property value within the Lake Greenwood study area, as well as show that the 1999 algal bloom event, which occurred in mid-July and lasted for a couple of months, had effects on property values around the lake over the next couple of years.

Expected Results of the Hedonic Models

By looking at parcels on and adjacent to Lake Greenwood along the Greenwood County side of the lake, the hedonic models will be able to test for the correlation between sedimentation and decreased property value. The models will test whether increased sedimentation can have a negative effect on property values, and whether sale prices of properties around the lake are affected by algal bloom events. The results of these models should give some representation to the costs placed on the downstream residents due to the failure of those upstream to utilize the proper best management practices to prevent soil runoff and erosion. This study will create a monetary value to represent the cost of heavy sedimentation into our waters. Often within cost-benefit studies, several different sources are utilized to attribute costs to non-market environmental consequences such as sedimentation. Perhaps this study can be used in combination with others to help change the erosion and sediment control and stormwater management practices to help ensure that our waters, reservoirs, lakes, and streams can remain in a sustainable condition for generations to come.

CHAPTER V

RESULTS AND ANALYSIS

Beginning with the research question: "Can a monetary value be estimated (using a hedonic model) for the losses incurred by lakeside property owners due to the effects of sedimentation?" This thesis has examined the nature of the problem, researched how other investigations have pursued this issue, collected data and information from the local study area, Lake Greenwood, and prepared the data to fit the two hedonic models, which have been designed to measure the effects of sedimentation and major algal bloom events on lakeside properties. The literature supported the use of accreted sediment and algal bloom events as variables due to the high propensity for these attributes to be observed by the public: either personally, through local media, government reports, or as hearsay from fellow citizens. Previous studies have found that observable environmental variables tend to have the greatest likelihood to have effects on property values. This study will test the research question established at the beginning of this thesis and in doing so will attempt to advance or support the knowledge base and help perpetuate the use of insightful economic valuation techniques in order to gauge the effects of depredated water quality. Economic valuation techniques are not pretty or without their flaws, but they hold one of the best opportunities to grab the attention of stakeholders, politicians, and the public as a whole and work towards creating effective change in the way that our limited water resources are managed.

Initial Trials and Correlations

Initial trials showed that one of the selected variables was not correlated with the independent variable and was omitted from further trials to simplify the model and prevent inaccurate results. The neighborhood attribute MHP500ft, which tagged properties that were within 500 feet of a motor home park, was found to be insignificant in predicting the dependent variable. This may be because only 16 of the original 634 properties and only 15 out of the 558 property SP-model had this attribute. This neighborhood attribute may also have been nullified because the mobile home parks near the lake are small and may not create a disamenity for nearby properties. Since the variable was having no effect on the dependent variable, it was left out of the models.

A correlation matrix was created for each set of independent variables to test for problems of multicollinearity. The correlation matrix for the two models can be seen in Appendix B. The environmental attributes appear not to be highly correlated with any of the other explanatory variables. The correlation analysis does show that several of our housing attributes have relationships with other housing attributes. Bedrooms and bathrooms have a strong correlation with the square footage of the house and with each other. This of course makes sense, as the size of the house increases so does the likelihood for more bedrooms and bathrooms. The waterfront variable is moderately correlated with dock ownership and the parcels within 300 feet of the lake. In addition, within the market value model, waterfront length is moderately correlated with parcel acreage. These relationships again make sense, a parcel would need to be waterfront to have a dock on the property and many within the 300 foot distance of the lake are also waterfront as well. Also, a larger lot size could correspond to greater length along the water's edge. Ultimately, these relationships within the housing attributes will not affect the results for the environmental variables, however they may detract away from the accuracy of the coefficients for these correlated housing variables. All of these variables will be considered for inclusion within the models.

MV-model Results

The equation for the market value model will be created through a step-wise regression process. The full model including all variables will be calculated and the weaker variables, those that appear to have little significance, will be excluded in an effort to make the model stronger. From this process, the optimum MV-model equation includes all variables except for bedrooms, parcels within 300 feet, and proximity to grocery store. The bedrooms variable likely showed little significance because of its high correlation with both bathrooms and square footage. Many of the parcels within 300 feet of the lake are also represented by the waterfront variable and so this variable likely added little to the predictive power of the equation. The proximity to the grocery store failed to achieve statistical significance, perhaps because all parcels inside the study area are within a 7-mile distance to a grocery store or because distance to the nearest grocery store is not be a major factor in purchasing a home along the lake.

The results of the market value model are shown in table 5 below. Full results can be seen in Appendix C. The adjusted R^2 is 0.869, showing that the independent variables within the model explain nearly 87 percent of the variation in the dependent variable, in this case the market values for selected properties within 1000 feet of Lake Greenwood. When reviewing the table it is important to remember that the dependent variable was recorded as units of a thousand.

Table 5: Market Value Model Results

MV-model	Coefficients	t- statistics	P- value	95% Sig	90% Sig
Intercept	-9.407	-1.165	0.244	no	no
SqFt	0.067	23.510	0.000	yes	yes
FinBsmtSqF	0.033	9.394	0.000	yes	yes
UnfinBsmtS	0.011	2.870	0.004	yes	yes
Bathrooms	16.937	5.299	0.000	yes	yes
Age	-1.359	-9.529	0.000	yes	yes
Acres	0.615	1.174	0.241	no	no
WF_Length	0.438	7.497	0.000	yes	yes
WF	33.724	5.470	0.000	yes	yes
Dock	8.059	1.511	0.131	no	no
GolfCourse	49.710	10.977	0.000	yes	yes
StatePark	31.846	4.885	0.000	yes	yes
NPDES	-2.516	-0.468	0.640	no	no
Sediment	-1.717	-3.177	0.002	yes	yes

The majority of the housing characteristics behave as one might have suspected. The variables describing the size of a home: SqFt, FinBsmtSqF, and UnfinBsmtSqF are found to be significantly correlated with the market value of a home. For example, the SqFt variable shows a coefficient of 0.067. With all other variables remaining equal, an extra square foot of living space will increase the price of a home by $67. As one adds space to their home, they should be sure to add a bathroom. Again, with all other things being equal, an extra bathroom can add approximately $16,937 to the value of a home. However, it was found within the correlation matrix that the bathroom variable was highly correlated with square footage, therefore the coefficient for either of these variables may not be entirely reliable, but likely reflects a true relationship and helps account for all the elements considered within the market value of a home. The age of the house is found to be negative, which of course seems logical, as a house gets older it will depreciate and houses built in more recent years are likely to be larger than older homes and therefore hold a larger appraised value. Not surprisingly for these lakeside houses, the attributes that add the most value deal with its location in proximity to the lake and the length of the waterfront edge. A waterfront home will be show an increase in value of over $30,000 compared to other homes not located directly along the lake. Within this model, the dock variable is not found to be statistically significant at either the 95 or 90 percent levels. This lack of statistical significance is likely related to this variables correlation with the waterfront variable. The waterfront length variable shows that an extra meter of property along the edge of the lake will equate to an increase of $438 in value with all other variables being held constant. The acreage of the property is not found to be statistically significant in the model and may reflect the correlation between the acreage variable and WF_Length. Although many of these housing attributes have issues with multicollinearity amongst themselves, the inclusion of these variables helps strengthen the model and more accurately calculate the values of the location and environmental attributes.

The neighborhood or locational attributes that remained in the refined model are statistically significant and show the value of nearby amenities. Having a house within a golf course community could raise the value of a home by nearly $50,000. A home located within a half mile distance of Greenwood State Park is also a valuable attribute, adding over $30,000 to the value of a home.

Important to the interests of this study, the sediment coefficient is -1.717 and is found to be significant within the 95 percent confidence level. With all other attributes held constant a one percent gain in accreted sediment within the local vicinity of a home could decrease the value of the property by just over $1,700. This finding is significant, however the sale price model may provide us with a more accurate account since the dependent variable in the SP-model is a product of a true market transaction and not a broad appraisal of worth across properties.

SP-model Results

Following the process established in the creation of the MV-model, the equation for the sales price model will be created through a step-wise regression process. The full model will be calculated and the weaker variables, those that appear to have little significance, will be excluded in an effort to make the model stronger. From this process, the sales price model equation excludes the same variables as the MV-model: bedrooms, parcels within 300 feet, and proximity to grocery store. Additionally, the variable for unfinished basement square footage is left out of the model. This unfinished basement square footage variable held little significance within this sales price model and may reflect a difference between appraisal values and the true market price found from the sales price.

Running a least squares regression on the remaining variables, the resulting model has an adjusted R^2 of 0.795, showing that the independent variables within the model explain nearly 80 percent of the variation in the sale price for properties within our study area. The results of the sale price model are shown in Table 6 below. The full results can be found in Appendix C.

Table 6: Sale Price Model Results

SP-model	Coefficients	t- statistics	P- value	95% Sig	90% Sig
Intercept	6.907	0.898	0.369	no	no
SqFt	0.077	12.366	0.000	yes	yes
FinBsmtSqF	0.045	5.815	0.000	yes	yes
Bathrooms	23.251	4.052	0.000	yes	yes
Age	-1.525	-7.041	0.000	yes	yes
Acres	3.556	1.776	0.076	no	yes
WF_Length	0.199	1.895	0.059	no	yes
WF	44.010	4.199	0.000	yes	yes
Dock	25.615	2.827	0.005	yes	yes
GolfCourse	49.998	6.923	0.000	yes	yes
StatePark	43.216	4.114	0.000	yes	yes
NPDES	-17.536	-1.953	0.051	no	yes
AlgalBloom	-22.230	-2.680	0.008	yes	yes
Sediment	-2.135	-2.334	0.020	yes	yes

Once again, we see many of the housing attributes behaving as we might expect. Bathrooms retain their significance, with each additional bathroom adding approximately $23,251 to the value of a home. Square footage and Finished Basement square footage continue to have a significant effect on home values, with sellers receiving an extra $77 per additional square foot and $45 per additional square foot of basement space. Again, the age of a house is found to have a negative relationship to its value. Parcel acreage is found to be significant at the 90 percent confidence level within this model, reflecting a predictable positive relationship. The waterfront length does not show as strong a statistical significance as within the MV-model but again shows a positive relationship, with an extra meter of waterfront adding nearly $200 to the price of a waterfront property. The coefficient for the waterfront variable shows an approximate $44,000 increase in the sale price of a property if it is located lakefront. The dock variable is found to be statistically significant in this model, reflecting over $25,000 increase in the sale price of a home by adding a dock to the property.

Similar to the MV-model, the sale price model shows a large coefficient for both neighborhood amenities used within the model: a neighborhood golf course and proximity to the Greenwood State Park. Living in a neighborhood with a golf course could add $50,000 to the sale price of a home, and living near the State Park could add over $40,000 to the price of a property. An environmental variable that did not show statistical significance in the MV-model, proximity to a NPDES industrial site is found to be siginificant at the 90 percent confidence level within this SP-model. A property within a mile proximity of one of the industrial NPDES sites has a negative effect on the property value with the potential for over a $17,000 decline.

The sediment coefficient found within this model is -2.135, which closely corresponds to the coefficient found within the MV-model. One might expect to find a more accurate estimator using the sales price of properties over the market value, because of the direct connection with the true market behavior. On the other hand, this SP-model can only explain 80 percent of the dependent variable's behavior, whereas the MV-model can explain 87 percent of that dependent variable's behavior. With this in mind, it may be best to look at a range from the two estimates. For each one percent gain in accreted sediment within the local vicinity of a home, the property value for that home could decrease by just over $1,700 to around $2,100. This could have major consequences for the areas of the lake that have had significant portions of the original water line filled in with sediment. For example, in the upper portions of the Saluda arm, where lake houses located around segment EE have seen over 22 percent of the original lake area filled in with sediment, this could equate to a loss in the value of $37,750 to nearly $47,000 per home.

Another important finding within the results of this SP-model is the large negative coefficient for the algal bloom variable. This variable represented all the houses sold in the two years immediately following the algal bloom event. Significant at the 95 percent level, the -22.230 coefficient shows that with all other things being equal, a property sold within the two years following the 1999 algal bloom event could have been expected to receive $22,230 less than one sold during other periods of time. Though the algal bloom occurred mainly in the upper portions of the lake, particularly the Reedy arm, the calculations were made for the entire west side of the lake showing that the event had outreaching effects that at least temporarily within the snapshot 2-year period caused a significant reduction in property values.

Implications

Both models show that there is an effect on property values around Lake Greenwood caused by the environmental attributes of interest. The results for the accreted sediment variable show a range of $1,700 to $2,100 decrease in property values for every percentage of the surrounding lake area that is lost due to accreted sediment. The area of influence for each property is established by calculating the total accreted sediment per lake area for the nearby segments. The segments of the lake evaluated within this project exclude some of the extreme upper reaches of the Saluda and the entire Reedy River arm. However, even in the areas of the lake that were analyzed, the study found an average of 4.6 percent of the local lake area around lake properties to be affected with accreted sediment. This loss in property value could equate on average to over $7,800 or nearly $10,000 in lost value per property. With up to 632 properties selected for this study, the effect that accreted sediment could equate to an estimated loss of $5 to $6 million or nearly 5 percent of the total market value for the selected properties. With many more properties located along the lake, total property value losses could be much higher. The loss in property value results in reduced property tax revenues received by Greenwood County. The true dispersion of property value loss is shown in Figure 11 below.

It should be noted that the method used to calculate accreted sediment within this study was performed very conservatively and most likely underestimated the percentage of original lake extent that has been filled with sediment. Therefore, the use of higher estimates of sedimentation obtained from previous reports could result in an even greater calculation of property value losses.

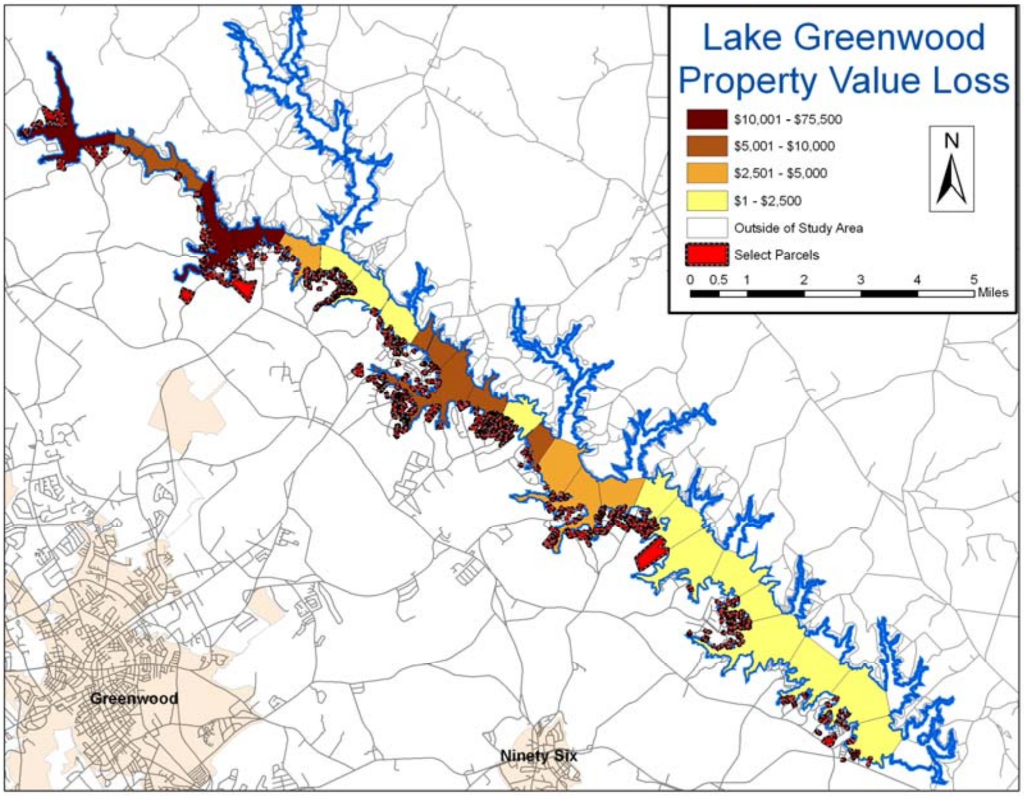


Figure 11: Property Losses for Lake Greenwood by Segment

The figure above shows that the higher property value losses mainly occur in the upper arms of the lake and in some of the upper coves where the majority of the sediment has accumulated. The upper regions of Lake Greenwood will likely continue to see sedimentation within the lake because of the transitional nature of the land in the upper watershed of the Saluda River. The watershed along the Saluda is mostly rural, but is likely to see increased development and possible urbanization in many areas. This transition in land use could result in increased runoff containing sediment and nutrients or through an increase in peak flow cause the scouring of channels and the transfer of existing upstream sediment down into the lake.

As these land use changes take place in the upper watershed, the likelihood for cultural eutrophication within the lake is increased. The occurrence of algal blooms may increase and therefore put Lake Greenwood at risk of future algal bloom events on the scale of the one that occurred in 1999. The hedonic model evaluating sale prices for properties around the lake found that properties sold within the two year period following the 1999 algal bloom were valued at approximately $22,000 less than if they were sold at any other time. Among the selected parcels used for this study, 75 homes were sold during this two-year period. The total loss in property value for these 75 homes equates to over $1.6 million. The observable algal bloom event can affect the public's perceived value of the lake and cause a decrease in property values (as verified in this study) and to associated lake tourism and recreation. Greenwood County tax revenues would likewise drop, and there may be impacts throughout the regional economy.

This thesis discovered a negative correlation between property values and sediment accretion along Lake Greenwood, as well as a negative correlation during the immediate couple years following an algal bloom event. The affects of these environmental variables could have appreciable financial consequences for those living along the lake. Correspondingly, the local governments may receive decreasing tax revenues as a result of these water quality issues. The main causal relationship for these water quality issues can be traced upstream to the land uses and policies existing within the upper watershed. Unfortunately, the costs of actions upstream are not captured by users in the upper watershed, but instead are carried downstream and passed on to those downstream.

Future Research

Future studies may be able to support these findings and help continue to evaluate the effect water quality issues have on reservoir property values. Within this thesis, the variable chosen for the algal bloom event was created by selecting properties sold within the two year time period following the 1999 event. This variable represents only a snapshot of a time period where market transactions are likely to be affected by the recent event. It is likely that the residual affects of this visibly perceived environmental event would still have effects beyond this time period but may begin to wane as it fades out of the public consciousness. Future studies may wish to evaluate the entire effects of a major algal bloom event. This study was also limited in that it focused only on the west side of the lake because of the lack of data for properties on the opposite side of the lake. Also, due to data limitations this thesis was only able to focus on accreted sediment. If an original bathymetry model of the lake is found or created, a future study could potentially compare these contours with a current bathymetry model in order to calculate the sedimentation that has occurred within the lake filling up the original lake bottom. Future studies may also want to utilize a hedonic model such as used within this thesis in order to analyze other water quality variables in order to discover what effect they may have on property values as well.

Conclusions

The findings within this thesis show that sediment variables can be used within a hedonic model to calculate the effects that sedimentation has on property values located around a reservoir. Furthermore, the study has shown that observable environmental variables, such as accreted sediment and the occurrence of algal bloom events, can have significant effects on the public's perception and thereby affect the values of properties located in these areas.

The hope with any environmental evaluation is that it can bolster support for better environmental management approaches that will help solve important environmental issues. This thesis supports the argument that: Lake Greenwood residents, Greenwood County citizens and local governments, and visitors to the lake have been affected by sediment loads and algal bloom events stemming in a large part from non-point sources farther up the Saluda- Reedy Watershed. The wealth of knowledge that is building around these issues will begin to bolster support from concerned stakeholders and politicians. Management techniques and solutions will need to be developed to help alleviate the sediment problem.

Managing sediment within a reservoir can be achieved from two different approaches. The first approach is to remediate by removing or flushing the sediment and reestablishing the natural lake conditions. The remediation approach can be expensive and may only temporarily relieve the problem. The other approach is to support effective erosion and sediment control policies, stormwater management practices, smart growth ordinances, and buffer requirements. This policy approach requires a concerned public, along with active leadership from policy leaders and stakeholders. It is the hope of this author that in the future the results of this thesis and other similar studies may help foster and support the debate on water quality policy by supplying monetary values to non-market environmental goods.

APPENDICES

Appendix A

Sediment Variable Calculations

ID	Total Acres	Sed Acres	3-Segment Acres	3-Segment Sed Acres	Sediment Variable
GG	91.56	75.12			
FF	61.23	21.70	409.92	162.74	39.701
EE	257.12	65.92	385.69	87.91	22.792
DD	67.34	0.29	401.40	68.14	16.976
CC	76.95	1.93	265.05	7.99	3.015
BB	120.76	5.77	281.54	10.73	3.811
AA	83.83	3.03	299.26	10.07	3.364
Z	94.67	1.27	442.26	32.91	7.441
Y	263.76	28.62	536.87	35.45	6.603
X	178.44	5.57	647.52	38.01	5.870
W	205.32	3.83	553.52	9.49	1.714
V	169.76	0.10	599.66	5.74	0.957
U	224.58	1.81	596.05	2.76	0.464
T	201.71	0.85	617.74	6.74	1.091
S	191.45	4.07	854.02	28.78	3.369
R	460.86	23.85	813.91	30.10	3.699
Q	161.60	2.18	804.55	29.20	3.630
P	182.08	3.17	480.06	5.86	1.221
O	136.37	0.51	646.90	4.49	0.694
N	328.45	0.81	836.88	15.65	1.870
M	372.05	14.33	923.53	15.53	1.682
L	223.03	0.40	822.29	15.86	1.929
K	227.21	1.14	740.99	4.88	0.658
J	290.76	3.34	990.79	9.89	0.998
I	472.82	5.40	1070.26	11.09	1.036
H	306.68	2.34	1006.98	8.55	0.849
G	227.48	0.81	1115.21	9.44	0.846
F	581.05	6.29	1260.90	9.59	0.761
E	452.37	2.49	1482.65	13.02	0.878
D	449.24	4.23	1212.48	9.95	0.821
C	310.88	3.22	928.99	7.46	0.803
B	168.87	0.00			

The ID column shows the segment ID. The Total Acres and Sed Acres give the approximate acreage of lake area and the acreage of accreted sediment for each defined segment. Correspondingly, the 3-Segment Acres and 3-Segment Sed Acres show the acreage of lake area and accreted sediment calculated by looking at the area of influence for each parcel, which includes the closest segment, the upstream segment and the downstream segment. The Sediment Variable is the percentage of sediment acre per total acre of lake area for the area of influence. The Sediment Variable is the variable used within the hedonic models.

Appendix B
Correlation Matrices

Correlation Matrix for independent variables within MV-Model

Market Value	SqFt	FinBsmtSqF	UnfinBsmtS	Bedrooms	Bathrooms	Age	Acres	300_feet	WF_Length	WF	Dock	GolfCourse	Grocery_St	StatePark	NPDES	Sediment
SqFt	1.00															
FinBsmtSqF	0.26	1.00														
UnfinBsmtS	0.13	0.17	1.00													
Bedrooms	0.55	0.33	0.14	1.00												
Bathrooms	0.69	0.41	0.15	0.70	1.00											
Age	-0.44	-0.17	-0.18	-0.39	-0.48	1.00										
Acres	-0.04	0.01	-0.03	-0.11	-0.05	0.01	1.00									
300_feet	0.07	0.19	0.10	0.03	0.12	0.08	-0.02	1.00								
WF_Length	0.04	0.12	0.02	0.01	0.07	0.07	0.66	0.36	1.00							
WF	0.13	0.24	0.12	0.09	0.19	0.07	0.03	0.76	0.47	1.00						
Dock	0.16	0.22	0.07	0.12	0.19	0.07	-0.02	0.59	0.35	0.77	1.00					
GolfCourse	0.36	0.03	0.05	0.27	0.29	-0.35	-0.12	0.02	-0.14	-0.10	-0.01	1.00				
Grocery_St	0.07	-0.06	0.01	0.01	0.09	-0.04	-0.01	-0.07	0.02	-0.02	0.00	-0.09	1.00			
StatePark	0.15	-0.01	-0.02	0.11	0.14	-0.23	-0.06	0.09	-0.06	0.03	0.03	0.39	-0.06	1.00		
NPDES	0.00	-0.09	-0.03	0.01	-0.01	-0.01	-0.02	-0.04	-0.05	-0.04	-0.06	-0.05	0.39	0.00	1.00	
Sediment	-0.07	0.05	0.11	-0.06	-0.06	-0.02	0.17	0.03	0.27	0.10	0.05	-0.31	0.02	-0.16	-0.03	1.00

Correlation Matrix for independent variables within SP-Model

Sales Price	SqFt	FinBsmtSqF	UnfinBsmtS	Bedrooms	Bathrooms	Age	Acres	300_feet	WF_Length	WF	Dock	GolfCourse	Grocery_St	StatePark	NPDES	AlgalBloom	Sediment
SqFt	1.00																
FinBsmtSqF	0.38	1.00															
UnfinBsmtS	0.23	0.18	1.00														
Bedrooms	0.91	0.35	0.22	1.00													
Bathrooms	0.92	0.40	0.25	0.95	1.00												
Age	0.33	0.06	0.03	0.42	0.34	1.00											
Acres	-0.06	0.04	-0.03	-0.07	-0.07	-0.01	1.00										
300_feet	0.03	0.10	0.06	0.02	0.04	0.09	-0.08	1.00									
WF_Length	-0.05	0.04	0.01	-0.08	-0.07	0.04	0.42	0.42	1.00								
WF	-0.01	0.13	0.04	-0.04	-0.01	0.06	-0.01	0.76	0.56	1.00							
Dock	0.04	0.10	0.05	0.00	0.03	0.07	-0.08	0.60	0.43	0.78	1.00						
GolfCourse	-0.02	-0.08	-0.09	-0.10	-0.06	-0.31	-0.24	0.01	-0.15	-0.10	0.00	1.00					
Grocery_St	-0.05	0.00	0.02	-0.06	-0.04	-0.04	0.06	-0.08	0.03	-0.03	0.00	-0.11	1.00				
StatePark	-0.03	-0.04	-0.07	-0.07	-0.03	-0.20	-0.12	0.09	-0.06	0.05	0.04	0.39	-0.07	1.00			
NPDES	0.00	-0.05	0.00	0.05	0.01	0.03	-0.05	-0.04	-0.07	-0.04	-0.03	-0.07	0.40	-0.01	1.00		
AlgalBloom	-0.12	-0.03	-0.02	-0.15	-0.13	-0.13	0.09	0.02	0.12	0.06	0.06	0.08	-0.04	0.02	-0.04	1.00	
Sediment	-0.12	0.01	0.04	-0.11	-0.12	-0.04	0.38	0.04	0.34	0.10	0.04	-0.31	0.03	-0.15	-0.05	0.10	1.00

Appendix C
Summary Statistical Output

SUMMARY OUTPUT FOR MV-MODEL

Regression Statistics	
Multiple R	0.933761027
R Square	0.871909655
Adjusted R Square	0.869215198
Standard Error	41.48358359
Observations	632

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	13	7239292.102	556868.6	323.5938	1.4348E-265
Residual	618	1063508.603	1720.888		
Total	631	8302800.705			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	-9.407	8.075	-1.165	0.244	-25.264	6.450
SqFt	0.067	0.003	23.510	0.000	0.061	0.072
FinBsmtSqF	0.033	0.004	9.394	0.000	0.026	0.040
UnfinBsmtS	0.011	0.004	2.870	0.004	0.004	0.019
Bathrooms	16.937	3.197	5.299	0.000	10.659	23.214
Age	-1.359	0.143	-9.529	0.000	-1.639	-1.079
Acres	0.615	0.524	1.174	0.241	-0.413	1.643
WF_Length	0.438	0.058	7.497	0.000	0.324	0.553
WF	33.724	6.165	5.470	0.000	21.617	45.831
Dock	8.059	5.332	1.511	0.131	-2.412	18.530
GolfCourse	49.710	4.528	10.977	0.000	40.817	58.603
StatePark	31.846	6.519	4.885	0.000	19.044	44.647
NPDES	-2.516	5.379	-0.468	0.640	-13.078	8.047
Sediment	-1.717	0.540	-3.177	0.002	-2.778	-0.656

SUMMARY OUTPUT FOR SP-MODEL

Regression Statistics	
Multiple R	0.894065604
R Square	0.799353304
Adjusted R Square	0.794558439
Standard Error	65.05083813
Observations	558

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	13	9170889.395	705453	166.7103	4.8754E-180
Residual	544	2301996.679	4231.612		
Total	557	11472886.07			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	6.907	7.690	0.898	0.369	-8.198	22.013
SqFt	0.077	0.006	12.366	0.000	0.065	0.089
FinBsmtSqF	0.045	0.008	5.815	0.000	0.030	0.060
Bathrooms	23.251	5.738	4.052	0.000	11.980	34.521
Age	-1.525	0.217	-7.041	0.000	-1.951	-1.100
Dock	25.615	9.061	2.827	0.005	7.816	43.414
WF_Length	0.199	0.105	1.895	0.059	-0.007	0.406
WF	44.010	10.481	4.199	0.000	23.421	64.598
Acres	3.556	2.003	1.776	0.076	-0.378	7.489
GolfCourse	49.998	7.222	6.923	0.000	35.811	64.186
StatePark	43.216	10.504	4.114	0.000	22.582	63.849
NPDES	-17.536	8.980	-1.953	0.051	-35.176	0.104
AlgalBloom	-22.230	8.296	-2.680	0.008	-38.526	-5.934
Sediment	-2.135	0.914	-2.334	0.020	-3.931	-0.338

REFERENCES

Beatley, T. (1994). *Ethical land use: Principals of policy and planning*. Baltimore, MD: The John Hopkins University Press.

Bishop, R. C., & Welsh, M. P. (1999). Contingent Valuation: Incorporating nonmarket values. In K. Sexton, A. A. Marcus, K. W. Easter, & T. D. Burkhardt (Eds.), *Better environmental decisions*. Washington D.C.: Island Press.

Boyle, M.A., Kiel, K.A. (2001). A survey of house price hedonic studies of the impact of environmental externalities. *Journal of Real Estate Literature, 9(2)*. pp117- 144.

Boyle, K.J., Lawson, S.R., Michael, H.J., & Bouchard,R. (1998). Lakefront property owners' economic demand for water clarity in Maine lakes. *Maine Agriculture and Forest Experiment Station- Miscellaneous Report 410*. University of Maine.

Brashares, E.N. 1985. "Estimating the Instream Value of Lake Quality in Southeast Michigan". Dissertation. University of Michigan.

Brasington, D.M., & Hite, D. (2005). Demand for environmental quality: A spatial hedonic analysis. *Regional Science and Urban Economics, 35(1)*. pp 57- 82.

Brookshire, D.S., Thayer, M.A., Schulze, W., & D'Arge, R. (1992). Valuing public goods: A comparison of survey and hedonic approaches. In A. Markandya, & J. Richardson, (Eds.). E*nvironmental economics: A reader*. New York, NY: St. Martin's Press.

Colwell, P.F., & Dehring, C.A. (2005). The pricing of lake lots. *Journal of Real Estate Finance and Economics, 30(3)*. pp 267-283.

Davenport, T. (2005). The framework for managing lakes in the USA. In P.E. O'Sullivan, & C.S. Reynolds, (Eds.). *The lakes handbook: Volume 2- Lake restoration and rehabilitation*. Malden, MA: Blackwell Publishing.

David, E.L. 1968. "Lakeshore Property Values: A Guide to Public Investment in Recreation". Water Resources Research 4(4). Pp697-707.

DeJanvry, A., Sadoulet, E., & Santos, B. (1995). Project evaluation for sustainable rural development: Plan Sierra in the Dominican Republic. *Journal of Environmental Economics and Management, 28*. pp 135- 154.

Easter, K.W., Becker, N., Archibald, S.O. (1999). Benefit-cost analysis and its use in regulatory decisions. In K. Sexton, A.A. Marcus, K.W. Easter, & T.D. Burkhardt (Eds.), *Better environmental decisions*. Washington D.C.: Island Press.

Elder, J.F., &Gouddard, G.L. (2005). Sediment and nutrient trapping efficiency of a constructed wetland near Delavan Lake, Wisconsin. In W.M. Marsh. *Landscape planning: Environmental applications* (4th ed.). Hoboken, NJ: John Wiley & Sons, Inc.

Epp, D.,& Al-Ani, K.S. (1979). The effect of water quality on rural non-farm residential property values. *American Journal of Agricultural Economics, 61*. pp 529-534.

Feenberg, D., and E. Mills. 1980. Measuring the Benefits of Water Pollution Abatement. Academic Press, New York.

Freeman III, A.M. (2000). Water pollution policy. In P.R. Portney, & R.N. Stavins, (Eds.). *Public policies for environmental protection (2nd ed.)*. Washington D.C.: Resources for the Future.

Haestad, M., & Dietrich, K. (2003). *Stormwater conveyance modeling and design (1st ed.)*. Waterbury, CT: Haestad Methods, Inc.

Hanson, T.R., Hatch, L.U., Clonts, H.C. (2002). Reservoir water level impacts on recreation, property, and nonuser values. Journal of the American Water Resources Association, 38(4). pp 1007- 1018. August 2002.

Holdren, C. (1997). NALMS looks at greater national focus, welcomes board members. *Lakeline, 17(2)*. p 9.

Kashian, R., Eiswerth, M.E., & Skidmore, M. (2005). Lake rehabilitation and the value of shoreline real estate: Evidence from Delavan, Wisconsin. Department of Economics, University of Wisconsin- Whitewater.

Jørgenson, S.E. (Ed.). (2005). Lake and reservoir management (1st ed.). Boston, MA: Elsevier.

Kiel, K.A. (2006). Environmental contamination and house values. In J.I. Carruthers & B. Mundy, (Eds.). *Environmental valuation: Interregional perspectives*. Ashgate Publishing, Ltd.

Krysel, C., Boyer, E.M., Parson, C., & Welle, P. (2003). Lakeshore property values and water qualtiy: Evidence from property sales in the Mississippi Headwaters Region. Submitted to the Legislative Commission on Minnesota Resources by *Mississippi Headwaters Board and Bemidji State University*. Online: November 14, 2006.
Internet: http://www.co.cass.mn.us/esd/intralake/bsu_study.pdf

Leggett, C.G., & Bockstael, N.E. (2000). Evidence of the effects of water quality on residential land prices. *Journal of Environmental Economics and Management, 39*. pp 121-144.

Leopold, L.B. (1968). Hydrology for urban land planning- A guidebook on the hydrologic effects of urban land use. *U.S.Geological Survey: Circular554*.

Mahmood, K. (1987). Reservoir sedimentation: Impact, extent, and mitigation. *World Bank Technical Paper Number 71*. September 1987.

Markandya, A., & Richardson, J. (Eds.). (1992). The economics of the environment: An introduction. In E*nvironmental economics: A reader*. New York, NY: St. Martin's Press.

Marsh, W.M. (2005). *Landscape planning: Environmental applications* (4th ed.). Hoboken, NJ: John Wiley & Sons, Inc.

McKinney, M.L., & Schoch, R.M. (2003). *Environmental science: Systems and solutions (3rd ed.)*. Sudbury, MA: Jones and Bartlett Publishers.

Michael, H.J., Boyle, K.J, & Bouchard, R. (2000). Does the measurement of environmental quality affect implicit prices estimated from hedonic models? *Land Economics, 76 (2)*. pp 283-298.

Michael, H.J., Boyle, K.J., & Bouchard, R. (1996). Water quality affects property prices: A case study of selected Maine lakes. *Maine Agriculture and Forest Experiment Station Miscellaneous Report 398*.
University of Maine. February 1996.

National Academy of Public Administration [NAPA]. (2001). Policies to prevent erosion in Atlanta's watersheds: Accelerating the transition to performance. January 2001. Online: November 14, 2006.
Internet:http://71.4.192.38/napa/napapubs.nsf/9172a14f9dd0c3668525696 7006510cd/1085b708cb159e4b85256a0100711feb/$FILE/dirt2.pdf

Palmieri, A., Shah, F., & Dinar, A. (2001). Economics of reservoir sedimentation and sustainable management of dams. *Journal of Environmental Management, 61*. pp 149- 163.

Palmquist, R.B., Roka, F.M., Vukina, T. (1997). Hog operations, environmental effects, and residential property values. *Land Economics, 17(1)*. pp114-124. February 1997.

Peterson, Spencer A. 1982. "Lake Restoration by Sediment Removal". Water Resources Bulletin, Vol. 18, NO.3. pp 423-435.

Poor, P.J., Boyle, K.J., Taylor, L.O., & Bouchard, R. (2001). Objective versus subjective measures of water clarity in hedonic property value models. *Land Economics, 77 (4)*. pp 482-493.

Portney, P.R., & Stavins, R.N. (Eds.). (2000). Introduction. In *Public policies for environmental protection (2nd ed.)*. Washington D.C.: Resources for the Future.

Phillips, G.L. (2005). Eutrophication of shallow temperate lakes. . In P.E. O'Sullivan, & C.S. Reynolds, (Eds.). *The lakes handbook: Volume 2- Lake restoration and rehabilitation*. Malden, MA: Blackwell Publishing.

Randolph, J. (2004). *Environmental land use planning and management.* Washington D.C.: Island Press.

Sargent, F.O., Lusk, P., Rivera, J.A., & Varela, M. (1991). *Rural environmental planning for sustainable communities*. Washington D.C.: Island Press.

Saluda Reedy Watershed Consortium [SRWC]. (2006). Watershed insights report No. 7: Nutrient Loading in Lake Greenwood. June 26, 2006.

Saluda Reedy Watershed Consortium [SRWC]. (2004). Watershed insights report No. 1: Sedimentation in the upper reaches of Lake Greenwood. April 01, 2004.

Seiler, M.J. Bond, M.T., & Seiler, V.L. (2001). The impact of world class Great Lakes water views on residential property values. *The Appraisal Journal*, *July 2001*. pp 287- 295.

South Carolina Department of Health and Environmental Control [SCDHEC]. (2004). Watershed Water Quality Assessment: Saluda river basin. Technical Report No. 004-04. Bureau of Water, Columbia, SC.

Steinnes, D. (1992). Measuring the economic value of water clarity: The case of lakeshore land. *Annals of Regional Science, 26*. pp171-176.

Stockwell, P.D. (2006). The proximate principle of parks and greenways: An hedonic and cost-benefit approach for Cary, North Carolina. [Thesis-Master of City and Regional Planning] Clemson University.

Straškraba, M. (2005). Reservoirs and other artificial water bodies. In P.E. O'Sullivan, & C.S. Reynolds, (Eds.). *The lakes handbook: Volume 2- Lake restoration and rehabilitation*. Malden, MA: Blackwell Publishing.

Todd, H. 1990. Importance of lakes to Minnesota's economy. pp 4-6 in Lakeline 10(6) Special Issue - Minnesota Lake Management Conference; Oct. 8-9, 1989. Mpls., MN. North American Lake Management Society.

United States Department of Agriculture – Natural Resources Conservation Service [USDA-NRCS]. (2002). Lake Greenwood Lake Survey Sedimentation Report, Greenwood County, South Carolina. Kim Kroeger. November 8, 2002.

United States Environmental Protection Agency [USEPA]. (1995). Economic benefits of runoff controls. Office of Wetlands, Oceans, and Watersheds. *EPA 841-S-95-002*. September 1995.

Waldman, Daniel. 2006. "Fun With Numbers". Erosion Control. May/ June 2006. Internet: http://www.erosioncontrol.com/ecm _ 0605 -publisher.htrnl

Young, C.E., and Teti, F.A. 1984. "The Influence of water Quality on the Value of Recreational Properties Adjacent to St Albans Bay. US Department of