Water Quality and Housing Value on Lake Greenwood: A Hedonic Study on Chlorophyll-a Levels and the 1999 Algal Bloom

By

Robert T. Carey[1] and R. Wayne Leftwich[2]

[1] Research Associate, Strom Thurmond Institute of Government and Public Affairs

[2] Graduate, Master's Program in City and Regional Planning, Clemson University

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Abstract

Attributes of houses and land located on the Greenwood County shore of Lake Greenwood in South Carolina are examined for indicators of the effects of environmental factors on sale price. Data from properties sold between 1980 and 2006 are utilized in two hedonic models that measure the impact of the 1999 algal bloom and chlorophyll-a levels at time of sale. The models are intended to demonstrate the difference in effect of visible as opposed to invisible environmental conditions. The algal bloom was clearly a visible manifestation of ecological problems in the lake, but chlorophyll-a levels, although indicating serious ecological problems, are not visible without specialized testing. The findings of the model, however, are that neither of these environmental factors is significantly correlated with sale price.

Introduction

On a warm summer morning in 1999, residents living along the shores of Lake Greenwood in South Carolina awoke to find a layer of green slime spreading across the surface of the water. Algae, which always live in the waters of the lake, had found conditions amenable for rapid growth and had quickly taken over the ecosystem, leaving the lake largely unusable for recreation and much less hospitable for fish and other wildlife. Because the greatest draw for prospective residents to the shores of lakes such as Lake Greenwood are aesthetic and recreational, the 1999 algal bloom can reasonably be expected to have affected property values along the lake.

However, an algal bloom such as that described above is merely a symptom of underlying ecological problems in a body of water. Algae bloom because the level of nutrients carried in the water rise to a level that is out of balance with the remainder of the ecosystem. This largely occurs because of runoff from industrial, agricultural or residential sources. Fertilizers, soil erosion or dumping contaminate surface water with nitrogen and phosphorus which result in explosive growth of flora. These blooms only occur when a number of environmental conditions come into alignment, however. Blooms are only a visible manifestation of an underlying set of problems; when the blooms do not occur, this does not mean that these problems are not present. It is the goal of this study, therefore, to measure the effect that these ecological problems have on property values along Lake Greenwood, both when they are visible, as in the case of the algal bloom, or when they are not visibly manifest.

Lake Greenwood is located in Upstate South Carolina along the border between Greenwood County to the west and Laurens County to the east; Newberry County also borders a small portion of the eastern shore of southern Lake Greenwood. The lake is fed primarily by the Saluda and Reedy rivers, by which nutrients and sediments and other pollutants are often transported into the lake from the heavily urbanized areas in Greenville, Pickens and Anderson counties to the north.

The purpose of studying effects on property values stemming from environmental issues is to place some quantifiable value on the affected environmental attribute. The environment – in our example, water quality in Lake Greenwood – is not directly exchanged on any market; therefore there is no explicit price by which one can quantify its value to consumers. This can be remedied by and large, however, by using the price of property along the shores of the lake, which are exchanged on a market, as a proxy for the environmental good. Because at least some portion of the value of these properties is derived from the amenity value of the lake, changes in this value that can be correlated to changes in the lake's amenity value give a quantifiable value to this natural resource. This method of non-market valuation is called hedonic pricing; the details of how this is carried out shall be discussed presently.

A further question arises from this discussion: if the market value of properties along the lake is tied to the lake's amenity value, will these values be responsive to changes in the environmental quality of the lake that are not immediately evident, i.e. that are less visible? In other words, one might fully expect an algal bloom to effect property values due to its effect on the physical appearance of the lake and on the lake's usefulness for recreational activities such as swimming, boating and fishing. But if the lake is unhealthy yet not visually affected, will this sufficiently affect amenity value to be reflected in property values? This question will also be addressed by this study. This will be done by comparing property values both during the 1999 algal bloom and during times with the level of chlorophyll-a, an indicator of poor water quality in the lake, is at high levels, but no algal bloom is present.

Hedonic Pricing Models

Typically, the value placed upon a particular good or resource is that which is assigned to it through the operation of the marketplace. Copper, for example, is a resource that is used for the production of electronic goods and for commercial and residential plumbing. Copper has a specific value, reflected in its price, based upon its availability (supply) and its usefulness (demand). As copper either becomes more scarce (that is, more expensive to produce) or becomes more in-demand for greater uses – or for that matter, if the products it is used to produce become more valuable – the price of copper, its market value, will increase. Clean air, clean water and wildlife are typically not priced through supply and demand, at least not directly. This certainly does not mean that they are without value, however. Hedonic pricing models are used to assign some quantifiable value to these "goods" that are not exchanged in the marketplace. As stated by Palmquist, Roka and Vukina (1997): "housing markets are one of the few places where environmental quality is traded" (p.115).[1]

Hedonic pricing models use data on housing attributes, such as number of rooms, square footage and age of structure, and neighborhood attributes – for example proximity to a major urban center or school – in order to isolate the effect of the environmental factor on the market value of a home. This method has been used in a number of previous studies. Correll, Lillydahl and Singell (1978), for example, found that home values decreased by $4.80 for each additional foot of distance from a greenbelt. Palmquist, Roka and Vukina (1997) modeled housing values in southeastern North Carolina against their proximity to a hog farm and found that the location of a hog farm within a half mile of a home diminishes the home's value by nearly 5 percent (p.122). Gayer (1999) found that willingness to pay for homes increases by $1,085 for each additional mile of distance from a Superfund cleanup site, and that each additional printed word of publicity regarding Superfund sites decreases proximate home prices by 19 cents.

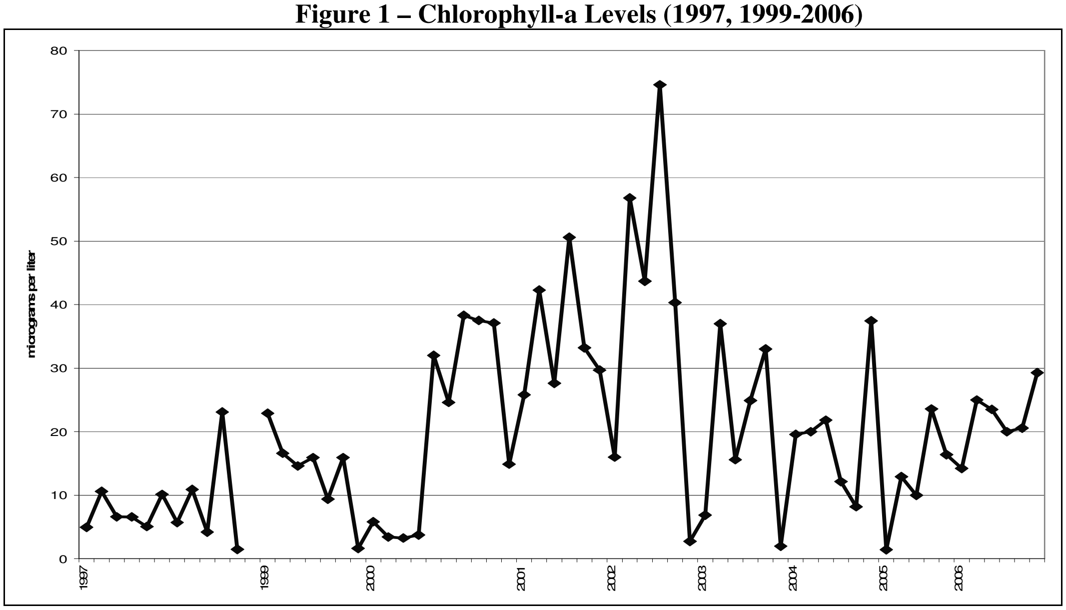
[1] It should be noted that this valuation only measures the value of the water quality to consumers; it is not argued to be an assessment of the full inherent value of the lake as a natural resource. See Bockstael, Freeman, Kopp, Portney and Smith (2000).

The Study

This study uses two hedonic models to measure the effects of the 1999 algal bloom and chlorophyll-a levels on real property sales prices. Model I uses data on property sales during the years 1980 through 2006. The properties included in this study are located within 1000 feet of the western shore of Lake Greenwood in Greenwood County.[2] Property data were obtained courtesy of the Greenwood County GIS department. Any properties with incomplete data were excluded.

Model II estimates the effect of chlorophyll-a levels on property sale price. Data on chlorophyll-a levels were compiled by South Carolina Department of Health and Environmental Control (DHEC) and are housed on the Environmental Protection Agency STORET database.[3] Due to a lack of observations at the Lake Greenwood DHEC monitoring stations during the 1980s and much of the 1990s, data for the chlorophyll-a model is limited to the years 1997 and 1999 through 2006. Chlorophyll-a levels during this study period are presented in Figure 1. Chlorophyll-a measurements were taken during the Spring and Summer months; therefore, only property transactions close to sampling dates are used. Due to the most consistently available readings, measurements from DHEC station S-308, located in the northern portion of the Reedy River arm of the lake, are used. Exceptions to this are for early May 2001, for which there was no current data from S-308, and for data from the year 1997, when no data from S-308 was available. In these cases, data from S-131, located south of the confluence of the Saluda and Reedy arms of the lake, and S-024, located on the Saluda arm of the lake, were used, respectively.

Figure 1 – Chlorophyll-a Levels (1997, 1999-2006)



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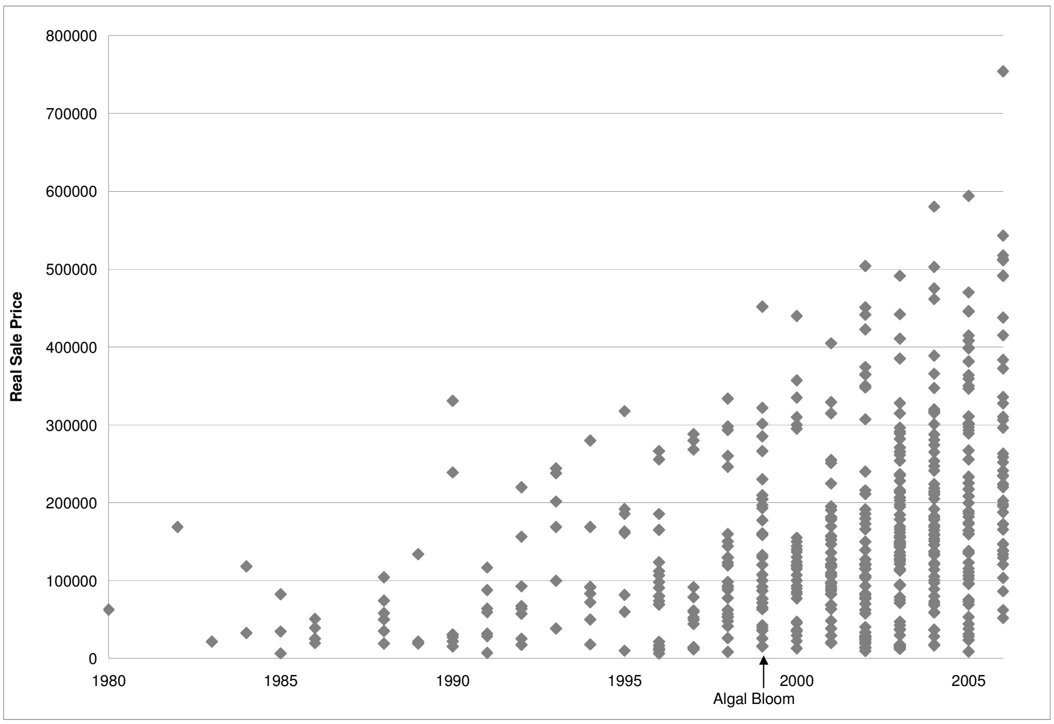
[2] Data on Laurens County properties on the Eastern shore of the lake were not included due to a lack of available data.

[3] Thanks to David Chestnut and Jake Bickley at DHEC for their assistance in gathering and interpreting this data.

While the 1999 algal bloom is included in Model II in order to avoid any omitted variable bias, Model I is presented as the better measure of the algal bloom's effect, as the first model includes a larger number of observations of property sales that predate the bloom event. It should be noted, however, that a much larger number of transactions occur in the later years of the study period. Residential development on the shores of Lake Greenwood is fairly nascent. Therefore, differences in some of the estimates seen between the two models can partly be accounted for by the tighter "clustering" of datapoints in the latter years of the period, as illustrated in Figure 2.

Figure 2 – Transactions and Sale Price per Year



Model Specification

The study uses the following structure:

$$P_i = \alpha + \beta_1 S_i + \beta_2 N_i + \beta_3 V_i + \beta_4 T_i + \varepsilon_i , \qquad \text{[Eq.1]}$$

where P is the selling price of property "i", S represents structural characteristics, N is the neighborhood characteristics, V is environmental attributes, T is a time index, and ε is a random error term (see Gayer, 1999).

In this model, structural characteristics include the total heated square footage of the home, the number of square feet in either a finished or unfinished basement, the age of the home at time of sale, the length of the property's lake frontage in meters (if the lot is located on the water), whether the lot has a view of the lake, and lot size in acres. In cases where property was sold without a preexisting home, all structural variables except for lot size, view of lake and lake frontage are set to zero.

Neighborhood characteristics include golf course access, location within one-quarter mile of Greenwood State Park, and location in either Fire District 40 (omitted), 50 or 60. Fire districts are here used for the purpose of locating the neighborhood along the lake, as District 40 is located in the northernmost portion of the lake and District 60 covers the southernmost areas of the western shore, in order to control for variations in water quality that may occur from one portion of the lake to another.

Environmental attributes include location within one-half mile of a National Pollutant Discharge Elimination Service (NPDES) site and whether the property was sold during the period of July 1999 through July 2001, which corresponds to the 1999 algal bloom and the period immediately following. In Model II, chlorophyll-a levels at the time of sale are also included. Negative coefficients are predicted for each of these parameters, although the coefficient corresponding to the algal bloom is predicted to be larger in absolute terms and more statistically significant than that of chlorophyll-a levels.

Finally, a time index is included. The time index was created by sequentially assigning a number ranging from one to 324 to each month during the study period. Based upon the month and year of sale, each transaction was designated with the appropriate index number. This index is included in the model in order to account for secular appreciation of real property values that tends to occur over time. Additionally, the prime rate at time of sale is included as a means of controlling for effects from the broader market on the demand for homes. Summary statistics for all of the data included in the two models is presented in Tables 1 and 2.

Results

Results for Model I are presented in Table 3. All coefficients have the predicted signs, except for lot size, which is insignificant. Lakefront lots are typically not very large; the average lot size in this study is just over one acre, with a median of 0.7 acres. Given this relative homogeneity, lot size can be expected not to show as a major determinant of sale price.

Eight of the sixteen explanatory variables show the most significant influence on sale price, holding all else constant. Time is positive and highly significant. This is an indicator of growing demand for lakefront residential property over the study period, likely tied to the national "housing boom", which occurred in the latter years of the study, and increased residential property values nationwide. Square footage is found to increase the sale price of the average home by $80 per additional square foot. A finished basement adds nearly $48 per square foot to the home price, and access to a golf course increases the value of the average home by some $51,000. The age of an existing home on the property lowers its sale price by over $1,100 for each additional year of age at the

Table 1 – Data for Model I (1980-2006)

Variable	Mean	Std Dev	Min	Max	Count
Sale Price (2000 dollars)	162,036.40	123,990.50	6,179.48	753,907.40	548
Square Feet^	2,034.23	719.41	425	4,736	335
Unfinished Basement^ (sq ft)	717.59	583.69	120	2,674	54
Finished Basement^ (sq ft)	1,132.40	490.35	120	2,224	65
Age of Home	8.28	13.68	0	75	548
Prime Rate	6.57	2.06	4	19	548
Lot Size (acres)	1.12	1.70	0.02	17.68	548
Lake Frontage^ (meters)	44.05	39.16	7	600	358
Located in Subdivision	0.93	-	0	1	548
View of Lake	0.92	-	0	1	548
Golf Course Access	0.32	-	0	1	548
Proximity to Park (¼ mile)	0.03	-	0	1	548
Proximity to NPDES site (½ mile)	0.19	-	0	1	548
Fire District 50	0.69	-	0	1	548
Fire District 60	0.28	-	0	1	548
Algal Bloom (July 1999- July 2001)	0.14	-	0	1	548

^ Excluding zero values.

Table 2 – Data for Model II (1997, 1999-2006)

Variable	Mean	Std Dev	Min	Max	Count
Sale Price (2000 dollars)	172,566.20	126,951.30	12,052.61	753,907.4	295
Square Feet^	2,018.66	754.05	429	4,736	191
Unfinished Basement^ (sq ft)	813.00	608.63	168	2,674	30
Finished Basement^ (sq ft)	1,194.47	555.61	120	2,224	34
Age of Home	8.96	14.06	0	75	295
Prime Rate	6.15	1.84	4	9.5	295
Lot Size (acres)	1.06	1.80	0.02	17.68	295
Lake Frontage^ (meters)	43.57	48.13	7	600	185
Chlorophyll-a (μg/l)	20.91	13.59	1.41	74.60	295
Located in Subdivision	0.94	-	0	1	295
View of Lake	0.90	-	0	1	295
Golf Course Access	0.35	-	0	1	295
Proximity to Park (¼ mile)	0.03	-	0	1	295
Proximity to NPDES site (½ mile)	0.20	-	0	1	295
Fire District 50	0.67	-	0	1	295
Fire District 60	0.31	-	0	1	295
Algal Bloom (July 1999- July 2001)	0.20	-	0	1	295

^ Excluding zero values.

time of sale. Additionally, regardless of whether an existing home is located on the property, the sale price of a given parcel increases by over $600 for each additional meter of lake frontage. Finally, sale price is also positively impacted if the parcel provides a view of the water and if it is located within one quarter mile of Greenwood State Park. No significant effect is observed for fire districts, which are indicators of location on the northern, central or southern portion of the lake.

In terms of the environmental parameters, no significant effect on home price is observed. While the coefficient for the parameter indicating that the property was sold during the 1999 algal bloom and the period following is negative, its level of significance provides little confidence in the actual presence of this effect. The coefficient for proximity to a NPDES site is likewise negative but not significant.

The results for Model II, presented in Table 4, are similar. The coefficient for the algal bloom variable has a higher t-value in the second model, but it is still below the 90 percent significance level. The coefficient on chlorophyll-a levels is positive, which is counterintuitive, but it is likewise not statistically significant.

Chlorophyll-a levels are not visible to potential property owners unless they incur some information costs in terms of research; therefore, a lack of correlation would not be an unreasonable expectation. The algal bloom, however, was clearly visible to potential property owners, and was covered in area newspapers and newscasts. However, these prospective buyers may have viewed the algal bloom as an isolated event that would not significantly impact their expected future enjoyment of the lake as an amenity. If buyers are by and large not aware of environmental problems that are not visibly manifest, as is suggested by the results in Model II, then it may be the case that they will likewise be uninformed regarding conditions leading up to the bloom, and given the uncertainty of whether or when another bloom may occur, the buyers may interpret this as a low probability that the algal bloom would recur in the near future. Any such event that occurs in a distant future would be greatly discounted – that is, expected consumption of lake amenities in the near term outweighs what they perceive to be the remote possibility of a bloom in an uncertain future.

Conclusion

Property sales data from the western shore of Lake Greenwood indicate that the amount of lake frontage, a view of the lake, and access to a golf course have a statistically significant positive correlation with sale price. For properties that include an existing home, square footage and the presence of a finished basement have the most significant positive effect, while the age of the home at time of sale has the most significant negative impact. Environmental parameters, however, show no significant correlation with sale price. These parameters include proximity to a NPDES site, chlorophyll-a levels at time of sale, and whether the sale occurred during or immediately following the 1999 algal bloom.

Table 3 – Model I Results

Sale Price:	Estimate (t-value)
Time Index	271.81 (5.80***)
Located in Subdivision	5,255.01 (0.46)
Square Feet	80.05 (30.18***)
Unfinished Basement (sq. ft.)	15.14 (1.55)
Finished Basement (sq. ft.)	47.87 (6.71***)
Age of Home	-1,121.59 (-4.91***)
Prime Rate	-211.57 (-0.14)
Lot Size (acres)	-2,384.92 (-1.26)
Lake Frontage (meters)	606.92 (7.47***)
View of Lake	26,044.32 (2.51**)
Golf Course Access	51,453.06 (8.17***)
Proximity to Park (within ¼ mile)	27,791.24 (1.78*)
Proximity to NPDES site (½ mile)	-9,097.29 (-1.36)
Fire District 50	-12,787.56 (-0.68)
Fire District 60	-8,135 (-0.42)
Algal Bloom (July 1999 – July 2001)	-6,099.14 (-0.71)
Intercept	-51,614.97 (-1.66*)
Adjusted R^2 = 0.7589	

* Significant at the 90 percent level
** Significant at the 95 percent level
*** Significant at the 99 percent level

Table 4 – Model II Results

Sale Price:	Estimate (t-value)
Time Index	746.74 (4.36***)
Located in Subdivision	19,815.89 (1.27)
Square Feet	77.61 (21.09***)
Unfinished Basement (sq. ft.)	-2.01 (-0.17)
Finished Basement (sq. ft.)	52.61 (5.85***)
Age of Home	-1,345.88 (-4.42***)
Prime Rate	4,864.16 (1.95*)
Lot Size (acres)	173.64 (0.07)
Lake Frontage (meters)	646.18 (6.61***)
View of Lake	28,999.90 (2.33**)
Golf Course Access	51,910.26 (6.13***)
Proximity to Park (within ¼ mile)	27,031.32 (1.32)
Proximity to NPDES site (½ mile)	-8,399.03 (-0.95)
Fire District 50	47,530.84 (1.90*)
Fire District 60	49,683.60 (1.95*)
Algal Bloom (July 1999 – July 2001)	-16,250.78 (-1.33)
Chlorophyll-a	347.79 (1.33)
Intercept	-292,565.50 (-4.62***)
Adjusted R^2 = 0.7866	

* Significant at the 90 percent level
** Significant at the 95 percent level
*** Significant at the 99 percent level

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