Use of the Hedonic Method to Estimate Lake Sedimentation Impacts on Property Values in Mountain Park and Roswell, GA

Elizabeth S. Hill , Samuel Pugh, and Jeffrey Mullen
The University of Georgia

Selected paper prepared for presentation at the American Agricultural Economics Association Annual Meeting. Portland, OR. July 31, 2007.

Introduction

Metropolitan Atlanta has experienced explosive population growth in the past few decades, which has resulted in rapid residential growth. One of the best examples of this trend can be seen in Roswell, GA, a city on the urban fringe of Atlanta. Roswell is predominated by suburban residential land use, and from 1990 to 2000, the city's estimated housing stock increased approximately 55 percent (Roswell 2005). This growth has begun to strain environmental amenities not only in Roswell but also in the wildlife refuge of its neighbor, the City of Mountain Park. The degradation of environmental amenities is of concern in these two cities, since it has the potential to reduce the value of properties and investments that were made prior to Roswell's residential growth.

Mountain Park's most defining environmental amenity is its two adjoined lakes, Lake Garret and Lake Cherful, whose combined area (1,471,253 square feet) is approximately equal to the area of 33 American football fields and accounts for one-ninth of the city's total area. Although Roswell has several large lakes, the largest sampled in this study (582,224 square feet) was one-third the size of the combined area of Lake Garret and Lake Cherful (GGISC). The importance of these two lakes is associated with the amenities that they provide. For example, the lakes in Mountain Park are large enough to provide fishing, boating, and wildlife viewing opportunities that may not be offered by lakes in Roswell.

It is likely that without changes in policies, lakes in Roswell and Mountain Park will experience housing value depreciation associated with increased lake sedimentation. Since sedimentation is redistributed through stormwater runoff traveling downstream, Mountain Park's lakes are at a particularly high risk due to its location in the basin of a 6.8 mile-wide watershed, which encompasses Roswell. Natural rates of sedimentation are often accelerated when land is converted from forest to residential uses. Lake amenities that are threatened by sedimentation vary from lake to lake. For example, some lakes are valued for recreational activities, while others are valued purely for their scenic qualities. Homebuyers, developers and other stakeholders spend a great deal of investment creating and protecting these lakes for their varied amenities. The purpose of this study is to use a hedonic model to assess how homebuyers' willingness to pay is affected by general lake size and the proximity of a property to a lake in this suburban Atlanta area. Because sedimentation tends to fill-in and shrink lakes, our results will provide some indication of the potential property damages associated with sedimentation.

Previous Literature:

Few studies have examined the effect of lake size on property values. As a result, this literature review examines studies that estimate the value of other lake qualities. Much of the literature is devoted to water clarity and sedimentation, which can lead to lake eutrophication. Unlike the lakes in this study's area, the lakes examined by the studies reviewed below are, for the most part, exceptionally large and permit activities such as motorboat recreation. Despite these limitations, this review can inform research into lake size.

A study conducted in Maine by Michael, Boyle and Bouchard (1996) uses the hedonic method to examine lake quality with respect to clarity. The authors note that

Maine's lakes are threatened by non-point source pollution originating from development, silviculture and agriculture. The run-off from these processes loads the lakes with nutrients and sediment that affect water clarity. This in turn affects the recreational opportunities of the lakes and alters their value. The study describes lake-front property owners as the greatest recipient of the benefits of water clarity and examines the marginal value of each lake frontage foot of lake-front properties surrounding forty lakes. The results estimate the price per foot of lake frontage in the region of lakes with the highest water clarity to be $870/ft with an average sale price of $96,304. For the region with the lowest lake clarity the price per foot of lake frontage is $317/ft, with an average sale price of $35,160. This study demonstrates the value of lake quality and how it differs from lake to lake.

Another study conducted in Maine by Boyle and Taylor. (1999) also examines water clarity. This study departs from the Michael, Boyle and Bouchard's investigation by using a second-stage hedonic demand function to estimate the demand for water clarity in Maine. The authors use separate real estate markets to calculate demand parameters for the value of the lakes. The real estate market is split into fours across which lake front properties surrounding 25 lakes are estimated to generate the lakes' implicit prices. The authors note an important specification of their hedonic-price function, which suggests that water clarity is more important to lake front property owners on large lakes. This implies that consumers are willing to trade water clarity to locate on a smaller lake in order to avoid boat traffic and other problems characteristic of larger lakes. Their results indicate that, accepting the assumption of distinct markets, implicit price estimates can identify the demand perimeters for environmental amenities in a second-stage, hedonic demand model.

A study conducted in Ohio (Bejranonda, Hitzhusen, and Hite 1999) examines the effects of sedimentation on lake quality. The authors note earlier estimations that agricultural run-off diminishes recreational values where boating is the large recreational subgroup affected. They also note that scenic values can be lost due to excess weeds and algae growth. Their analysis uses a two-stage hedonic model to estimate the welfare impacts of policies meant to mitigate sedimentation. One such mitigation technique is dredging – where sediment is directly removed from the lake. Distance to the lake, up to 4000 ft, is also included in their first stage model. Their results indicate that lakeside property values increase as lakes become deeper. Likewise they increase as sediment dredging increases, which justifies the expense involved in dredging. Their measurement for sediment inflow has a negative effect on property values.

Finally, in regards to the effect that recreational and aesthetics values have on sales prices, Landford and Jones (1995) found that the recreational possibilities associated with a lake and the quality of a lake's overall scenic beauty have a substantial effect on a homebuyers' willingness to pay. The study indicates that during the fall and winter, a homebuyers' willingness to pay is estimated to be $6,800 less than it is in the spring and summer, given that the water levels in the fall and winter are six feet below their spring and summer average. Furthermore, Landford and Jones suggest that these effects are not only on waterfront properties, but on sales prices for other houses within the community as well. Since one of the main effects from sedimentation is reduced water level, the results from this finding may provide some indication of the effect that lake sedimentation may have on housing prices.

Study Area

Roswell and Mountain Park are both incorporated cities located in the northwest area of Fulton County, Georgia. As previously mentioned, Mountain Park was developed around two large, adjoined lakes; in Roswell, however, development has primarily been in distinct subdivisions, some of which are lake communities and some of which are not. The population in Roswell was 79,334 in 2000, and it has experienced explosive population growth, with a 26.5% increase from 1990 to 2000. On the other hand, Mountain Park's population in 2000 was 506 persons, and experienced minimal population change between 1990 and 2000. Furthermore, although Mountain Park and Roswell cover a half of a square mile and 38 square miles, respectively, Roswell's population density is double that of Mountain Park.[1] This may be related to development limitations in Mountain Park, given its wildlife refuge status, or possibly to the subdivision style land development in Roswell, which has occurred due to heightened housing demand and land scarcity throughout the metropolitan Atlanta region in recent years. In 2000, the median household income was $71,726, while in Mountain Park, the median household income was $55,875 (U.S. Census Bureau).[2] Since it is expected that the premium on housing sales price for lake size and proximity in Mountain Park is greater than for houses in Roswell, these incomes will hopefully provide reasoning behind homebuyers' willingness to pay for larger lakes in environmentally protective settings which yield greater recreational and visual resources than of those in Roswell.

Methodology

In this study, the hedonic method is used to estimate the value of being in proximity to lakes categorized as small, medium, large or the very large lake in Mountain Park. By splitting these lakes into categories, the hedonic method can determine whether or not the lakes are qualitatively different from one another. Theory suggests that larger lakes, offering, for example, a broader range of recreational opportunities, should be valued higher than smaller lakes with limited opportunities. Since other lake sizes may have different aesthetic or wildlife opportunities, use of the hedonic method is ideal because it allows for comparison across these categories.

Data and Model

This study uses 308 residential housing transactions that took place in Mountain Park and Roswell between 1989 and 2006; 108 of these were observed in Mountain Park. The data for these properties' characteristics come from the Fulton County Tax Assessors' online records. Transactions that were non-arms-length transactions were omitted from the data set.[3]

In keeping with the hedonic pricing method, the log of sales price, "*lnprice*," is the dependent variable. Since sales prices were collected over nearly twenty years, nominal sales prices were converted to real prices using the Office of Federal Housing

Enterprise Oversight's (OFHEO) price index for the Atlanta region for period four of 2006. Although previous studies have largely focused on lakeside property sales, this study also considers the sales prices for properties in the surrounding lake area. The underlying assumption is that property owners derive value from functions of the lake that do not require lakefront proximity, such as recreational amenities of the lake like walking, viewing, and boating, and those values are assumed to be embedded in the value of properties near the lake. Bejranonda, Hitzhusen, and Hite (1999) and other studies only used observations within 4,000 feet of the lake, since residences that derive value from the lake tend to be clustered in this area. In this study, the furthest property measured was approximately 2,500 feet from the lake, well within the limitations suggested by Bejranonda, Hitzhusen, and Hite.

Housing characteristics that will be used as independent variables were found using information provided by the Fulton County Tax Assessors' on-line records. These characteristics include the natural log of: square footage of the home, "*lnsqft*," the age of the home, "*lnage*," and the size of the property in acres, "*lnpropsize*".[4] Other housing characteristics variables that will be used as independent variables include number of bedrooms, "*bed*," the number of bathrooms, "*bath*," and dummy variables for whether or not the house contains a basement, brick exterior, fireplace, or a garage – "*basement*," "*brick*," "*fireplace*," and "*garage*", respectively. For these dummy variables, a value of one indicates the presence of the respective feature, zero otherwise.

Two independent variables are of particular interest in this study. The first is the distance from the property to the lake measured in feet. In order to derive these values, the Euclidean distance tool in ArcGIS was used in combination with parcel and hydrographic maps, which were provided by the Georgia GIS Clearinghouse. The resultant measurements reflect the distance from the closest point of the property on which a house was located to the closest point on the nearest neighboring lake. Since lakefront properties have a distance equal zero, ten feet were added to each of the distance values in order to make it possible to take the natural log of the distance. Second, a categorical variable was created to account for the differences in lake sizes among Roswell's and Mountain Park's lakes. These categories include "*small*," which includes lakes whose areas are between 30,510 and 114,221 square feet, "*medium*," which includes lakes whose areas are between 116,522 and 189,344 square feet, and "*large*," which includes lakes whose areas are between 248,672 are 582,224 square feet. The two connected lakes in Mountain Park counted as one lake measured at 1,471,253 square feet, and was used as the baseline comparison lake for this variable. The areas for the lakes accounted for in this study were found using 1996 hydrographic polygon data provided by the Georgia GIS Clearinghouse. To further illustrate this data, table 1 provides information on the number of lakes in each category as well as the number of sales transactions observed for each category.

To estimate the effect of lake size and proximity on sales prices, the following log-log regression model was estimated:

$$\ln price_i = \beta + \ln dist_i \beta_{\ln dist} + small_i \beta_{small} + medium_i \beta_{medium}$$
$$+ large_i \beta_{large} + \ln sqft_i \beta_{\ln sqft} + \ln age_i \beta_{\ln age}$$
$$+ \ln propsize_i \beta_{\ln propsize} + bed_i \beta_{bed} + bath_i \beta_{bath}$$
$$+ basement_i \beta_{basement} + brick_i \beta_{brick} + fireplace_i \beta_{fireplace}$$
$$+ garage_i \beta_{garage} + \varepsilon_i$$

where the variables are constructed as described in the previous section, and have their summary statistics displayed in table 2. The β's are parameters to be estimated and the subscript *i* refers to individual sales transactions. Because of questions concerning efficiency, the model was estimated by generalized least squares (GLS), and was weighted by the inverse of the residual from the squared error term. The GLS estimates of the above model are presented in table 3.

Empirical Results

The R^2 of 0.79 is respectable for this type of data. Furthermore, eleven out of thirteen explanatory variables are statistically significant. Diagnostic tests indicate the model is well-specified and does not suffer from undue multicollinearity or endogeneity. Possible heteroscedasticity issues are handled using generalized least squares. Although some of the coefficients' magnitudes differ from expected results, all of the coefficients' signs coincide with expectations. Select estimation results are discussed below.

The coefficient on *lndistance* shows that, holding all other factors constant, for an additional percent increase in the distance from a lake that a house is located, the housing price will decrease by 1.89 percent (significant a the .05 level).[5] Specifically, given that the mean sales price for houses observed in our study area is $297,625, and these houses' mean distance to the lake is 879 feet, then for a one percent increase in distance to 888 feet, the estimated sales price will decrease by $5,263. This result is slightly inflated compared to expected results; however, one explanation may be that the sales price for a lakefront property may be much higher than that for a non-lakefront property, which is consistent with previous findings (Lansford 1995; Michael, Boyle, and Bouchard 1996).

The coefficient on large lakes indicates that houses located near or on large lakes in Roswell sell for approximately 20.30 percent less than houses located near or on the lakes in Mountain Park, holding all other factors constant (significant at the .01 level).[6] This is in line with expected results, since it was anticipated that the amenities provided by Mountain Park's lakes would offer a premium over lakes in Roswell whose lake amenities were estimated to be of lesser quality and quantity. Similar findings were reached in the case of medium and small lakes. Specifically, the coefficient on medium lakes indicates that, holding all else constant, houses located near medium size lakes in Roswell sell for approximately 13.83 percent less than houses in Mountain Park (significant at the .01 level). The coefficient on small lakes indicates that, holding all else constant, houses located near or on small lakes in Roswell sell for approximately 16.61 percent less than houses located near on Mountain Park's lakes (significant at the .01 level). It may seem unusual that the premium on medium lakes is most similar to Mountain Park, followed by small lakes and lastly large lakes. There are several possible explanations for this. First, the possibility is that more exclusive subdivisions are located around smaller lakes in Roswell. Aerial photos and parcel maps of Roswell provide evidence to support this theory, with larger, less clustered subdivisions being located around smaller lakes, while denser subdivisions are more often located around larger lakes. However, in some cases it may be that lakes are very small, therefore providing less utility to housing consumers than medium lakes provide, which results in the slight difference in premiums paid by homebuyers. Another possible explanation is that lake attributes other than lake area are influencing the premium that lakes provide on housing prices. This explanation is expected to be the most likely possibility, and is will be elaborated on in the next section.

To further assess whether similarities existed between small and medium lakes, an F-test was used to compare whether or not the two were statistically similar. Results indicate that that there is evidence that the variables representing small and medium sized lakes are jointly statistically significant (at the .01 level). The same conclusions hold for joint statistical significance existing between small and large lakes in Roswell; interestingly, however, no evidence to suggest that medium lakes and large lakes were jointly statistically significant.

Finally, to illustrate the differences between the four classes of lakes, the value of an average sized home on an average size property, which is also an average distance to the nearest lake can be estimated.[7] This standard home has three bedrooms, three bathrooms, a basement and a fireplace. Given this standard home, the only difference considered is the classification of the nearest lake. If this standard home were located near Mountain Park's lakes, it would be worth $311,929. However, if this home was located near a small, medium, or large lake in Roswell, it would be worth $51,794,

$37,924, $63,321 less than the value of a standard home located in Mountain Park, respectively.

Discussion

This information concerning homebuyer's willingness to pay regarding lake amenities being higher for the lakes in Mountain Park versus lakes in Roswell suggests that the lake degradation caused by sedimentation would have exacerbating effects on the loss of housing values in Mountain Park, relative to housing values in Roswell; however, further research would be necessary to estimate its influence. As an illustration of the problems of lake sedimentation in Mountain Park, environmental assessments by various groups, including the U.S. Army Corps of Engineers, have found that Lake Garret lost three to six feet of open water and 18 to 20 inches of water depth over a period of five years from 2001 to 2006, with an 80 foot silt bar forming. The area of this silt bar is substantially, covering approximately 30,000 cubic feet in Lake Garret and 100,000 cubic feet in Lake Cherful.

This sedimentation has had multiple effects on Mountain Park's lake amenities. For example, in regards to recreational resources, eight lakefront homeowners, who previously could directly launch their canoe from docks located on their property, can no longer do so due to lowered water levels and silt accumulation. Wildlife resources have also been affected by sedimentation, which is of concern given that the area is recognized as a wildlife refuge. According to the Environmental Protection Agency (EPA), sedimentation affects wildlife resources by clogging fish gills, changing water quality through increases in phosphorus levels, and smothering spawning areas. Recent autopsy reports indicate that birds that depend on Mountain Park's lake have died due to liver necrosis, capillary thrombosis, and intestinal track hemorrhaging, all of which are caused from exposure to phosphorus and blue-green algae, a product of lake sedimentation (Athens Diagnostic Laboratory 2006). Furthermore, visual resources have been degraded, not only from lake metamorphosis, but also due to decreased lake clarity, with an average of 1,300 maximum turbidity units (MTUs) in the lakes during rain in 2006, which is considered extremely high, and translated, implies that lake water is wholly opaque after rain due to sedimentation.[8] Given the findings of Boyle and Taylor (1999), Michael, Boyle and Bouchard (1996), and Lansford and Jones (1995), the loss of these factors is of economic consequence, since degraded lake amenities can have substantial effects on sales prices for homes in close proximity to the lake.

The lakes in Roswell are also expected to be affected by sedimentation. Aerial photos of Roswell from different points in time provide evidence that sedimentation is occurring in the lakes, given the visual change in lake area and turbidity. However, the degradation incurred depends on individual lake characteristics, and since the lakes in Roswell differ greatly from those in Mountain Park, estimated sedimentation affects are not comparable. Lake characteristics of interest include the slope of the surrounding land, size of the lake, wave action, and lake depth (Hilton 1985). These factors may be one reason that small lakes were found to have a higher premium than medium lakes in Roswell. For example, shallower lakes are more likely to experience random redistribution of sediment than are deeper lakes. Thus the shape of a shallow lake is more prone to changing than deeper lakes are. Since the depths of the lakes in Roswell are unknown, it could very well be that medium size lakes are shallower than smaller lakes in the area, making them more prone to the effects from sedimentation in the area. Thus, in order to determine the effects of these factors on housing values, further research would be necessary to define lake characteristics for each of the lakes in the study area.

Another factor that enhances the uniqueness of the relationship between the premiums paid for housing values in Mountain Park relative to Roswell is that the median household income is approximately $16,000 less in Mountain Park than in Roswell. Given that less affluent households are paying the premium to live by Mountain Park's lakes, there is reason to believe that Mountain Park's residents' willingness to pay for lake amenities is much higher than for households in Roswell. Future research exploring household preferences and willingness to pay for particular lake amenities would likely provide supplemental information to better compare household preferences for lake amenities in Mountain Park and Roswell.

Conclusion

The model used in this study suggests that lake value is not monotonically increasing with lake size. One possible explanation for this result is that lake factors other than lake area influence the value lakes add to housing value, may they be geographic, environmental, or social in nature. It is expected that sedimentation directly and indirectly affects each of these factors; therefore, in order to properly define the influence of each of these factors and the effects that sedimentation may have on them, further research in this area is needed.

Footnotes

[1] 2087 persons per square mile and 1012 persons per square mile, respectively.

[2] These values have not been adjusted for inflation.

[3] Non-arms-length refers to transactions that have unquestionably been influenced by factors unrelated to market demand, such as housing sales transactions in which family members sell property to family members at a large discount.

[4] The natural log of these variables will be used for ease of interpretation and comparison.

[5] Note that with a log-log form, natural logs are only an approximation of the exact percentage change; therefore, $100 * g = 100(e^b - 1)$ is used to calculate exact percentage values.

[6] Note that due to its small size, all sales transactions within the City of Mountain Park occurred within 4,000 feet of its lakes.

[7] Note that this average house is not synonymous with the average price of a home; rather, this looking at an standard type of home.

[8] Turbidity is an indicator of the amount of sediment and other constituents.

References

Athens Diagnostic Laboratory. "Mountain Park Swan Autopsy Report." The College of Veterinary Medicine at the University of Georgia. Athens, GA, 2006.

Bejranonda, S., F.J. Hitzhusen, D. Hite. "Agricultural Sedimentation Impacts on Lakeside Property Values." *Agricultural and Resource Economics Review* U*(1999): 208-218.

Boyle, K.J., and L.O. Taylor. 1999. "Estimating the Demand for Protecting Freshwater Lakes from Eutrophication." *American Journal of Agricultural Economics* 81(1999):1118-1122.

City of Roswell, Georgia (Roswell). "2025 Comprehensive Plan." Jerry Weitz & Associates, Inc., 2005.

Environmental Protection Agency (EPA). "Aquatic Biodiversity: Sedimentation." http://www.epa.gov/bioiweb1/aquatic/sediment.html (accessed 12/1/06).

Fulton County GIS Department. "Online Records: Tax Parcels Query". http://wms.co.fulton.ga.us/ (accessed 10/3/07).

Landford, N.H., and L.L Jones. "Recreational and Aesthetic Value of Water Using Hedonic Price Analysis." *Journal of Agricultural and Resource Economics* 20,2(1995): 341-55.

Georgia GIS Clearinghouse (GGISC). "Fulton County 1996 Hydographic Polygons." https://gis1.state.ga.us/login.asp?CookieTest=2 (accessed February 26, 2007).

Hitlon, J. "Framework for Predicting the Occurrence of Sediment Focusing and Sediment Redistribution in Small Lakes. *Limnology and Oceanography* 30,6(1985):1131-1143.

Michael, H. K.J. Boyle. R. Bouchard. "Water Quality Affects Property Prices: A Case Study of Selected Maine Lakes." Miscellaneous Report 398. Maine Agricultural and Forest Experiment Station, 1996.

Office of Federal Housing Enterprise Oversight (OFHEO). "Price Index for the Atlanta Region for Period Four of 2006. http://www.ofheo.gov/index.asp (accessed 12/1/06).

U.S. Census Bureau. "State and County Quickfacts." http://quickfacts.census.gov/qfd/ states /13000.html (accessed November 28, 2006).

Table 1: Lakes and Transactions across Categories

Lake Category	Mountain Park	Small	Medium	Large
Number of Lakes	1	4	7	4
Number of Transactions	108	43	76	81

Table 2: Summary Statistics

Variable	*Mean*	*Standard Deviation*	*Minimum*	*Maximum*
Price	297625	133653	55053.98	975818.1
Acreage	0.5406493	0.3389256	0.08	2
Bathroom	2.516234	0.9784632	0.5	5.5
Bedroom	3.282468	0.979306	1	6
Age	26.53571	18.5109	1	86
Basement	0.5681818	0.4961355	0	1
Brick exterior	0.2207792	0.4154469	0	1
Fireplace	0.8474026	0.3601842	0	1
Garage	1.216828	10.67137	0	188
Square footage	2362.403	1030.591	441	7217
Mountain Park lake	0.6990291	6.14252	0	108
Small lake	0.2783172	2.462752	0	43
Medium Lake	0.4919094	4.330963	0	76
Large lake	1.167742	12.23017	0	200
Distance	879.4188	897.9531	10	11258

Table 3: Results for the GLS Estimation

Variable	β	Standard Error	Err.	t-score	Sig.
Intercept	9.5498	0.3446	27.7100	0.0000	8.8710
lnAcreage	0.0504	0.0214	2.3600	0.0190	0.0083
Bathroom	0.1020	0.0301	3.3900	0.0010	0.0426
Bedroom	0.0493	0.0270	1.8200	0.0690	-0.0039
lnAge	-0.0937	0.0262	-3.5800	0.0000	-0.1453
Basement	0.1104	0.0302	3.6500	0.0000	0.0508
Brick exterior	0.1282	0.0329	3.9000	0.0000	0.0634
Fireplace	0.0468	0.0471	0.9900	0.3210	-0.0459
Garage	0.0772	0.0315	2.4500	0.0150	0.0151
Square footage	0.3807	0.0567	6.7200	0.0000	0.2690
Small lake	-0.1816	0.0408	-4.4500	0.0000	-0.2619
Medium Lake	-0.1296	0.0451	-2.8800	0.0040	-0.2184
Large lake	-0.2269	0.0421	-5.3900	0.0000	-0.3099
lnDistance	-0.0191	0.0073	-2.6300	0.0090	-0.0333
			n: 254	*df: 253*	R^2 *: 0.796*