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The Impact of Changing Lake Levels on Property Values: A Hedonic Model of Lake Thurmond

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Abstract: This study uses hedonic pricing models to examine the relationship between lake levels and property values for properties adjacent to Lake Thurmond. Lake Thurmond is located along the Savannah River Basin, bordering Georgia and South Carolina. Of the 1,030 properties from 2000-2009 for which data was reliable and available, 388 were lake front homes. The model of the effect of lake level on sales prices also includes home characteristics, home condition variables, lake attributes, and macroeconomic control variables. Results reveal a statistically significant change in sales price when the lake is closer to full pool. Results confirm that declining Lake Thurmond water levels have an impact on real estate values within some ranges below full pool. As climate variability places increasing pressure on communities, future research would benefit from further exploration into the relationship between economic activity and changing lake levels.

Keywords: housing prices, hedonic model, lake levels
JEL Codes: R14, R13, R11

1. INTRODUCTION

Hedonic price models are able to use housing markets as proxies for a wide range of environmental qualities or amenity values (Palmquist et al., 1997). It has been stated that "housing markets are one of the few places where environmental quality is traded" (Palmquist, Roka and Vukina, 1997, p.115). Hedonic price modeling has also been used to measure the impact of water quality on property values (Brashares, 1985; David, 1968; Feenberg and Mills, 1980; Michael et al., 2000; and Young and Teti, 1984). A number of hedonic studies have evaluated the impact of water's aesthetic and recreational properties on local property values (Brown and Pollakowski, 1977; D'Arge and Shogren, 1989; Darling, 1973; David, 1968; Feather et al., 1992; Knetsch, 1964). A common finding among these studies is that proximity to water source and the size of lake (water) frontage increase property values (Lansford and Jones, 1995a; Cho et al., 2006, Cebula, 2009). Additionally, much of this research indicates that water quality variables, which are physically observable to residents, yield the strongest correlations with property values.

One of the gaps in the research described above is an understanding of the relationship between lake level changes and property values. For example, if two lakefront homes are identical in every way except one area of the lake has more shoreline exposure due to declining

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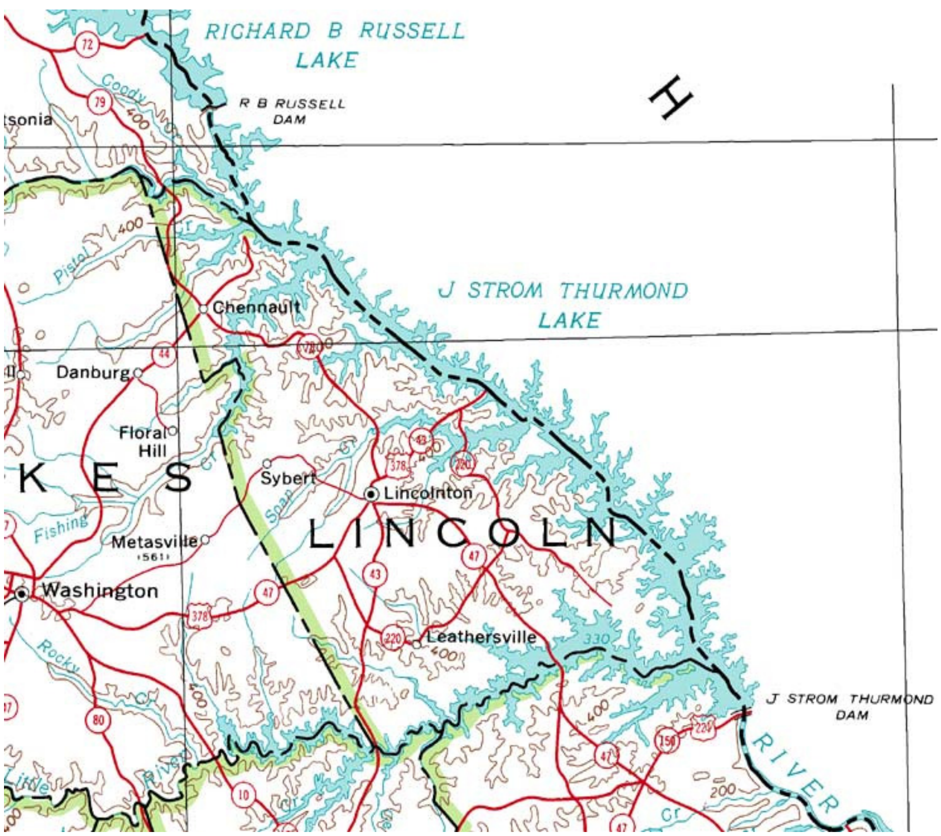
lake levels, the price differential between these two homes reflects the marginal value associated with lake level, or effectively the value of "full pool." Thus, property on or near the lake, or with lake access, is bought and sold regularly and should reflect the intrinsic value of lake activity and amenities. It is of interest for many different stakeholders whether lake levels below full pool are perceived as a negative amenity housing characteristic and is capitalized into home values. As lake-adjacent communities around the nation are faced with increasing climate variability, with many experiencing severe drought over the past 10-15 years, this question is of interest for public fiscal agents, water policy professionals, real estate agents, homeowners, and others.

Through the use of hedonic pricing models, this study expands upon the literature by examining the relationship between lake level changes and property values for properties located in the six counties that are adjacent to Lake Thurmond. Lake Thurmond, illustrated in Figure 1, is located along the border between South Carolina and Georgia. Its primary function is flood control, the production of hydropower, and navigation, although recreation use and real estate development have also become important roles for the lake since its completion. Lake Thurmond has a surface area of over 71,000 acres and 1,200 miles of shoreline. It is bordered to the south by the Savannah River, which flows to the Atlantic port of Savannah, Georgia. The lake is bordered to the north by Richard B. Russell Lake, which is in turn bordered to the north by Hartwell Lake, both of which are also U.S. Army Corps of Engineers (USACE) lakes. Lake Keowee, a Duke Energy lake, borders Lake Hartwell to the north, such that releases from the Keowee Dam affect water levels in Lake Strom Thurmond (a.k.a. Clarks Hill Lake) by way of Lake Hartwell and Richard B. Russell Lake.

Figure 1: Lincoln, Georgia and Lake Thurmond



Source: georgiainfo.galileo.usg.edu

Figure 2: Lincoln County, Georgia

Source: georgiainfo.galileo.usg.edu

This project examines selected lake, real estate, and economic data from 1998 to 2009. The study focuses on properties in Lincoln County, Georgia, one of the six counties bordering Lake Thurmond. Figure 2 shows Lincoln County's location within the state. In the next section of the paper, the hedonic pricing model and data are defined. Empirical estimates and interpretations of the model specifications are summarized in the results section. Finally, we conclude with a summary and areas for further research.

2. EMPIRICAL MODEL

2.1 Theoretical Background

The hedonic pricing technique, as applied to housing, is based on the idea that the value of a house is a function of the value of the individual attributes that comprise the house, such as square footage, number of bedrooms, number of bathrooms, exterior walls, material of exterior walls, and proximity to such amenities as schools or parks (Sirmans et al., 2005). The sales price of a home is positively impacted by the number of bathrooms, fireplaces, bedrooms, garage spaces, stories, as well as square footage, whether there is a deck, whether there is a pool, the composition of exterior walls, whether there is a sprinkler system, and newness of the property (Cebula, 2009). Additionally, historic preservation designation has a positive impact on property values (Clark and Herrin, 1997). The price of a house (P_h) can be written as:

$$P_h = f(S_j, N_k, Q_m) \qquad (1)$$

where S_j, N_k, and Q_m indicate vectors of structural, neighborhood, and other quality variables, respectively. Quality variables can represent a range of relevant study features. The implicit price of any characteristic, for example Q_m, a quality variable, can be estimated as

$$\delta P_h/\delta Q_m = P_h N_k\,(Q_m) \qquad (2)$$

This partial derivative gives the change in expenditures on housing that is required to obtain a house with one more unit of Q_m, ceteris paribus. If the value of the partial derivative is positive, then the attribute is an amenity. Generally, if the value is negative then the attribute is a disamenity, such as declining lake levels.

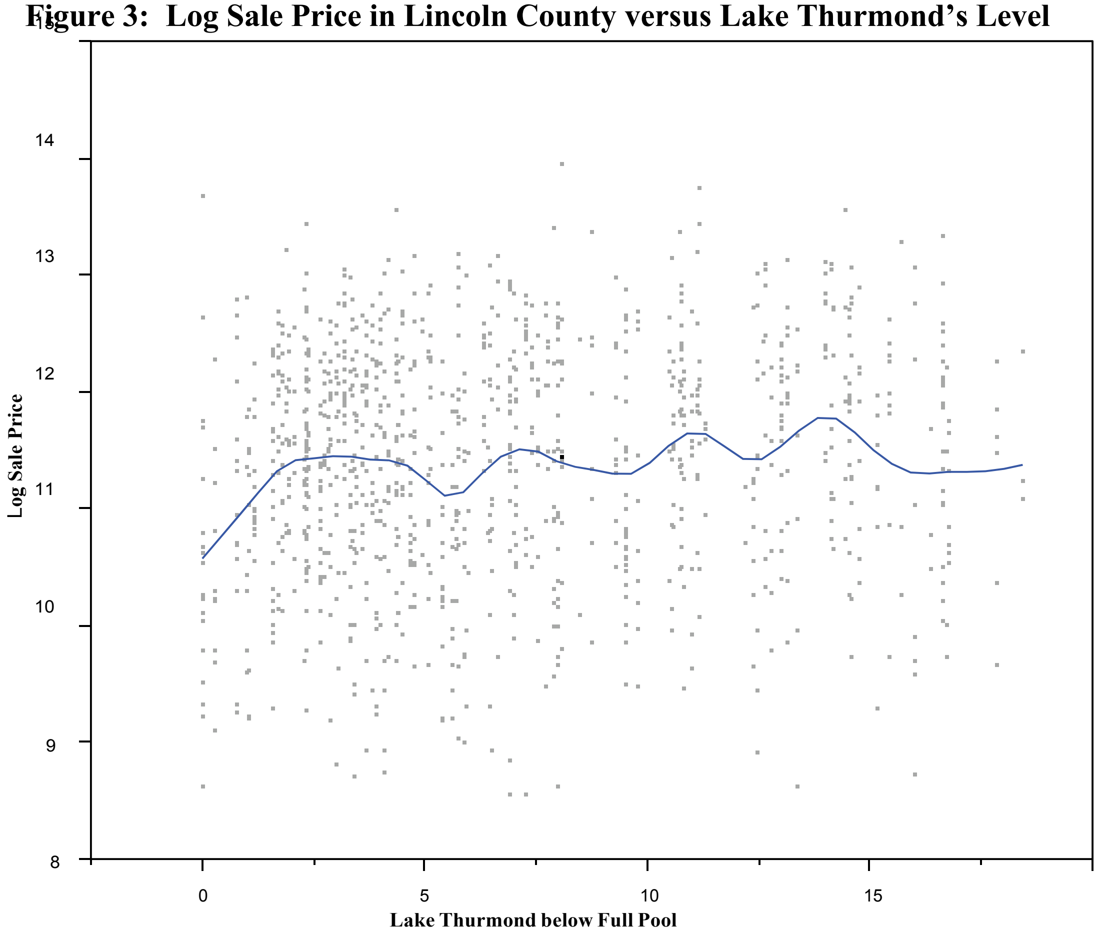
2.2 Model Specification

There are several econometric issues involved with the estimation of hedonic models (Sheppard, 1999). The first is specification. Model specification is particularly important when estimating a hedonic model as nonlinearities in the relationship between price and attributes may exist. Ordinary least squares, frequently used for hedonic modeling, assumes that the relationship between the independent variable (*lake level*) and the dependent variable (*property values*) is linear and does not change over the period of analysis. But this assumption may or may not be reasonable. For this reason, linear regression analysis was used as a baseline technique before other approaches were tried. Initial model testing indicated the need for polynomial transformations of the Lake Thurmond water level variable.

Figure 3 provides a graphical illustration of the relationship between lake level and home sales price. While the nature of this relationship is at least, in part, confounded by seasonal variation, we hypothesize that the nonlinearity of this relationship deserves further exploration. To further examine this relationship, we performed polynomial tests on the estimation between lake level and property values. A number of Lake Thurmond elevation models were tested for Lincoln County. The below full pool (BFP) measurement was found to yield the strongest overall model. Polynomial tests for this data confirmed the need for a squared BFP variable.

Figure 3 illustrates the relationship between Lake Thurmond elevation levels and log of sales price over the time period. This figure reveals multiple ranges where the relationship

Figure 3: Log Sale Price in Lincoln County versus Lake Thurmond's Level



between water level and sales price change and confirms our decision to test lake elevation as a polynomial for Lincoln County. Upon visual inspection, there are several ranges of lake elevation where it appears sales price increases as water level declines and vice versa. Polynomial and structural break models were used to explore this relationship in greater detail.

Several specifications of the lake level variable were tested to determine the best fit for the overall model: Lake Thurmond elevation in feet above mean sea level (MSL), number of feet below full pool (BFP), lake elevation less minimum elevation during period, and lake elevation less mean elevation during the sample period. The purpose of this research was to begin to explore the importance of lake level as a potential amenity or disamenity for home value. This idea was explored during a time when this region experienced several severe droughts and area lake stakeholders frequently expressed concern for their home values as lake level(s) declined. In considering the specification for the lake level variable, we first considered what variable represented this idea of declining lake levels as a potential disamenity. Researchers explored the use of all lake level measures in individual variable testing but the BFP measure was chosen as the independent variable of interest for two primary reasons: (1) It was decided that the psychology of lake level as a disamenity was contingent on the lake being below full pool; and (2) Model estimations revealed this variable to be the best overall predictor. Additionally, the BFP measure has potential benefits in measuring the impact of declining lake levels as there are well identified upper and lower bounds.

Polynomial transformations can also be modeled using linear regression with structural breaks or spline regression. Structural break regression models allow for the analysis of independent variables partitioned into different intervals, or clustered groups. These models are useful when it is hypothesized that there may be unique relationships with dependent variables at different intervals than the independent variable. For example, one might expect to see a smaller effect on real estate transactions when lake levels are less than one foot below full pool than would be seen if levels were more than five feet below full pool. In exploring the full model estimation, structural break models (spline regression) were also tested to better understand the nature of lake level variation and its relationship to residential property values.

Several model tests suggest a nonlinear relationship between lake level and home value. One way to account for a nonlinear relationship is through a higher order regression model including polynomial terms for the variable of interest. The basic structure of this model is as follows:

$$(3) \quad Y_i = b_0 + b_1 \cdot X_1 + b_2 \cdot X_1^2 + b_3 \cdot X_1^3 + b_4 \cdot X_{2i} + b_5 \cdot X_{3i} X_1 + \cdots + e_i$$

where Y is the predicted home value with polynomial representations of changing lake levels and interaction terms for selected home attributes. This model is a general regression model with key independent variables raised to the power p, where $p = 1$ to k and ε_i, $i = 1 \ldots n$.

One of the benefits of regression analysis is that it separates the effect of the dependent variable (property value) on the independent variable (water level). Regression analysis can further control for economic and seasonal variables that affect property values but may have no relationship to lake level.

Omitted variables may lead to an incorrectly specified model (Craig, Kolhase, and Papell, 1991). While omitted variable bias is always a concern with hedonic models, hedonic variables deemed relevant, as well as accessible, were included. But collinearity among variables is also an issue in hedonic modeling. In order to test for this, we calculated the correlation coefficients between all predictor variables to confirm that none of the variables were perfectly correlated, positively or negatively. Additionally, the variance inflation factor (VIF) for each variable was calculated to determine whether any variables needed to be omitted due to a collinear relationship. A more thorough discussion of the variables is included in the next section.

OLS regression analysis can be applied to large datasets but is limited in its ability to account for spatial autocorrelation. The spatial structure of housing markets and subsequent estimation problem of spatial autocorrelation is notable (Dubin, 1992). Geo-statistical approaches using maximum likelihood estimation (MLE) can account for spatial autocorrelation but are limited to relatively small data sets (Neill, Hassenzahl, and Assane, 2007). Unfortunately, neither GPS coordinates nor addresses were included in the dataset. While we would have liked to have tested for spatial autocorrelation, this is not possible with this data set.

A critical assumption of hedonic models is homogeneity of the study region. It can be argued that an entire county for a hedonic study is not homogeneous as within county variation creates the potential for heterogeneity. However, White's test for heteroskedasticity did not reveal a nonhomoskedastic error structure (White, 1980). Lincoln County provides enough homogeneity to understand the relationship between lake level and residential housing values. Given the rural nature of this community and the characterization of this county as one dominated by lake activities, including a large percentage of lake front homes, this county meets the criteria for homogeneity in OLS regression to a much greater degree than many other hedonic studies.

2.3 Data

Our study employs a hedonic model of home prices for Lincoln County, Georgia, one of the six adjacent Lake Thurmond counties. Only three of the six counties surrounding Lake Thurmond were able to provide data sufficient to use hedonic modeling. Columbia, Elbert, and Lincoln Counties in Georgia all provided a range of property characteristics data, including sales price, over a range of years between 1998 and 2010. Of those three, small sample sizes for lake transactions in Columbia and Elbert counties did not allow for reliable model interpretations and thus were excluded from the results.

Lake level is one of many attributes that determine a home's value. If a lake dried up over the course of a year, the home's value would fall but it would not lose all of its value. The actual loss of value would be unique to each home, lake, and time period. The actual decline in value would not be complete because homes are bundles of characteristics, such as bedrooms, bathrooms, square footage, acreage, and nearby schools, that all add value even without a lake at full pool or even if the lake dries up. But as the number of lake stakeholders has grown across the nation, along with an increasing awareness of the scarcity of water resources, it is increasingly important to understand the unique lake-related characteristics that impact economic activity like real estate transactions.

Measuring the importance of water level(s)—and more specifically the impact of declining water levels—on these communities is of prime interest in this analysis. The primary independent variable is Lake Thurmond's average monthly water level, or elevation, measured in feet above mean sea level (MSL). Lake Thurmond's average monthly elevation for the years 1998 through 2009 was provided by the USACE. Full pool for Lake Thurmond is 330 feet above MSL.

The minimum lake level over this time period was 314 MSL and the median was 326 MSL. Clearly, water level is likely to be higher in the spring and lower in late summer. This seasonal variation may weigh in on the sales price of a home. We explored seasonal lake-level variation using average temperature and sale date indicators. Average temperature was not a good fit for the model, while sale date provides additional explanatory power to the model.

The dependent variable is the log of the real sales price. Real estate data was obtained by first identifying privately owned parcels with direct access to Lake Thurmond within Lincoln County. These data were collected from the Lincoln County government. For Lincoln County, unique identifiers (IDs) were provided for each property and the following property characteristics were collected: sales price, acreage, year built, observed condition, number of bedrooms, number of rooms, type of foundation, number of exterior walls, attic, number of full bathrooms, number of half bathrooms, and the amount of heated area.

Once lake-adjacent parcels were identified, county property records were searched to determine the number of real estate transactions involving these parcels that occurred from January 2000 to December 2009. Table 1 reveals the total number of lakefront real estate transactions per year in Lincoln County.

This time period was chosen to capture periods of full lake pool and periods of drought. One of the most severe droughts on record occurred from 1998-2002. The Southeast experienced further drought conditions in 2005, with some relief over the winter of 2006-2007, followed by a more severe drought period from 2008-2009 (Bazemore, 2008). As a new century turned, drought impacted South Carolina and Georgia, as lakes across these states become more attractive to second home buyers, retirees, and individuals looking for a warmer location and lower cost of living. As drought conditions lingered, many lake stakeholders questioned the economic value of the lake and its management. As such, these variations in precipitation patterns provide a time period from which to capture a wide range of lake levels to evaluate the role of this amenity on housing values.

This model contains 1,030 real estate sales observations. Of these 1,030 sales transactions, 388 were lakefront sales. The sample of lakefront lots, 37.8 percent of total sales over the period, and the larger pooled sample are statistically robust.

Table 1: Annual Lakefront Real Estate Transactions, Lincoln County, Georgia; 2000-2009

Year	# of Lakefront Transactions
2000	45
2001	56
2002	46
2003	52
2004	23
2005	48
2006	29
2007	50
2008	25
2009	14

Many hedonic models include variable(s) representing local property taxation. The median property effective property tax rate in Lincoln County is 0.83 percent of property value. Lincoln County has relatively low property taxes, and of the 159 counties in Georgia, Lincoln County is ranked 67th by median property taxes. Additionally, the state of Georgia has a $2,000 homestead exemption for all residential properties. Over the time period 2000-2009 there has been little change in the property tax rate in the county. Property tax rates were not significant in early model testing. We hypothesize this was true as the vast majority of the sample had the same tax rate and qualified for the state homestead exemption.

As much as possible, structural characteristics were chosen in an effort to avoid omitted variable bias. Many hedonic models include location attributes and other neighborhood characteristics but data constraints did not make this feasible for our analysis. Furthermore, Lincoln County, Georgia, is classified as 100 percent rural and consists primarily of rural residences or lake front communities, where homes are a mix of primary and secondary residences. Given the rural nature of the region and lack of broader amenities, we did not consider proximity to schools, parks, golf courses etc. as part of this analysis. The home attributes included in this analysis were bedrooms, full baths, half baths, heated area, sale date, total acres, total rooms, wood acres, year built, exterior walls, foundation, and observed condition. A number of these variables had to be excluded from the final model due to data concerns and model validity. Table 2 illustrates the summary statistics for all model variables tested for this analysis.

The county saw a slight decrease in population over the 2000 to 2010 census. But the population of those aged 55 and over has increased significantly over the same time period. The town of Lincolnton is the largest city in the county with 1,512 residents. The nearest population center is Augusta, Georgia, which is approximately 55 miles away in Columbia County. Columbia County abuts Lincoln and has seen substantial population growth over the same time period and an even larger increase in the age 55 and over population. The Augusta region is projected to have over 60 percent population growth from 2010-2030, with Lincoln county expected to realize over 30 percent population growth through 2030. Positive population projections, in combination with a mild climate and access to lakes and rivers, create an environment popular for second home investments and retirement.

Data availability and consistency remain a problem in county level data sets of this type. We found little consistency among counties as to the types of variables they collect and the consistency of data collection among variables. Some of the counties considered for this study have only recently digitized property tax records for public access and download. Additionally, many variables that one might assume are in a property tax record are not included in county records. As such, variables like fireplaces, brick construction, garage space, number of windows, and others were not available for our analysis. An additional consideration with regard to data collection is the subjectivity of how variables like home condition are classified. According to county representatives, home-condition ratings are left up to the individual assessing the home and vary across property assessor. Given the potential variation in this data, we did not include the condition variable in the model. Issues surrounding data consistency and validity are important considerations for future analysis and county policy considerations.

3. EMPIRICAL RESULTS

This section provides the results of empirically estimating a hedonic model for Lincoln County. Table 3 provides parameter estimation results. These results must be carefully interpreted

Table 2: Hedonic Summary Statistics: Lincoln County, Georgia

Variables	Observations	Mean	Standard Deviation	Minimum	Maximum
Dependent Variable					
Sale Price	1,168	$120,614.38	$117,122.99	$4,500	$1,121,490
Home Attributes					
Sale Date	1,168	7/16/2004	NA	1/4/2000	12/18/2009
Year Built	1,168	1/12/05	5/20/01	0	07/02/05
Total Acres	1,168	5.11	15.00	0	167.06
Total Rooms	1,168	6.12	1.54	0	12
Bedrooms	1,168	2.94	0.86	1	8
Full Baths	1,168	1.87	0.74	0	7
Half Baths	1,168	0.16	0.41	0	2
Heated Area	1,168	1,804.55	934.47	0.00	7,528.00
Condition Variables					
Exterior Walls	1,168	4.21	3.14	1	14
Lake Related Attributes					
Lake Thurmond Level	1,168	325.70	4.54	314.03	332.46
Average Temperature	1,168	63.68	12.81	39.8	96.21
Macroeconomic Variables					
Unemployment (Augusta Metro)	1,168	5.54	1.10	3.3	10.1
Per Capita Income (Lincoln Co)	1,168	$26,748.24	1,118.93	28,245.30	24,638

as spatially oriented omitted variable bias may have occurred. While this research did not allow for spatial analysis, future research would benefit from the inclusion of location and distance attributes. Specifically, distance to the lake and other hypothesized amenities could be instructive. Overall model results indicate that this analysis contributes to our understanding of the variables that influence housing prices in Lincoln County. The adjusted R-squared for Lincoln County is 0.31, or 31percent of the variation in Lincoln County housing prices can be explained by this set of variables. The F-statistic also indicates that the overall model is statistically significant and different than zero.

Model results for Lincoln County are divided into home characteristics, condition variables, and lake attributes. The home attribute variables of acreage, year built, number of rooms, exterior walls, heated area, and sale date are all statistically significant at the 95 percent significance level and above. Home attributes yield the expected positive coefficients, with the exception of exterior walls, full bathrooms, and the number of bedrooms. Bedrooms and bathrooms were not statistically significant. While this is unexpected for this type of model, we suspect that this can be partially explained by data and modelling limitations.

Researchers have also explored potential interaction effects of different variables, considering that the value of a home in Lincoln County may be impacted not just by individual home attributes but also by the interaction of some of these attributes. Several hypothesized interactions were considered. The interaction of heated area and the lakefront dummy variable was included in the final model and confirm the hypothesized positive, statistically significant relationship. Modelling interaction terms to clarify these relationships improves our understanding of the marginal impacts of these variables.

Model results reveal that the BFP lake level variables are statistically significant at the 99 percent significance level. Polynomial variable tests reveal a better overall model fit with the

Table 3: Lincoln County, Georgia, Parameter Estimation Results

Variable (n=1,030)	Coefficient	t-Ratio	p-value
Intercept	1.37	.81	0.419
Sale Date	0.0000000016	1.61	.108
Year Built	0.00011	2.43	0.015
Total Acres	0.00097	5.87	<0.0001
Number of Rooms	0.088	3.08	0.002
Exterior Walls	-0.37	-4.6	<0.0001
Heated Area	0.0002	4.14	<0.0001
Half Baths	-0.006	0.09	0.93
Full Baths	0.024	0.46	0.64
Number of Bedrooms	-0.016	-0.32	0.749
Lakefront Dummy	-0.4	-14.43	<0.0001
Lakefront Dummy ^{x} Heated Area	.0001	3.99	<0.0001
BFP	0.076	3.35	0.0008
BFP^2	-0.016	-3.4	0.0007
BFP^3	0.0008	3.16	0.0016
Average Temperature	.0016	.83	.412
Augusta Metro Area Unemployment	-.094	-2.51	.012
Lincoln County Personal Income (per capita)	.00017	2.54	.011
Adjusted R^2= .313			
F statistic= 32.26 (p-value <0.001)			

inclusion of BFP polynomial terms. With the inclusion of these terms, polynomial variable estimates of the marginal change in home value due to lake level fluctuations is estimated by taking the partial derivative of the lake level variable. The minimum, maximum, and average of the percentage impact on housing prices were found by taking the appropriate partial derivatives of the BFP. These results are illustrated in Table 4. When the lake is closest to full pool, declining lake levels do not negatively impact housing prices. Results reveal a statistically significant positive change in sales price when the lake is closer to full pool. The maximum positive impact on housing value is a 17.6 percent increase in housing prices when the lake is effectively at full pool.

Table 4: Variation in Individual Percentage Impact

	Percentage Impact
Maximum	0.1763
Minimum	-0.0311
Average	0.0318
Standard Deviation	0.05

Table 5: Marginal Impact of Lake Thurmond Elevations on Percentage Change in Home Sales Price

	25% Quartile (0.641 BFP)	50% Quartile (3.17 ft. BFP)	75% Quartile (8.07 ft. BFP)	90% Quartile (11.54 ft. BFP)
Sales price change (%)	4.2	10.4	-1.20	-3.0
+/- Standard error	0.013	0.040	0.0635	0.068
t ratio	3.28	2.61	-.188	-0.44
Prob > $\|t\|$	0.0011	0.009	0.851	0.66

However, the positive impact on sales price declines as lake levels decline. A more detailed interpretation of the percentage impact on sales price is provided in Table 5. This table illustrates the specific marginal impacts given different below full pool measurements. The four levels of below full pool correspond to the 25th, 50th, 75th, and 90th percentiles of this measurement, 0.641, 3.17, 8.07, and 11.54 feet below full pool respectively. These results further highlight the complex nature of lake level variation and its impact on price. At both the 75th and 90th quartiles BFP, as lake level declines further there is a decline in home sales price. It is also worth noting that the 25th quartile is only 0.641 feet BFP because there were a number of months where the lake was above mean full pool of 330 feet. This may also explain some of the variation in impact between the 25th and 50th quartile. These results, while instructive, should also be considered with caution as they are estimating the marginal impact of lake level changing holding all other variables constant.

Based on these estimations, Table 6 illustrates the differential impacts for the average priced lakefront home over the study period. The price effects illustrate that declining lake levels may indeed be viewed as a disamenity by home buyers. This analysis confirms anecdotal evidence that loss of home value due to declining lake levels occurs at relatively low levels of lake elevation. When and if declining lake levels result in a negative impact on sales price, this effect likely varies by home site, lake, and region. Furthermore, we hypothesize that the magnitude of the impact is a function of variables like geography, slope of the lot, tree cover, and other variables that may impact a potential buyers perception of "how bad" lower lake levels are. Overall, these results confirm that lake front homes are generally an amenity with respect to home price but especially in times of drought, sellers should beware that declining lake levels may impact their sales price negatively.

Table 6: Price Impact on the Median-priced Lakefront Home

	Price Impact
0.641 Ft. BFP	$7863.9
3.17 ft. BFP	$19,472.75
8.07 ft. BFP	-$2,246.86
11.54 ft. BFP	-5617.14

4. CONCLUSIONS

Hedonic modeling is an informative tool for understanding the marginal impacts of a range of attributes on real estate values. It is used as a tool to clarify the values of amenity and/or disamenity characteristics of housing attributes. Lakes and lake related activities have become increasingly popular as lake adjacent residential and retirement communities have increased in popularity throughout the Southeast. As the number of stakeholders has grown, there has been increasing pressure to understand the full economic impact of lakes and lake related activity.

These results provide valuable insight into the relationship between lake level and residential real estate values. Moreover, this research confirms the statistically significant relationship between lake level and residential price for Lincoln County, Georgia. These results should be treated with caution, however, as they are a snap shot of real estate price impacts at a specific lake level at a specific point in time. These are not cumulative impacts and are limited to the point of sale of these specific transactions within these counties. These results also highlight the complexity of modeling temporal events and those with a multitude of possible interaction effects.

The statistical significance of lake elevation leads us to question the rational assumptions that buyers and sellers make when considering lake purchases. Water level changes are almost always temporal events. Even in record drought years, it is generally assumed that at some point the drought will be over. If consumers understand and internalize this knowledge, water level would not be significantly correlated with sales price. But a range of economic and psychology research confirms that the consumer rationality assumption is often flawed.

Given these results, are consumers and homeowners behaving irrationally in their capitalization of lake level? Research on negative environmental characteristics indicates that a consumer's physical view of the lake and his or her perceptions of current and future events also influence the capitalization of these different characteristics. As drought and climactic events become more frequent, consumers may have altered perceptions about the temporary nature of events like lake level changes. Understanding how buyers and sellers conceptualize this characteristic is an important area for additional research. Survey research, in addition to hedonic models, could provide additional insight into consumer perceptions.

Overall, this analysis begins to provide evidence of the relationship between lake level and home sales prices. A longer time series panel could increase the sample size of lakefront sales and further clarify the relationship between lake characteristics and sales price. As well, spatial lakefront characteristics, like length of shoreline, cove versus full water lake access, slope of lakefront, and others would provide additional understanding of the value of the lake as a housing amenity. Future research would also benefit from an analysis of multiple lakefront counties. This would provide a better understanding of how unique the lake level and sales price relationship is between counties and regions.

This research further highlights the need for more robust and consistent property data at the county level. Data limitations for these counties highlights problems related to the consistency of data collection, subjectivity in data characterization, and general data access. This is a challenge for modelling the marginal value of housing amenities as it is important to capture the widest range of housing, neighborhood, and community characteristics. Future research should capture more detailed spatial neighborhood and amenity characteristics, such as distance to schools, distance to competing amenities, and distance to golf courses, for example. These would add to our understanding of the wide range of attributes that contribute to the overall value of a home. Future research may consider deploying primary source methods to capture a wider range of attributes in lake front communities, as opposed to county level secondary source data. Finally, this analysis confirms that some of these variables do not have a simple linear relationship and that future research would benefit from further exploration of model specification.

As the number of lake related stakeholders continues to grow, these are questions that will remain important for consumers, businesses, and policymakers. This analysis underscores that while lake related economic activity is important and statistically significant, it still remains a small portion of the total economic activity of most counties. This does not diminish the impact to local businesses and/or homes that are most directly impacted by declining lake levels, but it provides evidence that short-term drought or other lake related events make only a relatively small impact on total property values in a region. However, as climate variability increases the frequency and severity of weather related events, the impact of natural resource variables on the property value of homes and businesses may be increasingly relevant for future analysis.

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APPENDIX

Housing variables for which data was available:

- sales price
- sale date
- total acreage
- wooded acres
- year built
- observed condition
- number of bedrooms
- number of rooms
- type of foundation
- number of exterior walls
- attic
- number of full bathrooms
- number of half bathrooms
- amount of heated area

Lake variables for which data was available:

- lake level
- lake front
- average temperature
- below full pool

Macroeconomic variables for which data was available:

- county population
- county per capita personal income
- MSA GDP
- county employment
- county unemployment rate
- Augusta MSA unemployment rate
- # of establishments
- Average wages