US Army Corps of Engineers ®
Savannah District

AN ECONOMIC ANALYSIS OF LOW WATER LEVELS IN HARTWELL LAKE

FINAL REPORT
NOVEMBER 8, 2010

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Hart County, GA
Stephens County, GA
Anderson County, SC
Oconee County, SC
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EXECUTIVE SUMMARY

This study examines the regional economic impacts of low lake levels on the six county region bordering Hartwell Lake. Hartwell Lake is a United States Army Corps of Engineers (USACE) impoundment of the Savannah River constructed between 1955 and 1963 as a part of a flood control, navigation and hydropower project on the borders of South Carolina and Georgia. In addition to the original reasons for its creation, the lake is widely used today for tourism and recreation and is a key element in regional water quality, water supply, and fish and wildlife management efforts.

From April 2007 through December 2008, widespread regional drought conditions caused persistent low water levels in Hartwell Lake. During this period the lake remained well below full pool, making some private docks, public boat ramps, and marinas unusable and reducing traffic at lake-oriented businesses. The estimated economic impact of low lake levels over this 21 month period on the value of goods and services produced in the region is well below one percent of the value of total output in each of the six counties bordering Hartwell Lake.

For the entire region, this extended period of low water levels in Hartwell Lake reduced output by only approximately one-tenth of one percent. This study demonstrates that Hartwell Lake is not a primary economic driver in the region and provides evidence that the six counties surrounding Hartwell Lake have sufficient economic breadth and depth to weather prolonged low lake levels without realizing substantial declines in their economic well-being.

Background and Methodology

As the economic role of Hartwell Lake has evolved, it has become necessary to characterize the relationship between the lake and general economic activity in the surrounding region. Two major droughts between 1998 and 2008 focused concerns on lake level management and the effect of prolonged low water levels on the region. An earlier study and anecdotal evidence from project stakeholders suggested that low lake levels were causing a large negative impact on the local economy, especially in counties adjacent to the lake.

This study was designed to estimate whether changes in Hartwell Lake's water level affect regional economic activity, and by how much. Two analytical tools were used to estimate the economic impact of low lake levels on the six county region bordering Hartwell Lake (Figure ES1). Linear and nonlinear regression analysis and other statistical techniques were used to evaluate the strength of the relationships between key measures of lake-related activity and water levels in Hartwell Lake. Where appropriate, these analyses take into account the effects of the recent recession and seasonal factors. These measures are:

- Recreation use at USACE facilities on Hartwell Lake,
- Sales of real estate with direct lake access (lakefront), and
- Gross retail sales in selected sectors of the economy.

Results from the statistical analyses of lake level with real estate transactions and gross retail sales were entered into the Regional Dynamics (REDYN) input-output modeling engine to estimate the total regional economic impacts of changing lake levels on the six county Hartwell Lake region. These results include direct economic impacts (jobs and income created directly from the exchange of real estate or from the sale of goods and services), and indirect and induced impacts ("spillover" generated in the broader economy from the direct impacts).

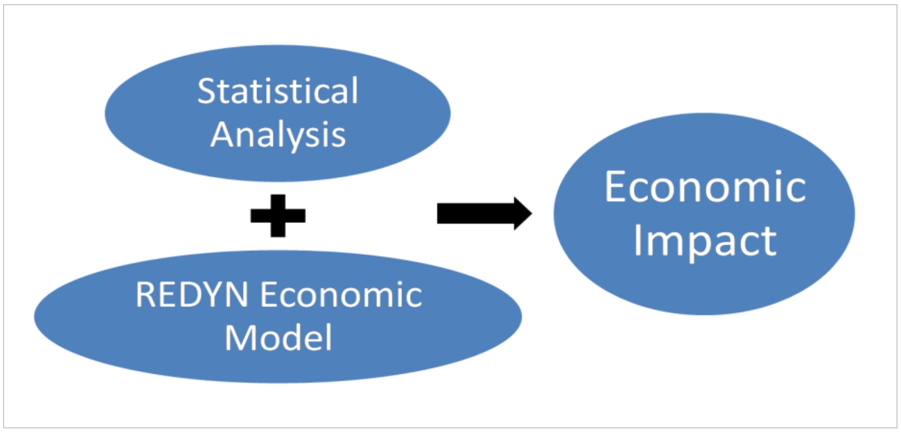

Figure ES1. Hartwell Lake Economic Impact Project Framework

Findings: Recreation, Real Estate, and Retail Sales

Results of the analysis for lake level and recreation confirm a statistically significant and direct relationship. For every one foot increase (or decrease) in lake level, monthly visits to USACE recreation sites on Hartwell Lake increased (or decreased) by nearly 21,200 visitors. This corresponds to a 2.5 percent change in the average number of visitors per month to USACE recreation sites per foot of lake level change. This relationship is support for consumer sensitivity to lake level changes.

One of the economic sectors expected to be sensitive to water level changes in Hartwell Lake was sales of real estate parcels with direct lake access. As with recreation, the analysis showed a direct relationship with lake level. As the water level in Hartwell Lake increased toward (or decreased away from) summer full pool of 660 feet above mean sea level, the number of transactions of lake-access parcels increased (or decreased) by a statistically significant amount (Figure ES2). The relationship between lake level and transactions was evaluated for each county at six ranges of lake levels.

The relationship between lake level and lake-access real estate transactions is unique for each county with shoreline on Hartwell Lake. For example, in Anderson County, when Hartwell Lake is seven feet or more below full pool, about two transactions are lost per month for every foot decline in lake level. When the lake is four feet or more below full pool, Oconee County loses less than one real estate transaction for every foot decline in lake level. Hart County loses about one-third of a transaction for every foot decline in lake level when the lake is only two feet below full pool. If Hartwell Lake's water level increases toward full pool, these real estate transaction losses turn into gains.

This analysis estimates that persistent low lake levels from April 2007 to December 2008 resulted in 56 fewer sales of lake-access property in the six county region bordering Hartwell Lake than would have taken place had the drought not occurred. These findings are independent of the housing bust that began in 2007, as well as other seasonal and economic factors. The estimated 56 fewer sales are 3.4 percent of total sales that would have occurred over the period. The impact varied among the six counties, however.

The loss or gain of a few sales in any location can make a big difference to individual real estate agents and firms. In Anderson and Oconee counties, which have the largest volume of transactions over the period, the estimated number of transactions lost over the drought were less than three percent of total transactions of lake-access property. In the counties with relatively few real estate transactions over the period, such as Franklin, Hart, and Stephens counties, estimated lost transactions were a larger share of total activity.

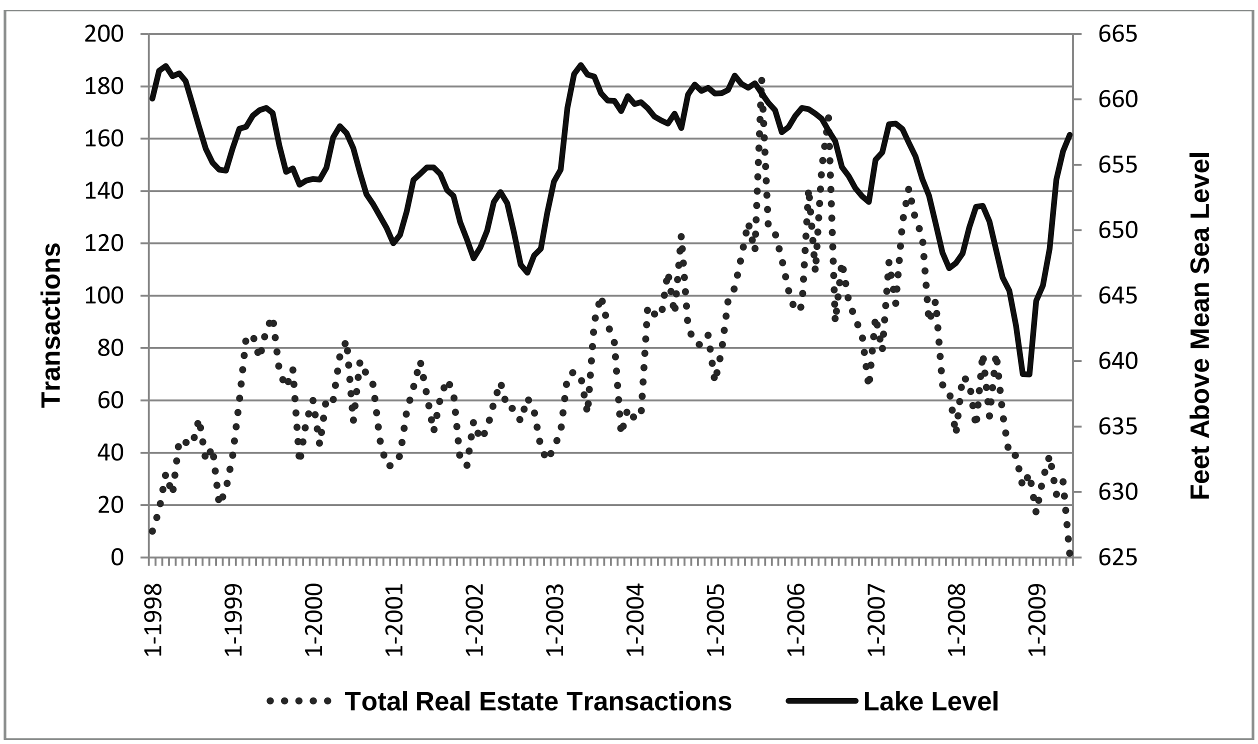

Figure ES2. Lake level and real estate sales (Hartwell Lake, 6 county total).

Linear and nonlinear regression models were also used to assess the strength of the relationship between the water level in Hartwell Lake and monthly gross retail sales. Twelve gross sales categories were selected as business types potentially influenced by proximity to the lake. Only nine of those categories showed a statistically significant correlation (90% confidence level or above) with lake levels, although the sectors differed by county. Results of these gross sales models indicated both positive and negative correlation with lake levels, depending on the sector. Bars, boating stores, gas stations, general merchandise stores, and sporting goods stores were the most common categories to exhibit a statistically significant relationship with the water level in Hartwell Lake. As with real estate transactions, these findings are independent of national and regional economic conditions.

Findings: Economic Impacts

The economic impacts of low lake levels were estimated using the REDYN economic model for the Hartwell Lake counties in each of six lake level ranges. When water levels in Hartwell Lake are low and/or declining, the economic impact is negative in Franklin, Hart, Anderson, and Pickens counties. In Oconee and Stephens counties, however, the economic impacts are positive.

The economic impacts of different lake levels on each county were used to estimate the total economic impact of the persistent low water levels caused by the recent drought. For the region the overall economic impact was negative (Table ES1). From April 2007 through December 2008, low lake levels are estimated to have resulted in a $18.8 million decline in regional output, a $6.2 million decline in aggregated household after-tax income, and a decrease in net local government revenues of $805,000. Job loss over the period is estimated to be 23 jobs (in full time equivalents).

Table ES1. Total Estimated Economic Impact of Low Lake Levels (April 2007 – Dec. 2008)

County	**Employment (FTEs)**	**Output (2009 $)**	**Disposable Income (2009 $)**	**Net Revenue (2009 $)**
Franklin	-2	-1,015,024	-229,631	-23,305
Hart	-2	-1,174,840	-295,908	+21,614
Stephens	+4	+1,780,665	+658,462	+66,351
Anderson	-32	-22,475,015	-7,469,207	-983,306
Oconee	+10	+4,215,073	+1,443,975	+153,785
Pickens	0	-117,997	-292,100	-40,551
Total	-23	-18,787,138	-6,184,409	-805,412

The estimated economic impacts of low water levels in Hartwell Lake, while measurable, are small when compared to the overall level of economic activity in these six counties. Table ES2 shows the changes in county output resulting from low lake levels during the drought as a percentage of total output for all business sectors in each county over that same period, which was approximately $30.2 billion. In the six county region as a whole, the estimated decrease in output resulting from low water levels was about one-tenth of one percent of the value of total regional output.

Table ES2. Economic Impacts in Context

County	**Output Impact of Low Water Levels (2009 $)**	**Total County Output During 21 Month Drought ($Billions)**	**Output Impact as % of Total County Output**
Franklin	-1,015,024	1.509	-0.07%
Hart	-1,174,840	1.678	-0.07%
Stephens	+1,780,665	1.960	+0.09%
Anderson	-22,475,015	13.811	-0.16%
Oconee	+4,215,073	5.424	+0.08%
Pickens	-117,997	5.862	+0.00%
Total	-18,787,138	30.244	-0.06%

In Oconee and Stephens counties the economic impact of low water levels in Hartwell Lake is positive. These results provide support for the theory that Lake Keowee, which has a more stable water level than Hartwell Lake, is in direct competition with Hartwell Lake as a recreation destination. When water levels in Hartwell Lake are low and/or declining, economic activity decreases in Anderson County and increases in Oconee County. When water levels in Hartwell Lake are increasing toward full pool, economic activity increases in Anderson County and decreases in Oconee County. These results suggest that some activity associated with Hartwell Lake and Lake Keowee may shift back and forth, depending on lake levels. Economic activity in Stephens County also has an inverse relationship with the water level in Hartwell Lake. For Stephens County, the analysis suggests that lake activity and activity in different business sectors may substitute with each other as lake level changes.

The study team would like to thank the US Army Corps of Engineers, Savannah District and the six counties adjacent to Hartwell Lake for their contributions, whether in expertise or funding or both. The team realizes that studies such as this one tell an imperfect story, capturing statistics and data reasonably well, but not all of the human factors. The writers of this report acknowledge that economic fluctuations, like lake levels, tend to be felt most by the people most vulnerable to changes in specific areas of economic activity.

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1. Project Inception

In 2005, at the request of the Anderson Area Chamber of Commerce's Water Resources Committee, the Appalachian Council of Governments (ACOG) prepared a proposal for a comprehensive Hartwell Lake economic impact analysis (ACOG, 2005). The proposed project was not funded, but the idea did not die. With the exception of the 2003 Lake Hartwell Association study (discussed below) and recreation impact studies by the USACE, no economic impact analyses had been conducted for Hartwell Lake to this point (ACOG, 2005).

As Hartwell Lake remained well below full pool during the recent drought, stakeholders pressured the Corps to undertake a comprehensive analysis of Hartwell Lake's role in the regional economy. Meetings were held throughout 2007 that brought together Hartwell Lake stakeholders to discuss a possible project. Participants included representatives from:

- US Army Corps of Engineers, Savannah District
- Hart, Franklin, and Stephens counties (GA)
- Anderson, Pickens, and Oconee counties (SC)
- Strom Thurmond Institute, Clemson University
- Lake Hartwell Association
- Hartwell 660 Coalition, and
- Other organizations and individuals

As discussions continued it was agreed that the six counties bordering Hartwell Lake and the USACE would each provide half of the total project cost, which was $211,522. Each county's financial responsibility in the project was apportioned by its share of Hartwell Lake shoreline mileage. Researchers at Clemson's Strom Thurmond Institute were asked to perform the study. The project was fortunate to have prominent and respected local champions such as Mike Gray (SC, now deceased) and Tom Coley (GA) who strongly advocated for the study and helped to secure county financial participation.

An intergovernmental agreement between the "Counties" (Anderson County and the other five counties) on 20 October 2008 provided the mechanism from which funds were collected to cost share with the USACE, Savannah District. On 22 December 2008 Anderson County, representing all six counties, entered into a *Planning Assistance to States Agreement* with the Department of the Army. With the project funding in place, Clemson University entered into a research cooperative agreement with USACE on 20 May 2009 to conduct this analysis.

II. Study Description

The purpose of this study is to answer the following question:

> Do low water levels have a measurable economic impact on the six counties in Georgia and South Carolina that surround Hartwell Lake?

The project examined selected lake, real estate, and economic data over a period of approximately 11 years from 1998 to 2009. Hartwell Lake data includes monthly average lake level, recreation use, and air temperature. Real estate data are the number of monthly transactions on lake-access parcels. Economic data includes monthly gross retail sales in selected sectors plus other measures of the local and regional economy. This period of study includes two extended droughts when Hartwell Lake remained eight feet or more below full pool for months at a time.

Standard statistical techniques were used to assess the strength of the relationship between lake level and the following variables: recreation use, real estate sales, and selected categories of gross retail sales. The six counties bordering Hartwell Lake comprised the area of study. The REDYN economic modeling engine generated estimates of the overall economic impact of changing lake levels on the study area.

We found statistically significant relationships between recreation use, real estate sales, gross retail sales and water levels in Hartwell Lake. The estimated economic impact of prolonged low lake levels between April 2007 and December 2008 on the six counties bordering Hartwell Lake is estimated to be $18.8 million in reduced output, $6.2 million in lost disposable income and $805,400 in lost revenue to local governments. These low lake levels are also estimated to have cost the region 23 jobs (in full time equivalents).

III. Project Background

A. HARTWELL LAKE

The United States Army Corps of Engineers (USACE) built Hartwell Dam and Hartwell Lake on the border of South Carolina and Georgia between 1955 and 1963 as a part of a larger flood control, navigation and hydropower project in the Savannah River Basin. The lake encompasses about 56,000 surface acres and 962 miles of shoreline (Figure 1).

Hartwell Lake is one of three lakes in the Savannah River Basin managed by the USACE's Savannah District: Hartwell, Richard B. Russell and J. Strom Thurmond. Lake water levels can vary throughout the year as the USACE adjusts dam flow rates to accommodate downstream environmental requirements, power generation, and flood control needs in the river basin. In drought conditions, lake levels may fall well below full pool, as were experienced in recent years. Hartwell Lake also provides a variety of recreation uses and is considered a tourism and economic stimulus in the region.

The lake is a major recreation destination for area residents and tourists and is one of the top five most visited USACE sites in the US[1]. The USACE maintains 53 recreation areas and nine campgrounds on Hartwell Lake. State and local governments operate 24 additional recreation areas and the lake has five commercial marinas (Figure 1).

Hartwell Lake also supplies drinking water to local governments in both states, including the Anderson Regional (SC) Joint Water Commission, City of Hartwell (GA), City of Lavonia (GA), and the Hart County (GA) Water and Sewer Utility. Water supply and quality, and fish and wildlife management are important to Hartwell Lake users and others downstream in the Savannah River Basin. Private property with lake access commands a premium in the real estate market, given the amenity value added by Hartwell Lake.

B. HARTWELL LAKE STAKEHOLDERS

The USACE Savannah District is Hartwell Lake's first and most important stakeholder because of its federal core mission to manage the lake and Hartwell Dam for environmental protection, flood control, and power generation within the larger Savannah River Basin. The USACE also is responsible for the construction, operation and maintenance of projects within the Savannah River Basin involving recreation, water supply and water quality, shoreline protection, wetland, and ecosystem protection, fish and wildlife management, and disaster response and mitigation.

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[1] http://www.sas.usace.army.mil/lakes/hartwell/recreation.htm

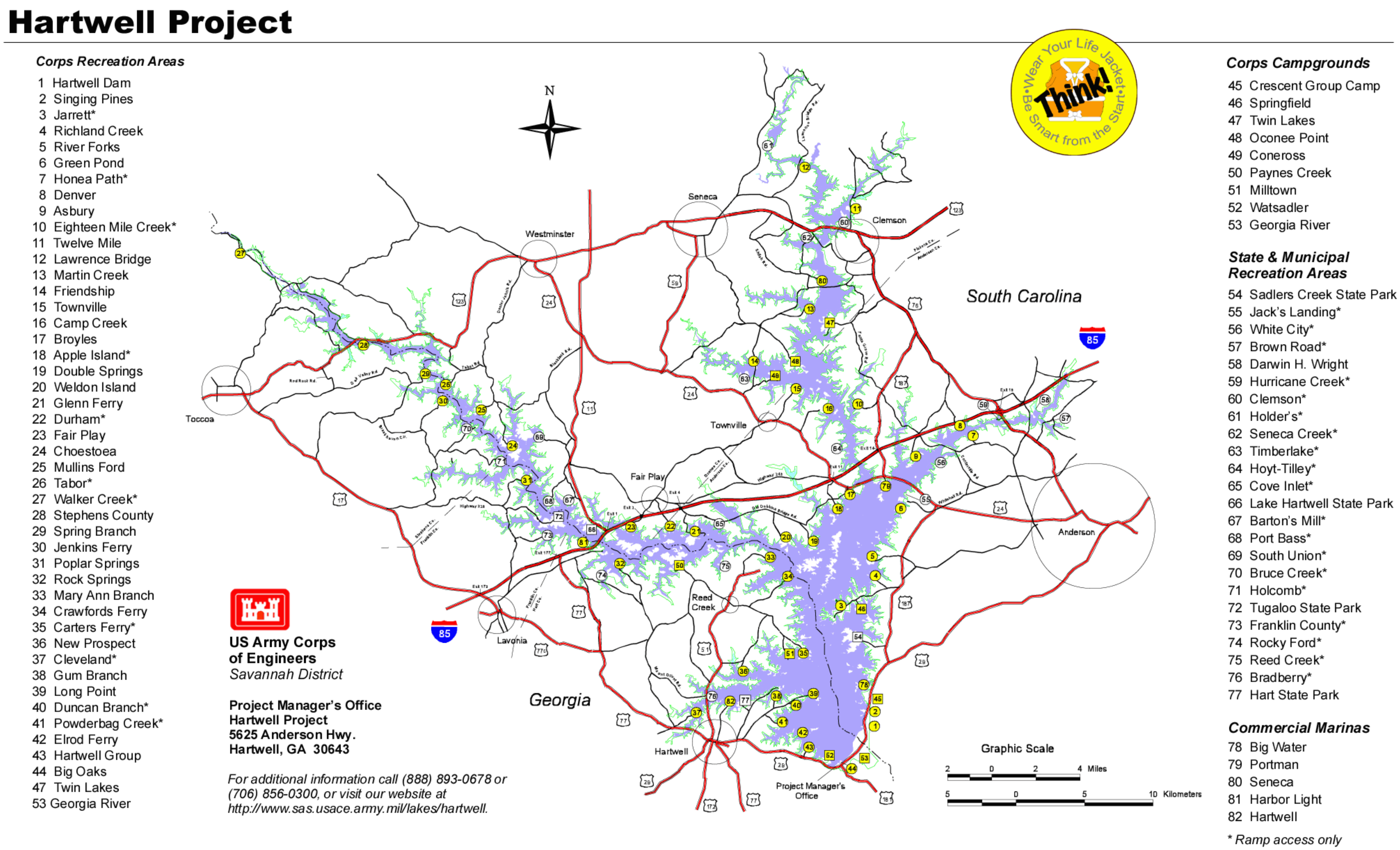

Figure 1: Hartwell Lake

Source: USACE, http://www.sas.usace.army.mil/lakes/hartwell/hartmap.htm

As Hartwell Lake's regional importance as a recreation destination has grown, the number of stakeholders has grown. State and regional examples include:

- Georgia Department of Natural Resources
- South Carolina Department of Health and Environmental Control
- South Carolina Department of Natural Resources
- South Carolina Department of Parks, Recreation and Tourism
- Savannah River Basin Coalition, and
- Southeastern Power Administration

State and regional stakeholders are focused on their organization's mission, be it water quality, wildlife management, or electric power generation. Local stakeholders bring their economic interests to lake management discussions. Since Hartwell Lake was built in the 1950s, businesses have expanded to meet the demands of a growing lake-oriented population of both residents and visitors.

All six counties bordering the lake have real estate stakeholders that specialize in lake property, and other firms supply construction and renovation services for lake homes and businesses. These companies all benefit from a strong real estate market for lake property. Lake-oriented homeowners buy boats, other water craft, and recreation supplies. Tourists bring money into the Hartwell Lake area by buying gas, groceries, restaurant meals and recreation supplies, and by staying overnight in local hotels or motels. Hartwell Lake local stakeholders include:

- Anderson County Chamber of Commerce Water Resources Committee,
- Anderson County Office of Economic Development,
- Lake Hartwell Association, and
- Hartwell 660 Coalition.

Local stakeholder concerns about the economic impact of prolonged low lake levels on lake-oriented real estate and business activity escalated as a result of the two most recent multiyear droughts to affect Hartwell Lake. These droughts occurred from July 1999 to March 2003 and from June 2007 to November 2009.

C. Drought and Lake Levels

Hartwell Lake is at summer full pool at 660 feet above mean sea level (MSL). From mid October to mid April, lake levels are somewhat lower. Lake levels also vary over time under normal Corps lake management practices. During long droughts Hartwell Lake has remained well below summer full pool for months at a time (Figure 2). For example, the lake was below summer full pool for the entire period from September 2005 to November 2009. The lake hit its lowest level of the most recent drought on December 9, 2008, 22.47 feet below summer full pool (Figure 3). Public boat ramps, private docks and marinas dried up as the drought worsened throughout 2007 and 2008. Previously submerged vegetation created boating hazards, lake use fell, and sales of lake-access real estate slowed. Various stakeholders called for changes to the USACE's Drought Management Action Plan in response.

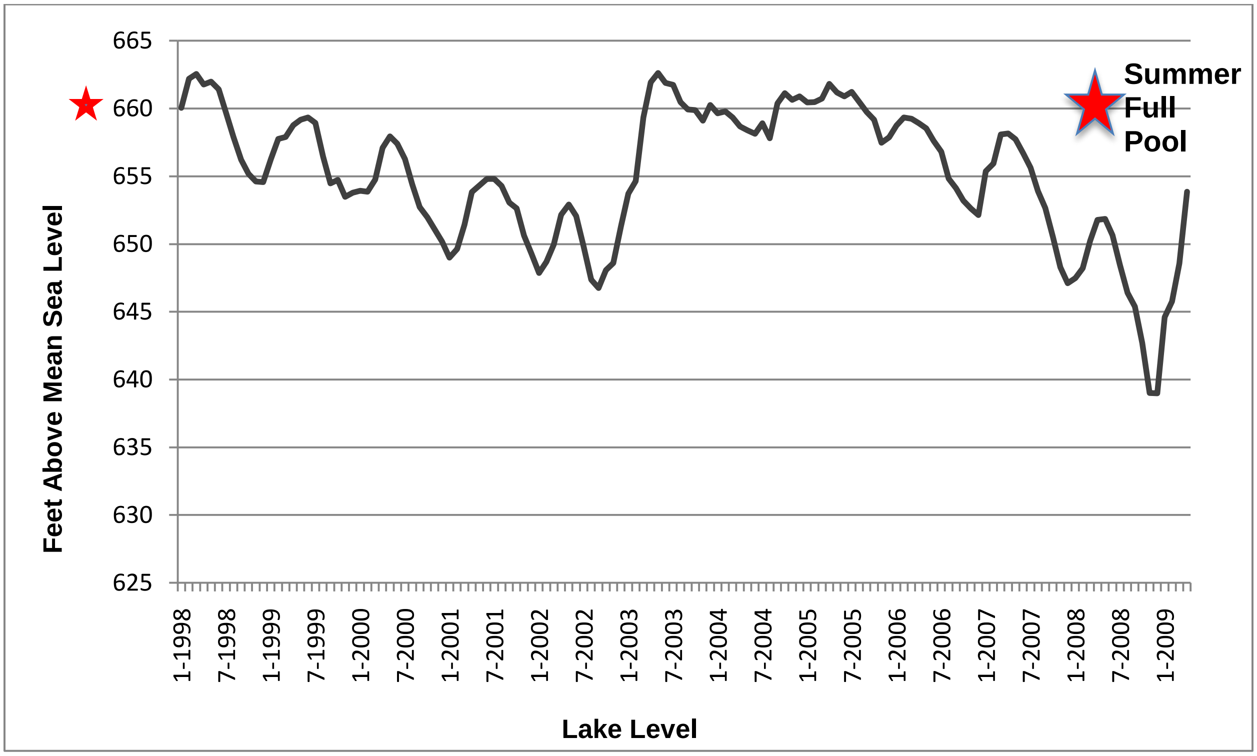

Figure 2. Hartwell Lake average monthly lake levels in feet above mean sea level.
Source: USACE, http://www.usace.army.mil/

Figure 3. Hartwell Lake December 2008 (Clemson, SC view).

Prior to the greatest historical decline in water levels in Hartwell Lake, water levels reached drought trigger Level 1 on July 5, 2007. At Level 1 (656 feet above MSL), flows are reduced at Thurmond Dam, the lowest dam on the three USACE-maintained lakes (Hartwell, Russell, and Thurmond) that flow into the Savannah River. Flows are also reduced as appropriate at Hartwell Dam to maintain balance among these pools. As the drought continued, Level 2 status (654 feet above MSL) was reached on August 15, 2007. On September 4, 2008, drought trigger Level 3 (646 feet above MSL) was reached. On December 9, 2008, Hartwell Lake reached its lowest level on record of 637.53 feet above MSL.

Hartwell, Russell and Thurmond Lakes are operated as a cascade system of reservoirs. The drought plan calls for balancing the Hartwell and Thurmond pools foot per foot for the 15 feet of conservation storage to balance shoreline impact. For example, when Thurmond Lake is six feet down, the target is six feet down at Hartwell Lake. As releases are made at Thurmond Dam there are corresponding releases at Hartwell Dam to maintain balance. Russell Lake only has a small five foot conservation pool and it is a pump storage project, so its changes are smaller. The amount of reduction at Hartwell and Russell Lakes varies with changes in inflows to meet balanced elevation targets during drought. Beyond 15 feet, the lowering of Hartwell and Thurmond Lakes is based on percentage of depth remaining in the conservation pool.

As the drought worsened the USACE heard from various stakeholders. Some wanted to restrict dam outflows, others did not. The National Oceanic and Atmospheric Administration (NOAA) Fisheries Service and the US Fish and Wildlife Service maintained that flow reductions out of the Thurmond Dam could potentially have a negative effect on the habitat of the short-nosed sturgeon, an endangered species that spawns in the Savannah River floodplains below Augusta, Georgia. Downstream environmental, safety, water supply and water quality needs drive releases once the drought triggers are reached.

In contrast, Hartwell Lake and Thurmond Lake home and business owners were concerned that the value of their assets would be permanently compromised if the USACE’s drought management plan was not modified to permit long term maintenance of lake levels closer to full pool.

IV. Prior Economic Impact Analyses of Hartwell Lake

Within the past decade, only two organizations have conducted formal studies investigating aspects of the economic impact of Hartwell Lake on the surrounding region.

A. LAKE HARTWELL ASSOCIATION

The Lake Hartwell Association conducted a survey of lake-oriented homeowners and businesses in 2003, just after a prolonged drought. The purpose of the survey was to "quantify the impact of low lake levels on the recreational use of the lake and consequently the impact on the local economy" (Lake Hartwell Association, 2003, p. 1). Sixty-two businesses and 1,227 residents completed the survey in February and March 2003.

Of property owners responding to the survey, 92 percent owned permanent or vacation homes on the lake and the remainder owned undeveloped land. Eighty-three percent of respondents believed that their property value fell during the drought years of 2000, 2001, and 2002. Survey responses also indicated that during 2002 (when Hartwell Lake was eight feet BFP or more for the entire year), the number of recreational boat trips declined by 62 percent on average, and the number of boat trips for fishing declined by 72 percent, on average, compared to trips taken in years with "normal" lake levels. Eighty percent of property owners agreed with the general statement that eight feet BFP was the minimum lake level for safe boating and water sports.[2] Nearly 100 percent of dock owners reported having to move their docks during times of low water to allow for lake access.

Business owners responding to the survey reported an average decline in gross income in each of the three drought years: 2000 (21 percent decline), 2001 (20 percent decline), and 2002 (25 percent decline). Twenty-nine percent of business owners surveyed observed that they started to see a decline in sales when lake levels dropped to five feet BFP. Real estate firms were 44 percent of business respondents and retail businesses were 33 percent of respondents. Over the three year period, the Lake Hartwell Association estimated that the average decline in gross income for all respondent businesses was $28.2 million. Projecting this loss to include 163 non-responding businesses surveyed, the Lake Hartwell Association estimated that the total three-year loss in gross income in lake-oriented businesses attributable to low lake levels was $123 million.

The Lake Hartwell Association's study is informative and provides useful anecdotal insights into relationships between lake use, economic activity, and lake levels. However, this study suffers from several shortcomings. One of the primary

[2] The survey instrument was not included in the report so the exact wording of survey questions is unknown.

shortcomings is the nature of survey respondents: property and business owners with lake-access property or a portion of their income from lake activity. It is natural to expect that these individuals and groups would be most strongly impacted by lake level changes, but these specific impacts do not necessarily result in broader economic impacts within the Hartwell Lake region. Another shortcoming concerns the breadth and type of data collected. Lake recreation activity reported by property owners is annual and anecdotal, not based on actual counts.

The most important shortcoming of the Lake Hartwell Association's study is that no statistical analysis was performed on survey and secondary source data to further clarify the relationships between lake level and economic activity. For example, the United States was in a recession during years 2000 through 2003—what impact did the recession have on reported gross sales? Isolating the impact of lake level changes, while controlling for other secondary factors, is an important component for this type of analysis. To clarify broader economic impacts requires a more thorough development of methodology, including a wider consideration of data sources and the use of appropriate statistical tools. Thus, one should treat the Lake Hartwell Association's gross income loss estimate of $123.2 million for 2000, 2001, and 2002 with a great deal of caution.

B. US Army Corps of Engineers

A 2008 USACE study examines *The Economic Impacts from Spending by Private Dock Owners at Lake Hartwell*. This study is based on a 1999 survey sample of Hartwell Lake dock owners. In 1999, the Corps permitted over 8,700 private docks on Hartwell Lake. Based on the survey, the Corps estimated that approximately 539,000 trips were taken by private dock owners in 1999, about 16 percent of the estimated total recreation usage of the lake that year. The Corps also estimated that private dock owners spent $69.5 million in trip-related expenditures and $14.8 million in new boats and related annual expenses in 1999 (reported in 2004 dollars).

The direct economic impact of spending by private dock owners at Hartwell Lake in 1999 was estimated to be $53.5 million in direct sales and $20 million in direct personal income in the 16-county region surrounding the lake. Direct economic activity largely impacts the retail trade, restaurant, manufacturing, and service sectors. However, this activity also generates indirect—or secondary—economic impacts because spending by dock owners circulates through the local economy. These indirect economic impacts were estimated to be $34.5 million in 2004 dollars, making the total estimated economic impact of private dock owner spending equal to $108 million. These results confirm that recreation activity at Lake Harwell makes a substantial contribution to the regional economy.

V. Literature Review

There is considerable research relating lake attributes to regional economic activity. A variety of research methodologies are used, from survey and interview data (primary source) to secondary data sources and statistical tools. This research supports the selection of data types and analytical techniques for the Hartwell Lake study.

A. Lake Amenity Value

Hedonic modeling is one tool that has become a popular method for assessing the value of environmental amenities such as lakes and green space. Hedonic models are used to assign a quantifiable value to goods that are not directly exchanged in the marketplace. For example, it is difficult to define the amenity value in dollars of a fishing trip on Hartwell Lake. However, housing markets can be used as a proxy for environmental qualities or amenity values (Palmquist et al., 1997).

Hedonic models use data on a variety of real property attributes— such as the number of bedrooms and bathrooms, square footage, and age—to isolate the impact of an environmental variable on the market value of housing. One study (Correll et al., 1978) found that housing values declined by $4.80 for every additional foot a home was farther from a greenbelt space. Other research (Palmquist et al., 1997; Gayer, 1999) has found that housing values experience a significant decline the closer they are to environmental factors like hog farms and EPA Superfund sites.

A more recent study (Carey and Leftwich, 2007) used hedonic modeling to measure the impact of water quality (specifically, a 1999 algal bloom) on housing values on Lake Greenwood in Greenwood, South Carolina. This research found that the algal bloom did not have significant negative impacts on property values adjacent to Lake Greenwood. Temporary or isolated events, such as algal blooms, may not be internalized in the market value of property.

Hedonic modeling of the impact of low lake levels on housing values was not used in this project because of budget limitations and the difficulty of collecting detailed housing attribute data over time for a lake with such a large number of private homes as Hartwell Lake.

B. Lake Economic Impact

Lake economic impact studies have used different statistical modeling techniques to estimate total impacts. Oh and Ditton (2005) estimate the economic impact on recreational fishing from an algal bloom at Possum Kingdom Lake (PKL), Texas. They use an intervention time series method with three time series data sets: sales tax revenue, gross retail sales for five lake tourism-related SIC categories, and gross retail sales for recreational fishing. Their results indicate that the 2001 algal bloom explains a 57 percent reduction in the number of visitors to PKL State Park, with an estimated total economic loss of $2.8 million to the three surrounding counties. Their estimates also reveal that lake algal blooms in 2001 and 2003 can be blamed for small declines in gross sales at grocery stores, eating and drinking establishments, retail places, hotels and motels, and miscellaneous amusement and recreation sales.

A number of studies document the economic importance of water-based recreation. Cameron et al. (1996) and Fadali and Shaw (1998) reveal relationships between recreation participation, number of trips, and potential changes in economic activity. Cameron et al. also found that water level could be a “barrier” to near term future recreation visits. Cordell and Bergstrom (1993) confirmed that visits and water level are strongly correlated and found that a near full pool generated a positive net economic benefit of $5 million a month across four Tennessee Valley Authority (TVA) reservoirs.

Terrell and Johnson (1999) found that dropping the level of water in the Ogallala Reservoir would have a negative impact on all sectors of the local economy, which is heavily agricultural and relies on the reservoir for irrigation. Hanson, et al. (2002) found that property values dropped more (35%) with a lake drawdown than they increased (15%) with a rise in lake levels.

A number of studies have been conducted to evaluate the overall economic impact of lake tourism and recreation on their surrounding regions. Mead Hunt (2002) determined that the annual value of lake tourism and recreation on Lake Murray near Columbia, South Carolina was around $365 million. F. W. Bell, et al. (1995 and 1998) estimated that Lakes Jackson and Tarpon in Florida each were responsible for over $10 million in spending and hundreds of jobs. Apogee Research, Inc. (1996) determined that the Indian River (Florida) lagoon had a range of economic value stretching from $43.3 million to $193 million on county levels. Other economic impact studies from the state of Florida can be found in Wiley’s (1997) NOAA Annotated Bibliography. The USACE has conducted numerous studies on individual Corps projects, among them Lake Sidney Lanier near Atlanta (Probst et al., 1998).

One of the most relevant studies for this project is one for a lake managed by the TVA. The TVA and the USACE face similar challenges in lake management. LOUD, the Land Owners and Users of Douglas Lake (1998) and the Cherokee Lake Users Association have policy concerns similar to those expressed by the Lake Hartwell Association and the Hartwell 660 Coalition.

Since the mid 1990s these groups have urged the TVA to alter their water management policy to allow for fuller pools in August and September when lake recreation demand is high. To provide support for their arguments, these organizations urged the State of Tennessee and the six local governments near Douglas Lake to consider a study of the economic benefits of the TVA altering its lake level policy. The University of Tennessee’s Center for Business and Economic Research completed the *Economic and Fiscal consequences of TVA’s Draw Down of Cherokee and Douglas Lakes* in October 1998.

The Tennessee study used primary source survey data along with multiple secondary sources for additional statistical analysis. The economic effects of changing lake level policy were estimated using three separate methodologies. The first methodology estimated the increase in expenditures from non-resident visitors in response to higher lake levels. Using survey data, estimates indicate that higher lake levels will result in an increase of $1 million to $1.8 million in nonresident expenditures. The resulting employment is estimated to generate total personal income in the range between $588,000 and $976,000.

The second approach used a statistical model relating county-level retail sales to lake level. This model estimates that higher lake levels will create $1.6 million in additional retail sales in the local region, generating 43 annual full time positions and $700,000 in personal income. The third model used a survey of area retail businesses to estimate the direct impacts of higher lake levels. Based on survey responses, higher lake levels in August and September were estimated to increase area spending by $7 million through the first of October. Increased sales would support 351 annual full time positions and have an income impact of $4.2 million.

These three different approaches all suggest that higher lake levels will generate positive economic benefit to the region but they yield considerably different results. The authors conclude that their analysis is a lower bound estimate of the economic impacts of higher lake levels and should be taken into consideration by the TVA when considering future policy change. (University of Tennessee, Center for Business and Economic Research, 1998)

Another study with information useful for the Hartwell Lake project is the 2001 study of the economic impact of recreation associated with Lake Lanier, Georgia. The study was commissioned by the Marine Trade Association of Metropolitan Atlanta (2001) to identify key financial indicators that illustrate the recreational impact of the lake. A large part of the impetus for this study, like the Hartwell Lake study, was a severe drought. Residents of the region were concerned that their local economy was negatively affected by low lake levels.

The Lake Lanier study used primary source interview data from 173 individuals representing 57 organizations and secondary source data from a wide range of organizations involved in lake management and/or recreation. The authors estimated the economic impact of Lake Lanier recreation activity to be approximately $5.5 billion in 1999. While there is no doubt that Lake Lanier has an economic impact on the region, this figure is extremely high and may be questionable (Marine Trade Association of Metropolitan Atlanta, 2001).

VI. Data Sources and Methodology

A. Data Sources

This study was designed to capture the county-level economic impact of changing water levels on Hartwell Lake as accurately as possible given data availability and the project budget. The independent variable used in each analysis is Hartwell Lake's average monthly level measured in feet above MSL. Three dependent variables were chosen and agreed upon by stakeholders involved in project planning. These variables measure lake-related economic activity in the six counties bordering Hartwell Lake:

- Lake recreation use
- Lake-access real estate transactions
- County gross retail sales

Data was collected from a variety of local, state, and federal government secondary source material. Although secondary source data does not allow us to clearly differentiate between nonresident and resident spending, we are confident that our analysis will provide, at a minimum, a statistically significant upper bound for nonresident-generated economic impacts. These variables will capture both resident and nonresident economic activity as people from outside the six counties buy new homes on the lake, purchase goods and services on or near the lake, and visit lake sites for recreation.

1. Lake Level

The most important independent variable for this analysis is Hartwell Lake's average monthly lake level. Data was collected for the years 1998 through 2009 and was obtained from the USACE Savannah District. The average monthly temperature at the Greenville-Spartanburg International Airport is used as a seasonal indicator (many boaters prefer warmer to colder temperatures).

2. Lake Recreation Use

The USACE provided monthly recreation use data for the years 1998 through 2009 for Corps-managed recreation sites on Hartwell Lake. Data accounts for visitors to USACE facilities, but not what activities those visitors are engaged in. Appendix A shows monthly lake levels and recreation visits for a drought year (2008) and a non-drought year (2005).

In 2005 Hartwell Lake stayed very close to full pool for the entire year and visitors to USACE recreation sites numbered almost 10,362,000. In 2008, the average lake level was 13 feet BFP and recreation visits dropped by nearly 298,000.

3. Lake-Access Real Estate Transactions

Real estate data was obtained by first identifying privately-owned parcels with lake access within each county. This data was collected from GIS (Geographical Information System) mapping parcels obtained from each of the six counties bordering Hartwell Lake. Figure 4 shows lake-access parcels in Oconee County, SC. Table 1 shows lake-access parcels as a percent of total real estate parcels. These range from a low of three percent of the total in Stephens County to a high of 20 percent in Hart County.

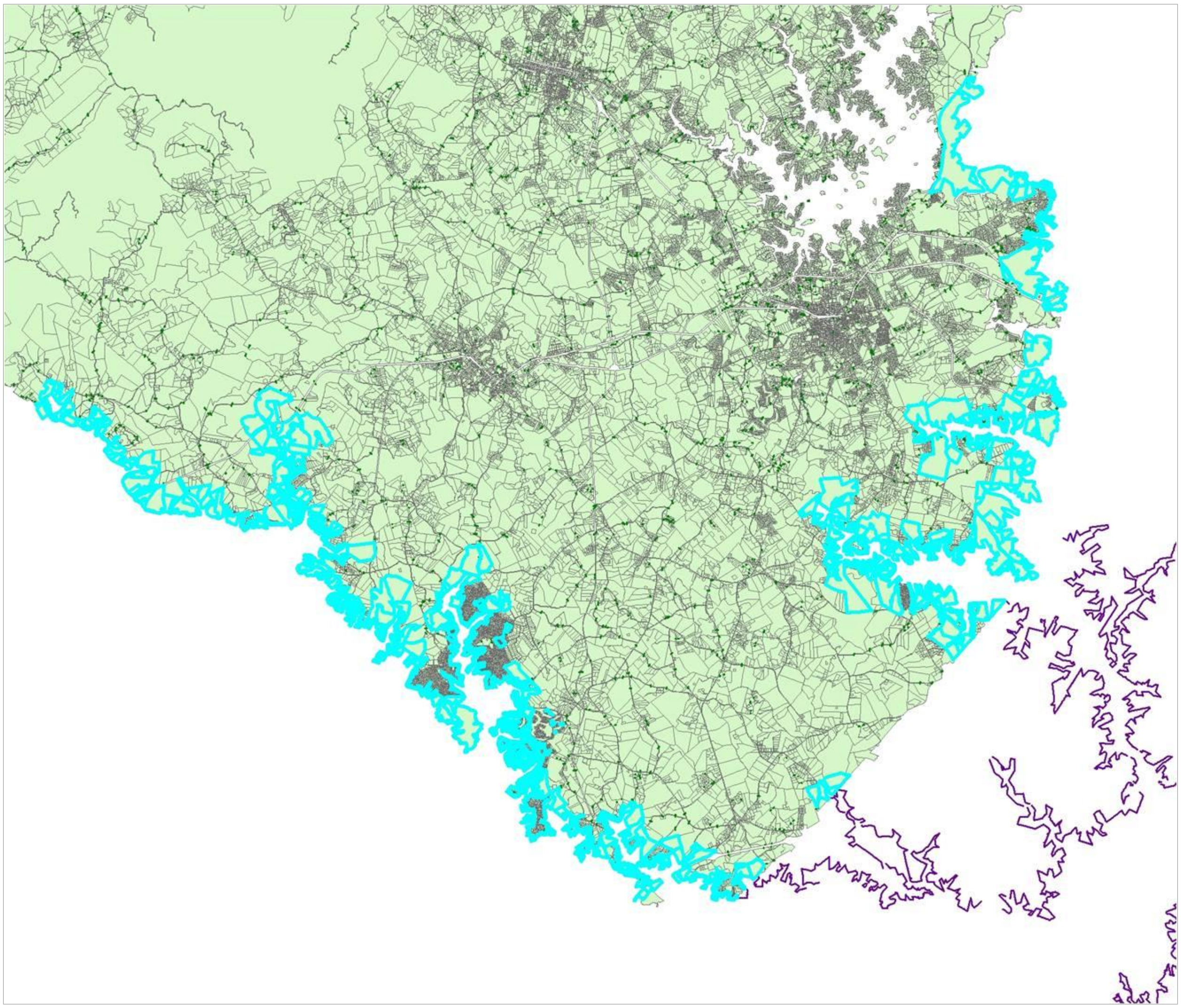

Figure 4. Lake-access parcels (highlighted), Oconee County, SC.

When lake-access parcels were identified, the number of real estate transactions occurring from January 1998 through May 2009 was gathered for those parcels. Over the study period there were 9,736 real estate transactions for 14,878 lake access parcels. Some parcels had multiple transactions over that period.

Table 1. Lake-Access Parcels as a Percent of Total County Parcels

County	Total Parcels in County	Lake-Access Parcels	Lake Parcels as % of Total
Franklin	15,364	1,002	6.5%
Hart	18,700	3,785	20.2%
Stephens	17,234	524	3.0%
Anderson	104,000	5,385	5.4%
Oconee	57,086	3,887	6.8%
Pickens	60,185	295	0.5%
Total	272,569	14,878	5.5%

4. County Gross Retail Sales

Data was collected on more than 25 categories of gross retail sales for each county bordering Hartwell Lake. These categories were restricted to business and industry sectors most likely to experience measurable economic impacts resulting from changing lake levels.

Gross retail sales data for South Carolina was obtained from the state's Department of Revenue (DOR) for five years from 2005 to 2009. (Earlier data was unavailable at the level of detail required for the study.) The South Carolina DOR provided the dollar value of total reported monthly sales of all businesses in each county, organized by SIC (Standard Industrial Classification) code.[3]

Georgia's DOR provided monthly state *sales tax revenue* (rather than gross retail sales) by county for the years 2001 through 2008. The revenue data was converted into a close approximation of total gross sales by dividing by the state's sales tax rate of four percent. Georgia also uses its own unique commodity classification codes. In order to convert the Georgia commodity classifications into comparable SIC categories, text descriptions provided by the Georgia DOR were used to match up each respective category. Ultimately, our analysis focused on data from 12 SIC codes (Table 2).

[3] In 1997 the federal government changed its industry classification system to the North American Industrial Classification System (NAICS), but South Carolina only recently changed its reporting from SIC to NAICS.

Table 2. Gross Retail Sales Categories

SIC Code	Category
2099	Retail Trade
5331	General Merchandise
5399	Miscellaneous General Merchandise
5411	Groceries
5511	Cars
5541	Gas Stations
5551, 5599	Boating Stores
5812	Restaurants
5813	Drinking Establishments (Bars)
5921	Liquor Stores
5941	Sporting Goods Stores

B. ANALYTICAL TECHNIQUES

In this study, we combined several statistical analysis techniques to analyze the strength of the relationship between lake levels in Hartwell Lake and economic activity in the surrounding counties. That information was then used with the REDYN economic model to estimate the total economic impact of changing lake levels on the region (Figure 5). Hartwell Lake data was analyzed starting with the most basic method: visual examination. Then progressively more sophisticated techniques were used.

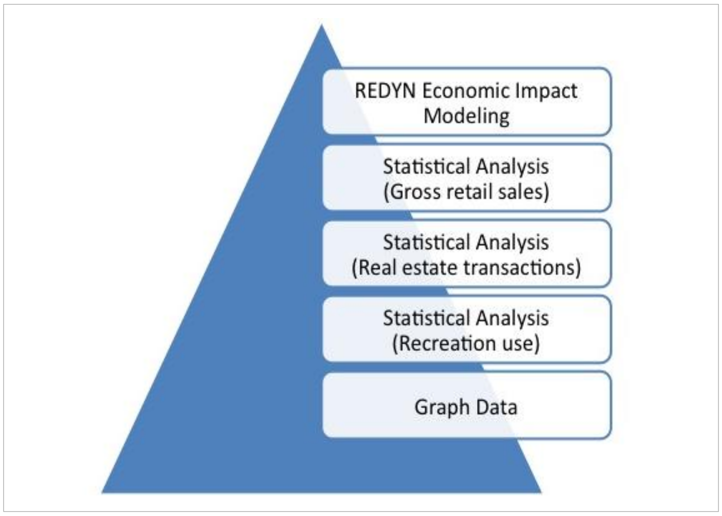

Figure 5. Method of analysis.

1. Linear Regression Analyis

Linear regression analysis was used to directly estimate the strength of the relationship between water levels in Hartwell Lake and the following variables: recreation use, gross sales of goods and services in the six counties bordering the lake, and real estate transactions on lake-access parcels. The basic structure of linear regression models is as follows:

Model: $y_i = b_0 + b_1x_{\mathbf{i1}} + b_2x_{i2} + e_I$, i = 1…n

> y_1 = dependent variable (recreation use, real estate transactions, gross retail sales)
>
> x_{i1} = independent variable (lake level)
>
> x_{i2} = independent control variables (per capita personal income, temperature, etc.)
>
> b_1 = estimate of change in dependent variable per unit increase in lake level, all controls held constant
>
> b_2 = estimate of change in dependent variable per unit increase in control variable, lake level held constant
>
> i = month
>
> e_1 = error term

Linear regression analysis is a prerequisite for the use of the REDYN economic modeling system. The variable coefficients that result are necessary inputs into the REDYN model. These coefficients estimate the impact of lake level on each dependent variable analyzed (recreation use, gross sales, or real estate transactions).

One of the benefits of linear regression analysis is that it separates the effect of each dependent variable analyzed (recreation use, gross sales, or transactions) on the independent variable (lake level). Thus, linear regression analysis can control for economic and seasonal variables that may affect recreation activity, gross sales, or real estate sales, but may have no relationship to lake level.

In this study, it was important to remove the effect of seasonal temperature variations on lake activity (Figure 6). The variable chosen to remove seasonal variation was average monthly temperature from the Greenville/Spartanburg (GSP) weather reporting station. As well, the nature of the dependent variables made it especially important to control for regional economic conditions, because some recent droughts occurred during periods of national economic downturn.

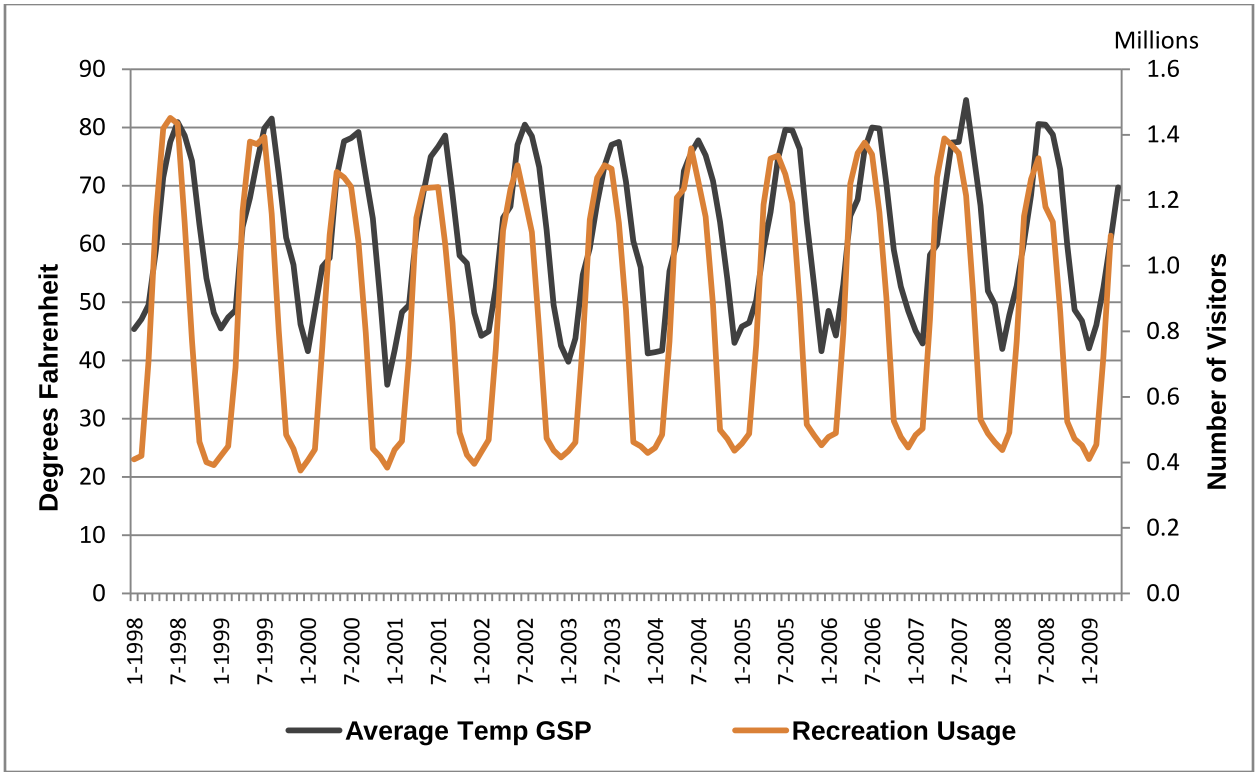

Figure 6. Average monthly temperature and recreation use at USACE facilities on Hartwell Lake.

A wide variety of data was collected to control for economic and seasonal factors. Two state-level economic variables were collected: annual gross state product and quarterly state personal income. County[4] level economic data collected included the following.

- Population
- Population over 16 years old
- Labor force
- Mean household income
- Median household income
- Per capita personal income (Anderson MSA)
- Percentage change in per capita personal income
- Percentage of population poverty
- Population density
- Monthly county employment
- Monthly annual employment percentage change

Many of these variables, when tested, did not significantly affect our dependent variables or improve the overall statistical analysis and were therefore not incorporated into our models.

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[4] All data collected is annual unless otherwise stated.

Linear regression analysis requires one to assume that the relationship between the independent variable (lake level) and the dependent variable (recreation use, gross sales, or real estate transactions) is linear and does not change over the period of analysis. 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.

2. Advanced Statistical Techniques

To further clarify the relationship between lake level and real estate transactions, linear regression models with structural breaks[5] were estimated for each county. Structural break 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 study variables at different intervals of the independent variable.

For this analysis, the structural break intervals were set for different lake levels below full pool (BFP). Structural break analysis has the potential to highlight the unique and nuanced relationship between each county's real estate market and the water level in Hartwell Lake over time.

For a number of gross retail sales categories, preliminary linear regression results suggested possible substitution effects between Hartwell Lake and Lake Keowee, which borders Pickens County and Oconee County, South Carolina. These early results also suggested that nonlinear relationships existed between gross retail sales and lake level. As a result, linear regression models were tested using interaction terms for Hartwell Lake and Lake Keowee. For the gross retail sales categories that appeared to exhibit nonlinear characteristics, models were tested using quadratic terms for both Hartwell Lake, Lake Keowee, as well as an interaction term for both lakes. Where appropriate, complete models were tested with interaction and quadratic terms for both lakes in the region.

3. Economic Impact Analysis

A thorough economic impact analysis attempts to measure direct, indirect and induced economic impacts of specific types of economic activity. In thisstudy:

- Direct economic impacts are spending by residents and visitors to the lake on lake-related activities (boat purchases, boat repairs, gasoline purchases, food purchases, etc.). Direct spending generates revenue that allows the recipients to pay wages, income, and taxes to individuals and government in the local economy.

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[5] Linear regression analysis with structural breaks is also called piecewise linear regression or segmented regression.

- Indirect economic impacts are the wages paid, income received, and tax revenues paid by the recipients of direct lake-related spending that are also spent in the local and regional economy. This spending creates indirect impacts that generate additional wage, income, and tax revenue in the economy.

- Induced economic activity occurs as additional local and regional expenditures increase disposable income in the region that further enhances aggregate local and regional demand for goods and services.

Input-Output (I-O) models are used to predict the impact of a change in one or more industries on other industries, consumers, and governments.[6] I-O models estimate direct, indirect, and induced economic impacts. REDYN is an I-O model of the US economy with detail down to the county level. The REDYN model uses the most current data available in order to forecast a baseline level of regional economic activity within over 800 Standard Occupation Classification (SOC) and 703 North American Industrial Classification System (NAICS) industry sectors.[7]

Results from the linear and nonlinear statistical models described above were used as inputs to the REDYN model to estimate the total economic impact of changing lake levels on the six counties surrounding Hartwell Lake. The statistical models yielded estimates of the changes in selected industry sectors as a result of changing lake levels. When these estimates are entered into the REDYN model, it generates the predicted economic impact of changing lake levels. Methodologically, this twofold approach to the analysis, along with the choice of variables used to estimate economic activity, provides for a thorough and instructive approach to estimating the impact of drought conditions on overall economic activity.

[6] IMPLAN and REMI are other popular Input-Output modeling systems.

[7] In order to enter study data into the REDYN model, a detailed crosswalk was used to convert all gross sales figures from SIC codes used in the study to NAICS codes used in REDYN.

VII. Hartwell Lake Recreation and Lake Levels

We started our investigation of the data by examining the strength of the relationship between recreation use and temperature, and recreation use and lake level. Simple observation suggests that there is a relationship between lake level and recreation (Figure 7).

Monthly visits to selected USACE recreation facilities averaged close to 863,500 in 2005, a non-drought year when the lake level remained close to full pool. In 2008, a drought year when the lake averaged 13 feet BFP, average monthly visits were 838,700. This is a difference of about 24,800 visitors a month between these two years (Appendix A). But this simple two-year comparison does not take into account the impact of other factors on recreation, such as temperature and economic conditions.

The statistical technique used is linear regression analysis. The USACE supplied monthly counts of visitors to selected Corps recreation sites on Hartwell Lake from January 1998 through April 2009. These counts do not contain detail about visitor activities.

In this analysis, the number of visitors (dependent variable) was regressed against three independent variables: lake level, average temperature, and per capita income (economic control variable).

As was apparent from looking at the data (Figure 7), the number of monthly visits to USACE recreational facilities on Hartwell Lake is closely linked to the season of the year, as indicated by the temperature variable. The relationship between lake level and recreation use is less obvious (Figure7). This regression model estimates that the number of additional monthly visitors to Corps recreation sites increases by over 22,000 for every degree the average monthly temperature increases, and vice versa. This finding is statistically significant at the 99 percent level (Table 3).

The findings from this analysis support the hypothesis that more people visit Hartwell Lake's recreation sites when the lake level is higher than when it is lower. In the regression analysis, the relationship between recreation visits and lake level is highly statistically significant. This model estimates that Corps recreation facilities get close to 21,200 more (or less) visitors per month for every one-foot increase (or decrease) in lake level. The average number of visitors per month at all of these Corps facilities is approximately 838,000. Therefore, this analysis estimates that Hartwell Lake could see a 2.5 percent change in the number of visitors to these facilities per month per foot of change in lake level.

The strong relationship between recreation use and lake levels is relevant to the current study because visitors to the lake spend money in the region. Local residents are assumed to spend money on goods and services within the region, regardless of water levels in Hartwell Lake. Their spending patterns may change as a result of the recreation opportunities afforded by higher lake levels and these variations should be detected by the appropriate statistical analyses. However, most of any positive regional economic impact from higher gross retail sales that may occur during periods of higher average lake levels will result from spending by tourists from outside of the region.

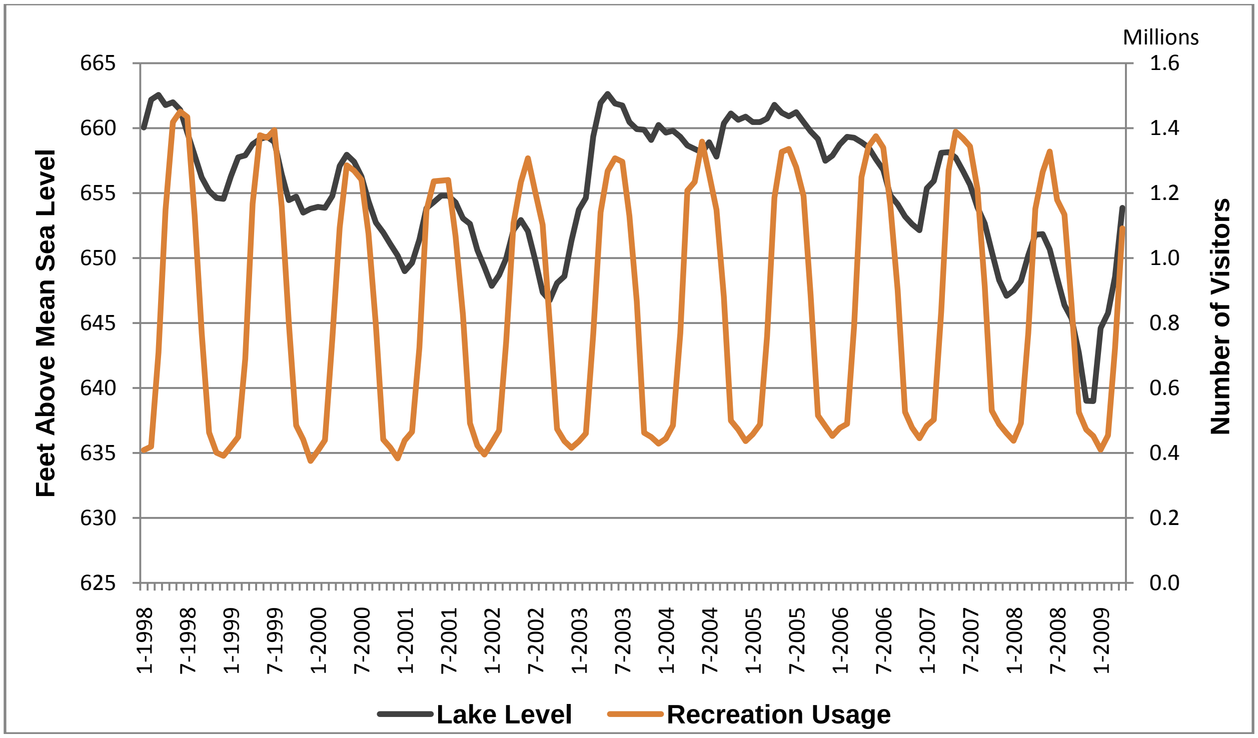

Figure 7. Lake level and recreation use (USACE Facilities on Hartwell Lake).

Table 3. Model Results: Recreation and Lake Level

Recreation Use	**Coefficient (t-stat)**
Average temperature	22,127.43 (15.58)*
Lake level (feet above MSL)	21,187.17 (4.68)*
Anderson per capita income	10.14 (1.14)
Constant (intercept)	-14,700,000 (-4.93)*
Adjusted R-squared	0.7102

* 99% confidence level

This study could be improved by knowing how many of the visitors counted in the Corps recreation data were from outside of the study region, but such data were not available to differentiate between spending by local residents and visitors in this study. Similar data is, however, available in a 2008 study of visitors to Lakes Keowee and Jocassee in northern Oconee and Pickens counties (a small portion of Lake Jocassee is located in Transylvania County, North Carolina). This study was commissioned by Duke Energy (Louis Berger Group, 2008), which owns and manages the two lakes. Lake Keowee and Lake Jocassee are roughly comparable to Hartwell Lake in size and are located almost entirely within the same study region, so visits to them can be used as a close proxy for visits to Hartwell Lake.

This study found that a total of 66.8 percent of visitors to Lakes Keowee and Jocassee were from the counties immediately surrounding the lakes (including Transylvania County). The remaining one-third (33.2 percent) of visitors were nonlocal, with some from other regions of the country.

These figures were applied to the findings on visits to USACE facilities on Hartwell Lake. With the assumption that one-third of visitors are non-local, some 278,000 of monthly visitors to these recreation facilities could be from outside of the study region. If the responsiveness of recreation visits to lake level is assumed to be evenly distributed across local and non-local visitors—an argument can be made that nonlocal visitors would actually be more responsive to lake level than local residents—then each one-foot change in lake level can be estimated to result in a change of 6,950 nonlocal visitors to these recreation facilities.

VIII. Lake-Access Real Estate and Lake Levels

Simple observation of monthly transactions involving lake-access real estate against water levels in Hartwell Lake in the six county study region suggests that there may be a relationship between the two (Figure 8). In 2005, a non-drought year where lake levels remained near full pool, an average of 119 transactions occurred per month on lake-access parcels. In 2008, a drought year with persistent low lake levels, the region averaged only 54 transactions a month (Appendix B).

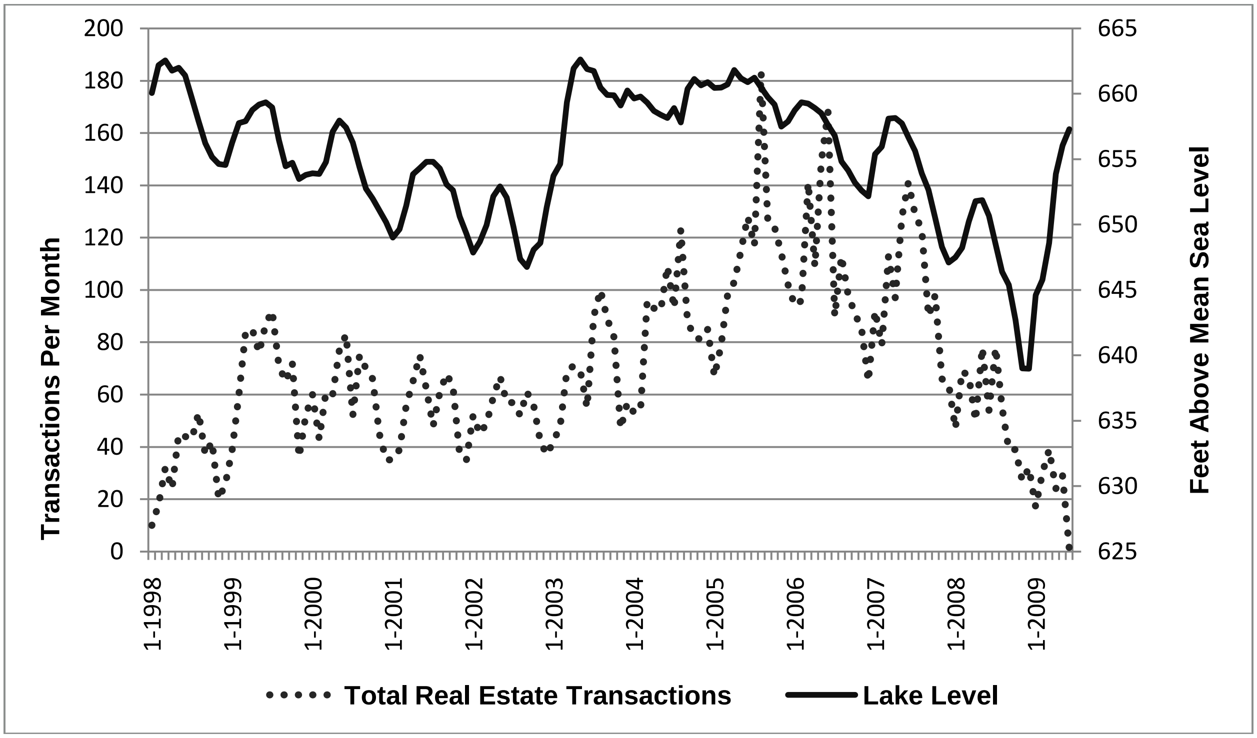

Figure 8. Lake level and real estate sales (Hartwell Lake, six-county total).

Table 4 illustrates the number of real estate transactions involving lake-access property over the past decade compared to the number of lake access parcels. Anderson and Oconee counties have significantly higher real estate activity than the other four counties that border Hartwell Lake. These two counties are relatively populous and also have many miles of shoreline with a high number of lake-access parcels. Hart County has nearly as many lake-access parcels as Oconee County, but many fewer transactions over the 10 year period of analysis. (Table 4, Figure 9).

Season, local economic conditions and other factors also affect real estate activity, however. For example, the number of transactions involving lake-access parcels ranged between approximately 30 and 70 per month from mid 1998 to mid 2003, with higher levels of activity occuring during the warmer months of the year. This fairly stable range of transactions per month doubled by 2005 and remained much higher than average until returning to earlier levels in 2008. In the first half of 2009, the level of monthly transactions dropped to very low levels.

Table 4. Hartwell Lake Real Estate Transactions (lake-access parcels)

County	Transactions 1-1998 to 5-2009	Lake-Access Parcels
Franklin	338	1,002
Hart	646	3,785
Stephens	643	524
Anderson	5,540	5,385
Oconee	2,916	3,887
Pickens	13	295
Totals	10,096	14,878

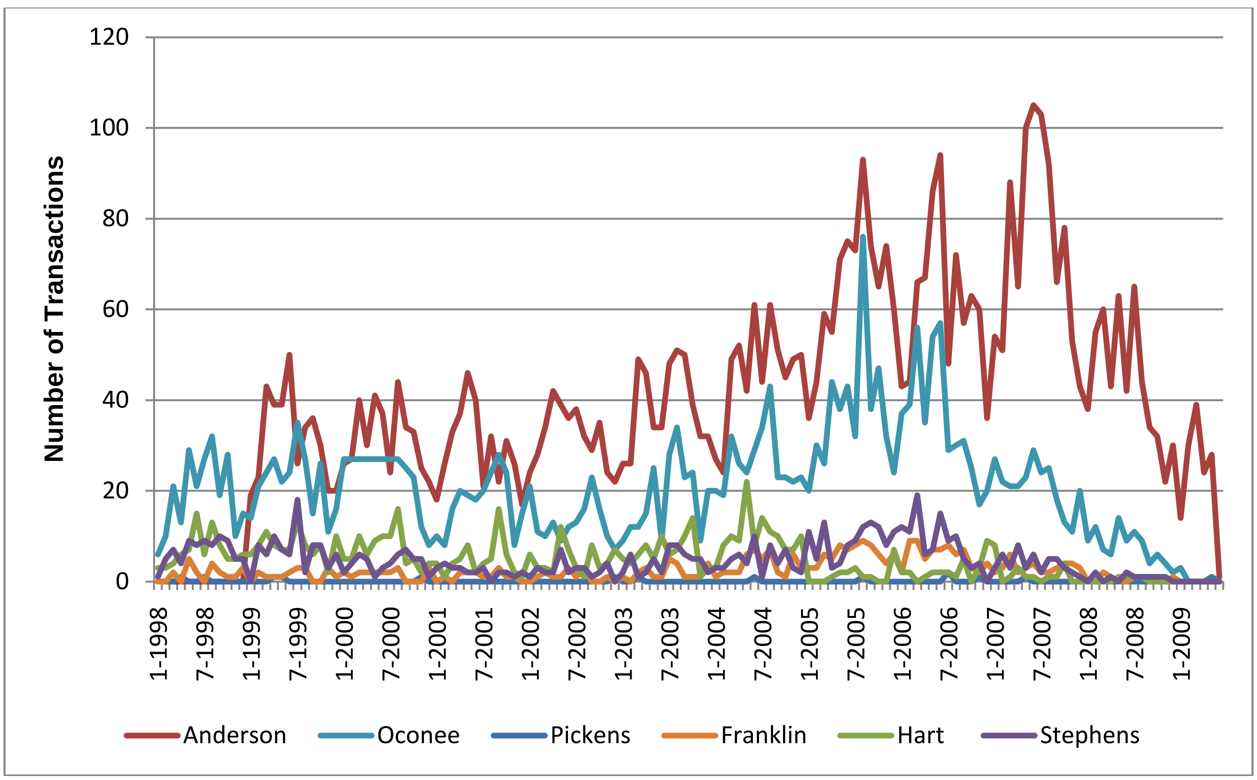

Figure 9. Lake-access parcel transactions by county.

How much of the year-to-year variation in transactions involving lake access parcels can be attributed to low water levels in Hartwell Lake? We used statistical techniques to isolate the effects of water levels from seasonal variations, the state of the economy, and other factors.

Both national and state economic conditions are a large factor influencing the behavior of regional real estate markets. By 2003, housing prices in South Carolina, like much of the nation, began increasing. Around this same time subprime lending by private loan originators began increasing as well. For the next few years, credit was easy and investors looked to real estate as a way to make a quick profit. Rising home prices and a strong economy boosted sales until the housing bubble started to burst in 2007. Data from the National Association of Realtors[8] shows that the volume of home sales declined 13.1 percent between 2007 and 2008 nationwide. In Georgia, home sales declined by 16.7 percent and in South Carolina, sales declined 23.5 percent over the same period. For lake-access parcels on Hartwell Lake, the decline in transactions was 49 percent, from 1,258 transactions in 2007 to 642 in 2008.

One of the purposes of this study was to evaluate the impact of low lake levels on real estate activity. One of the challenges of this study was to isolate the impact of low lake levels from the broader factors influencing the real estate market, such as the unique and volatile housing bubble and the recession. These three events collided in 2007, the same year in which Hartwell Lake's water level started its long decline.

A. Single Breakpoint Models

The technique selected to examine the strength of the relationship between sales of lake-access real estate and lake level is linear regression analysis with structural breaks. Structural break models allow for the analysis of independent variables that are partitioned into different intervals or clustered groups. The intervals are bounded by "breakpoints," which for this analysis are represented as different lake levels in feet below Hartwell Lake's summer full pool of 660 feet above mean sea level.

Structural breakpoints from one foot below full pool (BFP) to 20 feet BFP were tested for their statistical significance. In addition, models with more than one breakpoint were also tested. For each model, a Chow test was used to confirm that lake level is a variable that is more accurately modeled with this regression technique, as opposed to a single linear model. The model formulation and results are described in detail in Appendix C.

The results of this analysis illustrate that the relationship between lake level and real estate transactions is unique for each county bordering Hartwell Lake. Five counties had at least one statistically significant structural breakpoint (Table 5). Pickens County was excluded from this analysis because only 13 transactions occurred over the decade.

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[8] www.realtor.org

Anderson County had two models with different, but statistically significant breakpoints. The first model estimates that when the Hartwell Lake is seven feet or more BFP, 2.15 real estate
transactions are lost for every foot decline in lake level in this range. However, when the lake is between full pool and four feet below full pool, for every foot decline in lake level Anderson County gains 3.65 real estate transactions. These results reveal a range where real estate transactions may be stable or even growing when lake levels are dropping. When Hartwell Lake is four feet or more BFP, Oconee County loses less than one (0.8) real estate transaction for every one-foot decline in lake level in this range.

Hart and Stephens counties also had examples of individual structural breakpoints. When Hartwell Lake is two feet or more BFP, Hart County loses 0.35 real estate transactions for each foot decline in the lake. In other words, a three foot lake level decline from 657 feet to 654 feet (above MSL) results in one less lake-access real estate transaction in Hart County. Similar results were found for Hart County when the lake is more than five feet BFP. When Hartwell Lake is more than three feet BFP, Stephens County loses 0.30 real estate transactions for each foot decline in the lake. In all models, ranges of lake levels that are not mentioned did not show statistically significant relationships between lake level and real estate transactions.

Table 5. Single Structural Break Real Estate Sales Model

One Structural Break Point			
County	**Lake Level**	**Transactions Lost/Gained Per Foot Decline**	**R-squared(Non-Adjusted)**
Georgia			
Hart	2 feet or more BFP	-0.35	0.21
Hart	5 feet or more BFP	-0.33	0.26
Stephens	3 feet or more BFP	-0.30	0.32
S. Carolina			
Anderson	7 feet or more BFP	-2.15	0.26
Anderson	4 feet or less BFP	+3.65	0.25
Oconee	4 feet or more BFP	-0.80	0.49

B. Multiple Breakpoint Models

Models that allow for more than one breakpoint in lake level refine the analysis of the relationship between lake level and real estate sales. Anderson, Oconee, and Franklin counties all had models with two statistically significant structural breakpoints (Table 6). When Hartwell Lake is three feet or less BFP, Anderson County gains eight transactions for every foot decline in lake level. However, the county loses 2.15 transactions for every foot decline in the lake when Hartwell Lake is more than seven feet BFP.

In Oconee County there is a structural break range from four feet BFP to less than or equal to 11 feet BFP. When Hartwell Lake falls within this range, for every foot decline in the lake, Oconee County loses two real estate transactions.

Franklin County also has a structural break range but it is a much narrower range than Oconee County. When Hartwell Lake is between three feet BFP and five feet BFP, for every foot decline in lake level, Franklin County loses 2.5 real estate transactions.

Table 6. Multiple Structural Break Real Estate Sales Model

Two Structural Break Points			
County	**Lake Level**	**Transactions Lost/Gained Per Foot Decline**	**R-squared(Non-Adjusted)**
Georgia			
Franklin	Between greater than 3 feet BFP and less than or equal to 5 feet BFP	-2.15	0.41
S. Carolina			
Anderson	Less than 3 feet BFP Or 7 feet or more BFP	+8 (less than 3 ft) or -2.15 (7 ft. or more)	0.33
Oconee	Between greater than 4 feet BFP and less than or equal to 11 feet BFP	-2.04	0.60

These single and multiple structural break models illustrate that each county's real estate market has a unique relationship to Hartwell Lake. Thus we cannot make a uniform statement for the Hartwell Lake region about the strength of the relationship between sales of lake-access property and lake level. One explanation for the differences in these relationships among counties is the volume of lake-access property relative to the total real estate market in the county. The geography of the lakefront varies around the lake as well, which likely affects how quickly consumers respond to changes in lake level. Moreover, each of these communities is unique and the level of real or perceived problems caused by low lake levels may vary as well. Nevertheless, these results support stakeholder assertions that lake-access real estate transactions are negatively impacted by declining lake levels.

C. COMPARISON TO LAKE MURRAY, SC

Linear regression models with structural breaks were also calculated for Lexington County, South Carolina as a control. Lake levels in Lake Murray are more stable than they are in Hartwell Lake.[9] The findings for Lexington County are presented in Appendix C. This
constitutes a 1.7 percent decrease in average monthly real estate transactions per foot change in lake level. This is a smaller impact than our findings for the Hartwell counties.

No statistically significant structural breaks were found for the Lexington County real estate model. In other words, the relationship between lake level and real estate transactions does not vary across various lake levels.

[9] Lake Murray data includes a period from late 2002 through mid 2004 in which the lake was drawn down for scheduled work on the dam.

D. Real Estate: Low Lake Levels During the Drought

The impact of the recent drought on the number of transactions involving lake-access real estate can be estimated using results from the structural break models. The structural break models estimate the number of transactions gained or lost per month at different levels of Hartwell Lake. We selected the 21 month period from April 2007 to December 2008. By April 2007, Hartwell Lake had begun its continuous downward trend to its lowest point in December 2008.

A total of 1,605 transactions involving lake-access parcels on Hartwell Lake took place from April 2007 through December 2008. Our statistical analysis estimates that low lake levels resulted in 56 fewer sales of lake-access property in the six county region than would have occurred otherwise during this period, had the drought not occurred. This impact is independent of seasonal and economic conditions. These 56 sales are 3.4 percent of total sales (Table 7).

The impact of low water levels on real estate transactions is highly variable among the six counties. In Anderson and Oconee counties, which had the largest volume of transactions over the study period, the estimated number of transactions lost due to low water levels during the drought were less than three percent of total transactions of lake-access property estimated to occur. In the counties with relatively few real estate transactions per year, such as Franklin, Hart, and Stephens counties, lost transactions were a larger share of total activity. The loss or gain of a few sales in any location can make a big difference to individual real estate agents and firms.

Table 7. Drought Impact on Lake-Access Real Estate Transactions
(April 2007 – December 2008)

County	Actual Sales	Estimated Sales Lost	Estimated Sales w/o Drought	Gained/Lost % of Total
Franklin	34.0	-5.2	39.2	-13.3%
Hart	15.0	-5.4	20.4	-26.5%
Stephens	45.0	-5.6	50.6	-11.1%
Anderson	1,233.0	-32.1	1,265.1	-2.5%
Oconee	277.0	-7.7	284.7	-2.7%
Pickens	1.0	0.0	1.0	0.0%
Total	**1,605.0**	**-56.1**	**1,661.1**	**-3.4%**

This study analyzed the relationship between low lake levels and sales of lake-access real estate during a drought event. Unfortunately, this drought was also part of a perfect storm. As the Hartwell Lake region suffered from a record drought, the state and national economy tumbled into a recession. The recession and the dramatic national housing crisis exacerbated the impact of the drought on the market for lake access properties on Hartwell Lake. This analysis shows that the impact of low lake levels on real estate sales is measurable, but not the primary factor driving the large decline in transactions starting in 2007.

IX. Gross Retail Sales and Lake Levels

We continued our analysis by examining the strength of the relationship between county-level spending and lake level. Monthly gross retail sales were selected as the appropriate data to capture variation in local spending resulting from changing lake levels. We obtained data from the Georgia DOR for the years 2001 through 2008 and data from the South Carolina DOR for the years 2005 through 2009.

Gross retail sales are a good measure of county economic activity, particularly at the consumer level. It encompasses spending increases (or decreases) resulting from changes in income and employment, and also captures spending by visitors to the region. Gross retail sales are the dollar value of sales before state and local taxes are applied. Most states collect and report gross retail sales using SIC or NAICS codes, which represent specific industry sectors. Anderson County, South Carolina has by far the highest amount of economic activity of the six counties surrounding Hartwell Lake, as measured by total gross retail sales (Table 8).

Table 8. Economic Activity by County 2007

County	Gross Retail Sales ($ mill.)	% of Total By State
Franklin, GA	671	40.2
Hart, GA	336	20.1
Stephens, GA	663	39.7
GA total	***1,670***	***100.0***
Anderson, SC	2,615	54.3
Oconee, SC	932	19.4
Pickens, SC	1,265	26.3
SC total	***4,812***	***100.0***

A. Linear Regression Analysis

We evaluated the strength of the relationship between gross retail sales and lake level in several stages. Unlike Hartwell Lake recreation use and real estate transactions, simple observation did not reveal straightforward linear relationships (Figure 10).[10]

[10] Due to rules regarding the disclosure of information that might reveal proprietary information, a zero value was reported in some counties or in some months. In some instances, this required the exclusion of an SIC sector from a county's data.

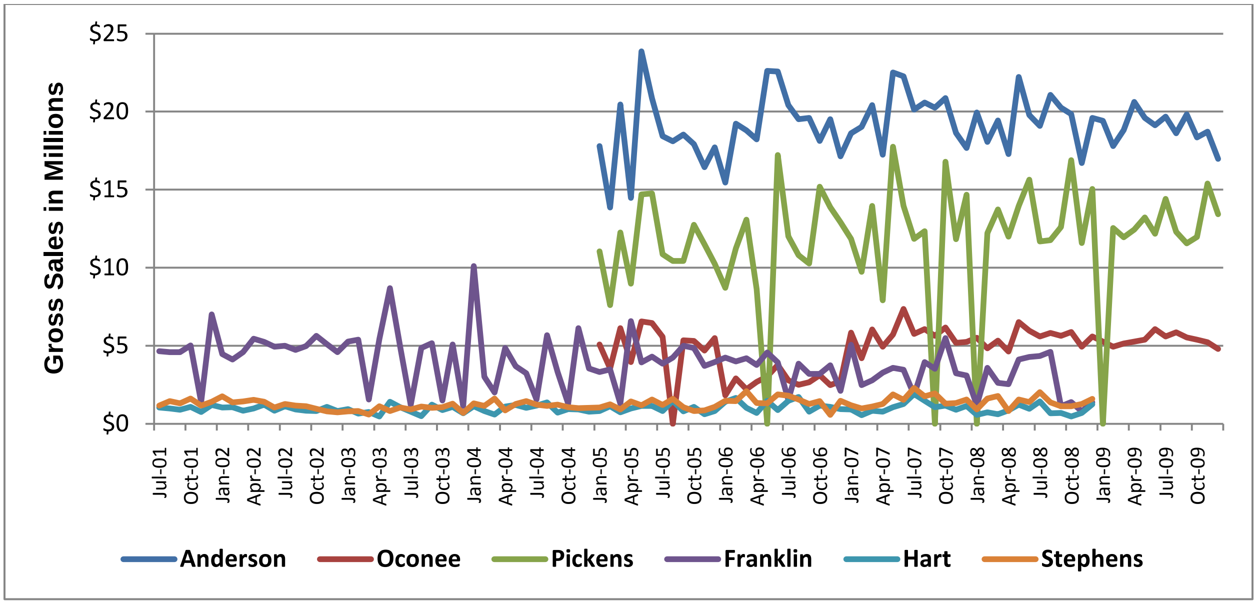

Figure 10. Gross retail sales, restaurants.

To confirm our suspicions, we began the analysis by testing linear regression models, with each gross sales category as the dependent variable and lake level as the primary independent variable. Instead of absolute lake level in feet above mean sea level, several alternative measures were tested. Lake level as a percentage of full pool was chosen as the primary independent variable for all gross sales models. Average monthly temperature and county per capita income were included in the models as control variables for seasonal variations and local economic conditions. County gross retail sales in 12 SIC codes were evaluated against lake level (Table 2).

The study team expected that certain gross sales categories would be more likely than others to exhibit a statistically significant relationship with Hartwell Lake water levels. The team also anticipated that these relationships might vary in direction and magnitude. For example, the dollar volume of boat sales might naturally vary with lake level: up when the lake is close to full pool and down when the lake is much lower. However, even this hypothesized relationship was difficult to discern by visual inspection (Figure 11). Other categories, such as groceries and general merchandise, were more difficult to predict.

The results of these linear regression models revealed that lake level is statistically significant with only a few of the gross sales categories in each county. Bars, boating stores, gas stations, general merchandise stores, and sporting goods stores were the most common categories to exhibit a statistically significant relationship with the level of Hartwell Lake (Table 9).

But these results also hinted at two possible levels of complexity in the relationship between the level of Hartwell Lake and county gross retail sales: substitution effects between nearby lakes and nonlinearity. The proximity of Lake Keowee to Hartwell Lake could cause some lake users to favor one lake over another depending on lake levels. Such behavior would likely affect the level and pattern of gross sales, especially in Anderson and Oconee counties, as levels in the two lakes vary. In addition, if the relationship between lake level and gross sales is nonlinear, then the linear regression models used would not correctly describe that relationship.

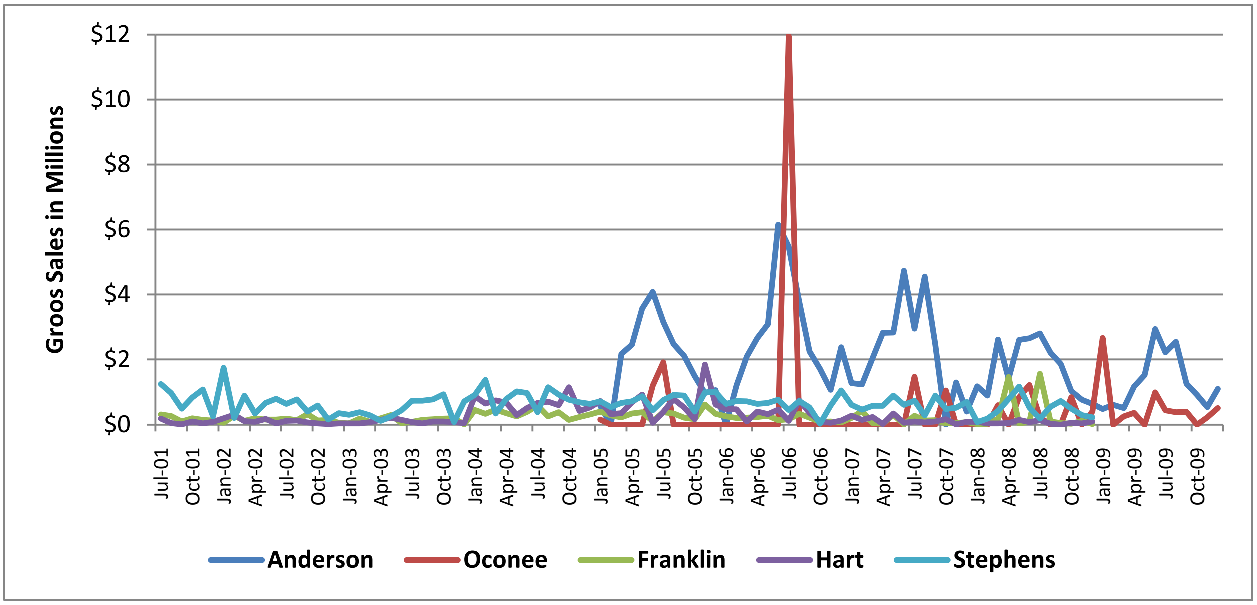

Figure 11. Gross retail sales, boat and other recreational dealers.

Table 9. Statistically Significant Gross Sales Categories by County

	Franklin (GA)	Hart (GA)	Stephens (GA)	Anderson (SC)	Oconee (SC)	Pickens (SC)
Gas Stations	X	X	X			
Autos	X		X			
Bars			X	X		
Restaurant			X			
Boating Stores		X	X	X		
General Merchandise	X		X		X	X
Misc. General Merchandise						X
Sporting Goods			X	X		
Groceries					X	

B. Substitution Effects Between Hartwell Lake and Lake Keowee

Lake Keowee borders Oconee and Pickens counties in South Carolina. It was constructed and is owned and operated by Duke Energy. Lake Keowee supplies water for use as coolant to the Keowee Toxaway nuclear power plant located in Oconee County. Because of the power plant's cooling requirements and water intake placement, Lake Keowee is not allowed to fall below a certain level, about five feet to six feet below full pool. Duke Energy uses Lake Jocassee, another Duke Energy lake located just north of Lake Keowee, to regulate Lake Keowee's level. As a result, Lake Keowee did not drop as far below full pool as Hartwell Lake during the most recent drought and it remains more stable over time than Hartwell Lake.

Both Hartwell Lake and Lake Keowee have shoreline bordering Oconee and Pickens counties. We hypothesized that Lake Keowee could provide competition for Hartwell Lake in terms of recreation use, especially when Hartwell Lake was well below full pool. Conversations with area residents, fisherman, and boaters support this hypothesis. If these two lakes substitute for each other, then spending by area residents and tourists could reveal this behavior.

We also hypothesized that Russell Lake, a USACE lake immediately south of Hartwell Lake, could also be a substitute for Hartwell Lake. Like Lake Keowee, Russell Lake has relatively stable levels when compared to those in Hartwell Lake. The nearest study counties to Russell Lake are Anderson County, South Carolina and Hart County, Georgia.

A range of models were used to test for the presence of substitution between Lakes Keowee and Hartwell in Anderson, Oconee, and Pickens counties. We also tested for substitution effects between Hartwell Lake and Russell Lake in Hart and Anderson counties. In order to gauge the impact that changing water levels in Hartwell Lake have on gross sales in the region, it is necessary to hold constant for both Lake Keowee and Russell Lake's water levels. These relationships were modeled using linear regression models that included an interaction term for Hartwell Lake and Lake Keowee, and for Hartwell Lake and Russell Lake. An example of such a model is illustrated in Appendix D.

The analysis showed that Anderson, Oconee, and Pickens counties had statistically significant substitution effects between gross sales and lake levels in Hartwell Lake and Lake Keowee in the following categories:

- Anderson County: Bars and Sporting Goods Stores
- Oconee County: General Merchandise and Groceries
- Pickens County: Miscellaneous General Merchandise

No statistically significant substitution effects were found between Hartwell Lake and Russell Lake in either Hart or Anderson counties.

C. NONLINEARITY

Although linear statistical models tested as the appropriate functional form for several of the relationships between Hartwell Lake's water level and gross sales, other relationships exhibited nonlinear characteristics. After graphing these relationships, it appeared that the inclusion of quadratic terms would model these characteristics. We used squared terms for both Hartwell and Keowee lake levels in models where nonlinear characteristics appeared. An example of a quadratic model used in this analysis is illustrated in Appendix D. This appendix also illustrates the form of a statistical model that combines interaction terms and nonlinearity.

The results from the various analyses of gross retail sales and its relation to water levels in Hartwell Lake and Lake Keowee are essential inputs to the REDYN economic impact analysis model. The model output isolates the impact on county gross sales as lake levels change. The way the models are specified using interaction terms holds one lake level constant while estimating the impact on gross sales from lake level changes in the second lake. The choice of linear or nonlinear model form assured the best possible description of the fit between each individual gross sales category and lake level.

D. GROSS RETAIL SALES: SUMMARY

The results of these different statistical models reveal that there is a statistically significant relationship between economic activity—as defined by county-level gross retail sales— and lake level— as measured as percent BFP—in the counties bordering Hartwell Lake. R-squares from these models range from a low of 0.2 to a high of over 0.4, revealing that between 20 percent and 40 percent of the variation in county gross sales related to changing lake levels can be explained by the statistical models. In the social sciences this is considered a fairly strong result.

However, we must caution that the nature of this relationship is complex and that its predictive ability is limited. Economic activity in any county is affected by a diverse set of conditions and it is difficult to control for all of these conditions within a statistical model. County-level gross sales data does not fully capture all of the economic activity related to lake activity and lake level. Thus, some aspects of the relationship between gross sales and lake level may be obscured. A major limitation to our analysis was having access to only five years of gross sales data for the South Carolina counties and eight years of data for the Georgia counties. Additional years of gross sales data from both states would have allowed us to more fully characterize the relationships between gross sales activity and lake levels in Hartwell Lake and Lake Keowee.

X. Estimated Economic Impact of Low Lake Levels

The overall economic impact of low water levels in Hartwell Lake was estimated for the surrounding six counties using input-output (I-O) analysis. Results from the linear and nonlinear regression models described earlier in this report were used as inputs into the REDYN modeling system. These inputs allowed REDYN to estimate monthly economic impacts by county resulting from changes in gross sales and income generated through real estate transactions that could be attributed to changes in Hartwell Lake's water level.[11]

The REDYN model provides an estimate of the total impact of changing lake levels on the broader economy, including direct, indirect, and induced effects. We present this information in two different ways. First, we discuss the monthly economic impact of a one-foot change in lake level on the six counties bordering Hartwell Lake. Then, we illustrate how these results can be used to estimate the regional economic impact of Hartwell Lake's unprecedented low water levels during the most recent drought.

A. Monthly Economic Impacts

The REDYN model generates estimated monthly (or annual) economic impacts as four measures: employment, output, disposable income, and net government revenue. In this analysis:

- Employment is the total number of jobs (including full and part time, in full time equivalents) gained or lost in the county over one month associated with a one-foot increase or decrease in lake level;

- Output is the change in dollar value of all goods and services produced within the county over one month associated with a one-foot increase or decrease in lake level;

- Disposable income is the change in aggregated (summed across all households) household after-tax income over one month associated with a one-foot increase or decrease in lake level, and

- Net revenue is the change in total revenue received by local (county and municipal) governments in each county, less expenses over one month associated with a one-foot increase or decrease in lake level. These revenues are from all sources, including all taxes, licensing, and fees.

No county is an island. Economic impacts from one county will naturally spill over into the surrounding counties, be they positive or negative. These cross-county effects are

[11] Estimated real estate income was quantified in terms of estimated real estate commissions and government revenue from taxes and fees.

very important in estimating the overall impact of lake level changes on the regional economy. Larger urban areas also tend to draw economic activity away from nearby smaller urban areas. Some of the positive economic activity associated with higher lake levels in the smaller Hartwell Lake counties will leak over into Anderson County as a result of that county's larger size and greater degree of urbanization. The REDYN model takes these factors into account when estimating the overall impact numbers.

Over the six county study region, the REDYN model estimated that a one-foot increase in Hartwell Lake's water level in one month would add (Table 10):

- 1.1 jobs,
- $1.0 million in the value of goods and services produced in those counties,
- $313,450 in disposable income, and
- $43,450 in net revenue to local governments.[12]

These estimates apply only when Hartwell Lake is below full pool and when the lake level is increasing towards full pool. Reversing the signs yields estimates of the monthly economic impact of a one-foot decrease in the lake level below full pool. We focused on monthly impacts because the water level in Hartwell Lake can vary widely over the year. Monthly figures also allowed us to estimate the economic impact of low lake levels during the recent drought on the Hartwell Lake counties. Because there was relatively little variation within individual counties of the economic impact of changes in lake level, we only report the median values. Detailed county economic impacts at different lake levels are provided in Appendix E.

Table 10. Median Monthly Economic Impact of a One-Foot Increase in Lake Level

County	Employment (FTEs per mo.)	Output ($ per mo.)	Disposable Inc. ($ per mo.)	Net Revenue ($ per mo.)
Franklin	+0.1	+44,750	+9,100	+1,000
Hart	+0.1	+57,800	+15,100	0
Stephens	-0.2	-85,650	-34,200	-3,350
Anderson	+1.6	+1,087,550	+379,250	+50,250
Oconee	-0.5	-220,750	-75,600	-8,000
Pickens	0.0	+11,200	+14,950	+2,150
Total	+**1.1**	**1,011,250**	+**313,450**	+**43,450**

Anderson and Oconee counties in South Carolina show the largest magnitude of economic impact due to a one foot change in lake level in all categories. These two

[12] It is important to note that the per-foot impacts in Table 9 cannot be added (or multiplied) to arrive at an estimate for a specific lake level. In other words, (20 * output) does not equal the monthly economic impact of the lake at 20 feet BFP.

counties are the largest in population of the six counties in the study region. They also have diverse economies and extensive shoreline on Hartwell Lake. The other four counties show a much smaller economic impact from a one-foot change in lake level, which is consistent with their size and/or amount of shoreline. For example, Pickens County is a populous county but its larger economic centers (Easley, Liberty, Pickens) are located far from Hartwell Lake. Pickens County has only a small amount of Hartwell Lake shoreline in private ownership.

The most notable result in these two tables is not the relative magnitude of county economic impact, but its sign. Both Stephens County, Georgia and Oconee County, South Carolina show a decrease in employment, output, income, and net government revenue when Hartwell Lake increases by one foot. In the other four counties, these same economic indicators increase when Hartwell Lake goes up. What does all this mean?

B. SUBSTITUTION EFFECTS: ACTIVITIES AND LAKES

The study team hypothesized that the negative economic impact of increasing lake level is caused by two different substitution effects in the counties. In Stephens and Oconee counties there appears to be substitution between lake recreation and other activities. In Oconee County there is also a much larger impact from substitution between Hartwell Lake and Lake Keowee.

1. Substitution Between Activities

In our analysis of the relationships between lake level and gross retail sales, we found that some business sectors in some counties were inversely affected by increases in Hartwell Lake's water level toward full pool. For example, restaurants in Stephens County, Georgia showed a decline in gross sales as the level of Hartwell Lake increased. This result suggests that some aspect of lake recreation and eating out in restaurants may be substitutes for each other, at least in economic terms. That is, when lake levels are up, area residents may visit restaurants less often in favor of spending time on the lake. Conversely, when lake levels are down and residents' visits to the lake decrease, they may choose to eat at restaurants more often. This applies to other sectors in Stephens County as well.

The study team believes that the inverse relationship between some retail sectors and lake level may hold in those Hartwell Lake counties where there is relatively little economic activity located adjacent to the lake. Most of the businesses in Stephens County are located in and around the City of Toccoa rather than near Hartwell Lake. Individuals in Stephens County enjoying recreational activities associated with the lake are far from any opportunity to spend at local business establishments. A similar effect was observed in Oconee County, where the major business centers of Seneca, Walhalla, and Westminster are all located a significant distance from Hartwell Lake (although Seneca is very close to Lake Keowee). The observed impacts were larger in Oconee County due to the county's higher population and larger size of the commercial sector relative to that in Stephens County. Appendix D provides detail on these statistical models.

2. Substitution Between Lakes

In our analysis of the relationships between lake level and gross retail sales, we also found that Lake Keowee may be a substitute for Hartwell Lake, particularly when Hartwell Lake's water level is well below full pool. An inverse economic impact from Lake Keowee was found in select business sectors in Oconee, Pickens, and Anderson counties. That is, when Hartwell Lake's water levels declined, economic activity in these sectors increased in these three counties. For example, as the water level in Hartwell Lake falls, both general merchandise and grocery sales in Oconee County increased in most months of recorded sales. The models used to provide the inputs for the REDYN model were therefore constructed to isolate the Hartwell impact on these sectors from that of Lake Keowee.

C. Economic Impact of Low Lake Levels During the Drought

The total economic impact from low water levels in Hartwell Lake was computed for each county using the monthly estimates generated by the REDYN model. We started in April 2007, which we identified as the point at which lake levels began their steady downward trend in response to the growing drought. We ended the analysis in December 2008, when Hartwell Lake reached its lowest point in many years. The drought officially ended in November 2009, even though Hartwell Lake had returned to near full pool earlier in the year as a result of heavy winter rains and USACE management practices.

The economic impact of low lake levels during the recent drought was estimated as follows. The per-foot impact on employment, output, disposable income, and net local government revenue in each lake level range (Appendix E) was multiplied in each applicable month by that month's change in lake level from the previous month. This number was then added across months to obtain the total economic impact on the counties. There were months during this 21-month period in which lake levels rose slightly; in these months, the net impact to the counties was positive, thus offsetting a portion of the cumulative negative impact.

In aggregate, the total economic impact of low lake levels associated with the recent drought on the six county Hartwell Lake region was negative (Table 11). The persistent low lake levels during this period are estimated to have resulted in an estimated $18.8 million decline in regional output over the period, a $6.2 million decline in aggregated household after-tax income, and a decrease in net local government revenues of close to $805,000. The recent drought is also estimated to have cost the region 23 jobs (in full time equivalents). Anderson and Oconee counties had the largest economic impacts in dollar terms, although they were in the opposite direction. Oconee County had an increase in economic indicators when Hartwell Lake was down, likely due in part to the hypothesized Lake Keowee substitution effect.

Table 11. Total Estimated Economic Impact of Low Lake Levels (April 2007 – Dec. 2008)

County	Employment (FTEs)	Output (2009 $)	Disposable Inc. (2009 $)	Net Revenue (2009 $)
Franklin	-2	-1,015,024	-229,631	-23,305
Hart	-2	-1,174,840	-295,908	+21,614
Stephens	+4	+1,780,665	+658,462	+66,351
Anderson	-32	-22,475,015	-7,469,207	-983,306
Oconee	+10	+4,215,073	+1,443,975	+153,785
Pickens	0	-117,997	-292,100	-40,551
Total	-23	-18,787,138	-6,184,409	-805,412

The estimated economic impacts of changing water levels in Hartwell Lake, while measurable, are small when compared to the overall regional economy. Table 12 shows the changes to county output resulting from persistent low lake levels during the recent drought as a percentage of total output for all business sectors in each county. The estimated economic impact of the recent drought on total regional output is about two-tenths of one percent in Anderson County and below one-tenth of one percent in the other five counties. Total regional output over the period was $30.2 billion. Longer sustained periods of low water levels could have larger detrimental effects on the regional economy, but could not be tested fully in this study because Hartwell Lake has never remained at a level of 15 feet or more BFP for more than two months.

Table 12. Economic Impacts in Context

County	Output Impact of Low Water Levels (2009 $)	Total County Output During 21 Month Drought ($Billions)	Output Impact as % of Total County Output
Franklin	-1,015,024	1.509	-0.07%
Hart	-1,174,840	1.678	-0.07%
Stephens	+1,780,665	1.960	+0.09%
Anderson	-22,475,015	13.811	-0.16%
Oconee	+4,215,073	5.424	+0.08%
Pickens	-117,997	5.862	+0.00%
Total	-18,787,138	30.244	-0.06%

This analysis demonstrates that Hartwell Lake is not the primary economic driver in the region. While the importance of the lake, as well as tourism in general, cannot be minimized, our analysis demonstrates that the region is not critically dependent on this one factor for its economic well-being.

X1. Conclusion

Hartwell Lake's impact on regional identity is undeniable, but what is the lake's impact on the regional economy? Two major droughts between 1998 and 2008 focused concerns on lake level management and the effect of prolonged low water levels on the regional economy. Anecdotal evidence from some project stakeholders and an earlier study suggested that low lake levels were causing a large negative impact on the economy, especially in the six counties bordering the lake. The strong statistically significant relationship between recreation use and lake level provided important early confirmation that lake level has an impact on lake-related activity. The project team, along with stakeholder input, designed a rigorous statistical approach to investigate this question.

This study was designed to estimate the amount by which changes in lake level affect economic activity in the six counties bordering Hartwell Lake. The economic impact of changing lake levels was evaluated using the number of sales of lake-access real estate and the dollar value of gross retail sales in lake-related enterprises. Results from these analyses provided input for the REDYN model, which generated monthly estimates of changes in employment, output, disposable income and net government revenue that could be attributed to changing lake levels for each county. These figures were used to estimate the regional economic impact of the low lake levels that persisted from April 2007 to December 2008.

The number of transactions occurring among parcels with lake access was the most easily identified impact of low water levels in Hartwell Lake. This study demonstrated that a statistically significant relationship exists between lake level and the average monthly sales of private property with direct access to Hartwell Lake. This study estimates that during the recent drought, the region failed to capture about 3.4 percent of the sales of lake-access real estate transactions it might have experienced had lake levels remained higher.

This study also demonstrated that a statistically significant relationship exists between the water level in Hartwell Lake and selected categories of gross retail sales. Initially, twelve categories were selected as business types potentially influenced by the proximity of Hartwell Lake. In various combinations with the six counties, nine of the twelve categories proved statistically significant. Direct and inverse relationships between lake levels and gross sales were identified, depending upon the specific business category.

This study shows that during times of drought when lake levels are substantially below full pool, area residents choose recreation substitutes. Oconee County has a nearby substitute for Hartwell Lake—Lake Keowee—which has a more stable water level than Hartwell Lake. For example, gross retail sales in selected categories in Oconee County increase slightly when Hartwell Lake remains low and decrease when the water level in Hartwell Lake increases toward full pool. In Stephens County, there are few businesses located near Hartwell Lake. Restaurant sales increase in the county when the lake is low and decrease when the water level increases.

The total economic impact of low water levels in Hartwell Lake was computed for each county using the monthly estimates generated by the REDYN model. This analysis was calculated for the most recent drought, starting in April 2007, the point at which lake levels began their steady downward trend, and ending in December 2008 when lake levels reached their lowest point.

The total economic impact of low lake levels associated with the recent drought on the six- county Hartwell Lake region was negative. Persistent low lake levels during 2007 and 2008 resulted in an estimated $18.8 million decline in regional output (the value of goods and services produced) over the period, a $6.2 million decline in aggregated household after-tax income, and a decrease in net local government revenues of $805,400. These low lake levels are also estimated to have cost the region 23 jobs (in full time equivalents).

The study shows that the low water levels of 2007 and 2008 adversely affected the economies of four of the six counties bordering Hartwell Lake. While some individual lake-related businesses may have experienced large impacts, these results also indicate that the economic impact of low lake levels is small when compared to overall regional economic activity. The estimated economic impact of the recent drought on total regional output is about two-tenths of one percent in Anderson County and below one-tenth of one percent in the other five counties. Total regional output over the period was $30.2 billion.

While water is clearly a prerequisite to lake-based economic activity, this study suggests that the economies of the counties bordering Hartwell Lake are able to weather lower lake levels for relatively short amounts of time without major negative economic impacts. The economy of Upstate South Carolina and northeast Georgia, while historically dependent on agriculture and textiles, is now relatively diverse; so no single factor is the primary driver of economic activity. The presence of Hartwell Lake draws visitors to the region, but it is not the only attraction. While tourism and lake-related recreation activity is an important contributor to economic activity, residents should consider lake recreation and tourism as one piece in their basket of economic growth and development options. Regional breadth and depth of economic activity is the objective for sustainable growth and development.

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APPENDICES

Appendix A. Visitors to Selected USACE Recreation Sites on Hartwell Lake

Months	Lake Level	Visitors
2005 * NON-DROUGHT CONDITIONS *		
January	660.46	457,027
February	660.48	487,875
March	660.73	758,998
April	661.81	1,186,299
May	661.19	1,327,259
June	660.90	1,335,791
July	661.23	1,279,886
August	660.47	1,191,189
September	659.75	886,877
October	659.17	515,262
November	657.48	482,917
December	657.88	452,422
	Avg. Lake Level	**Avg. Monthly Visitors**
	660.13	863,484
		Total Yearly Visitors
		10,361,802
2008 * DROUGHT CONDITIONS *		
January	647.49	437,734
February	648.23	491,700
March	650.22	769,524
April	651.79	1,151,953
May	651.86	1,264,575
June	650.66	1,327,878
July	648.48	1,179,523
August	646.39	1,133,583
September	645.38	859,600
October	642.70	524,709
November	639.01	471,542
December	638.99	451,833
	Avg. Lake Level	**Avg. Monthly Visitors**
	646.77	838,680
		Total Yearly Visitors
		10,064,154

APPENDIX B. Real Estate Transaction Data: Lake-access Parcels on Hartwell Lake

Months	Hartwell Lake Level (Full Pool, 660.00 feet)	Monthly Real Estate Transactions	Median Monthly Transaction Price (in 2009 Dollars)
2005 * NON-DROUGHT CONDITIONS *			
January	660.46	70	$126,236.87
February	660.48	82	$151,045.16
March	660.73	104	$126,236.87
April	661.81	108	$126,708.89
May	661.19	123	$133,920.86
June	660.90	135	$136,665.14
July	661.23	125	$134,469.71
August	660.47	192	$131,725.43
September	659.75	134	$135,567.42
October	659.17	130	$126,236.87
November	657.48	118	$143,745.38
December	657.88	108	$155,051.81
	Avg. Lake Level	**Avg. Transactions**	**Average Sale Price**
	660.13	119	$135,634.20
		Total Transactions	
		1,429	
2008 * DROUGHT CONDITIONS *			
January	647.49	47	$101,803.20
February	648.23	69	$115,151.92
March	650.22	69	$143,282.18
April	651.79	51	$122,943.39
May	651.86	78	$136,502.58
June	650.66	54	$133,694.62
July	648.48	79	$126,484.97
August	646.39	56	$131,544.37
September	645.38	40	$155,070.58
October	642.70	39	$119,250.03
November	639.01	27	$118,389.94
December	638.99	33	$136,603.77
	Avg. Lake Level	**Avg. Transactions**	**Average Sale Price**
	646.77	54	$128,393.46
		Total Transactions	
		642	

APPENDIX C. Real Estate Transactions Models for Six Counties Surrounding Hartwell Lake

Lake level is measured against full pool = 660 feet above mean sea level

Model Description

Technique: Linear regression analysis using structural breaks

Model: $y_i = \beta_0 + \beta_1(x_{i1} - z) + \beta_2 x_{i2} + \varepsilon_I$, i = 1…n

y_1 = number of transactions per month of lake-access parcels

x_{i1} = actual lake level

x_{i2} = county per capita personal income (PCPI)

β_1 = estimate of change in transactions per unit increase in lake level, PCPI held constant

β_2 = estimate of change in transactions per unit increase in county PCPI, lake level held constant

z = 660 feet above mean sea level

ε_1 = error term

Structural breaks: Also known as piecewise linear regression, structural breaks allow the model to calculate different straight-line relationships for different intervals over the range of x, which in this case is lake level.

Model Note: For the ease of interpretation, “below full pool” is abbreviated “BFP” throughout the description of results.

REAL ESTATE TRANSACTIONS MODELS

GEORGIA COUNTIES

FRANKLIN

Model: Lake level structural breaks at 3 feet and 5 feet, with an intermediate range between 3 and 5 feet

Three groups defined as follows

- Group one: lake level range: full pool (0) up to 3 feet BFP
- Group two: lake level range: greater than 3 feet BFP up to 5 feet BFP
- Group three: lake level is greater than 5 feet BFP

HART

Model One: Lake level structural break at 5 feet

Two groups defined as follows

- Group one: lake level is 5 feet or more BFP
- Group two: lake level is less than 5 feet BFP

Model Two: Lake level structural break at 2 feet

Two groups defined as follows

- Group one: lake level 2 feet or more BFP
- Group two: lake level is less than 2 feet BFP

STEPHENS

Model: Lake level structural break at 3 feet

Two groups defined as follows

- Group one: lake level is 3 feet or more BFP
- Group two: lake level is less than 3 feet BFP

SOUTH CAROLINA COUNTIES

ANDERSON

Model One: Lake level structural break at 7 feet

Two groups defined as follows

- Group one: lake level is 7 feet or more BFP
- Group two: lake level is less than 7 feet BFP

Model Two: Lake level structural break at 4 feet
Two groups defined as follows

- Group one: lake level is 4 feet or more BFP
- Group two: lake level is less than 4 feet BFP

ANDERSON

Model Three: Lake level structural breaks at 3 feet and 7 feet
Three groups defined as follows

- Group one: lake level range: full pool (0) up to **3** feet BFP
- Group two: lake level range: greater than 3 feet BFP up to 7 feet BFP
- Group three: lake level is greater than 7 feet BFP

OCONEE

Model One: Lake level structural break at 4 feet
Two groups defined as follows

- Group one: lake level is 4 feet or more BFP
- Group two: lake level is less than 4 feet BFP

Model Two: Lake level structural breaks at 4 feet and 11 feet
Three groups defined as follows

- Group one: lake level range: full pool (0) up to 4 feet BFP
- Group two: lake level range: greater than 4 feet BFP up to 11 feet BFP
- Group three: lake level is greater than 11 feet BFP

PICKENS

No data due to low volume of transactions in the established time frame

FRANKLIN COUNTY
Real Estate Transactions Model
Model: Lake level structural breaks at 3 feet and 5 feet

Model: Three groups defined as follows

- Group one: lake level range: full pool (**0**) up to **3** feet BFP
- Group two: lake level range; greater than **3** feet BFP up to **5** feet BFP
- Group three: lake level is greater than **5** feet BFP

Lake level is measured against full pool = 660 feet above mean sea level

Interpretations: When Hartwell Lake is between full pool and 3 feet BFP, there is not a significant relationship between lake level and lake-access real estate transactions. However, when Hartwell Lake is between 3 and 5 feet BFP, Franklin County loses 2.5 lake-access real estate transactions for every foot decline in lake level. When Lake Harwell is greater than 5 feet BFP, there is not a significant relationship between lake-access real estate transactions and lake level. An R-squared of .41 indicates that this model explains 41% of the variation in lake-access real estate transactions in Franklin County.

Group One: 36 observations between 0 and 3 feet BFP

R-Square	Coeff Var	Root MSE	y Mean
0.281799	62.84622	2.286904	3.638889

Parameter	Estimate	Std Error	t Value	Pr > |t|
Intercept	-17.50966342	5.95816596	-2.94	0.0060
Lake level	-0.31059811	0.48059977	-0.65	0.5226
PCPI	0.00087872	0.00025275	3.48	0.0014

Group Two: 10 observations between greater than 3 feet and less than or equal to 5 feet BFP

R-Square	Coeff Var	Root MSE	y Mean
0.503273	64.01577	1.728426	2.700000

Parameter	Estimate	Std Error	t Value	Pr > |t|
Intercept	4.110470152	6.90237571	0.60	0.5702
Lake level	2.486828806	1.06201074	2.34	0.0517
PCPI	0.000351545	0.00024471	1.44	0.1940

Group Three: 63 observations greater than 5 feet BFP

R-Square	Coeff Var	Root MSE	y Mean
0.145711	97.93401	1.430148	1.460317

Parameter	Estimate	Std Error	t Value	Pr > |t|
Intercept	1.074334754	0.90761747	1.18	0.2412
Lake level	0.052432990	0.06165649	0.85	0.3985
PCPI	0.000047510	0.00002384	1.99	0.0509

Compared to linear model: 133 observations

R-Square	Coeff Var	Root MSE	y Mean
0.213111	83.22406	2.115017	2.541353

Parameter	Estimate	Std Error	t Value	Pr > |t|
Intercept	1.898295704	0.82377418	2.30	0.0228
Lake level	0.151414910	0.04451799	3.40	0.0009
PCPI	0.000064947	0.00003159	2.06	0.0418

Model Tests

R-Square	Coeff Var	Root MSE	y Mean
0.410705	77.53193	1.778255	2.293578

Parameter	Estimate	Std Error	t Value	Pr > |t|
Intercept	1.07433475	1.12853786	0.95	0.3434
Lake level (x1)	0.05243299	0.07666410	0.68	0.4956
PCPI (x2)	0.00004751	0.00002965	1.60	0.1122
group 1	-18.58399818	4.76843137	-3.90	0.0002
group 2	3.03613540	7.19048048.	0.42	0.6738
group 3	0.00000000	.	.	.
x1* group 1	-0.36303110	0.38148833	-0.95	0.3436
x1* group 2	2.43439582	1.09531411	2.22	0.0285
x1* group 3	0.00000000	.	.	.
x2* group 1	0.00083121	0.00019876	4.18	<.0001
x2* group 2	0.00030404	0.00025351	1.20	0.2332
x2* group 3	0.00000000	.	.	.

Chow Test

Obs	dfr	ssr	dff	ssf	f	p
1	130	581.529	100	316.219	2.79668	.000069728

HART COUNTY
Real Estate Transactions Models

MODEL ONE: Lake level structural break at 5 feet

Model One: Two groups defined as follows

- Group one: lake level is **5** feet or more BFP
- Group two: lake level is less than **5** feet BFP

Lake level is measured against full pool = 660 feet above mean sea level

Interpretations: When Hartwell Lake is greater than 5 feet BFP, Hart County loses 0.32 lake-access real estate transactions for every foot decline in lake level. Between full pool and 5 feet BFP, there is not a significant relationship between lake-access real estate transactions and lake level. An r-squared of .256 indicates that this model explains approximately 26% of the variation in lake-access real estate transactions in Hart County.

Group One: 62 observations 5 feet or more BFP

R-Square	Coeff Var	Root MSE	y Mean
0.263147	82.45708	3.218486	3.903226

Parameter	Estimate	Std Error	t Value	Pr > |t|
Intercept	4.903238265	2.04900201	2.39	0.0199
Lake level	0.326306735	0.13955975	2.34	0.0228
PCPI	0.000112542	0.00005829	1.93	0.0583

Group Two: 70 observations less than 5 feet BFP

R-Square	Coeff Var	Root MSE	y Mean
0.192395	72.14560	4.163832	5.771429

Parameter	Estimate	Std Error	t Value	Pr > |t|
Intercept	37.91333077	8.08563544	4.69	<.0001
Lake level	-0.29079160	0.27298458	-1.07	0.2906
PCPI	-0.00150751	0.00037783	-3.99	0.0002

Compared to linear model: 132 observations

R-Square	Coeff Var	Root MSE	y Mean
0.110957	82.79912	4.052139	4.893939

Parameter	Estimate	Std Error	t Value	Pr > |t|
Intercept	4.026742777	1.57253040	2.56	0.0116
Lake level	0.205041514	0.08389288	2.44	0.0159
PCPI	0.000093663	0.00006610	1.42	0.1589

Model Tests

R-Square	Coeff Var	Root MSE	y Mean
0.255924	76.64480	3.750950	4.893939

Parameter	Estimate	Std Error	t Value	Pr > |t|
Intercept	37.91333077	7.28387080	5.21	<.0001
Lake level (x1)	-0.29079160	0.24591567	-1.18	0.2392
PCPI (x2)	-0.00150751	0.00034037	-4.43	<.0001
group 1	-33.01009250	7.66532823	-4.31	<.0001
group 2	0.00000000	.	.	.
x1* group 1	0.61709834	0.29483727	2.09	0.0384
x1* group 2	0.00000000	.	.	.
x2* group 1	0.00162005	0.00034708	4.67	<.0001
x2* group 2	0.00000000	.	.	.

Chow Test

Obs	dfr	ssr	dff	ssf	f	p
1	129	2118.16	126	1772.77	8.18277	.000050946

HART COUNTY
Real Estate Transactions Models

MODEL TWO: Lake level structural break at 2 feet

Model Two: Two groups defined as follows

- Group one: lake level **2** feet or more BFP
- Group two: lake level is less than **2** feet BFP

Lake level is measured against full pool = 660 feet above mean sea level

Interpretations: When Hartwell Lake is greater than 2 feet BFP, Hart County loses 0.35 lake-access real estate transactions for every foot decline in lake level. When Hartwell Lake is between full pool and 2 feet BFP, Hart County gains 0.92 lake-access real estate transactions for every foot decline in lake level. An R-squared of .207 indicates that this model explains approximately 21% of the variation in lake-access real estate transactions in Hart County.

Group Two: 49 observations less than 2 feet BFP

R-Square	Coeff Var	Root MSE	y Mean
0.151983	78.96669	4.480151	5.673469

Parameter	Estimate	Std Error	t Value	Pr > |t|
Intercept	40.43655130	12.32219291	3.28	0.0020
Lake level	-0.92362733	0.56223555	-1.64	0.1072
PCPI	-0.00161497	0.00057223	-2.82	0.0070

Compared to linear model: 132 observations

R-Square	Coeff Var	Root MSE	y Mean
0.110957	82.79912	4.052139	4.893939

Parameter	Estimate	Std Error	t Value	Pr > |t|
Intercept	4.026742777	1.57253040	2.56	0.0116
Lake level	0.205041514	0.08389288	2.44	0.0159
PCPI	0.000093663	0.00006610	1.42	0.1589

Model Tests

R-Square	Coeff Var	Root MSE	y Mean
0.207334	79.10777	3.871486	4.893939

Parameter	Estimate	Std Error	t Value	Pr > |t|
Intercept	40.43655130	10.64812366	3.80	0.0002
Lake level (x1)	-0.92362733	0.48585132	1.90	0.0596
PCPI (x2)	-0.00161497	0.00049449	-3.27	0.0014
group 1	-34.84048711	10.83541380	-3.22	0.0017
group 2	0.00000000	.	.	.
x1* group 1	1.27502376	0.50246352	2.54	0.0124
x1* group 2	0.00000000	.	.	.
x2* group 1	0.00169555	0.00049912	3.40	0.0009
x2* group 2	0.00000000	.	.	.

Chow Test

Obs	dfr	ssr	dff	ssf	f	p
1	129	2118.16	126	1888.54	5.10659	.002282488

STEPHENS COUNTY
Real Estate Transactions Model

MODEL: Lake level structural break at 3 feet

Model: Two groups defined as follows

- Group one: lake level is **3** feet or more BFP
- Group two: lake level is less than **3** feet BFP

Lake level is measured against full pool = 660 feet above mean sea level

Interpretations: When Hartwell Lake is greater than 3 feet BFP, Stephens County loses 0.30 lake-access real estate transactions for every foot decline in lake level. When Hartwell Lake is between full pool and 3 feet BFP, there is not a significant relationship between lake-access real estate transactions and lake level. An R-squared of .32 indicates that this model explains 32% of the variation in lake-access real estate transactions in Stephens County.

Group One: 73 observations 3 feet or more BFP

R-Square	Coeff Var	Root MSE	y Mean
0.306417	67.49687	2.172845	3.219178

Parameter	Estimate	Std Error	t Value	Pr > |t|
Intercept	4.869453756	1.23275099	3.95	0.0002
Lake level	0.298109269	0.08250078	3.61	0.0006
PCPI	0.000044276	0.00003415	1.30	0.1991

Group Two: 60 observations less than 3 feet BFP

R-Square	Coeff Var	Root MSE	y Mean
0.035820	60.04586	4.083119	6.800000

Parameter	Estimate	Std Error	t Value	Pr > |t|
Intercept	0.4702491443	6.69866447	0.07	0.9443
Lake level	-.3233844693	0.36653100	-0.88	0.3813
PCPI	0.0002645318	0.00028481	0.93	0.3569

Compared to linear model: 133 observations

R-Square	Coeff Var	Root MSE	y Mean
0.270816	67.24650	3.251090	4.834586

Parameter	Estimate	Std Error	t Value	Pr > |t|
Intercept	5.188003453	1.21143503	4.28	<.0001
Lake level	0.338168294	0.06656752	5.08	<.0001
PCPI	0.000059163	0.00004606	1.28	0.2013

Model Tests

R-Square	Coeff Var	Root MSE	y Mean
0.320309	65.68659	3.175675	4.834586

Parameter	Estimate	Std Error	t Value	Pr > |t|
Intercept	0.470249144	5.20993433	0.09	0.9282
Lake level (x1)	-0.323384469	0.28507212	-1.13	0.2588
PCPI (x2)	0.000264532	0.00022151	1.19	0.2346
group 1	4.399204612	5.51267108	0.80	0.4264
group 2	0.000000000	.	.	.
x1* group 1	0.621493738	0.30952381	2.01	0.0468
x1* group 2	0.000000000	.	.	.
x2* group 1	-0.000220256	0.00022707	-0.97	0.3339
x2* group 2	0.000000000	.	.	.

Chow Test

Obs	dfr	ssr	dff	ssf	f	p
1	130	1374.05	127	1280.78	3.08258	0.029809

ANDERSON COUNTY
Real Estate Transactions Models

MODEL ONE: Lake level structural break at 7 feet

Model One: Two groups defined as follows

- Group one: lake level is **7** feet or more BFP
- Group two: lake level is less than **7** feet BFP

Lake level is measured against full pool = 660 feet above mean sea level

Interpretations: When Hartwell Lake is greater than 7 feet BFP, Anderson County loses 2.15 lake-access real estate transactions for every foot decline in lake level. Between 0 and 7 feet BFP, there is not a significant relationship between lake-access real estate transactions and lake level. An R-squared of .19 indicates that this model explains 19% of the variation in lake-access real estate transactions in Anderson County.

Group One: 43 observations 7 feet or more BFP

R-Square	Coeff Var	Root MSE	y Mean
0.188294	36.19698	13.42655	37.09302

Parameter	Estimate	Std Error	t Value	Pr > |t|
Intercept	68.02999468	10.36050754	6.57	<.0001
Lake level	2.15383678	0.73469600	2.93	0.0056
PCPI	-0.00043407	0.00019434	-2.23	0.0312

Group Two: 95 observations less than 7 feet BFP

R-Square	Coeff Var	Root MSE	y Mean
0.263382	53.47909	22.50625	42.08421

Parameter	Estimate	Std Error	t Value	Pr > |t|
Intercept	-24.64278268	12.20861419	-2.02	0.0465
Lake level	-0.19057901	0.86710078	-0.22	0.8265
PCPI	0.00269535	0.00047198	5.71	<.0001

Compared to linear model: 138 observations

R-Square	Coeff Var	Root MSE	y Mean
0.054219	55.75449	22.59673	40.52899

Parameter	Estimate	Std Error	t Value	Pr > |t|
Intercept	28.57432888	7.27057160	3.93	0.0001
Lake level	0.12794149	0.44612476	0.29	0.7747
PCPI	0.00056743	0.00025471	2.23	0.0276

Model Tests

R-Square	Coeff Var	Root MSE	y Mean
0.261683	49.81797	20.19072	40.52899

Parameter	Estimate	Std Error	t Value	Pr > |t|
Intercept	-24.64278268	10.95254132	-2.25	0.0261
Lake level (x1)	-0.19057901	0.77788986	-0.24	0.8068
PCPI (x2)	0.00269535	0.00042342	6.37	<.0001
group 1	92.67277735	19.04456477	4.87	<.0001
group 2	0.00000000	.	.	.
x1* group 1	2.34441579	1.35120641	1.74	0.0851
x1* group 2	0.00000000	.	.	.
x2* group 1	-0.00312942	0.00051448	-6.08	<.0001
x2* group 2	0.00000000	.	.	.

Chow Test

Obs	dfr	ssr	dff	ssf	f	p
1	135	68932.65	132	53811.78	12.3638	.000000353

ANDERSON COUNTY
Real Estate Transactions Models

MODEL TWO: Lake level structural break at 4 feet

Model Two: Two groups defined as follows

- Group one: lake level is **4** feet or more BFP
- Group two: lake level is less than **4** feet BFP

Lake level is measured against full pool = 660 feet above mean sea level

Interpretations: When Hartwell Lake is between 0 and 4 feet BFP, Anderson County gains 3.65 lake-access real estate transactions for every foot decline in lake level. When the lake is more than 4 feet BFP, there is not a significant relationship between lake-access real estate transactions and lake level. An R-squared of .246 indicates that this model explains 25% of the variation in lake-access real estate transactions in Anderson County.

Group One: 70 observations 4 feet or more BFP

R-Square	Coeff Var	Root MSE	y Mean
0.022468	51.41092	19.12486	37.20000

Parameter	Estimate	Std Error	t Value	Pr > |t|
Intercept	46.53371945	10.73192845	4.34	<.0001
Lake level	0.87753241	0.75691958	1.16	0.2504
PCPI	-0.00007663	0.00025637	-0.30	0.7659

Group Two: 68 observations less than 4 feet BFP

R-Square	Coeff Var	Root MSE	y Mean
0.341237	49.24973	21.64815	43.95588

Parameter	Estimate	Std Error	t Value	Pr > |t|
Intercept	-36.75875322	14.31577152	-2.57	0.0125
Lake level	-3.65302721	1.54789788	-2.36	0.0213
PCPI	0.00316324	0.00055954	5.65	<.0001

Compared to linear model: 138 observations

R-Square	Coeff Var	Root MSE	y Mean
0.054219	55.75449	22.59673	40.52899

Parameter	Estimate	Std Error	t Value	Pr > |t|
Intercept	28.57432888	7.27057160	3.93	0.0001
Lake level	0.12794149	0.44612476	0.29	0.7747
PCPI	0.00056743	0.00025471	2.23	0.0276

Model Tests

R-Square	Coeff Var	Root MSE	y Mean
0.245823	50.35019	20.40642	40.52899

Parameter	Estimate	Std Error	t Value	Pr > |t|
Intercept	-36.75875322	13.49462211	-2.72	0.0073
Lake level (x1)	-3.65302721	1.45911081	-2.50	0.0135
PCPI (x2)	0.00316324	0.00052744	6.00	<.0001
group 1	83.29247267	17.69836134	4.71	<.0001
group 2	0.00000000	.	.	.
x1* group 1	4.53055962	1.66771946	2.72	0.0075
x1* group 2	0.00000000	.	.	.
x2* group 1	-0.00323988	0.00059416	-5.45	<.0001
x2* group 2	0.00000000	.	.	.

Chow Test

Obs	dfr	ssr	dff	ssf	f	p
1	135	68932.65	132	54967.71	12.3638	.000001384

ANDERSON COUNTY
Real Estate Transactions Models

MODEL THREE: Lake level structural breaks at 3 feet and 7 feet

Model Three: Three groups defined as follows

- Group one: lake level range: full pool (**0**) up to **3** feet BFP
- Group two: lake level range: greater than **3** feet BFP up to **7** feet BFP
- Group three: lake level is greater than **7** feet BFP

Lake level is measured against full pool = 660 feet above mean sea level

Interpretations: When Hartwell Lake is between full pool and 3 feet BFP, Anderson County gains 8 lake-access real estate transactions for every foot decline in lake level. Between greater than 3 and 7 feet

BFP, there is not a significant relationship between lake-access real estate transactions and lake level. However, when Hartwell Lake is greater than 7 feet BFP, Anderson County loses 2.15 lake-access real estate transactions for every foot decline in lake level. An R-squared of .33 indicates that this model explains 33% of the variation in lake-access real estate transactions in Anderson County.

Group One: 37 observations between 0 and 3 feet BFP

R-Square	Coeff Var	Root MSE	y Mean
0.457314	37.98473	18.32506	48.24324

Parameter	Estimate	Std Error	t Value	Pr > |t|
Intercept	-50.47510215	18.77618774	-2.69	0.0110
Lake level	-8.04174181	3.79182770	-2.12	0.0413
PCPI	0.00349176	0.00066313	5.27	<.0001

Group Two: 34 observations between greater than 3 feet and less than or equal to 7 feet BFP

R-Square	Coeff Var	Root MSE	y Mean
0.190154	65.61084	24.44969	37.26471

Parameter	Estimate	Std Error	t Value	Pr > |t|
Intercept	14.63969969	26.78052849	0.55	0.5885
Lake level	3.34260698	4.08844710	0.82	0.4198
PCPI	0.00168710	0.00065711	2.57	0.0153

Group Three: 43 observations greater than 7 feet BFP

R-Square	Coeff Var	Root MSE	y Mean
0.188294	36.19698	13.42655	37.09302

Parameter	Estimate	Std Error	t Value	Pr > |t|
Intercept	68.02999468	10.36050754	6.57	<.0001
Lake level	2.15383678	0.73469600	2.93	0.0056
PCPI	-0.00043407	0.00019434	-2.23	0.0312

Compared to linear model: 138 observations

R-Square	Coeff Var	Root MSE	y Mean
0.054219	55.75449	22.59673	40.52899

Parameter	Estimate	Std Error	t Value	Pr > |t|
Intercept	28.57432888	7.27057160	3.93	0.0001
Lake level	0.12794149	0.44612476	0.29	0.7747
PCPI	0.00056743	0.00025471	2.23	0.0276

Model Tests

R-Square	Coeff Var	Root MSE	y Mean
0.334896	46.15024	18.81230	40.76316

Parameter	Estimate	Std Error	t Value	Pr > |t|
Intercept	68.0299947	14.51638027	4.69	<.0001
Lake level (x1)	2.1538368	1.02940194	2.09	0.0388
PCPI (x2)	-0.0004341	0.00027229	-1.59	0.1139
group 1	-118.5050968	24.13020786	-4.91	<.0001
group 2	-53.3902950	25.20557075.	-2.12	0.0365
group 3	0.0000000	.	.	.
x1* group 1	-10.1955786	4.02645774	-2.53	0.0128
x1* group 2	1.1887702	3.30991477	0.36	0.7202
x1* group 3	0.0000000	.	.	.
x2* group 1	0.0039258	0.00073320	5.35	<.0001
x2* group 2	0.0021212	0.00057426	3.69	0.0004
x2* group 3	0.0000000	.	.	.

Chow Test

Obs	dfr	ssr	dff	ssf	f	p
1	135	68932.65	105	37159.76	2.99262	.000019693

OCONEE COUNTY
Real Estate Transactions Models

MODEL ONE: Lake level structural break at 4 feet

Model One: Two groups defined as follows
- Group one: lake level is **4** feet or more BFP
- Group two: lake level is less than **4** feet BFP

Lake level is measured against full pool = 660 feet above mean sea level

Interpretations: When Hartwell Lake is greater than 4 feet BFP, Oconee County loses 0.80 lake-access real estate transactions for every foot decline in lake level. Between full pool and 4 feet BFP, there is not a significant relationship between lake-access real estate transactions and lake level. An R-squared of .497 indicates that this model explains 50% of the variation in lake-access real estate transactions in Oconee County.

Group One: 70 observations 4 feet or more BFP

R-Square	Coeff Var	Root MSE	y Mean
0.492989	38.72641	5.908543	15.25714

Parameter	Estimate	Std Error	t Value	Pr > |t|
Intercept	16.07902803	3.26445160	4.93	<.0001
Lake level	0.79650723	0.23201631	3.4	0.0010
PCPI	0.00030967	0.00007526	4.11	0.0001

Group Two: 68 observations less than 4 feet BFP

R-Square	Coeff Var	Root MSE	y Mean
0.277072	40.91011	11.11792	27.17647

Parameter	Estimate	Std Error	t Value	Pr > |t|
Intercept	-6.192676728	6.85879456	-0.90	0.3699
Lake level	-0.629063412	0.79426605	-0.79	0.4312
PCPI	0.001277112	0.00025597	4.99	<.0001

Compared to linear model: 138 observations

R-Square	Coeff Var	Root MSE	y Mean
0.405994	45.08633	9.526938	21.13043

Parameter	Estimate	Std Error	t Value	Pr > |t|
Intercept	14.10181706	3.01860094	4.67	<.0001
Lake level	0.87232173	0.18811013	4.64	<.0001

PCPI	0.00049023	0.00010132	4.84	<.0001

Model Tests

R-Square	Coeff Var	Root MSE	y Mean
0.497104	41.95354	8.864965	21.13043

Parameter	Estimate	Std Error	t Value	Pr > |t|
Intercept	-6.19267673	5.46891448	-1.13	0.2595
Lake level (x1)	-0.62906341	0.63331436	-0.99	0.3224
PCPI (x2)	0.00127711	0.00020410	6.26	<.0001
group 1	22.27170476	0.00020410	3.03	0.0029
group 2	0.00000000	.	.	.
x1* group 1	1.42557065	0.72268035	1.97	0.0506
x1* group 2	0.00000000	.	.	.
x2* group 1	-0.00096745	0.00023325	-4.15	<.0001
x2* group 2	0.00000000	.	.	.

Chow Test

Obs	dfr	ssr	dff	ssf	f	p
1	135	12252.94	132	10373.56	7.97148	.000063366

OCONEE COUNTY
Real Estate Transactions Models

MODEL TWO: Lake level structural breaks at 4 feet and 11 feet

Model Two: Three groups defined as follows

- Group one: lake level range: full pool (**0**) up to **4** feet BFP
- Group two: lake level range: greater than **4** feet BFP up to **11** feet BFP
- Group three: lake level is greater than **11** feet BFP

Lake level is measured against full pool = 660 feet above mean sea level

Interpretations: When Hartwell Lake is between full pool and 4 feet BFP, there is not a significant relationship between lake level and lake-access real estate transactions. However, when Hartwell Lake is between 4 feet BFP and 11 feet BFP, Oconee County loses 2.04 lake-access real estate transactions for every foot decline in lake level. When Hartwell Lake is greater than 11 feet BFP, there is not a significant relationship between lake level and lake-access real estate transactions. An R-squared of .60 indicates that this model explains 60% of the variation in lake-access real estate transactions in Oconee County.

Group One: 44 observations between 0 and 4 feet BFP

R-Square	Coeff Var	Root MSE	y Mean
0.359491	35.86733	9.920579	27.65909

Parameter	Estimate	Std Error	t Value	Pr > |t|
Intercept	0.0981636007	7.70738493	0.01	0.9899
Lake level	0.3272029837	1.43288142	0.23	0.8205
PCPI	0.0011007335	0.00024838	4.43	<.0001

Group Two: 51 observations between greater than 4 feet and less than or equal to 11 feet BFP

R-Square	Coeff Var	Root MSE	y Mean
0.453752	33.81582	5.834887	17.25490

Parameter	Estimate	Std Error	t Value	Pr > |t|
Intercept	23.80795243	4.52525787	5.26	<.0001
Lake level	2.04089405	0.45708433	4.47	<.0001
PCPI	0.00033760	0.00010142	3.33	0.0017

Group Three: 19 observations greater than 11 feet BFP

R-Square	Coeff Var	Root MSE	y Mean
0.592060	47.64748	4.714593	9.894737

Parameter	Estimate	Std Error	t Value	Pr > |t|
Intercept	10.37466407	6.42389540	1.62	0.1259
Lake level	0.32402760	0.41993371	0.77	0.4516
PCPI	0.00034698	0.00009017	3.85	0.0014

Compared to linear model: 138 observations

R-Square	Coeff Var	Root MSE	y Mean
0.405994	45.08633	9.526938	21.13043

Parameter	Estimate	Std Error	t Value	Pr > |t|
Intercept	14.10181706	3.01860094	4.67	<.0001
Lake level	0.87232173	0.18811013	4.64	<.0001
PCPI	0.00049023	0.00010132	4.84	<.0001

Model Tests

R-Square	Coeff Var	Root MSE	y Mean
0.600168	37.79215	7.575006	20.04386

Parameter	Estimate	Std Error	t Value	Pr > |t|
Intercept	10.37466407	10.32136694	1.01	0.3171
Lake level (x1)	0.32402760	0.67471365	0.48	0.6321
PCPI (x2)	0.00034698	0.00014487	2.40	0.0184
group 1	-10.27650047	11.88128297	-0.86	0.3890
group 2	13.43328835	11.87619514.	1.13	0.2606
group 3	0.00000000	.	.	.
x1* group 1	0.00317538	1.28541390	0.00	0.9980
x1* group 2	1.71686645	0.89853266	1.91	0.0588
x1* group 3	0.00000000	.	.	.
x2* group 1	0.00075375	0.00023865	3.16	0.0021
x2* group 2	-0.00000938	0.00019577	-0.05	0.9619
x2* group 3	0.00000000	.	.	.

Chow Test

Obs	dfr	ssr	dff	ssf	f	p
1	135	12252.94	105	6024.97	3.61792	.000000580

LEXINGTON COUNTY-CONTROL VARIABLE
Real Estate Transactions Model

MODEL:

For Lake Murray (full pool 358 feet) in Lexington County, SC there were no lake level breaks that proved significant. Thus, a linear model was used and revealed a significant lake level effect on lake-access real estate transactions.

Interpretations: When Lake Murray's level declines by one foot, Lexington County loses 0.89 lake-access real estate transactions. An R-squared of 0.468 indicates that this model explains almost 50% of the variation in lake-access real estate transactions in Lexington County.

Summary of Fit

RSquare	0.477566
RSquare Adj	0.467614
Root Mean Square Error	17.00228
Mean of Response	57.92593
Observations (or Sum Wgts)	108

Parameter Estimates

Parameter	Estimate	Std Error	t Value	Pr > |t|
Intercept	-457.6679	151.1627	-3.03	0.0031
PCPI	0.006553	0.000674	9.72	<.0001
Lake level	0.8949662	0.418977	2.14	0.0350

APPENDIX D. Interaction Model: Gross Sales from Drinking Establishments in Anderson County

The following interaction model illustrates one of the techniques utilized to assess the relationship between Lake Keowee and Hartwell Lake. The dependent variable modeled is gross sales from drinking establishments (bars) in Anderson County. The inclusion of an interaction term highlights the economic importance of both lakes in the region. The interaction term illustrates that the marginal impact of gross sales due to Hartwell Lake water level changes is also impacted by Lake Keowee level and vice versa. Thus, as one lake level changes, the other lake level continues to influence the gross bar sales in Anderson County.

Model: $y_i = \beta_0 + \beta_1 x_1 x_2 + \varepsilon_I$, i = 1…n

y_1 = dependent variable (gross retail sales)
x_1 = Hartwell Lake water level (measured as percent of full pool)
x_2 = Lake Keowee water level (measured as percent of full pool)

β_1 = estimate of change in dependent variable per unit change in lake levelsε_1 = error term

Analysis of Variance

R-Square	F Ratio	Prob > F
0.22	15.6554	0.0002*

Parameter Estimates

Term	Estimate	t-Ratio	Prob>[t]
Intercept	-5187261	-3.71	0.0005*
Hartwell % * Keowee %	560.33164	3.96	0.0002*

NONLINEAR QUADRATIC MODEL: GROSS SALES OF BOATING STORES IN ANDERSON COUNTY

The following model illustrates one of the techniques utilized to assess potential nonlinear characteristics between lake level and gross sales. The dependent variable modeled is gross boating store retail sales in Anderson County. The inclusion of a quadratic term (Hartwell Lake water level squared) highlights the significance of nonlinear behavior between lake level and gross sales. These characteristics are illustrated below in a graph relating lake level to gross sales of boating stores in Anderson County. The nature of this graph highlights the nonlinear nature of this relationship. Where these terms are significant, the marginal impact of gross sales due to Hartwell Lake water level changes is further impacted by these nonlinear characteristics.

Model: $y = \beta_0 + \beta_1 x_1 + \beta_2 x_1^2 + \beta_3 x_3$

y = dependent variable (gross retail sales)
x_1 = Hartwell Lake water level (measured as percent of full pool)
x_1^2 = Hartwell Lake water level squared (measured as percent of full pool)
x_3 = County per capita income

β_1 = estimate of change in dependent variable per unit change in Hartwell Lake water levels
β_2 = estimate of change in dependent variable per unit change in Hartwell Lake water level squared
β_1 = estimate of change in dependent variable per unit change in County per capita income.
ε_1 = error term

Analysis of Variance

R-Square	F Ratio	Prob > F
0.305406	4.2503	0.0132*

Parameter Estimates

Term	Estimate	t-Ratio	Prob>[t]
Intercept	-9.958e+9	-2.60	0.0145*
Hartwell %	199298114	2.58	0.0152*
Hartwell $\%^2$	-997777.4	-2.56	0.0158*
Anderson PC Income	305.30026	0.95	0.0158*

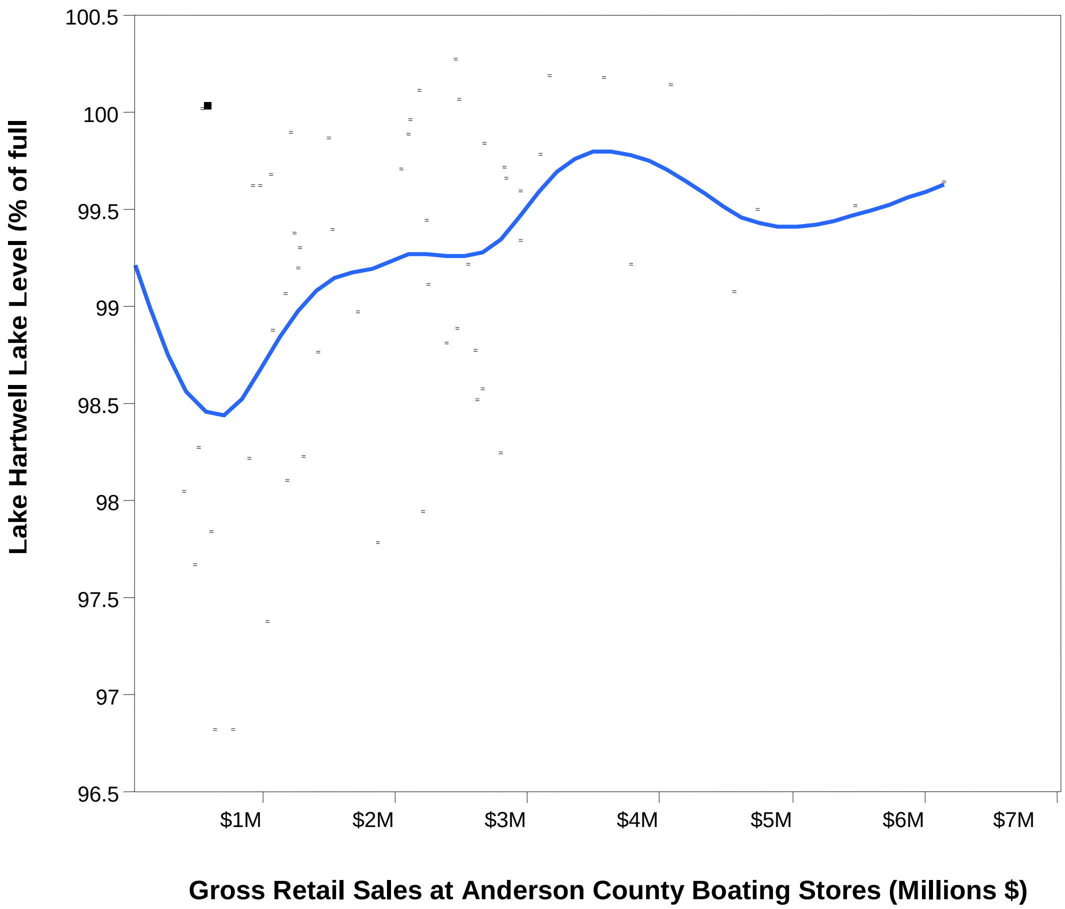

Figure D.1. Anderson Boating Store Retail Sales and Lake Level

FULL MODEL: GROSS SALES OF GENERAL MERCHANDISE IN OCONEE COUNTY

The following model illustrates one of the techniques utilized to assess the significance of both interaction between area lakes and nonlinear characteristics between lake level and gross sales. The dependent variable modeled is gross sales of general merchandise in Oconee County. This model includes quadratic terms for both Hartwell Lake and Lake Keowee, an interaction term for Hartwell Lake and Lake Keowee, and a quadratic interaction term. This model highlights the complex nature of the relationship between lake level and gross sales. In several gross sales categories, there are individually significant relationships between Hartwell Lake and Lake Keowee and gross sales, significant interaction between Hartwell Lake, Lake Keowee and gross sales, significant quadratic terms for both lakes, and a significant quadratic interaction between both lakes and gross sales. The statistical significance of these different terms illustrates the complex nature of the relationship between lake level and gross sales economic activity. Even though economic activity in any county is impacted by a diverse set of conditions, these modeling techniques provide solid evidence that there is a relationship between gross sales and lake level changes, even if it one that is more complex than originally hypothesized.

Model: $y = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \beta_3 x_1^2 + \beta_4 x_2^2 + \beta_5 x_1 x_2 + \beta_6 x_1^2 x_2^2$

y = dependent variable (gross retail sales)
x_1 = Hartwell Lake water level (measured as percent of full pool)
x_2 = Lake Keowee water level (measured as percent of full pool)
x_1^2 = Hartwell Lake water level sqaured (measured as percent of full pool)
x_2^2 = Lake Keowee water level sqaured (measured as percent of full pool)
$x_1 x_2$ = Hartwell Lake water level (measured as percent of full pool) * Lake Keowee water level (measured as percent of full pool)
$x_1^2 x_2^2$ = Hartwell Lake water level squared (measured as percent of full pool) * Lake Keowee water level squared (measured as percent of full pool)

β_1 = estimate of change in dependent variable per unit change in Hartwell Lake water levels
β_2 = estimate of change in dependent variable per unit change in Lake Keowee water levels
β_3 = estimate of change in dependent variable per unit change in Hartwell Lake water level squared
β_4 = estimate of change in dependent variable per unit change in Lake Keowee water level squared
estimate of change in dependent variable per unit change in Hartwell Lake water levels
β_5 = estimate of change in dependent variable per unit change in Hartwell Lake/Lake Keowee lake levels
β_6= estimate of change in dependent variable per unit change in Hartwell Lake/Lake Keowee lake levels sqaured
ε_1 = error term

Analysis of Variance

R-Square	F Ratio	Prob > F
0.244175	2.8537	0. 0.0175*

Parameter Estimates

Term	Estimate	t-Ratio	Prob>[t]
Intercept	3.037e+11	2.09	0.0417*
Hartwell %	-4.112e+9	-2.09	0.0411*
Keowee %	-4.097e+9	-2.09	0.0412*
Keowee%^{2}	10586514	2.12	0.0417*
Hartwell %* Keowee %	41158922	2.09	0.0417*
Hartwell%^{2}* Keowee%^{2}	-1068.226	-2.11	0.0397*
Hartwell%^{2}	10658612	2.12	0.0387*

APPENDIX E. Monthly Economic Impact of a One-Foot Increase in Hartwell Lake Level

Table E-1. Monthly Impact at 0-3 Feet BFP

County	Employment Monthly/Annual	Output ($)	Disposable Income ($)	Net Revenue ($)
Franklin	+0.1 / +0.7	+37,600	+6,900	+700
Hart	0.0 / +0.5	+27,200	+14,800	+400
Stephens	-0.2 / -2.3	-101,500	-34,400	+3,500
Anderson	+1.5 / +18.5	+1,071,300	+377,100	+48,800
Oconee	-0.5 / -5.7	-232,500	-75,900	-8,500
Pickens	0.0 / +0.1	+2,100	+13,400	+1,700
Total @ 0-3 ft BFP	+0.9 / +11.8	+804,200	+301,900	+47,600

Table E-2. Monthly Impact at 3-4 Feet BFP

County	Employment Monthly/Annual	Output ($)	Disposable Income ($)	Net Revenue ($)
Franklin	+0.3 / +4.0	+207,300	+37,800	+3,000
Hart	+0.1 / +1.0	+52,400	+18,500	+700
Stephens	-0.2 / -2.0	-92,000	-39,800	-5,000
Anderson	+1.6 / +19.0	+1,081,800	+490,100	+49,400
Oconee	-0.5 / -6.0	-222,600	-104,400	-8,200
Pickens	0.0 / +0.1	+4,600	+1,800	+1,900
Total @ 3-4 ft BFP	+1.3 / +16.1	+1,031,500	+404,000	+41,800

Table E-3. Monthly Impact at 4-5 Feet BFP

County	Employment Monthly/Annual	Output ($)	Disposable Income ($)	Net Revenue ($)
Franklin	+0.3 / +3.7	+208,100	+38,300	+3,100
Hart	+0.1 / +0.8	+53,600	+18,800	-700
Stephens	-0.2 / -2.2	-75,700	-37,000	-3,000
Anderson	+1.6 / +18.8	+1,090,200	+492,400	+51,100
Oconee	-0.5 / -5.9	-230,400	-100,000	-7,700
Pickens	0.0 / +0.3	+17,900	+5,500	+2,300
Total @ 4-5 ft BFP	+1.3 / +15.5	+1,063,700	+418,000	+45,100

Table E-4. Monthly Impact at 5-7 Feet BFP

County	Employment Monthly/Annual	Output ($)	Disposable Income ($)	Net Revenue ($)
Franklin	+0.1 / +1.0	+44,200	+9,000	+1,000
Hart	+0.1 / +1.0	+62,000	+15,100	-1,500
Stephens	-0.2 / -2.0	-79,300	-33,800	-3,400
Anderson	+1.6 / +19.0	+1,084,900	+380,000	+49,400
Oconee	-0.5 / -6.0	-207,600	-75,300	-7,900
Pickens	0.0 / +0.3	+16,400	+17,400	+2,200
Total @ 5-7 ft BFP	+1.1 / +13.3	+920,600.0	+312,400.0	+39,800.0

Table E-5. Monthly Impact at 7-11 Feet BFP

County	Employment Monthly/Annual	Output ($)	Disposable Income ($)	Net Revenue ($)
Franklin	+0.1 / +1.0	+45,100	+9,200	+1,000
Hart	+0.1 / +1.0	+64,000	+15,100	+1,400
Stephens	-0.2 / -2.0	-77,300	-33,700	-3,300
Anderson	+1.7 / +20.0	+1,198,700	+378,500	+52,300
Oconee	-0.5 / -6.0	-199,700	-75,200	-7,600
Pickens	0.0 / +0.3	+19,300	+19,900	+2,500
Total @ 7-11ft BFP	+1.2 / +14.3	+1,050,100	+313,800	+46,300

Table E-6. Monthly Impact at 11+ Feet BFP

County	Employment Monthly/Annual	Output ($)	Disposable Income ($)	Net Revenue ($)
Franklin	+0.1 / +1.0	+44,400	+8,800	+1,000
Hart	+0.1 / +1.0	+62,800	+15,100	-1,500
Stephens	-0.2 / -2.0	-93,600	-34,000	-3,600
Anderson	+1.7 / +20.0	+1,190,300	+378,300	+51,900
Oconee	-0.5 / -6.0	-218,900	-71,600	-8,100
Pickens	0.0 / +0.1	+6,000	+16,500	+2,100
Total @ 11+ ft BFP	+1.2 / +14.1	+991,000.0	+313,100.0	+41,800.0