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Dockin' USA—A Spatial Hedonic Valuation of Waterfront Property

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Abstract

A spatial hedonic model was constructed to price over 1,000 waterfront properties on a lake in South Carolina. We confirmed a hierarchy of pricing premiums relative to quality of a property's view, but we also found the ability to build and use a dock resulted in a statistically significant price premium of almost 45%, compared to undockable properties. Results suggest that permanent changes in waterfront levels due to an extended drought or change in lake management policies that affects a property owner's ability to build and use a dock could have a significant negative impact on property value.

Lake Keowee is a pristine, blue lake formed in 1971 by Duke Power as part of the Keowee-Toxaway Complex to provide cooling waters for the Oconee Nuclear Station. The complex includes a nuclear station that generates enough electricity to power 1.9 million homes (Connor, 2012) plus three hydroelectric stations: Keowee, Jocassee, and Bad Creek. Created from the damming of two rivers, Lake Keowee is over 23 miles long and about 3 miles at its widest point. The natural beauty of the lake is complemented by abundant recreational amenities including swimming, fishing, and boating.

Crescent Land and Timber (now Crescent Resources) was formed as an unregulated subsidiary of Duke Power to manage surplus lands acquired in the construction of dams and lakes for hydroelectric power generation (Mildenberg, 2004).[1] Crescent's initial focus was on leasing farmland and harvesting commercial forestry (Boyd, 1999; Mildenberg, 2004), thus, it was not heavily involved in real estate development in its early days. However, the company changed directions in 1988 with a mandate to start development from the corporate stockpile of 270,000 acres of raw land, including several thousand acres of undeveloped property on Lake Keowee.[2] As Crescent owned approximately 95% of the land surrounding Lake Keowee,[2] real estate development had been fairly sparse and basically limited to the remaining 5% of the area.[3]

Crescent created an in-house market study in the early 1990s and mapped every section available on Lake Keowee, comparing potential yields if a section was developed internally or if it was sold to an outside developer (Hamrick, 2010, pers. comm., May 10). Essentially, Crescent's strategy on Lake Keowee was to create two real estate divisions: a commercial one responsible for making bulk land sales to developers and a retail division focused on developing their own residential communities to sell lots from, the eponymous Crescent Communities. From the market study, the retail division cherry-picked some of the best sites to create their own amenitized communities. All Crescent

Communities were developed with strict standards and covenants to protect property values (Carolinalivingrealty.com, 2008). In total, over 100 residential communities have been developed on Lake Keowee with an estimated 8,700 buildable lots located on 300 miles of shoreline. Over 2,000 lakefront homes have been built in the last twenty years, many of them high-end residential homes (Williams, 2008).

The development of high-end residential real estate was facilitated by a Nuclear Regulatory Commission decree in 1995 stating that the water level of Lake Keowee should operate at a minimum level of 794.6 feet above mean sea level (AMSL) in order to satisfy the cooling water requirements for the Oconee Nuclear Station. As "full pond" for Lake Keowee is measured at an elevation of 800 feet, this meant that Lake Keowee would be required to stay within 5.4 feet of full pond during standard operations. In comparison, water levels in the neighboring lakes—Lake Jocassee and Lake Hartwell—are not regulated and have fallen by over 20 feet below full pond during periods of drought. Lake Jocassee lies upstream and its water level is drawn down in order to maintain Lake Keowee's water level. This lake has limited development. On the other hand, Lake Hartwell is downstream from Lake Keowee and has a significant amount of development on it and property owners have experienced three major droughts since 2000, often resulting in having docks that were unusable.

This is the first known academic study to examine whether the usability of waterfront property, as distinct from its view, affects the value of waterfront properties. We use bathymetric data to model whether any given Keowee lakefront property has sufficient water level depth in order to construct a dock. Properties with insufficient water level depth to be navigable are termed undockable and hypothesized to have a lower price premium compared to dockable properties. This study is important as changing water levels owing to drought or lake management policies could change the number of dockable properties and subsequent price premiums associated with those dockable lots.

We begin by reviewing the extensive literature on the pricing of lakefront properties. Next, we explain the methodology and design of our spatial hedonic model constructed to test the above hypothesis. Finally, we will present the data, interpret the results, and provide a summary of the implications of these findings.

Literature Review

The path and depth of future climate change is uncertain, but some researchers suggest that the climate is changing at unprecedented speed compared to historic patterns. One consequence is a recent series of severe droughts that has created record low lake levels ranging from the southern lakes (Lakes Travis, Powell, Hartwell, Thurmond, etc.) to northern lakes such as Lake St. Clair and the Great Lakes. The specter of future droughts has led to analysts referring to water as the "oil of the 21st century" (Tulley, 2000).

Water is not only in demand as an explicit resource, but an extensive body of research indicates that an aesthetic view of water provides a price premium for properties. An early study of pond views found a premium of between 4% and 12% for single-family homes in Massachusetts (Plattner and Campbell, 1978). Benson, Hansen, Schwartz, and Smersh (1998) and Benson, Hansen, and Schwartz (2000) examined different types of

views. In the first study, the authors found higher premiums for lake and ocean views; the premium ranged from 10% (for a partial ocean view) to 147% for direct ocean frontage. In the second study, the researchers compared eight different view types and found the highest premium, 126%, was paid for direct lake frontage views. Similarly, Bond, Seiler, and Seiler (2002) found a significant price premium of 90% for waterfront properties with a view of Lake Erie. Finally, Bourassa, Hoesli, and Sun (2004) found that a wide water view increased values by 59%, although the increase in value fell sharply with distance from the coast.

A few researchers have tried to isolate the value of the view even further by focusing their analysis on vacant lots to alleviate the statistical noise often associated with potential omitted variables, such as the construction quality of a house. Rinehart and Pompe (1999) found that lot values increase by almost 60% for a golf course view, 113% for a creek or marsh view, and 147% for an ocean view on Seabrook Island, SC. Similarly, Wyman, Hutchison, and Tiwari (2014) found a hierarchy of view premiums for three different types of waterfront properties, with the best waterfront properties commanding the highest premiums: 223% for point lots, 178% for the deep water, and 117% for the cove lots when compared to the value of interior lots.

Another group of researchers has focused their efforts on studying the impact of water quality/clarity on property values and results indicate that, as with water views, the water quality can also impact the value of waterfront property (Poor, Boyle, Taylor, and Bouchard, 2001). In an early study, David (1968) examined the correlation between lakeshore property value and the water quality of various artificial lakes in Wisconsin. These researchers found a direct relationship with prices increasing in line with the higher water quality. As with the value of a view, researchers have primarily used hedonic models to measure the impact of water quality on property prices and all of the studies have shown that water quality does have a statistically significant impact on the value of residential properties. For example, studies on water quality have been conducted in Michigan (Brashares, 1985; Adelaja et al., 2007; Kevern, 2008), Maine (Bouchard, Boyle, Lawson, and Michael, 1998; Michael, Boyle, and Bouchard, 2000; Boyle and Bouchard, 2003), Mississippi (Boyer, Krysel, Parson, and Welle, 2003; Kryse, Boyer, Parson, and Welle, 2003), New Hampshire (Gibbs, Halstead, Boyle, and Huang, 2002; Huang, Boyle, Halstead, and Gibbs, 2002), and along the Chesapeake Bay (Leggett and Bockstael, 2000).

Research on Lake Delavan in Wisconsin provides a before and after case study that documents the positive impact that a lake rehabilitation (the opposite impact of a reduction in water level) can have on property value. Kashian, Eiswerth, and Skidmore (2006) found that a $7 million rehabilitation project resulted in an appreciation rate of 273% compared to only a 148% increase in lake property located on nearby non-rehabilitated lakes. In addition, these authors estimate that a one-foot increase in the water clarity adds $5,207 to the value of a Delevan lakefront property.

There is some limited evidence that lake levels do affect property values. Lansford and Jones (1995a, 1995b) completed two hedonic models: one for property located in close proximity to Lake Austin and the other for property in close proximity to Lake Travis, respectively. Lake Austin is considered to be a "constant level lake and the water level seldom varies more than a foot except for planned, temporary draw-downs" (Lansford

and Jones, 1995a, p. 216). In contrast, Lake Travis is a flood control lake and water levels can vary substantially. In their study period, the mean lake level was 667 feet above sea level and the standard deviation was seven feet. However, over the two-year time period (1988-1990) analyzed, there was a change of 22 feet. In the first study of Lake Austin, the lake level deviation variable did not have an impact on property prices, but in the second study of Lake Travis, buyers were willing to pay a statistically significant higher price for property when the lake levels were higher.

Finally, a few researchers have attempted to measure the impact of changing water levels (in most cases caused by severe droughts) on economic value. In most of these studies, researchers focused on the economic impact to the community in terms of tourism, recreational spending, real estate transactions and related brokerage commissions, and gross retail sales in the general economy.[4] Recent examinations of the economic impact of reduced water levels include studies of Lake Lanier (Bleakly Advisory Group, 2010), Lake Travis (RCLCO Company, 2011), Lake Conroe (Rogers, Moore, Saginor, and Brody, 2012), Lake Hartwell (Allen et al., 2010), and Lake Keowee (Carey, Dickes, Saltzman, and Allen, 2011). For example, researchers analyzing the impact of drought conditions on Lake Lanier estimate an economic loss of $87 million in 2007-2008 due to low water levels. They contend that continued droughts could lead to a potential property value loss of $1.8 billion for property adjacent to Lake Lanier. These researchers calculate that this could result in lower property tax revenues of $6.1 million (Bleakly Advisory Group, 2010). Carey, Dickes, Saltzman, and Allen (2011) focused on Lake Keowee—the same lake as this study—and found that a one-foot decline in water level is correlated with a 12% decline in monthly real estate transactions in Oconee County. This earlier study did not examine of the impact of water levels on property values that is the focus of this study.

The only known research to examine the potential impact on property values if the lower water levels are sustained is a survey of Lake Conroe residents where respondents indicate that they would expect a 28% decline in property values if water levels were reduced to 6.3 from 10.9 feet below full pond (Rogers, Moore, Saginor, and Brody, 2012). Further, Lake Conroe residents estimate that they are over three times more likely to put their house on the market if the water levels drop.

Methodology and Data

We employ a semi-log spatial hedonic model to observe the revealed preferences for specific property attributes of vacant lakefront properties. The dependent variable, *LnPRICE*, is the natural log of the sales prices of an individual vacant lakefront property in Oconee County, South Carolina. The formal semi-log model is as follows:

$$LnPi = f(V_i, S_i, A_i, Y_i, U_i, \varepsilon_i), \tag{1}$$

where:

LnP_i = A scalar of natural log of lot prices observed at a particular location i;
V_i = A vector of variables describing the view of a property at a particular location i;

S_i = A vector of variables describing the spatial characteristics of a property at a particular location i;

A_i = A vector of variables describing the accessibility of a property at a particular location i;

Y_i = A vector of variables describing the year of sale of a property at a particular location i;

U_i = A vector of variables describing the dockability of a property at a particular location i; and

ε_i = A random error term that is normally distributed.

Geographic information system (GIS) analysis is used to create a hedonic model based on 1,024 vacant waterfront lots sold between 2002 and 2012. To minimize the impact of externalities as far as possible, only vacant waterfront property sales located in Oconee County are considered. We follow prior convention (Wyman and Sperry, 2010; Dickes, Carey, Saltzman, and Allen, 2011) and utilize GIS analysis to classify waterfront lots into three categories: *COVE*, *OPENWATER*, and *POINT*. A *COVE* lot has a view corridor of less than 300 feet across the lake, whereas an *OPENWATER* lot has a view corridor of 300 feet or greater. A *POINT* lot is differentiated from an *OPENWATER* lot by its location on the point creating an open water view with a wide angle of over 45 degrees. The mean sales price of a *POINT* lot on Lake Keowee is over $500,000, a substantive price premium over *OPENWATER* lots ($301,839) and *COVE* lots ($219,815), as detailed in the summary descriptive statistics found in Exhibit 1.

A number of other spatial variables are also measured. The length of shoreline (*FRONTAGEFT*) for each lot is measured as a continuous variable using the ruler tool in GIS. We hypothesize that buyers will pay a premium for increased shoreline. Due to the steep topography surrounding Lake Keowee, the mean slope (*AVESLOPE*) of each property is measured using the slope tool in GIS. It is hypothesized that a steeper slope property would have a negative coefficient in our model due to the increased construction costs and reduced dock accessibility (Wyman and Sperry, 2010). As Lake Keowee was constructed to generate power, a dummy variable (*POWER200*) has been created to measure the negative externality if any property is located within 200 feet of a high voltage overhead transmission lines.[5] The network analyst tool in ArcGIS is employed to measure the over-road distance from each lot to the closest market cities: Pickens, Seneca or Walhalla (*CLOSESTDIST*). Given the rural location, proximity to one of the cities is expected to result in a positive pricing premium. Exhibit 2 details the location of each of the 1,024 lots in Oconee County and their distance to the closest market city.

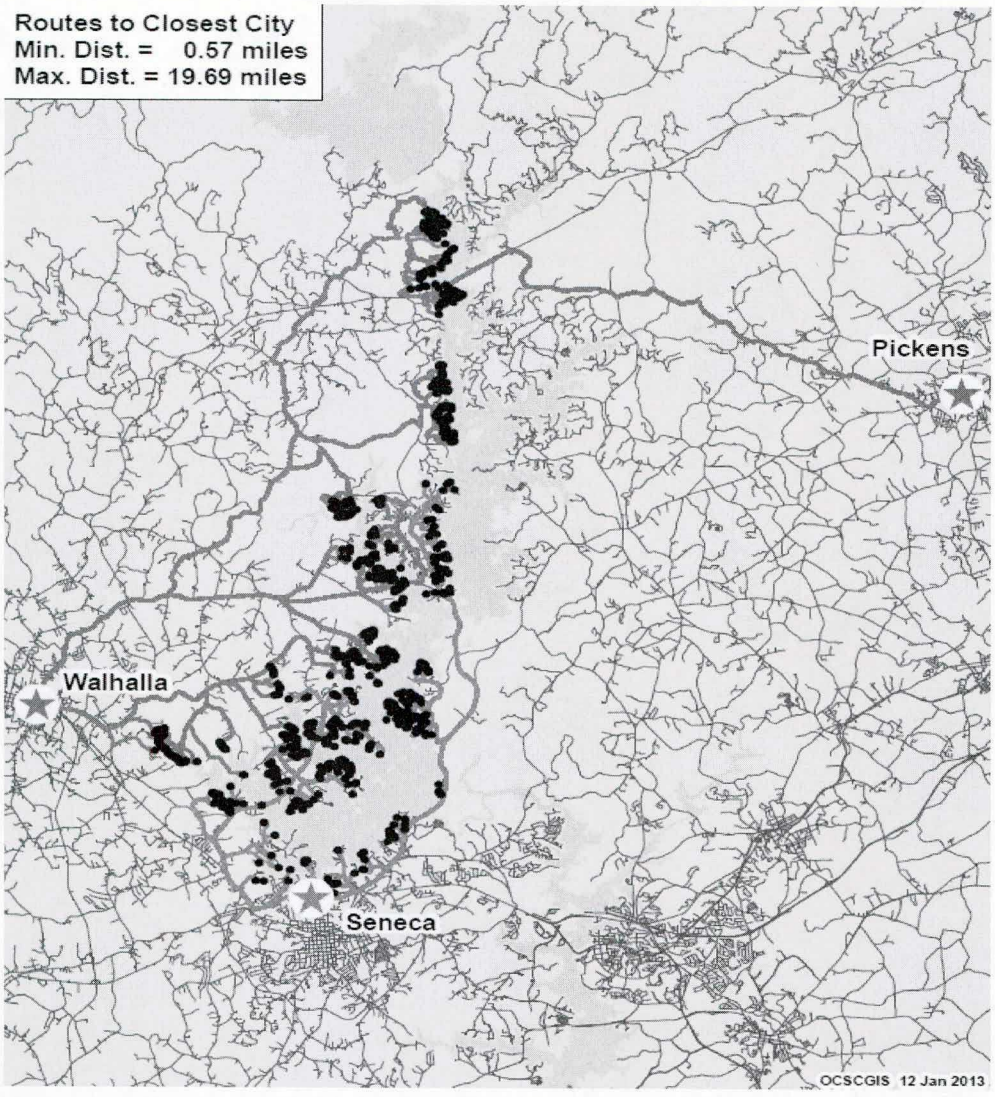
The sales price (*SOLDPRICE*), days on market (*DAYSONMARK*), year sold (time trend dummy variables YR02 to YR12), and name of community/subdivision for each lakefront property was acquired by examining MLS data for sales in Oconee County. A dummy variable is used to segment lakefront properties for three communities on Lake Keowee: The Cliffs at Keowee Falls, Crescent Communities, and Keowee Key. The Cliffs at Keowee Falls is a member of the Cliffs Communities, an exclusive group of seven premium golf course communities in two states. Crescent Communities refers to the high-end residential communities developed by the retail division of Crescent Resources, while Keowee Key is the oldest gated community on Lake Keowee. Started in 1973, it is hypothesized that this community would incur a negative pricing coefficient as Keowee

Exhibit 1. Descriptive Statistics for Lot Sales on Lake Keowee (2002–2012)

Variable	Description	Mean	Std. Dev.	*N*
SOLDPRICE	Sales price taken from MLS records for most recent sale	275,612	173,791	1,024
COVE	Dummy view variable, view < 300 feet	$219,815	$139,479	453
OPENWATER	Dummy view variable, view > 300 feet	$301,839	$165,796	523
POINT	Dummy view variable, view > 300 feet and wide angle lot	$516,427	$261,000	48
FRONTAGEFT	Calculated waterfront frontage in feet	182.125	112.485	1,024
AVESLOPE	Average slope (%)	25.171	7.711	1,024
POWER200	Dummy, if property is within 200 feet of transmission line	0.030	0.157	1,024
ACRES_DEED	Acreage per recorded deed or plat	0.976	0.60	1,024
CLIFFS	Dummy, if located in Cliffs Community	0.060	0.237	1,024
CRESCENT	Dummy, if located in upscale Crescent Community	0.450	0.498	1,024
KEOWEEKEY	Dummy, if located in Keowee Key Community	0.050	0.214	1,024
DAYSONMARK	Days on Market per MLS	271.750	363.969	1,024
CLOSESTDIS	Over-road distance to the closest city	9.313	3.275	1,024
UNDOCKABLE	Undockable at 795 AMSL	0.143	0.350	1,024
Y02	Time trend dummy	$197,307	$108,354	31
Y03	Time trend dummy	$177,758	$95,162	113
Y04	Time trend dummy	$189,487	$80,353	196
Y05	Time trend dummy	$280,321	$150,263	221
Y06	Time trend dummy	$430,682	$226,244	130
Y07	Time trend dummy	$411,733	$171,616	80
Y08	Time trend dummy	$440,023	$185,666	34
Y09	Time trend dummy	$363,661	$181,486	25
Y10	Time trend dummy	$217,473	$99,743	51
Y11	Time trend dummy	$208,964	$112,117	64
Y12	Time trend dummy	$246,689	$167,290	79

Note: The sources are GIS, SPSS, and authors' calculations.

Exhibit 2. Network Analysis of Road Distance to the Closest City for each Lakefront Lot

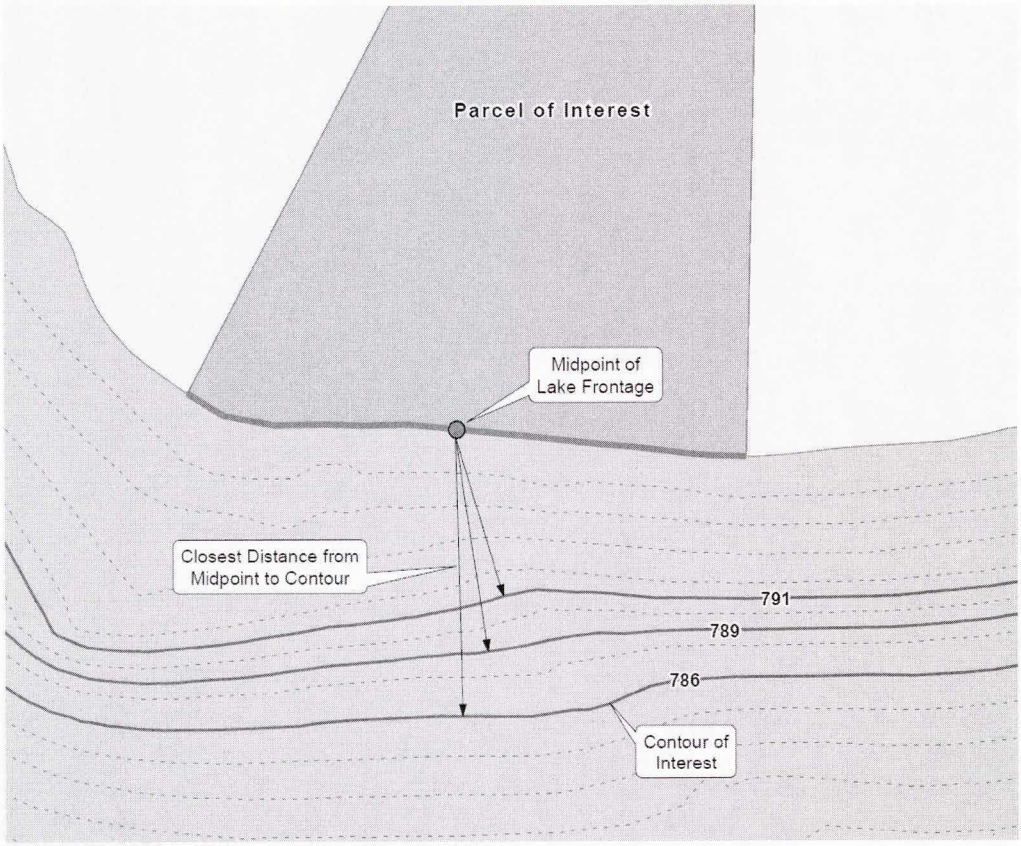


The sources are GIS and authors' calculations.

Key has facilities within this community that are dated when compared to the communities that were more recently developed.

Finally, this is the first known academic study to employ bathymetric data to model the dockability of any given waterfront property. Given the present minimum operating water level of Lake Keowee of 794.6 feet AMSL, we hypothesize that properties where a standard dock is not permissible or usable at the 795 feet contour would sell at a discount to dockable properties. According to local dock builders, most lake boats require a minimum three-foot clearance for ingress and egress from the dock, so construction of a

Exhibit 3. Measurement of the *UNDOCKABLE* Variable for Each Lot



The sources are GIS, SPSS, and authors' calculations.

navigable dock requires a maximum bathymetric contour of 792 feet AMSL. Given the longest permissible dock constructed on Lake Keowee is typically 88 feet, a property must reach the 792 contour within 88 feet or there is insufficient water depth for a dock and the property is termed *UNDOCKABLE*.[6] GIS-based analysis was used to calculate the midpoint of each lakeshore property, and then the researchers measured the distance from this midpoint to the 792 feet AMSL contour. The methodology used to construct the *UNDOCKABLE* variable is illustrated in Exhibit 3.

We hypothesize that *UNDOCKABLE* vacant waterfront lots will sell at a discount to dockable lots as the utility of the dock, if one is permitted, is severely impaired if it is not navigable. This negative impact is compounded by a reduction in the quality of the view aesthetics as the water recedes and the property owner's view devolves into an unpleasant terrain of red clay. Additionally, even a five foot drop in the water level below full pond diminishes the overall quality of recreational utility for lake consumers as tree stumps, rock piles, and other hazards make navigation hazardous (Brutzman, 2012). Close to 15% (14.2%) of all lakefront properties were found to be *UNDOCKABLE* using the 792 bathymetric (meaning that they were not navigable at the 795 contour).

Alternative bathymetric contours measured the case where drought conditions required authorities to lower the water level of Lake Keowee. As expected, the number of *UNDOCKABLE* properties increases with lower water levels.

Spatial Hedonic Model Results

Overall, the spatial hedonic model has an R^2 of 0.643. Ten independent variables were tested in the model, with nine of them proving to be of statistical significance at the 1% confidence level with the exception of the size of the lot (*ACRES DEED*). The percentage price premium for the coefficient, *B*, for dependent variables was measured using the formula $100^*(e^{b-1})$ per Halvorsen and Palmquist (1980). The model developed for this study supports results found in other studies that identify a hierarchy of pricing premiums according to the quality of the water view. We find a price premium of 35% for *OPENWATER* views and almost 60% for *POINT* lots compared to *COVE* lots. The significance of the other spatial variables was as expected. Proximity to high voltage overhead transmission lines was associated with a price diminution of 28%, while proximity to local market cities created a small, positive price premium. A marginal increase in shoreline created a positive price premium and a marginal increase in the slope gradient of 1% produced a 1% decrease in lot prices.

The three communities represented by dummy variables exhibited widely different pricing coefficients. The oldest golf community, Keowee Key, suffered a 71% pricing diminution, while Crescent Communities had a 23% pricing premium, and the renowned Cliffs Communities enjoyed a pricing premium of over 60%, reflecting the high quality of this community's amenities including a Jack Nicklaus signature designed golf course.

The annual dummy variables representing year of sale were statistically significant from 2005 to 2010, but property sales outside of this time frame were not statistically significant, perhaps reflecting the paucity of sales during these periods. Mirroring the recent national property boom and bust cycle, prices of lots more than doubled by 2006, but slumped after that year (Wyman, Hutchison, and Tiwari, 2014).

Returning to the question of interest, the variable *UNDOCKABLE* is associated with a marginal pricing diminution of 45% with all other variables held constant. This statistically significant discount for undockable waterfront properties at 795 feet AMSL indicates that ability to permit, build and/or use a dock is an essential element in pricing of lakefront property. The results imply that permanent changes in water level can adversely impact the value of waterfront property. A methodology for attempting to address the number of properties affected by a change in water level is offered in the next section. The regression results of this model are in Exhibit 4.

The 45% premium for a dockable lot may seem excessive, but a hypothetical example details how the pricing premium diminishes once a home is constructed, all other factors remaining constant. For example, a typical lakefront home sells for over $1 million on Lake Keowee, if we hold the price of the housing structure constant at $800,000, the calculated price premium for a dockable waterfront home is less than 9%, compared to an undockable waterfront home. This is detailed in Exhibit 5.

Exhibit 4. Regression Results for Lake Keowee Lot Sales

	Unstand. Coeff.			Stand. Coeff.		
	B	Std. Error	% Impact	Beta	*T*-test	Significance
Constant	11.735	0.096				
View Variables						
OPENWATER	0.298	0.026	34.71	0.235	11.574	0.000
POINT	0.469	0.069	59.84	0.156	6.774	0.000
Spatial Variables						
FRONTAGEFT	0.001	0.000	0.10	0.182	7.593	0.000
AVESLOPE	−0.011	0.002	−1.11	−0.131	−6.239	0.000
POWER200	−0.249	0.078	−28.27	−0.062	−3.212	0.001
ACRES_DEED	0.005	0.023		0.005	0.220	0.826
CLIFFS	0.483	0.068	62.09	0.180	7.096	0.000
CRESCENT	0.210	0.027	23.37	0.165	7.759	0.000
KEOWEEKEY	−0.537	0.064	71.09	−0.181	−8.437	0.000
DAYSONMARK	0.000	0.000	0	−0.085	−4.282	0.000
CLOSESTDIS	0.019	0.005	1.92	0.098	4.064	0.000
UNDOCKABLE795	−0.369	0.035	−44.63	−0.203	−10.501	0.000
Time Trend						
Y03	−0.094	0.077		−0.047	−1.223	0.222
Y04	0.084	0.074		0.052	1.144	0.253
Y05	0.435	0.073	54.50	0.282	5.930	0.000
Y06	0.863	0.077	137.02	0.453	11.227	0.000
Y07	0.834	0.081	130.25	0.353	10.322	0.000
Y08	0.769	0.095	115.76	0.217	8.125	0.000
Y09	0.639	0.102	89.46	0.155	6.243	0.000
Y10	0.198	0.087	21.90	0.068	2.273	0.023
Y11	0.043	0.083		0.016	0.516	0.606
Y12	0.093	0.081		0.039	1.146	0.252

Notes: The sources are GIS, SPSS, and authors' calculations. The adjusted R^2 is .643; the F-stat is 84.72.

Exhibit 5. Breakdown of Price Premium for Dockable Lots

	Dockable	Undockable	Price Premium
Lot	$275,612	$190,603	44.6%
House[a]	$800,000	$800,000	0%
Total	$1,075,612	$990,603	8.58%

Notes: The sources are GIS, SPSS, and authors' calculations.
[a]Assume a 4,000 square foot house at $200 per square foot.

Robustness of Results

As a robustness check, we examined the raw data to ensure that all of the undockable lots were not simply *COVE* lots and therefore driving the results by including primarily inferior lots in the sample. Summary data in Exhibit 6 show that the lot sales are split almost evenly between the inferior *COVE* lots and the *OPENWATER* and *POINT* lots that are undockable.[7,8]

Exhibit 6. Breakdown of Undockable Lots in the Sample by Type of Lot

	Frequency	Percent	Valid Percent	Cum. Percent
COVE	76	52.1	52.1	52.1
OPEN WATER	66	45.2	45.2	97.3
POINT	4	2.7	2.7	100.0
Total	146	100.0	100.0	

Note: The sources are GIS, SPSS, and authors' calculations.

Number of Lakefront Properties Affected at 790 Feet AMSL

The original 50-year license for the Keowee-Toxaway project granted to Duke Energy by the Federal Energy Regulatory Commission (FERC) expires in 2016, prompting Duke Energy to draft an Agreement in Principal (AIP) as part of its a new license application in September 2012. The first draft of the AIP proposes modifying the minimum operating level of 794.6 ft. AMSL for Lake Keowee as drought conditions increase in severity (Duke Energy, 2012; Jester, 2012). For example, Duke proposes to lower the water level of Lake Keowee in stages (stage 1 to 794 ft. AMSL; stage 2 to 793 ft. AMSL; and stage 3 to 792 ft. AMSL). According to the AIP, stage 4 would lower the water level elevation to 790 feet AMSL, or 10 feet below full pond in order to ensure continuous production of electricity in periods of severe drought (Allen, 2012). Duke Energy utilizes hydrology records of the past 70 years to predict that the water level would be reduced below 795 AMSL only 4% of the time (equivalent to roughly 15 days a year) assuming that history repeats itself.

Using the regression results for the variable *UNDOCKABLE* in Model 1, results suggest that the pricing of waterfront property would be adversely affected if there was any sustained reduction in water levels, such as those suggested by Duke Energy. Particularly, since they would likely create a large number of undockable properties. The bathymetric model suggests that 42% of all lakefront properties would have restricted dock use if the water level was reduced to 790 feet AMSL. Although the number seems large, this statistic is considered reasonable given that Duke Energy using their own proprietary models have suggested that up to 46% of all properties would be adversely affected at a water level of 790 feet AMSL (Turetzky, 2013, pers. comm.).[9]

Unfortunately, Duke's drought records indicate an increasing incidence of drought in the period after 1995, perhaps reflecting the phenomena of climate change. Lake Keowee has been affected by a Stage 1 drought almost 50% of the time since January 1995, compared with roughly 30% of the time in the preceding 25 years. The increasing incidence of droughts affecting Lake Keowee is detailed in Exhibit 7.

Although Lake Keowee is stabilized by the buffering effect of Lake Jocassee's upstream water supply, downstream from Lake Keowee, the experience of Lake Hartwell is sobering as it indicates how recent droughts have been much more severe than what has happened in the past (Mitchell, 2012). At full pond, Lake Hartwell is 660 feet AMSL. In the 37 years from 1962 to 1999, there were only five years where drought conditions

Exhibit 7. Drought Records of Lake Keowee (1971–2011)

	April 17, 1971 to January 1995 (8,660 days)		January 1995 to 2011 (6,209 days)	
	Days	Percent	Days	Percent
Stage 1 or Greater	2,655	30.65	3,009	48.5
Stage 2 or Greater	1,550	17.89	2,067	33.3
Stage 3 or Greater	337	3.89	330	5.3

Note: The source is Duke Energy (2012).

reduced the average annual water level of Lake Hartwell five feet below full pond. In contrast, the evidence since 2000 shows that droughts can be frequent (three droughts since 2000), intense (the water level fell to its lowest lake level of 637.49 ft. AMSL on December 9, 2008, over 22 feet below full pond),[10] and enduring (the drought that started in August 2007 lasted for 21 months). This increasing frequency, intensity and duration of droughts on Lake Hartwell may be congruent with evidence of climate change seen on a global perspective.

Given the apparent recent increase in droughts in this locality, caution should be exercised in projecting future weather patterns from historical records. If any reduction in water level was limited and transitory, then waterfront property values may be unaffected by the proposed reduction in guidelines for minimum water level elevation (Allen, 2012; Chandler, 2012). However, the Bleakly Advisory Group (2010) observes that a frequent pattern of low water levels may produce an adverse impact on long-term waterfront property values.

Summary and Implications of this Research

In summary, this study has broad implications for waterfront property owners, local tax authorities, and public or private managers of lakefront water levels. First, it suggests that lakefront property values are directly related to the water level of the lake. Our model of vacant waterfront lots on Lake Keowee indicates that undockable properties suffer a 45% diminution in value. Ceteris paribus, a permanent reduction in the lake water level for any reason would increase the number of undockable properties and thereby adversely impact local property values and tax assessments.

Secondly, the empirical data is supported by anecdotal discussions with local real estate brokers who forecast that a reduction in water level on Lake Keowee could have a severe impact on property values. For example, Lake Keowee realtor Justin Winter (pers. comm., March 18, 2013) states that "very easily property values could diminish by 50% if the dock is sitting on clay and could not be positioned so that the property owner could have easy ingress and egress." Similarly, the aforementioned survey of Lake Conroe residents projects a 28% decline in property values if lake levels drop by 4.6 feet to 10.9 feet below full pond (Rogers, Moore, Saginor, and Brody, 2012).

Given the recent experience of climate change, the pricing and management of scarce water resources is a fertile area for additional research. Future studies could investigate the impact of varying rates of recurrence, intensity and duration of droughts on alternative property sub-markets. Additionally, the impact of droughts on local retailers, recreational users or tax authorities is an important issue for further economic research.

Endnotes

[1] As an unregulated subsidiary, Crescent Land and Timber was closely held and did not have to pay dividends back to ratepayers (Mildenberg, 2004). Crescent had a total of five real estate divisions, but they will be collectively referred to as Crescent in this study.

[2] Duke Power had accumulated the land stockpile from the usage of the right of eminent domain. Duke provided Crescent with $50 million in cash and debt access. In an interview with Art Fields in April 2009, he said that Crescent returned a total of $2 billion in land sales to Duke Power over the next 20 years.

[3] Much of the following information is attributable to an interview with John Hamrick on May 10, 2010.

[4] Additional studies have tried to capture the impact of droughts on water for irrigation purposes and therefore the value of impacted agricultural land and activity (Terrel and Johnson, 1999; Wittwer and Griffith, 2011).

[5] There is a large precedent in the high-voltage transmission line literature for 200 feet (61 meters) as a proximity indictor where values are negatively impacted. See Wyman and Worzala (2013) for a full review of the literature.

[6] All docks require permitting permission from Duke Energy; it has been rare for a property owner to receive permission to build a dock longer than 88 feet.

[7] To ascertain if our results had any relation to the "real world," this study has been presented to numerous real estate professionals, as well as residents within the Lake Keowee market. Presentations have been made to local lake residents, government officials for Oconee County, officials at Duke Power, the spring meetings of American Real Estate Society (2013), Daniel Kolhepp, who was with Duke Power/Crescent Resources at the time the lake was being developed, local real estate agents, and members of the Real Estate Counselors of America.

[8] In addition, we interviewed a local real estate expert, John Barrett, who has been working on Lake Keowee for many years. He is currently working in one of the communities on the lake (The Reserve) and gave us some recent lots sales that were adjacent to each other, where one lot was dockable and the other lot was not. Although these lots are not part of our sample, as they are not in Oconee County, they do provide evidence of the premium for a dockable lot on Lake Keowee. (1) C-21, originally sold for $800,000 in 2004. Barrett estimates that it would likely sell for $650,000 to $700,000 in this market. The lot directly next to C-21, C-36, sold in late 2003 for $550,000. At the time of closing, it had a full dock permit from Duke. The owners were repeatedly told to not let the permit lapse. It has lapsed and ten years later Duke will not allow a dock. He estimates that the lot might be worth $150,000 in today's market (it is extremely steep). (2) M-3. The development office let the dock permit lapse. If they are not able to rectify the problem, the lot might sell for $125,000, if at all. Two neighboring lots were sold for $443,700 (M-2) and $517,500 (M-4) earlier this year. (3) D-17 was not approved for a dock. It has been difficult to market and is currently listed for $175,000. Neighboring lots that are dockable sold for $287,500 (D-18) and $245,000 (D-16), premiums of 39% and 29%, respectively.

[9] Ben Turetzky is the Executive Director of FOLKS, Friends of Lake Keowee Society, whose mission is to preserve and protect Lake Keowee. He was interviewed on several occasions in 2013.

[10] Data taken from U.S. Army Corps of Engineers. Retrieved from, http://water.sas.usace.army.mil/hist.htm.

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