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The Pricing of Lake Lots

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Abstract

This article reveals aspects of lakefront property pricing especially with respect to lot frontage and depth. A clearer understanding of how these lot dimensions affect price should be of interest to those engaged in lake development, land use control, valuation, and marketing. A data set with eighty observations of vacant Lake Michigan residential properties sales is used. The unique geography of northwest Michigan provides an opportunity to tackle empirical issues associated with zoning when zoning is correlated with lot attributes, such as lot topography.

Key Words: lakefront property values, frontage and depth, recreational land values, hedonic pricing

The frontage of lake lots is the principal focus of attention for regulators, practitioners, and market participants in the market for lake lots. The key zoning policy variable for lake lots is the minimum frontage. This constraint is used, however imperfectly, to control the intensity of lake and beach use as well as to provide sufficient separation between wells and septic systems (Spalatro and Provencher, 2001).[1] This constraint is also a device that can be used to exclude the less-than-wealthy. Practitioners who estimate the value of lake lots for the purposes of transactions and assessment almost always focus on frontage as the most important attribute (Boyle and Taylor, 2001). Owners of lake lots covet frontage, because it guarantees a breadth of lake view, especially if owners choose to locate their home or cottage back from the lake farther than the minimum setback defined by zoning or covenant (Benson et al., 1998).

One of the most durable valuation rules-of-thumb is that lake lots are priced by frontage alone. It is nearly always implied that this pricing relationship is linear and proportional. See, for example, Hearn (1999). This may or may not be substantially true. It cannot be precisely true. If it were, then developers of lake lots would just sell one very wide lot. This is because there would be no value increment associated with subdivision under linear prices, yet there are incremental costs associated with subdivision. Most frequently we observe lake lots with wide frontage being subdivided and relatively narrow frontage being sold. As a result, we might expect the true pricing relationship to be at least slightly concave, making it possible for the value increment associated with subdivision to cover the cost associated with subdivision; that is, making concave prices an equilibrium condition. On the other hand, there are examples of lake lot assembly in which two or three small, old cottages are demolished to make way for a large new home. The existence of this sort of behavior suggests that prices are convex with respect to frontage. That is, there must be value increment from assembly to offset the costs of assembly if convexity is an equilibrium condition. While we suspect that subdivision is by far more frequent than assembly so that concave prices should be observed with respect to frontage, we admit that this is an open question.[2]

Beyond frontage, the observer of these markets is left wondering what the role of lot depth might be, since depth is seldom ever mentioned by practitioners (i.e., brokers, appraisers and assessors) in this context and zoning controls are seldom binding in this dimension. Of course, there are zoning controls in the depth dimension in the form of minimum setbacks from the road and the lake, but these are like side setbacks that pale in comparison to minimum frontage. Is depth just irrelevant? Alternatively, does depth play a complex role that eludes the casual observer? It would seem that more would be preferred to less, holding other factors constant, but along with depth comes longer driveways and utility extensions. So the net effect of greater land area in the depth dimension and the greater expected costs of building and maintenance are not obvious.

There are variables other than lot dimensions that play critical roles in the pricing of lake lots. For example, the quality of the beach could vary from rocky or swampy to sugar sand. Access to shopping and other entertainments is critical. The topography can vary from low and flat to extreme bluff. Zoning can profoundly restrict the ability to build, especially when the topography is profoundly variable. The market environment can change dramatically from year to year as market participants may attempt to move their assets into the second home market and out of the stock market, and vice versa.

The purpose of this article is to reveal more information about residential recreation lot pricing. Specifically, we examine lake lots in northwest Michigan to discover the role of frontage and depth in the pricing of recreational lots. In doing this, we also look at beach quality, location, topography with special zoning issues, and time. In the next section we review the literature. Following that, we describe our data set which is relatively small but well suited to our purpose. The basic methodology is hedonic analysis with close attention to modeling the frontage and depth effects. This basic methodology is examined next followed by the results using the methodology. These results prove more definitive for frontage than for depth. Alternative depth specifications are developed and tested in the next section. Finally, we offer some conclusions. Principal among the conclusions is that the folk wisdom is incorrect regarding frontage but might be largely correct regarding depth.

1. Literature review

In general, we know quite a bit about lot dimensions and land value. Depth rules developed in the latter part of the nineteenth century and early in the twentieth century recognized the nature of diminishing returns to parcel size as well as the necessity of not measuring size just in terms of area. Holding frontage constant it was thought that value increased at a decreasing rate as depth increased. The famous 4-3-2-1 depth rule, in which the first quarter of a standard lot is worth 40% of the value and the next quarter is worth 30%, etc., is an example of this nonlinear pricing. The depth rule literature has been reviewed by Colwell and Scheu (1994). While early advocates of depth rules believed that doubling frontage would double value, today there is a substantial literature that at least suggests that value increases at a decreasing rate with increasing frontage or depth.[3] Generally, the consensus seems to be that the value elasticity of frontage is closer to unity than the value elasticity of depth.[4] The implications of lot value being a Cobb-Douglas function of frontage and depth for optimal development are developed by Colwell and Scheu (1989) and Cannaday and Colwell (1990). See also Colwell and Turnbull (2003).

The pricing of lake property has been examined in several studies. Some of these efforts have focused on price effects related to proximity to water. Others have examined the effects of various lake attributes, such as water quality, on property values. Finally, some studies have considered how a water view affects property values. In our review of this literature we concentrate on the manner in which frontage and depth are modeled.

Knetsch's 1964 paper is the first study of lake property values to appear in the economic literature. He examines the effect of proximity to Tennessee Valley Authority reservoirs on land values. While lot dimensions are addressed, they are not included in his model as a determinant of land values.[5] Other papers examining lake property values but which do not control for lot dimensions include David (1968) and Wilman (1981). David examines properties contained in 40-acre tracts which are adjacent to manmade lakes in Wisconsin to determine how various lake and tract attributes affect property values, while Wilman examines the effects of pollution on vacation home rents in Cape Cod. Finally, Plattner and Campbell (1978) examine water views and property values in western Massachusetts, but include only sales from two condominium developments in their sample, and hence lot dimensions are not examined.

A number of studies of lake property values use lot area as the sole measure of lot dimension. Darling (1973) uses lot area as an explanatory variable in a linear regression model to explain the values of properties near three California water parks. Brown and Pollakowski (1977) similarly control for lot area with a linear functional form to study of the effects of open space and proximity to water on the prices of property adjacent to three lakes in Seattle, WA, one of which is surrounded by a greenbelt.[6] Of course, for a generally rectangular lot, lot area is the product of frontage and depth, and the iso-area curve (in two-dimensional frontage and depth space) is a rectangular hyperbola. If the form of the value function is linear, and area is the only lot size variable, all possible combinations of frontage and depth which have the same area will result in equal values of land. That is, an iso-area curve is an iso-value curve.

Epp and Al-Ani (1979) control for lot area in a log-linear model in their examination of properties values near clean and polluted small waterways in Pennsylvania. They find a lot area elasticity of between 0.30 and 0.35. Using a Box-Cox (functional form) transformation, Cassel and Mendelsohn (1985) control for lot area in their examination of the effect of water view type on housing values in Seattle, WA. The transformation parameters on the dependant and independent variables (0.8 and 2.1, respectively) suggests that there exists increasing marginal value with respect to lot area. The finding of increasing marginal valuation is not a usual result. If, however, all the transformations of the explanatory variables are constrained to be equal, odd results may ensue.[7] Finally, Benson et al. (1998) utilize a dummy variable indicating whether properties have one acre or more of land in their study of view type and quality affecting Bellingham, WA property values.

An additional number of papers on lake property values control for both lot area and lot frontage simultaneously. Conner et al. (1973) use a linear regression model to examine the effect of being on a lake and/or canal on price per front foot, while controlling for lot area, for a sample of vacant residential lots in Florida. Having water frontage contributed up to an additional $40 per front. Lansford and Jones (1995) use a Box-Cox transformation to examine the effects of proximity to a central Texas lake on nearby property values. They control for lot frontage in their analysis, but do not distinguish between frontage for non-lake properties and that for lake properties (6% of the sample). The transformation parameters on the dependent and independent variables are 0.08 and 0.35, respectively. Evaluated together these parameters are significantly different from either the log-log or the semi-log functional forms. Spalatro and Provencher (2001) examine the effect of minimum frontage zoning on vacant lakefront properties in Wisconsin. Variation in the log of price per frontage foot is explained by lot frontage, the natural log of frontage, lot area, and a number of zoning/frontage interactive terms. The authors report average coefficient estimates for ten year-specific price functions. There is so much going on here that is difficult to sort it all out. However, their finding that, when controlling for frontage, lot area generally is not significant perhaps suggests that depth is an irrelevant matter in the pricing of lakefront property.

Michael et al. (2000) control for both frontage and area with a linear functional form in their examination of water clarity and lakefront property values in Maine.[8] Seiler et al. (2001), similarly use both frontage and lot size in a linear model to examine the effect of a view of Lake Erie on the assessed values of nearby properties. The same authors use these same variables and functional form with a transactions-based sample to determine the effect of a water view on Lake Erie properties (Bond et al., 2002). With a linear functional form that controls for both lot area and frontage, the iso-value curve in frontage and depth space is a hyperbola shifted vertically by the parameter on frontage alone.[9]

Poor et al. (2001) control for lake frontage, but not lot area, with a linear functional form in their own examination of water clarity and lakefront property values in Maine. Gibbs et al. (2002) also use a linear regression model with frontage as the only lot dimension variable in their study of the effect of water clarity on New Hampshire lakefront property values. We will see later that these approaches may be the closest to the results that we obtain. Although there are obvious differences between the linear and Cobb-Douglas specification, the differences may not amount to much when considered over a small range of data points.

Other than having been developed with differing research objectives, we should point out some distinctions between the research outlined above and this article. All properties in our sample either have lakefront or would be marketed by local brokers as “view properties,” with the majority of the sample falling into the former category. This eliminates the need to control for distance from the lake beyond making the distinction of whether or not the property has lake frontage. Moreover, all properties are on a thirteen mile stretch of Lake Michigan. This feature of the data set reduces the need to control for differences in lake-related attributes such as water clarity or environmental quality (although we do control for differences in the quality of shoreline). Steep slopes and bluffs are a distinctive feature of the three townships studied. Because our sample includes both bluff lots and non-bluff lots, we control for this variation in topography. Finally, we address the empirical issues associated with various zoning restrictions which are related to lot topography and proximity to a highway designated as a scenic resource.

2. Data

Our sample includes eighty vacant land sales occurring between January of 1990 and May of 2003. The sales are along the Lake Michigan shoreline in Emmet County, Michigan, which is located in the northwestern most part of Michigan's lower peninsula. The sample includes sales from the three contiguous townships of Friendship, Readmond, and Cross Village, which feature the M-119 Michigan Scenic Heritage Route known as the "Tunnel of Trees." Sales information was obtained from the Emmet County Equalization Office tax records with the assistance of a local Realtor. All sales were at arms length. Because of the potential for intra-family transfers, we relied heavily on the local Realtor to indicate those non-arms length transactions not apparent from review of the tax records. The sample includes some repeat sales.[10] Descriptive statistics on information collected for each lot are provided in Table 1.

Vacant lake lots had a median selling price of $215,000 for the sample period. The standard deviation of the sale price is fairly substantial, with sale price ranging from a low of $25,000 to a high of $600,000. As one would expect, the distribution of selling prices is skewed to the right. This suggests, but does not prove, that a log transformation would make the residuals more normally distributed.

Toward the end of the sample period the stock market was bullish or just ending the bull market. One can envision people moving their money from stocks to real estate during this time. Additionally, second home values were rising in the late 1990's.[11] Because ninety percent of the residences sold in the region are second homes, it is not hard to imagine that recreational land was appreciating very rapidly for our sample of lake lots during this period.[12] Sample transaction activity was in fact high from 1999 through 2001.[13] Thus, it is extremely important to control for time in the model while accommodating price changes for relevant sub-periods.

Observations are fairly evenly distributed across the three townships. The sample consists of both bluff property sales and non-bluff property sales, with the latter comprising sixty percent of sample. The Emmet County Zoning Ordinance, adopted by the Emmet County Board of Commissioners on August 24, 1972, defines a shoreline bluff as "a geologic land form consisting of a promontory, cliff, or palisade having a

Table 1. Descriptive statistics.

Variable	*Description*	*Mean*	*Std. dev.*	*Min*	*Max*
Price	Sale price	230,012	129,441	25,000	600,000
YEARS	Years from 1/1/1990	7.68	3.126	0.003	13.40
1999	Sale occurred in 1999	0.30	0.461	0	1
2000	Sale occurred in 2000	0.125	0.333	0	1
2001	Sale occurred in 2001	0.038	0.191	0	1
CROSSVIL	Cross Village township	0.375	0.487	0	1
READ	Readmond township	0.325	0.471	0	1
BLUFF	Lot is elevated	0.400	0.055	0	1
*F*BLUFF*	frontage for bluff lots	197	76	100	420
*F*NON-BLUFF*	frontage for non-bluff lots	156	49	90	332
*D*BLUFF*	depth for bluff lots	800	494	189	1,932
*D*NON-BLUFF*	depth for non-bluff lots	418	198	120	950
*F*D*BLUFF*	lot area for bluff lots	167,189	144,947	24,570	629,160
*F*D*NON-BLUFF*	lot area for non-bluff lots	67,805	43,773	19,200	172,556
SR	Lot zoned Scenic Resource	0.675	0.471	0	1
DOD	Lot in Dune Overlay Dist.	0.238	0.428	0	1
BEACHQUAL	Lot is on undesirable beach	0.050	0.291	0	1
*BLUFF*LAKE*	Bluff lot has lakefront	0.213	0.412	0	1
SPLIT	Bluff bldg site across road	0.263	0.443	0	1

broad steep face."[14] The bluffs parallel the shoreline of Lake Michigan, and are nearest to the lake in various north-south stretches within the three township area. Along these particular segments, bluff lots have lake frontage in that no other property lies between the bluff and the lake. In other areas, where the bluff lies farther away from the lake, there are non-bluff lots nestled between the lake and the bluff along low-lying access roads.

Bluff lots in our sample tend to be larger than the beach lots. This may be related in some way to land use restrictions on shoreline bluff areas, as discussed later. Bluff lots have a median lot size of 2.3 acres, while non-bluff lots have a median lot size of 1.2 acres.[15] The median frontage and depth in linear feet is 167 and 746, respectively, for bluff lots, and 150 and 378, respectively, for non-bluff lots. Fifty-three percent of the bluff lots in the sample have lake frontage, while the remainder feature a clear view of Lake Michigan but do not "own the lake."[16] For fifty-six percent of the bluff lots the future building site is on the lake-side of the bluff. For the remaining bluff lots the designated building site is separated from the lake by a road.

2.1. *Zoning*

Lake properties in the three townships studied fall into two underlying zoning districts: Recreational Residential (RR) and Scenic Resource (SR). The SR district generally flanks the M-119 Michigan Scenic Heritage Route. More specifically, for properties along M-119, the SR District extends to a depth of 400 feet from M-119, or to the depth of the abutting property, whichever is less. Therefore, a lot can be zoned under both districts simultaneously, with the section of the lot nearest to M-119 zoned SR and the remainder of the lot zoned RR. The RR district stipulates a minimum lot size of 22,000 square feet, and a minimum lot width (i.e., the minimum frontage on a rectangular lot) of 100 feet. The minimum lot size in the SR district is 30,000 square feet, and the minimum lot width is 150 feet. All uses permitted in a RR district are permitted in a SR district. SR zoning applies to 69% of the sales in our sample, with 32% of sales zoned SR exclusively. Lots created prior to the passing of the zoning ordinance may be non-conforming.[17]

The underlying zoning districts discussed above are supplemented with two zoning overlay districts: a Shoreline Bluff Overlay District (SBOD) and a Dune Overlay District (DOD). The SBOD was put in place to protect the environment and the integrity of the bluffs and to minimize bluff instability through the enforcement of responsible development. The Dune Overlay District (DOD) was established to protect the environment and ecology of Critical dune areas as identified by the Michigan Department of Natural Resources. Any new land use occurring in a DOD or in a Steep Slope within a SBOD requires a site plan which complies with various standards and requirements that exceed those for the underlying districts.[18] However, all uses permitted in the underlying district are permitted in the overlay district subject to any such superceding requirements. Generally lot size, density and setbacks are established in the underlying district with the exception that newly created lots in a DOD must be at least 200 feet in width or must meet some alternative standard designed to minimize the impact of development on the dune environment.[19]

The zoning overlay districts and accompanying regulations apply to our sample in the following way. The regulated Shoreline Bluff lots are those we identify as bluff lots for the purposes of this study. More formally, these are lots along the single contiguous and highest bluff feature that generally parallels the West side of M-119. The Dune Overlay District applies to all lands contained in the "Atlas of Critical Dunes."[20] Roughly twenty-four percent of the sample, and sixty-three percent of the Cross Village sales, are designated in a DOD.[21] The DOD is not a contiguous area within Cross Village township, but rather consists of three geographically distinct parts along the lake shore.

3. Methodology

We use hedonic analysis to explore the frontage and depth pricing relationships for lake properties. Several concerns arise in this context. The hedonic model must address the difference that may exist between elevated bluff lots that overlook the lake and non-bluff lots. The model must accommodate price movements throughout the sample period and within sub-periods. The model must control for the fact that the sample includes sales from three different townships, each of which may have a different price level. The model must also control for the effects of various zoning restrictions where appropriate.

The hedonic model we employ to address these particular concerns is as follows:

$$price = K\exp\left\{\begin{array}{l}\delta_1 YEARS + \delta_2 1999 + \cdots + \delta_4 2001 + \sum_{i=1}^{2}\lambda_i TOWNSHIP \\ +\phi_1 BEACHQUAL + \phi_2 BLUFF{*}LAKE + \phi_3 SR + \phi_4 DOD\end{array}\right\} \quad (1)$$

where

$$K = F^{\beta_1+\beta_2 NON\text{-}BLUFF} D^{\alpha_1+\alpha_2 NON\text{-}BLUFF} \quad (2)$$

The model can be characterized as a device to explain variation in the sales price, the dependent variable. The explanatory variables describe either the lot or the market environment. Market environment variables include *YEARS* as years as a continuous time variable, certain year of sale dummy variables, and *TOWNSHIP* for township dummy variables. Specifically, δ_1 is the constant annual rate of price appreciation throughout the entire sample period after controlling for several boom years. The parameters δ_2, δ_3, and δ_4 reveal any (intra-year) differences in prices from the exponential time function that occur in 1999, 2000 and 2001, respectively. λ_i reveals the difference in price level between Friendship, selected as the base township because it is the closest in proximity to Harbor Springs via M-119, and other Emmet County townships included in our study. We might expect that any price level difference should be negative due to diminished access to Harbor Springs as one travels further north along M-119. On the other hand, inland roads allow for near equal travel time to Harbor Springs and nearby Petoskey from the Readmond and Friendship townships. Thus, while the model allows price levels to differ across townships, price movements over time are constrained by the model to be the same across the three townships.

In this paper we follow Colwell and Scheu (1989) and use a Cobb-Douglas specification for the variable for lot frontage (in linear feet), *F*, and for *D*, the variable for lot depth. The Cobb-Douglas specification allows for non-constant returns to scale in frontage and depth. Decreasing returns to scale (concavity) is intuitively appealing, and is ultimately suggested by our findings. Nevertheless, increasing returns (convexity), or constant returns (proportionality) would be revealed if they exist over the ranges of data that exist in this data set. β_1 is the frontage elasticity of value for bluff properties, while the sum of β_1 and β_2 is the frontage elasticity of value for non-bluff properties. The variable *NON-BLUFF* is a dummy variable which equals 1 if a lot is not located in the SBOD district. We expect that $0 < \beta_1 < 1$ because we do observe subdivision of lake lots, as discussed earlier. β_2 is the incremental difference in the frontage elasticity of value for non-bluff properties versus bluff properties. We note that a linear functional form which controls only for frontage as a lot variable (Poor et al., 2001; Gibbs et al., 2002) would come close to our handling of frontage as Cobb-Douglas, as long as the domain was limited in size such that the non-linearity assumption would be relatively unimportant.

Depth may affect value very differently than frontage. Thus, we introduce a separate depth variable rather than just using a lot area variable to represent both frontage and depth (again, frontage and area variables used together would get us to the same point). The coefficient on the depth variable, α_1, is the depth elasticity of value for bluff properties. The sum of α_1 and α_2 is the depth elasticity of value for non-bluff properties, where α_2 is the incremental difference in the depth elasticity of value for non-bluff properties as compared to bluff properties. While we would expect that $\alpha_1 < \beta_1$ and $\alpha_1 + \alpha_2 < \beta_1 + \beta_2$, more central to our hypothesis is whether $0 < \alpha_1$ and $0 < \alpha_1 + \alpha_2$.

In addition to frontage and depth, the model features four other lot-related variables. The first addresses differences in beach quality. Along the three-township lakeshore there is a segment of beach which is perceived by local market participants as relatively undesirable. This stretch of beach is perpetually wet and has hard sand, in contrast to the soft, dry sand which characterizes the rest of the County's shoreline. The variable *BEACHQUAL* is a dummy variable which equals 1 if a lot is on this undesirable stretch of beach. Accordingly we expect $\phi_1 < 0$. A second variable measures the value of lake frontage for bluff properties. An interactive dummy variable, *BLUFF*LAKE*, takes the value 1 for those bluff lots having lake frontage. We expect that having lake frontage is desirable, and thus anticipate that $\phi_2 > 0$. Finally, we control for two zoning variables, *SR* and *DOD*. *SR* takes the value 1 if the lot is zoned Scenic Resource, and 0 if it is zoned Recreation Residential. The variable *DOD* indicates whether that the lot is regulated as a critical dune. We expect $\phi_4 < 0$ because of the nature of the zoning and the zoning district geography. Dune regulation increases the expected future cost of construction, yet offers no additional protection against negative externalities in that all uses permitted in the underlying zoning district are permissible in a DOD.[22]

A logarithmic transformation of (1) yields the regression equation:

$$\begin{aligned}\ln(price) = {} & \beta_1 \ln(F) + \beta_2 \ln(F)^{*}NON\text{-}BLUFF + \alpha_1 \ln(D) \\ & + \alpha_2 \ln(D)^{*}NON\text{-}BLUFF + \delta_1 YEARS + \delta_2 1999 + \delta_3 2000 \\ & + \delta_4 2001 + \lambda_1 READ + \lambda_2 CROSSVIL + \phi_1 BEACHQUAL \\ & + \phi_2 BLUFF^{*}LAKE + \phi_3 SR + \phi_4 DOD. \qquad (3)\end{aligned}$$

4. Results

Overall, the model explains a large proportion of the variation in the log of price. The regression yields an adjusted R-squared of .825. The results for this regression appear in Table 2. There are some significant differences among the townships. The data reveal that Cross Village had a lower price level, and Readmond had a higher price level, than Friendship township. The annual rate of appreciation for all townships was around 4.5% throughout the entire sample period. For the calendar years 2000 and 2001 there was a significant jump in prices. While controlling for appreciation, 2000 and 2001 sales were 34% and 58% higher, respectively, than if they had been on the trend line defined by the annual rate of appreciation result. The results suggest the surge in recreational land prices in northwest Michigan commenced in 2000, since there were no significant price changes for the calendar year 1999. Significant price movements over time are depicted in Figure 1.

The quality of beach appears to play a role in pricing lake lots. Those sales occurring along an undesirable stretch of beach sold for 38% less than otherwise comparable lots. Whether or not the lot is directly on the lake also appears to be of considerable importance.

Table 2. Dependent variable = ln(*price*) *t*-values in parenthesis.

Variable	*Model 1 (N = 80)*	*Model 1 (N = 80)*	*Model 2 (N = 80)*	*Model 3 (N = 80)*
Adjusted R-squared	0.825	0.829	0.821	0.822
Intercept	8.157 (12.78)	8.180 (13.00)	7.881 (12.40)	7.816 (12.23)
YEARS	0.044 (2.89)	0.043 (2.88)	0.040 (2.63)	0.039 (2.51)
1999	−0.018 (0.19)	−0.014 (0.15)	−0.005 (0.05)	0.004 (0.04)
2000	0.295 (2.11)	0.309 (2.31)	0.362 (2.68)	0.379 (2.81)
2001	0.461 (2.28)	0.470 (2.42)	0.476 (2.39)	0.490 (2.45)
READ	0.249 (2.28)	0.275 (2.80)	0.269 (2.64)	0.259 (2.55)
CROSSVIL	−0.220 (1.77)	−0.237 (2.33)	−0.237 (2.24)	−0.240 (2.28)
ln(*F*)	0.633 (4.66)	0.628 (4.75)	0.549 (4.43)	0.552 (4.50)
ln(*F*)**NON-BLUFF*	−0.058 (0.41)	−0.073 (0.55)	0.057 (0.53)	0.067 (0.65)
ln(*D*)	−0.113 (1.47)	−0.120 (1.62)	–	–
*D*BLUFF*	–	–	−0.0000469 (0.11)	0.0000712 (0.27)
D^2**BLUFF*	–	–	−0.000000023 (0.11)	–
*(D-800)*D > 800*BLUFF*	–	–	–	−0.000276 (0.68)
ln(*D*)**NON-BLUFF*	0.305 (2.66)	0.318 (2.94)	0.208 (2.45)	0.209 (2.48)
BEACHQUAL	−0.479 (2.86)	−0.458 (2.84)	−0.439 (2.66)	−0.429 (2.61)
*BLUFF*LAKE*	1.186 (10.62)	1.171 (11.03)	1.169 (10.63)	1.169 (10.81)
SR	−0.058 (0.55)			
DOD	−0.043 (0.33)			

Note: Absolute value of *t*-statistics appear in parenthesis.

Bluff lots which had lake frontage sold for over 200% more than comparable view lots. Zoning, on the other hand, appears at first blush not to influence the pricing of lake property. The coefficients on both *SR* and *DOD* were negative, but neither was significant. However, as will be discussed later, this may be a feature of a collinearity issue.

The results related to the first of this paper's central hypotheses are quite definitive. The frontage elasticity of value is 0.63 for bluff properties and is not significantly different

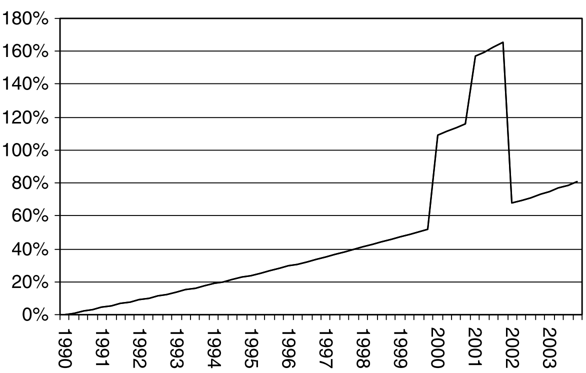

Figure 1. Percentage change in price from January 1990.

than this for non-bluff properties. Our results suggest that the relationship between recreational land values and lake frontage is not linear and proportional. On the other hand, results related to depth and lake property values are varied. The depth elasticity of value for bluff lots is negative but not significant, while the coefficient on ln(*D*)**NON-BLUFF* is positive and significant. These results suggest that a percentage change in lot depth does not affect the price of bluff properties. For non-bluff properties, the additional percentage change in price from a one percent change in lot depth is 0.305, and is 0.192 if evaluated with both significant and insignificant results for the ln(*D*) variables.[23]

The result concerning bluff depth is curious. Some level of depth should be necessary to make development feasible. Of course, our observations are all in the range that permits building. Given the physical size of bluff lots in the sample relative to non-bluff lots, high depth ranges may be swamping any measurable value increment from marginal depth. We consider the possibility that our handling of depth as a Cobb-Douglass function does not accommodate the nature of recreational bluff lots, the Lake Michigan data, or both. We utilize two alternative specifications for bluff depth after addressing issues of collinearity in the model.

4.1. Zoning, collinearity, and interpretability

Intercorrelation among the independent variables in a regression equation can cause a loss in precision in the parameter estimates. This statistical problem applies to our data in the following ways. First, recall the Scenic Resource zoning classification is defined in terms of proximity to the M-119 Michigan Scenic Heritage Route. As discussed earlier, proximity to M-119 is generally associated with proximity to the predominant bluff feature throughout the three township area. The Scenic Resource zoning classification, therefore, is not surprisingly negatively correlated with the variables ln(*F*)**NON-BLUFF* and ln(*D*)**NON-BLUFF*.[24] Because we wish to reduce the opportunity for imprecision in our estimates of the frontage and depth elasticities, we drop *SR* from the regression. Second, recall that Dune Overlay District sales are found only in Cross Village. Also, all *DOD* sales are non-bluff lots. As a result, *DOD* is positively correlated with *CROSSVIL*, and is positively correlated with the non-bluff frontage and depth variables.[25] The higher the degree of correlation the greater the likelihood that the frontage and depth elasticity estimates, as well as the estimate on the price level for Cross Village, will be imprecise with the inclusion of the *DOD* zoning variable. Accordingly, we drop *DOD* from the regression model.

There is a second reason unrelated to collinearity for dropping the *SR* and *DOD* zoning variables from the regression model. Because of the interrelationship between zoning districts, geographic location, and topography, it is impossible to determine if any measurable price effect is due to the zoning itself or rather to the physical location or topographical nature of the land related to the zoning. This a problem that restricts our ability to interpret results on relative value of bluff lots versus non-bluff lots. We find that bluff lots are worth less, but cannot say whether this is because being on the bluff is undesirable (e.g., vertical access is costly) or because of the *SBOD* zoning restrictions. In a similar way, a negative and significant coefficient on *SR* could indicate either that the restrictions required under the *SR* classification, as compared to the recreation residential classification, are less desirable, or that it is disadvantageous to be located along M-119. Moreover, we cannot disentangle the extent to which any price effect revealed in the coefficient on *DOD* is related to the restrictions for the Dune Overlay District or to the physical character of the dune topography. We would expect that any negative price effects associated directly with the nature of the zoning classification, should they exist, would be greater for the *DOD* than the *SR* district. As discussed earlier, the overlay district essentially tightens, but does not relax, the restrictions contained in the underlying district, resulting in a higher expected cost of construction without any offsetting increase in protection against incompatible uses. This argument might seem especially relevant for the Emmet County *DOD*, which is not a geographically contiguous district. As such, there is a greater likelihood than with a similar but contiguous district that an adjacent lot is not similarly regulated.

Regression results without the zoning variables *SR* and *DOD* appear in the second column of Table 2. Dropping the *DOD* dummy variable increases the significance on *CROSSVIL* from 10% to 5% (two-tailed test), and results in a slight increase in the parameter estimate in absolute magnitude. Omitting zoning from the model does not change the significance of the non-bluff frontage and depth elasticity estimates in any significant way.

Here we make one last mention of collinearity as it concerns *BLUFF*LAKE* and the non-bluff frontage and depth elasticities of value. *BLUFF*LAKE* is not surprisingly negatively correlated with both ln(*F*)*NON-BLUFF* and ln(*D*)*NON-BLUFF*. $\rho = -0.63$ for both variables pairs. To examine the extent to which this correlation affects the parameter estimates we run the regression model omitting the 15 bluff lots without lake frontage. These results are presented in Table 2, column 3. The basic findings of the model remain unchanged except that now the coefficient on ln(*F*)*NON-BLUFF* is significant at 10%. The results suggest the price of non-bluff properties is less responsive than that for bluff properties to a percentage change in lot frontage. Of course, the obvious problem with this approach is that model loses explanatory power on account of the loss in observations.

5. Alternative depth specifications

The results from modeling depth as Cobb-Douglas suggest that bluff depth doesn't matter. The coefficients on bluff depth, while not significant, are actually negative. In this section we try various alternative specifications for bluff depth (Davidson and MacKinnon, 1981). The idea is that these specifications are flexible enough to reveal what is happening in the relatively smaller depth ranges.

The first alternative specifies that value is a quadratic exponential function of depth. If, for example, small amounts of depth contribute positively to value, but excessive amounts of depth detract from value, the quadratic can accommodate these different effects, and would reveal a depth that maximizes value. Why might depth detract from the value of bluff lakefront properties? Deep lots often require long driveways and utility runs, which add to development cost. Additionally, long driveways need to be maintained. This can be an especially large problem in the winter when snow must be removed. Finally, tax assessors may have a different set of implicit prices than exist in the market. For example, they might emphasize lot area rather than lot frontage in determining assessed values. Model 2, which utilizes the quadratic exponential function of depth is as follows:

$$price = K \exp \left\{ \begin{array}{l} \delta_1 \; years + \delta_2 1999 + \cdots + \delta_4 2001 + \sum_{i=1}^{2} \lambda_i TOWNSHIP \\ +\phi_1 BEACHQUAL + \phi_2 BLUFF{*}LAKE + \theta_1 D{*}BLUFF + \theta_2 D^2{*}BLUFF \end{array} \right\} \quad (4)$$

where

$$K = F^{\beta_1 + \beta_2 NON\text{-}BLUFF} D^{\alpha_2 NON\text{-}BLUFF} \quad (5)$$

Non-bluff depth we continue to treat as Cobb-Douglas. For bluff properties, the percentage change in value from an additional foot of depth is $\theta_1 + 2\theta_2 D$. Here a dummy variable, *BLUFF*, serves to distinguish lots as being located within the SBOD. We expect the coefficient θ_1 to be positive, while we expect θ_2 to be negative, but less in absolute magnitude than θ_1. This would indicate an upside-down U-shaped function for bluff depth.

A logarithmic transformation of (4) yields the regression equation for Model 2. The overall explanatory power is slightly less for this model. Regression results are presented in Table 2, column 3. The regression yields an adjusted R-squared of .821. Both bluff depth coefficients are negative, very small in magnitude, and insignificant. The results do not yield an optimal bluff depth, but instead suggest that neither small nor large amounts of depth contribute in any way to value.

The second alternative depth specification utilizes a piecewise linear treatment of depth. This flexible modeling technique allows the price per additional foot of bluff depth to vary over different depth ranges. The depth function thus kinks between the ranges, which are determined in part by the number of observations available within each range. We can directly determine how smaller amounts of depth affect price by allowing the function to kink at relatively small amounts of depth. Model 3, with a piecewise formulation for depth, is as follows:

$$price = K \exp \left\{ \begin{array}{l} \delta_1 \, years + \delta_2 1999 + \cdots + \delta_4 2001 + \sum_{i=1}^{2} \lambda_i TOWNSHIP + \phi_1 BEACHQUAL \\ +\phi_2 BLUFF{*}LAKE + \xi_1 D{*}BLUFF + \xi_2 (D - 800){*}D > 800{*}BLUFF \end{array} \right\} \quad (6)$$

where K is as in equation (5).

As in Model 2, depth enters the hedonic function in the exponent and features the *D*BLUFF* variable. There is also an interactive depth variable which utilizes a depth dummy variable, $D > 800$. This depth dummy variable is equal to 1 if bluff depth is greater than 800 feet. We multiply the depth dummy variable by the difference between actual depth and the 800 feet. The interactive variable, $(D-800)D > 800$, will equal 0 if actual depth is not greater than that indicated by the accompanying depth dummy variable and will equal the amount by which depth is greater than the indicated amount otherwise. With this formulation we effectively place a knot in the depth function at 800 feet, the mean value of depth for bluff properties.

The coefficients on the piecewise depth variables in equation (6) can be interpreted as the percentage price change per foot of depth between the various knots. ξ_1 gives the percentage price change per additional foot of depth over the full range of depth for bluff properties, and is therefore the percentage price change per additional foot of depth for those bluff properties having less than 800 feet of depth. ξ_2 indicates the additional percentage price change per foot of depth greater than 800 feet. The sum of ξ_1 and ξ_2 gives the total percentage price change per additional foot of depth for bluff depth beyond 800 feet. A logarithmic transformation of (6) yields the regression equation for Model 3. Regression results are presented in Table 2, column 4. The regression using piecewise depth yields an adjusted R-squared of 0.822. Neither piecewise depth variable is significant, although the coefficient on *D*BLUFF* is positive. The third specification for bluff depth, like the other two, suggests that depth does not play a role in the pricing of vacant lake property within acceptable building ranges.

6. Conclusions

A number of studies on the pricing of lake properties have considered the effects of lot frontage. The majority of these include frontage as a right-hand side variable with a linear functional form specified. The implication is that additional foot of frontage contributes an equal amount of value to the property. We examine lakefront properties on the west coast of Michigan to test the effect of frontage and depth of the pricing of recreational properties. We specifically test whether properties are priced by frontage alone and whether this pricing relationship is linear. Our hedonic analysis reveals that lots are not priced proportionately to lot frontage. Frontage elasticities of value were estimated between 0.55 and 0.63 for vacant lake properties. These findings are as expected, since we do observe subdivision of lakefront properties. On the other hand, we find that the depth relationship is fairly ambiguous. Practitioners are to some extent justified in ignoring depth, since we find that depth is not a contributor to the value of bluff lakefront properties. However, depth for lots at lake level does contribute to the pricing of recreational land. We find the depth elasticity of value for non-bluff properties in the range of 0.19 (with both significant and insignificant results) to 0.32.

Researchers conducting hedonic analysis of lake property should be mindful of the economic implications associated with lot variable choice and functional form. A linear model which controls only for lot area suggests that all combinations of frontage and depth producing the same area will result in the same price. This specification would not seem appropriate if it is depth in no way contributes to lakefront property values, such as would seem top be the case with our bluff lot sample.

Why does additional depth matter in the case of lake-level lots, and yet appear not to contribute to value for bluff lots? These results could be due to peculiarities with the data. Bluff lots in the sample are deeper, on average, than lake level lots. This fact, combined with a limited number of bluff observations, restricts us from satisfactorily testing the effects of additional depth over relatively small depth ranges (less than 800 feet). At the same time, lake-level lots are all on the lake side of the street, where the street is generally an access road having developable lots on either side. By contrast, many of the bluff lots are on the opposite side of M-119 from the lake, and behind them may be forest or farmland. Thus, the results may be driven by a demand for privacy.

This study finds a few other noteworthy results. Not surprisingly, for bluff lots, having lakefront is better than not having lakefront. The quality of beachfront, such as sand consistency, matters. Finally, bluff lots having lakefront are worth less than comparable non-bluff, lake-level, lots. This finding suggests that topography (extent of elevation) may be important, and/or that zoning may be important.

The study's central findings may have implications for practitioners working with lake property. Consider a developer who makes subdivision decisions to maximize the price per square foot of a lakefront development. Our findings suggest that there is probably an optimal frontage, but it may be that the developer would want to make depth as small as possible. Consider an assessor or appraiser valuing vacant lakefront property. Any adjustment to a subject parcel that differs in area from available comparables should probably not be based on a price per square foot. Moreover, the standard depth rules may not apply in this case. Brokers (or sellers) marketing lakefront property should be cautioned in applying a uniform price per linear foot of frontage. Finally, consider a planner who wishes to make minimum frontage larger. This, in combination with concave prices, will make the aggregate value of lake property less and thus diminish property tax revenue. At the same time the use of the lakefront may not be diminished if easements to cross lakefront properties can be granted. Thus, the planner faces costs associated with larger minimum frontage, while the presumed benefits of minimum frontage zoning may be questionable.

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Notes

1. It is a fact that this separation must be 50 feet in some jurisdictions. In this context it is unlikely that frontage could be less than 70 or 80 feet with setbacks. Of course, minimum frontage cannot effectively

control beach and lake use as long as access easements can be granted through beachfront lots. This view is in contrast to that of Spalatro and Provencher (2001).

2. It is necessary to state that, in the context of hedonic theory from Rosen (1974), if the firm offer curves are concave, then the lower envelope of firm offer curves must be concave, and the hedonic function must be concave. This implies that there is diminishing marginal utility on the demand side and that the bid curves are even more concave. So while we are focusing on the supply side, there are implications for the demand side.
3. Although most studies examining land values and lot size find concavity, Yuming et al. (2002) find evidence of convex prices associated with lot assembly in Hong Kong.
4. Colwell and Scheu (1989) examine vacant land sales in two central Illinois cities, and find the frontage elasticity of value to be 0.83 and 0.87, respectively, and the depth elasticity of value to be 0.29 and 0.38, respectively. Colwell, Dehring and Lash (2002) find the frontage and depth elasticities of value to be 0.18 and 0.12, respectively, for a sample of developed properties in Western suburbs of the Chicago region. We should expect that these elasticity estimates are greater for vacant land than developed land.
5. In estimating land values for a control group of properties not adjacent to a reservoir he controls for road frontage.
6. A distance to waterfront variable and a setback size variable have a log-linear specification.
7. The purpose of their article was to illustrate important deficiencies of the Box-Cox methodology as applied to hedonic analysis.
8. A independent water clarify variable enters the function in logs.
9. $P = \beta_1 F + \beta_2 AREA = \beta_1 F + \beta_2 FD$. $\partial F/\partial D = (\beta_1 + \beta_2 D)/\beta_2 F$.
10. 12.5% of transactions are repeat sales.
11. According to the NAR, the median sale price of a second home in 2001 was 26.8% higher than the median price in 1999. The median price in 1999 was up 11% from the 1995 median second home price.
12. Barrons 12/17/2001 and Newsweek 7/1/2002.
13. 46.25% of sales took place between 1991 and 2001, with 1999 sales making up 30% of the total sample.
14. ARTICLE XVI Section 1600, (7).
15. Here lot area is approximated as the product of frontage and depth.
16. Bluff lots sales not having a sucient view so as to be considered a "view lot" by the local market were omitted from the sample.
17. 12.5% of sales in the sample are non-conforming with regard to minimum lot width requirements.
18. A Steep Bluff slope is defined as having grade not less than 33% with a vertical extent of not less than 15 feet. ARTICLE XVI Emmet County Zoning Ordinance.
19. ARTICLE XVII Section 1702 Emmet County Zoning Ordinance.
20. As designated by the Michigan Department of Natural Resources for Emmet County pursuant to PA 222 of 1976, the Sand Dune Protection and Management Act.
21. We did not include sales from the northern-most shoreline of Cross Village Township, all of which is considered Dune Overlay District. The physical appearance of lots in this area was substantially dissimilar to the rest of the sample in ways that we do not control for in our model (e.g., tree coverage).
22. A dummy variable indicating whether a bluff lot's building site was on the lake-side of the bluff was initially included in the model, but removed due to lack of significance.
23. The depth elasticity of value for non-bluff lots is 0.192 if evaluated with both significant and insignificant results for the ln(*D*) variables.
24. The correlation coefficient, ρ, for *SR* and ln*(F)*NON-BLUFF* is 0.52. It is the same between *SR* and ln(*D*)* non-bluff.
25. ρ is 0.72 between *CROSSVIL* and *DOD*. *DOD* and ln*(F)*NON-BLUFF* have $\rho = 0.48$, while *DOD* and ln*(D)*non-bluff* have $\rho = 0.44$.

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