TECHNICAL REPORT

EFFECTS OF LCRA LAKES ON RIPARIAN PROPERTY VALUES: Recreational and Aesthetic Components of Lake Side Housing in the Colorado River Basin

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INTRODUCTION AND PROBLEM STATEMENT

The Lower Colorado River Authority (LCRA) manages the Colorado River Basin in a ten county area stretching from central Texas to the gulf coast of Texas. In its recent "Water Management Plan for the Lower Colorado River," the Lower Colorado River Authority (LCRAb) stated:

> The "business" of water resources management in Texas, and throughout the nation, is in the midst of transition and transformation. The transition is largely the result of ever increasing demands and competition for renewable but limited water supplies and a growing awareness of the limits of "traditional" water supply management strategies. ... In response to new challenges and uncertainties, it is imperative that water management institutions, at all levels, adopt a balanced, flexible approach that gives due weight to all the conflicting demands on the water, including the heavy economic dependence of the rice farmers on historic uses of irrigation water, rapidly emerging public interest in recreation, and environmental values. (p. 1)

The problem is that the total quantity demanded is increasing and peak demand for agricultural, municipal, industrial, and recreational uses occurs at the same time of year. Since the supply is limited in any given year, efficient water management requires knowledge of the benefits to the various user groups. The research described in this paper focuses on the user group whose benefits have received relatively little attention in the past. These are the recreational and aesthetic users who own property and live around reservoirs in the Lower Colorado River basin.

This study employs a "hedonic" or "implicit" price approach to examine a component of the recreational (and aesthetic) value of two lakes in the "Highland Lakes" chain. The study addresses the implicit recreational and aesthetic (RA) price placed on Lakes Austin and Travis by homeowners living near the lakes. It also examines the relationship between lake management practices and the value of lake front properties.

Texas' Highland Lakes

LCRA's Highland Lakes system is comprised of two water storage reservoirs, Lakes Buchanan and Travis, and three intermediate pass-through reservoirs, Lakes Inks, LBJ, and Marble Falls. Lake Austin, a pass-through reservoir owned by the City of Austin, is also managed by LCRA and is considered to be a part of the Highland Lakes chain (Figure 1). The pass-through reservoirs are maintained at virtually constant levels while the levels of Lakes Buchanan and Travis vary depending upon supply and demand.

Figure 1. Study Area Map, the Highland Lakes

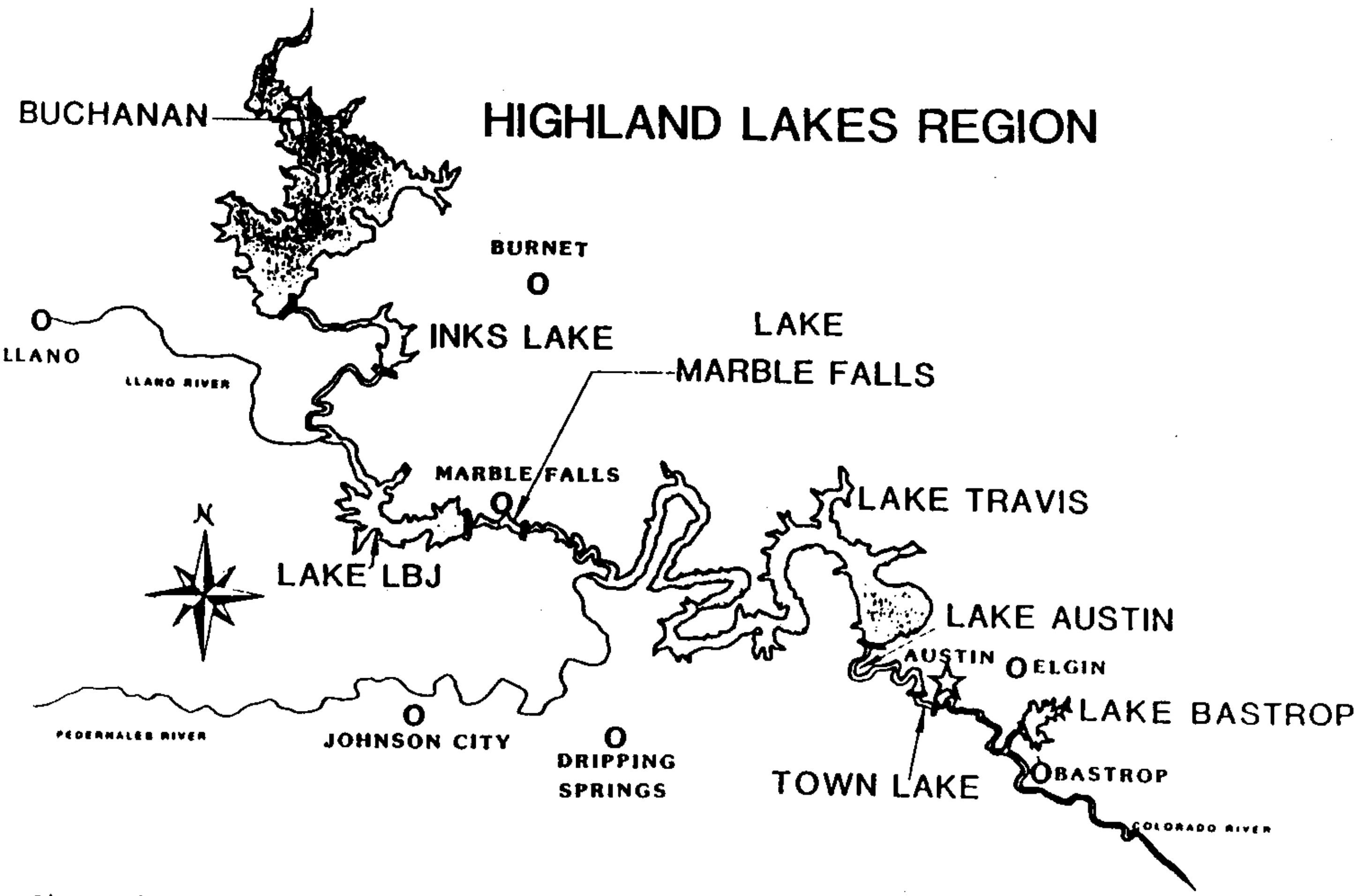

Figure 1. Study Area Map, the Highland Lakes

Lakes Austin and Travis

This study compares and contrasts the two LCRA-managed lakes at the lower end of the Highland Lakes chain. Lake Travis lies immediately upstream (northwest) from Lake Austin. It is the only designated flood control lake. The Mansfield Dam flood storage space is between 681 feet mean sea level (MSL) and the spillway crest elevation of 714 MSL. When Lake Travis was being constructed, LCRA bought flood easements, if not out-right ownership, around the reservoir to an elevation of 715 feet MSL. Therefore, many individuals with "lake front property" own property down to 715 feet. Others however, have ownership rights extending to 680 feet or more and some have rights extending to the original river channel. In these latter cases, LCRA owns a flood easement.

Few, if any, property owners around Lake Travis want the water level to rise much above 681 feet since this would result in flooding of low lying properties. Neither is it desirable for the water level to fall considerably below this level due to (1) the possible loss of the right of ingress, (2) the distinct possibility that boat slips will become dry, and (3) the general loss of aesthetic appeal of the lake. Nevertheless, Lake Travis has experienced considerable variability over the years. During the past fifteen years (1976-1990), Lake Travis had a mean water level of 673 feet MSL and a standard deviation of 9.41 feet. Not only does the water level vary from month to month and year to year, it varies seasonally in an inconsistent pattern. Normally, Lake Travis is lowest towards the end of the Summer. It tends to be highest in late Spring and early Summer following the Spring rains.

By contrast, Lake Austin had a mean level of approximately 492 feet MSL with standard deviation of 2.13 feet. (Lake Austin in purposely drawn down periodically to control aquatic plant growth otherwise the deviation would be much smaller.)

LCRA Water Management

The LCRA manages the surface water in the Colorado basin and must allocate supply to meet several demands. The quantity demanded by senior water rights holders must be met first. Senior rights are primarily held by the City of Austin and four large irrigation operations downstream from the lakes. Approximately 25% of the Texas rice crop is irrigated from the Colorado River. Texas sells about 20% of the rice that is sold on the world market (LCRAb, pp. 15-16). The majority of irrigation needs are supplied by normal river flows. However, on average, 30% of annual irrigation water comes directly from the lakes (LCRAb, p. 16). LCRA also provides "firm demand" or uninterruptible water supplies from Highland Lakes' to area municipalities, LCRA-owned steam electric power plants, the South Texas Nuclear Project, and the Lavaca-Tres Palacios Estuary. In addition to "firm demand," LCRA sells "interruptible water" by contract to other users. Interruptible water is that amount of annual water in the reservoirs in excess of the "firm yield" (the amount that is expected to be available during a repeat of the design drought or the drought of record). Table 1 provides an overview of projected water use from the Colorado River Basin. Total annual water use within the basin is currently 941,905 acre-feet, with about sixty percent going to irrigation (TWDB). Irrigation is expected to remain a major use in the future but will decline relative to municipal and industrial uses.

Table 1. Projected Annual Water Use from the Colorado River Basin in 2000 and 2040

Type of Use	2000	2040	% Change
Municipal	353,859	546,757	54.5
Manufacturing	45,016	112,090	149.0
Steam Electric	74,000	104,100	40.7
Mining	36,428	26,447	-27.4
Irrigation	649,578	602,285	-7.3
Livestock	37,228	37,228	0.0
TOTAL	1,196,109	1,428,907	19.5

Source: "Water for Texas Today and Tomorrow." Texas Water Development Board. November 1990. Austin, Texas.

The large increases in municipal, manufacturing, and steam electric uses are largely driven by the demands of increasing population in the urban areas. The current Colorado River basin population is approximately 1.3 million and is estimated to range between 2.2 and 2.8 million by 2040 (TWDB). Agriculture is projected to decrease its water consumption between the years 2000 and 2040 due to conservation measures and more effective use.

> Historical data shows that as much as seven acre-feet of water had to be pumped from the river to irrigate one acre of rice. The Texas Water Commission, in its Final Adjudication order of all the irrigation rights in the lower Colorado River stated that the use of more than 5.25 acre-feet of water for the irrigation of an acre of rice constituted a waste of water. (LCRAb, p. 17)

LCRA has reported that it is possible to reduce irrigation use by 25 to 30 percent, bringing water use per acre within the 5.25 acre-feet requirement. This should help alleviate the conflicting demands for water in the near-term.

All the uses listed in Table 1 are consumptive in nature. Although each has some amount of return flow to the river, each uses up some of the water. These are the traditional uses among which water supplies have typically been divided. However, recreational and aesthetic use of lake and river waters is a nonconsumptive use that has received relatively little attention in the past. Boating, fishing, swimming, skiing, picnicking, sailing, and scuba diving are some of the recreational activities provided by bodies of water. Scenic views and lake breezes are two of the aesthetic benefits. LCRA is aware of the growing recreational and aesthetic demand. Although the original purposes of the lakes were flood control and water supply for irrigation and other consumptive uses, LCRA recognizes that recreationists typically desire that the lakes be kept full at their conservation storage levels (LCRAb).

> Because these multiple purpose reservoirs were not constructed to maximize the recreational use of the reservoirs, the demands for stability in the reservoir levels by these incidental beneficiaries (the recreation interests) present conflicts which are extremely difficult to accommodate. If limits are to be placed on how far down the reservoirs' water levels are allowed to decline, a corresponding limitation on the amount of water that is available to supply the other demands on the reservoir system must also be agreed to.
> (LCRAb, p.19)

Although the recreationist desires Lake Travis to be held about 681 feet MSL, the "LCRA is recommending that consideration be given to the recreational economy of the region by committing not to sell additional interruptible water if the impact of such sales would draw Lake Travis below 660 feet MSL ..." (LCRAb, p. 19). Yet LCRA emphasizes that a minimum water level cannot be guaranteed. The conflict between consumptive users and nonconsumptive users is aggravated by the seasonal nature of demand. The greatest recreational demand occurs in the summer, concurrent with the greatest need for irrigation of crops, watering of lawns, and other consumptive uses.

Nonconsumptive, Recreational Water Use

None of the recreational activities "uses up" the water. Hence, one recreational use is not competitive with other non-consumptive uses (except in the case of crowding). Furthermore, since the State (or public) owns the water, recreation is by law nonexclusive. Anyone can access the water for recreational purposes via a public boat ramp or park. This means that lake water has a distinct public good character to it. It is important to note, however, that the recreationists have no adjudicated (legal) rights to any quantity of water. Their only current recourse is to apply political pressure to LCRA and the State. It is also necessary to note that water becomes a private good when pumped from a river or lake and sold to consumers or producers.

The assumption of some minimum and maximum water level in Lake Travis is important to recreational interests. It seems clear that recreational value is sensitive to water level. At flood levels and drought levels, public and private property around the lakes becomes unusable. Boat ramps, picnic areas, and marinas are adversely affected. The aesthetic appeal of a lake is also adversely affected by unusually high or low water. Low water levels in particular expose barren, rocky banks and previously submerged litter. Thus, the recreational value is likely to be maximized as the water level approaches and stabilizes around the conservation reserve level. Hence, the question of increasing concern is how much of the water should be allocated to recreation and to each of the other competing uses?

Recreational and Aesthetic Price or Value

Total recreational and aesthetic value depends on several factors. Accessibility, water quality, topography, vegetation, water depth, weather conditions, distance to the lake, size of the body of water, and other characteristics may affect the desirability of the resource and influence people's willingness to pay for recreational and aesthetic benefits. People living on a lake, near a lake, or a considerable distance away from a lake may all place value on its recreational and aesthetic benefits. These benefits may be expressed by traveling to the lake, spending time on or beside the lake, buying property near the lake, buying recreational equipment to use in conjunction with it, working with others to preserve desirable features of the lake, and other activities. Clearly, there are a number of market transactions and nonmarket activities that indicate recreational and aesthetic value. This hedonic study of shoreline and "near the lake" properties will capture an important component of the recreational and "amenity" (aesthetic) values that are provided by the existence of such a lake. To estimate the total recreational and aesthetic value, other components would need to be added to the hedonic study component. These include: (1) the value to persons living outside the immediate area who travel to the lake to enjoy its benefits, and (2) a component for existence, bequest, or option value by those who never visit the lake yet who believe it to be beneficial. Furthermore, it is acknowledged that property owners around the lake may actually value the lake more highly than is reflected in their property value. In summary, all indications of value must be accounted for in order to estimate the total recreational and aesthetic value of a given lake. Hence, an hedonic study such as this may place a lower bound on the total recreational and aesthetic value of a lake.

This study focuses solely on the recreational and aesthetic value as reflected in the value of residential properties around the lake. It is hypothesized that within a certain proximity around a lake, residential property values reflect the recreational and aesthetic benefits received from a lake by the residents. The study attempts to isolate this value from the numerous valuable attributes and amenities that compose the total value of a residential property. The hedonic pricing method allows estimation of the marginal value of proximity as reflected in the market value of residential properties around Lakes Austin and Travis in Travis County, Texas.

Lake Level Implications

This study also explores some of the characteristics of a variable level lake (Lake Travis) that have policy relevance for water management. During its history, Lake Travis has experienced average monthly lake levels below 620 feet and above 700 feet. From January 1976 through May 1990 the average monthly level varied over a range of 50 feet with standard deviation of more than nine feet (LCRAa). Real estate practitioners in the area report variation in site values corresponding to the likelihood of maintaining water access. Therefore, it is useful to examine the relationship between lake level and residential land value. Hence, the first objective of this study is to identify those lake and housing characteristics significantly affecting property value. Second, the price paid for each lake amenity (RA characteristic) will be measured. Third, an estimated price model will be used to estimate the total market value (price) of RA benefits. That is, sum the market price of RA across all residences around the lake.

METHODOLOGY

Selection of Variables

A properly specified hedonic pricing model for housing includes all the important characteristics of that housing. Physical characteristics of the housing, as well as neighborhood characteristics and environmental characteristics of the area, must all be considered. Size of the dwelling, size of the lot, quality of construction, condition of the improvements, and garage or carport space are key structural features. Location is an important attribute of real estate in general. Location of housing around lakes is important since location defines accessibility to and view of the lake. Proximity to employment, shopping, leisure, and other economic activities are other important locational features.

Neighborhood characteristics, such as municipal and school services, are often important factors. Other neighborhood characteristics may include crime rate, racial mix, and other socio-economic characteristics. Local zoning ordinances and subdivision building codes may also influence the price of housing. Likewise, community property such as parks and boat ramps exclusively for the use of residents within a particular subdivision may be influential neighborhood characteristics.

Environmental characteristics may affect only a few residences, but more often affect a larger area such as a city or county. In this study, the presence of relatively clean, freshwater lakes and their associated amenities can be considered to be an environmental characteristic of some importance. However, the study area around the lakes in question is rather homogeneous with respect to economic and environmental factors, thus the influence of environmental factors is minimal. In fact, variation in lake level is perhaps the primary difference between the two lakes (other than Lake Travis being further from the City of Austin).

This analysis includes selected structural and locational characteristics, available neighborhood data, and variation in lake level. Selection of variables to be included is based on conversations with realtors, real estate appraisers, and ad valorem tax appraisers, plus personal inspection of the area. The particular characteristics used in the price equation are specified and defined later. The following section specifies the functional form of the model employed.

The Box-Cox Model

The literature shows the advantages of using the Box-Cox model. The linear Box-Cox subsumes several common functional forms and has been shown to be robust (Cropper, Deck, and McConnell). Economic theory indicates that no particular functional form is expected. The price equation may be linear, quadratic, log-linear, semi-log, or some other form. The Box-Cox form allows the data to reveal the functional form rather than the researcher imposing a functional form. Therefore, the model used in this study is specified as a linear Box-Cox transformation.[1] Its' general form is given by

$$(1)\quad \frac{Y^{\lambda}-1}{\lambda} = B_o + \sum_{i=1}^{k} B_i \frac{X_i^{\theta}-1}{\theta} + \sum_{j=1}^{m} \delta_j D_j + \varepsilon$$

where λ and θ are Box-Cox transformation parameters to be estimated, B_o, B_i, and δ_j are parameter estimates, ε is the residual, Y is the selling price of a residence, the X_i are non-negative, continuous variables, and the D_j are dummy variables or discreetly measured characteristics of housing.[2] ε is assumed to be normally distributed with mean, zero, and variance, σ^2.

Sample Selection

The local ad valorem assessment agency is the principal source of data. Travis County Appraisal District (TCAD) identifies individual properties by map grid then block, lot, and owner identification number, respectively. The sample area is identified by these rectangular map grids. The sample grids encompass all properties within approximately one mile to two and one-half miles of the lakes, depending upon the location of the lake within a particular map grid. Previous research regarding proximity of residences to lakes found that the contribution of a lake to property value approached zero between 2,000 and 4,000 feet (Dornbusch and Barrager, p. 33). An effort was made to collect records of all sales occurring from January 1988 through December 1990 within the sample area.

The data set contains 609 Lake Austin area sales and 593 Lake Travis area sales. Although the samples are not randomly selected, it is believed that they are representative of the area. There was a relatively large number of sales in each of the sample years. Furthermore, the sales appear to be adequately spread over the study area.

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[1] For further explanation, see Lansford.

[2] Transformed variables cannot be negative since X_i^{θ} is undefined for negative values of X_i when θ is between -1 and +1. Zero valued characteristics, such as dummy variables are not transformed since the transformation, $\frac{X_i^{\theta}-1}{\theta}$, equals ln X_i when $\theta = 0$ and ln 0 is undefined.

Descriptive Statistics - Lake Austin

Table 2 provides descriptive statistics for selected components of housing value around Lake Austin.[1] There are 609 viable sales included in the sample with dates of sale between January 1988 and August 1990, inclusive. The mean sale price was $188,050 with a standard deviation of $127,620. Similarly, the average house size, in terms of square feet of living area (IMPSF), is 2,557 square feet with a range of almost 9,000 square feet.

Table 2. Partial List of Descriptive Statistics for Residences Located On and Around Lake Austin

NAME	N	MEAN	STANDARD DEVIATION	MINIMUM	MAXIMUM	SUM
SPRICE*	609	188.050	127.620	14	905	114,520
IMPSF*	609	2.557	1.084	640	10	1,557
FRONTFT	609	112.9	192.98	31	4,755	68,757
CQUAL	609	4.78	0.80	3	7	2,909
WATFRT	609	0.062	0.242	0	1	38
BLUFF	609	0.012	0.107	0	1	7
VIEW	609	0.207	0.405	0	1	126
LDIST*	609	4.099	3.138	1	16	2,496
CDIST*	609	31.610	15.416	4.640	74	19,250
LLDEV	609	-0.104	1.712	-6.400	0.68	-63.34

* Expressed in thousands (000).

The typical residential lot has 112.9 feet of street frontage (FRONTFT). This amount varies greatly due to the odd shape of some lots and the relatively large size of others. Construction quality (CQUAL) varies between construction quality levels three and seven (assigned by TCAD) with a mean close to five. The standard deviation indicates that the majority of the sale residences are construction quality four, five, or six.

Thirty-eight of the residences are lake front properties and seven of these are on bluffs. (High bluffs with virtually vertical cliffs are characteristic of the lower part of Lake Austin.) One hundred twenty-six other residences are designated as "VIEW" locations, either having scenic views of the lake, the hills, or both. The variables WATFRT, BLUFF, and VIEW were discrete variables, represented in the model as a 1 if the observation had the variable and

[1] For a comprehensive list of characteristics used in this study, see Appendix A.

a 0 if it did not. All variables shown in Tables 3 and 4 with a minimum value of 0 and a maximum value of 1 were treated similarily.

The mean distance from a sale property to the lake (LDIST) is approximately 4,100 feet. The maximum LDIST is 15,680 feet. The mean distance from a sale property to the State Capitol in downtown Austin (CDIST) is about 32,000 feet. The range in CDIST is approximately 69,000 feet (about thirteen miles).

Finally, lake level deviation (LLDEV) shows an average deviation (in the three months prior to the sale date) of one-tenth foot below the long term average level. As discussed earlier, 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.

Descriptive Statistics - Lake Travis

Table 3 provides descriptive statistics for important components of housing value around Lake Travis.[1] There are 593 viable sales included in the sample with dates of sale between January 1988 and December 1990 inclusive. The mean sale price was $125,320 with a standard deviation of $85,091. Similarly, the average house size, in terms of square feet of living area (IMPSF), is 2,169 square feet with a range approaching 7,000 square feet. The typical residential lot has 95.6 feet of street frontage (FRONTFT). This amount varies greatly due to the odd shape of some lots and the relatively large size of others. Construction quality (CQUAL) varies between construction quality levels two and seven with a mean of 4.64. The standard deviation indicates that the majority of the sale residences are construction quality four, five, or six - about average for the study area.

The remaining residential characteristics can be described as locational factors. Forty of the residences are lake front properties but, unlike the Lake Austin sample, none of these are on bluffs. The water front properties are divided into three groups depending upon the elevation of the lots. It is hypothesized that lots with lower elevations will have greater RA value due to better access to the water. Ten of the water front properties have the 715 foot contour as their property line. Although these lots are "water front," they do not actually touch (extend to) the water. Nineteen water front lots have lot boundaries in the 670 to 680 foot range. These lots often have water on them but not always. (The mean level of the lake was 667 feet during the three year period under study.) Eleven more water front lots have boundaries extending well below 670 feet elevation. Some extend to the original river bed.

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[1] For a comprehensive list of characteristics used in this study, see Appendix B.

One hundred nineteen other residences are designated as "VIEW" locations, either having scenic views of the lake, the hills, or both. Ninety-two are identified as "lake view" (LVIEW) lots and twenty-seven as "other view" (OVIEW) lots.

Table 3. Selected Descriptive Statistics for Residences Located On and Around Lake Travis

NAME	N	MEAN	STANDARD DEVIATION	MINIMUM	MAXIMUM	SUM
SPRICE*	593	125.320	85.091	10.500	1,000.000	74,313.950
IMPSF*	593	2.169	.790	496	7.126	1,286.152
FRONTFT	593	95.58	38.38	30	641	56,676.06
CQUAL	593	4.64	0.75	2	7	2,749
WFHIGH	593	0.017	0.129	0	1	10
WFMED	593	0.032	0.176	0	1	19
WFLOW	593	0.019	0.135	0	1	11
LVIEW	593	0.155	0.362	0	1	92
OVIEW	593	0.046	0.209	0	1	27
LDIST*	593	3.715	3.182	1	13.306	2,203.242
CDIST*	593	84.540	11.308	55.055	108.850	50,132.410
LLDEV	593	-6.225	6.207	-18.06	4.04	-3,691

* Expressed in thousands (000).

The mean distance from a sale property to the lake is approximately 3,700 feet. The maximum LDIST is 13,300 feet. The mean distance from a sale property to the State Capitol is about 84,500 feet (sixteen miles). Finally, lake level deviation (LLDEV) shows the average deviation in lake level from the long-term average level in the three months just prior to the date of sale. During the three years (1988-1990), LLDEV averaged a little more than six feet below the fifteen year average lake level.

Estimated Hedonic Price Functions

The estimated hedonic price functions resulting from the Box-Cox routine (maximum likelihood function) are presented in Table 4. For the Lake Austin model the adjusted R^2 value (0.8774) is relatively large and the F statistic is highly significant. More than half the parameter estimates are significant at the $\alpha = 0.05$ level. Furthermore, the signs on the parameters are as expected in all cases for which there is a particular expectation.

Table 4. Estimated Hedonic Price Functions for Lakes Austin and Travis via Box-Cox Transformation using Iterative Ordinary Least Squares

LAKE AUSTIN			LAKE TRAVIS		
VARIABLE NAME	ESTIMATED COEFFICIENT	STANDARD ERROR	VARIABLE NAME	ESTIMATED COEFFICIENT	STANDARD ERROR
WATFRT	0.54922**	0.10547	WFHIGH	1.3582 **	0.26967
			WFMED	1.5564 **	0.20971
			WFLOW	1.2940 **	0.26047
VIEW	0.13725**	0.03601	LVIEW	0.32251**	0.09236
			OVIEW	0.30542**	0.15375
BLUFF	-0.05383	0.14809			
LTISD	-0.09550	0.08683	LTISD	0.19092*	0.11596
EISD	-0.03376	0.04678			
LISD	0.03866	0.09558	LISD	-0.23515	0.15787
CITY	-0.16165**	0.05038	CITY	-0.02180	0.08381
HCON	0.10749**	0.04613	HCON	0.44594	0.34918
LCON	-0.26154	0.20117	LCON	0.11443	0.22732
GARAGS	0.06623**	0.01720	GARAGS	0.17981**	0.04009
CPORTS	0.02660	0.02363	CPORTS	0.11620**	0.05047
			GOLF	0.17654*	0.10351
OBSOL	2.4143 **	0.43246	OBSOL	1.6423 *	0.95704
LLDEV	0.00747	0.00952	LLDEV	0.01655*	0.00870
IMPSF	0.38767**	0.01812	IMPSF	0.20305**	0.01221
CDIST	-0.07212**	0.00687	CDIST	-0.01041**	0.00203
LDIST	-0.03650**	0.01512	LDIST	-0.03130**	0.00805
CQUAL	0.84119**	0.08047	CQUAL	0.85076**	0.09863
TIME	-0.02902**	0.00972	TIME	-0.00965	0.01188
FRONTFT	0.04455**	0.01328	FRONTFT	0.06652**	0.01593
LDUM2	0.00940	0.00832	LDUM4	0.02230**	0.00608
CONSTANT	1.1702 **	0.48501	CONSTANT	3.4663 **	1.1576
λ	0.08	0.00130	λ	0.22	0.00137
θ	0.35	0.00	θ	0.77	0.00
LLF***-3,013.20			LLF***-2,825.17		
adj R^2	0.8774		adj R^2	0.7855	
F	218.48		F	99.55	
MSE	0.1137		MSE	0.5855	
N	609		N	593	

* Denotes significance at the α = .10 level.

** Denotes significance at the α = .05 level.

***LLF denotes Log-likelihood Function Value.

The Lake Travis hedonic equation parameter estimates are also shown in Table 4. The adjusted R^2 value (0.7855) is not as large as that of Lake Austin but still indicates that the model explains almost 79 percent of the variation in residential sale prices. Again, the F value is highly significant and more than half the parameter estimates are significant at the α = 0.05 level. In addition, four parameter estimates are statistically different from zero at the α = 0.10 level. Excluding the intercept, seventeen of the twenty-two parameter estimates are significant at the ninety percent or higher level (α Ŏ 0.10). Only one parameter estimate (for LCON) has an unexpected sign. Overall, both models appear to contain the primary components of housing prices.

Marginal Price Estimates

Marginal prices are the implicit prices of individual housing characteristics obtained from the first partial derivatives of the hedonic price function with respect to each characteristic. The nonlinear functional form implies marginal prices that are dependent upon all characteristics. This makes analysis of marginal prices more complex. For this reason, the analysis focuses on marginal prices of a typical (hypothetical) residence. Marginal price estimates of selected characteristics are shown in Table 5.[1] These marginal prices are for a typical 2,363 square foot house with a two car garage on a 105 front foot lot within a municipality. This house is of construction quality level five, has no obsolescence, and is in average condition. The time of sale is December 1990. The Lake Austin house described in Table 5 is in the Austin Independent School District (AISD) and is located 31,600 feet from downtown Austin. The Lake Travis house in Table 5 is in the Lago Vista Independent School District (LVISD) and is located 84,540 feet from downtown Austin. (The marginal prices shown for water front and bluff are for a water front home.) The remaining marginal prices are for an otherwise identical home located 2,000 feet from the lake. These characteristics are used since they are indicative of the sample properties.

The $80,000 to $100,000 premium paid for water front property is within the expected range. Although the marginal value for Lake Austin, $83,262, is smaller than that of Lake Travis for this hypothetical house, water front on Lake Austin is generally higher priced than that of Lake Travis (Table 5). Because the marginal prices are dependent upon all characteristics, larger water front homes common to Lake Austin imply larger water front premiums for these residences.

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[1] See Lansford for a comprehensive presentation of marginal price estimates for all characteristics.

Table 5. Estimated Marginal Values of Selected Housing Characteristics for Average Residences in Proximity to Lakes Austin and Travis

Lake Austin		Lake Travis	
Characteristic Name	Marginal Value	Characteristic Name	Marginal Value
WATFRT	83,262.0	WFHIGH	88,456.0
		WFMED	101,364.0
		WFLOW	84,274.0
VIEW	13,165.0	LVIEW	12,663.0
		OVIEW	11,992.0
BLUFF	-8,160.0		
CITY	-15,506.0	CITY	-856.0
GARAGS	6,353.0 /space	GARAGS	7,060.0 /space
CPORTS	2,552.0 /space	CPORTS	4,563.0 /space
		GOLF	6,932.0 /lot
LLDEV	717.0 /foot	LLDEV	650.0 /foot
IMPSF	47.60/sq.ft.	IMPSF	38.52/sq.ft.
CDIST	-1.64/foot	CDIST	-.87/foot
LDIST	-3.71/foot	LDIST	-6.17/foot
CQUAL	28,346.0 /step	CQUAL	23,070.0 /step
TIME	-271.0 /month	TIME	-166.0 /month
FRONTFT	92.68/foot	FRONTFT	152.08/foot

Those water front lots located on a bluff are estimated to sell for approximately ten percent less than those with better access (Table 5). This implies that direct lake access is worth about ten percent of the total water front premium. This may not actually be the case. Direct (or convenient) access may be worth more than this. Bluff locations often provide the best panoramic views of Lake Austin and the surrounding countryside. It is likely that the enhanced view value partially offsets the loss in access. However, insufficient data are available to test this hypothesis.

The scenic view characteristic for both lakes commands a similar premium. On Lake Travis, where lake view is differentiated from "other" views, it is interesting that lake view premium is slightly larger. Perhaps this is because most lake views also provide the "hill country" views typical of the area.

The marginal price of lake level deviation (LLDEV) is $717 per foot in Lake Austin and $650 per foot in Lake Travis. This implies that the hypothetical Lake Travis house will sell for $650 more if the water level at the date of sale is one foot above average. This finding is discussed more fully in a later section.

The marginal price of a square foot of living space differs by about $9 between the two lakes (Table 5). This difference seems excessive. Perhaps shopping, leisure time activities, and other benefits associated with a metropolitan area are reflected here (and not fully captured in CDIST). The opportunity cost of travel time could be an associated factor. Additionally, the real estate price slump beginning in 1985 may have impacted resort type properties around Lake Travis relatively more than prices in the predominantly non-resort, residential areas of Lake Austin.

The marginal price of moving from one construction quality level to another changes residential prices substantially, though similarly for both lakes. For Lakes Austin and Travis the increase in price for a one step increase in the level of construction quality is indicated to be $28,246 and $23,070, respectively (Table 5). Likewise, housing prices are declining at similar amounts per month even though TIME is only statistically significant for Lake Austin properties.

An additional front foot of residential lot commands a fifty percent higher price in the Lake Travis area. This seems contrary to expectations of higher property values around Lake Austin, but it may reflect, in part, the smaller average front footage of Lake Travis lots. That is, smaller lots will tend to have a higher price per front foot, other things being equal.

An increase in distance to downtown Austin is more costly in the Lake Austin area. At a marginal value of $ -1.67 per foot, it is double that of Lake Travis area housing (Table 5). This is the expected relationship - one of diminishing marginal cost. One reason for this is the relatively large number of commuters around Lake Austin. Lake Travis neighborhoods are both further from Austin and require greater travel time.

Finally, a key component of lake recreational value is proximity to the lake. Recreational value is shown to decline much more rapidly with distance from Lake Travis, sixty-six percent faster than that for Lake Austin (Table 6). However, this is only a point estimate. The following discussion shows the marginal price of LDIST to be larger (in absolute value) around Lake Austin when the distance to the lake is less than 1,000 feet.

Table 6. Predicted Sale Prices and Marginal Prices of Proximity to Lake for a Representative House at Varying Distance

	Distance from the Lake					
Lake	Water* Front	150 Feet	300 Feet	450 Feet	1,000 Feet	2,000 Feet
	Marginal Prices in dollars, $					
Austin	-1,104.12	-28.72	-17.94	-13.58	-7.80	-3.71
Travis	-58.79	-12.33	-10.40	-9.39	-7.58	-6.17
	Sales Price in thousands of dollars, $					
Austin	234.6	153.2	149.8	147.5	142.0	142.6
Travis	211.5	125.1	123.4	121.9	117.3	110.6

* Distance equals "1 foot" for water front properties.

Marginal Price of Proximity

Table 6 shows that the loss per foot with distance to the lake is about the same for the two lakes at a distance of 1,000 feet. At shorter distances, the value of proximity is substantially larger for Lake Austin. This is, the recreational value reflected by proximity to a lake is greater for Lake Austin than for Lake Travis at distances of less than 1,000 feet. However, this implied rapid decline in recreational value around Lake Austin results in lower marginal prices beyond 1,000 feet. At 2,000 feet the marginal price declines to -$3.71 per foot for Lake Austin but continues to decline more slowly for Lake Travis.

In addition to focusing solely on a hypothetical, "typical" house, it is also helpful to examine the RA value indicators for larger and smaller residences. Table 7 shows the average size Lake Austin residence plus residences approximately one standard deviation below and above the average. All other housing characteristics are held constant. The sale price estimates drop $49,000 - $91,000 between water front location and location 150 feet from the shore (reflecting the water front premium). Thereafter, prices decline more slowly, becoming asymptotic to some minimum. The model appears to adequately reflect housing prices over the range of residential size and location presented in Table 7.

Table 7. Predicted Sale Prices of Three Different Size Residences at Varying Distance from Lake Austin

House Square Feet	Water Front	Distance from the Lake 150 Feet	300 Feet	450 Feet	1,000 Feet	2,000 Feet
1,500	168.6	119.5	116.9	115.0	110.6	105.9
2,550	246.8	176.8	173.0	170.4	164.0	157.2
3,600	326.9	235.9	231.0	227.5	219.2	210.3

Predicted house prices are in thousands of dollars.

Table 8 shows the same analysis for Lake Travis. Again, price estimates are shown for the mean size home in terms of square feet and homes one standard deviation larger and smaller. All other characteristics are fixed at their mean values. Water front premiums are estimated to be in the $60,000 to $89,000 range. In contrast to Table 7, the set of distances in Table 8 is changed slightly to include 4,000 feet. Within these distances, the model predicts housing market prices included in the sample.

Table 8. Predicted Sale Prices of Three Different Size Residences at Varying Distance from Lake Travis when Lake Level is at the Average for the Study Period

House Square Feet	Water Front	Distance from the Lake 150 Feet	300 Feet	1,000 Feet	2,000 Feet	4,000 Feet
1,400	168.2	108.6	107.1	101.6	95.6	85.9
2,200	218.8	145.0	143.1	136.3	128.6	116.4
3,000	275.2	186.2	183.9	175.6	166.3	151.3

Predicted house prices are in thousands of dollars.

The Price of Deviation in Lake Level

Notice that Table 8 assumes that LLDEV is the same as the average value of the sample (six feet below the long-term average). The average size Lake Travis residence (2,200 square feet) located on the water front is estimated to be worth $6,800 more if the lake is at its long term average level rather than six feet below normal at the time of sale (Table 9). The smaller water front house (1,400 square feet) is predicted to sell for $5,400 more if the sale takes place at a time when the lake is at its long-term average level rather than being six feet below average. Overall, prices are indicated to be $3,200 to $8,000 higher if LLDEV is zero at the time of sale. In other words, a few feet change in water level is indicated to be worth thousands of dollars per home. Of course, the largest impacts are indicated for water front properties. The impact of water level declines with distance regardless of the size of the residence. Even at several thousand feet from the lake the model indicates higher prices for housing. This implies that higher lake level results in greater demand, not only for lake front properties, but also for those within relatively close proximity.

Table 9. Predicted Price Differences between Houses Sold at Zero and Negative Six Feet Deviation (LLDEV=0 and LLDEV=-6, respectively) from Long Term Lake Levels; Varying Distances from the Lake

House Square Feet	Water Front	Distance from the Lake 150 Feet	300 Feet	1,000 Feet	2,000 Feet	4,000 Feet
1,400	5.4	3.9	3.8	3.7	3.5	3.2
2,200	6.8	4.9	4.8	4.6	4.5	4.1
3,000	8.0	5.9	5.9	5.7	5.4	5.0

Estimated prices are in thousands of dollars.

These results raise some questions: (1) Do non-water front properties actually have greater value when the water level rises or do the price differentials presented in Table 9 indicate a flaw in the model? (2) What are the implications for water level management indicated by the answer to question (1)?

The first question is answered by deleting the water front observations and re-estimating the hedonic equation for Lake Travis. If LLDEV is still statistically significant, it indicates that lake level does have an impact on more than just the water front properties; it impacts the price of all properties within some proximity around the lake. Results of this estimation indicate that this is indeed the case. However, this result may lead to another question: is the level of the lake the only factor or do other factors such as seasonality play a role? The results of further tests indicate that seasonality, in general, is not a significant factor (Lansford).

The second question, regarding implications for water management, is more difficult to address analytically. The present analysis does not purport to provide a definitive answer.

One purpose of this study, however, is to examine the implications for lake level management. Recreation is now a residual water user since recreationists have no allocated quantity of water. Recreational use may be thought of as a byproduct of reservoir operations.

Agriculture controls legal water rights within the LCRA system, but is generally acknowledged as the low value user among consumptive users (Kelso, Martin, and Mack). As demand grows, it may be that agricultural and RA users will compete for the marginal water. Lake level management to meet the competing demands is expected to become increasingly difficult.

The results presented in Table 9 imply that the maintenance of higher water level in Lake Travis adds value to homes surrounding the lake and increases the RA portion of value. If this is true, both individual property owners within reasonable proximity of the lake and local officials interested in economic growth may want more water kept in Lake Travis. Homeowners seek to maximize their benefits in terms of RA returns and housing value. Local officials realize that greater local wealth tends to stimulate the local economy. Likewise, they realize that greater property values provide a larger tax base. A larger tax base allows either a lower property tax rate for the existing level of public services, more services for the same property tax rate, or some combination of the two.

Conversely, it is likely that downstream users will object to such action. Downstream users may use the same or similar arguments for maintenance of river flow. LCRA, as manager of these waters, will need to weigh the benefits and costs of water level policy for the entire region.

Lake View

The other housing characteristic to be examined is that of scenic view of the lake. Zoning, deed restrictions, and other institutions impact residential view value by limiting the types of structures that can be built, housing density, and building height, among other things. In this analysis, however, the goal is to isolate the amenity, lake view. The observations around Lake Travis are identified as having lake view, other view, or no view. The hedonic price model for Lake Travis implies that lake view is somewhat more desirable than scenic views of the countryside excluding the lake. However, it is difficult to argue that there is a significant difference in the premium paid for a view. The analysis does show that a view of the lake is just as valuable as other scenic views and without the presence of the lake, there would probably be fewer views to enjoy. Thus, it is suggested that the lakes provides RA value by way of scenic views that would not otherwise exist. This is especially true of Lake Travis which is much wider than Lake Austin and, therefore, more visible at a distance.

Summary

The estimated hedonic price functions for housing around Lakes Austin and Travis fit the data well and most of the parameter estimates are statistically significant and of the expected sign. Marginal value estimates appear to be reasonable for the amenities estimated. Those marginal prices related to recreational value of the lakes are shown to be significant components of total property market price. The water front property premium, lake view premium, marginal value of proximity, and lake level variability are all components of that portion of the recreational value of a lake reflected in housing prices. More specifically, they provide market prices of lake recreation and aesthetics. Water front lots have the largest portion of lake recreational value. Most home buyers pay premiums of $60,000 to $100,000 to purchase the amenities associated with these locations. Recreational value is found to decline rapidly at first as distance to a lake increases. At 1,000 feet from either lake the price declines at a rate of approximately $7.60 to $7.80 per foot. The marginal price of distance declines very slowly beyond approximately 2,000 feet. For Lake Travis, the lake level just prior to the date of sale has a significant impact on the sale price. The hedonic price function indicates that most lake area residences sell for $3,000 to $8,000 more if the water level is at its long-term average level rather than six feet below it. Lastly, a house with a view, whether it be of the lake or other scenery, is indicated to sell for a significantly higher price than a house without this attribute. The analysis indicates that a lake view is priced $700 to $900 above other scenic views but this may not be a statistically significant difference. The next section presents aggregation of recreational price estimates across homesites to estimate a total market value of lake recreational benefits.

Total Market Price of Residential Recreational Benefits

Four housing characteristics shed light on the marginal price of recreational benefits: water front premium, distance to lake, variation in lake level, and lake view. The water front premium and distance from the lake capture the price of proximity or access (a measure of consumer preference for water related recreation). Variation in lake level indicated by deviation of level from the long-term average level captures both an accessibility component and aesthetic component of RA value. The lake view premium captures an aesthetic component of recreational value. The price of these recreational benefits can be estimated using the estimated hedonic price equation by predicting housing prices with and without the

RA components. The difference in housing prices is an estimation of the RA benefits of the lakes.

Proximity to a lake is the key variable in these estimations. Homes close to or on the lake front command higher prices. The question is, at what distance from the lake do home buyers no longer pay for recreational benefits? Dornbusch and Barrager found benefits extending to distances of 2,000 to 4,000 feet on the lakes they studied. Brown and Pollakowski found benefits diminished seventy-five percent at a distance of 300 feet from the three lakes studied. Functional form, no doubt, plays a role here. The estimated Box-Cox functions in the current study indicate that the marginal price of lake distance becomes asymptotic to the axis. The implication is that the marginal price of recreation slowly declines but never reaches zero. However, conversation with local Travis County officials and appraisers (Corey; Welcome; Nuckles), plus the studies cited above indicate that anywhere from a few hundred feet to approximately 4,000 feet is more reasonable. Inspection of the marginal price of LDIST shows that the decline in marginal price "flattens out" at a distance of about 2,000 feet. Therefore, 2,000 feet is selected as the distance at which RA benefits become rather insignificant with regard to the market price of residences.

After estimating the distance at which recreational benefits approach zero (i.e. 2,000 feet), the process of estimating recreational benefits for each residence within 2,000 feet of a lake is relatively straightforward. The price of each residence within 2,000 feet is estimated "as is" and again as if it were located 2,000 feet from the lake in question. Summation of the differences suggests a total price of recreational benefits reflected in single family housing prices.[1]

Although the marginal RA value of proximity is deduced in this way, it is more difficult to capture the value of a lake view. The only accurate method of determining the existence of a view is to survey all residences. This being impractical and the lake view premium being of questionable significance, the RA premium for LVIEW is omitted in the analysis. Furthermore, lake level deviation is held constant at the mean of the sample observations.

The aggregate market value of residential recreational benefits are $65,860,596 and $49,164,089 for Lakes Austin and Travis, respectively (Table 10). In the Lake Austin study area, approximately 1,561 single family residences are located within 2,000 feet of the shore. The mean predicted price per residence is $193,444. This is reasonably similar to the sample average sale price of $188,050 (Table 2). The mean predicted sale price if the houses are at a

[1]Note that the lake views and other scenic views are not included since the data is unavailable for every dwelling.

distance of 2,000 feet from the lake is $151,253. This indicates a substantial average price of proximity to the lake of $42,191 per residence or 22 percent of the current location price. This result is due to the existence of numerous large, high quality homes located on or close to the water front in prime locations.

Table 10. Marginal Value of Recreational and Aesthetic Value Summary Statistics for Lake Austin; Residences with 2,000 Feet of the Lake

Variable	N	Mean	Standard Deviation	Maximum Value	Minimum Value	Sum
			Lake Austin			
Predicted Price in Current Location	1561	193,444	153,582	1,395,602	14,486	301,966,809
Predicted Price at 2,000 Feet	1561	151,253	110,918	940,434	9,718	236,106,213
Estimated RA Price	1561	42,191	64,991	524,722	55	65,860,596
			Lake Travis			
Predicted Price in Current Location	3,672	87,964	62,777	596,592	5,566	323,003,316
Predicted Price at 2,000 Feet	3,672	74,575	52,691	539,349	5,516	273,839,227
Estimated RA Price	3,672	13,389	24,127	189,110	0	49,164,089

In the Lake Travis study area, approximately 3,672 residences are located within 2,000 feet of the shore (Table 10). This is more than double the number around Lake Austin, yet is reasonable given that Lake Travis covers ten times the surface area of Lake Austin and, thus, has more shoreline. The mean predicted housing price is $87,964. This is well under the mean sample price of $125,320 (Table 3). This difference is probably due to a larger proportion of lower quality, "cabin" type structures around Lake Travis relative to Lake Austin. The mean predicted sale price of these houses at 2,000 feet from the lake is $74,575.

This implies a mean RA price of $13,389 per house (15 percent of the current location price).

Table 11 gives a break down of the estimated RA price by distance to the lake. As expected, the vast majority of the aggregate price is included in the price paid for water front properties. Within 2,000 feet of Lake Austin, 87 percent of the estimated RA is captured in the price of water front properties. For Lake Travis, this percentage drops to 75 percent. This difference reflects the larger proportion of houses on Lake Austin water front relative to Lake Travis. For Lake Austin, 33 percent (520 or 1,561) of the residences within 2,000 feet of the lake are on the water front. For Lake Travis, 18 percent (643 of 3,672) are on the water. In contrast to the above, for residences located 1,001 to 2,000 feet from the water's edge, the percent of sale price attributable to RA price is 2 percent, both for Lake Austin and for Lake Travis.

Table 11. Aggregate Marginal Recreational and Aesthetic Value Estimates by Distance from the Lakes

Distance	Number of Residences	Mean Price of Recreation	Total Price of Recreation	Percent of Total
		Lake Austin		
Water front	520	109,959	57,178,660	87%
0 - 500'	680	87,393	59,427,340	90%
501 - 1,000'	426	12,023	5,121,875	8%
1001 - 2,000'	455	2,882	1,311,382	2%
0 - 2,000'	1,561	42,191	65,860,596	100%
		Lake Travis		
Water front	643	57,499	36,971,580	75%
0 - 500'	871	44,991	39,187,261	80%
501 - 1,000'	1,192	5,985	7,133,701	14%
1,001 - 2,000'	1,609	1,767	2,843,127	6%
0 - 2,000'	3,672	13,389	49,164,089	100%

In summary, the difference in average recreational price per home is dramatically different between the two lakes. The average marginal price of recreation around Lake Austin is three and one-half times larger than that of Lake Travis. This substantial difference is likely due to more limited supply and greater demand for homes in the Lake Austin area.

Lake Austin has a smaller supply of homes due to its smaller size, steeper slopes, and building restrictions. Lake Austin is one-tenth the size of Lake Travis, hence there is simply less land area for homes. The terrain around the lake is more rugged, with steeper slopes and more bluffs as compared to Lake Travis. The constant water level is also a favorable factor. In 1986 the City of Austin adopted the Comprehensive Watershed Ordinance that imposes restrictions on development in the hills to protect the environment. This limits the supply of building sites. At the same time, the location, the hills, and Lake Austin are preferred by consumers. The proximity to employment, shopping, and other city amenities, combined with the scenic beauty of the hills and lake, make the Lake Austin area a rather appealing residential area. Hence, demand is relatively high. The results imply that demand is greatest for the water front properties.

Combining the aggregate marginal prices of recreational benefits from Lakes Austin and Travis gives a total in excess of $115 million, about fifty-seven percent of which comes from the Lake Austin area residents. These results provide estimates of part of the total recreational and aesthetic values for the lakes. Hence, they provide a first step in developing RA values that may be compared with other end use values for purposes of lake water management.

Implications for Lake Level Management

Estimates of the total or aggregate marginal price of RA benefits (with the specified limitations) allow estimation of the average RA market prices. However, it is marginal price that is of interest to water managers seeking to efficiently use resources. Economic theory shows that resources (inputs) are most efficiently used when the marginal prices (values) are equal across all uses of the resource. Hence, water is efficiently used when the marginal value (of the last unit) is equal across all uses (industrial, agricultural, residential, recreational, etc.). This section examines the implied marginal prices associated with changes in water level. Lake Austin is a constant level lake and is assumed to remain as such. Lake Travis' level varies according to weather conditions and the quantity of water demanded by municipal, industrial, and agricultural users. For these reasons, the discussion focuses on water level management of Lake Travis.

Among the results presented earlier is the significance of lake level deviation (LLDEV) in the Lake Travis model. The LLDEV regression coefficient is positive, implying that higher lake levels result in higher sale prices. The implication is that the higher sale prices are directly attributable to the RA benefits provided by the additional lake water. The average deviation in lake level in the three months prior to each sale is six feet below the average, long-term lake level of 673 feet. The following evaluation is restricted to lake levels at the sample mean LLDEV and two standard deviations above and below the mean. The estimated price function for Lake Travis is used to predict the aggregate price of housing at each level. That is, the aggregate market price of houses within 2,000 feet of Lake Travis is estimated for lake levels equal to 679, 673, 667, 661, and 655 feet (Table 12). (These levels are the sample mean lake level plus one and two standard deviations above and below it.) To estimate marginal changes in RA value, the aggregate housing price is estimated again for values of LLDEV equal to 680, 674, 668, 662, and 656 feet, each of these being a one foot increase in lake level with respect to the first set of levels. The difference in aggregate price at each level, divided by the difference in quantity of lake water at each level, provides an estimate of the marginal RA value per acre foot (Table 12).

Table 12. Estimated Marginal Value of Water in Recreational and Aesthetic Use Reflected in Housing Values around Lake Travis

	Lake Level (feet)	Predicted Aggregate Housing Price, $	Volume of Water in Lake Travis (acre-feet)	Price per Acre-Foot, $	95% Confidence Interval $/Ac.-Ft.*
	680	348,813,660	1,151,854		
	679	346,771,842	1,133,289		235.65
Change		2,041,818	18,565	109.98	-15.69
	674	336,704,899	1,044,154		
	673	334,719,713	1,027,044		245.34
Change		1,985,186	17,110	116.02	-13.29
	668	324,933,028	944,914		
	667	323,003,316	929,151		255.38
Change		1,929,712	15,763	122.42	-10.54
	662	313,491,130	853,473		
	661	311,615,747	838,940		265.46
Change		1,875,383	14,533	129.04	-7.38
	656	302,372,374	769,088		
	655	300,550,189	755,648		274.93
Change		1,822,185	13,440	135.58	-3.77

* See Lansford for the confidence interval estimation method.

The indicated marginal prices of RA benefits appear to be reasonable. The decline in marginal price from $136 per acre-foot at 656 feet MSL to $110 per acre-foot at 680 feet MSL, shows the expected relationship. This result may be attributed to diminishing marginal returns[1] and the increasing capacity of the lake at higher elevations.

These marginal prices of Lake Travis RA benefits are generally smaller than the marginal value of water used in municipal, industrial, and many agricultural uses. Note that the marginal price estimates presented in Table 12 are the capitalized value of homeowners perceived future benefits, as opposed to annual values. Many studies of water value report annual marginal value products (MVP's) of water use. However, Chang and Griffin report actual water purchases by municipalities in the Lower Rio Grande Valley of Texas. These market transactions are at prices of $500 to $600 per acre-foot. Chang and Griffin also estimate the net present value[2] (NPV) of water in cotton production in the same region. Two scenarios are presented: (1) the NPV including government farm program deficiency payments and (2) the NPV without deficiency payments ("social water values"). Depending upon the price and yield of cotton, the first scenario indicates NPV's of water ranging from $306.58 to $2,336.29 per acre-foot. The second scenario indicated NPV's of water ranging from -$72.41 to $1,600.60 per acre-foot. Hence, a comparison with their analysis suggests that the marginal price of water in residential RA use is lower than that in municipal use and may also be less than that in cotton production depending upon the various variables and assumptions used.

Because estimates of the marginal value of water are often expressed in terms of annual values, comparison can be facilitated by annualizing the capitalized marginal value estimates presented in Table 12. Discount rates of two, four, six, eight and ten percent and time periods of 10, 30, and 50 years provide a matrix of annualized marginal RA values ranging from $3.69 to $20.99 per acre-foot for water levels one standard deviation above and below the sample mean.[3] Gibbons cites several studies of annual marginal value product of water in crop production throughout the United States. The MVP's per acre-foot range from less than $15 per acre foot for grain sorghum in New Mexico to $698 per acre-foot for potatoes in Idaho.

In summary, the annual MVP's of water in municipal and agricultural uses generally exceed the recreational and aesthetic MVP's found in this study of housing. Yet the RA

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[1] Diminishing marginal returns is the economic concept that says that as someone gets more and more units of a particular item, the lower is the value to the individual of each additional unit.

[2] The net present value computations are based on a fifty year period and 6 percent discount rate.

[3] The range of discount rates and time periods gives consideration to both private and social rates and similar variance in the projected lifetime of RA benefits.

benefits examined in this study do not reflect all recreational and aesthetic use of lakes. A complete assessment of recreational and aesthetic value includes the value of the lake to persons traveling to the lake from remote areas plus the value of the lake to those who may never visit the lake but place value on the benefits offered (option and existence values). Thus, a proper comparison of marginal value among water uses requires the addition of other components of recreational and aesthetic value to the housing RA component estimated in this study. Those components include the value to persons traveling to the lake from other areas, the value to commercial, industrial, and agricultural land owners in the area, and the potential "existence" value to persons who may never visit the lake.

Conclusions

Lakes have a substantial impact on riparian property values. This impact can be attributed to the recreational and aesthetic characteristics accruing to property located near a lake. The study described in this paper indicates significant demand by homeowners for the lake amenities. However, since non-consumptive users of lake water have no legal rights to the water, it seems advisable that some mechanism be put into place that recognizes this set of consumer preferences. Perhaps homeowners would be willing to compensate consumptive users (who own the water rights), such as rice farmers, in order to maintain water level in the variable level lake.

Lake managers, legislators, and others exercising authority over public bodies of water need to consider recreational interests when appropriating water rights. Ideally, allocation of water rights will be such that the resource is efficiently used, maximizing the benefits. The information needed to guide water managers in this endeavor probably requires a comprehensive watershed study of water use and marginal values from each use. A study of riparian property values can be one component of a system-wide study.

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Appendix A

Descriptive Statistics for Residences Located On and Around Lake Austin

NAME	N	MEAN	STANDARD DEVIATION	MINIMUM	MAXIMUM	SUM
TIME	609	15.54	8.84	1	32	9,464
SPRICE*	609	188.050	127.620	14.000	905.000	114,520.200
IMPSF*	609	2.557	1.084	640.000	9.603	1,556.901
SPPERSF	609	69.68	25.39	13.622	260.91	42,434.87
GARAGS	609	1.787	1.061	0	4	1,088
CPORTS	609	0.238	0.665	0	4	145
FRONTFT	609	112.9	192.98	31	4,755	68,756.97
CQUAL	609	4.78	0.80	3	7	2,909
HCON	609	0.107	0.309	0	1	65
ACON	609	0.888	0.315	0	1	541
LCON	609	0.005	0.070	0	1	3
OBSOL	609	0.994	0.032	0.710	1	605.37
WATFRT	609	0.062	0.242	0	1	38
BLUFF	609	0.012	0.107	0	1	7
VIEW	609	0.207	0.405	0	1	126
LDIST*	609	4.099	3.138	1	15.680	2,496.058
LDUM2*	609	3.851	3.393	.001	15.68	2,345.058
CDIST*	609	31.610	15.416	4.640	73.575	19,250.440
AISD	609	0.310	0.463	0	1	189
EISD	609	0.593	0.492	0	1	361
LTISD	609	0.061	0.239	0	1	37
LISD	609	0.036	0.187	0	1	22
CITY	609	0.424	0.495	0	1	258
COAUS	609	0.343	0.475	0	1	209
COWLH	609	0.058	0.233	0	1	35
CORW	609	0.023	0.150	0	1	14
LLDEV	609	-0.104	1.712	-6.400	0.68	-63.34

* Expressed in thousands (000).

Appendix B

Descriptive Statistics for Residences Located On and Around Lake Travis;

NAME	N	MEAN	STANDARD DEVIATION	MINIMUM	MAXIMUM	SUM
TIME	593	16.61	8.35	1	36	9,847
SPRICE*	593	125.320	85.091	10.500	1,000.000	74,313.950
IMPSF*	593	2.169	.790	496	7.126	1,286.152
SPPERSF	593	55.936	22.171	6.280	212.50	33,169.76
GARAGS	593	1.783	1.065	0	4	1,057
CPORTS	593	0.283	0.745	0	4	168
FRONTFT	593	95.58	38.38	30	641	56,676.06
CQUAL	593	4.64	0.75	2	7	2,749
HCON	593	0.008	0.092	0	1	5
ACON	593	0.966	0.181	0	1	573
LCON	593	0.025	0.157	0	1	15
OBSOL	593	0.994	0.034	0.68	1	589.28
WFHIGH	593	0.017	0.129	0	1	10
WFMED	593	0.032	0.176	0	1	19
WFLOW	593	0.019	0.135	0	1	11
LVIEW	593	0.155	0.362	0	1	92
OVIEW	593	0.046	0.209	0	1	27
LDIST*	593	3.715	3.182	1	13.306	2,203.242
LDUM4*	593	2.879	3.715	.001	13.306	1,707.300
CDIST*	593	84.540	11.308	55.055	108.850	50,132.410
LISD	593	0.164	0.370	0	1	97
LVISD	593	0.147	0.354	0	1	87
LTISD	593	0.690	0.463	0	1	409
CITY	593	0.690	0.463	0	1	409
VOLW	593	0.516	0.500	0	1	306
COJT	593	0.051	0.219	0	1	30
COLV	593	0.123	0.329	0	1	73
GOLF	593	0.125	0.331	0	1	74
LLDEV	593	-6.225	6.207	-18.06	4.04	-3,691

* Expressed in thousands (000).

APPENDIX C

Variable Names Defined

TIME is assigned according to date of sale and is meant to capture any time trend in sale prices. For January 1988, TIME = 1. For December 1990, TIME = 36.
SPRICE is the sale price of the property.
IMPSF is the number of square feet of improved (heated living) area.
GARAGS is the number of garage car spaces.
CPORTS is the number of carport spaces.
FRONTFT is the number of linear feet along the front property line of the lot.
CQUAL is a construction quality index assigned by Travis Central Appraisal District.
HCON represents better than average condition of the residential improvements (structures).
ACON represents average condition of the residential improvements (structures).
LCON represents worse than average condition of the residential improvements (structures).
OBSOL is a measure of "percent good," that is, 100% - percent obsolescence (functional and economic) as measured by Travis Central Appraisal District.
WATFRT is a dummy variable to identify properties located on the water front.
BLUFF is a dummy variable to identify properties located on a bluff, on the water front.
VIEW is a dummy variable to identify properties with a scenic view.
LVIEW is a dummy variable to identify properties with a scenic lake view.
OVIEW is a dummy variable to identify properties with a scenic view other than a view of the lake.
LDIST is the number of feet the sample property is from the water front. For water front properties, LDIST = one foot.
LDUM2 is a dummy variable intended to capture change in slope of the hedonic function beginning at 2,000 feet from the Lake Austin.
LDUM4 is a dummy variable intended to capture change in slope of the hedonic function beginning at 4,000 feet from the Lake Travis.
CDIST is the number of feet from the sample property to the central business district of downtown Austin.
AISD is a dummy variable for Austin Independent School District.
EISD is a dummy variable for Eanes Independent School District.
LTISD is a dummy variable for Lake Travis Independent School District.
LISD is a dummy variable for Leander Independent School District.
LVISD is a dummy variable for Lago Vista Independent School District.
CITY is a dummy variable for sample properties located within a municipality.
COAUS is a dummy variable for properties located within the City of Austin.
COWLH is a dummy variable for properties located within the City of West Lake Hills.
CORW is a dummy variable for properties located within the City of Rolling Wood.
COJT is a dummy variable for properties located within the City of Jonestown.
COLV is a dummy variable for properties located within the City of Lago Vista.
VOLW is a dummy variable for properties located within the Village of Lakeway.
GOLF is a dummy variable for properties located adjacent to a golf course fairway.
LLDEV is the number of feet that the three month avearage lake level (month of sale and two prior months) varies from the long term average lake level.