ISSN 1070-1516

Lakefront Property Owners' Economic Demand for Water Clarity in Maine Lakes

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Miscellaneous Report 410 **September 1998**

MAINE AGRICULTURAL AND FOREST EXPERIMENT STATION
University of Maine

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This research was supported by the Maine Agricultural and Forest Experiment Station, Maine Department of Environmental Protection, and the University of Maine Water Research Institute.

CONTENTS

INTRODUCTION 1

LAKE MANAGEMENT IN MAINE 2

HEDONIC MODELS 3

MODEL 4

DATA 7

RESULTS 10

EXTENSIONS AND LIMITATIONS 15

CONCLUSIONS 15

REFERENCES 16

APPENDIX I—MEAN VALUES FOR VARIABLES BY LAKE GROUP AND FOR EACH LAKE WITHIN THE GROUPS. 17

APPENDIX II—REGRESSION RESULTS FOR THE FIRST STAGE HEDONIC-PRICE EQUATIONS. 20

FIGURES

1. Expected relationship between property prices and water clarity. 4
2. Demand for lake-water clarity 7
3. Estimated demand for lake-water clarity 14

TABLES

1. Explanatory variables included in hedonic, property-price equations. 5
2. Department of Environmental Protection lake monitoring data for study lakes. 8
3. Lake restoration projects (DEP 1993). 9
4. Descriptive Statistics for Variables in the Hedonic Price Equations. 10
5. Equations with grand constant for calculating implicit prices for individual lakes. 11
6. Changes in property prices on selected lakes for a one meter (1m) change in water clarity. 12
7. Estimated Second-Stage, Demand Equations 13

INTRODUCTION

Maine is a state that takes great pride in the quality and abundance of its natural resources. Maine's freshwater lakes and ponds, covering close to a million acres, play a key role in defining the natural landscape of the state. These freshwater bodies provide recreational and economic opportunities to the people of Maine as well as aesthetic beauty and habitat for many species of flora and fauna.

While Maine is known for clear, high-quality lakes, lake-water quality is threatened by organic enrichment (Maine Department of Environmental Protection 1990). Currently, 260 lakes and ponds totaling more than 238,188 acres do not meet federal and state standards for swimming, aquatic life support, or trophic status.[1] There are 44,004 additional acres considered to be unimpaired but threatened (Maine Department of Environmental Protection 1996). The threat to lake-water quality is due mostly to nonpoint source pollution originating from excess runoff from development, silviculture, and agriculture (Maine Department of Environmental Protection 1989, 1994). The general symptom of increased nutrient loading, eutrophication, is manifested by increased photosynthetic productivity, primarily in the form of algal growth. Excess algal growth leads to decreased water transparency and reduced oxygen content in the water, and it often causes changes in a lake's biological community such as in the distribution of fish species (Monson 1992; Cooke et al. 1993). Eutrophication that does not occur naturally, but is induced by human activity, is known as cultural eutrophication and is the most important cause of poor water quality in Maine's lakes. Reduced water clarity associated with eutrophication reduces a lake's aesthetic appeal, decreases recreational benefits, and lowers the prices of properties around the lake.

Although eutrophication is characterized by changes in water quality measurements such as dissolved oxygen levels and chlorophyll levels, water clarity is the most observable manifestation to the public. Water clarity is typically measured using a secchi disk.[2] Water clarity is correlated with other indicators of cultural eutrophication such as chlorophyll levels, dissolved oxygen, fish habitat, and swimmability. Secchi disk data are available through the DEP lake-monitoring program.

Protecting lake water is not without costs, and monies to prevent and reduce eutrophication have been allocated with little or no information about the economic benefits of protecting lake-water clarity. During the 1980s, $80,000 to $250,000 a year had been allocated by the state for lake protection and restoration. Information about the economic effects of protecting lake-water clarity would be useful in prioritizing lake management efforts, and in public education programs to reduce eutrophication.

Lakefront property owners are potentially the recipients of the greatest economic gains from improved lake-water clarity because the benefits of water clarity can be capitalized in the prices of lakefront properties. These same lakefront owners may also directly affect lake-water clarity through the actions they take on their properties. A 1996 study by Michael et al. (Michael study hereafter) took a first look at the effect of lake-water clarity on the prices paid for lakefront properties. A hedonic model (Freeman 1993) can be used to estimate the share of property prices that are attributable to property characteristics such as water clarity. The word hedonic comes from individuals acting in their own self-interest to select the property with the most desirable set of characteristics. Thus, all other characteristics being equal, people will pay more for a property on a lake with high water clarity than they would for a property on a lake with lower water clarity.

The purpose of this report is to update the Michael study that estimated the effects of water clarity on lakefront property prices for six groups of lakes ranging from a Lewiston/Auburn group in southern Maine to a northern Maine group in northern Aroostook County. Michael collected data during the summer 1994 for lakefront property sales that occurred between January 1, 1990, and June 1, 1994. Sales prior to 1990 were not selected to avoid the speculative real estate market for lakefront properties that occurred in the late 1980s. Data on sale prices and property characteristics were obtained from town offices for lakes located in Maine's organized communities. These data were obtained from the State Bureau of Taxation for lakes located in Maine's unorganized territories. Water clarity data were provided by the Maine Department of Environmental Protection. The Michael study was able to estimate hedonic equa-

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[1] Trophic means nutrition or growth. The trophic state of a freshwater pond or lake indicates the level of photosysnthetic activity in the lake (algae and aquatic plant growth).

[2] Secchi disks are round disks that are white and black on alternating quadrants. The disks are lowered into the water on a metered line. The point where the disk disappears from sight is a measure of water-clarity.

tions with water clarity as one of the variables explaining variation in sales prices for four lake groups; Lewiston/Auburn area, Augusta area, Waterville area and northern Maine. Hedonic models were not estimated for two lake groups. A Newport/Dexter area model could not be estimated because communities in this area do not maintain sufficient data on property characteristics to describe differences in sale prices. A model could not be estimated for an Ellsworth area group due to all lakes in the group having similar levels of water clarity.

The current study refines estimates presented in the Michael study. First, an additional year and a half of sales data were collected (June 1, 1994 through December 31, 1995). As the number of sales in any given year is not large, and the real estate markets have been quite stable in Maine in the 1990s, adding more observations increases the confidence that can be placed in the estimated hedonic equations. Second, a seventh lake group was added in the midcoast (Camden area). All of the lake groups in the Michael study included large lakes that are typically over 1,000 acres in surface area, while most of the lakes in the Camden area are less than 1,000 acres in surface area. Adding the Camden group allowed the analysis to provide insights about the effects of water clarity on property prices in small, coastal lakes. Third, the treatment of missing water clarity observations was handled more systematically. When water clarity data were missing for some lakes in some years, Michael used data from the most recent preceding year for which water clarity data were available to replace missing water-clarity data. In the current study, lakes were excluded from the analyses if water-clarity data were not available for more than 50% of the study years. For lakes with water-clarity data for more than 50% of the years, but still missing water-clarity data for some years, water-clarity equations were used to predict the missing levels of water clarity. This approach removes the restrictive assumption imposed in the Michael study that missing water clarity data implied that water clarity was constant over the respective time periods.

The remainder of this paper presents the results of the analysis of the seven market groups described above. Hedonic equations, with water clarity as one of the variables explaining variations in sales prices, are estimated for each of the seven lake groups. These equations can be used to identify the effects of lake-water clarity on lakefront property prices, i.e., the implicit prices of water clarity. This information can be useful in public education efforts to educate landowners that actions they take on their properties to protect water clarity can have a direct effect on the values of their properties. We also combine the data from the lake groups to estimate a demand equation that portrays the marginal amounts that people are willing to pay for cleaner lakes (Freeman 1993; Palmquist 1991). The demand equation can be used to measure the benefits (losses) from improving (degrading) water clarity for benefit-cost analyses of lake protection efforts.

LAKE MANAGEMENT IN MAINE

The water quality standards of the Clean Water Act (1977) and related state standards require lakes to support uses for fishing, swimming, aquatic life support, and human fish consumption. A major management goal for the Maine DEP is to maintain a stable or decreasing trophic state for Maine (DEP 1994). Lakes may be categorized as eutrophic (high nutrient levels and high plant growth), mesotrophic, or oligotrophic (low nutrient concentrations and low plant growth). Of the 695 lakes greater than 10 acres in size for which the Maine Department of Environmental Protection (DEP) has monitoring data, 79% are mesotrophic, with 12% and 9% rated as eutrophic and oligotrophic, respectively. The trophic status of a lake is affected by the age and shape of the lake, geology of the watershed, ratio of watershed area to lake area, flushing rate of water through the lake, human impact, and other factors. Therefore, lakes that are lumped into one category such as eutrophic, may each have a unique set of attributes that contribute to their trophic status (Monson 1992).

To prevent the degradation of Maine's lakes, DEP sets lake protection policies and undertakes lake restoration projects. While regulation, education, technical assistance, and restoration are all components of a comprehensive lake management plan for the state, preventative management strategies are emphasized. The future of Maine lake-water quality will depend greatly on how well DEP promotes evolving guidance for protection and educates Maine citizens about lake-water quality. Restoration of lake-water quality, with its great expense and technical difficulty, will be rare and emphasis will remain on planning for protection and the inevitable growth of development in lakes watersheds (DEP 1990:42). Large-scale restoration projects can range in cost from $100 to well in excess of $2,000 per acre (Cooke et al. 1993), while education programs are less costly in terms of direct expenditures. The more informed property owners are of the nonpoint source pollution causes of lake eutrophication and the benefits they enjoy by protecting lakes from cultural eutrophication, the more incentives they will have to take voluntary actions to prevent nonpoint source pollution and to support lake protection regulations. The effect of water quality on the price of lakefront properties can provide a substantial incentive for individual property owners to take actions to protect lake-water clarity.

HEDONIC MODELS

Lakefront properties are heterogeneous goods; they have a number of characteristics and are differentiated from each other by the quantity and quality of these characteristics. When consumers purchase differentiated goods, they are purchasing the characteristics that make up that good (Lancaster 1966). If the quality of one characteristic changes, we expect the price of the good to change. If consumers have a choice in the quantity and quality of characteristics of a market good, and an environmental amenity is a characteristic of the market good, then the implicit price of a nonmarket amenity, such as water clarity, can be observed through consumers' purchases in the market. If two lakefront properties are exactly the same and only differ by the level of water clarity for their respective lakes, the price differential between the two properties is the implicit price paid for water clarity. Most comparisons are not this simple and a hedonic model can be used to control for other characteristics of properties when estimating the effect of water clarity on overall property prices. The value of environmental amenities (or disamenities) are capitalized in the value of the land, not the structure or other improvements on the land, so it is important to net out these other property characteristics when attempting to isolate the price effect of the environmental variable.

Hedonic pricing techniques have been used in a wide variety of applications to estimate prices of nonmarket amenities that may be capitalized in the price of a property, ranging from earthquake risk perception (Brookshire et al. 1988) to countryside attributes (Garrod and Willis 1992). The most common application has been the measurement of the effect of air pollution on property prices (Anderson and Crocker 1971; Murdoch and Thayer 1988; Graves et al. 1988; Brucato et al. 1990; Smith and Huang 1995). Hedonic property models have also been used to measure the implicit price that property owners pay for water quality as a portion of the overall prices of properties in a number of studies (David 1968; Epp and Al-Ani 1979; Feenberg and Mills 1980; Young and Teti 1984; Brashares 1985; Mendelsohn et al. 1992).

The earliest study that used a hedonic model to estimate the implicit price of water quality was done for artificial lakes in Wisconsin, using a subjective water quality rating of poor, moderate, or good (David 1968). David (1968) found that water quality significantly affected property prices.

Epp and Al-Ani (1979) examined the effect of water quality on rural nonfarm-residential property prices. A subjective variable developed from property owners' impressions of acidity and several other physical measures of water quality were tried in this study. The investigators found that owners' perceptions of water quality and acidity had significant effects on the property prices, but only measures of acidity had a consistently significant negative effect. Therefore, acidity was used as the physical indicator of water quality in the model.

Feenberg and Mills (1980) built upon an air pollution study done by Harrison and Rubinfeld (1978) in the Boston area by adding water quality into the hedonic equation. Thirteen physical measures of water quality were considered. Of the thirteen water quality variables, oil and turbidity (a measure somewhat analogous to water clarity) showed the strongest correlation with property prices and were included in the final model.

Young and Teti (1984) estimated a hedonic model to determine the impact of water quality on the price of seasonal homes adjacent to St. Albans Bay on Lake Champlain in northern Vermont. Properties outside the bay were compared with properties around the bay. They found that degraded water quality in the bay significantly depressed property prices relative to properties outside the bay.

Brashares (1985) estimated the implicit price of lake-water quality for 78 lakes in southeast Michigan. Brashares considered eight different measures of water quality and found that only turbidity (which is analogous to secchi disk measurements of clarity used in the current study) and fecal coliform were significantly correlated with property prices. Turbidity is another water quality measure that is visible. Fecal coliform levels, although not visually perceptible, were monitored by the state board of health and were reported to potential property buyers.

These studies, and the Michael study, show that water quality can significantly affect property prices and provide insight for the design of this study. Water quality variables not perceivable to the public, although important to water quality managers, are not likely to be capitalized into property prices (Brashares 1985). Subjective measures of water quality, although statistically significant, may only be applicable to the individual case study for which they are developed, and may be problematic for policy-makers because questions arise concerning how to equate changes in subjective perceptions with biological changes in the lake (Young 1984). Therefore, a nonsubjective measure of water quality that is readily perceivable to property buyers and sellers is most likely to affect property prices. Secchi disk readings of water clarity satisfy these criteria.

Only two studies have used a hedonic-price model of property sales to estimate the demand for property characteristics (Palmquist 1984; Parsons 1986). Both of these studies estimated the demand for housing characteristics, not the demand for environmental characteristics. The approach to estimating the demand for property characteristics, including environmental characteristics, involves estimating first-stage, hedonic equations that express the sale prices of properties as a function of the characteristics of the property for a number of real estate markets. This was done in the Michael study using different lake groups to represent different real estate markets. The estimated coefficients on the property characteristics of interest, water clarity in our case, are used to derive implicit prices for the respective attribute. Estimating separate equations for different market groups provides variation in the implicit price data, i.e., the same level of water clarity would have different implicit prices in each market. The implicit prices and the respective levels of water clarity are then used to estimate a demand equation where water clarity is expressed as a function of the implicit price for water clarity and other variables that might explain why people choose different levels of water clarity when choosing a lake to purchase a property on. This approach is outlined in Freeman (1993) and Palmquist (1991).

MODEL

The hedonic-price equations for this study express the property price (PP), as a function of property characteristics (P), characteristics of structures on the property (S), characteristics of the property location (L), and the natural log of water clarity (WATERC) multiplied by the total surface area of the lake (SA).

$$PP = f(P, S, L, \ln WATERC*SA).$$

Water clarity is expressed as the natural log in the equation to reflect an expected nonlinear relationship between property prices and water clarity (Figure 1). While a modest change in water clarity is quite noticeable at low levels of water clarity, a similar change in water clarity on a very clear lake can be imperceptible. Smeltzer and Heiskary (1990) have demonstrated that changes in clarity occurring from a base level above four meters are less noticeable than changes in clarity below this threshold. A separate hedonic equation is estimated for each of the seven groups of lakes.

A time-series, or repeat-sales model, is sometimes used to estimate hedonic price models to identify the effect of environmental variables on property prices. These models are used when an event has occurred, such as the announcement of a leaking toxic waste dump, to investigate how property prices change over time. Lake eutrophication is a slow process and a repeat sales model would require a long history of sales data and accompanying water quality data, and would cover a sufficient time that structural changes may occur in the real estate market. In turn, cross-sectional data on sales of different properties are used in this study for a number of reasons. First, trends in water clarity change slowly so a long period of time is required to capture the change in the market for lakefront properties. Second, when using time-series data, market trends must be accounted for in the model. For example, lakefront property prices increased dramatically in the late 1980s in Maine and then rapidly decreased in value. Third, transfer tax records were required by law to be held as public records after 1986 in Maine. Records of transfers occurring before that date are not generally avail-

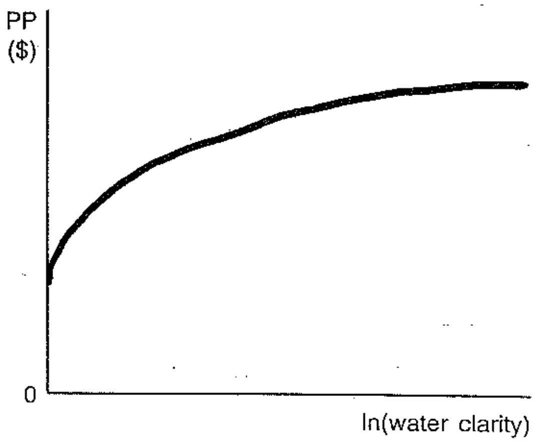

Figure 1. Expected relationship between property prices and water clarity.

able. Finally, accurate property characteristics for historical sales are not available. Property records are updated with each new assessment and only reveal the most recent data.

Only one land characteristic was included in the model: feet of frontage on the lake (Table 1). Other land characteristics that might be considered include the shape and size of the lot. Neither of these variables were recorded consistently on property records. Moreover, frontage on the lake appears to be the key attribute of both developed and undeveloped lakefront properties in Maine, which are often priced in terms of lake frontage.

The structural and locational variables included in the model were based on a review of previous studies, unique characteristics of lakefront properties, and availability of property data. Structural characteristics chosen are the natural log of the square feet of living area ln(LVAREA). The natural log of living area is used because of diminishing marginal returns. Initially, extra living area provides needed space, however, a threshold is likely to be reached more space will not be as important as previous increments of living area and may also be diminished by increased maintenance costs. For recreational homes, characteristics that distinguish camp style construction from year-round residential living also need to be included, so information about the type of bathroom facilities (FULLBATH), source of water (LKWATER), and heating system (HEAT) were collected from property records. The presence of, or increase in size of, all of these variables except LKWATER are expected to increase the price of a house so the coefficients on these variables are expected to be positive. LKWATER is expected to be negative because of the inconvenience of pumping water from the lake and the health risks associated with drinking this water.

Locational characteristics or neighborhood characteristics are included to control for local amenities that contribute to the price of a property. The locational variables incorporated into the model are housing density along the lake within 500 feet on both sides of the property (DNSTY) and distance to the largest community in the vicinity of the lake (DIST). The housing density variable was constructed by counting the number of lots that fell within one thousand feet of shore frontage around the sale property. The DIST variable was constructed by measuring the distance to a common city for each lake group, which would be the business/shopping center for the area. For example, all of the properties in lake group 1 were measured to Auburn.

Dummy variables for lakes with special features or circumstances were also included in the hedonic-price model (ANDROSCG, PUSHAW, PHILLIPS, and PITCHER). These lakes were singled out because their special circumstances

Table 1. Explanatory variables included in hedonic, property-price equations.

Variable Type/Name	Description
Property Characteristics	
FF	feet of frontage on the lake
Structural Characteristics	
LVAREA	square feet of living area
FULLBATH	1= full bath, 0 otherwise
LKWATER	1= primary source of water is directly from the lake, 0 otherwise
HEAT	1= central heating system (oil, electric, or wood), 0 otherwise
Locational Characteristics	
DNSTY	lots/1000 ft of frontage adjacent to property
DIST	distance to nearest city (miles)
ANDROSCG	1= property located on Androscoggin Lake, 0 otherwise
PUSHAW	1= property located on Pushaw Lake, 0 otherwise
PHILLIPS	1= property located on Phillips Lake, 0 otherwise
PITCHER	1= property located on Pitcher Pond, 0 otherwise
LKAREA	area of the lake (acres)
Environmental Quality Variable	
WATERC	secchi disk readings (meters) of the minimum clarity in the lake during the summer months for the year the property was sold

influenced house prices on these lakes in unique ways that are not accounted for by the other explanatory variables in the model. Androscoggin and Pushaw lakes are large, shallow lakes that experience seasonal flooding. Phillips Lake and Pitcher Pond are lakes in highly desirable locations near Bangor and Camden, respectively. These proximities have led to a bidding up of property prices above levels experienced for properties on other lakes in the respective lake groups.

Water clarity (WATERC) was expressed as the minimum clarity during the summer months (June 1 though September 30) for the year the property sold. It may have been more appropriate to use the water clarity measure closest in time to the date when buyers first visited the properties, or first visited the lakes if earlier than the first visit to the properties, or the date when the sale price was agreed. We do not know this information, only the date the sale closed, so we used the minimum clarity for the year the sale closed as the best proxy for buyer/seller perceptions of water clarity at the time of the sale (see James 1995). The minimum water clarity is used because this is a measure of the extent of eutrophication. Water clarity during the summer months was the focus because this is the period when the effects of eutrophication are particularly obvious and are most likely to affect human uses. Reduced water-clarity in the spring and fall is controlled by lake circulation and is less likely to be noticed by property purchases.

The natural log of the minimum water clarity in the lake for the year the property was sold (WATERQ) was multiplied by the total surface area of the lake (LKAREA), to create the environmental variable (WQ). The interaction between water clarity and lake area is used because of the collinearity between water clarity and lake area. This specification implies that water clarity is more important to consumers of lakefront property on larger lakes. For instance, a person may be willing to lower their standard for water clarity to locate on a small lake in order to avoid the boat traffic and other activities that occur on larger lakes.

The estimated hedonic equations differ from those used in the Michael study in two ways. First, Michael expressed the dependent variable as the sale price of each property divided by the property's feet of frontage on the lake. This was done to reflect more accurately the role of feet of frontage as a characteristic that explains differences in sale prices. Second, fewer explanatory variables were used in the current study. This was done because Michael found that most of the property characteristics included in the initial hedonic equations were not statistically significant in explaining differences in property prices. This finding appears to arise from result that a more basic set of important attributes exists being for rural residences than properties located in cities and suburbs.

The demand equation is specified as

$$\ln(WATERC) = f(\ln(PWATERC), \ln(PLVAREA), \ln(PFF), \ln(INCOME), VISIT, EXPIMP, EXPDEG, FRIENDS)$$

where ln(x) denotes the natural logarithm of the variable, WATERC is as defined above, PWATERC, PLVAREA and PFF are the respective implicit prices of these characteristics derived from the first-stage, hedonic equations for each group of lakes, INCOME is the household income of the purchaser, VISIT equals one if the purchaser visited the lake before purchasing the property and zero otherwise, EXPIMP equals one if the purchaser expected lake-water clarity to improve in the future and zero otherwise, EXPDEG equals one if the purchaser expected lake-water clarity to decline in the future and zero otherwise, and FRIENDS equals one if friends or relatives of the purchaser own property on the lake. Data on INCOME, VISIT, EXPIMP, EXPDEG AND FRIENDS were obtained from a mail survey of property purchases (Lawson 1997).

As PWATERC increases, it is expected that the level for water-clarity demanded will decline (Figure 2). LVAREA is presumed to be a complement to water clarity so that as the implicit price of living area increases, people will choose a lower level of water clarity. FF is presumed to be a substitute for water clarity so as the implicit price of foot frontage increases, people will choose a higher level of water clarity, i.e., people will choose to purchase a property on a lake with a higher level of water clarity but with less property frontage. As income increases, it is expected that the demand for water clarity will increase. The signs of VISIT, EXPIMP and EXPDEG are indeterminate. There is no particular reason to believe that someone who has visited a lake prior to purchasing a property is likely to pay a higher or lower price than someone who first visits the lake when looking for a property to purchase. However, there is reason to expect that someone who has visited the lake previously may have experience that others do not possess that would affect their decision to purchase the property. EXPIMP and EXPDEG can have two affects. If the market has adjusted to these expectations, then an expected improvement should increase demand and an expected degradation should decrease demand. Alternatively, if prices are sticky

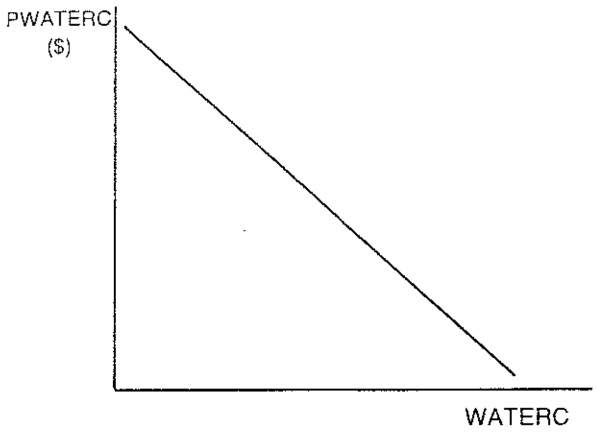

Figure 2. Demand for lake-water clarity

and have not adjusted to expectations, then these variables could have the opposite effects. Anecdotal evidence from purchaser inquires with the DEP regarding lake-water clarity suggest that expectations of future water quality are important to at least some potential purchasers. We suspect that people will be more likely to purchase a property on a lake where friends of family own property.

DATA

Thirty-six Maine lakes were selected for inclusion in the study and were grouped into seven separate markets. A market was defined as a group of lakes in close proximity to each other and near a large community. The purpose of selecting groups of lakes representing separate markets is to allow estimated implicit prices for water clarity to vary across real estate markets. This provides one piece of the information necessary to estimate the demand for water clarity. The seven markets selected for the study are Lewiston/Auburn, Augusta, Waterville, Newport, Ellsworth, northern Aroostook County, and Camden. The lakes within each group are listed in Table 2. The lakes differ from the Michael study, with the exception of the new Camden group, because lakes where water clarity data were missing for over 50% of sales were excluded from the current study.[3]

Data on lakefront property sales were collected for sales occurring between January 1, 1990, and December 31, 1995. This time period was selected for two reasons. The real estate boom of the 1980s was over and house prices were rising very little during the early 1990s in Maine (Institute for Real Estate Research and Education, University of Southern Maine). Second, the DEP possessed extensive water clarity records for this time period. Data for several years were used because of the small number of sales that occur in any given year.

Property sales data were obtained from transfer tax records at town offices for lakes in the organized towns. Property characteristics including the characteristics of structures on the property, were transcribed from property tax records held in the town offices. Property sales and characteristics data for unorganized territories are held in the state office of the Bureau of Taxation in Augusta. The 36 lakes in the sample encompassed 64 organized towns.

Only residential or recreational, single-family homes with lake frontage or unimproved land sales of less than 20 acres with lake frontage were included in the sample. Condominiums or any property purchased with common property rights were not included in the sample. Properties purchased with multiple, single-family housing units, not including sleep camps, were also excluded. There are too few sales of these unique properties to statistically control for their unique characteristics in the analyses. The final number of observations used in estimating the models consisted of 862 property sales. There were 83 property sales in the Lewiston/Auburn group, 105 in the Augusta group, 258 in the Waterville group, 41 in the Newport group, 165 in the Ellsworth group, 152 in the northern Maine group, and 58 in the Camden group.[4]

Secchi disk readings have been recorded for hundreds of Maine lakes, from May through October of each year, since the early 1970s, by DEP employees and volunteers. Table 2 documents the water clarity for each of the study lakes using 1992 transparency data for illustrative purposes. Water clarity varies among lakes within each of the lake groups in Table 2, ranging from minimum clarity measurements of 2 m or less to above 4 m. With the exception of the Ellsworth group, all groups contain one or more lakes that have undergone restoration projects that involved media coverage of water quality problems and causes (Table 3).

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[3] The excluded lakes are Sabbattus lake in the Lewiston/Auburn group; Echo Lake in the Augusta group; Great Moose and Sebasticook Lakes in the Newport/Dexter group; Beech Hill Pond and Graham Lake in the Ellsworth group; and Eagle Lake in the Northern Maine group.

[4] The data were also screened for outliers. The reported sample sizes exclude 60 observations that were removed as a result of this screen.

Table 2. Department of Environmental Protection lake monitoring data for study lakes.

		-------- 1992 Water Clarity[a] ---------			------------- Lake Size -------------	
		Min	Mean[a]	Max (meters)	Lake area (acres)	Average depth (meters)
Group 1:	Lewiston/Auburn Area					
	Taylor Pond	3.7	4.8	5.5	625	17
	Thompson Lake	5.8	8.1	9.9	4,426	35
	Tripp Pond	4.3	5.7	7.3	768	11
Group 2:	Augusta Area					
	Anabessacook	1.4	3.2	5.3	1,420	21
	Androscoggin Lake	3.1	3.8	4.4	3,980	15
	Cobbossecontee	1.4	2.5	3.2	5,543	37
	Maranacook	5.0	5.4	6.0	1,673	30
	Togus Pond	4.0	5.4	7.0	660	20
Group 3:	Waterville Area					
	China Lake	1.6	2.9	4.4	3,845	28
	East Pond	3.4	4.4	5.8	1,823	18
	Great Pond	4.9	6.0	6.8	8,239	21
	Messalonskee Lake (1991)[b]	4.0	5.6	6.9	3,510	33
	North Pond	2.5	4.0	6.3	2,873	13
	Threemile Pond	1.5	3.7	4.9	1,162	17
	Webber Pond	1.4	3.0	4.4	1,201	18
Group 4:	Newport/Dexter Area					
	Big Indian Lake	5.8	5.9	6.2	990	15
	Unity Pond	1.1	2.3	3.4	2,528	22
	Lake Wassookeag	5.0	8.9	11.0	1,062	27
Group 5:	Ellsworth Area					
	Alamoosook Lake	5.0	5.7	6.9	1,133	16
	Branch Lake (1991)	6.5	7.4	7.7	2,703	39
	Green Lake (1991)	4.4	5.8	7.5	2,989	44
	Phillips Lake	7.5	8.3	8.5	828	40
	Pushaw Lake	3.0	4.5	5.5	5056	11
	Toddy Pond	4.0	5.2	6.8	1,987	27
Group 6:	Northern Maine					
	Cross Lake	2.3	3.2	3.5	2,515	20
	Long Lake	2.5	3.8	5.0	6,000	48
	Madawaska Lake	1.9	2.8	4.0	1,526	16
	Square Lake	3.0	3.5	4.9	8,150	36
Group 7:	Camden Area					
	Alford Pond[c] (1991)	5.0	6.4c	8.0	577	31
	Chickawaukie Pond	3.9	6.4	9.4	352	24
	Coleman Pond	5.5	5.9	6.4	223	14
	Hobbs Pond	4.0	5.6	6.5	264	13
	Lake Megunticook	4.5	6.0	7.0	1,305	23
	Lermond Pond	5.5	7.0	8.3	171	14
	Pitcher Pond	3.8	4.7	5.6	367	16
	Quantabacook Lake	3.4	4.4	4.9	693	21
	Seventree Pond (1991)	2.0	2.5	3.4	523	24

[a] The secchi disk measurements represent the mean for the measurements taken between May and October 1992.

[b] If 1992 measurements were not available, data are reported for the most recent preceding year for which measurements were available, year denoted in parentheses after the lake name in the left column.

[c] Mean and Max reported for Alford Pond are for 1996.

Most of the lakes in the study had readings taken every two weeks. However, some lakes are not monitored as closely because of the difficulty of finding monitors for every lake. A regression equation was estimated for each of the seven market groups to predict minimum water clarity estimates for cases without water-clarity data. The regression equation was specified as

$$\text{WATERQ} = f(\text{TEMPADJ}, \text{LAKED})$$

where TEMPADJ is the average July temperature in the market group for the year the property was sold, divided by the maximum depth of the lake, and LAKED is a vector of dummy variables for each lake (1 if lake and 0 otherwise) in the market group multiplied by a trend variable. The trend variable was defined to equal one for the first year of water clarity data and incremented by integer values for each subsequent year (1, 2, 3, 4, 5, 6). Data to estimate these water clarity equations are simply the 1990 through 1995 water clarity observations that were available for properties in the data set. If the minimum water clarity measurement was not available for the year that a property was sold, water clarity was predicted using these equations.

Low readings of water clarity in lakes selected for the study are not necessarily the sole result of human activity, some lakes have reduced water clarity due to their geological features and some have natural coloration. If people have preferences for clear water, the price of properties on lakes with reduced clarity will be less than on clear lakes regardless of the source of coloration. Including naturally eutrophic lakes in the model along with culturally eutrophic lakes expands the data base

Table 3. Lake restoration projects (DEP 1993).

Group 1: Auburn

Sabattus Pond—restoration project included enhanced seasonal flushing and installation of Best Management Practices on farms in the watershed in 1987. Seasonal drawdown continues.

Group 2: Augusta

Anabessacook Lake—restoration in 1976–1979 involved control of agricultural sources of phosphorus in the watershed and an alum treatment in 1978.

Cobbossee Lake—restoration in 1976–1979 involved control of agricultural sources of phosphorus in the watershed.

Togus Pond — shorefront homeowners have independently and voluntarily cooperated by correcting problems with septic systems since 1983.

Group 3: Waterville

China Lake—project, designed in 1988, consisted of reduction of major nonpoint sources of erosion and adoption of a long-term lake protection strategy. This program is still being implemented.

Threemile Pond—restoration project involved control of nonpoint sources of phosphorus and an alum treatment (1988). Watershed management work continues.

Webber Pond—restoration project included control of agricultural nonpoint sources of phosphorus, reduction of shoreline erosion problems and seasonal drawdown. Seasonal drawdown and watershed management continues.

Group 4: Newport

Sebasticook Lake—restoration project, 1979–1990, addressed elimination of point sources at Dexter, reduction of point sources at Corinna, reduction of agricultural nonpoint sources of phosphorus, and enhanced seasonal drawdown. Annual drawdown continues.

Group 6: Northern Maine

Long Lake and Cross Lake—problem agricultural sites were targeted for installation of innovative nutrient control wetland/pond systems. To date, ten of these have been constructed. An aggressive educational campaign by the area lakes association has been conducted over the last three years.

Madawaska Lake—diagnostic/feasibility study was completed in a coordinated effort between DEP, the Soil and Water Conservation District, major landowners and volunteers. Several land-based recommendations were made for the major land uses including forestry, agriculture, camp and home lots, shoreline erosion, commercial property, public property, and roads and associated ditches.

Group 7: Camden

Chickawaukie Pond—restoration of Chickawaukie Pond water quality during 1990–1994 had two components: reduction in the number of sources of pollution coming from the watershed and an aluminum treatment to suppress phosphorus recycling in the lake during the summer.

and enhances the precision with which the hedonic price equation can be estimated. However, it would not be appropriate to apply the estimated implicit prices for changes in water clarity to lakes that are naturally eutrophic or colored and can not easily be manipulated by management when making policy decisions regarding lake-water quality.

In addition to water clarity, other lake characteristics may influence the price of a property. Some of these characteristics might be the type of fishery the lake supports, fish stocking in the lake, and the potability of the water. Many of these variables are correlated with water clarity because as water clarity improves swimming, potability and fishing for some species may also improve. Excluding these variables from the model that may be correlated with water quality and may affect property prices, still results in estimated implicit prices for improved water clarity which include the effects of these related water quality variables.

The data to estimate the demand equations came from three sources. The water clarity variable is the same variable that was used to estimate the hedonic-price equations. The implicit prices were derived from the hedonic-price equations for each market group. The data for INCOME, VISIT, EXPIMP, EXPDEG and FRIENDS were taken from a mail survey that was sent to all property purchasers (n = 1191) for which we were able to obtain a usable address from tax records. The response rate to the survey, as a percentage of the surveys deliverable by the U.S. Postal Service, was 65% (n = 649). Lawson (1997) presents a detailed discussion of how the implicit prices were derived and also presents a copy of the mail survey.

RESULTS

The final data set indicates that property sales prices are highest in the Auburn area and lowest in the northern Maine market, with averages ranging from $107,378 to $34,040 per property (Table 4). Average minimum water clarity was also highest for the Auburn group (6.09 m) and lowest for the northern Maine group (2.74 m). Summary statistics for all variables by lake are reported in Appendix II.

Separate hedonic equations were estimated for each lake group. This allows the implicit price of water quality to vary across lake groups to reflect differences in water quality market conditions. Water clarity was a significant variable in predicting variations in property prices for four of the seven market groups investigated (Lawson 1997). The markets where water clarity was not significant were Augusta, Newport and northern Maine groups. Water clarity was significant in the Michael study in the Augusta and northern Maine groups, but was not significant in the Newport group. The reasons for the differences between the Michael study and the current estimates, for the Augusta and northern Maine groups, is likely due to the addition of recent sales data and the differing treatments of missing water clarity data as discussed above. In the remainder of the text of this report we present results for groups where water clarity was a significant variable. The estimated

Table 4. Descriptive statistics for variables in the hedonic price equations.

				Groups			
Variables	Auburn	Augusta	Waterville	Newport	Ellsworth	Northern Maine	Camden
PP ($)	107,377.83	77,847.00	82,583.46	48,885.00	68,670.24	34,039.66	97,322.41
FF (Feet)	145.60	133.26	143.33	161.68	162.75	147.09	256.10
LVAREA (Square Feet)	934.33	829.17	750.13	496.66	704.13	611.74	582.24
HEAT (=1)	0.53	0.61	0.41	0.29	0.41	0.55	0.33
FULLBATH (=1)	0.77	0.73	0.64	0.37	0.53	0.47	0.45
LKWATER (=1)	0.36	0.24	0.29	0.20	0.47	0.30	0.14
DNSTY (Lots/1000 feet)	8.15	8.23	8.87	9.12	7.61	9.05	7.16
DIST (Miles)	10.98	4.50	9.42	10.54	10.35	18.23	4.67
WATERQ (Meters)	6.09	3.22	3.91	4.35	5.45	2.74	3.88
LKAREA (Acres)	3039.08	2,895.95	4,756.35	1,498.73	2,482.79	4,838.41	678.88
LnWATERQ* LKAREA	5814.40	2,474.76	6,903.38	1,242.31	3,744.31	5,064.43	887.20
TOTAL LAKE FRONTAGE (feet)	231,264	385,398	544,055	100,512	480,311	334,030	165,090
N	83	105	258	41	165	152	58

hedonic equations for all seven groups are presented in Appendix III.

Within the text (Table 5) we report what we refer to as reduced equations that include a grand constant (a) and the water quality effect (b):

$$PP = \alpha + ß \ln(WATERC)*LKAREA.$$

The grand constant varies from lake to lake. For each lake, all variables in the equation, except WATERC and LKAREA, are evaluated at their means for each lake (Appendix I). The means are multiplied by their respective coefficients for the lake group (Appendix II) and the products are summed, including the lake-group intercept terms. Thus, the grand constant varies across lakes according to the variable means for each specific lake and the different equation coefficients for each lake group. The results of these computations are reported in Table 5. The coefficient on water quality (ß) varies across lake groups, but not across lakes within a group. Mean WATERC in Table 5 is the mean minimum water clarity for the property sales observations from each lake that were used in the estimation of the hedonic-price equations. LKAREA is the total surface area of each lake used in the estimation of the hedonic-price equations.

The data in Table 5 provide the basis for developing a number of interesting estimates. For example, the China Lake equation can be used to predict that the average property sells for $91,808 (where $91,808 = [87,353 + 2.05(ln(1.76)*3845)]), and the share (implicit price) that is attributable to WATERC is $4,456 (where $4,456 = [2.05(ln(1.76)*3845)]). Or, the percentage of the average purchase price that is attributable to WATERC is 4.6% (where 4.6% = [$4,457/$97,810]). These calculations can be done for any lake in the study using the appropriate equation. These estimates are averages for developed and undeveloped lots.

Policy questions most often consider incremental changes in water clarity, not marginal changes. For example, how much would property prices increase on China Lake if water clarity increased to 4 m of transparency (approximately the mean for the Waterville group). This figure is computed by subtracting the current implicit price of $4,456 from what the implicit price would be if water clarity improved to 4 m, $10,927 per foot of frontage (where $10,927 = [2.05(ln(4.0)*3845)]). The increase in property prices would be $6,471 (where $6,471 = [$10,927 – $4,456]). On the other hand, if water

Table 5. Equations with grand constant for calculating implicit prices for individual lakes.

Group	Lake	α	ß	WATERC	Mean LKAREA	Total Foot Frontage on Lake
1	Taylor Pond	85,037	9.00	3.64	625	29,040
	Thompson Lake	55,353	9.00	7.15	4,426	163,680
	Tripp Pond	65,817	9.00	4.75	768	38,544
3	China Lake	87,353	2.05	1.76	3,845	114,048
	East Pond	71,356	2.05	2.40	1,823	NA
	Great Pond	75,928	2.05	5.65	8,239	194,832
	Messalonskee Lake	75,318	2.05	4.91	3,510	110,000
	North Pond	64,357	2.05	2.40	2,873	NA
	Threemile Pond	77,431	2.05	2.39	1,162	43,290
	Webber Pond	71,594	2.05	1.25	1,201	36,500
5	Green Lake	63,415	4.21	4.87	2,989	129,000
	Phillips Lake	79,584	4.21	8.03	828	73,000
	Branch Lake	75,480	4.21	7.36	2,703	36,782
	Toddy Pond	55,676	4.21	4.33	1,987	79,000
	Alamoosook Lake	76,376	4.21	4.67	1,133	18,385
	Pushaw Lake	31,618	4.21	3.32	5,056	144,144
7	Seventree Pond	49,877	40.92	1.18	523	14,618
	Chicawaukie Pond	90,452	40.92	2.89	352	15,312
	Lake Megunticook	92,575	40.92	4.81	1,305	113,520
	Quantabacook Lake	35,074	40.92	3.11	693	14,004
	Coleman Pond	4,086	40.92	4.60	223	7,636
	Pitcher Pond	210,828	40.92	5.00	367	11,019
	Lermond Pond	58,574	40.92	5.97	171	NA
	Hobbs Pond	13,609	40.92	3.17	264	21,120
	Alford Pond	11,786	40.92	6.40	577	26,400

clarity declined to 1 m, the loss would be $4,456 (where $4,456 = [2.05(ln(1.76)*3845) - 2.05(ln(1.0)*3845)]), or the entire premium because ln(1.0)=0. The loss for a 0.76 m decline in water clarity is only slightly less than the gain for a greater than 2 m increase in water clarity due to the nonlinear relationship of the hedonic-price equation (Figure 1).

Table 6 provides examples of the change in property prices for Thompson Lake, China Lake, and Pushaw Lake for a one meter change in water clarity. All three lakes have surface areas in excess of 3,500 acres. Each of these lakes is in a different market group so the effect of water quality varies, i.e., the respective b's are 9.00, 2.05 and 4.21. The lakes vary substantially in their current levels of water clarity. The Maine DEP considers the water clarity in China Lake to be substantially compromised with an average clarity of 1.76 m. Pushaw Lake, is mesotrophic with an average minimum clarity of 3.32 m, is just above the DEP's cut off of 3 m for lakes with compromised water clarity. Thompson Lake has very clear water with an average of 7.15 m. While Pushaw Lake has low clarity impact due to natural color, the results of our study are not irrelevant for this lake. The average minimum clarity of 3.32 m is close to the DEP's threshold of 3 m for lakes with compromised water clarity. For lakes that have high levels of natural color, controlling nutrient loadings that would further reduce clarity, is still an important policy issue.

For each example, the effect of a one meter improvement in water clarity on property prices is smaller than the effect of a one meter decline in water clarity (Table 6). This outcome is due to the nonlinear relationship between property prices and water clarity portrayed in Figure 1 and imposed on the hedonic price equations by specifying water clarity as the natural log of water clarity. It is also interesting to note that China Lake, with the lowest water clarity, has the smallest price change for a one meter improvement and the second largest price change for a one meter degradation. This effect across markets is due to the differing coefficients on water clarity estimated for each market. The Waterville group, where China Lake is located, has the lowest estimated effect (b) of water clarity on property prices.

Finally, legislators, community leaders, and others involved in protecting Maine's lakes, may want to know by how much a change in water clarity will affect aggregate property prices around a lake. This information is computed by multiplying the change in implicit price associated with a change in water clarity by the total number of properties on the lake:

> Total change in property prices = (Average Change in implicit price/property) * (# of Properties)

The results in Table 6 indicate that a one meter change in water clarity can result in millions of dollars in gained or lost property values on Maine's major lakes. These estimates assume 90% of the lake frontage meets the criteria used to select properties for the study; developable land and single family structures. Some of the properties around a lake may not meet these criteria. If accurate information is available on the proportion of lake frontage that is developed with single family residences or developable for single family residences for specific lakes, these estimates could be refined.

The estimated demand equation for water clarity is presented in Table 7. The coefficients on the implicit prices of water clarity (PWATERQ), living area (PLVAREA) and feet of frontage (PFF) are all significant and have the expected signs. The demand for water quality declines as the price of

Table 6. Changes in property prices on selected lakes for a one meter (1m) change in water clarity.

	Thompson Lake	China Lake	Pushaw Lake
Baseline Av. min. clarity	7.15m	1.76m	3.32m
Change in prices for			
1m improvement	$5,214/property	$3,545/property	$5,604/property
1m degradation	$6,001/property	$6,620/property	$7,629/property
Feet of Frontage	163,680	114,048	144,144
Average Feet of Property Frontage	144.5	128.5	94. 4
Estimated Number of Properties[a]	1,019	799	1,374
Total change in property prices for lake			
1m improvement	$5,313,066	$2,832,455	$7,699,896
1m degradation	$6,115,019	$5,289,380	$10,482,246

[a] Estimated numbers of properties are derived by assuming 90 percent of the lake frontage is developable and dividing the developable lake frontage by the average feet of frontage for properties on each lake.

Table 7. Estimated second-stage, demand equations.

Variables	Coefficient Estimates (Standard errors)
Intercept	0.32
	(1.00)
ln(PWATERQ)	-0.11**
	(0.05)
ln(PLVAREA)	-0.18 *
	(0.10)
ln(PFF)	0.53 ***
	(0.11)
ln(INCOME)	0.004
	(0.08)
Visited = 1	-0.03
	(0.09)
Expimp = 1	-0.46 ***
	(0.07)
Expdeg = 1	-0.03
	(0.11)
Friends = 1	0.09
	(0.06)
R-Square	0.21
F-Statistic	10.24 ***
d.f.	278

* = significance at the 10% level.
** = significance at the 5% level.
*** = significance at the 1% level.

quality increases and as the price of structures (PLVAREA) on the property increases, but increases as the price of lot frontage (PFF) on the lake increases. These results indicate that water clarity and living area are complements and water clarity and feet of frontage are substitutes. That is, as the price of existing or new structures increases a buyer will choose to buy a property on a lake with lower water clarity. An increase in the implicit price of lake frontage would result in purchasers choosing a property with less frontage on a lake with higher water clarity. These results for the effects of the implicit prices of living area and feet of frontage are important and are disappointing in terms of the economic incentives for protecting lake-water clarity. As the cost of building increases, people will choose to locate on lakes with lower water quality, which puts more development pressure on lakes that may be susceptible to eutrophication. People's choice to buy a property with higher water quality as the price of frontage increases puts more development pressure on clear, pristine lakes.

The variable for whether purchasers expected an improvement in water clarity is also significant and has a negative coefficient; indicating people who expected water quality to increase paid less for their properties. This is somewhat counter intuitive and suggests that the market has not adjusted to these expectations and these purchasers are buying properties on lakes with lower water clarity in the anticipation that water quality will increase in the future.

The key result is the relationship between water clarity and the implicit price of water clarity, which can best be represented by a figure (Figure 3). The DEP's staff suggests that the threshold for a lake with compromised water clarity is 3 m. The graph of the demand function shows that buyers preferences follow this threshold quite closely. To the left of 3 m the demand curve is very steep, indicating that people are willing to pay substantial amounts for improved water clarity. To the right of 3 m, the demand curve is relatively flat indicating that the people are willing to pay relatively less for additional units of water clarity. This later result is consistent with the fact that it is more difficult for people to observe changes in water clarity at higher thresholds of clarity. It also indicates that the economic losses from reduced water clarity are greater than the gains from reduced water clarity.

While the hedonic-price equations reveal the effect of water clarity on property prices, the area below the demand equation represents the economic benefit to property owners from changes in water quality, i.e., an economic measure of satisfaction with changes in water clarity. For example, the DEP records indicate the average water clarity in Maine is 3.78 m for all lakes and 5.15 m for lakes that do not have compromised water clarity (WATERC>3m). The area under the demand curve between 3.78 m and 5.15 m in Figure 3 is $3,048. If someone lived on a lake with water clarity of 3.78 m, the benefit to them of increasing water clarity to 5.15 m is $3,048. Conversely, the loss to someone who owns a property on a lake with clarity of 5.15 m of decline to 3.78 m is also $3,048. Whereas a decline in water quality from 3.78 to 2.41 m would represent a decline in benefits of approximately $36,538. These areas can be developed for any change in water clarity using the estimated demand equation reported in Table (Parsons 1986) and are useful for conducting benefit-cost analyses of lake protection efforts.

The shape of the demand equation graphed in Figure 3 is important. Just as the loss in property prices from a 1 m decline in water clarity is greater than the increase in property prices for a 1 m increase in property prices, a similar relationship holds for the economic benefits of protecting lake-water clarity. The area under the demand curve between 3 m and 4 m is greater than the area below the demand curve between 4 m and 5 m. Thus, both

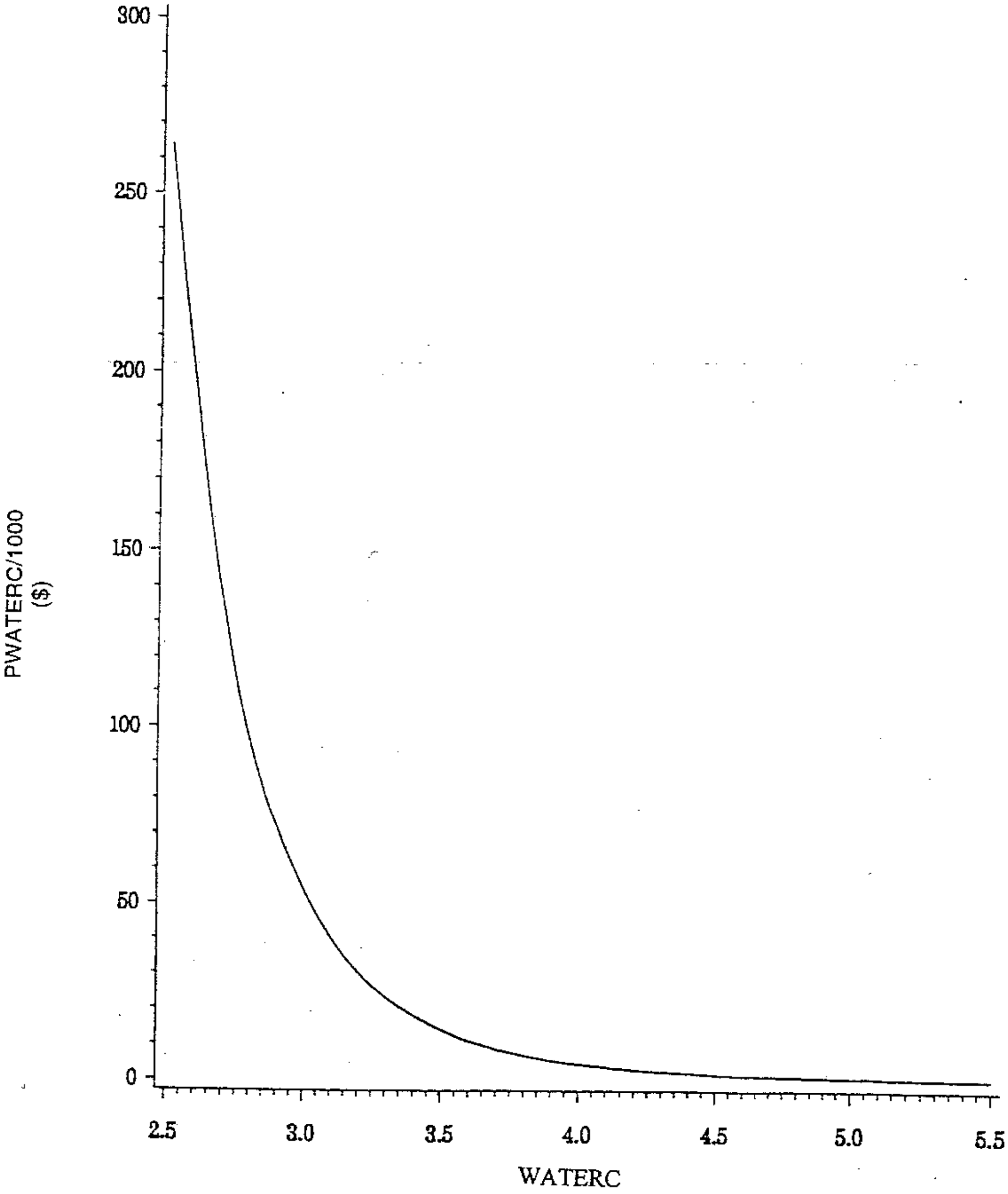

Figure 3. Estimated demand for lake-water clarity

the hedonic-price equations and the demand estimation suggest that from an economic perspective it is better to protect water clarity than it is to allow clarity to decline and then try to reverse the negative trend; each increment of decline results in increasing economic losses and greater costs of lake rehabilitation.

EXTENSIONS AND LIMITATIONS

It is important to realize there are limitations to the study results. The estimated implicit prices for water clarity are based on everything else being equal. For example, if the DEP's efforts to protect Maine's 5,786 lakes are successful and water clarity in most lakes improves, the supply of properties on clear lakes would increase. A larger supply of properties on clear lakes will reduce the impact of water clarity on property prices. For current applications, with small changes in water clarity on a small number of lakes, the estimates are appropriate.

The estimates reported here are actually based on a very small percentage of Maine's 5,786 lakes and ponds. The equations may be used to predict changes in property prices on lakes not selected for the study, but that are adjacent to the lakes within each lake group. For lakes not included in the study, the mean values for the variables in the equations need to be calculated for the properties on each lake to compute a new grand constant unique to each lake. The equations estimated in this study are not accurate predictors of changes in property prices occurring on lakes that are outside the lake groups included in the study and which have substantially different characteristics from the lakes included in the study.

While the demand curve is very steep to the left of three meters, it is important to keep in mind that only about five of the lakes studied had sales occurring when water clarity was 3 m or less. Thus, we have more confidence in the estimated demand curve to the right of 3 m. This is still useful because the most relevant policy issue is protecting water clarity from deteriorating to 3 m or less.

CONCLUSIONS

The results of this study show that water clarity significantly affects property prices around Maine lakes, and there is a significant economic demand for water clarity by lakefront property owners. The implicit prices for individual properties, when aggregated for an entire lake, equate to substantial improvements in property prices per lake. These findings clearly indicate that it is in a lakefront property owner's best interest to take actions to protect water quality in their lakes. This can be done by creating buffer zones, controlling drainage and other landscaping on their properties that minimize nutrient run off from their properties into the lake and that intercepts nonpoint source pollution from elsewhere in the watershed running through their properties to the lake, and encourage their neighbors to take similar actions. In addition, people who do not own lake frontage, but have a lake in their community, have incentives to protect the lake from nonpoint source pollution in the watershed because this will help protect the community's property tax base and influx of money to the community from nonresidents who use to the lake for recreational purposes.

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APPENDIX I—MEAN VALUES FOR VARIABLES BY LAKE GROUP AND FOR EACH LAKE WITHIN THE GROUPS.

Group 1—Auburn area.

	Group	Taylor Pond	Thompson Lake	TrippPond
HP	107,377.83	85,871.67	125,526.92	71,289.47
FF	145.60	101.67	144.50	176.37
LVAREA	934.33	998.28	862.21	1,091.11
HEAT	0.53	0.67	0.52	0.47
FULLBATH	0.77	0.75	0.69	1.00
LKWATER	0.36	0.08	0.35	0.58
DNSTY	8.15	10.42	8.13	8.32
DIST	10.98	2.00	12.67	12.00
WATERQ	6.09	3.64	7.15	4.75
LKAREA (acres)	3039.08	625.00	4426.00	768.00
WQ	5,814.40	806.81	8,659.77	1,189.76
TOTAL LAKE FRONTAGE (ft)	231,264	29,040	163,680	38,544
N	83	12	52	19

Group 2—Augusta area.

	Group	Anabessacook Lake	Androscoggin Lake	Cobbossee Lake	Maranacook Lake	Togus Pond
HP	77,847.00	83,625.00	37,516.58	72,080.48	97,290.44	73,616.63
FF	133.26	128.75	152.50	153.55	117.29	116.81
LVAREA	829.17	880.83	490.00	677.74	1,012.79	948.00
HEAT	0.61	0.83	0.25	0.35	0.74	0.94
FULLBATH	0.73	0.75	0.33	0.71	0.85	0.81
LKWATER	0.24	0.17	0.17	0.29	0.24	0.25
DNSTY	8.23	9.00	6.75	7.35	8.76	9.31
DIST	4.50	2.42	7.42	4.19	3.76	6.00
WATERQ	3.22	1.22	3.32	1.79	4.58	4.55
LKAREA (acres)	2,895.95	1,420.00	3,980.00	5,543.00	1,673.00	660.00
WQ	2,474.76	231.55	4,702.02	3,205.32	2,509.66	997.11
TOTAL LAKE FRONTAGE (ft)	385,398	23,636	36,442	192,000	92,664	40,656
N	105	12	12	31	34	16

Group 3—Waterville Area

	Group	China Lake	East Pond	Great Pond	Messalonskee Lake	North Pond	Three-mile Pond	Webber Pond
HP	82,583.46	86,622.16	87,616.00	90,655.20	91,360.02	47,652.50	59,225.00	31,266.73
FF	143.33	128.49	158.56	163.22	136.45	107.00	123.08	109.64
LVAREA	750.13	903.09	717.52	744.78	898.98	477.00	470.76	464.55
HEAT	0.41	0.56	0.40	0.27	0.49	0.30	0.44	0.73
FULLBATH	0.64	0.67	0.68	0.63	0.75	0.40	0.48	0.64
LKWATER	0.29	0.35	0.52	0.26	0.39	0.20	0.08	0.00
DNSTY	8.87	9.05	8.64	8.80	8.53	9.40	9.04	10.00
DIST	9.42	15.79	6.60	8.39	5.88	10.00	13.20	7.00
WATERQ	3.91	1.76	2.40	5.65	4.91	2.40	2.39	1.25
LKAREA (acres)	4,756.35	3,845.00	1,823.00	8,239.00	3,510.00	2,873.00	1,162.00	1,201.00
WQ	6,903.38	2,128.66	1,441.49	14,225.26	5,567.85	2,461.94	818.31	137.84
TOTAL LAKE FRONTAGE (ft)	544,055	114,048	27,687	194,832	110,000	17,698	43,290	36,500
N	258	43	25	93	51	10	25	11

Group 4—Newport Area

	Group	Lake Wassookeag	Unity Pond	Big Indian Pond
HP	48,885.00	42,666.67	52,454.62	50,648.44
FF	161.68	221.00	96.23	170.38
LVAREA	496.66	335.67	691.92	458.75
HEAT	0.29	0.25	0.23	0.38
FULLBATH	0.37	0.42	0.46	0.25
LKWATYER	0.20	0.25	0.31	0.06
DNSTY	9.12	7.50	12.23	7.81
DIST	10.54	4.00	12.31	14.00
WATERQ	4.35	7.67	1.08	4.53
LKAREA (acres)	1,498.73	1,062.00	2,528.00	990.00
WQ	1,242.31	2,160.85	108.90	1,518.44
TOTAL LAKE FRONTAGE (ft)	100,512	17,365	62,300	20,847
N	41	12	13	16

Group 5—Ellsworth Area

	Group	Green Lake	Phillips Lake	Branch Lake	Toddy Pond	Alamoosook Lake	Pushaw Lake
HP	68,670.24	75,147.06	81,555.88	89,942.86	56,805.85	58,461.11	48,411.50
FF	162.75	177.68	134.09	206.62	188.66	191.67	94.38
LVAREA	704.13	702.12	933.03	668.95	517.22	644.89	751.08
HEAT	0.41	0.41	0.59	0.52	0.15	0.33	0.54
FULLBATH	0.53	0.56	0.76	0.57	0.27	0.56	0.58
LKWATYER	0.47	0.50	0.56	0.48	0.29	0.56	0.58
DNSTY	7.61	7.03	7.94	8.14	6.00	6.00	10.62
DIST	10.35	10.82	13.00	9.00	9.54	6.00	10.12
WATERQ	5.45	4.87	8.03	7.36	4.33	4.67	3.32
LKAREA (acres)	2,482.79	2,989.00	828.00	2,703.00	1987.00	1133.00	5056.00
WQ	3,744.31	4,713.25	1,724.83	5,389.27	2,892.56	1,721.47	5,832.81
TOTAL LAKE FRONTAGE (ft)	480,311	129,000	73,000	36,782	79,000	18,385	144,144
N	165	34	34	21	41	9	26

Group 6—Northern Maine

	Group	Cross Lake	Long Lake Lake	Madawaska Lake	Square Lake
HP	34,039.66	29,293.42	31,768.88	47,019.70	10,366.67
FF	147.09	159.17	164.49	85.88	166.67
LVAREA	611.74	489.42	557.32	923.67	56.83
HEAT	0.55	0.50	0.45	0.97	0.17
FULLBATH	0.47	0.25	0.42	0.82	0.00
LKWATER	0.30	0.33	0.25	0.45	0.17
DNSTY	9.05	7.42	8.26	11.88	10.00
DIST	18.23	23.00	17.01	19.00	25.00
WATERQ	2.74	1.84	3.02	2.11	3.17
LKAREA (acres)	4,838.41	2,515.00	6,000.00	1,526.00	8,150.00
WQ	5,064.43	1,503.77	6,524.25	1,113.11	9,344.46
TOTAL LAKE FRONTAGE (ft)	334,030	88,735	180,114	53,730	11,451
N	152	12	101	33	6

Group 7—Camden Area

	Group	Seventree Pond	Chickawaukie Pond	Lake Megunticook	Quantabacook Lake	Coleman Pond
HP	97,322.41	55,866.67	98,210.00	186,902.94	34,190.00	70,833.33
FF	256.10	121.67	199.80	298.53	322.60	253.33
LVAREA	582.24	677.67	910.80	832.06	228.20	0.00
HEAT	0.33	0.67	0.50	0.35	0.10	0.00
FULLBATH	0.45	0.67	0.50	0.71	0.20	0.00
LKWATER	0.14	0.00	0.20	0.18	0.30	0.00
DNSTY	7.16	5.83	5.30	8.76	4.90	13.00
DIST	4.67	9.00	1.00	2.00	8.00	6.00
WATERQ	3.88	1.18	2.89	4.81	3.11	4.60
LKAREA (acres)	678.88	523.00	352.00	1,305.00	693.00	223.00
WQ	887.20	-27.64	352.54	2,039.24	773.33	340.31
TOTAL LAKE FRONTAGE (ft)	165,090	14,618	15,312	113,520	14,004	7,636
N	58	6	10	17	10	3

Group 7—Camden Area (cont.)

	Pitcher Pond	Lermond Pond	Hobbs Pond	Alford Pond
HP	235,000.00	33,200.00	34,333.33	25,250.00
FF	180.00	345.00	80.00	230.00
LVAREA	0.00	574.00	48.67	0.00
HEAT	0.00	0.43	0.00	0.00
FULLBATH	0.00	0.43	0.00	0.00
LKWATYER	0.00	0.00	0.00	0.00
DNSTY	17.00	6.14	7.67	7.00
DIST	5.00	7.00	5.00	6.00
WATERQ	5.00	5.97	3.17	6.40
LKAREA (acres)	367.00	171.00	264.00	577.00
WQ	590.66	305.04	293.23	1,071.08
TOTAL LAKE FRONTAGE (ft)	11,019	NA	21,120	26,400
N	1	7	3	1

APPENDIX II—REGRESSION RESULTS FOR THE FIRST STAGE HEDONIC-PRICE EQUATIONS.

	Lewiston/Auburn	Augusta	Waterville	Newport	Ellsworth	Northern Maine	Camden
intercept	34274.00 (24953.33)	34396.00** (17291.72)	25899.00* (13525.54)	-38771.00 (41348.29)	31527.00** (13682.48)	27835.00** (11808.23)	40061.00 (34487.19)
ln(lvarea)	6947.46*[a] (3647.14[b])	2379.26 (2074.33)	6789.67*** (1472.03)	3767.82 (2757.91)	5505.73*** (1080.74)	1643.15** (838.38)	1974.79 (6499.77)
heat	32975.00*** (12451.41)	22387.00*** (8335.52)	11572.00* (6682.62)	11979.00 (14641.99)	24805.00*** (5477.60)	14157.00*** (5373.62)	23230.00 (42876.14)
fullbath	21824.00 (22274.03)	22776.00** (10899.61)	23465.00*** (7792.16)	39840.00** (17252.01)	33274.00*** (6143.58)	19194.00*** (4137.19)	47733.00 (42076.89)
lkwater	-12972.00 (11281.42)	-25232.00*** (7685.94)	-17579.00*** (6340.40)	-1283.82 (13554.86)	-25083.00*** (5131.56)	-7893.16** (3456.68)	7126.16 (39984.28)
ff	166.26*** (47.61)	90.82** (44.32)	83.21*** (28.72)	7.40 (23.24)	75.05*** (24.41)	67.82*** (20.03)	69.14** (33.27)
dist	-3360.93*** (1114.03)	-3070.17 (2064.90)	1516.82*** (575.87)	2102.68 (1331.06)	-3367.50*** (1026.06)	-917.81** (465.57)	-5552.05* (2905.97)
dnsty	-4304.14** (1830.35)	291.13 (1022.51)	-3919.92*** (833.76)	1597.08 (2195.51)	379.14 (1047.41)	-525.46 (549.03)	-1552.16 (3217.89)
androscg	—	-21049.00 (13663.78)	—	—	—	—	—
pushaw	—	—	—	—	-31533.00*** (6239.21)	—	—
phillips	—	—	—	—	15225.00* (8577.21)	—	—
pitcher	—	—	—	—	—	—	212469.00** (87513.00)
ln(watrq)*lkarea	9.00*** (1.53)	2.33 (2.64)	2.05*** (0.52)	13.75 (11.67)	4.21*** (1.71)	-0.96 (0.59)	40.92*** (14.15)
R-Square	0.62	0.50	0.53	0.68	0.66	0.56	0.57
F-Statistic	14.90***	10.67***	35.41***	8.48***	30.25***	22.95***	7.20***
d.f.	74	95	249	32	154	143	48

* = significance at the 10 % level
** = significance at the 5% level
*** = significance at the 1% level.
[b] Numbers in parentheses are standard errors.

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