Maine DEP Lake Assessment Program

More on Dollars and Sense: The Economic Impact of Lake Use and Water Quality

The value of lakes is often taken for granted by those who enjoy them, and many people assume that the value of "clean water" is obvious. However, in a time when the bottom line is increasingly invoked to evaluate everything from state government programs to local decisions on ordinances, we need tools to better define the value of our natural resources. These tools must credibly illustrate the value of water quality to local officials and property owners, who make the bulk of land-use decisions which affect water quality by changing lake watersheds.

Until recently, there has been relatively little information to reliably estimate the economic effect of lakes in economies, either local or statewide. Such estimates can range from models relating environmental variables such as water clarity to economic signals in the marketplace ("hedonic" studies) to studies using choice surveys which examine individuals' willingness to pay for an environmental amenity such as clean water ("contingent valuation"). Studies can also use primary data (derived directly from consumers) or secondary data (available from tax records, resource use and expenditure data etc.) to estimate economic impact of lake use and water quality effects on that use. The University of Maine has pioneered the development of these studies. This paper will summarize the the results of several recently completed studies.

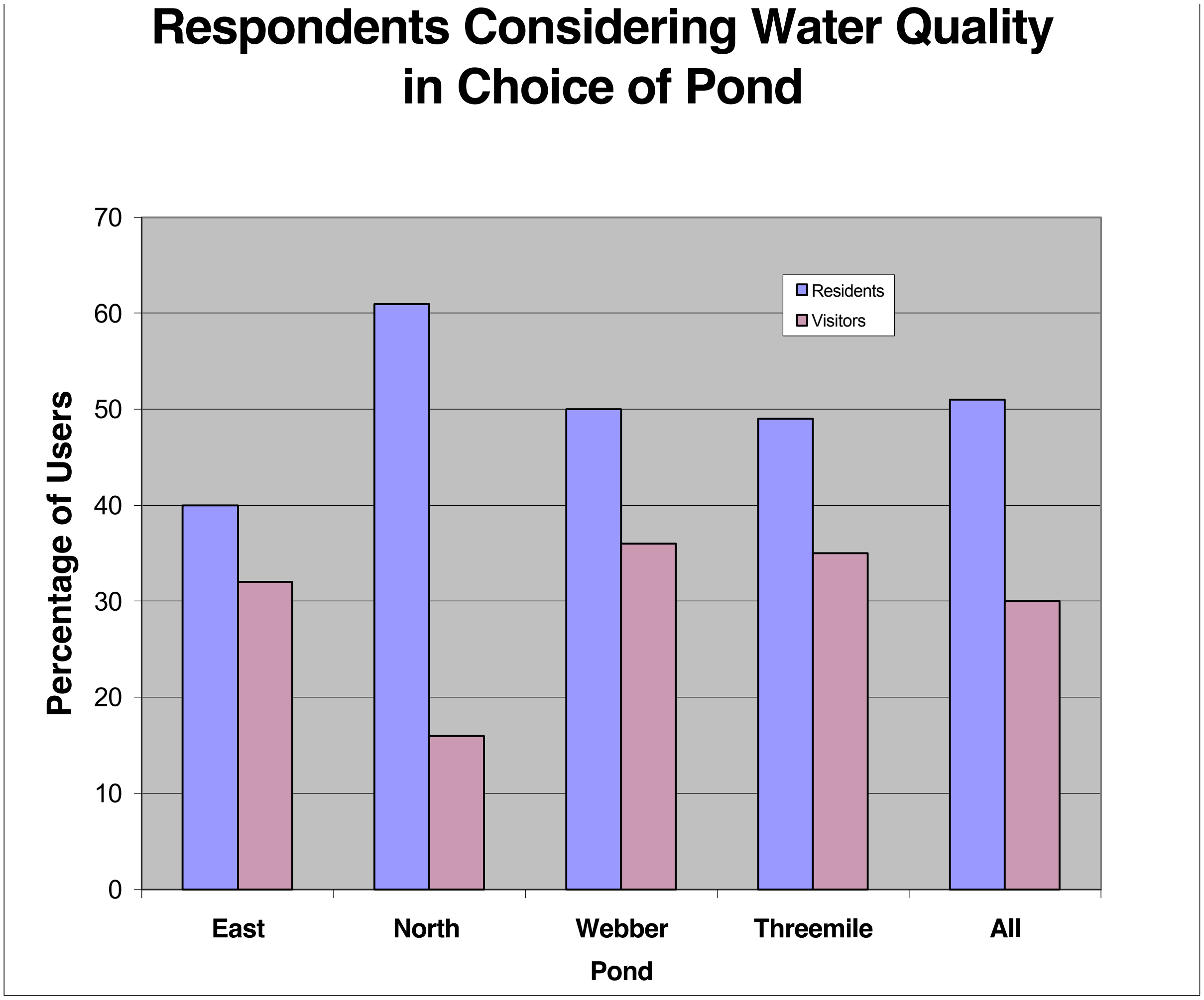
Estimating the value of lakes in local economies:

Understanding that there are substantial local economic effects of lake use can put the value of resources into perspective. One study of the value of lakes in local economies in Minnesota (Todd, 1989) estimated contributions of as much as $506-830 per lake acre (1985 dollars) to the local economy from fishing, lodging and other recreation-related activities, although a link between preserving water quality and assuring local economies was not examined.

In order to provide a vehicle for economic activity estimates in Maine, Braley et al. (1996) developed a survey instrument which was field tested at four lakes in central Maine. This instrument was designed to estimate the recreational use of lakes, lake user's perceptions of water clarity, and the expenditures on local communites associated with recreational uses of lakes. The survey tool developed in this study could be easily adapted to other areas of the country as a way to develop local perspective on the econoomic value of lakes.

During the summer of 1995, 96 lake users were surveyed at public launch ramps and 151 lakefront resident surveys were administered door-to-door. This represented a random sample of approximately 25% of shorefront cottages with a response rate of almost 100%. Swimming and fishing were the predominant acitvities for all lake users, but residents listed swimming as the primary use by 2 to 1 while visitors tended to use lakes mainly for fishing. However, public access is becoming a problem in central Maine, and the boat launch ramps at two of the lakes were used heavily for swimming by local residents who had no other means of lake access.

Choice of pond is a relevant factor in determining economic effects of lake use in local economies. An average of 70% of the visitors listed water quality as a very important to them and more than 30% said they considered it when selecting the pond to visit. Almost half said they had also considered other ponds in the area for their use. For residents, the reasons for choosing the location to buy included water clarity (98%), quality of swimming (87%) and scenic beauty (82%). Over 51% of residents had specifically considered water clarity prior to buying their property. This illustrates the importance of water quality to the long term investment in a property.



Visitors and residents were asked if they would be more or less likely to choose the pond if water clarity was increased or reduced significantly (i.e. by one half). Respondents indicated that changes in water clarity would substantially affect their choice, with 60-70% indicating they would have been less likely to choose the pond if water clarity was degraded. We note that average summer clarity these four ponds was 2.4-3.9 meters which is below the state average of 4.9 meters.

Overall economic activity related to pond use was segregated between visitors and residents. Visitors spent an average of $107/day, 54% of which was spent in the towns that border the ponds. Among owners, total annual expenses related to the lake (e.g. not including property taxes or items which are part of normal maintenance of a dwelling) averaged $1076, mostly property improvements for recreation, boating expenses, and for dock and road maintenance. More than 75% of these expenditures were made in the bordering towns. While data from this pilot study were not sufficient to accurately estimate total use or expenditures, simple extrapollation of the expenditures by property owners and renters alone places annual economic activity due to these lakes at somewhere between $87-290/lake acre (or twice that using multiplier effects) and a total expenditure for the four lakes between one and two million dollars. Considering the large number of developed properties on hundreds of Maine lakes (most of which are of higher water quality than those in this trial), the total for spending on recreational properties statewide is substantial. This means that a large amount of local economic activity and employment results simply as a result of having a desireable lake in the locality.

Value of lakes in Maine's statewide economy

Boyle et al. (1997) used economic activity data and models to estimated at how lakes are used and how this translates into economic activity. The money people spend to use lakes (so called "direct expenditures") for things like gasoline, fishing tackle, and food gives rise to money being re-spent within communities. This re-spending creates additional sales, income and jobs ("indirect" expenditures such as services to supply and maintain lake-related businesses, wages in thee business being used in the community to make other purchases etc.). Economists can also estimate the difference between what people are wiling to pay to use lakes and what they actually spend ("net economic value"). This is a combination of peoples' satisfaction with their lake experience and the total value they place on the use. The high net economic value associated with uses of Maine's lakes draw nonresident users to Maine and is a measure of the enjoyment and pride Maine people take in their lakes. If water quality in Maine's lakes declined, the enjoyment of Maine residents and visitors, and the economic activity it creates, would be reduced. Improving water quality would have the opposite effects. Net economic values are economic barometers that tell us what is happening to the quality of Maine's lakes.

A few statistics derived from available data suggest a substantial effect on Maine's economy. For example, Maine's Great Ponds (those over 10 acres) generate nearly 13 million recreation user days each year. This recreation generates $1.1 billion each year and 15 % of this is money brought into Maine by nonresidents. Other uses of lake water (drinking water, youth camps, commercial uses) is worth $ 400 million annually. Our public drinking water systems provide 93.5 million user days valued at over $141 million dollars. Seasonal drinking water supplies account for an additional 9.8 million user days.

Lake-front property owners also contribute to economic activity within the state through the taxes they pay and investments they make in their properties. These costs total $349 million in economic activity annually, with 25% coming from nonresident property owners. In a state with a small population, the total direct expenditures each year are substantial: almost $1500 per capita.

Total Direct Expenditures for All Uses of Maine's Great Ponds. (1996 dollars)

Type of Use	Aggregate Annual Expenditures		
	Residents	Nonresident	All Users
Recreation	$928,730,424	$158,652,660	$1,087,384,084
Other Uses	$189,962,159	$23,070,497	$392,170,419
Lake-Front Properties	$262,468,444	$87,489,481	$349,957,925
Total Expenditures	$1,381,162,028	$269,212,638	$1,829,512,429

As money is spent and re-spent within the economy, additional income and jobs for Maine residents are supported. For example, the $1.1 billion in direct expenditures for recreation alone results in an additional $629 million of economic activity due to this "multiplier effect". The total economic activity surrounding Maine lakes ($2.8 billion) leads to over $1.2 billion in annual income for Maine residents and supports over 50,000 jobs. Of these, about 8,000 (roughly equal to the State's largest private employer, Bath Iron Works) are generated as a result of money brought into the state by nonresidents.

In addition to the direct and indirect effects on Maine's economy, the total net economic value of Maine's Great Ponds is at least $6.7 billion dollars annually.

Total Net Economic Values Associated with Uses of Maine's Great Ponds (1996 dollars).

Type of Use	Aggregate Annual Net Economic Value		
	Resident	Nonresident	Total
Recreation Uses	$173,823,970	$34,366,596	$208,190,567
Other Uses	$110,919,526	$4,036,700	$114,956,227
Lake-Front Properties	$4,803,876,456	$1,601,292,152	$6,405,168,608
Total Net Economic Values	$5,088,619,952	$1,639,695,448	$6,728,315,400

Eutrophication of Maine's lakes, the primary cause of diminished water clarity and the major threat to Maine's lakes, reduces the desirability of lakes for all recreation activities.

Based on comparisons of the clarity of developed lakes versus lakes with undeveloped watersheds, there are at least 189 lakes that have compromised water quality due to eutrophication. This is reflected in lower net economic values, lower use rates, and decreased direct and indirect sales.

A simulation was conducted to investigate how a reduction in eutrophication would enhance net economic values and use rates, with consequent increases in expenditures and total economic impacts. The effects were computed from existing studies that have investigated the effect of lake eutrophication on net economic values. Improvement of lakes with poor water clarity to the average summer minimum of unimpacted lakes would lead to an increase in net economic value over the current situation of over 2 billion dollars annually. The improvement in water clarity would be expected to increase recreation statewide use rates by up to 13 percent (1.6 million user days) over the current estimate. Swimming and open-water fishing account for over 75 % of the additional days of use. Reducing eutrophication would also increase direct expenditures by $107 million. Twenty-three percent ($24.7 million) of the increase in direct expenditures would be attributable to nonresidents (new money entering Maine's economy) of which $7 million (28 %) would be property taxes paid by nonresidents.

Increase in Annual Net Economic Value
Due to Reduction in Lake Eutrophication

Type of user	Daily Net Value	Aggregate Annual Increase in Net Value		
		Resident	Non Resident	All Users
Swimmers	$1.77	$10,829,954	$1,547,136	$12,377,090
Anglers				
Open Water	$1.55	$2,971,428	$1,635,943	$4,607,371
Ice Anglers	$2.46	$1,700,356	$ 180,683	$1,881,040
Boaters	$2.60	$5,169,705	$ 738,529	$5,908,324
Lake front Owners	N/A	$1,490,464,950	$496,821,650	$1,987,286,600
Total Values	N/A	$1,511,136,393	$500,923,941	$2,012,060,335

Perhaps more important is the reality that wholesale degradation of water quality is more likely than improvements. The studies cited below illustrate that the relative effects of degrading water quality are greater than for improvement and we expect that failure to protect Maine's lakes will result in even greater losses than the figures cited above.

Relationship of water quality and property values

There is no single feature of lakes which affects people's enjoyment of the resource more than water clarity. Repeated nuisance algal blooms have been recorded on more than 53 Maine lakes and another 493 are considered at significant risk of increased phosphorus levels (and attendant water clarity declines) due to projected development. Michael et al. and co-workers (1996) completed the first ever definitive study which clearly demonstrate one facet of economic loss when lake water quality declines: reduced property value. Lake front property values represent huge personal investments and a substantial public interest. In Maine, more than 60% of all municipal revenues come from property taxes; taxes which are directly related to property values. There are a number of studies which show that perceived environmental quality affects property values, but relatively little research had been done on lakes until completion of these studies.

What people are willing to pay for lakefront property reflects several factors including amenities such as house size, type of water supply and proximity to town centers. It also reflects the percieved quality of the resource which draws the owner there: the lake itself. Michael used hedonic valuation models to relate minimum lake clarity and propetrty characteristics to property values. Boyle et al. (1998) extended this with a two stage model which added more data and market areas. It also included an estimate of owners demand for water quality based on a visual survey instrument designed to offer alternative water clarity scenarios and elicit owners willingness to pay to maintain or improve water quality (contingent valuation). Both studies shed light on the statewide value of maintaining clean lakes.

Michael chose 34 lakes in six regional groups across Maine. Regional groups were intended to represent different market areas, with lakes chosen for each cluster so as to provide a range of water clarities and nearly continuous seasonal secchi clarity data for 5-21 years prior to 1994. The lakes ranged in size from 640 to 8186 acres, and a variety of estimates based on seasonal minimum clarity were constructed. Data on property attributes were taken from transfer tax records for all shorefront property sales (> 900) between 1990 and 1994. Due to limitations in tax data (Newport area) or the regional range in lake clarities (Ellsworth group) models were constructed on four of the groups represented by 543 property transfers (groups were Northern Me., Waterville, Augusta and Auburn areas).

Property attribute data eventually used in models included 11 "structural" variables such as number of stories and living area and 5 "locational" variables such as proximity to public roads, distance to nearest large town and lake surface area. Water clarity variables of most use included "WATERQ" (summer minimum clarity reading in meters for the year a property was sold) and "TREND" (difference between WATERQ and the ten year average minimum for the lake). Multiple regression models were fitted for each lake group which accounted for the effect of the property attributes and the marginal effect of differences in water clarity. These models estimated the dollars per front-foot change in property price for a 1 meter increase or decrease in minimum clarity. The general relationship between property price and water quality is illustrated as:

ftprice=f(S,L,Ln{W})

Where: ftprice = house price/lot frontage
S=Structural Characteristics
L=Locational Attributes
W=Water Quality

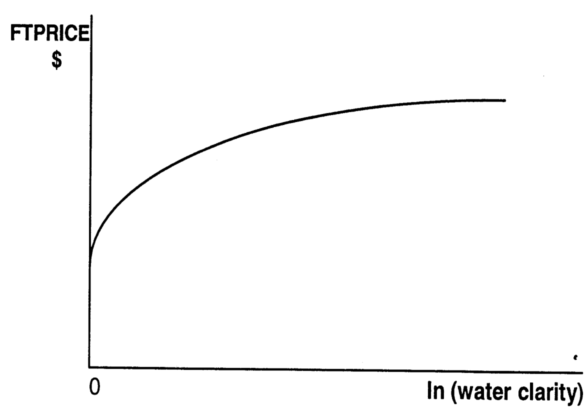


Figure 1. Expected relationship between property price and water clarity.

Average property prices ranged from $35,160 (Northern Maine) to $96,304 (Auburn area), with a mean price per lakefront-foot of $317 and $870 respectively. The range of average minimum clarity also was highest between the Auburn group (5.7 m) and the Aroostook group (3.1 m). Individual models were fit for 22 lakes which allow calculation of the average price per foot, the component of that price which is affected by water clarity (WATERQ), the total average value of properties, and the total estimate for property values on the lake. Mean property values for the properties on a lake can be calculated as :

Mean Property Value= Mean # feet frontage *(A + B *Ln (WaterQ))

Where A gives the per foot property price attributable to structural and locational variables and B gives the component influenced by water clarity (WaterQ).

For example, properties on China Lake (mean WATERQ of 1.9 m) sold for an average of $107,070, of which 15 % ($15,996) was dependent on water quality. The models also allow us to estimate the effect of an improvement or decrease in water quality. We can compute the increase or loss in value if water clarity changes. If we aggregate effects over the entire lake frontage, we can estimate how much loss or gain would be realized with changes in water quality. The table below shows that these effects can be very large and that they are greater for degrading water quality than for improving.

Aggregate changes in property prices on selected lakes for a one meter (1m) change in water clarity.

	China Lake	Cobbossee Lake	Long Lake
Av. min. clarity	1.9m	1.7m	2.8m
Improving price for 1m	$81/ft	$34/ft	$52/ft
Degrading price for 1m	$141/ft	$65/ft	$75/ft
Total Lake Frontage	114,048 ft	192,000 ft	180,114 ft
Total change in property prices			
Improving	$9,237,900	$6,528,000	$9,365,900
Degrading	$16,080,700	$12,480,000	$13,508,600

The future property tax implications of these losses can be substantial. As an example, the Town of Belgrade has a total tax valuation of almost $211 million, of which 60% is lakefront property. If the average water clarity in the local lakes were to decline one meter, the town stands to lose almost $10.5 million (5%) in total property value which should eventually be reflected in tax rates. At the 1997 fiscal commitment, Belgrade would have to raise its tax rate and the actual taxes paid by non-shoreline owners would rise by over 5%, while those paid by shoreline owners would decrease as they lost property value. This supposes that only shoreline in Belgrade would be affected. In reality, Belgrade shares frontage with four other towns on four major lakes (all interconnected). Three of these towns are in the same school district, the budget for which accounted for as much as 62% of the municipalities' 1994 fiscal obligations. The degree to which tax burdens would be shifted among towns is difficult to estimate and depends in part on which lakes experience significant water quality declines. No matter what the distribution of this loss would be, the real losers are the taxpayers and landowners whose investments have been eroded.

Another way to look at the impact of degraded water quality is to compare the estimated loss of property value for lakes which are less clear than the expectation for their regions. We estimated the median summer minimum clarity on lakes with low disturbance watersheds in four ecoregions of Maine (Bacon, 1996). We then determined the departure from expectation for individual lakes and applied the model for the lake group closest to the lake in question. For 58 lakes (51,440 acres) which have had two or more algal blooms (clarity minimum < 2 m) the estimated property value loss is in excess of $150-285 million, depending on assumptions about the degree to which shorelines can be developed in the future. Of 451 lakes with substantial clarity data, 191 lakes are below the overall regional expectations. Extending the model to these yields an estimated potential property loss of $256-512 million. While these models have been adapted to other lakes in their regions in only an approximate way, it is clear from these estimates that the economic losses due to declines in lake water quality which have already occurred are real and very large.

Additional work by Lawson and co-workers (Boyle et al. 1998) extended the "first stage" hedonic model, adding another year of property sales data for 1995 and two market areas in central Maine. A total of thirty-six lakes with 674 sales (1990-95) in seven market areas were included. Total shore frontage on these lakes exceeds 2 million feet and summer minimum water clarity ranged from 2.7 to 6.1 meters. The sales price of the property was modeled using property characteristics (including the total lakefront footage) and minimum water clarity. All the groups showed a relationship between water quality and property values and the relationship was statistically significant in four market areas. In addition, the study developed a "demand curve" for the entire market area estimating the value of water quality using results of the hedonic equations.

Individual equations for each lake offer options to calculate expected sales prices for properties and the component of that price attributable to water quality component. The form of these equations is:

$$PP = A + B \times \ln(\text{Minimum Water Clarity}) \times \text{Lake Area}$$

Where PP is property price, A is a coefficient for each lake, and B is a coefficient for the market area. It also uses average minimum water clarity (meters) for the study period and the surface area in acres for each lake. This last variable is important because it is now clear that there is a significant interaction between the size of a lake and the market response to clarity. In other words, the amenity provided by clear water is affected by people's expectations and patterns of recreation which differ on large vs. small lakes. The positive signs of all these components suggests that water clarity has a greater effect on property values as lake size increases.

As an example, for China Lake the expected mean property price is $91,808, 4.6 percent ($4,456) of which is attributable to water quality (the so called implicit price of water quality). Similar to the Michael study, we can compute the expected effect of an increase or decrease of one meter in minimum clarity. In this case, these correspond to an increase in value of $3,545 for improvement vs. a loss of $6,620 for a decline in clarity. The table below illustrates similar calculations for three lakes. Using the estimated numbers of properties on each lake, the gain/loss in total property values with one meter shifts varies from two to seven million dollars. As in the previous study, the loss due to a reduction in water clarity is much greater than for an improvement, suggesting the greater relative value of protecting water quality vs. trying to improve conditions in a degraded system.

Changes in property prices on selected lakes for a
one meter (1 m) 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 ($/Property)	$5,214	$3,545	$5,604
1 m degradation	$6,001	$6,620	$7,629
Feet of Frontage	163,680	114,048	144,144
Average Feet of Property Frontage	144.5	128.5	94.4
Estimated Number of Properties	1,019	799	1,374
Total change in property prices for lake			
1 m improvement	$5,313,066	$2,832,455	$7,699,896
1 m degradation	$6,115,019	$5,289,380	$10,482,246

(Estimated numbersof properties are derived by assuming 90 percent of the lakefrontage is developable and dividing the developable lake frontage by the average feet of frontage for properties on each lake.)

Demand equations were developed using the above results to estimate an implicit price for water quality. This relationship was calculated using the prices for square footage of living area and lake front footage. It also used variables for income level, whether the buyer had visited the lake prior to sale, whether friends or relatives were located nearby, and the buyers' expectations of improvement or decline in water quality in the future. As the price of water quality increases, we expect the demand to decline to fit owners financial means. As the price of living area (structures) increases, people would also choose a lower clarity to offset this. However, as the foot frontage price increases, people may opt for higher water clarity but smaller properties to compensate.

These results suggest some problems for water quality protection. As the cost of buildings increases, more demand may be put on construction and development of properties on lakes of lower clarity, thus increasing development pressure on these sensitive waters. Likewise, if costs of frontage on more remote lakes increases as properties on developed lakes become less available and the overall market for second homes expands, people may opt to develop smaller lots and increase development pressure.

The key finding here is the curve illustrating the demand (cost) for water clarity in the study areas. User perception surveys in Maine and elsewhere suggest that 3-4 meter minimum clarity marks a significant dividing region in peoples' perception and satisfaction with their lake experience. Above that range, the incremental response becomes less for each unit of clarity increase while people become more sensitive to changes as clarity declines below that. To the left of the demand curve, people are willing to pay substantially more for incremental improvements in water quality while the relationship to the right is flatter, indicating a that people are willing to pay relatively less for additional units of water clarity. It also indicates that the economic loss from a reduction in water clarity is greater than for an improvement.

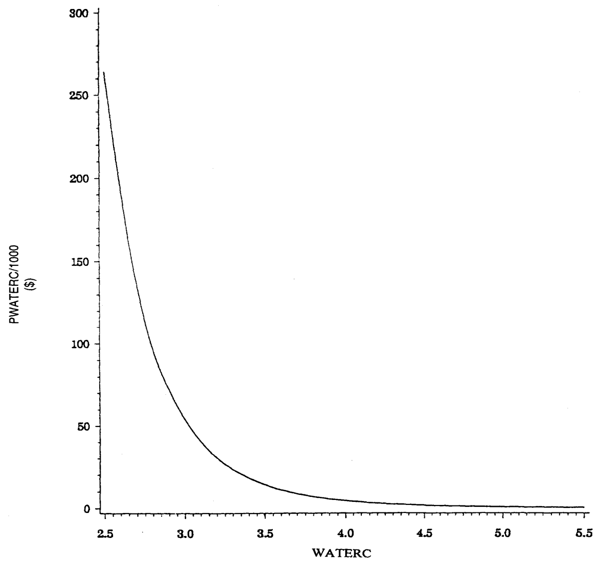


Figure 3. Estimated demand for lake-water clarity

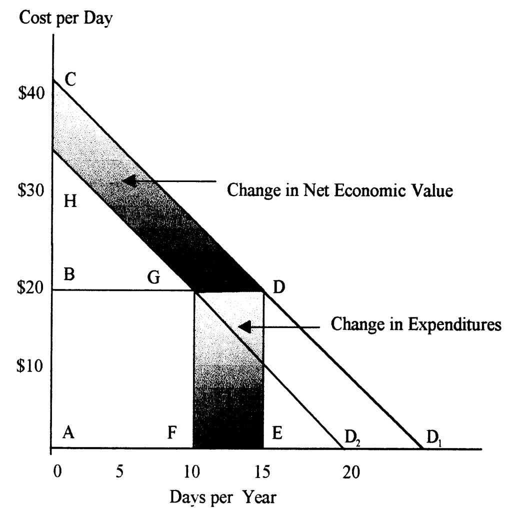
The area under the demand curve is a measure of people's economic benefit or liability from changes in water clarity. For Maine, the average minimum clarity for all lakes is around 3.8 m and for those lakes which are not classified as having impaired water quality it is 5.2 meters. There area under the demand curve between 3.8 and 5.2 meters is $3,048, indicating that the "average" property owner would see a gain if the clarity increased by this amount. Likewise, a decline from 3.8 to 4.4 meters suggests a loss of $36,538 in benefits to the owner.

While the results derived from the hedonic equations and the generalized demand curve are expressed as a loss in property value, they really represent losses in enjoyment and perceived value of the lake experience. These results clearly indicate that it is better to protect water quality than to allow clarity to decline and then try to reverse the negative effects; each increment of decline results in increasing economic losses. Along with this are the increasing difficulty and costs and reduced feasibility of lake restoration as conditions deteriorate further from acceptable conditions.

<u>Value of lake use and water quality to transient users</u>

There are a large number lake users who do not own lakefront. These so called "transient' or "access" users represent a part of the total lake use which is are often overlooked in our public contacts because lake front property owners are the people with whom we most often interact. Boyle et al. (in prep.) derived information from access users identified by

Figure 1. Hypothetical Example of an Individual's Demand for Boating Days



---

a mail survey and randomly contacted for substantial follow-up surveys. These data allow an estimate of the proportion of Maine residents who are access users. It also allows the construction of demand curves for various aspects of lake use. In the example above, total expenditures for an activity are a function of the cost of the activity times the number of days days participating (area ABDE). Willingness to participate declines as per-day cost increases (D to E). The net economic value of the activity to the user (a measure of the value a user places on an activity in excess of its cost) is illustrated by the area BDC. Loss of both value in the economy and net economic value to the users with changes in resource quality (in this case water clarity) can be estimated by gathering data allowing us to evaluate the change in participation rates and value per day from user survey data.

This study is a partial estimate of user's economic value and satisfaction because methods constrained estimates to only the 143 most popular Maine lakes identified in the sample and could not include out-of -state users. Extrapollation of the data to all residents shows that well over 200,000 Maine adults are access users on lakes annually. It revealed that these users are similar in socio-economic status and age compared with the adult population in general but tend to have a high percentage of males and higher education levels. About 78% swim, 64 % recreate near the shore, 49% fish from a boat and roughly equal numbers (ca. 40%) use powerboats and canoes. Maine resident access users spend as much as $153 million annually on their recreation, 59% of which is spent in the communities nearest those lakes. This use supports as many as 3,000 jobs and generates in excess of $30 million income for Maine residents.

Aggregate Use of Maine Lakes by Resident Adults

User Category	Aggregate Number of Users		Percentage of Adults	
	Low Estimate	High Estimate	Low Estimate	High Estimate
Own lakefront property	53,521	126,156	6%	14%
Do not own lakefront property	201,339	474,587	22%	52%
(Renters)	(10,067)	(23,730)	(1 %)	(2%)
(Access users)	(191,272)	(450,857)	(21%)	(50%)
Total lake users	254,860	600,743	28%	66%

'Residents who are 20 years of age and older

Access Users' Aggregate Annual Net Economic Values and Economic Impacts

	Low'	High
Net economic value	$7,566,760	$17,835,903
Economic Impact	$63,988,224 b	$147,797,784
Direct sales	$38,445,614	$90,620,938
Indirect sales	$9,545,760	$21,368,042
Induced sales	$15,996,850	$35,808,804
Income	$24,126,905	$54,007,862
Employment'	1,282	3,023

Low and high estimates were obtained using the low and high estimates of use rates
All monetary data are converted from 1995 to 1997 dollars using annual average consumer price index

Access Users' Consumer Surplus Associated with Use of the Most Popular Maine Lakes

Consumer Surplus Estimates				
Per-person per year	$39.56	90%	Confidence Interval	$0 to $202
Aggregate annual	Low	$7,566,760'		
	High	$17,835,903		

(Low and high consumer surplus estimates are obtained using the low and high estimates of use rates (191,272 and 450,857 people, respectively)

This study also found that access users place substantial value on their use of Maine lakes (between $7.6 and 17.8 million dollars) in excess of the cost to them of participation in fishing, swimming, camping etc. This satisfaction is negatively affected by reductions in water clarity and is greater on clear, large lakes than small, less clear waterbodies. Models derived from the survey results suggest that a 1/2 meter decline in the water clarity of the 143 most popular Maine lakes will result in a loss of up to half a million dollars in net economic benefit (user satisfaction) and $1.6 million in total sales activity associated with those lakes.

Access Users' Annual Net Economic Value Associated with a Statewide Lake Protection Program

	Program to Prevent a Decline in Average Minimum Clarity of	Value of Program	90% Confidence Interval
Net economic value per person	1/2 rn (from 3.78 to 3.28 m)	$3.87	($1 to $7)
	1 m (from 3.78 to 2.78 m)	$8.68	($3 to $15)
	1 1/2 rn (from 3.78 to 2.27 m)	$13.01	($5 to $23)
Aggregate net economic value		LoWa	High
	1/2 m (ftorn 3.78 to 3.28 m)	$740,223	$1,744,817
	I rn (from 3.78 to 2.78 m)	$1,660,241	$3,913,439
	1 1/2 m (from 3.78 to 2.27 m)	$2,488,449	$5,856,650

Low and high net economic value estimates were obtained using the low and high estimates of use rates

The study also found evidence that these access users place a value of as much as $1.7 million on a statewide program to prevent a relatively small (1/2 meter) reduction in the current minimum water clarity. The value of such a program is much higher ($6 million) if it was designed to prevent a decline to bloom conditions on all lakes. This represents an annual willingness to pay of $13 per user for the preservation of water quality.

Other Work in Progress:

Work continues at the University of Maine to determine appropriate ways to quantify market economic signals as a function of environmental variables. Work now being done by T. Hsu and K. Boyle the University of Maine is estimating hedonic models and demand curves for property prices in Vermont. In addition to use of water clarity estimates as in previous studies, they are examining the relationship between objective measures of aquatic plant growth and property prices. They compiled Vermont DEC data for weed density and data for 301 properties sales in three market groups during 1990-95. Preliminary property price-water quality relationships show simlar patterns to Maine data. However, modeling attempts for aquatic plant effects are proving more difficult in part due to the nature of plant survey data that are both less quantitative in nature and less easily attributable to conditions at specific properties than lake-wide clarity measurements (K. Boyle, pers. comm.) Regardless of this, anecdotal information suggests that there is probably a real relationship awaiting development of adequate monitoring data to enable successful modeling. Alternatively, the use of subjective data from property owners may allow developing meaningful models, although relating these observations to objective field data may prove difficult.

Poor and others (in press) tested the relationship between objective measures of water clarity (the minimum clarity during the year of each property purchase collected by trained observers) and owners' subjective estimates of clarity. These subjective data were collected from 350 owners as part Lawson's earlier surveys. Owners were asked to rate the minimum clarity of their lake on a 0-21 foot scale. Subjective and objective measures were significantly correlated for most of the market areas. For all of the market areas combined, 47 percent of respondents' subjective measures were within one meter of the corresponding objective water clarity measure (and 16 percent were within one foot).   In general, 61 percent of respondents underestimated water clarity by more than one foot, while approximately 23 percent overestimated water clarity by more than one foot.

Hedonic property price models were estimated for both measures. As in previous studies, the implicit price of water quality was estimated, in this case between $2000 and $6500 per meter evaluated at the means for the market areas. In each of the areas the value calculated with subjective measures were within 10-15% of those for objective measures. In addition to continued verification of the economic benefits water quality, this research also suggests that most property owners do observe water clarity and that it has a meaning for them which is expressed in the market.

The market signals discussed above demonstrate the very large value of lakes in the economy of a small state such as Maine. Whether these effects are expressed in local economies and tax revenues of towns bordering lakes or in the larger state economic performance perspective, the value of lake use and contributions to quality of life are very large. Huge investments are made in properties by owners and both the current and future value of these investments are tied to water quality. Failure to consider these values or the users' net economic value (consumer surplus) when evaluating lake protection measures significantly undervalues the resource and the consequence of environmental degradation. State and community actions to protect water quality can have a significant pay off by maintaining and enhancing future tax revenues, employment and enjoyment of Maine's lakes. This is a core issue for the future of Maine's quality of life.

Literature Cited

Bacon, Linda, 1996. *Geographic Analysis and Categorization of Maine Lakes: A Trial of the Draft Bioassessment and Biocriteria Technical Guidance*, Maine DEP, March 1996.

Braley, Mark, Kevin Boyle and Roy Bouchard 1996 *Lake Recreational and Economic Activity Survey Report*. Uniuversity of Maine Dept. of Resource Economics and policy. Ag. And forest experimental Station Reoprt #471. July 1996.

Boyle, Kevin, Jennifer Scheutz and Jeffery Kahl, 1997. *Great Ponds Play an Integral Part in Maine's Economy*. Univ. of Maine Water Research Institute Report # 473

Boyle, Kevin, Steve Lawson, Holly Michael and Roy Bouchard 1998. *Lakefront Property Owners' economic Demand for Water Clarity in Maine Lakes*. Maine Ag. and Forest Experiment Station Report 410 Sept 1998.

Boyle, Kevin, Jennifer Scheutz and Roy Bouchard, in prep. *Economic Values and Economic Impacts of Recreational Users of Maine's Great Ponds. University of Maine-Orono*

Michael, Holly, Kevin Boyle, and Roy Bouchard 1996. *Water Quality Affects Property Prices: A Case Study of Selected Maine Lakes*. Maine Agricultural and Forest Experiment Station Misc. Report 398, Feb 1996, Univ. of Maine

Poor**,** Joan, Kevin Boyle, Laura Taylor and Roy Bouchard, in prep. *Objective Verses Subjective Measures of Environmental Quality in Hedonic Property-Value Models*. Department of Resource Economics and Policy, University of Maine

Todd, Hank (Minnesota Office of Tourism, St. Paul Minn.) 1989. *The Importance of Lakes to Minnesota's Economy*. Minnesota Lake Mangement Conference, Oct. 1989

(file= NEAEB3_00_notitle 3/31/00 by Roy Bouchard, Maine DEP Lake Assessment Program, SHS 17, Augusta Maine 04333)