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The Effects of Water Clarity on Economic Values and Economic Impacts of Recreational Uses of Maine's Great Ponds

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INTRODUCTION

Maine's Great Ponds define much of the state's natural landscape and are important ecological, cultural, and economic assets. Approximately 2,700 Great Ponds (natural lakes 10 acres or greater or impoundments 30 acres or greater) cover about one million acres in Maine, which accounts for 6% of the state's surface area (Maine Department of Environmental Protection 1998). Maine's Great Ponds support diverse habitats for fish, aquatic plants, and other living organisms. In addition, Great Ponds provide recreational opportunities, desirable residential development sites, potable water, and commercial opportunities for residents and nonresidents of the state (Boyle et al. 1997). While these waters are legally referred to as Great Ponds in Maine, this report will use the more common nomenclature and refer to them as "lakes".

There is a general perception of clean, clear lakes in Maine, but the Department of Environmental Protection (DEP) (1998) states that lake water clarity is threatened by organic enrichment from nonpoint source (NPS) pollution. NPS pollution increases nutrient loads to lakes, which increases algae productivity and can lead to eutrophication of a lake. While eutrophication can occur naturally, cultural (human-induced) eutrophication is the major cause of these reductions in water clarity. Land-use practices in lake watersheds, such as residential development, timber harvesting and agricultural production all contribute to NPS pollution that leads to increasing trophic levels in Maine lakes (Maine DEP 1998).

Intense algae growth ("algae blooms") in lakes is characterized by reduced water clarity. Clarity is measured by lowering an 8-inch "Secchi" disk, which is black and white in alternating quadrants, into the water. The depth where the disk disappears from sight is a measure of clarity and is an indirect measure of lake productivity and algae growth.

Of the 639 lakes where water clarity has been assessed, 54 are considered impaired because they have diminished water clarity (less than a 2-meter minimum reading during the summer months of May through August) (Maine DEP 1998). These monitoring data and modeling suggest that water clarity in another 589 of Maine's lakes is considered threatened (Maine DEP 1998). This means that about one quarter of Maine's 2,700 lakes have compromised water clarity or are threatened with significant increases in algae growth. Water clarity is a concern even in lakes where clarity readings are well above 2 meters. For example, Boyle et al. (1998) found that any reduction in water clarity reduces the value of shoreline properties around a lake, and user perception surveys suggest that any reduction in clarity will diminish user satisfaction (Volunteer Lake Monitoring Program 1997; Smeltzer and Heiskary 1990).

Current programs for controlling eutrophication of Maine lakes include altering agricultural and forestry practices to minimize erosion, and shore-land zoning. Non-regulatory means of protecting Maine lakes consist of broadening the public's awareness of sources of NPS pollution flowing into lakes and the consequences of increased eutrophication, as well as providing technical guidance to land owners, builders, and lake communities on ways to reduce NPS pollution.

As efforts to protect water clarity in Maine's lakes compete for limited funds with other worthy projects, having a strong economic justification for lake protection is very important. Economic measures, such as "net economic value" and "economic impacts," can be used to determine the economic effects of lake-protection efforts. Net economic value is a measure of the economic benefits individuals derive from lake use. Net economic values measure the benefits of water clarity to users and can be used in benefit-cost analyses of lake protection programs. Economic impacts arise from expenditures in local economies by people who visit lakes and the consequent indirect effects on secondary sales, income, and employment (commonly referred to as multiplier effects). Economic impacts can be used to help demonstrate to local communities that they have a vested economic interest to protect water clarity in lakes in their communities. Economic impacts are not counted in benefit-cost analyses of lake protection programs because a loss in expenditures in one area of the state will generally be offset by the money being spent in other areas of the state.

No study has been done, in Maine or elsewhere, to examine how different levels of water clarity affect the values people place on lakes they visit for recreation. These are people who do not own property, but use some form of public access for lake recreation such as swimming, boating, and fishing. Specifically, we focus on these people, whom we will refer to as "access users," to find out who uses Maine's lakes for recreation and how their use is affected by water clarity. The specific research objectives addressed include

1. Estimate the number of access users.

2. Estimate the effects of water clarity on net economic values and expenditures, and consequently economic impacts, of access users.
3. Estimate the net economic value access users place on a statewide program to protect Maine's lakes from eutrophication.

Data to address these objectives were collected using a mail survey sent to a random sample of Maine residents who were at least 20 years of age.

Minimum water clarity during the summer months (May–August) is used by the Maine DEP as a measure of eutrophication. This represents the "worst case" conditions encountered by access users, and it is these minimum clarity levels that are most likely to affect use and enjoyment. All analyses in this paper will be based on the current minimum water-clarity levels in Maine lakes and reductions in these minimums. DEP policy focus is on preventing reductions in the minimum clarity, as it is very difficult to reverse eutrophication and most of the policy issues in Maine deal with protecting lakes from eutrophication.

NET ECONOMIC VALUES AND ECONOMIC IMPACTS OF LAKE USE

The marginal economic values that access users place on visiting a lake and the cost of visitation largely determine the extent of use and the magnitudes of net economic values and economic impacts for any given level of water clarity. While net economic values and economic impacts both contribute to the economic importance of lakes, they do so in separate and distinct ways. Net economic value is a measure of the "satisfaction" an access user receives from visiting a lake after paying all of the costs of participation. Expenditures are the costs of participation to recreationists. These expenditures generate economic activity, referred to as economic impacts, that provide jobs and income in local communities.

The relationships between use rates, net economic values, and expenditures can be explained using a graphical representation of the concept of recreation demand. Demand for an individual lake user represents the relationship between the marginal value the user places on each visit to the lake and the number of visits taken. Figure 1 presents a demand relationship for a hypothetical boater's annual use of a lake. The demand relationship indicates that this individual is willing to pay less for each additional day of boating, with the line CD_1 representing the demand for days of boating at the current water clarity. If the cost per day exceeds $40, the individual would not visit the lake. When the cost of a day of boating is $20, this person would choose to go boating 15 days per year. The person will continue to go boating as long as the value of the last day of boating, as represented by the demand line, exceeds the cost per day. The person would boat fewer days at a cost per day higher than $20 (but less than $40) and more days at a daily cost lower than $20. The person would not go more than 25 days per year, which would be the visitation at a cost of $0. The cost per day, what we might refer to as the effective access price, includes transportation costs to the lake, launch fees, gas for the boat, and food and beverages purchased for the trip.

Each point on the demand line represents the marginal value the individual places on a day of boating, and the area under the demand line represents the total economic value the individual places on boating at this lake. At a cost of $20 per day the total economic value the individual places on boating on the lake is the area ACEF (the area below the demand line and to the left of 15 days), which is equal to $450. While the area under the demand curve and to the left of the selected participation rate measures the total economic value to the individual, part of this value is offset by the annual costs of participation (rectangle ABEF), which is $300. These expenditures are the basis of the economic impact generated by the boater's use of the lake. The retained value, which is the net economic value, is the triangle BCE, which equals $150.

While net economic values do not involve the actual exchange of money, they represent the value retained by users after all costs of participation are paid. This is the reason a person would not go boating at a cost in excess of $40 per day, as there would be no retained value. Likewise, the person would not boat more than 15 days at a cost per day of $20 because the cost of an additional day would exceed the marginal value the individual places on a 16th day of boating on the lake.

The boater's expenditures constitute an exchange of money and economic impacts are a consequence of these expenditures. Direct expenditures by the boater could include purchases of gas, oil, food and beverages from a local convenience store (direct expenditures). The store obtains some of its stock from local suppliers (indirect sales) and some from sources outside Maine (leakage from the state's economy). Expenditures in Maine by people who earn income from the direct and indirect sales lead to additional (induced) sales. The indirect and induced sales are called multiplier effects. An expenditure multiplier of 1.25 would indicate that every dollar of expenditures by the boater would generate

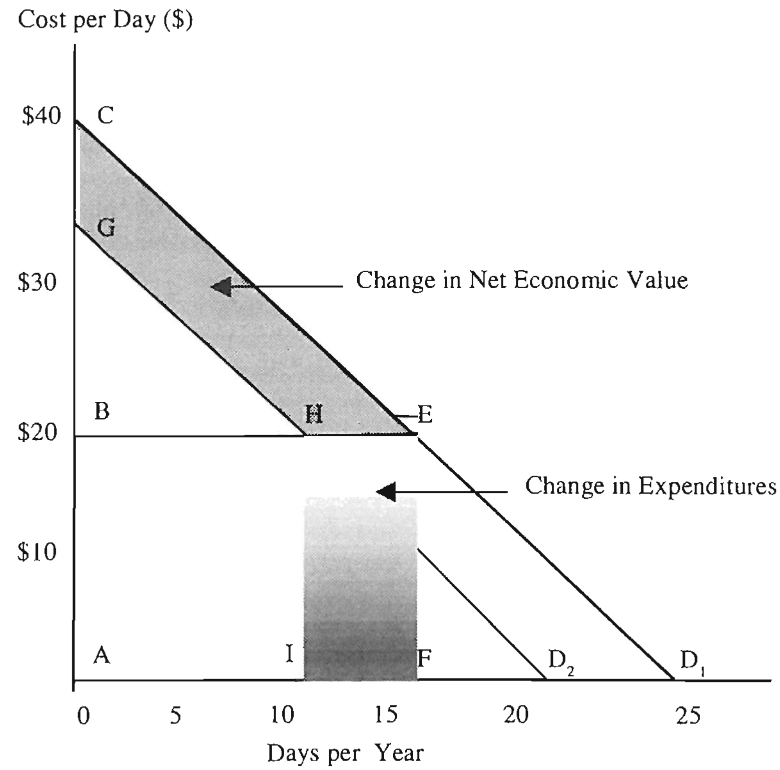

Figure 1. Hypothetical example of an individual's demand for boating days.

an additional 25¢ in indirect and induced sales. Multipliers can also be developed for the employment and income generated by the boaters' expenditures as well. These multiplier effects constitute what is referred to as economic impacts.

Economic impacts must be interpreted very carefully. If the boater ceased to visit the lake due to reduced water clarity, the economic impact would not be lost to the state's economy. It is likely that this person would choose to visit another lake, which means that expenditures, and therefore economic impacts, would just be shifted to another region of the state. This redistribution is simply a loss in economic activity from one community that is likely offset by gains in economic activity in other regions of the state. There would only be a loss to the state if water clarity were diminished in all lakes such that Maine residents chose to use lakes outside of Maine and nonresidents no longer chose to come to use Maine's lakes, but this is not a plausible scenario.

If the boater prefers clearer water, a change in water clarity would cause the demand curve to shift out for an increase in water clarity and shift in for a decrease in water clarity. A decrease in water clarity is portrayed by the shift in demand from line CD_1 to line GD_2 in Figure 1. The reduction in water clarity renders the lake less desirable for boating. As a consequence, the boater's total economic value declines to the area AGHI, which leads to a lower net economic value for this user and a reduction in expenditures and that diminishes the economic impact. At $20 per day, the person would now go boating 10 days per year—a reduction of five days. Net economic value is now $70 (area BGH), which constitutes a loss of $80. Total expenditures are reduced to $200, which is a reduction of $100 (area ABHI). These losses represent the direct economic consequences of a reduction in water clarity. Again, considering an expenditure multiplier of 1.25, direct, indirect and induced sales in communities near the lake would be reduced by $125.

The conceptual framework presented here can be generalized to swimming, fishing from the shore and from a boat, motorized and nonmotorized boating, and shore use of a lake. In the results presented in this paper, we do not estimate net economic values and expenditures for each of these uses singularly. Nor do we estimate these economic concepts for specific lakes. Rather, we estimate net economic values and expenditures for an average user and investigate how these estimates vary with water clarity and recreational activities on the lakes these people visit most often.

METHODS

Estimating Use Rates

An estimate of the number of people who use Maine lakes for recreation is necessary to expand per person estimates of net economic value and expenditures to the population of access users. There are no lists that identify Maine residents who visit the state's lakes to recreate. Thus, a survey was required to identify people who visit lakes and then inquire about their use of lakes in the past year.

Access users' data were identified through the first stage of a two-stage survey process. The first stage consisted of a postcard that was sent to a random sample of 3,000 Maine residents (20 years of age and older)[1]. The sample was obtained from the Maine Department of Motor Vehicles and was drawn from driver's license or state identification card records for 1996. Drawing the sample from these sources means that 95% of the adult population in Maine was eligible for selection in the sample.

The postcard survey asked people if they had visited a Maine lake during the previous year. People who had visited a lake were then asked to indicate what lake they visited most often and how they usually accessed that lake (lakefront property they owned, lakefront property they rented, or other access). Access users are those who said they accessed a Maine lake via land that they don't own or rent. The postcard survey results allowed us to estimate the number of Maine residents who are access users.

Estimating Net Economic Values and Economic Impacts

Data obtained directly from access users are needed to estimate net economic values and economic impacts. These data were collected in the second-stage survey mailed to all individuals who identified themselves as access users in their responses to the postcard survey. In addition to asking these individuals to answer questions to estimate net economic values and economic impacts, these people were also asked questions about their demographic characteristics and types of recreation activities they participate in on Maine's lakes.

We only report summary results from the statistical analyses of net economic values and economic impacts to address Objective (2). Brief technical explanations of specific aspects of the analyses are provided in footnotes, and estimated equations are reported in Appendix B. Readers seeking an understanding of the technical aspects of the analyses are referred to Schuetz (1998).

Net economic values

The absence of markets for many of the services provided by natural resources, such as recreational uses of lakes, necessitate the need for nonmarket valuation methods to estimate net economic values. For example, a boater has implicit costs of going boating, but use of the lake is free when public boat launches are provided. When fees are charged, they are usually small amounts that do not reflect the marginal cost of participation. Thus, there are no explicit market data on the price of participation and days of use to estimate a demand relationship.

Contingent valuation (CV) is one method for estimating net economic values for recreational uses of lakes. CV is a survey-research methodology that is used to ask people to reveal their net economic value for an amenity or change in the quality of an amenity (Mitchell and Carson 1989). For example, people are asked in a survey "how much more would you pay over your current cost of participation" and their responses are a measure of their net economic value. For the hypothetical example in Figure 1 our boater's answer would be $150.

A number of studies have used CV to estimate net economic values for recreation on rivers and lakes (Bishop et al. 1996; McGinnis et al. 1995 a, b, c, d; Carson and Mitchell 1993; Lant and Roberts 1990; Desvousges et al. 1983; Gramlich 1977; Oster 1977). All of these studies were conducted in other regions of the country. To our knowledge none of these studies estimated net economic values for changes in water clarity due to cultural eutrophication.

For this study, the questionnaire contained two CV questions.[2] The first CV question, designed to address the net economic value component of Objective 2, asked respondents their values for the lake they used most often during the previous year. Respondents were asked if they would have visited

[1] We knew that only some Maine residents would be access users, but we did not know the incidence in the population. Thus, we used as large a sample as the budget would allow for the postcard survey to increase the number of access users we would actually contact.

[2] Both questions employed a dichotomous-choice format (Mitchell and Carson 1989).

the lake if their expenses associated with use of that lake were a certain amount higher. Responses to this question provide estimates of the current value they attach to visiting a lake at the existing water clarity. The second CV question, designed to address Objective 3, asked respondents their net economic values for a statewide lake-protection program. The question was preceded by a written description of a program that would prevent a specified decline in the average minimum clarity in Maine lakes. Individuals were asked if they would pay a certain amount of money each year to prevent the specified decline in water clarity.

The net economic value component of Objective 2 was accomplished in the statistical analysis of responses to the first CV question. Current water clarity in the lakes visited most often was used in an equation designed to explain why some people answered "yes" to the CV question and others answered "no." If water clarity is a significant predictor of responses to the first CV question, then it is possible to conclude that water clarity does indeed affect net economic values of access users. If a higher level of water clarity makes respondents more likely to answer yes to the CV question, this implies that people prefer clearer water and that net economic values would be diminished by a decline in water clarity.

Objective 3 was accomplished by having different people in the sample evaluate a program that would prevent different magnitudes of decline in the statewide average water clarity (½, 1 and 1 ½ meters). That is, each respondent was asked to answer a CV question for only one of the three levels of change in clarity. The level of change was included as a variable in the statistical analysis of responses to the second CV question. If the level of change is a significant predictor of responses to the second valuation question, then the net economic value people place on the state program is affected by the magnitude of the change in clarity. If a larger decline makes people more likely to answer yes, then it can be concluded that access users place higher net economic values on a program that prevents larger declines in clarity.

Expenditures and economic impacts

Like net economic values, there are no readily available data on recreation expenditures associated with lake use from which to calculate economic impacts. These data, however, can be collected in the same survey as used to collect data to estimate net economic values. While others have estimated the economic impacts of recreational uses of lakes in other regions of the U.S. (McGinnis et al. 1995 a, b, c, d; Propst et al. 1992), none have linked economic impacts to the level of water clarity in lakes.

Respondents were asked to report their total expenditures associated with the lake they visited most often in the questionnaire. Expenditures included money spent in Maine for gas, food, and beverages, and lodging costs. For the hypothetical example in Figure 1, our boater would answer $300.

To address the economic impact component of Objective 2, responses to the expenditure question were analyzed to determine if they were statistically related to water clarity in the lakes respondents visited most often. A statistically significant relationship would indicate that expenditures, and consequently economic impacts, are affected by water clarity in lakes. If people spend more when they visit lakes with higher clarity, then a reduction in clarity for any lake will reduce the local economic impacts. This analysis constitutes the expenditure component of the second objective.

Responses to the expenditure question were used to compute the statewide economic impacts on sales, income, and employment of access users visits to lakes using IMPLAN (Minnesota IMPLAN Group, Inc. 1997). Again using a hypothetical sales multiplier of 1.25, the economic impact for the hypothetical example in Figure 1 would be $375. The effect of the economic impact of reduced water clarity depends on the effect of water clarity on expenditures from the analysis described in the preceding paragraph.

RESULTS

Of the 3,000 postcard surveys mailed, 1,165 usable postcards were returned and 315 were undeliverable by the U.S. Postal Service (a response rate of 43%). Of the 1,165 individuals who returned the postcard, 762 indicated they used a Maine lake during the previous year and were asked the name and address of the lake they visited m often.

One hundred and five (14%) people who indicated they used a Maine lake were excluded from the sample for the second survey because there was no water clarity data for the lake they used most or the available water-clarity data were outdated (from the 1970s and 1980s). It was necessary to have people in the sample that visited lakes with known water clarity so that we could assess the effect of water clarity on net economic values and expenditures to address Objective (2). A total of 657 individuals were mailed the detailed lake-use questionnaire for the second phase. Of the 657 questionnaires mailed, 508 were completed and returned, and 24 were undeliverable (a response rate of 80%). This response rate is higher than that of the postcard survey because the sample is comprised of access users who had already indicated a willingness to participate in the study by responding to the postcard survey.

Selected Respondent Characteristics

In general, access users who responded to the survey are similar to Maine residents in terms of gender, average age, employment status, and household size. However, respondents have a higher education level and a higher household income (19% greater) than the average Maine resident (Table 1).[3] Our experience conducting surveys indicates that people with more education and higher incomes are more likely to respond to surveys. Thus, we suspect that the differences in education and income are due, at least in part, to differences between access users who did and did not respond to the survey.

Most access users swim in Maine's lakes (Table 2). The second most popular activity for access users is shore-based recreation. The activity with the lowest participation rate is riding personal watercraft.

Estimates Of The Number Of Access Users

Two estimates are developed of the number of access users. This is done because the response rate to the postcard survey is low and we are not able to determine if the people who did not respond to this survey do or do not use lakes. Survey researchers have long known that the saliency of a topic affects survey response rates, which would imply that people who do not use lakes would be less likely to respond to the postcard survey. At the same time, some lake users may not respond due to lower education, as noted above, or for a variety of other reasons. Thus, the estimates of the number of access users we present are upper and lower bounds for the actual number of access users.

According to the results of the postcard survey, 66% of the respondents (762) use Maine's lakes and 75% of these individuals (572) are access users. This means there are three access users for every user who owns or rents property to gain access to a lake. In addition, owners and renters may be access users on lakes where they do not own or rent

Table 1. Socioeconomic characteristics of the general maine population and access users.

Characteristics	Maine Adults	Access Users
Gender (% female)	52	45
Average age (years)	46	46
Percentage unemployed	5.7	5.0
Average household size (persons)	2.5	2.9
Percentage whose highest degree is a B. A.	13	26
Average household income (1997 $)	$32,116	$39,524 [a]

[a] 1994 income data were converted to 1997 dollars

Table 2. Access users' participation in lake recreational activities.

Recreational Activity	Percentages of Access Users
Swim	78%
Recreate on the shore	64
Fish from a boat	49
Canoe/kayak	43
Other boating[a]	42
Camp beside a lake	30
Ride personal watercraft	9

[a] Other boating includes motorboating while not fishing, sailing, etc.

[3]Socioeconomic characteristics of the Maine population were obtained from the *Statistical Abstract of the United States* (U.S. Department of Commerce 1996a and 1996b).

property, but this type of access use is not reflected in our data.

If we assume that people who did not respond to the postcard survey are, as a group, the same as respondents, then our **upper-bound** estimate of the incidence of access users among adults in Maine is 50% (0.66*0.75). The **lower-bound** estimate is developed by assuming that people who did not respond to the postcard survey do not use Maine's lakes (57% of the surveys were deliverable by the U.S. Postal Service), and this estimate is 21% (0.43*0.50). Using an estimate of the adult population in Maine of 910,216 people, the number of access users ranges from 191,272 to 450,857 people. Our experience would lead us to believe that the predominant reason for not responding to the postcard survey was that nonrespondents do not use lakes and this implies that the actual number is closer to the lower bound than the upper bound.

Effects Of Water Clarity On Net Economic Values And Economic Impacts

Access users' perceptions of water clarity in the lakes they visited most often were investigated to determine if they are consistent with actual clarity measurements. Respondents were asked to rate the current minimum water clarity of the lake they visited most often on a four-point scale with ratings of "very acceptable," "somewhat acceptable," "somewhat unacceptable," and "very unacceptable," and only 10% of respondents indicated that they did not have an opinion. The correlation between the ratings of water clarity and actual Secchi disk measurements of clarity in these lakes was 0.41 and is statistically significant. This result suggests that access users do recognize water clarity in the lakes they use for recreation. Smeltzer and Heiskary (1990) found that clarity differences of 0.5 meters are visually perceptible to people. This suggests that water clarity should affect estimates of net economic values and economic impacts.

In the remainder of this section we will consider whether water clarity affects net economic values of, and expenditures by, access users for the lakes they visited most often. Having identified effects, we calculate the reductions that occur with three decrements in water clarity: ½ meter (m) (1.6 feet [ft]), 1 m (3.3 ft) and 1½ m (4.6 ft). The ½ m and 1 m declines were chosen because these changes represent declines in lake water clarity that could potentially occur and are large enough to be visually noticeable to the public.

Net economic values

An interesting result that arose from the data is that 150 lakes (5% of Maine's Lakes) were identified as being visited most frequently by respondents (Appendix A). While our data does not address other lakes visited by respondents, it is very likely that the 150 lakes are also secondary choices for many respondents. This finding suggests that most of the use, net economic value, and economic impact are associated with a very small number of the approximately 2,400 lakes in Maine.

Annual net economic value for access users at the lakes they visit most often is $40 per person.[4] Aggregate net economic value ranges from $7.6 million to $17.8 million, based on the high and low estimates of the number of access users. The aggregate net economic value for all lake use by access users exceeds $7.6 million. Sixty-eight percent of access users recreate on more than one lake. For example, a person may visit Lake A most often and may also visit Lake B. The survey only asks this person about their net economic value for the lake they visited most often (Lake A), which means that their net economic value for visiting Lake B is not counted in the figures reported here.

Responses to the CV question were analyzed using an equation where average minimum lake water clarity over the previous three years, lake surface area, and average water clarity multiplied by lake surface area, along with other variables, were used to explain why respondents answered yes or no to the CV question (Appendix B, Table 1).[5] If either water clarity or water clarity multiplied by lake surface area have positive and significant effects on responses to the CV question, this indi-

[4] Model 3 in Appendix B, Table 2 was used to calculate this net economic value. This calculation was done by evaluating all variables in the equation, except BID, LKAREA and LWCLKAREA, at their means. LKAREA and LWCLKAREA were evaluated at their means, multiplied by their respective coefficients and added to the intercept estimate to compute a grand mean (B). Average net economic value was computed as (1/-b)*(ln [1 + e(**B**)]) where b is the coefficient for BID (-0.00133).

[5] Other variables used to explain differences in responses include the bid amount used in the CV question and the type(s) of recreation access users participate in at the lake they visit most often (swimming, shore activities, fishing, other boating, and camping). The types of recreational activities are not mutually exclusive and a person can both swim and camp, for example. We also include variables to indicate if the lake visited most often was either Sebago Lake or Moosehead Lake. This was done because these are the two largest lakes in Maine and were the lakes visited most often for many of the respondents.

cates that net economic values are affected by water clarity and people place higher net economic values on lakes with clearer water. We found that water clarity by itself was not a significant predictor of CV responses, but that water clarity multiplied by lake surface areas was a significant predictor of CV responses (Appendix B, Table 2, Model 3). This result indicates that net economic values for lake use are affected by water clarity and the net economic values of clarity are even higher for larger lakes. In other words, people who use larger lakes, which generally have clearer water, place a higher premium on recreating on a lake with clearer water.

Expenditures and economic impacts

Access users spent an average of $341 per year when using the lake they visit most often, and 59% of this amount ($201) is spent within 10 miles of the lakes they visit. Total annual expenditures range from $65 million to $154 million using the low and the high estimates of the number of access users, or $38 to $91 million within 10 miles of the lakes visited most often. Multiplier effects of expenditures within 10 miles of lakes are $64 million in total sales impact (a multiplier effect of 1.66), $24 million in income, and 1,282 full-time equivalent jobs (Table 3).

As with net economic values, we investigated whether access users' expenditures made in conjunction with the lake they visited most often are affected by water clarity in the lakes they visited. Responses to this expenditure question were analyzed using a model where average minimum lake water clarity over the previous three years, lake surface area, and average water clarity multiplied by lake surface area, along with other variables, were used to explain differences in the magnitudes of respondents expenditures (Appendix B, Table 3).[6] If either water clarity or water clarity multiplied by lake surface area have positive and significant effects on access users' expenditures, this would indicate that people spend more money when they visit lakes with clearer water. As with net economic values, we found that water clarity was not a significant predictor of expenditures, but that water clarity multiplied by lake surface area is a significant predictor (Appendix B, Table 4, Model 3). Water clarity does affect access users' expenditures and the effect is larger for users of larger lakes.

Effects of reductions in minimum water clarity

Results suggest that net economic value is more sensitive to clarity declines than expenditures (and consequently economic impacts). Declines of ½ m, 1 m, and 1½ m reduce net economic value by 3%, 6%, and 10%, respectively, while the comparable reductions in expenditures are 1%, 2%, and 4%.[7] While the percentage changes in net economic values are larger than those of economic impacts, the absolute change in economic impacts exceeds the changes in net economic values because current expenditures are substantially larger than current net economic values. The actual changes are reported in Table 4. For example, a ½ m decline results in low estimates of the reductions in aggregate net economic value and total sales impact of $195,000 and $697,000, respectively.

These results suggest that water clarity changes do affect the values access users place on their uses of Maine's lakes and the economic contribution of lakes to local economies. The low calculations are clearly underestimates because they exclude lakes that were not visited most often by access users. As

[6] Other variables used to explain differences in expenditures include the distance respondents traveled from their homes to visit the lake, their annual household income, and the type(s) of recreation access users participate in at the lake they visit most often (swimming, shore activities, fishing, other boating, and camping). These recreational activities are not mutually exclusive and a person can both swim and camp for example. Variables were included to indicate if the lake visited most often was either Sebago Lake or Moosehead Lake.

[7] The reductions in net economic values were calculated using the equation specified in footnote (4). The mean minimum clarity was reduced by either ½, 1, or 1½ m to compute net economic values at reduced clarity. These new estimates were each subtracted from the original estimate to calculate the reductions in net economic value for each of the reductions in clarity. Reductions in expenditures were calculated using model (3) in Appendix B Table 4. All variables in the equation were evaluated at their sample means, except LWCLKAREA and LKAREA, to compute a grand mean of –45.47. The following equation was used to compute expenditures at the state average minimum clarity, and reductions in the average of ½, 1, and 1½ m: $EXP = -45.47 + 0.036*LWCLKAREA - 0.1005*LKAREA$. Reductions in expenditures were calculated by subtracting expenditures at each of the reductions from expenditures at the current state average minimum clarity. Aggregate changes in net economic values and expenditures were then calculated by multiplying the estimated changes per by the high and low estimates of the number of access users.

Table 3. Economic impacts of access users' annual expenditures within 10 miles of the lakes they visit most often.

	Low[a]	High
Total Sales Impact	$63,988,2324	$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 (jobs)	1,285	3,023

[a] Low and high estimates were obtained using the low and high estimates of the number of

Table 4. Annual economic losses due to a decline in water clarity at the lakes access users visited most often in the previous year (x 1,000).

Loss in:	½ m Decline		1 m Decline		1½ m Decline	
	Low[a]	High	Low	High	Low	High
Aggregate net economic value	$195	$460	$430	$1,014	$637	$1,501
Aggregate expenditures	$419	$987	$941	$2,218	$1,415	$3,336
Total sales impact	$697	$1,610	$1,566	$3,618	$2,356	$5,441
Income	$263	$588	$590	$1,322	$888	$1,988
Employment (jobs)	14	33	31	74	47	111

[a] Low and high estimates were obtained using the low and high estimates of the number of

noted earlier, it is important to recognize that the reductions in net economic values are true losses to Maine residents, while the reductions in expenditures and economic impacts are local in nature. The reductions in expenditures and economic impacts are just transferred from communities with lakes where water clarity has declined to communities with lakes where water clarity is unchanged.

Net Economic Values For A Statewide Program To Protect Water Clarity

Access users' net economic values associated with a statewide lake protection program were estimated for the same declines in water clarity (0.5, 1.0, and 1.5 meters), but the declines were for the statewide average in minimum clarity, not just clarity in the lakes visited most often.The current minimum clarity for all lakes is 3.78 m (12 ft) and the reduction of 1½ m reduces clarity to the average (2.27 m or 7.4 ft) for lakes with compromised clarity.[8] Three meters is the threshold below which water clarity may be considered compromised in Maine lakes.

Respondents would pay an average of $4 (½ m decline) to $13 (1½ m decline) per year to protect water clarity in Maine's lakes (Table 5).[9] Preventing a ½ m decline translates into an annual aggregate benefit that ranges from $740,000 to $1,745,000 depending on whether the low or high estimate of the number of access users is used.

Responses to this CV question were analyzed in the same manner as were responses to the net economic value and expenditure questions for the lakes respondents visited most often. Responses to the CV question were statistically analyzed to see if they are affected by the change in the statewide average in minimum water clarity, the average minimum clarity over the previous three years for

[8] The clarity reading of 3.78 m is calculated as the average of annual minimum readings for lakes with moderate to low natural color less than 30 standard platinum units (SPU).

[9] Model 2b in Appendix B, Table 6 was used to calculate these net economic values. This calculation was done by evaluating all variables in the equation, except BID and LCHWC, at their means. LCHWC was then evaluated at reductions of ½, 1, and 1½ m. Average net economic value was computed as (1/-b)*(ln [1 + e(**B**)]) where b is the coefficient for BID (-0.0227) and **B** = 1.1306 + 0.2917 LCHWCLWC. Net economic value is estimated using one of the two equations given at the end of Appendix A, with **B** given above and b_1 being the coefficient for BID, or -0.0227.

Table 5. Access users' annual net economic values associated with a statewide program to protect water clarity in lakes.

Declines in Average Minimum Clarity	Average Net Economic Values Per Person Per Year	Aggregate, Annual Net Economic Values (x 1,000) Low[a]	High
½ m (from 3.78 to 3.28 m)	$3.87	$740	$1,745
1 m (from 3.78 to 2.78 m)	$8.68	$1,660	$3,913
1½ m (from 3.78 to 2.27 m)	$13.01	$2,488	$5,857

[a] Low and high net economic value estimates were obtained using the low and high estimates of the number of access users.

the lake visited most often, and the change in water clarity multiplied by the average clarity (Appendix B, Table 5).[10] The combined effect of the clarity change and water clarity in the lake used most often during the previous year significantly affects net economic values for the statewide protection programs (Appendix B, Table 6). The significance of the clarity change multiplied by the clarity in the lake used most often implies that people who use clear lakes place a higher value on the lake protection program than do people who use lakes with lower minimum clarity. This implies that people who visit clear lakes are more concerned about protecting water clarity than people who visit less-clear lakes. This is the same result we observed for net economic values for the lakes respondents visited most often in the previous year. User perception studies show that in regions with lower water clarity people are less sensitive to reduced clarity (Heiskary 1998).

WHAT DO THESE RESULTS IMPLY FOR LAKE POLICY IN MAINE?

The first insight this data provides is that there is a large number of access users of Maine's lakes, which means that lakes are not just used by those who own lakefront properties. While our estimated range of the number of access users is large, from about 191,000 to 450,000, even the low estimate still represents about 20% of the population of Maine.

The second insight is that net economic values and expenditures are affected by water clarity. Access users enjoy lakes with higher clarity more than they do those with lower clarity, and they spend less money when they visit lakes with lower clarity. It is also important to note that the premium access users place on clear water is higher for larger lakes. These results suggest that local communities have a substantial, vested economic interest in protecting water clarity in lakes within their municipal jurisdictions.

Finally, access users do value a statewide program to protect water clarity in Maine's lakes. A minimum estimate of the benefit of such a program is $740,000 to prevent a ½ m decline in the statewide average minimum clarity of 3.78 m. This estimate is low because it is based on the lower-bound estimate of the number of access users, but also because it omits the benefits that accrue to lakefront property owners and the benefits to nonresident, access users who visit Maine each year.[13] Thus, the modest amount spent to protect water clarity in Maine's lakes from eutrophication, the biggest threat to water clarity, is clearly justified from an economic efficiency perspective. In fact, a doubling or tripling of the budget to protect lakes from eutrophication would still be very modest given the size of the economic benefits.

[10] Other variables used to explain differences in responses include the bid amount and the type(s) of recreation access users participate in at the lake they visit most often (swim, shore use, fish, boating, camping). The types of recreational activities are not mutually exclusive and a person can both swim and camp, for example.

[11] Boyle et al. (1998) estimate the benefits to lakefront property owners of protecting Maine's lakes from reductions in water clarity.

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APPENDIX A—LAKES VISITED MOST OFTEN BY SURVEY RESPONDENTS

List of Lakes Visited Most Often

# People Who Visit Lake	Lake Name	Nearest Town
45	Sebago L	Sebago
17	Moosehead L	Greenville
10	Damariscotta L	Jefferson
9	Sebago L (Little)	Windham
8	Grand L (East)	Weston
8	South P	Buckfield
7	Great P	Belgrade
6	Cobbosseecontee L	Winthrop
5	Maranacook L	Winthrop
5	Pushaw L	Old Town
5	Rangeley L	Rangeley
5	Saint George L	Liberty
4	Cold Stream P	Enfield
4	Echo L	Mount Desert
4	Long L	T17 R04 Wels
4	Sabattus P	Greene
3	Auburn L	Auburn
3	Chickawaukie P	Rockport
3	China L	China
3	Grand L (West)	T05 Nd Bpp
3	Green L	Dedham
3	Lake George	Canaan
3	Long L	Bridgton
3	Long P	Mount Desert
3	Moose P	Hartland
3	Mooselookmeguntic L	Rangeley
3	Mousam L	Acton
3	North & Little Ponds	Rome
3	Pemaquid P	Nobleboro
3	Range P (Middle)	Poland
3	Sebec L	Willimantic
3	Swan L	Swanville
3	Toddy P	Surry
3	Togus P	Augusta
3	Wassookeag L	Dexter
2	Allagash L	T08 R14 Wels
2	Bay Of Naples	Naples
2	Boyd L	Orneville Twp
2	Chesuncook L	T03 R12 Wels
2	Clearwater P	Industry
2	Cross L	T17 R05 Wels
2	Drews(meduxnekeag) L	Linneus
2	East P	Smithfield
2	Flagstaff L	Flagstaff Twp
2	Granny Kent P	Shapleigh
2	Great East L	Acton
2	Hatcase P	Dedham
2	Indian P (Big)	St Albans

# People Who Visit Lake	Lake Name	Nearest Town
2	Kezar L	Lovell
2	Long P	Belgrade
2	Megunticook L	Camden
2	Molasses P	Eastbrook
2	Narrows P (Lower)	Winthrop
2	Phillips (Lucerne) L	Dedham
2	Range P (Lower)	Poland
2	Richardson Lakes	Richardsontown Twp
2	Round P	Livermore Falls
2	Sabbathday L	New Gloucester
2	Sand P (Tacoma Lks)	Litchfield
2	Sebasticook L	Newport
2	Sennebec P	Appleton
2	Square P	Acton
2	Trickey P	Naples
2	Unity P	Unity
2	Wilson P (Lower)	Greenville
1	Alamoosook L	Orland
1	Alligator L	T34 Md
1	Androscoggin L	Leeds
1	Bauneag Beg L	North Berwick
1	Bear P	Waterford
1	Beech Hill P	Otis
1	Biscay P	Damariscotta
1	Bottle L	Lakeville Plt
1	Branch L	Ellsworth
1	Brettun's P	Livermore
1	Cathance L	No 14 Plt
1	Cedar L	T03 R09 Nwp
1	Chamberlain P	T07 R06 Wels
1	Chemo P	Bradley
1	Crescent L	Raymond
1	Crystal L (Dry P)	Gray
1	Crystal(anonymous) P	Harrison
1	Dam P	Augusta
1	Drew P	Newfield
1	Eagle L	Eagle Lake
1	Eagle L	Bar Harbor
1	Echo L (Crotched P)	Fayette
1	Ellis (Roxbury) P	Byron
1	Embden P	Embden
1	Endless L	T03 R09 Nwp
1	Faulkner L	Weston
1	Flanders P	Sullivan
1	Forest L	Windham
1	Gander P	Dennistown Plt
1	Garland P	Sebec
1	Heart P	Orland
1	Holland (Sokosis) P	Limerick
1	Hopkins P	Mariaville

# People Who Visit Lake	Lake Name	Nearest Town
1	Indian L	Whiting
1	Jackson Brook L	Forest Twp
1	Jo-mary L (Middle)	T4 Indian Purchase
1	Jo-mary P	Tb R10 Wels
1	Jordan P	Mount Desert
1	Junior L	T05 R01 Nbpp
1	Kennebunk P	Lyman
1	Knickerbocker P	Boothbay
1	Labrador P (Big)	Sumner
1	Lermond P	Hope
1	Levenseller P	Searsmont
1	Lovewell P	Fryeburg
1	Mattanawcook P	Lincoln
1	Mattawamkeag L	Island Falls
1	Messalonskee L	Belgrade
1	Morrill P	Hartland
1	Nesourdnehunk Dwtr	T03 R10 Wels
1	Nicatous L	T40 Md
1	Nickerson L	New Limerick
1	Norton P	Lincolnville
1	Norway L	T05 R01 Nbpp
1	Ossipee L (Little)	Waterboro
1	Panther P	Raymond
1	Pennesseewassee L	Norway
1	Pierce P	Pierce Pond Twp
1	Pine P (Big)	T03 R13 Wels
1	Piper P	Abbot
1	Pleasant L	T04 R03 Wels
1	Pleasant P	Caratunk
1	Pleasant River L	Beddington
1	Pocamoonshine L	Alexander
1	Province L	Parsonsfield
1	Pushaw P (Little)	Hudson
1	Quantabacook L	Searsmont
1	Richardson P (Lo E)	Adamstown Twp
1	Roach P (First)	Frenchtown Twp
1	Sand P	Norway
1	Schoodic L	Lake View Plt
1	Silver L	Katahdin Irn Wks Twp
1	Smith P	Elliottsville
1	Springy P (Middle)	Clifton
1	Squapan L	Squapan Twp
1	Thompson L	Oxford
1	Threemile P	China
1	Toothaker P	Phillips
1	Tunk L	T10 Sd
1	Webber P	Vassalboro
1	Wesserunsett L	Madison
1	Wilson L	Acton
1	WORTHLEY P	PERU
1	WORTHLEY P	POLAND
1	WYMAN L	CARRYING PLACE TWP

APPENDIX B—SUMMARY INFORMATION FOR STATISTICAL ANALYSES OF NET ECONOMIC VALUES AND ECONOMIC IMPACTS

Table B1. Explanatory variables used to analyze responses to CV question for the lakes respondents visited most often in the previous year.

Variables	Definitions	Expected Signs[a]
BID	Bid amount (dollars)	-
LWC	Natural log of the average minimum water clarity over the past 3 years for the lake visited most often (feet)	+
LKAREA	Area of the lake visited most often (acres)	+
LWCLKAREA	LWC*LAREA	?
SWIM	=1 if the respondent swam in the lake; = 0 otherwise	?
SHORE	=1 if the respondent recreated on the shore of the lake (excluding camping); = 0 otherwise	?
FISH	=1 if the respondent participated in open water fishing at the lake; = 0 otherwise	?
OTHB	=1 if the respondent went motor boating or sailing on the lake (excluding boating while fishing on nonmotorized boat); = 0 otherwise	?
CAMP	=1 if the respondent camped beside the lake; = 0 otherwise	?
DSEBAGO	=1 if the lake visited most often was Sebago Lake; = 0 otherwise	+
DMOOSEH	=1 if the lake visited most often was Moosehead Lake; = 0 otherwise	+

[a] The signs on the coefficients indicate that the variable is expected to increase (+), decrease (-) or have an indeterminate effect (?) on the probability respondents will answering yes to the CV question.

Table B2. Maximum likelihood analysis (logit model) of responses to the CV question for the lakes respondents visited most often.

Variables	Model 1 Original Model	Model 2 No Influential Cases[a]	Model 3 No Influential Cases, No LWC Used
INTERCEPT	2.1856	11.0579*	2.2229**
	(2.5306)[b]	(6.1722)	(1.0091)
BID	- 0.0087***[c]	- 0.0131***	- 0.0133***
	(0.0027)	(0.0036)	(0.0036)
LWC	- 0.1579	- 3.1991	NA
	(0.8995)	(2.1797)	
LKAREA	- 0.0010	- 0.0056***	- 0.0030***
	(0.0008)	(0.0022)	(0.0011)
LWCLKAREA	0.0003	0.0020***	0.0011***
	(0.0003)	(0.0008)	(0.0004)
SWIM	1.0295*	1.8350**	1.7249**
	(0.5564)	(0.7793)	(0.7436)
SHORE	0.0595	0.3520	0.3606
	(0.4839)	(0.5944)	(0.5845)
FISH	1.6089***	1.5077**	1.4885**
	(0.5580)	(0.6985)	(0.6895)
OTHB	0.2985	1.1975	1.2193
	(0.5513)	(0.7626)	(0.7576)
CAMP	0.1782	0.2727	0.2610
	(0.6806)	(0.8086)	(0.8054)
DSEBAGO	- 5.4219	- 40.4760**	- 23.6262**
	(5.5972)	(15.8548)	(9.8069)
DMOOSEH	- 3.6027	- 36.2036**	- 21.5433*
	(6.5767)	(17.0240)	(12.8603)
Chi-square	26.40	38.15	35.72
% Concordant	77.8%	85.5%	84.8%
N	148	136	136

[a] Influential cases are identified using DFBETAS for LWC and LWCLAREA (Neter et al. 1996).

[b] Standard errors are in parentheses.

[c] One-tailed t-test: * Significant to the 90th percentile; ** Significant to the 95th percentile; *** Significant to the 99th percentile.

Table B3. Explanatory variables used to analyze access users' expenditures for lakes they visited most often in the previous year.

Variables	Definitions	Expected Signs[a]
LWC	Natural log of the average minimum water clarity over the past 3 years for the lake visited most often (feet)	+
LKAREA	Area of the lake visited most often (acres)	+
LWCLKAREA	LWC*LAREA	+
DIST	Distance from lake visited most often to respondents' homes (miles)	+
INC	Respondents' annual household income after taxes (dollars)	+
SWIM	=1 if the respondent swam in the lake; = 0 otherwise	?
SHORE	=1 if the respondent recreated on the shore of the lake (excluding camping); = 0 otherwise	?
FISH	=1 if the respondent participated in open water fishing at the lake; = 0 otherwise	+
OTHB	=1 if the respondent went motor boating or sailing on the lake (excluding boating while fishing on nonmotorized boat); = 0 otherwise	+
CAMP	=1 if the respondent camped beside the lake; = 0 otherwise	+
DSEBAGO	=1 if the lake visited most often was Sebago Lake; = 0 otherwise	+
DMOOSEH	=1 if the lake visited most often was Moosehead Lake; = 0 otherwise	+

[a] The signs on the coefficients indicate that the variable is expected to increase (+), decrease (-) or have an indeterminate effect (?) on access users expenditures.

Table B4. OLS regression analysis of expenditures by respondents for the lakes they visited most often.

Variables	Model 1 Original Model	Model 2 No Influential Cases[a]	Model 3 No Influential Cases, No LWC Used
INTERCEPT	136.9329 (184.6552)[b]	- 44.7966 (169.5365)	- 16.1159 (39.2420)
LWC	- 32.6446 (64.2252)	10.3485 (59.4936)	NA
LKAREA	- 0.0625 (0.0623)	- 0.0925 (0.0578)	- 0.1005*** (0.0350)
LWCLKAREA	0.0209 (0.0217)	0.0332 (0.0202)	0.0360*** (0.0122)
DIST	1.6580***[c] (0.5548)	1.4078*** (0.4359)	1.4090*** (0.4337)
INC	- 0.0001 (0.0006)	- 0.0003 (0.0004)	- 0.0003 (0.0004)
SWIM	- 14.8618 (42.7318)	75.9380** (31.2130)	76.5506** (30.8614)
SHORE	6.8705 (36.3654)	- 18.3898 (25.6647)	- 18.5646 (25.5191)
FISH	105.3091*** (37.2327)	100.5119*** (26.8885)	100.0772*** (26.6406)
OTHB	63.0119* (36.6095)	43.0439 (26.2455)	42.4248 (25.8754)
CAMP	95.1031** (46.2557)	96.7817*** (34.2878)	97.7088*** (33.7048)
DSEBAGO	- 313.0057 (398.9973)	- 685.2154* (370.5875)	- 729.7600*** (266.5543)
DMOOSEH	- 24.3498 (447.7456)	- 469.4076 (397.4458)	- 498.3231 (359.2385)
R-square	0.34	0.49	0.49
N	123	111	111

[a] Influential cases are identified using DFBETAS for LWC and LWCLAREA (Neter et al. 1996).
[b] Standard errors are in parentheses.
[c] One-tailed t-test: * Significant to the 90th percentile; ** Significant to the 95th percentile; *** Significant to the 99th percentile.

Table B5. Explanatory variables used to analyze responses to CV question for a statewide program to protect water clarity in lakes.

Variables	Definitions	Expected Signs[a]
BID	Bid amount (dollars)	-
LCHWC	Natural log of the change in the statewide average minimum clarity, $[\ln(WC_C/WC_D)]$ where "C" designates the current average and "D" designates the diminished clarity (feet)	+
LWC	Natural log of the average minimum clarity over the past 3 years for the lake visited most often during the previous year (feet)	NA[b]
LCHWCLWC	LCHWC*LWC	+
SWIM	=1 if the respondent swam in any Maine lakes; = 0 otherwise	+
SHORE	=1 if the respondent recreated on the shore of any Maine lakes (excluding camping); = 0 otherwise	?
FISH	=1 if the respondent participated in open water fishing at any Maine lakes; = 0 otherwise	+
OTHB	=1 if the respondent went motor boating or sailing on any Maine lakes (excluding boating while fishing on nonmotorized boat); = 0 otherwise	?
CAMP	=1 if the respondent camped beside any Maine lakes; = 0 otherwise	?

[a] The signs on the coefficients indicate that the variable is expected to increase (+), decrease (-) or have an indeterminate effect (?) on the probability respondents will answering Yes to the CV question.
[b] NA indicates the variable was not included by itself in the model.

Table B6. Maximum likelihood analysis (logit model) of responses to the CV question for the statewide program to protect water clarity in lakes.

	--------- Change in Clarity Models --------------		Change in Clarity Multiplied ---------- by Baseline Clarity Models ---------	
Variable	Model 1a Original Model	Model 1b No Influential Cases [a]	Model 2a Original Model	Model 2b No Influential Cases
INTERCEPT	0.2926	0.2964	0.1706	0.0993
	(0.5279)[b]	(0.5700)	(0.5276)	(0.5604)
BID	- 0.0209***[c]	- 0.0253***	- 0.0207***	- 0.0227***
	(0.0067)	(0.0074)	(0.0067)	(0.0071)
LCHWC	0.1388	0.5043	NA	NA
	(0.2552)	(0.3330)		
LCHWCLWC	NA	NA	0.1100	0.2917**
			(0.0900)	(0.1169)
SWIM	0.8836**	0.9754**	0.8608**	0.7792*
	(0.3921)	(0.4149)	(0.3925)	(0.4145)
SHORE	0.0868	- 0.0122	0.0734	0.0332
	(0.3166)	(0.3411)	(0.3176)	(0.3367)
FISH	0.5168*	0.6076*	0.5746*	0.4585
	(0.3011)	(0.3249)	(0.3014)	(0.3184)
OTHB	0.3586	0.5348	0.3778	0.5479*
	(0.3085)	(0.3319)	(0.3094)	(0.3278)
CAMP	- 0.2430	- 0.3889	- 0.2427	- 0.3094
	(0.3170)	(0.3373)	(0.3174)	(0.3333)
Chi-square	22.16	31.35	23.38	30.78
% Concordant	67.4%	71.6%	67.6%	71.0%
n	231	217	231	219

[a] Influential cases are identified using DFBETAS for LNCHWC and LNCHWCLWC (Neter et al. 1996).
[b] Standard errors are in parentheses.
[d] One-tailed t-test: * Significant to the 90th percentile; ** Significant to the 95th percentile; *** Significant to the 99th percentile.