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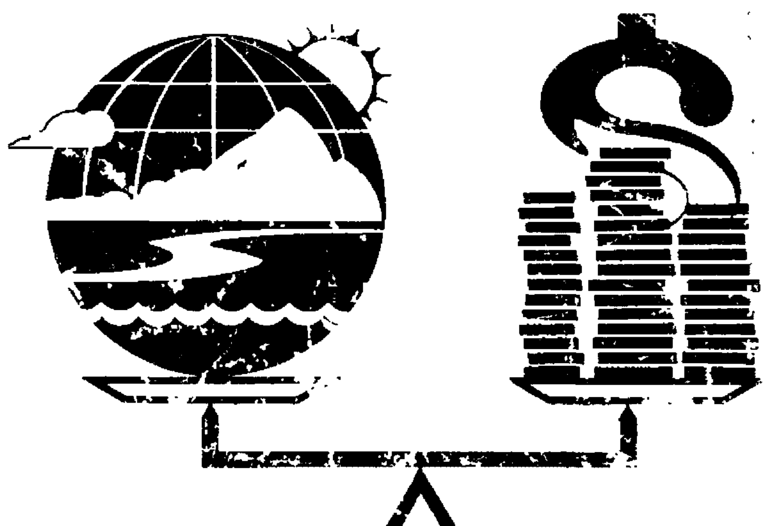
A Model Estimating the Economic Impacts of Current Levels of Acidification on Recreational Fishing in the Adirondack Mountains



A Model Estimating the
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A MODEL ESTIMATING THE ECONOMIC IMPACTS OF CURRENT LEVELS OF ACIDIFICATION ON RECREATIONAL FISHING IN THE ADIRONDACK MOUNTAINS

Prepared for:
Dr. Ronald Nesse
Acid Deposition Assessment Staff
National Acid Deposition Task Force
and
Dr. Thomas Lareau
Benefits Staff
Economic Analysis Division
United States Environmental Protection Agency

Submitted by:
Daniel M. Violette
Energy and Resource Consultants, Inc.
P.O. Drawer O
Boulder, Colorado 80306
(303) 449-5515

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ABSTRACT

The purpose of this project was to estimate the parameters of an economic model that can be combined with information on the current extent of fresh water acidification to produce economic estimates of damages in the Adirondack Mountains of New York State. One traditional approach for estimating the economic value of recreational sites has been to use the travel and on-site costs incurred by visitors as proxy measures of the price paid to use that site. Early travel costs studies focused on changes in the supply of sites, i.e., the addition of a new site or the loss of an existing site. However, the estimation problem faced by this project is different. Acidification not only changes the number of sites available for fishing, but also changes important characteristics of fishing sites. As there are approximately three thousand lakes and ponds in the Adirondack Ecological Zone, a lake by lake analysis was not possible. Instead, each site was viewed as a geographic area containing a number of lakes. Sites were characterized by the number of lakes they contained with certain characteristics. Possible site characteristics include the number of acres of cold water, two story, or warm water lakes. In this framework, acidification could change the area of cold water lakes able to support fish populations. The estimation problem is to determine how a change in these site characteristics will affect the value of a site as a recreational fishery. Both a site characteristics based travel cost model and a simpler participation model were used to obtain estimates of the use values of recreational fishing in Adirondack lakes and the reduction in use values due to acidification were also estimated. The estimates of damages resulting in current levels of acidification ranged from approximately $1 million to $12 million. It should be emphasized that travel cost models are only able to estimate use values. Reviews of the possible magnitude of non-use values indicates that non-use values may be larger than use values.

1.0 INTRODUCTION

The purpose of this project is to estimate the parameters of an economic model that can be combined with information on the extent of the current effects of fresh water acidification to produce economic estimates of damages. A travel cost model is applied to fishing sites in the Adirondack Mountains of New York State. A travel cost model uses information on travel costs to develop estimates of the value of that site; however, these models only estimate a portion of the total benefits derived from the aquatic resources available at each site. The economic value of a site is a combination of both use and non-use values. A travel cost model only estimates use values. Estimates of non-use values must be obtained from other methods. Reviews of the possible magnitude of non-use values indicate that non-use values may be larger than use values.[1]

The Adirondack Mountain region was selected for this study because of the availability of survey data relating current levels of acidification to the presence or absence of desirable gamefish populations. Acidic deposition is commonly viewed as a regional problem since large areas in the eastern United States and Canada have elevated levels of deposition (National Research Council, 1983). However, from the perspective of damages to fish populations, the fresh water effects of current levels of acidic deposition are expected to occur in narrower geographic areas. Two factors must interact before fish populations will experience adverse effects from acidic deposition — first, the watersheds must be exposed to elevated levels of acidic deposition; and secondly, the watersheds must be sensitive to the increased hydrogen ion deposition (U.S. EPA, 1983). Even though broad regions are exposed to elevated levels of acidic deposition, sensitive lakes and streams are grouped into smaller areas. The regions containing sensitive lakes in New York are essentially limited to the Adirondack and Catskill Mountains, and the Hudson Highlands (U.S. EPA, 1985). Within these regions, the waters that tend to be the most susceptible to acidification effects are the high altitude brook trout ponds and streams (Schofield, 1982).

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[1] See Fisher and Raucher (1983) for a review of this material.

Past analyses of user damages to recreational fishing caused by acidification (Crocker et al., 1981 and Menz and Mullen, 1982) have estimated economic losses to be extremely small. The primary reason for these findings is the small number of affected ponds relative to the total lake and pond acreage in the Adirondack Mountains. The rationale for this result is that, even though there are some lakes that are being affected by acid deposition, the number of anthropogenically acidified lakes is not large enough to substantially affect the available fishing opportunities. Another way of stating this is that there are enough substitute lakes available for fishing, so that the loss of a limited number of gamefish populations does not have a large effect on the overall recreational use value of the aquatic resource in the Adirondack Mountains. In a recent study, Peterson (1983) estimated that a decrease in sulfate deposition of 25 percent would increase gamefish habitat in the sensitive Adirondack Mountains and Catskill-Hudson Highlands by only five percent. Assuming that only waters in the Adirondacks and Catskills are affected at current deposition levels and extrapolating to New York State, the statewide increase in gamefish habitat resulting from a 25 percent decrease in sulfate deposition is found to be less than one percent. The general order of magnitude of these estimates indicates that if all fishing sites are considered substitutes, estimates of damages likely will be small.

Because previous estimates of damages have been small, this study has been framed to, where possible, provide an upper-bound of consumer surplus damages related to acidification in the Adirondack Mountains. This approach was followed in order to provide policy makers and economists with estimates that indicate the largest probable loss of recreational fishing use values attributable to acidification. Results, presented in Chapter 5, indicate that consumer surplus losses associated with acidification are small. Because the analysis used assumptions that biased the calculations to provide an upper-bound damage estimate, the size of the consumer surplus losses supports the interpretation that recreational use value losses associated with acidification of ponds and lakes in the Adirondack Mountains are relatively small. Again, it is important to recognize that use values are only a portion of the overall value of an aquatic resource.

One issue of importance to the damage assessment that was not adequately addressed in this project is whether the sensitive, threatened lakes constitute a unique resource. Even though the area of threatened lakes is a small fraction of all fishable waters, it may represent a unique resource for which other fishing sites are less than perfect substitutes. In particular, the threatened lakes are largely small, high altitude book trout ponds. These ponds may provide a relatively unique recreation experience. Some of these lakes must be hiked to, and offer more of a combined wilderness/fishing experience than do other fishing sites. A number of these high altitude ponds have already been acidified or are in danger of acidification at current deposition rates (Colquhoun et al., 1984). While these ponds make up only a small portion of total fishable acreage, they may have a disproportionately high value to, at least, some recreationists.

A traditional approach for estimating the economic value of recreational sites has been to use the travel and on-site costs incurred by visitors as proxy measures of the price paid to use that site. Early travel costs studies focused on changes in the supply of sites, i.e., the addition of a new site or the loss of an existing site. However, the estimation problem faced by this project is different. Acidification not only changes the number of sites available for fishing, but also changes important characteristics of fishing sites. As there are approximately three thousand lakes and ponds in the Adirondack Ecological Zone, a lake by lake analysis was not possible. Instead, each site was viewed as a geographic area containing a number of lakes. Sites were characterized by the number of lakes they contained with certain characteristics. Possible site characteristics include the number of acres of cold water, two story, or warm water lakes. In this framework, acidification could change the area of cold water lakes able to support fish populations. The estimation problem is to determine how a change in these site characteristics will affect the value of that site as a recreational fishery.

Two data sets were identified that contain data useful for an analysis of Adirondack lakes — the New York Anglers' Survey and the Adirondack Ponded Waters Survey. The New York Anglers' Survey contains data on fishing activity throughout the state; however, the Adirondack Ponded Waters Survey only contains data on lakes and streams in the Adirondack Ecological Zone. As a result, the geographic scope of the study was necessarily limited to this area. This may not pose a significant problem for a national assessment of damages, since documented damages to recreational fisheries at current levels of deposition have largely been limited to the Adirondack Mountain region. Lakes and streams in other regions of the U.S. are sensitive to acidic deposition and may have suffered some damage. Nevertheless, at the current level of acidification most documented effects on recreational fisheries in the United States are occurring in the Adirondack Mountains.

2.0 INCORPORATING SITE CHARACTERISTICS IN TRAVEL COST MODELS

This chapter will discuss, in general terms, potential approaches to incorporate site characteristics within a multiple site travel cost model. The recent literature contains several approaches for incorporating site characterisitics within a travel-cost framework. Prominent applications incorporating site characteristics into a travel cost model are Vaughan and Russell (1982); Desvousges, Smith and McGivney (1983); Morey (1981, 1985); Greig (1983); and Brown and Mendelsohn (1984). This literature includes several diverse approaches, each with certain strengths and weaknesses. The use of site characteristics in travel cost models is a recent development. As a result, new applications and techniques are currently being researched.

The problem of incorporating site characteristics within a travel cost model can be illustrated using a conventional Burt and Brewer (1971) type travel cost model. This "conventional" travel cost model estimates a separate demand equation for each fishing site. These demand functions for "n" fishing sites are shown below.

Site 1 equation: $V_{1q} = B_{10} + B_{11} P_{11} + B_{12} P_{12} + \ldots + B_{1q} P_{1q} + C_{1j} S_{qj} + U$ (2-1)

. . .

Site n equation: $V_{nq} = B_{no} + B_{n1} P_{n1} + B_{n2} P_{n2} + \ldots + B_{nq} P_{nq} + C_{nj} S_{qj} + U$

where:

V_{iq} = the visitation rate to site i from origin q, usually measured in visitors per 10,000 people

P_{iq} = the price of visiting i from origin q in terms of travel and time costs.

B_{iq} = the regression coefficients on the price variables

S_{qj} = socioeconomic variables for origin q

C_{nj} = regression coefficients on socioeconomic variables

U = random term

For example, the data necessary to estimate the site 1 equation are the visitation rate, and the travel costs from each of the q origins to the site. The underlying assumption is that the visitation rates to site 1 will be lower for origins more distant from site 1; that is, as the costs of traveling to site 1 increase the visitation rate will decline.

In this specification, the own price[1] of visiting that site whose demand equation is being estimated is included. Also included are the prices of visiting other substitute fishing sites. This specification takes into account the cost of traveling to substitute fishing sites.

In this conventional model, it is not possible to examine how the characteristics of the site affects the visitor's demand function. The equation for each site is estimated separately. As a result, there can be no variability in the characteristics of just one site. Several different approaches for incorporating site characteristics within a travel cost framework have appeared in the recent literature. These new methods can be classified into three basic approaches:

1) The varying coefficient travel cost model as characterized by Vaughan and Russell (1982), and Desvousges, Smith and McGivney (1983);

2) The explicit utility function characterized by Morey (1981) and Grieg (1983);

3) The hedonic travel cost model as developed by Brown and Mendelsohn (1984).

A variant of the varying coefficient travel cost model was selected for this application. The characteristics of the available data posed problems for the other two approaches. The appropriateness of these alternative methods for this application are reviewed in Violette (1983).

The varying coefficient travel cost model approach is similar to that used by Vaughan and Russell (1982), and Desvousges, Smith and McGivney (1983). This approach utilizes a two step framework. The first step estimates a separate visitation-travel cost equation

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[1] For example, the own price in the site 1 equation is the price of visiting site 1. Thus, own price effects can be contrasted with substitution effects resulting from the prices of visiting other sites.

for each site. The second step uses the regression coefficients from the step one equations as dependent variables and regresses these coefficients on the site characteristics. To use a simple example, the conventional Burt and Brewer visitation demand function for site "i" is:

$$V_{iq} = B_{io} + B_{i1} P_{i2} + \dots + B_{iq} P_{iq} \tag{2-2}$$

where V_{iq} is the visitation rate from origin q to site i and P_{iq} is the travel cost from origin q to site i. Since a separate equation is estimated for each site, there are "i" different estimates of each coefficient. These regression coefficients represent the relationship between travel costs and visits. The variability in the magnitude of the regression coefficients in the different site equations may be due to the relative desirability of the site in terms of the site's characteristics. This can be tested in the second step regressions where the regression coefficients are regressed against the characteristics of each site:

$$\begin{aligned} B_{i0} &= A_{00} + A_{01} Z_{1i} + \dots + A_{0k} Z_{ki} \\ B_{i1} &= A_{10} + A_{11} Z_{1i} + \dots + A_{1k} Z_{ki} \\ &\vdots \\ B_{iq} &= A_{q0} + A_{q1} Z_{1i} + \dots + A_{qk} Z_{ki} \end{aligned} \tag{2-3}$$

where Z_{ki} is the level of the k^{th} characteristic at site i. This two step procedure can be combined into an equivalent one step method by substituting equation 2-3 into equation 2-2 to yield:

$$\begin{aligned} V_{iq} = \; & (A_{00} + A_{01} Z_{1i} + \dots + A_{0k} Z_{ki}) + (A_{10} + A_{11} Z_{1i} + \dots + A_{1k} Z_{ki}) P_{i1} + \dots \\ & + (A_{q0} + A_{q1} Z_{1i} + \dots + A_{qk} Z_{ki}) P_{iq}. \end{aligned} \tag{2-4}$$

Equation 2-4 includes both site characteristics and travel costs as interaction terms. This equation can be estimated using data pooled across sites.

Using ordinary least squares in this two stage procedure will introduce heteroskedasticity into the error term of the second stage regressions. The second stage regression using only one site characteristic as the dependent variable is:

$$B_{i0} = A_{00} + A_{01} Z_1. \quad (2\text{-}5)$$

The dependent variable B_{i0} is an estimated regression coefficient from the first stage regression; therefore, the error term for the regression shown as equation (2-5) is influenced by the error in the estimated coefficient. This introduces heteroskedasticity in the regression equation error term. Simply stated, if the estimated variance of B_{i0} from the stage 1 regression is large (i.e., B_{i0} is estimated imprecisely) this will influence the error term in the regression shown in equation (2-5). This can be corrected by using generalized least squares (GLS) procedures where the estimated standard errors for the regression coefficient from each site are used as the correcting weights.[2]

The two applications of varying coefficient travel cost model cited previously (Vaughan and Russell, 1982 and Desvousges, et al., 1983) found site characteristics to be significant in the second stage regression equations. The available data and nature of the estimation problem makes this application somewhat different from these previous applications. For example, Vaughan and Russell (1982) used a sample of fee fishing sites in the Northeastern United States. These sites were typically widely dispersed geographically making it unlikely that visitors to one site would have visited another of the sites included in the data set and, even if they had, there was no way to learn this from the data. The Desvousges, et al. (1983) visitation data were obtained from 46 U.S. Army Corps of Engineering recreation sites. Again, these sites were scattered throughout the United States. These applications can be contrasted to the Adirondack region where all of the sites are located in a small region. This results in a visitation data set where many fisherman have visited more than one site.

Because of available data it was desirable to use a variant of this two stage approach. Instead of using ordinary least squares techniques to estimate the coefficients of the first stage site demand equations, a Tobit procedure was used. The Tobit procedure takes full advantage of the available data on individual fishermen. First used in Tobin (1958), it estimates both the probability of an individual visiting a site as well as the number of days the individual will spend at that site, given that a visit is made. Taken

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[2] For more detail see G. Saxonhouse (1977).

together, these two estimates can be used to calculate the expected value of days spent at each site for each individual.

The procedure used to incorporate site characteristics within this travel cost model is very similar to the varying coefficient travel cost model as depicted by equations (2-2) and (2-3). The only difference is that the first stage regression coefficients of equation (2-2) are estimated using a Tobit procedure. In the second stage, these regression coefficients are used as the dependent variable and regressed against the site characteristics using a generalized least squares procedure to correct for heteroskedasticity. This procedure will be discussed in more detail in Section 4.3.

3.0 PROJECT DATA

There were two main data sources for this project. These were the 1976-1977 New York Anglers' Survey and the Adirondack Lake and Pond Survey (Ponded Waters Survey). Both data sets were compiled by the New York State Department of Environmental Conservation (NY DEC). Data used in the project are listed in Table 3-1. The site boundaries are shown in Figure 3-1. Names for the sites, based on a prominent water or geographic feature, are shown in Table 3-2. The balance of this section presents a short discussion of the Anglers' survey and the Ponded Waters survey, the procedures used to integrate these two data sets, and the criteria used to define the sites.

3.1 THE NEW YORK ANGLERS' SURVEY, 1976-1977

The New York Anglers' Survey for 1976-1977 is the most recent data source from which information on fishing activity and travel costs can be compiled for the Adirondack Mountains. The Anglers' Survey consisted of a questionnaire mailed to a three percent sample of fishermen licensed in New York State between October 1, 1975 and September 30, 1976. The questionnaire elicited responses about fishing activity in New York State between April 1, 1976 and March 31, 1977. Of the 25,564 questionnaires mailed, 11,721 responses were received.

The questionnaire consisted of three major sections: one - fishing activities, expenditures, and preferences; two - attitudes and opinions; and three - participant background. The first section examined fishing activities, expenditures and preferences. This section collected data on where, for how long, for what species, and by what methods the respondent fished. Data on expenditures per fishing location for that year and for total equipment expenditures were also requested. Questions relating to preferred species, reasons for fishing and what makes a fishing trip successful were included in this section. The attitudes and opinions section of the Anglers' Survey was mainly concerned with New York's fisheries management programs, procedures and regulations.

Table 3-1

Project Data

Angler Specific Data:

- Number of days spent fishing at each site (from Anglers' Survey)
- Years of fishing experience (from Anglers' Survey)
- Annual income (from Anglers' Survey)
- Travel expenditures on gas and oil (from Anglers' Survey)
- Total expenditures in transit to site including gas and oil, food and drink, lodging, and other (from Anglers' Survey)
- Total expenditures at the site including food, lodging, gas and oil, guide fees, and other (from Anglers' Survey)
- Number and species of fish caught (from Anglers' Survey)
- Distance from residence to each site (compiled from regional maps)

Site Characteristic Data:

- Total acreage of ponded waters in that site (from Ponded Waters Survey)
- Acres of private waters in the site (from Ponded Waters Survey)
- Net acreage—total minus private acres (from Ponded Waters Survey)
- Acreage of ponds with warm water fisheries (from Ponded Waters Survey)
- Acreage of ponds with two story fisheries (from Ponded Waters Survey)
- Acreage of cold water and brook trout ponds (from Ponded Waters Survey)
- Total fishing days spent at each site (computed from Anglers' Survey)
- Average daily catch rate (computed from Anglers' Survey)
- Average daily catch rate of brook trout (computed from Anglers' Survey)

Figure 3-1

Mapping of Sites 1 through 24 Used in the Travel Cost Model

(Dotted lines are 15 minute quadrangles, solid lines are either site boundaries or the boundary to the Adirondack Ecological Zone)

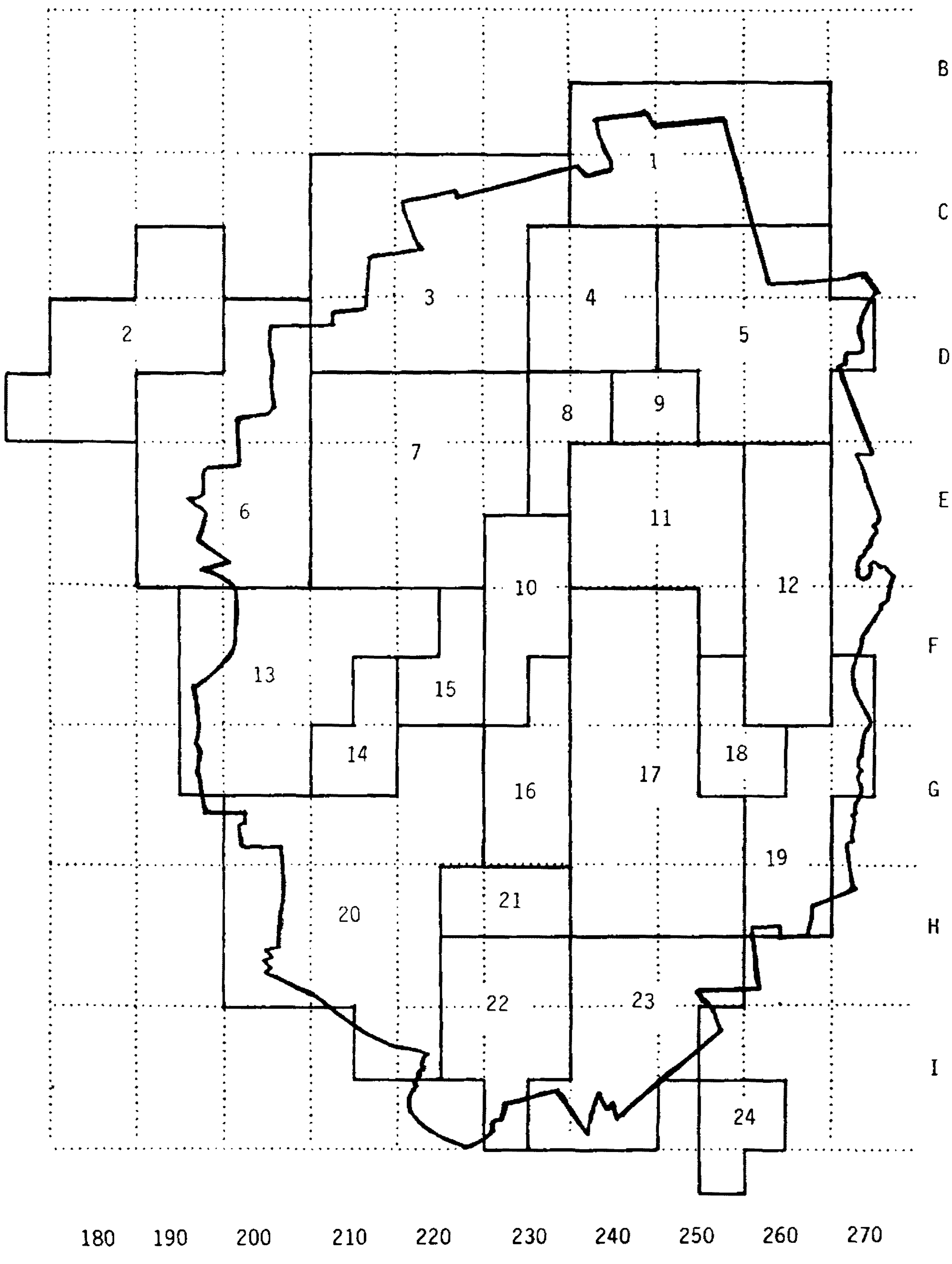

Table 3-2

Fishing Site Names[1]

List of Sites	
1	Chateaugay Lakes
2	Black Lake
3	Lake Ozonia
4	Meacham - St. Regis Lakes
5	Union Falls Pond
6	Lake Bonaparte
7	Cranberry - Tupper Lakes
8	Saranac Lakes
9	Lake Placid
10	Long - Blue Mountain Lakes
11	Mt. Marcy
12	Paradox Lake
13	Stillwater Reservoir
14	Fulton Chain
15	Raquette Lake
16	Indian Lake
17	Thirteenth Lake
18	Schroon - Brant Lakes
19	Lake George
20	Southwest Corner
21	Piseco - Pleasant Lakes
22	Peck Lake
23	Great Socadanga Lake
24	Saratoga Lake

[1] Site selection was based on several factors including lake and pond geography, accessibility of an area based on the location of paved roads, and the number of observations available for statistical analysis.

The participant background section elicited information on fishing background, whether or not the respondent belonged to a fish and game club, other recreational activities, and household income. A summary of the Anglers' Survey appears in Kretser and Klatt (1981).

Since the 1976-77 Anglers' Survey gathered information on fishing throughout New York State, it was necessary to select only observations on fishing trips to the Adirondack region. Fishing locations in the Anglers' Survey are identified by name of water and county. Relevant observations for this project were chosen by selecting only those fishing locations in Adirondack counties. The counties included are: Clinton, Essex, Franklin, Fulton, Hamilton, Herkimer, Lewis, Saint Lawrence, Saratoga and Warren. This resulted in data on 3015 individual anglers and 6053 fishing visits.

The 6053 visits by individuals were to 760 different fishing sites, 504 of which were lakes and ponds, the remainder being rivers and streams. Since adequate site characteristic data were available only for lakes and ponds, the effective sample size was further reduced to data on visits to the 504 lake and pond locations.

Data on expenditures in transit to the site and at the site were requested by the Anglers' Survey although not all individuals reported these expenditures. Travel expenditure data were available for 62.3 percent of the 6053 sites, and on-site expenditure data for 57.3 percent of these sites. Expenditures on equipment were also requested, but improperly coded and entered onto the tape, thereby making this data unuseable.

The Anglers' Survey contained no data on distances traveled to each site or time spent traveling to the site. Distance data was estimated using Zip Codes included in the Anglers' Survey.[1]

Socioeconomic and other respondent background data contained information on household income, date of birth, years of education, and years of fishing. Other questions in this section concerned whether the individual had a preferred species to fish for, whether or not the respondent was a member of a fish and game or other sportsmen's club, and his or her participation in other recreational activities. A number of attitudinal questions were

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[1] Given the large number of observations, this was a time consuming task.

also included examining the individual's reasons for fishing, factors important to a successful fishing trip, and limiting factors for respondents who do not fish as often as they would like.

3.2 ADIRONDACK LAKE AND POND SURVEY

Site characteristic data was obtained from the Adirondack Lake and Pond Survey[2] (ponded Waters Survey). This data base includes information on 3,506 ponded waters in the Adirondack area. The Ponded Waters Survey is not entirely comprehensive; not every ponded water in the Adirondack area has a complete record. For example, there are only 2,409 pH records in the most recent chemistry survey data for those waters which have been surveyed. Also, not all lakes and ponds are surveyed each year. The most recent survey for a particular pond or lake may have been last year, or it may have been 20 or more years ago. Only 1,217 of the 2,409 pH records date from 1960 to the present. The New York State Department of Environmental Conservation (NY DEC) is continuing to update this data base.

The data in the Adirondack Lake and Pond Survey refers to ponded waters only. Stream fishing is also important in the Adirondacks. There are approximately 5,000 miles of coldwater fishing streams in the Adirondacks, with about 3,500 miles of these open to public fishing (Pfeiffer, 1979). Over 700 miles of warmwater fishing streams also exist, with approximately 480 miles open to public fishing (Pfeiffer, 1979). Unfortunately, stream characteristic data are not as readily available as ponded water data. Miles of streams open to public fishing appears to be available on a county basis, but may be difficult to obtain on a more disaggregated basis. Some acidification data is available for select streams (Colquhoun, et al. 1981, 1984), and a new report on stream acidification in the Adirondacks will be released by the NY DEC in 1985. As a result of the lack of adequate stream and river chemistry and fish population data, this report does not consider potential effects to stream and river fishing opportunity.

The data in the Ponded Waters Tape consisted of seven files, each of which had several record types. Only three of these files were relevent to this project. These files contain

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[2] This survey is continually updated. The survey used in this analysis was the version available in February, 1984.

the most recent pond, chemistry and fish data. Waters are identified on each record in each file by their watershed code and pond number. A Fortran program was developed to create a single file in a fixed format containing only the information desired. The Ponded Waters Survey has an entry for the USGS 7-1/2 minute quadrangle location of all but 9 of the 3506 waters listed. As a result, 7-1/2 minute USGS quadrangles were chosen to form the basis of a site.

Of the general site characteristics, surface area and elevation were most commonly available, existing for at least 80 percent of the waters. Shoreline length could be a useful alternative to surface area, and is listed as a variable in the Tape's documentation, but did not exist for any waters. Another potentially useful characteristic listed in the documentation, but for which no data exist, is the distance from a pond or lake to the nearest public road or trail. This accessibility measure could have been quite useful. The public or private ownership classifications may be useful to limit the number of ponds, or surface area in a site, to those open to public use.

The current management class of a water can be useful for determining the different types of fishing opportunities available within a site, and their relative importance. Management classifications in the survey included warm water, two story, cold water and brook trout fishery classifications. Although only 38 percent of the waters were categorized by management class, these waters comprise 87.7 percent of the total measured surface area. Thus, this variable may be used with a reasonable level of confidence.

Two issues surround the relevance of the pH and alkalinity data which are available. One is the fact that much of the data, perhaps a large portion, may be old and thus no longer accurate. Secondly, pH data existed for only 35 percent of measured surface area and alkalinity for only 52 percent. As a result, estimates of the effect of acidification on fishable acreage of ponds made by others were used in this analysis. Other National Acid Precipitation Assessment Program research has calculated the change in fishable acres due to acidification.[3]

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[3] In this report, NAPAP funded work by Dr. Joan Baker at North Carolina State University was used to obtain estimates of how acidification will affect the acreage of water available for fishing.

Since 7-1/2 minute quadrangles were chosen as site components, the data extracted from the original Ponded Waters tape for each pond or lake needed to be aggregated by quadrangles. Site characteristics were defined in terms of surface area. For a quadrangle containing a number of lakes and ponds, a number of characteristics, including total surface area, were described. Surface area was further analyzed by elevation and fishery management class. Surface area was divided by elevation into acres below 1500 feet, acres between 1500 feet and 2000 feet, and acres above 2000 feet. Surface area was also broken down by ownership category.

3.3 INTEGRATION OF THE ANGLERS' SURVEY AND THE LAKE AND POND SURVEY

The Anglers' Survey and Ponded Water Survey used different methods for identifying particular water bodies and a mapping from one code to the other was necessary. Individual waters in the Ponded Waters Survey are identified by a watershed and pond number combination. For the Anglers' Survey, a water name and county was supplied by respondents.[4] However, NY DEC personnel cautioned against a one-to-one mapping of waters due to concern that anglers may not have accurately reported where they fished. Anglers may believe they are at one lake or pond when they are actually at a different lake. They may also use a name for the lake which is different from the official name for that lake. Also, there can be several lakes within a county with the same name. In these cases NY DEC personnel had to use their judgement, based on knowledge of popular fishing areas and species availability in these waters, in coding fishing locations. Since both the Gazatteer and the Ponded Waters Survey include identification of the 7-1/2 minute USGS quadrangle in which a water's outlet lies, the fishing locations from one survey to the other were mapped on the basis of 7-1/2 minute quadrangles. As a result, even if the fisherman gave the name of a nearby lake in error, his visit will still be mapped to the correct site as long as both lakes are in the same 7-1/2 minute quadrangle.

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[4] A code was created by the NY DEC for identifying waters in the Angler Survey which consisted of locating the water in the report, Characteristics of New York Lakes, Part 1 — Gazatteer of Lakes, Ponds and Reservoirs (Greeson and Robison, 1970). This was done by coding each water by a number where the first two digits indicated the page and the second two digits the line of the Gazatteer listing the water name and location. The result was a time consuming process where each lake or pond in the Anglers' Survey had to be be looked up by hand in the Gazatteer and matched to a lake with hopefully the same name and location in the Ponded Waters Survey.

3.4 SITE SELECTION

Site definition raised several issues. One of these issues has already been discussed, namely the problem of not being able to cross-reference waters between the Anglers' and Ponded Waters Surveys on a one-to-one basis. The use of 7-1/2 minute quadrangles may mitigate this problem. However, the use of 7-1/2 minute quadrangles poses other problems. Most importantly, the 7-1/2 minute quadrangle associated with any lake or pond refers to the quadrangle in which that water's outlet lies. For large bodies of water, this quadrangle can be several miles from where an angler actually fished. In other cases, a group of lakes may cross several quadrangle boundaries yet still exist in relatively close proximity with easy access from one to the other, making this group of lakes a reasonable candidate for a site (destination). There are few major roads within the Adirondacks, thus accessibility was another site determinant.

The issues mentioned above were considered when aggregating the individual 7-1/2 minute quadrangles into larger sites. The sites were constructed by grouping together as geographically homogeneous 7-1/2 minute quadrangles as was possible, given the best judgment of the project investigators. If the outlet of a lake was in one 7-1/2 minute quadrangle while the body of the lake was in a neighboring quadrangle, both quadrangles were included in the same site. Sites were also constructed to include groups of similar lakes, such as the Saranac Lakes. Another consideration was the highway system where quadrangles having a common access were included in the same site. From an empirical viewpoint, there have to be enough sites for sufficient degrees of freedom in the second step regression. A site specification resulting in 24 sites was ultimately decided upon (see Figure 3-1).

4.0 THE MODEL

This chapter is divided into three sections. Section 4.1 presents a simple participation model. A participation model relates recreational activity to the supply and quality of recreation opportunities available at different sites. Compared to travel cost models, participation models have less stringent data requirements and assumptions. Participation models do not use data on travel costs and, therefore, the assumptions required for travel costs to serve as the basis for calculating consumer surplus based values for the recreation activity do not have to be imposed. However, participation models do not have the ability to infer values for the resource, but show how participation is expected to change as recreation opportunities increase due to improved water quality. If the value of additional recreation days can be inferred from other sources, then an estimate of the value of the improved water quality can be obtained by multiplying the increase in recreation days times their daily value.

An empirical model designed to estimate the value of the resource for recreational fishing is presented in Sections 4.2 and 4.3. Section 4.2 takes advantage of the data available on expenditures to obtain an estimate of the average per mile travel cost incurred to produce one fishing day. The ability to estimate this dollars per mile per fishing day travel cost is important for the analysis since the visitation data from the Anglers' Survey is expressed in terms of fishing days spent at a site and the survey did not contain information on whether these days were taken during one trip, two trips or many trips. Section 4.3 presents the estimation of the relationship between travel costs and fishing days at each site. Section 4.4 incorporates the characteristics of the site into the travel cost framework.

4.1 PARTICIPATION MODEL

The first step in the analysis of the visitation data was to estimate a simple participation model. As was discussed above, participation models have less stringent data requirements and assumptions than do travel cost models, but entail the loss of the ability to infer values from the estimated model.[1] This model relates the number of fishing days at each of the 24 sites to selected characteristics of the site. Site characteristics used include measures of fishable acres of lakes and ponds, and the total catch rate defined as the average number of fish caught per fishing day at each site. The site characteristics are the variables that are affected by acidification. In this participation model, travel costs and distances traveled were not considered, but they are incorporated into the next phase of the analysis procedure. Once this model is estimated, it is possible to calculate the change in fishing days due to a change in the site characteristics.

The results of the participation model runs are shown in Table 4-1. The coefficients on the fishable acreage variables are significant in all runs and the magnitudes of the coefficients were consistent across the different specifications. The coefficients on the acreage variables ranged in magnitude from .061 to .0978, with the majority of the coefficients clustered between .0845 to .0978. The one exception was the coefficient on the acres of cold water in equation 2 which had a negative sign, but was not significant. These data show a relationship between the total number of fishing days spent at a site and fishing opportunities as measured in fishable acreage.

The total catch rate variable did not perform as well as the acreage variables. The catch rate variable was significant in two of the specifications, but the magnitude of the coefficients varied considerably — from 49.8 to 199.4. The lack of stability of the coefficients on the catch rate variable would tend to make predictions based on this variable less reliable than predictions based on the acreage variables.

The plausibility of the coefficients' magnitudes for the acreage variables can be examined by performing calculations using regression equation 1 from Table 4-1. The mean values across all 24 sites for the variables total days, acres of warm water, and acres of two story ponds are 1145.8 days, 451.6 acres of warm water, and 364.5 acres of two-story ponds. Using these values to depict an "average site," the effect on total fishing days of a 10 percent reduction in fishable acreage can be calculated as:

$$\text{days} = .0958 \times (451.6) + .0845(364.5)$$

$$= 74.06 \text{ days}$$

[1] This is discussed in more detail in Freeman (1979), Chapter 8.

Table 4-1

Participation Models using Total Fishing Days at a Site as the Dependent Variable

(t-values are in parentheses)

Regression Number	Total Park Acres	Net Park Acres	Warm Water Acres	Two Story Acres	Cold Acres	Acres at less than 1,500 feet in Elevation	Total Catch Rate	R^2	Overall F
1.	—	—	.0958 (4.44)	.0845 (3.80)	—	—	42.04 (.418)	.60	9.49
2.	—	—	.0972 (4.59)	.0851 (3.90)	-.540 (-1.33)	—	49.84 (5.04)	.635	7.849
3.	—	.0978 (5.66)	—	—	—	—	199.4 (1.97)	.615	16.03
4.	—	—	—	—	—	.076 (4.16)	-85.1 (.84)	.55	8.23
5.	.061 (3.16)	—	—	—	—	—	7.44 (.62)	.32	5.01

The predicted result of a 10 percent reduction in fishable acreage at the "average" site is a reduction of 74 fishing days, or a 6.5 percent reduction in fishing days at the site.

One problem that may limit the usefulness of these results is the lack of significance of the cold water acreage variable. Acid deposition may be expected to largely affect cold water lakes and ponds and to have a much smaller effect on warm water and two-story lakes and ponds. To further examine this particular issue, a second set of participation models were estimated. Rather than using total fishing days as the dependent variable in this model, a new variable defined as brook trout fishing days was used. This variable was constructed by taking all the days at each site where survey respondents reported catching at least one brook trout. Other species of fish may have been fished for and caught as well, but if brook trout were caught, then these days were classified as brook trout days.

The result of the participation models using brook trout days at each site as the dependent variable are shown in Table 4-2. In contrast to the participation models using total fishing days, the cold water acres variable in this model had the appropriate sign and a t-value of 1.38. Although the t-value is low, it is significant at the 80 percent confidence level with a two-tailed test and significant at the 90 percent level with a one-tailed test. The catch rate variable was significant and stable in magnitude across the specifications examined. These models indicate that a reduction in the brook trout catch rate from four fish per day to three fish per day would reduce the number of fishing days at that site by approximately 37 days. Also, the coefficient on the cold water acres variable was similar in magnitude to the coefficients on the warm water and two-story acreage variables in the total fishing day participation models. This suggests that it may not be unreasonable to use a value of .08 to .09 for the estimated loss in fishing days due to the loss of one surface acre of water, whether the acre represents warm water, two-story, or cold water ponds.

4.2 ESTIMATION OF PER MILE TRAVEL COSTS

The data contained in the New York Anglers' Survey present certain problems for use in a travel cost valuation model, but they also have certain advantages relative to the type of data commonly used in travel cost models. One problem with the Anglers' Survey data is that it contains information on the number of days spent at a site rather than the number

Table 4-2

Participation Models using Brook Trout Fishing Days as the Dependent Variable

(t-values in parentheses)

Regression No.	Cold Water Acres	Two Story Acres	Brook Trout Acres	Acres at Greater than 2000 ft in Elevation	Brook Trout Catch Rate	R^2	Overall F
1.	.088 (1.38)	.0086 (2.67)	—	—	37.81 (2.22)	.445	5.08
2.	—	—	.0224 (1.32)	—	32.55 (1.67)	.239	3.15
3.	—	—	.004 (.224)	.005 (.225)	37.98 (2.88)	.309	3.13

of trips made to a site. This is the reverse of the problem typically faced by travel cost models where there is data on the number of visits, but generally no information on the duration of the stay. A positive aspect of the Anglers' Survey is that it contains travel expenditures reported by the individual. This expenditure data can be used to obtain estimates of the per mile travel costs. These estimates may be preferable to estimates from external sources such as the often used American Automobile Association's (AAA) estimates of average travel costs, since they may better represent the individual's perceived travel costs (i.e., the costs on which individuals base their fishing location decisions). Another advantage of this particular data set is that it contains information on individuals who visited each site as well as those who chose not to visit the site. The decision by an individual not to visit a site provides useful information that can be incorporated into the estimation of the visitation equation.

One concern with the New York Anglers' Survey is that it only contains data on the number of days spent at a pond or lake. As a result, having a fisherman indicate that he spent eight days at a pond or lake does not provide any information on whether this was one eight-day trip, two four-day trips or four two-day trips. Depending on the number of trips taken to provide the eight fishing days at the pond or lake, the travel costs associated with those eight fishing days could be very different. For example, if the lake is 100 miles from the respondent's residence, and assuming travel costs of ten cents per mile, then one round trip would cost $20.00. If the eight days at the site represented one trip, then the total travel costs to produce those eight fishing days would be $20.00, or $2.50 per day. If the eight fishing days were the result of four two-day trips, then the total travel cost would be $80.00, or $10.00 per fishing day.

This problem results in potentially large measurement errors in the estimated travel costs. It could be solved if there were data on the number of trips and length of trips. With such data, separate models could be estimated for trips of different lengths. The problem faced by this analysis is not dissimilar from other travel cost applications that have used data containing information on the trips to a site, but not the number of days at a site. One commonly used procedure to address this problem is to use only trips of short distances that most likely represent one-day outings, and then assume that all days spent at the site are one-day trips. This option is not desirable for this application as the purpose of the model is to obtain an estimate of the total use value of the resource. Using a subset of data that represents only one-day trips could result in an underestimate.

Given the New York Anglers' Survey data set, the best option for the dependent variable in the travel cost model was the number of days at the site. For this dependent variable to be most meaningful in a travel cost model framework, an estimate of the travel cost incurred per day is desirable. As was shown above, the travel cost required to produce one fishing day will vary depending on the length of the trip. In turn, the length of trip could be expected to depend on the distance to the site, the individual's income and other factors such as the individual's fishing experience. The underlying problem is whether the travel cost per day can be estimated given data on the distance to the fishing site, and the number of days spent at the site. Fortunately, the New York Anglers' Survey contained selected data on expenditures. The Anglers' Survey asked the following questions:

- What amount was spent on travel to and from each fishing location in each category:
  - food, drink and refreshments
  - lodging
  - gas and oil
  - fares on buses, airlines, etc.
  - Total expenditures on travel

- What amount was spent at each fishing location on:
  - food, drink and refreshments
  - lodging
  - gas and oil
  - guide fees
  - access and boat launching fees
  - Total expenditures at the site

The goal of the statistical analysis presented in this section was to utilize this expenditure data to obtain an estimated travel cost per mile per fishing day. If the travel costs associated with one fishing day can be estimated, then the data on days at a site can be successfully used as the dependent variable in a travel cost model. It was expected that the travel costs per mile per day at a site would vary depending on the length of trip. For example, if a fisherman were to travel 150 miles to reach a site, it is likely that he would spend a greater number of days at the site than if he only had to travel 50 miles to reach the site. The higher fixed costs that have to be incurred to reach the more distant fishing sites would result in these costs being incurred only if the number of days spent at the site were sufficient to offset the travel costs. For example, assume that out-of-pocket travel costs are ten cents per mile. If a 50 mile travel distance is associated with one-day trips, then the 100 miles traveled round trip would result in a total cost of $10 to yield one fishing day. The travel cost per mile per fishing day would be $10 ÷ (100 mile * 1 day) = $.10. If 100 mile travel distances (200 miles round trip) are typically associated with three-day trips, then the travel cost per mile per fishing day would be $20 ÷ (200 miles * 3 days) = $.033. This implies that the travel costs associated with producing one fishing day, for this example, would be 3.3 cents per mile for a three-day trip.

4.2.1 Per Mile Travel Cost Estimation Results

The equations used to estimate the per mile travel costs all had the same basic specification. Travel expenditures per day were expressed as a function of distance to the site, the individual's income, and the number of years the individual had been fishing:

Travel Expenditures per Day = B_1(Distance) + B_2(Income) + B_3(years fishing experience)

The coefficient B_1 on distance has the dimension of dollars per mile per day. If significant, B_1 can be used as an estimate of the travel costs per mile per fishing day. The data were disaggregated into subsets of visits to sites that were 0 to 75 miles, 0 to 150, 0 to 225, and greater than 225 miles from the fisherman's residence. Equations using data on visits to sites 75 to 150 miles, and 150 to 225 miles were also estimated. Table 4-3 presents the estimation results using total travel expenditures per day as the dependent variable. These results are encouraging. The coefficient on the distance variable is highly significant in all equations except for visits to sites where the distance traveled is greater than 225 miles. However, this is not surprising in that trips of this length are more likely to be influenced by factors other than travel costs, in particular, income. As can be seen from Table 4-3, the income variable was significant only for the longer trips.

The regression equations in Table 4-3 also show the expected relationship between travel cost per mile per day and the distance traveled to the site. The average cost per mile per day is higher for the shorter trips, reflecting that trips of short distances likely are associated with fewer days spent at the site:

Table 4-3

Regression Results Using Total Site Travel Expenditures per day As the Dependent Variable

(t-values in parentheses)

Regression No.	Distance (t-value)	Income	Years Experience	Constant	R^2	Overall F
1. Sites 0 to 75 miles from Residence	.66E-01 (8.11)	.234E-01 (1.395)	1.28 (-1.77)	(2.67)	.077	24.22
2. Sites 0 to 150 miles from Residence	.55E-01 (9.78)	.153E-01 (.6999)	.418E-03 (.296E-01)	1.50 (2.44)	.067	32.63
3. Sites 0 to 225 miles from Residence	.4398E-01 (10.128)	.24E-01 (.9137)	.234E-01 (1.42)	1.3349 (1.956)	.0635	36.62
4. Sites greater than 225 miles from Residence	.544E-02 (.377)	.138 (2.38)	-.082 (-2.07)	6.95 (1.65)	.028	3.04
5. Sites 75 to 150 miles from Residence	.238E-01 (9.50)	.482E-01 (1.98)	.156E-01 (1.02)	2.59 (4.17)	.049	33.465
6. Sites 150 to 225 miles from Residence	.97E-01 (2.05)	.6376 (.37)	.132 (1.86)	-12.48 (-1.39)	.033	2.87

Distance Traveled to Site	Estimated Travel Costs (t-value)
0 - 75	6.6¢ per mile per day (8.11)
0 - 150	5.5¢ per mile per day (9.78)
0 - 225	4.4¢ per mile per day (10.13)
greater than 225	.05¢ per mile per day (0.38)

There is one anomaly in the estimated travel costs shown in Table 4-3. The regression equation #6 on trips of 150 to 225 miles shows an estimated per mile travel cost that is larger than those from the equations for visits of 0 to 75 and 75 to 150 miles. One possible explanation for this could be a clustering of trips with travel distances near the lower end of the 75 to 150 mile range; however, additional analysis of the data would be useful in interpreting this result. Still, the travel costs for the 0 to 75, the 0 to 150, and the 0 to 225 trip distance subgroups show the expected relationship and these regressions would not be as sensitive to the clustering of trip distances within each range. The results of these regressions show a declining relationship between trip distance and travel cost per mile per day.

A second set of regression equations were estimated using only oil and gas travel expenditures per fishing day rather than total travel expenditures. These costs may better represent the variable costs of traveling, since food and lodging would have to be provided on a trip of any distance. The same independent variables were used in the estimation. The results are shown in Table 4-4. Again the results are encouraging. The coefficients on the distance variables are significant in all equations, except for the visits to sites of greater distances:

Distance Traveled to Site	Estimated Oil & Gas Travel Costs (t-value)
0 - 75	5.8¢ per mile per day (7.84)
0 - 150	3.9¢ per mile per day (9.71)
0 - 225	2.5¢ per mile per day (8.58)
greater than 225	-.003¢ per mile per day (.36)

Table 4-4

Regression Results Using Expenditures on Oil and Gas As the Dependent Variable

(t-values in parentheses)

Regression No.	Distance (t-value)	Income	Years Experience	Constant	R^2	Overall F
1. Sites 0 to 75 miles from Residence	.579E-01 (7.84)	.258E-01 (1.72)	-.467E-01 (-1.679)	.834 (1.935)	.078	23.09
2. Sites 0 to 150 miles from Residence	.39477E-01 (9.71)	.2527E-01 (1.515)	-.1069E-01 (-1.06)	1.46 (3.29)	.0717	33.016
3. Sites 0 to 225 miles from Residence	.248E-01 (8.58)	.2864E-01 (1.63)	.7488E-02 (-.689)	2.1665 (4.75)	.05	26.779
4. Sites greater than 225 miles from Residence	-.326E-03 (-.36E-01)	.104 (2.85)	-.4035E-01 (-1.59)	4.855 (1.827)	.03	3.21
5. Sites 75 to 150 miles from Residence	.1015E-01 (6.42)	.489E-01 (3.21)	-.0061 -.627)	2.626 (6.71)	.028	19.267
6. Sites 150 to 225 miles from Residence	-.372E-01 (-1.369)	.423E-01 (.726)	.952E-02 (.2335)	11.97 (2.335)	.0092	.798

A third set of regression equations were estimated using total costs (travel and on-site) divided by days at the site. These equations were estimated for comparison purposes and as a consistency check. These estimates include expenditures at the site and are not appropriate for use as travel costs. Still, these estimates are informative. The coefficient on the distance variable is still dimensioned in dollars per mile per day. Also, it is possible that site expenditures may be related to distance. If a greater distance is traveled, then more activities may be required to make the time spent at the site worth the incremental travel costs. Although this hypothesis is weak theoretically and is entirely dependent upon the marginal utility and cost of activities available at the site visited, it is easily tested with this data. The results of these regressions are shown in Table 4-5. Again, the coefficient on the distance variable was significant except for the longer trips and declined in magnitude as trips of longer duration were included:

Distance Traveled to Site	Estimated Total Costs (t-values)
0 - 75	17.0¢ per mile per day (6.15)
0 - 150	16.1¢ per mile per day (8.03)
0 - 225	10.9¢ per mile per day (9.20)
greater than 225	4.6¢ per mile-day (1.7)

Another result worth noting from the regressions presented in Table 4-5 is that income was a more important variable for explaining total costs per day than for explaining travel costs only. It seems intuitively plausible to have high recreation expenditures at the site correlated with high individual incomes.

4.2.2 Estimated Travel Costs: Conclusions

The results of the travel cost estimation are encouraging and indicate that reasonable estimates of travel costs to provide a fishing day can be obtained. As expected, these costs tended to vary with the length of trip. In most travel cost models, the per mile travel cost comes from a source such as the American Automobile Association's published estimates of average travel cost per mile. This travel cost per mile estimate

Table 4-5

Regression Results Using Total Travel and Site Expenditures per day* as the Dependent Variable

(t-values in parentheses)

Regression No.	Distance (t-value)	Income	Years Experience	Constant	R^2	Overall F	DF
1. Sites 0 to 75 miles from Residence	.17 (6.15)	.0136 (.232)	-.066 (-2.08)	3.57 (2.16)	.0676	13.91	576
2. Sites 0 to 150 miles from Residence	.0251 (1.58)	.227 (2.47)	.089 (1.41)	11.01 (2.47)	.0216	378	517
3. Sites 0 to 225 miles from Residence	.0465 (1.70)	.294 (2.64)	.01 (.1439)	4.90 (.611)	.0324	3.25	292
4. Sites greater than 225 miles from Residence	.054 (6.78)	.1739 (3.40)	-.827E-03 (-.0257)	10.56 (8.95)	.0305	20.33	1938
5. Sites 75 to 150 miles from Residence	.161 (8.03)	.1107 (1.31)	-.22E-01 (-.4452)	1.93 (.867)	.065	22.45	955
6. Sites 150 to 225 miles from Residence	.1089 (9.20)	.1158 (1.566)	.0187 (.416)	3.56 (1.856)	.0723	30.56	1176

*Dependent Variable is the individual's total expenditures on travel to the site (includes gas and oil, food and lodging in transit), plus the cost of lodging, food and activities at the site divided by the number of days spent at the site.

poses problems due to the large variability in per mile costs that results from the variability in age and type of vehicles).[2] The estimates obtained from the regression equations reported in this section are based on reported expenditure data and, although subject to error, are probably no worse than those used in other travel cost studies. These estimates may even be preferred in that they may better represent the individual's perceived travel costs since they are based on expenditure data supplied by the respondent. In addition, individuals use perceived travel costs when making their site selections.

The estimation results are summarized in Table 4-6. The range of estimates for travel costs per day for sites of different distances was quite narrow. The per mile total travel costs ranged from 6.6 cents per mile per day for nearby sites (0 to 75 miles) to 4.4 cents per mile per day as more distant sites were included in the sample (0 to 225 miles). The estimates for only the oil and gas portion of travel costs were slightly less, ranging from 5.8 to 2.5 cents per mile per day.

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[2] For example, Vaughan and Russell (1982) use the AAA estimate of 7.62 cents per mile.

Table 4-6

Summary of Estimated Expenditures per Mile per Day

(t-values in parentheses, units are cents per mile per fishing day)

Distance to Site	Estimated Total Travel Costs	Estimated Oil and Gas Travel Costs Only	Estimated Total Costs: Travel and Site
0 to 75 miles	6.6 (8.11)	5.8 (7.84)	17.0 (6.15)
0 to 150 miles	5.5 (9.78)	3.9 (9.71)	16.1 (8.03)
0 to 225 miles[1]	4.4 (10.13)	2.5 (8.58)	10.9 (9.20)
Greater than 225 miles	.05 (.34)	-.003 (.36)	4.6 (1.7)

[1] These travel cost estimates for trips of 0 to 225 miles were used in Chapter 5.0.

4.3 TRAVEL COST MODEL

Several different techniques to estimate a relationship between travel costs and fishing days were considered. As mentioned previously, the data available for this project are different from the data typically used in travel cost models. To briefly review, the data set contained information on individuals, the distances from the individuals' home to each of the 24 sites, and the number of days that the individual spent at each of the 24 sites. The fewest number of individuals visiting any site was 30. In estimating the site demand function, the typical travel cost model would only use data on individuals that have actually visited the site. This would result in observations on a sample of 30 individuals being available for the least visited site. However, using data on only those individuals that have actually visited the site ignores a substantial amount of information, namely the travel distance to the sites and characteristics of the individuals that did not visit the sites. For many of these individuals, the price in terms of travel costs to sites not visited may have been too high relative to the costs of visiting other sites. This information is pertinent to the analysis and should not be omitted from the estimation. As a result, it is desirable that the travel cost models for each site be estimated using the entire data set.

A data set that contains observations on individuals who purchased the commodity (i.e., made a trip to the site), as well as on individuals who did not purchase the commodity, is termed a "limited" data set.[3] The data set is "limited" in that the dependent variable is not observable over the entire range. In this case, the dependent variable is fishing days at each site and is observable only when a trip to that site has been made. Therefore, the dependent variable is observable only when it is greater than zero. The regression model is:

$$D = BX + u; \qquad (4.1)$$

where "D" represents the number of days spent at the site. D is observed only if D is greater than 0. Therefore, the model is:

[3] This discussion follows Maddala (1977), pp. 162-164.

$$D = BX + u, \quad \text{if } BX + u > 0, \text{ which implies } u > -BX$$

or (4.2)

$$D = 0, \quad \text{if } BX + u \leq 0$$

Applying ordinary least squares (OLS) regression techniques to only those observations for which $D > 0$ results in biased estimates. The residuals in this equation will not satisfy the OLS assumption that the expected value of the error term is zero (i.e., $E(u) = 0$). If some specific assumptions are made about the distribution of the residuals, then maximum likelihood techniques can be used to estimate the parameters. If it is assumed that u has a normal distribution with a zero mean and variance σ^2, then the joint distribution of the observations is:

$$L = \prod_1 \frac{1}{\sigma} f\left(\frac{D_i - Bx_i}{\sigma}\right) \cdot \prod_2 F\left(\frac{-Bx_i}{\sigma}\right) \tag{4.3}$$

where $f(\cdot)$ is the standard normal density function and $F(\cdot)$ is the cumulative normal density. The first term corresponds to those individuals for which D_i is greater than 0, and, therefore, is known. The second term corresponds to those individuals for which all that is known is that D_i is less than or equal to 0. The earliest application of this technique was by Tobin (1958).

The use of OLS techniques rather than the maximum likelihood techniques discussed above will result in biased estimates of the coefficients. If OLS is applied to the data and $D_i = 0$ is used for those individuals who did not visit the site, there will be many non-visitors with a resulting concentration of observations at $D_i = 0$. The absence of any negative D_i's in the sample will tend to keep the estimated regression equation above the zero axis over the relevant range of the X's, but it will also tend to flatten the estimated curve. This results in the estimated number of days spent at the site being underestimated for individuals with a low travel price (i.e., short distance between the site and individual), and overestimated for individuals with a higher travel price.

A TOBIT procedure is recommended to correct for this bias. The TOBIT analysis takes into account both the individual's likelihood of visiting a given site and the number of days spent at the site, given that the individual decides to visit the site. These two values taken together can be used to calculate the expected value of days at each site for each individual. The TOBIT procedures also produce consistent estimates of the regression coefficients in equation 4.1. In this analysis, both TOBIT and OLS estimates of the regression coefficients are derived and compared.

A separate travel cost equation for each of the 24 sites was estimated. In each case, the dependent variable was the number of days spent at the site. The independent variables were the distance to the site, the individual's income, and the individual's years of fishing experience. Distance to the site rather than an actual travel cost estimate was used as an independent variable to allow for sensitivity analysis around the estimated per mile travel cost. If information on the marginal value of time (e.g., wage rates) across the individuals in the sample had been available, then it might have been desirable to include an estimate of actual travel time costs to determine the relative influence of each cost on the decision to take a fishing trip. Since both the out-of-pocket and time value components of travel costs are expressed on a per mile basis in this analysis, using distance in miles as the independent variable provides the most general formulation.

One advantage that the use of travel costs rather than distance traveled as the independent variable could provide is that the non-linear relationship between travel distance and per mile per day travel costs found in Section 4.2 could have been explicitly incorporated into the analysis. For each individual, a different per mile travel cost to each site, depending on that individual's distance from the site, could have added to the data set. However, the robustness of the per mile travel cost estimate over the entire 0 to 225 mile range,[4] the fact that to perform any sensitivity analysis around travel costs would have required the re-estimation of the entire set of site equations, and the time and budget constraints of the project resulted in the decision to use distance rather than actual travel costs as the independent variable.

Only observations on individuals within 225 miles of the site were used in this analysis. There were two reasons for this. First, trips of over 225 miles are more likely to be multiple purpose trips, which would result in interpretation problems. Second, the estimates of travel costs presented in Section 4.2 showed that the number of days spent at a site

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[4] The high level of significance, i.e., low standard error, implies that this estimated travel cost could be used as an average value for travel costs for trips of up to 225 miles distance without introducing an uncomfortably large amount of error.

were largely independent of the amount of money spent on travel when the distance traveled was greater than 225 miles. 1,040 observations remained after deleting visits to sites that required a one-way trip of greater than 225 miles. Prior to estimating the travel cost model for all of the sites, preliminary analyses were performed on three sites. These results showed that when the own price (i.e. travel cost) to each site and the substitute prices to the other 23 sites were included in the regression equation none of the travel cost coefficients were found to be statistically significant.[5] It was decided to include only the own price in each travel cost equation. The omission of cross-price effects should result in the estimates of damages due to acidification being over estimated. Since previous estimates (Menz and Mullen; 1982 and Crocker et al., 1981) have been very low, an estimate that is biased on the high side, if still found to be low, should provide useful policy information.

4.3.1 TOBIT Procedures Applied to Total Fishing Days

The TOBIT procedure in the SHAZAM econometric software package was used to estimate the model. Table 4-7 presents the estimated regression coefficients obtained by using this TOBIT procedure and total fishing days at a site as the dependent variable. Table 4-7 shows that the distance variable was highly significant in most of the equations. The coefficients on the distance variable were significant at the 1 percent level in eighteen out of the twenty-three estimated equations. The distance variable was not significant or had the wrong sign in the equations for sites 10, 16 and 20.[6] Inspection of these sites showed that the total number of fishing days at these sites was in the lower half of the data set. The coefficients on the income and the years of fishing experience variables were generally not significant. The R-squares were low, typically varying

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[5] This outcome was probably the result of multicollinearity across the distance variables. The inclusion of the travel distances to each of the 24 sites for all individuals provides many possible linear combinations of these variables that might result in a singular or near singular X'X matrix. There are other methods of including substitutes. One approach would be to reduce the dimension of the distance data set by using principal components. This would require a different set of principal components to be calculated for each site. This is due to the fact that the set of 23 substitute sites is different, by one site, for each of the 24 sites.

[6] The equation for site 13 was not estimated due to an error in the program that merged the distance data and the site characteristics data. The merging of the data sets involved two large data bases and was expensive.

Table 4-7

Travel Cost Model using Total Days as the Dependent Variable: Estimated with a TOBIT Procedure
(t-values in parentheses)

Site #	Distance	Income	Years Fishing	Constant	R^{2*}
1	-.3946 (7.71)	-.0727 (.19)	-.2661 (1.20)	-10.457 (1.25)	.083
2	-.2752 (8.32)	-.4038 (1.67)	.1052 (.88)	-1.5800 (.26)	.077
3	-.0780 (3.52)	.1205 (.76)	-.0302 (.30)	-24.371 (5.30)	.0018
4	-.1794 (6.51)	.0928 (.55)	-.1008 (.95)	-10.915 (2.58)	.035
5	-.1772 (5.63)	-.1298 (.56)	.1254 (5.63)	-25.871 (4.32)	.06
6	-.8122 (7.92)	.1421 (.28)	-.8122 (7.92)	1.4610 (.11)	.074
7	-.0726 (2.40)	.0843 (.53)	-.0726 (2.40)	-26.931 (5.22)	.009
8	-.2350 (5.72)	.0969 (.40)	-.2350 (5.72)	-25.511 (3.59)	.077
9	-.2877 (6.34)	.2334 (.99)	.4359 (2.90)	-38.819 (5.43)	.079
10	.1266 (2.62)	-.5379 (2.36)	.1250 (1.14)	-53.252 (7.46)	.001
11	-.0777 (3.38)	-.0304 (.26)	.0038 (.05)	-16.996 (4.80)	.011
12	-.1638 (3.18)	.2017 (.84)	-.0345 (.23)	-41.044 (5.44)	.006
14	-.1304 (3.81)	.3542 (2.47)	.1484 (1.59)	-31.192 (5.77)	.013
15	-.0842 (3.11)	.0903 (.87)	.0363 (.58)	-18.249 (4.73)	.007

*Note: R^2 between observed and predicted values.

Table 4-7

Travel Cost Model using Total Days as the Dependent Variable: Estimated with a TOBIT Procedure

(continued)

Site #	Distance	Income	Years Fishing	Constant	R^{2*}
16	-.0024 (.11)	-.2005 (1.75)	-.0432 (.73)	-19.036 (5.56)	.0006
17	-.1915 (3.53)	-.0731 (.35)	-.0072 (.06)	-26.191 (3.65)	.0119
18	-.2301 (3.07)	.0944 (.28)	-.0174 (.09)	-55.701 (5.22)	.007
19	-.3893 (10.24)	.6607 (4.75)	.0915 (1.04)	-9.9139 (2.21)	.058
20	.0543 (1.12)	-.1903 (.66)	.2764 (1.78)	-68.586 (7.94)	.004
21	-.1912 (4.25)	-.0816 (.43)	.1727 (1.59)	-27.370 (4.41)	.0117
22	-.3626 (6.62)	-.0584 (.37)	-.0794 (.90)	.2548 (.05)	.038
23	-.4553 (10.85	-.1374 (.95)	.1884 (2.31)	1.6300 (.38)	.098
24	-.3262 (10.04)	.0428 (.32)	-.0935 (1.22)	.1331 (.03)	.027

Note: R^2 between observed and predicted values.

between .01 and .10 for those equations where the distance variable was significant. While low, these R-squares are not atypical for travel cost models.[7]

The regression coefficients in the TOBIT model should be interpreted a little differently than conventional OLS regression coefficients. In the TOBIT procedure, an index "I" is created which is a function of the independent variables, I = XA; where A is a vector of normalized coefficients:

$$I_n = A_0 + A_1 X_{1n} + A_2 X_{2n} + \ldots + A_k X_{kn}; \tag{4.4}$$

where I_n is the value of the index for the n^{th} individual given the values of the X_k's for that individual. These A_k normalized coefficients can be transformed into estimates of the regression coefficients — the Bi's — by multiplying the Ai's by the calculated standard error of the estimate:

$$(B_0, B_1, \ldots, B_k) = (\sigma \cdot A_0, \sigma \cdot A_1, \ldots, \sigma \cdot A_k); \tag{4.5}$$

where σ is the standard error of the dependent variable.

The coefficients presented in Table 4-7 are transformed normalized coefficients, or the B_i regression coefficients. One intuitive explanation of the meaning of these regression estimates is that they are consistent estimates of the same regression coefficients that would have been estimated by OLS, if the data set was not truncated at zero; that is, if both positive and negative values of the dependent variable "DAYS" could have been observed. Recall that the OLS procedures applied to the truncated data set produces an estimate of the slope that will be biased downwards due to the many observations where the dependent variable is zero. As a result, the TOBIT coefficients should always be larger in magnitude than regression coefficients estimated using OLS.

A graphical depiction of the relationship between the expected relationship between the OLS estimates, the TOBIT estimates and the calculated expected values using the TOBIT procedures is shown in Figure 4-1[a]. The OLS estimated relationships is line segment BD and is shown to be flatter than the TOBIT maximum likelihood estimate. The expected

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[7] For example, see Brown and Mendelsohn (1984) and Desvousges, Smith and McGivney (1983).

Figure 4-1

Expected Relationship Between the OLS Estimates, TOBIT Estimates, and the TOBIT Generated Expected Values[1]

Figure 4-1a - Standard TOBIT, OLS Relationship

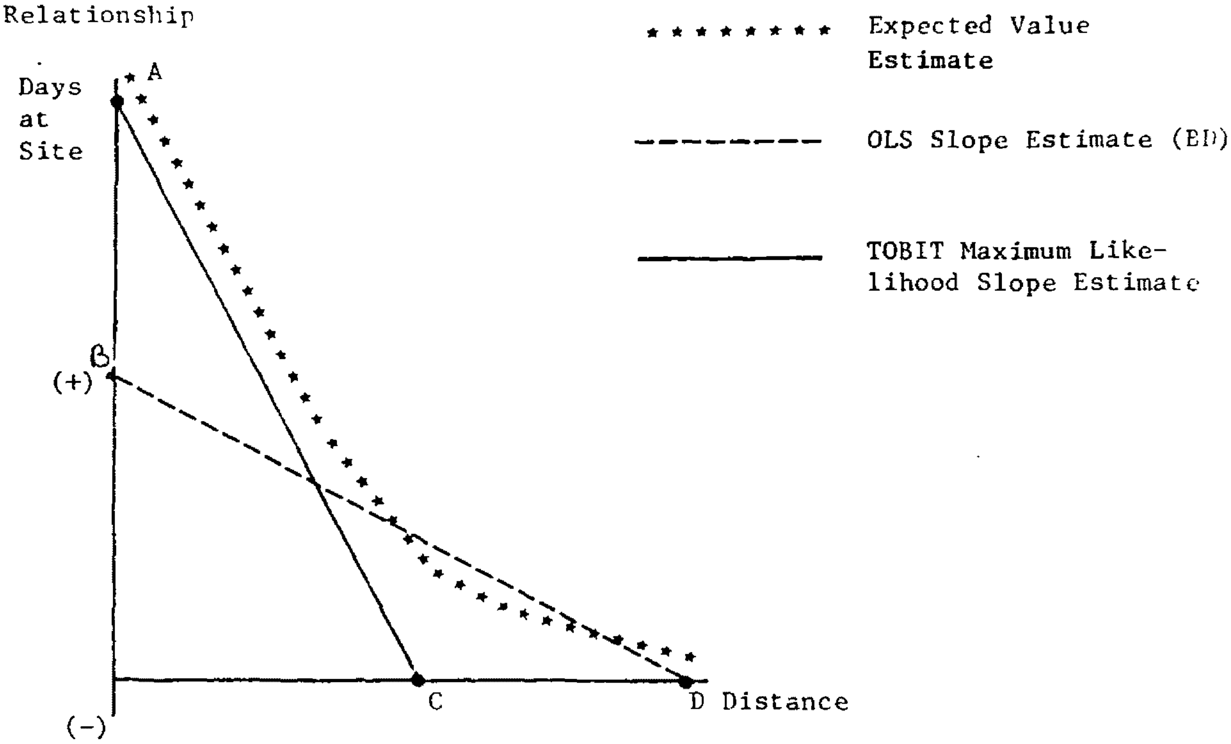
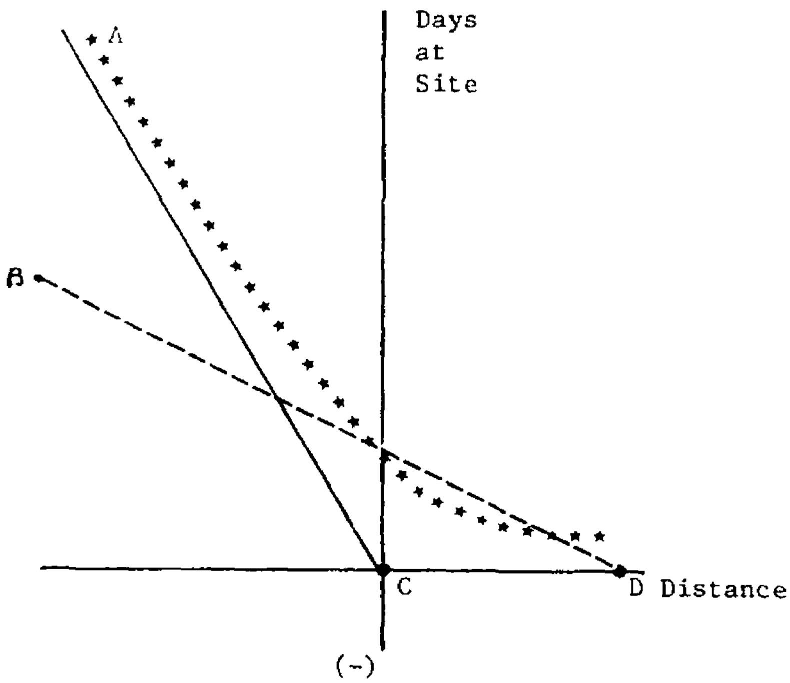


Figure 4-1b - Relationship when the probabilities of an individual visiting the site are less than .5 for all distances



[1]This figure is similar to Figures 3a and 3b in Tobin (1958).

value locus is also shown in Figure 4-1[a]. Each individual has some positive probability of visiting each site; however, this probability is lower the greater the distance to the site. For sites that are very distant, the probability may be close to zero. The expected value locus shown in Figure 4-1[a] is this probability multiplied by the expected number of fishing days at that site, given the individual visits to the site. This conditional expectation can be calculated from the following equation:[8]

$$E(D_n \mid I_n) = \sigma f\left(\frac{I_n}{\sigma}\right) + I_n F\left(\frac{I_n}{\sigma}\right) \tag{4.6}$$

where:

- $E(D_n \mid I_n)$ is the expected value of the number of days at a site given the value of the index (I_n) for that individual;
- I_n is the value of the index calculated from $I = AX$, i.e., equation 4.4;
- σ is the standard error of the dependent variable;
- $f(\cdot)$ and $F(\cdot)$ are the marginal and cumulative normal density functions.

As is shown in Figure 4-1[a], this method of calculating the expected value locus results in a nonlinear relationship. The expected value locus will always be above the TOBIT maximum likelihood equation (i.e., segment AC). At the left where the probabilities of visiting a site are high, the expected value locus will approach AC asymptotically. At the right where the probability of visiting a site approaches zero, the expected value locus will approach the line segment CD, which will be the horizontal axis in cases where the limiting value is zero.

Given the above explanation, some further analysis of certain peculiarities of the TOBIT regression results are possible. An examination of the coefficients estimated for site 1 in Table 4-7 shows that all of the coefficients are negative. This fact combined with the realization that the values of all the independent variables are positive results in any

[8] This equation is derived in Tobin (1958) and Goldberger (1964).

predicted number of fishing days from this model being negative. However, this result is consistent with the TOBIT interpretation presented above. There are two factors that must be considered when interpreting this outcome. First, the regression coefficients are used to calculate an index that in turn is used to calculate the probability of an individual taking a trip. This index is positive whenever the probability of taking a trip exceeds fifty percent and is negative whenever the probability is less than fifty percent.[9] This result for site 1 indicates that the probability of any one individual taking a fishing trip to that particular site is less than .5; however, the expected value for fishing days will still be positive. This outcome is illustrated in Figure 4-1b.[10] A second point that should be considered when interpreting the TOBIT coefficients for site 1 is the large standard errors of the coefficients on the non-distance variables. These make the actual intercept in Figure 4-1 very uncertain. This interpretation is important for calculating consumer surplus and willingness-to-pay estimates, and will be readdressed in Chapter 5.

4.3.2 Ordinary Least Squares Applied to Total Fishing Days

In spite of the fact that OLS estimates are biased, OLS was applied to the data sets to provide information on the strength of the relationship between fishing days and distance to the site. The OLS estimates provided a useful point of comparison as there is an explicit theoretic prior expectation of the relative magnitudes of the OLS and TOBIT regression coefficients.

The OLS estimates are presented in Table 4-8. As in the TOBIT analysis, only sites requiring trips of less than 225 one way miles were included in the data set. The results in Table 4-8 show that the distance variable was highly significant in most of the equations. The coefficients on the distance variable were significant at the 1 percent level in eighteen out of the twenty-three estimated equations. The distance variable was not significant for sites 3, 10, 12, 16 and 20. The income and the years of fishing experience variables were generally not significant. The R-squares were low, typically varying between .01 and .06 for those equations where the distance variable was significant.

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[9] See Tobin (1958), page 34 and Goldsmith (1983) footnote 19, page 39.

[10] A similar result was found by Deegan and White (1976) where their TOBIT regression coefficients only yielded negative values for the dependent variable over the entire range of X_1, with the other X_i held constant at their means.

Table 4-8

Travel Cost Model Using Total Days as the Dependent Variable: Estimated by Ordinary Least Squares
(t-values in parentheses)

Site #	Distance	Income	Years Fishing	Intercept	R^2
1	-.0158 (6.72)	-.0066 (.41)	-.0139 (1.48)	3.3441 (6.86)	.0468
2	-.0178 (6.45)	-.0254 (1.84)	.0075 (.93)	3.3922 (6.77)	.0445
3	-.0012 (1.02)	-.0027 (.32)	.0008 (.16)	.4533 (1.73)	.0012
4	-.0076 (5.92)	.0036 (.52)	-.0007 (.18)	1.21 (5.43)	.033
5	-.0133 (6.06)	-.0074 (.57)	.0114 (1.52)	2.0050 (5.00)	.0369
6	-.0235 (5.60)	-.0047 (.23)	.0082 (.69)	3.4523 (4.91)	.0303
7	-.0104 (3.51)	-.0060 (.25)	.0157 (1.89)	1.5810 (3.23)	.0155
8	-.0347 (6.76)	-.0065 (.25)	.0014 (.09)	5.5683 (6.64)	.0436
9	-.0168 (5.82)	-.0082 (.57)	.0174 (2.07)	2.0850 (4.62)	.0355
10	.0052 (1.18)	-.0167 (1.28)	.0109 (1.43)	-.1924 (.36)	.0044
11	-.0040 (3.38)	-.0021 (.37)	-.0016 (.49)	.75 (4.13)	.0118
12	-.0064 (1.59)	-.0048 (.26)	-.0076 (.70)	1.4612 (2.46)	.0031
13*	NA	NA	NA	NA	NA
14	-.0157 (3.96)	.0088 (.58)	.0112 (1.27)	1.9952 (3.33)	.0172
15	-.0091 (3.40)	.0050 (.63)	-.0019 (.41)	1.32 (3.83)	.0113
16	-.0010 (.58)	0.0054 (1.00)	-.0005 (.16)	.4222 (1.82)	.0014

* The equation for site 13 was not estimated due to an error in the program that merged the distance data and the site characteristics data.

Table 4-8

Travel Cost Model Using Total Days as the Dependent Variable: Estimated by Ordinary Least Squares

(t-values are in parentheses)

(continued)

Site #	Distance	Income	Years Fishing	Intercept	R^2
17	-.0182 (2.94)	-.0158 (.98)	.0058 (.61)	2.4106 (3.38)	.0102
18	-.0229 (3.19)	-.0033 (.13)	.0257 (1.68)	2.1425 (2.35)	.0126
19	-.0439 (6.63)	.0717 (2.44)	.0335 (1.94)	3.9322 (4.23)	.0498
20	.0022 (1.08)	-.0093 (.93)	.0126 (2.15)	-.1677 (.55)	.0062
21	-.0137 (2.64)	-.0310 (1.59)	.0281 (2.44)	1.9496 (2.74)	.0152
22	-.0180 (5.38)	-.0153 (1.43)	-.0023 (.36)	2.3041 (5.79)	.0291
23	-.0486 (7.56)	-.0719 (2.27)	.0248 (1.33)	6.5822 (6.93)	.0579
24	-.0316 (5.52)	-.0155 (.53)	-.0156 (.91)	5.2824 (6.15)	.029

Comparing the OLS results to the TOBIT results, the magnitudes of the coefficients conform to theoretic expectations. The absolute magnitudes of the TOBIT coefficients are greater than the OLS estimated coefficients. Also, the calculated t-values and R-squares were higher for the TOBIT equations.

4.3.3 Brook Trout Fishing Day Travel Cost Model Analyses

The participation models presented in Section 4.1 indicated that brook trout fishing days might be better analyzed separately. If possible, this could prove useful since acid deposition is expected to have a greater impact on the high altitude lakes that provide much of the unique brook trout habitat. As with the participation model, a new brook trout fishing days variable was defined. This variable was constructed by taking all the days at each site where the individual reported to have caught at least one brook trout. Other species of fish may have been fished for and caught as well, but if brook trout were caught, these days were classified as brook trout days.

This brook trout fishing day variable was used as the dependent variable in a TOBIT regression. The TOBIT procedure requires the use of iterative numerical methods. When brook trout days were used as the dependent variable, a number of the equations did not converge after the default number of iterations. As a result, TOBIT estimates were not able to be obtained for many of the sites. Table 4-9 presents the estimates for those sites where convergence was achieved. The fact that many equations did not converge may be explained by the limited number of non-zero observations. When total fishing days were used as the dependent variable, the sites with the least number of non-zero observations still had 30 non-zero observations out of 1,040 total observations. When only brook trout fishing days were used, several sites had less than 10 non-zero observations. Table 4-9 shows that only five sites achieved convergence and, of these five, only three had significant coefficients of the right sign on the distance variable. The R-squares of these equations were substantially lower than those found for the TOBIT results shown in Table 4-7. One interesting finding is that, where the coefficient on the

Table 4-9

Travel Cost Model using Brook Trout Fishing Days as the Dependent Variable: Estimated with a TOBIT Procedure

(t-values are in parentheses)

Site #	Distance	Income	Years Fishing	Constant	R^2
6	-.9785	.6716	.9690	-94.926	.0044
	(3.34)	(.44)	(1.14)	(2.39)	
9	-.3667	-1.5920	.6671	-53.748	.009
	(2.93)	(1.57)	(1.89)	(3.08	
10	.2447	.5675	.2559	-86.855	.0039
	(1.62)	(1.18)	(1.29)	(4.46)	
11	-.1160	.2602	-.0421	-37.776	.007
	(2.11)	(1.16)	(.27)	(5.05)	
12	.0315	.1096	-.0070	-76.104	.0022
	(.38)	(.29)	(.03)	(5.99)	

distance variable is negative and significant, it is similar to the magnitudes of the coefficients in the total days equations presented in Table 4-7:

	Brook Trout Fishing Day Coefficients (t-value)	Total Fishing Day Coefficients (t-value)
Site 6	-.978 (3.34)	-.812 (5.63)
Site 9	-.367 (2.93)	-.287 (6.34)
Site 11	-.116 (2.11)	-.078 (3.38)

The similarity in the magnitude of these coefficients may mean that it is less important to separately estimate a travel cost model for brook trout fishing days.

A semi-log specification for brook trout fishing days was also estimated. The results of this TOBIT estimation are presented in Table 4-10. The semi-log specification produced a modest improvement — more equations converged and the statistical results in terms of t-values, expected signs on the distance coefficients, and R-squares were slightly improved.

4.4 SECOND STAGE ANALYSIS OF THE CHARACTERISTICS OF FISHING SITES

The coefficients of a travel cost model using both TOBIT and OLS procedures were estimated following procedures discussed in Section 4.3. As discussed in Chapter 2.0, these travel cost models do not explicitly take into account site characteristics. Travel cost models do estimate the travel and time costs that an individual is willing to pay to visit a site. These willingness-to-pay amounts can be calculated from the coefficients on the independent variables in the visitation equation for each site. It seems likely that sites with more desirable recreational characteristics, such as fishing opportunities and catch rate, would attract fishermen from further distances. This should show up in the relative magnitudes of the estimated coefficients on the distance variable in the site equations. Also, the participation models estimated in Section 4.1 showed the number of visitor days to be positively related to site characteristics such as pond acreage and total catch rate.

This section presents results obtained by regressing the coefficients from each site equation on selected characteristics of that site. Two site characteristics were used: fishable acreage and total catch rate. The equation that was estimated is:

Table 4-10

Travel Cost Model using the Natural Log of Brook Trout Fishing Days as the Dependent Variable: Estimated with a Tobit Procedure

(t-values are in parentheses)

Site #	Distance	Income	Years Fishing	Constant	R^2
1	-.0435 (3.45)	.0781 (.82)	-.0852 (1.31)	-9.54 (4.10)	.043
3	-.0201 (3.06)	-.0041 (.08)	.0248 (.88)	-6.01 (.478)	.017
9	-.0544 (2.91)	-.2330 (1.55)	-.363 (.09)	-8.20 (3.13)	.011
10	.0459 (1.59)	.0977 (1.08)	.099 (1.88)	-15.8 (4.29)	.003
11	-.0255 (1.91)	.0798 1.54)	.032 (.86)	-9.43 (5.19)	.007
12	.0135 (1.25)	.0243 (.45)	-.004 (.12)	-11.5 (6.10)	.005
14	-.0466 (2.83)	.0490 (.78)	-.018 (.50)	-7.75 (3.49)	.007
15	-.0236 (1.22)	.0463 (.80)	.016 (.44)	-9.67 (3.94)	.001

$$B_{ij} = A_0 + A_1 \text{(Acres)}_j + A_2 \text{(Catch Rate)}_j$$

where B_{ij} is the i^{th} parameter (either a coefficient or intercept from the j^{th} site equation. Two parameters were used as the dependent variable in this second stage. The first was the coefficient on the distance variable (i.e., B_{1j}), the second was the intercept. The demand curve intercept was defined as:

$$B_{2j} \text{(Mean Income Value)} + B_{3j} \text{(Mean Experience Value)} + B_{4j}.$$

This composite variable represents the intercept of a demand equation relating fishing days to distance, holding the other variables constant at their mean values. It would have been possible to estimate each coefficient and intercept as a function of the site characteristics; however, the income and experience variables were not significant in most of the site equations. As a result, these coefficient estimates would have large standard errors and, at best, would be imprecisely estimated. This would make statistically significant estimates of the effects of the site characteristic levels on these coefficients unlikely and the results hard to interpret. Given this situation, only the above composite inter-cept was regressed against site characteristics. Since this intercept is the actual demand curve intercept, this was felt to be appropriate.

The results of regressing both the coefficient on the distance variable and the intercept against two site characteristics — net acres and total catch rate — are shown in Table 4-11a. Two other specifications were also estimated. The results of these are shown in Table 4-11b. The GLS procedure discussed in Chapter 2 was used in both instances. Table 4-12 presents similar GLS estimated equations for the parameters from the OLS estimated travel cost equations.

In Tables 4-11 and 4-12, the site characteristics have t-values that are small. Still, a t-value of 1.27 is significant at the 10 percent level for a one-tailed test and 20 percent for a two-tailed test. The coefficients on the site characteristics in the intercept equation have the expected sign. As fishable acres and catch rates decline, intercept moves downward, reducing the consumer surplus obtained from the site. The coefficients on the site characteristic in the equation using the stage one distance coefficient as the independent variable did not have the expected sign. In general, the composite effect of reductions in the level of the site characteristics was a reduction in consumer surplus because the influence of the change in the intercept was large enough to outweigh the

Table 4-11

Second Stage Generalized Least Squares Runs on the TOBIT Estimated Parameters from the Total Fishing Day Equations

(t-values)

a. Base Equations

Dependent Variable	Net Park Acres	Total Catch Rate	Constant	R^2
Coefficient on Distance Variable	$-.692 \times 10^{-5}$ (1.80)	-.007 (1.01)	-.116 (-1.27)	.161
Intercept	$.597 \times 10^{-3}$ (1.27)	4.81 (2.47)	45.01 (10.15)	.225

b. Additional Trial Specifications

Dependent Variable	Acres less than 1500 feet Elevation	Warm Water Acres	Two Story Acres	Total Catch Rate	Constant	R^2
Coefficient or Distance Variable	$-.519 + 10^{-5}$ (1.36)			-.0056 (.2907)	-.129 (1.89)	.108
Intercept		$.623 \times 10^{-3}$ (1.38)	$.211 + 60^{-3}$ (.449)	3.07 (1.13)	32.14 (3.15)	1.34

Table 4-12

Generalized Least Squares Runs on the Ordinary Least Squares Parameters from the Total Day Equations

Dependent Variable	Net Park Acres	Total Catch Rate	Constant	R^2
Coefficient on the Distance Variable	$-.852 \times 10^{-6}$ (1.91)	$-.254 \times 10^{-2}$ (1.48)	$+.583 \times 10^{-2}$ (.797)	.178
Intercept	$.135 + 10^{-4}$ (2.44)	.253 (1.04)	$.740 \times 10^{-1}$ (.072)	.235

effect from the change in the distance coefficient. For calculating the changes in consumer surplus associated acidification, only the effect of site characteristics on the intercept of each site's demand curve was used. This is consistent with the objective of selecting assumptions that would lead to a high estimate of damages as was discussed in Chapter 1.

4.5 TRAVEL COST MODEL ESTIMATES: CONCLUSIONS

The statistical results presented in this section show a strong relationship between visitor days at a site and the travel distance to the site. The analyses provide estimates that can be used to estimate the consumer surplus derived from each fishing site; however, only the most basic specifications have been estimated and additional analyses would be desirable.

Additional analysis may be beneficial in several areas. One could examine alternative functional forms including semi-log and Box-Cox specifications. A second issue warranting additional analysis would be the opportunity cost of time. To examine this issue, an estimate of the individual's marginal valuation of time is needed. Most often, the individual's wage rate is used as an estimate of the value of time. Unfortunately, the Anglers' Survey does not include information on the individual's wage. It would be possible, however, to perform an analysis similar to that contained in Section 7.4 of Desvousges, Smith and McGivney (1983).

Desvousges, et al. (1983) used a model that predicts the wage rate given the individual's annual income, occupation and related characteristics. They found the variation in estimated wage rates from the mean wage level to be approximately 50 percent.

Given the potential magnitude of other errors in the model, the error due to not capturing differences in individual's marginal valuation of time does not seem overwhelming, but it also should not be minimized. The present formulation of the model, where distance rather than a specific travel cost is entered into the model, allows alternative cost per mile values to be calculated using varying travel and time costs.

Another important issue concerns the current inability to estimate a separate model for brook trout fishing days. The TOBIT procedures applied to brook trout fishing days failed to converge on a set of coefficients for most of the sites because of too few non-zero observations. This could potentially be remedied by redefining the sites and using alternative numerical techniques. Since the brook trout fish population is the fishery most threatened by acid deposition, a separately estimated brook trout travel cost model may be useful.

5.0 RECREATIONAL FISHING RESOURCE VALUATION

Several procedures can be used to provide estimates of the value of damages (i.e., reduced benefits) to recreational fishing in the Adirondack Mountains from current levels of acidification. Section 4.3 discussed the relationships between demand curves based on OLS estimated regression coefficients, TOBIT estimated regression coefficients, and the expected value locus calculated from the TOBIT coefficients. A consumer surplus estimate associated with each of the sites can be calculated using each of these demand curves. Of these three options, the most appropriate curve to use for estimating the consumer surplus is the TOBIT based expected value locus, since this estimate takes into account both the probability of visiting the site and the estimated number of days at a site given that a trip is taken. In addition to the travel cost model, estimates of damages from acidification can be derived from the participation model presented in Section 4.1.

The reduction in benefits due to the effects of acidification can be estimated by examining the difference between the consumer surplus estimates in the current state and the pre-acidification state.[1] Figure 5-1 illustrates this benefits calculation. The shaded area in Figure 5-1 is a measure of the dollar value of the damages to recreational fishermen that have resulted from acidification.

5.1 ESTIMATE OF DAMAGES FROM ACIDIFICATION USING THE TRAVEL COST MODEL

Estimates of the value of each site, using the travel cost model results, were obtained by using the routine in the SHAZAM econometrics software package that produces the expected value locus. These expected value curves were estimated holding the values of

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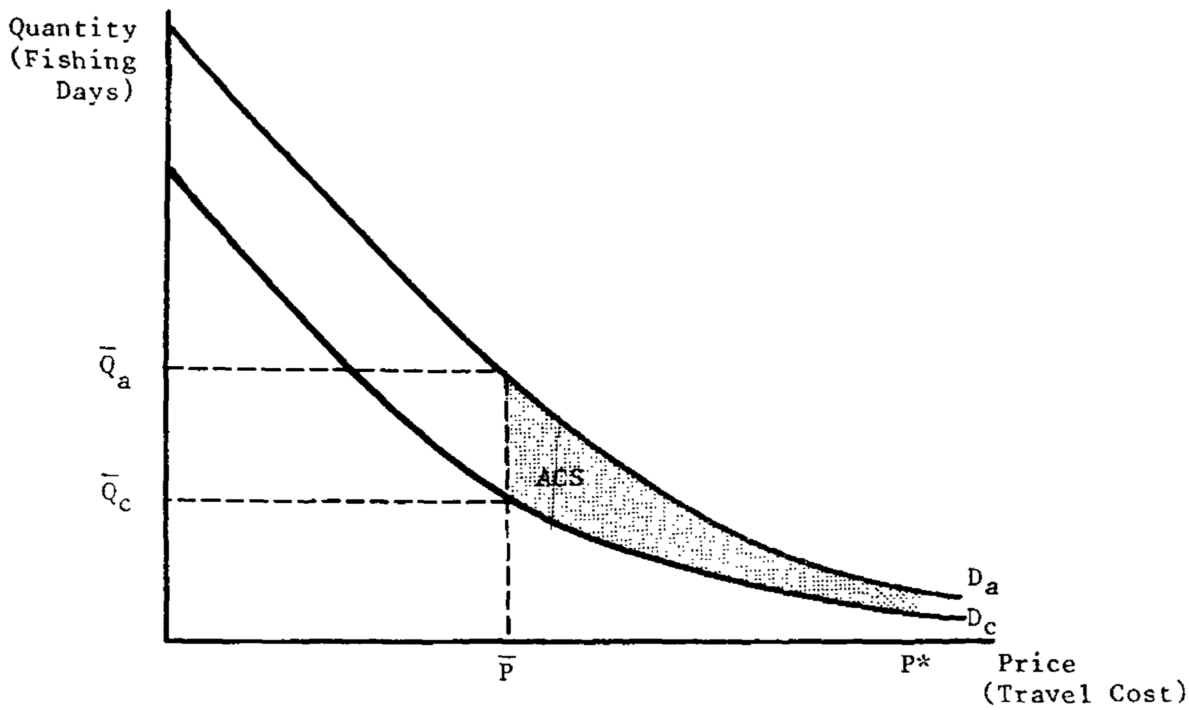
[1] This consumer surplus measure is termed the Marshallian consumer surplus. It is not a perfect welfare measure, but it is an adequate approximation for this application. Other consumer surplus measures are available, but Freeman (1979) concludes that the differences among these measures are "small and almost trivial for most realistic cases."

Figure 5-1

Measurement of Consumer Surplus Losses Caused by Acidification



- D_c is the demand curve in the current situation where acidification has reduced the fishing opportunities available at the site.
- D_a is the demand curve given that there is no acidification.
- ACS is the change (i.e., reduction) in consumer surplus due to acidification.

the income variable and fishing experience variable constant at the means of the sample. This resulted in a schedule for each site that shows the increase (decrease) in the expected number of fishing days the "average" individual would spend at a site as his distance from the site decreases (increases), other things held constant.

The estimated total willingness to pay and consumer surplus for each site is shown in Table 5-1. These are based on an out-of-pocket travel cost estimate of 4.4 cents per mile (from Table 4-6) and an opportunity of time cost of 9.06 cents per mile. The time cost was based on an assumed average driving speed of 40 miles per hour, and the deflated mean hourly wage of a sample of fishermen from Desvousges et al. (1983). The time cost was calculated as being two thirds of the wage rate to reflect the fact that some individuals may obtain enjoyment from the drive and, therefore, time in transit should not be valued at the full wage rate. Table 5-1 shows the value for the current recreational fishing experience in the Adirondacks to be 261 million dollars per year.

The next step in the analysis is to obtain an estimate of the losses that may have resulted from current levels of acidification. The second stage equations (shown in Table 4-9) that regressed the TOBIT regression coefficient on the characteristics of the sites can be used to show how the value of the resource has changed due to increased acidification. These estimates are based on analyses conducted by Dr. Joan Baker as part of the National Acid Precipitation Assessment Program (NAPAP), and are based on research that is still in progress.[2] Table 5-2 shows some sites to have experienced greater levels of acidification than others. This is due to a number of factors, including: differing amounts of acidic deposition; the varying sensitivity of the lakes in a site to elevated hydrogen ion loading; and the distribution of gamefish populations.

The reductions in fishing opportunities shown in Table 5-2 can be translated into an estimated economic loss by using the site characteristic equations from Table 4-9. These characteristic equations can be used to calculate how the TOBIT estimated regression coefficients change as a result of these site characteristic changes. The new TOBIT regression coefficients are then used to estimate a new expected value locus. New willingness-to-pay estimates can be calculated from these new curves. The difference be-

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[2] Caveats to these estimates are presented in the Appendix.

Table 5-1

Current Recreational Fishing Values in the Adirondack Mountains per year

Site	Expenditure[1]	Consumer Surplus[1]	Total Willingness To Pay[1]	Total Willingness To Pay Per Fishing Day	Consumer Surplus Per Fishing Day
1	7,294.5	3,033.0	10,327.5	107	31
2	8,483.8	2,912.6	11,396.4	104	26
3	4,157.5	1,267.5	5,425.0	118	27
4	3,228.4	1,489.8	4,718.2	97	31
5	5,870.5	2,510.4	8,380.9	98	29
6	6,586.6	4,038.1	10,624.7	105	40
7	7,784.2	4,373.6	12,157.8	107	38
8	13,615.6	6,334.5	19,950.1	96	30
9	5,679.1	2,934.3	8,613.4	96	32
10	(*)	(*)	(*)	(*)	
11	2,415.6	1,147.1	3,562.7	75	24
12	6,569.0	3,698.7	10,267.7	103	37
13	N.A.	N.A.	N.A.	N.A.	N.A.
14	7,557.9	3,054.7	10,612.6	80	23
15	4,417.9	2,120.4	6,538.3	75	24
16	2,610.1	2,082.4	4,692.5	88	39
17	5,649.7	2,181.0	7,830.7	66	18
18	7,469.4	3,785.0	11,254.4	64	21
19	18,583.9	10,285.3	28,869.2	79	28
20	(*)	(*)	(*)	(*)	(*)
21	8,881.9	3,982.7	12,864.6	71	22
22	3,691.4	3,053.6	6,745.0	78	35
23	18,429.6	17,460.4	35,890.0	85	41
24	16,657.0	13,400.6	30,057.6	81	36
TOTAL	165,580.3	95,146.1	260,726.4	85	31

[1] Thousands of 1984 dollars per year

* These sites had a positive coefficient on the travel cost variable.

Table 5-2

Losses of Fishable Lake Area Due to Acidification

Site	Total Area (km^2)	Percent Reduction Moderate Loss Estimate Scenario 1	High Loss Estimate Scenario 2
1	27.023	0.0	0.0
2	(*)	(used site 6 estimates)	
3	61.510	.1%	4.3%
4	22.595	2.2%	32.0%
5	28.126	.1%	.1%
6	7.008	5.3%	10.6%
7	145.445	.2%	8.6%
8	16.591	1.0%	19.5%
9	23.404	.3%	.3%
10	55.165	0.0	16.7%
11	12.545	5.1%	10.4%
12	22.146	.2%	32.0%
13	71.019	17.7%	21.3%
14	25.750	7.5%	7.5%
15	39.235	.2%	.2%
16	14.529	.2%	2.7%
17	36.319	.5%	3.4%
18	30.654	1.1%	3.3%
19	4.654	0.0	0.0
20	62.679	12.0%	27.7%
21	27.265	.6%	7.4%
22	17.411	20.2%	28.3%
23	125.79	0.0	0.0
24	(*)	(used site 23 estimates)	

* These sites lie outside the Adirondack Park boundaries. Dr. Baker's data set did not have information on these sites.

tween the original willingness-to-pay or consumer surplus estimates represents the change in the value due to the change in characteristics; in this case, fishable acres of water.

Two site characteristics were incorporated in the TOBIT analyses presented in Section 4.4. They were net fishable acres and the catch rate in the remaining fishable acres at that site.[3] It was assumed that the percentage change in net fishable acres due to acidification is equal to the percentage change in total fishable area estimated by Dr. Baker. How acidification at these levels actually influences the catch rate at a site is unknown. As a result, several assumptions regarding the catch rate were made. Tables 5-3 and 5-4 show how the value of the recreational fishing resource changes assuming that the catch rate is unaffected by whatever acidification has occurred. Tables 5-5 and 5-6 assume that acidification reduces the average catch rate experienced by fishermen at the site by the same proportion as fishable area. The resource value changes presented in Tables 5-3 through 5-4 may be summarized as follows:

1) The estimated current value of the recreational fishing sites in terms of total willingness to pay is 260.7 million dollars per year. The estimated current consumer surplus is 95.1 million dollars (Table 5-3).

2) Using the moderate acreage loss estimate and assuming no change in catch rates, acidification is estimated to have resulted in a decline in the resource value of 2.1 million dollars per year and reduced consumer surplus of .76 million dollars per year (Table 5-3).

3) Using the high acreage loss estimate and assuming no change in catch rates, acidification is estimated to have resulted in a decline in the resource value of 9.2 million dollars per year and a reduced consumer surplus of 3.3 million dollars per year (Table 5-4).

4) Using the moderate acreage loss estimate and assuming that the catch rate declines proportionately, the estimated decline in the resource value is 10.5 million dollars per year and the loss of consumer surplus is 4.4 million dollars.

5) Using the high acreage loss estimate and assuming a proportionate change in catch rate, the estimated decline in the resource value is 26.9 million dollars and the loss in consumer surplus is 11.6 million dollars.

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[3] Estimates were available for the amount of lake area that would no longer support a fish population, but catch rates at remaining fishable lake acreage might also be reduced by acidification.

Table 5-3

Valuation of Resource Losses Due to Acidification: Moderate Acreage Loss Scenario

($ x 10^3 per year, 1984 dollars)

Site	Current Willingess To Pay	Willingness to Pay Given No Acidification	Losses	Current Consumer Surplus	Consumer Surplus Given No Acidification	Consumer Surplus Losses
1	10,330	10,330	0	3,030	3,030	0
2	11,400	11,570	170	2,910	2,960	50
3	5,420	6,150	730	1,270	1,470	200
4	4,720	4,860	140	1,490	1,540	50
5	8,380	8,380	0	2,510	2,510	0
6	10,620	10,930	310	4,040	4,160	120
7	12,160	12,190	30	4,370	4,390	20
8	19,950	19,970	20	6,330	6,340	10
9	8,610	8,620	10	2,930	2,940	10
10	(*)	(*)	(*)	(*)	(*)	(*)
11	3,560	3,570	10	1,150	1,160	10
12	10,270	10,270	0	3,700	3,700	0
13	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.
14	10,610	10,760	150	3,050	3,100	50
15	6,540	6,600	60	2,120	2,140	20
16	4,690	4,690	0	2,080	2,080	0
17	7,830	7,850	20	2,180	2,190	10
18	11,250	11,270	20	3,780	3,790	10
19	28,870	28,870	0	10,280	10,280	0
20	(*)	(*)	(*)	(*)	(*)	(*)
21	12,860	12,900	40	3,980	3,990	10
22	6,740	7,140	400	3,050	3,240	190
23	35,890	35,890	0	17,460	17,460	0
24	30,060	30,060	0	13,400	13,400	0
'OTALS	260,760	262,800	2,110	95,110	95,870	760

These sites had a positive coefficient on the travel cost variable.

Table 5-4

Valuation of Resource Losses Due to Acidification: High Area Loss Scenario

($\$ \times 10^3$ per year, 1984 dollars)

Site	Current Willingess To Pay	Willingness to Pay Given No Acidification	Losses	Current Consumer Surplus	Consumer Surplus Given No Acidification	Consumer Surplus Losses
1	10,330	10,330	0	3,030	3,030	0
2	11,400	13,030	1630	2,910	3,400	490
3	5,420	6,190	770	1,270	1,490	220
4	4,720	5,670	950	1,490	1,850	360
5	8,380	8,380	0	2,510	2,510	0
6	10,620	10,980	360	4,040	4,180	140
7	12,160	13,320	1,160	4,370	4,830	460
8	19,950	22,240	2,290	6,330	7,150	820
9	8,610	8,620	10	2,930	2,940	10
10	(*)	(*)	(*)	(*)	(*)	(*)
11	3,560	3,600	40	1,150	1,160	10
12	10,270	10,940	670	3,700	3,960	260
13	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.
14	10,610	10,760	150	3,050	3,100	50
15	6,540	6,600	60	2,120	2,140	20
16	4,690	4,790	100	2,080	2,130	50
17	7,830	7,920	90	2,180	2,200	20
18	11,250	11,280	30	3,780	3,800	20
19	28,870	28,870	0	10,280	10,280	0
20	(*)	(*)	(*)	(*)	(*)	(*)
21	12,860	13,180	320	3,980	4,080	100
22	6,740	7,290	550	3,050	3,320	270
23	35,890	35,890	0	17,460	17,460	0
24	30,060	30,060	0	13,400	13,400	0
TOTALS	260,760	269,940	9,180	95,110	98,410	3,300

* These sites had a positive coefficient on the travel cost variable.

Table 5-5

Valuation of Resource Losses Due to Acidification: Moderate Area and Catch Rate Loss Scenario

($ x 10^3 per year, 1984 dollars)

Site	Current Willingess To Pay	Willingness to Pay Given No Acidification	Losses	Current Consumer Surplus	Consumer Surplus Given No Acidification	Consumer Surplus Losses
1	10,330	10,330	0	3,030	3,030	0
2	11,400	13,410	2010	2,910	3,540	630
3	5,420	7,740	2320	1,270	2,080	810
4	4,720	5,210	490	1,490	1,870	380
5	8,380	8,390	10	2,510	2,520	10
6	10,620	11,740	1120	4,040	4,510	470
7	12,160	12,200	40	4,370	4,390	20
8	19,950	20,230	280	6,330	6,430	100
9	8,610	8,640	30	2,930	2,940	10
10	(*)	(*)	(*)	(*)	(*)	(*)
11	3,560	3,970	410	1,150	1,290	140
12	10,270	10,270	0	3,700	3,700	0
13	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.
14	10,610	22,430	710	3,050	3,230	180
15	6,540	6,620	80	2,120	2,150	30
16	4,690	4,720	30	2,080	2,090	10
17	7,830	7,870	40	2,180	2,190	10
18	11,250	11,310	60	3,780	3,810	30
19	28,870	28,870	0	10,280	10,280	0
20	(*)	(*)	(*)	(*)	(*)	(*)
21	12,860	12,930	70	3,980	4,000	20
22	6,740	9,530	2,790	3,050	4,630	1,580
23	35,890	35,890	0	17,460	17,460	0
24	30,060	30,060	0	13,400	13,400	0
OTALS	260,760	282,360	10,490	95,110	99,540	4,430

These sites had a positive coefficient on the travel cost variable.

Table 5-6

Valuation of Resource Losses Due to Acidification: High Area and Catch Rate Loss Scenario

($\$ \times 10^3$ per year, 1984 dollars)

Site	Current Willingess To Pay	Willingness to Pay Given No Acidification	Losses	Current Consumer Surplus	Consumer Surplus Given No Acidification	Consumer Surplus Losses
1	10,330	10,330	0	3,030	3,030	0
2	11,400	15,770	4,370	2,910	4,320	1,410
3	5,420	8,140	2,720	1,270	2,280	1,010
4	4,720	7,760	3,040	1,490	3,200	1,710
5	8,380	8,380	10	2,510	2,510	0
6	10,620	12,910	2,290	4,040	5,060	1,020
7	12,160	13,520	1,359	4,370	4,920	550
8	19,950	22,860	2,910	6,330	7,400	1,070
9	8,610	8,690	80	2,930	2,940	10
10	(*)	(*)	(*)	(*)	(*)	(*)
11	3,560	4,400	840	1,150	1,470	320
12	10,270	13,280	3010	3,700	5,000	1,300
13	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.
14	10,610	11,320	710	3,050	3,230	180
15	6,540	6,620	80	2,120	2,150	30
16	4,690	5,050	360	2,080	2,250	170
17	7,830	8,070	240	2,180	2,250	70
18	11,250	11,440	190	3,780	3,850	70
19	28,870	28,870	0	10,280	10,280	0
20	(*)	(*)	(*)	(*)	(*)	(*)
21	12,860	13,550	690	3,980	4,210	230
22	6,740	10,780	4,040	3,050	5,510	2,460
23	35,890	35,890	0	17,460	17,460	0
24	30,060	30,060	0	13,400	13,400	0
TOTALS	260,760	287,690	26,939	95,110	106,720	11,610

* These sites had a positive coefficient on the travel cost variable.

There are a number of factors that must be considered when interpreting these results. First, the correct measure of benefits for use in a benefit-cost analysis of acidification is the change in consumer surplus.

Second, the data set used in the analysis only includes information on visits to lakes. Streams in the Adirondack Mountains were not examined due to the lack of data on the characteristics of the streams and uncertainty regarding the actual fishing location. Data in the Anglers' Survey indicated that approximately one third of fishing trips listed a stream as the final destination.

Third, sites 10, 13 and 20 were not assigned a value. Site 13 was not valued due to an error in the computer program that combined the data in the Anglers' Survey and the Ponded Waters Survey. Sites 10 and 20 had the wrong sign on the coefficients on the travel cost variables. As a result, willingness-to-pay estimates for these sites were not available from the statistical analysis. These sites certainly have some value. An examination of the data presented in Table 5-2 shows each of these sites is susceptible to acidification with the high estimates of fishable acreage losses being 16.7 percent, 21.3 percent, and 27.7 percent respectively. Thus, the exclusion of these sites in the value estimates contained in this report biases the estimated effects of acidification downward. Because of the estimated sensitivity of site 13 to acidic deposition, it could be argued that a substantial fraction of acidification damages have not been captured. To evaluate this hypothesis, changes in willingness to pay and consumer surplus values were estimated using the estimated relationship between fishing days and a site's fishable acreage and catch rate (equation 3 from Table 4-1), and the average willingness to pay and consumer surplus values calculated for the remaining sites using the travel cost model. The results of this analysis suggest that the omission of site 13 causes an underestimate in the consumer surplus values ranging from $7,000 to $14,000. In light of the uncertainty surrounding the aggregate consumer surplus losses, these damages are not likely to represent a serious downward bias to the estimates.

Fourth, the travel cost model in its present version does not explicitly take into account the substitutability of fishing sites. This will tend to result in estimates of losses that are overstated. See Section 5.3 for a more complete discussion of this point.

Fifth, the travel cost analysis considered only trips that have a one-way distance of 225 miles or less. This was done to avoid including multi-purpose trips where fishing may not have been the primary reason for the trip. The inclusion of these trips would have biased the estimates and made the results uninterpretable. Still, these trips represent fishing days spent at the site that have value. In scaling the sample estimates up to a population estimate, it was assumed that fishing days from trips of distances greater than 225 miles resulted in the same consumer surplus as shorter trips. The actual consumer surplus resulting from fishing days taken as part of a multi-purpose trip could be either greater or smaller than that estimated from the shorter trips. Still, over 70 percent of the fishing days were from trips of less than 225 miles.

5.2 ESTIMATING THE DAMAGES FROM ACIDIFICATION USING THE PARTICIPATION MODEL

The participation model developed in Section 5.1 can be used in conjunction with the resource value estimates from Table 5-1 to estimate the damages from acidification. The participation model found a robust relationship between the number of fishing days spent at a site and fishing opportunities measured by fishable acreage and fishing success measured by the total catch rate. Equation 3 from Table 4-1 presents the estimated relationship between fishing days and a site's fishable acreage and catch rate:

$$\text{Fishing Days} = \underset{(5.66)}{.0978}\,(\text{Net Park Acres}) + \underset{(1.97)}{199.4}\,(\text{Catch Rate}) + \text{intercept}$$

The R-square for this equation was .615. The moderate loss due to acidification scenario from Table 5-2 resulted in an average reduction in fishable acreage of 3.2 percent and the high loss scenario resulted in an average acreage reduction of 10 percent. The mean values across all sites for net park acres and catch are 7,420 and 3.47 respectively. Using these mean values to represent the average site, the effect of acidification on total fishing days for this average site can be calculated. Then, the average willingness to pay ($85) and consumer surplus ($31) per fishing day from the travel cost model (see Table 5-1) can be used to calculate an estimate of damages. Four scenarios are evaluated.

Scenario 1 — Assumes moderate acreage losses and no change in catch rate, causing a reduction of 56,000 fishing days across all sites. Estimated damages expressed as willingness to pay and consumer surplus are 4.8 and 1.7 million dollars per year respectively.

Scenario 2 — Assuming high acreage losses and no change in catch rate, a reduction of 173,000 fishing days across all sites is estimated. Estimated damages expressed as willingness to pay and consumer surplus are 14.7 and 5.4 million dollars per year respectively.

Scenario 3 — Assuming moderate acreage losses and a proportionate change in catch rate, a reduction of 109,000 fishing days is estimated. Estimated damages expressed as willingness to pay and consumer surplus is 9.3 and 3.4 million dollars per year respectively.

Scenario 4 — Assuming high acreage losses and a proportionate change in catch rate, a reduction of 340,000 fishing days across all sites is estimated. Estimated damages expressed as willingness to pay and consumer surplus are 28.9 and 10.5 million dollars per year respectively.

5.3 COMPARISON OF PARTICIPATION MODEL AND TRAVEL COST MODEL ESTIMATES OF DAMAGES

The damage estimates derived in terms of reduced consumer surplus from both the travel cost model and participation model are presented in Table 5-7. The estimates derived from the two models are quite similar in magnitude. There is no clear reason to prefer one set of estimates over the other. The use of average values in the participation model poses some problems, but are reasonable approximations for the modest changes in site characteristics examined in this study. One favorable attribute of the participation model results was the robust statistical relationship that was found between fishing days and site attributes. The statistical relationship found in the second stage of the varying coefficient travel cost model was less robust.

Table 5-7

Estimates of Damages Resulting from Current Levels of Acidification

($ x 10^6 per year, in 1984 dollars)

Assumed Acidification Scenario	Estimated Consumer Surplus Losses from the Travel Cost Model	Estimated Consumer Surplus Losses from the Participation Model
1. Moderate acreage losses and no change in catch rate	.8	1.7
2. High acreage losses and no change in catch rate	3.3	5.4
3. Moderate acreage losses and proportionate changes in catch rate	4.4	3.4
4. High acreage losses and proportionate changes in catch rate	11.6	10.5

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A P P E N D I X   A

North Carolina State University
Acid Deposition Program

1509 Varsity Drive
Raleigh, NC 27606
919-737-3520

School of Forest Resources
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E... ...OURCE
... , INC.

Dan Violette
Energy and Resource Consultants
P.O. Box Drawer O
Boulder, CO 80306

Dear Dan:

In response to your request for estimates of loss of fishable 'acres' in the Adirondacks as a result of acidification, I have prepared the attached table based upon the information in the FIN (Fish Information Network) database and in the draft report prepared for NAPAP project E3-25 (Baker, J. and T. Harvey. 1984. Critique of Acid Lakes and Fish Population Status in the Adirondack Region of New York State, draft report to the U.S. Environmental Protection Agency). It should be clear that these are preliminary estimates. Because of the quick turn around time required to provide numbers for your draft report, our approach has been very simple. Better estimates should be available by late February for inclusion in your final draft.

The numbers in the attached table are derived from evaluations of all available data (current and historic) on fish populations in the Adirondacks in FIN and from the assessment of fish community status as described in Baker and Harvey (1984). Briefly a rating of fish community status of 3, 4, or 5 for a given lake indicated that several to all species have disappeared from the lake overtime, apparently as a result of acidification. A rating of 2 was considered marginal; one or two species have apparently declined in abundance and/or disappeared from the lake but neither the evidence for loss of populations nor the indications of the potential influence of acidification are particularly strong. Ratings of 0 or 1 were indicative of 'healthy' fish communities and no adverse effects as a result of acidification. The 'reasonable' estimates of fishable acres lost in the the table are based on the number and surface area of lakes with fish community status rated 3, 4, or 5. The 'high' estimates are based on lakes with fish community status rated 2, 3, 4, or 5. Note that we have not, at this time, zeroed in specifically on game species. Such information will, however, be available for your next series of model runs.

The fraction of lakes with adequate fish survey data (historic and current) for assessment of fish community status is, unfortunately, quite small. Thus, it was necessary to extrapolate from our sample of lakes in FIN with adequate data to all lakes in the Adirondacks. Lakes with 'adequate' data (particularly surveys of fish populations pre-1970) tend to be larger, and have a higher pH. To partially adjust for this bias, lakes were

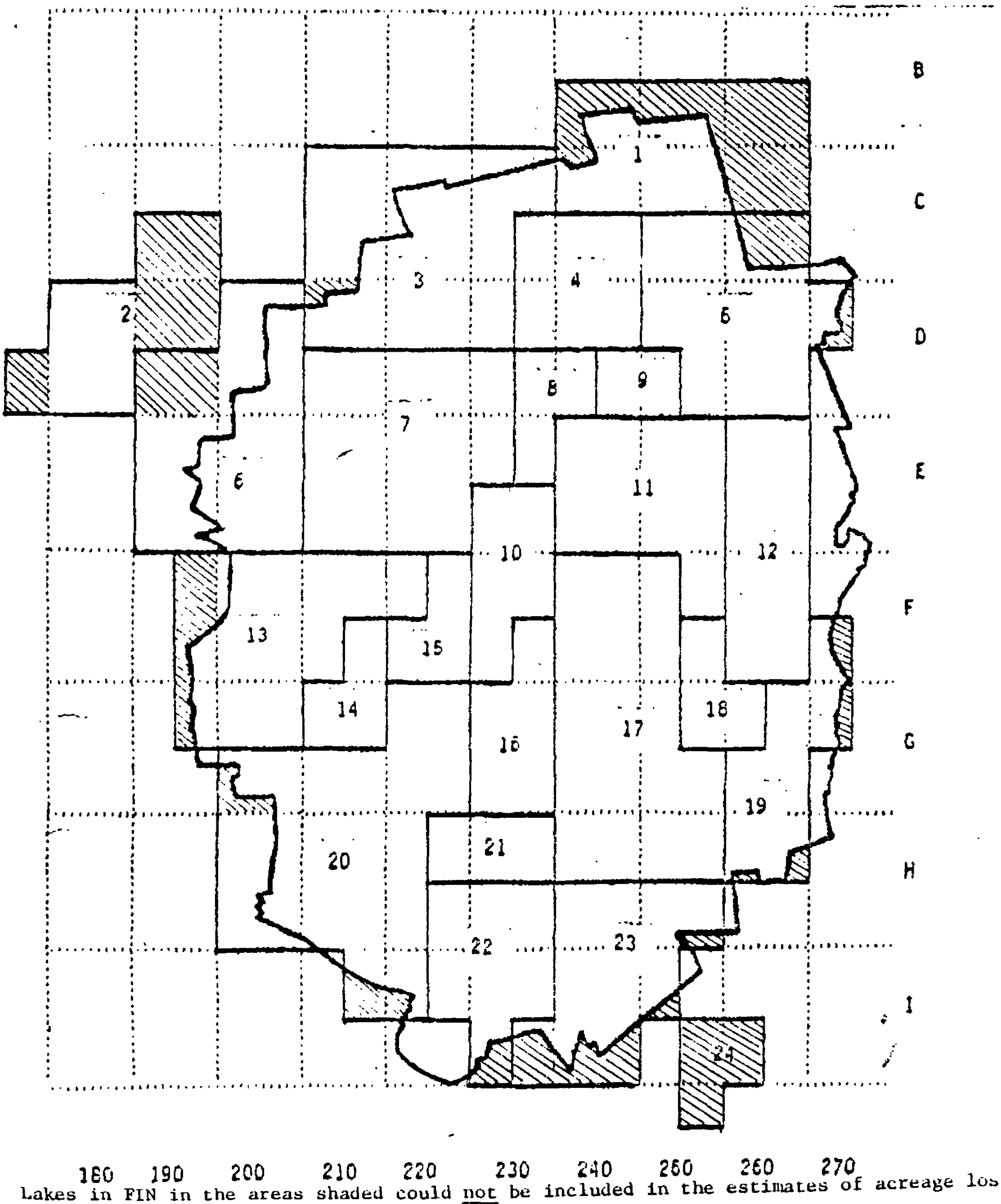
PRELIMINARY estimates of fishable 'acreage' lost in the Adirondacks as a result of acidification

	Total in Region		Estimates of 'Acreage' (km^2) lost			
			'Reasonable'		'High'	
Region+	Number of Lakes	Surface Area (km^2)	Total	%	Total	%
1	61	27.023	0	0	0	0
2	0	0	-	-	-	-
3	182	61.510	0.050	0.1*	2.634	4.3
4	130	22.595	0.500	2.2	7.225	32.0
5	66	28.126	0.013	<0.1*	0.013	<0.1*
6	131	7.008	0.371	5.3*	0.743	10.6*
7	331	145.445	0.309	0.2	12.473	8.6
8	105	16.591	0.174	1.0*	3.233	19.5
9	17	23.404	0.062	0.3*	0.062	0.3*
10	62	55.165	0	0	9.191	16.7
11	83	12.545	0.644	5.1	1.308	10.4
12	156	22.146	0.053	0.2	7.092	32.0
13	315	71.019	12.545	17.7	15.154	21.3
14	96	25.750	1.920	7.5	1.920	7.5
15	51	39.235	0.097	0.2*	0.097	0.2*
16	49	14.529	0.023	0.2*	0.398	2.7
17	199	36.319	0.171	0.5	1.225	3.4
18	58	30.654	0.351	1.1	0.557	3.3
19	45	4.654	0	0	0	0
20	308	62.679	7.527	12.0	17.376	27.7
21	45	27.265	0.158	0.6	2.021	7.4
22	121	17.411	3.523	20.2	4.927	28.3
23	84	125.790	0	0	0	0
24	0	0	-	-	-	-
TOTAL	2695	876.863	28.491	3.2%	87.649	10.0%

\+ Refer to attached figure

* Refer to letter for explanation

Mapping of Sites 1 through 24 Used in the Travel Cost Model
(Dotted lines are 15 minute quadrangles, solid lines are either site boundaries or the boundary to the Adirondack Ecological Zone)



Lakes in FIN in the areas shaded could not be included in the estimates of acreage lost because of the lack of information on 7½ minute quads.

classified into four strata based on lake area and elevation. These strata were originally designed for estimating the number of acidic lakes in the Adirondacks (Table 4, Baker and Harvey 1984). Again, because of time limitations we assumed that this stratification would also be appropriate for extrapolations regarding fish community status. We will check this assumption prior to providing final estimates.

Numbers in the table denoted by asteriks were, however, derived slightly differently. In all cases, procedures outlined above indicated zero acreage lost for these regions (i.e., no lakes in the sample with 'adequate' data had fish community status rated 3 to 5, or 2 to 5, as appropriate for the 'reasonable' estimate or 'high' estimate, respectively). In these regions, however, several lakes with no historical survey data and thus for which fish community status could not be rated, had current fish survey data suggesting a loss of fish populations as a result of acidification. Specifically, no fish, or only brown bullhead were caught but the habitat appeared suitable for brook trout and in some cases the lake had been stocked with brook trout in the years immediately preceeding the survey (coded 7 and 8). It was therefore presumed that the original estimate of zero acreage lost was too low. Instead, the estimates of percent acreage lost are based simply on the surface area of lakes coded 7 or 8 divided by the total area of lakes in the sample. These estimates were not adjusted by stratifying the sample by area and elevation due to time limitations. In all cases but one, the new estimates of acreage lost were quite small. For region 6, however, the surface area of lakes coded 7 or 8 represented 10.6% of the total surface area of the sample. Thus the 'reasonable' estimate of acreage lost was arbitrarily set at one-half of 10.6% (or 5.3%).

The table deserves one final note. Although the percentages of lake area impacted may be reasonably accurate, the surface area totals listed in the table are probably under-estimates. Lakes with surface area undefined in FIN (12% of the lakes in the Adirondack Ecological Zone) and lakes for which we could not identify the region in which they occurred (refer to the attached figure), could not be included in these totals.

I hope these numbers will be of some use. At the same time, please remember that these are preliminary estimates, to be used with caution. The problems and uncertainties associated with estimating the numbers of fish populations in the Adirondacks lost as a result of acidification are discussed in greater detail in Baker and Harvey (1984).

Sincerely,

Joan

Joan P. Baker
Aquatic Research Coordinator
NCSU Acid Deposition Program

JBP/rw

cc: John Malanchuk