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Effects of Reservoir Aquatic Plant Management on Recreational Expenditures and Regional Economic Activity

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ABSTRACT

Exotic aquatic plant management is a major concern for public reservoir management in many regions of the United States. A study was conducted to measure the effects of alternative aquatic plant management strategies on recreational expenditures and regional economic activity. The study area was Lake Guntersville, Alabama, and the local economy surrounding the lake. Lake Guntersville is one of the largest reservoirs in the Tennessee Valley Authority system. Results suggested that relatively moderate levels of aquatic plant control are associated with the highest levels of recreation-related economic effects on the economy surrounding Lake Guntersville.

Key Words: aquatic plants, input-output analysis, public reservoir management, recreational expenditures, regional economic activity.

Effects of spending by people engaged in recreational activities can have profound impacts on both local and regional economies. Quantifying these effects can be quite challenging. This study describes an analysis of the economic effects of recreational spending at Lake Guntersville, Alabama, under five different aquatic plant management scenarios. Lake Guntersville is located in northeastern Alabama approximately 30 miles southeast of Huntsville. It is one of the largest reservoirs in the Tennessee Valley Authority (TVA) system, with 67,900 surface acres and 949 miles of shoreline. Lake Guntersville has become renowned for its bass fishing opportunities as well as its support of myriad water-based activities.

The study was initiated by the TVA and U.S. Army Corps of Engineers (USACE) as a

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In this study, baseline use estimation results were produced primarily by Bergstrom, Cordell, Teasley, and Souter; economic impact results were produced primarily by Bergstrom, Cordell, Teasley, and English; and trip response model results were produced primarily by Bergstrom, Cordell, and Teasley. John Bergstrom and Ken Cordell, who served as principal investigators on this research, assume responsibility for any remaining errors and omissions.

result of high levels of exotic aquatic plant infestations in Lake Guntersville. High levels of aquatic plants result in increased problems associated with water-based recreation such as fouled boat propellers, swimming area closings, residential shoreline access problems, decreased skiing opportunities, and potential for large mosquito populations. However, aquatic plants also provide excellent fishing opportunities as well as excellent waterfowl habitats. Thus, there is a polarization of user group preferences with respect to plant coverage levels, which is of keen interest to the TVA and USACE from a management policy-making perspective.

Spinyleaf naid, Eurasian watermilfoil, and hydrilla were the species of exotic aquatic plants at issue in the study. Watermilfoil is the leader of the three in terms of coverage and has existed the longest in Lake Guntersville. The naid, least represented in amount of coverage, is also the least problematic of the exotic species. Hydrilla, though behind watermilfoil in coverage amount, represents the greatest potential problem of the three. Growth rates of hydrilla have been recorded at up to one inch per day under ideal growing conditions, which include low flow rates, clear water, and high sunlight levels. The plant has also been found growing at depths to 18 feet. The combination of high growth rate potential and ability to grow at considerable depth can pose difficulties for lake managers because of the inherent dangers to navigation.

The following analysis focuses on five different aquatic plant coverage management alternatives and two specific user group classifications: fishers and nonfishers. These user classifications were chosen to represent the Lake Guntersville recreationists for two reasons. First, the TVA felt this user division to be important from a management standpoint, and second, the two groups represented the polarity extremes on the issue of how much aquatic plant coverage should be managed for in the reservoir.

Key background concepts related to economic impacts are discussed first, followed by a description of the study area and surveys used to collect data. Because reservoir use (number of respondent trips to the reservoir) was an integral part of the analysis, a brief explanation of how use was estimated is presented, along with a discussion of the procedure for estimating use across management alternatives. Next, expenditure profiles for respondent groups are provided, as well as identification of the impacts to the local economy. Finally, implications drawn from the results of the analysis are discussed.

Background Concepts

Calculation of the economic impacts of recreation involves the estimation of the direct, indirect, induced, and total effects of increases in visitor expenditures. These effects were estimated with IMPLAN[1] through the application of input-output analysis. Because of the importance of these concepts, direct, indirect, and induced effects are reviewed in this section.

Firms in a regional economy are economically interdependent. This interdependency takes the form of intermediate purchases of goods and services which are needed for the provision of other goods and services for final delivery to consumers. Consider a regional economy surrounding a reservoir such as Lake Guntersville. Suppose increased recreational visits to the region by people outside the region cause demand for lake resort goods and services to increase. The resort must purchase increased inputs from other businesses to meet this increased demand. For example, in order to provide more meals to visitors, the resort would need to purchase more food from businesses in the food production and distribution sectors. To increase output, businesses in the food production and distribution sectors would have to purchase more inputs from their suppliers. These purchases, in turn, would result in even more economic activity since the suppliers of inputs to the food production and distribution sectors would be required to increase their purchases of inputs. These additional in-

[1] IMPLAN refers to the input-output data base and modeling system developed by the U.S. Forest Service (Alward et al.).

direct purchases are the indirect effects of the increase in demand for resort goods and services.

The direct and indirect effects of the increase in demand for resort goods and services can result in an overall increase in the production of goods and services in the regional economy. Such an increase in economic activity results in increased employment and household income. With the increase in household income, consumer demand for all types of goods and services could be expected to increase. This increase in consumer demand would stimulate further purchases of inputs in the regional economy. These purchases, which result from increased consumer expenditures, are the induced effects of the original increase in demand for resort goods and services. Input-output analysis in general, and IMPLAN in particular, measures the total economic impact on the region of a net increase in consumer demand for goods and services produced by businesses within the region (Alward et al.; Miller and Blair; Palmer and Siverts).

Data Collection

Baseline Visitation Survey

Because of the large size of the reservoir and the complex nature of the study, an intensive sampling plan was developed to capture users of Lake Guntersville. Data were collected from the summer of 1990 through the spring of 1991 at over 80 interviewing sites along the 949 shoreline miles of the lake. Sites included boat ramps, campgrounds, beach and picnic areas, marinas, and dispersed use areas. Users were approached by interview teams at these areas and were asked to participate in a 20- to 30-minute-long survey which collected socioeconomic, trip, preference, and demographic information. A total of approximately 1,800 surveys were conducted.

In addition to the long survey, a shorter (five-minute) survey was also developed and implemented for a separate group of respondents. As designed, no overlap could have occurred between the two survey groups. Respondents were asked in the screening questions of both surveys whether they had been interviewed previously be one of our interviewers. Because use was estimated using specific items from the short survey, traffic counts, and long survey, potential for "double-counting" was nullified. The short survey gathered limited use and activity information as well as axle count information to be used in conjunction with traffic counts obtained at access sites around the reservoir. Approximately 2,200 of these short surveys were conducted.

A team comprised of 12 interviewing couples was used for the data collection effort. These couples were hired through Bicentennial Volunteers, Inc., a retiree organization consisting mostly of former TVA workers. Interviewers participated in an intensive university-conducted survey training session in order to ensure quality and consistency across interview procedures.

Management Assessment Survey

A mail survey was conducted to collect data on expected visitation responses to changes in aquatic plant management at Lake Guntersville. This survey was mailed to all visitors contacted on-site during the Baseline Visitation Survey. The survey questionnaire presented respondents with five different management alternatives which were selected in cooperation with TVA and U.S. Army Corps of Engineers scientists and reservoir managers. The first alternative was a "minimum-control" scenario where aquatic plant coverage would be allowed to expand to its biological maximum under ideal growing conditions. This biological maximum was estimated to be about 34,000 acres of plant coverage (or about 50% of the lake). The four remaining management alternative scenarios were designated as A, B, C, and D. Management alternative A would reduce plant coverage to about 20,200 acres (or approximately 30% of the lake). Alternative B would reduce plant coverage to about 14,200 acres (or about 20% of the lake). Alternative C would reduce plant coverage to about 8,000 acres (or approximately 10% of the lake). The final scenario, alternative D, would reduce aquatic plant coverage to near zero.

Written descriptive information, combined with full-color pictures, was used to describe the management alternatives in the questionnaire. The questionnaire also contained a brief description of the potential positive and negative effects of aquatic plants in the lake. It is difficult to determine objectively how much information lake visitors need in order to develop accurate perceptions of the amount, distribution, and potential effects of aquatic plants. Given that we sampled visitors who as a group have been coming to Lake Guntersville for a relatively long period of time (many for a decade or more), we believe that the questionnaire contained adequate information for respondents to develop accurate perceptions of the nature and effects of the five management alternatives. Pretests of the survey instrument and written feedback from respondents to the actual survey suggest that the nature and effects of the management alternatives presented were well understood by respondents.

The questionnaire first asked respondents several questions designed to identify their preference for aquatic plants, their usual activity on the lake, and how familiar they were with aquatic plants on the lake. Then, after describing a management alternative, the questionnaire asked visitors to state the number of annual trips they would take to Lake Guntersville for outdoor recreation under each management alternative assuming trip costs would remain at current rates. After completing all five management scenario questions, the respondents were asked demographic and socioeconomic questions.

A sample size of 3,224 was obtained for this survey through both long and short on-site survey efforts. Following general mail survey procedures outlined by Dillman, an explanatory cover letter, questionnaire, and postage-paid return envelope were sent to each person in the sample. One week after the initial mailing, a postcard reminder was mailed to all individuals in the sample. Two weeks after mailing the postcards, another cover letter, questionnaire, and postage-paid return envelope were sent to nonrespondents. The final response rate for the Management Assessment Survey was 50%.

Expenditure Survey

Recreation trip expenditure data were collected via a mail-in survey handed to respondents after the long survey was completed. The Expenditure Survey instrument was organized into two parts. The first collected recreation equipment expenditures on an annual basis; the second collected trip expenses from the users for the trip to the actual site on which they were interviewed. Each of the sections was grouped according to major types of expenses (e.g., expenses for boat equipment, fishing equipment, off-road vehicle, food, and clothing). Each major expenditure section was then further detailed by requesting specific information concerning the major type of expense (e.g., boat trailer tires, boat accessories, rods and reels, drinks, processed food, shoes, and apparel).

After being handed the Expenditure Survey, respondents were asked to complete the questionnaire once they arrived home and return it in the self-addressed, postage-paid envelope included in the package. The follow-up process involving a postcard reminder and follow-up cover letter with a replacement questionnaire paralleled the Management Assessment Survey procedures and schedule. A total of 695 Expenditure Surveys were finally collected, representing a 39.8% return rate. Of the 695 surveys received, 673 were filled out sufficiently to allow their use in the estimation procedures.

Data Analysis

Baseline Visits

Baseline use was calculated from three basic sources: (*a*) on-site long survey data, (*b*) on-site short survey data, and (*c*) traffic count data. The long survey collected length of stay, group makeup, and activity information; the short survey collected number in group, axle count, and length of stay information; and traffic count data were collected via pneumatic

Table 1. "Baseline" Use at Formal Sites, Lake Guntersville Economic Impact Study

User Group	Total On-Site Visits	Confidence Interval (90%)	% of Total Visits
Fishers	976,508	±24.33%	34
Nonfishers	1,868,209	±43.74%	66
All Users	2,844,717	±29.63%	100

traffic counters set at the specific interviewing points around the reservoir.

A stratified random sampling process was used to estimate total use. A brief description of the estimation process is provided in this section. A more detailed description is found in the final report for this project submitted to the Tennessee Valley Authority and U.S. Army Corps of Engineers (Bergstrom et al.).[2] Background information on stratified random sampling estimators can be found in most standard statistics textbooks (e.g., Snedecor and Cochran).

A total of 54 strata were included in the stratified random sampling effort. Strata were defined by: season of the year (3), type of day in the week (2), type of site (3), and geographical zone (3). The stratified random sampling effort involved two sampling stages (Snedecor and Cochran, pp. 528–34). In the first stage, site/day combinations for each stratum were selected by simple random sampling without replacement. Each site/day combination or first-stage sampling unit represented a *cluster* of vehicles. The second-stage sampling consisted of randomly selecting vehicles for interviewing out of all the vehicles available in a given cluster of vehicles (site/day combination). The second-stage sampling units were therefore *individual* vehicles. Total use in each stratum was estimated by the following equation:

$$(1) \qquad \hat{Y}_h = \frac{N_h}{n_h} \sum_{i=1}^{n_h} M_{ih} \bar{y}_{\cdot ih} = \frac{N_h}{n_h} \sum_{i=1}^{n_h} \hat{Y}_{ih},$$

where the terms are defined as follows:

$\hat{Y}_h$ = estimate of the total in stratum h;
N_h = total number of site/day combinations (clusters) in stratum h;
n_h = number of clusters actually sampled in stratum h;
M_{ih} = total number of vehicles counted in the ith cluster sampled in stratum h;
m_{ih} = number of vehicles sampled in the ith cluster sampled in stratum h;
$\bar{y}_{\cdot ih}$ = the mean, $\sum_{j=1}^{m_{ih}} y_{jih} \div m_{ih}$, of the attribute of interest for the vehicles sampled at the ith cluster sampled in stratum h; and
$\hat{Y}_{ih}$ = the estimate of the ith cluster total sampled in stratum h.

The number of vehicles occurring at the sampled site/day combinations within each stratum [M_{ih} in equation (1)] was determined by complete vehicle counts using pneumatic traffic counters. Using the long and short surveys, data were collected from vehicles sampled at a given site/day combination. These data were used to estimate mean use per vehicle [$\bar{y}_{\cdot ih}$ in equation (1)]. Total use per strata was then estimated according to the formula given by equation (1). Finally, by summing across individual strata, total use for the reservoir was found (see table 1). Use estimates are given with confidence intervals calculated at 90% with specified bounds (e.g., for the fishers user group, 90% ± 24.33%).

Change in Baseline Visits Under Management Alternatives

In order to estimate economic impacts under each management alternative, estimates of total recreation visits under each management alternative are needed. As mentioned previously, the Management Assessment Survey asked respondents to state the number of annual trips they would take to Lake Guntersville under each management alternative assuming trip costs remained constant. This

[2] Because of space limitations, details on many aspects of this study are not discussed in this article. Readers interested in these details should refer to the final contract report for this study, copies of which are available from the authors upon request.

question format is an application of the intended visitation method, or trip response method (TRM). The TRM is used to estimate changes in visitation in response to changes in trip characteristics or factors (such as a change in site quality or trip costs) by directly asking visitors to state the number of trips they would take to a recreation site under given conditions (Loomis; Ward; Teasley, Bergstrom, and Cordell). In this study, the TRM question was designed to collect data for estimating a regression equation which can be used to estimate changes in trips to Lake Guntersville based on changes in aquatic plant management.[3]

The regression equation estimated from the TRM data was specified generally as follows:

$$(2)\quad TRIPS = f(DIST, PLNLIKE, NUMPEEP, BINCOME, RURAL, SEX, RESIDENT, AGE, M1, M2, M3, M4),$$

where *TRIPS* is the natural log of the number of intended trips given a specific plant coverage level; *DIST* is the distance from the respondent's home to Lake Guntersville; *PLNLIKE* is how much aquatic plant coverage respondents would like to see (with 1 denoting a small amount, 5 a large amount); *NUMPEEP* is number of people in household; *BINCOME* is the household income; *RURAL* is a dummy variable representing whether or not the respondent's household was located in a rural or urban area; *SEX* is the gender of the respondent; *RESIDENT* denotes whether or not the respondent lives on the lake (also a dummy variable); *AGE* is respondent's age; and *M*1–*M*4 are dummy variables representing the different management alternatives as defined in table 2.

From a theoretical perspective, the specification of equation (2) is similar to a standard travel cost method demand function with one primary exception. As a revealed preference technique, the dependent variable in standard individual travel cost method demand functions is a person's actual number of trips to a recreation site. In equation (2), the dependent variable is a person's *intended* or planned number of trips to a recreation site. Thus, the trip response method is a type of *stated preference* technique.

Stated preference techniques, which include the widely applied contingent valuation method, rely on stated or intended behavioral data rather than actual behavioral data to analyze economic preferences. Economists generally prefer to rely on actual behavioral data for such analyses. However, when faced with the need to evaluate alternative policy and management scenarios, actual behavioral data are not always available. For example, data on actual recreational trips taken to Lake Guntersville under alternative plant coverage scenarios do not exist. In such a situation, the trip response method provides a means for esti-

Table 2. Description of Aquatic Plant Management Dummy Variables and Alternatives, Lake Guntersville Economic Impact Study

Dummy Variables	Management Alternatives
$M1 = 0$ $M2 = 0$ $M3 = 0$ $M4 = 0$	*Minimum-Control Alternative:* 34,000 acres of aquatic plants, or approximately 50% of the total lake surface area
$M1 = 1$ $M2 = 0$ $M3 = 0$ $M4 = 0$	*Alternative A:* 20,200 acres of aquatic plants, or approximately 30% of the total lake surface area
$M1 = 0$ $M2 = 1$ $M3 = 0$ $M4 = 0$	*Alternative B:* 14,200 acres of aquatic plants, or approximately 20% of the total lake surface area
$M1 = 0$ $M2 = 0$ $M3 = 1$ $M4 = 0$	*Alternative C:* 8,000 acres of aquatic plants, or approximately 10% of the total lake surface area
$M1 = 0$ $M2 = 0$ $M3 = 0$ $M4 = 1$	*Alternative D:* Zero acres of aquatic plants, or 0% of the total lake surface area

[3] A copy of the survey questionnaire is available from the authors upon request.

mating a recreation demand function, as illustrated by equation (2).

In addition to a price or cost variable (*DIST*), equation (2) contains other demand function variables suggested by standard neoclassical economic theory and previous travel cost method studies (Walsh; Ward and Loomis). These variables include a budget constraint or income indicator (*BINCOME*), indicators of recreation site quality (*M*1, *M*2, *M*3, *M*4), and indicators of the direction and intensity of recreation tastes and preferences (*PLNLIKE, NUMPEEP, RURAL, SEX, RESIDENT, AGE*).

Respondents to the Management Assessment Survey only represented current participants in outdoor recreation at Lake Guntersville. Changes in aquatic plant management, however, may induce nonparticipants to become participants. To adjust for potential changes in trip behavior on the part of nonparticipants, the TRM equation [equation (2)] was estimated using TOBIT. TOBIT is a special case of the Heckman Selection Model. Both models fall into the general category of self-selection models (Kennedy, pp. 228–46). TOBIT is more restrictive than the general Heckman Selection Model in that it assumes the same variables affect both the decision of whether to become a participant or not (the participation decision) and the decision of how many trips to take once an individual becomes a participant (the frequency decision) (Bockstael et al.; Kennedy, pp. 238–41). It also implicitly assumes that the behavior of participants and nonparticipants with respect to these variables is similar.

In this study, an individual's participation decision is a discrete choice between becoming or not becoming a consumer of recreation at Lake Guntersville, i.e., "entering the market." This participation decision can be conceptualized using the recreation demand function specified in equation (2). Basically, holding all other variables constant, an individual will "enter the market" or become a consumer of recreation at Lake Guntersville if his or her "reservation distance" or "choke price" for trips is at or below the distance s/he must travel to the lake [*DIST* in equation (2)].

Suppose person A's reservation distance is 200 one-way miles and s/he lives 250 miles from the lake. Person A will therefore be a nonparticipant or nonconsumer of recreation at Lake Guntersville. Now, suppose a change in aquatic plant management [indicated by variables *M*1–*M*4 in equation (2)] improves the quality of recreation at Lake Guntersville in the eyes of person A. This perceived quality improvement will shift out person A's demand function for trips, say to the point where his or her reservation distance (*y*-intercept) increases to 250 miles. Person A will now become a participant or consumer of recreation at Lake Guntersville.

In sum, because an individual's participation decision is fundamentally determined by demand factors, the variables in equation (2) can be used to explain this decision. Once an individual "enters the market" or becomes a participant, the frequency of trips selected is also a function of the demand factors specified in equation (2). Moreover, there do not appear to be any strong conceptual reasons for suspecting that the participation and frequency decisions in this study are affected by different demand factors.

Using the Heckman Selection Model, the participation and frequency decisions could be estimated using separate equations in a two-step estimation process. However, because of the common explanatory variables across equations, this two-step estimation process would likely introduce serious multicollinearity problems. The TOBIT model avoids these multicollinearity problems by accounting for the participation and frequency decisions in the same equation (Bockstael et al.; Kennedy, pp. 238–41). On the practical side, to estimate the Heckman Selection Model, primary data must be collected on nonparticipants as well as participants (Bockstael et al.; Fletcher, Adamowicz, and Graham-Tomasi). Our data collection budget did not allow for expansion of the sampling frame for the Management Response Survey to all relevant nonparticipants, which (at a minimum) might include all households located in the southeastern U.S.

The TOBIT estimation results for the TRM equation are presented in table 3. Table 3 shows the estimation results of the procedure

Table 3. Estimation Results for Trip Response Model, Lake Guntersville Economic Impact Study

Independent Variables	Parameter Estimates (Standard Errors)	
	Fishers	Nonfishers
PLNLIKE	.1204***	.2002***
	(.0279)	(.0333)
NUMPEEP	.0555***	.0384
	(.021)	(.0260)
BINCOME	.000003***	.000003***
	(.0000008)	(.0000008)
RURAL	−.0116	.1463**
	(.0552)	(.0681)
DIST	−.0045***	−.0033***
	(.0003)	(.0004)
SEX	.3341***	−.3511***
	(.1021)	(.0788)
RESIDENT	.8936***	.9329***
	(.072)	(.0824)
AGE	.0072***	−.0071***
	(.0017)	(.0023)
SUBST	.0003***	.0002***
	(.00002)	(.00002)
*M*1	.1163	.5156***
	(.0784)	(.1007)
*M*2	−.1402*	.7233***
	(.0785)	(.1006)
*M*3	−.5214***	.7803***
	(.0788)	(.1006)
*M*4	−1.2378***	.7145***
	(.0798)	(.1007)
	N = 3,420	N = 2,005
	R^2 = .224	R^2 = .182

Note: Single, double, and triple asterisks (*) denote significance at the .10, .05, and .01 levels, respectively.

for both the fisher and nonfisher groups. Most variables in both models have statistically significant coefficient estimates with signs consistent with standard neoclassical demand theory expectations and previous recreation demand studies. The R^2 values were .224 and .182 for the fisher and nonfisher models, respectively. These R^2 values are very consistent with those for estimated individual recreation demand functions observed in previous studies (Walsh, Johnson, and McKean).

Of particular interest are the signs on the management alternative variables. Based on discussions with Lake Guntersville managers familiar with recreation users of the lake, we hypothesized that fishers would more highly value greater amounts of aquatic plant coverage and nonfishers would more highly value smaller amounts of aquatic plant coverage. Our empirical results generally support these expectations. As compared to the minimum-control alternative (50% coverage), nonfishers appear to favor lower amounts of aquatic plants (signs are positive for all management alternatives). Conversely, as compared to the minimum-control alternative, fishers appear to object to decreases in aquatic plant coverage (signs are negative for all statistically significant management alternative coefficients).[4]

The total number of baseline trips, as noted previously, was calculated using actual trip sampling data and equation (1). This number was assumed to represent total trips under management alternative C because aquatic plant coverage depicted by this alternative most closely matched that which was experienced during the year of our surveying (1991). To calculate the total number of expected trips under the minimum-control alternative and management alternatives A, B, and D, we first used the estimated trip response model to estimate the expected percentage changes in visits from management alternative C to each of the other management alternatives. These percentages were then multiplied by the total number of baseline trips to estimate total visits under each management alternative. The results of these calculations are shown in table 4.[5]

[4] Because of the similar magnitudes of the management alternative coefficient estimates, comparisons between management alternatives should be viewed cautiously—especially between those alternatives which are closest to each other in terms of coverage (e.g., alternatives B versus C, alternatives C versus D, etc.).

[5] Readers are cautioned that in this study for the economic impact work, the trip response model was used only to calculate percentage changes in trips across management alternatives. Applications of this model as a trip quantity estimator model (e.g., as in benefits transfer applications) should follow procedures for evaluating nonlinear models discussed by Souter and Bowker.

Table 4. Estimated Number of Visits by User Group and Management Alternative, Lake Guntersville Economic Impact Study

	Management Alternatives				
User Group	Minimum-Control	Alt. A	Alt. B	Alt. C	Alt. D
Fishers	1,644,440.26	1,847,554.03	1,429,608.40	976,508.47	476,536.13
Nonfishers	855,640.03	1,434,785.03	1,765,458.14	1,868,209.67	1,750,512.46

Because fishers generally appear to prefer more to fewer plants, visitation from this group displays a downward trend as plant coverage levels decrease. Nonfishers have a mirror-image visitation trend of the fishers. Because nonfishers generally appear to prefer less coverage, visitation from this group displays an upward trend as plant coverage levels decrease.

Economic Impacts

Lake Guntersville lies in Alabama's Marshall and Jackson counties.[6] In cooperation with the TVA and U.S. Army Corps of Engineers, the local impact region for this study was defined as the two counties in which the lake resides and those counties contiguous to them. The resulting 11-county impact region reached into three states: Alabama, Georgia, and Tennessee. The 11 counties are shown in table 5. A primary objective of the economic impact analysis was to estimate the contribution of recreational expenditures associated with Lake Guntersville visitation under the five management alternatives to the impact region economy.

The economic impact analysis only considered expenditures by nonlocal visitors, defined as visitors who live outside of the impact region. Expenditures by nonlocal visitors bring "new" dollars into a local economy and stimulate economic activity as suggested by export base theory; i.e., recreational services, in essence, are being "exported" (Alward et al.; English and Bergstrom; Miller and Blair; Palmer and Siverts). Thus, impacts in an economy attributable to recreation are traceable to spending by these visitors for recreation and related services. The first step in the process for estimating economic impact was to develop trip expenditure profiles from the Expenditure Survey data.

Mean expenditures per trip for fishers who live outside of the impact region (nonlocal fishers) and nonfishers who live outside of the impact region (nonlocal nonfishers) are shown in table 6. A general expenditure pattern observed was that fishers and boaters spent more than those who did not fish or boat. This finding was expected, as operating and traveling with the equipment needed to boat and/or fish requires more expense than activities other than boating or fishing.

All trip-related expenses made on-site were assumed to occur in the impact area. Expenditures made at home by visitors who live out-

[6] A small "riverine" portion of Lake Guntersville extends into a part of Marion County, Tennessee.

Table 5. Counties Used in Impact Analysis, Lake Guntersville Economic Impact Study

State	County	Population (000s)	Area (sq. miles)
Alabama	Blount	39.2	646
	Cullman	67.6	738
	De Kalb	54.7	778
	Etowah	99.8	535
	Jackson	47.8	1,079
	Madison	238.9	805
	Marshall	70.8	567
	Morgan	100.0	582
Georgia	Dade	13.1	174
Tennessee	Franklin	34.7	553
	Marion	24.9	500
Total		791.7*	6,957

* Column does not sum to total due to rounding errors.

Table 6. Mean Trip Expenses of Users, 11-County Impact Region, Lake Guntersville Economic Impact Study

	User Type	
Expense Category	Nonlocal Fishers ($)	Nonlocal Nonfishers ($)
Lodging	52.88	8.33
Food	43.21	58.90
Transportation	77.27	67.30
Activities	4.85	4.95
Miscellaneous	6.90	22.12
Total	185.11	161.60

Note: Reported dollar amounts are on a per person, per trip basis, in 1990 dollars.

Table 7. Mean Equipment Expenditures of Users, 11-County Impact Region, Lake Guntersville Economic Impact Study

	User Type	
Expense Category	Nonlocal Fishers ($)	Nonlocal Nonfishers ($)
Motor Boat	43.16	78.61
Other Boats	0.06	2.86
Skiing	0.30	0
Camping Vehicles	5.14	2.51
Backpacking	0.41	0.18
Fishing	20.46	3.14
Bicycles	0	0.36
Motor Bike	0	0
Off-Road Vehicles	0.68	0
Hunting	2.98	0.02
All Other Equipment	0.51	0.06
Total	73.70	87.74

Note: Reported dollar amounts are on a per person, per trip basis, in 1990 dollars.

side of the impact region were assumed to have no effects on economic activities within the impact region and were therefore deleted. En route expenses were attributed to the impact area according to the percentage of the respondent's travel within the impact area. This percentage was determined by computing the proportion of straight-line distance from the respondent's home to the lake represented by the amount of that straight-line distance that lay within the impact area.

Annual equipment expenditures attributable to an impact area were estimated in the following manner. First, if the respondent came from outside the impact region, all home expenses were deleted. Remaining expenditures were divided by the number of times the respondent reported s/he had visited the interview site or area with the equipment; thus, the annual dollar amount was used to determine expenses on a per trip basis. Mean expenditures per trip were then divided by the reported number of persons whose expenses the respondent paid; this provided an average expenditure profile per person per trip.[7] The resulting statistics of this process are detailed in table 7.

The final step required to prepare the expenditure profiles for IMPLAN analysis was to allocate the expenditures of lake users, by item, across economic sectors to derive final demand effects by sector. The procedures involved using national annual personal consumption expenditure (PCE)[8] data prepared by the USDA Bureau of Economic Analysis (BEA) to develop percentage allocations for each of the appropriate sectors for each expenditure item (Watson and Brachter).

The expenditures made by visitors for recreation-related items are allocated to specific economic sectors, including those representing the primary manufacture of the goods purchased. Basically, the process is to divide up the consumer's purchase price into components to be allocated among the economic sectors responsible for providing the product to the consumer. For example, if a recreationist

[7] The procedure for allocating equipment expenditures follows standard routines developed by the U.S. Forest Service and other cooperators. Under some circumstances, this procedure could lead to an upward bias in regional economic impact estimates (English and Bergstrom). More research is needed to determine how best to estimate the regional economic effects of annual recreation equipment expenditures.

[8] Personal consumption expenditures (PCEs) are the total purchases by the residences (households) of a region from each producing sector. These purchases may come from sectors inside the region, and as such are part of final demand.

Table 8. Total Gross Output Due to Nonlocal Users' Recreational Visits to Lake Guntersville, Under Different Management Alternatives (mil. 1990 $)

	Total Gross Output, Economic Impact by Management Alternative				
User Group	Minimum-Control	Alt. A	Alt. B	Alt. C	Alt. D
Fishers	75.61	84.95	65.73	44.90	21.91
Nonfishers	48.91	82.01	100.91	106.78	100.05
Total	124.52	166.96	166.64	151.68	121.96

were to buy a loaf of bread to make sandwiches for a fishing trip, a portion of the purchase price of that loaf would be assigned to the farmer who grew the wheat to make the flour to make the bread. Another portion would be allocated to the processing plant that made the loaf, another would be due the shipping company that delivered the loaf, and so on, down to the profit the store places on the loaf prior to sale. Many economic sectors are involved in the process of bringing commodities to consumers. A computer program was designed to allocate purchase price to different economic sectors, since there are over 500 IMPLAN economic sectors that potentially could be affected by recreation expenditures. This allocation method was designed for compatibility with the economic sector definitions in the IMPLAN model.

Economic impacts from recreational expenditures are determined by total expenditures defined as the product of total visits and expenditures per visit. For the economic impact analysis, total visits by nonlocals were calculated by multiplying the total use estimates under each management alternative by the proportion of total visits which represent visits from nonlocals[9] (fishers = 25.7%, nonfishers = 27.4%). Total visits by nonlocals were then multiplied by expenditures per trip for nonlocals to estimate total expenditures from nonlocals. These total expenditure estimates were used with the IMPLAN model to estimate regional economic impacts of nonlocal recreational spending.

Table 9. Total Income Due to Nonlocal Users' Recreational Visits to Lake Guntersville, Under Different Management Alternatives (mil. 1990 $)

	Total Income, Economic Impact by Management Alternative				
User Group	Minimum-Control	Alt. A	Alt. B	Alt. C	Alt. D
Fishers	41.25	46.34	35.86	24.49	11.95
Nonfishers	26.56	44.54	54.81	58.00	54.34
Total	67.81	90.88	90.67	82.49	66.29

Economic Impact Results

Economic impact results are reported for total gross output, total income, and total employment categories. Total gross output is the sum of all annual industry sales, or the annual value of outputs produced by industries in an economy. Total income is the sum of employee compensation (wages and salaries paid to employees of industries in an economy) and property income. Property income is defined as profits, rents, and royalties paid to owners of property and firms that are engaged in the production of outputs in an economy (Palmer and Siverts). Estimated economic impacts (total effects) include the direct, indirect, and induced effects of recreational spending. IMPLAN results for the marginal contribution of lake-related recreational expenditures are presented in tables 8, 9, and 10.

Based on the findings of this study, the greatest economic impacts are estimated to result from management alternatives A and B.

[9] The proportion of nonlocal visitation was estimated from the on-site visitation survey data. It is assumed that this proportion remains constant across management alternatives. This assumption can be tested and perhaps relaxed in future studies.

Table 10. Total Employment Due to Nonlocal Users' Recreational Visits to Lake Guntersville, Under Different Management Alternatives

	Total Employment (Number of Jobs) by Management Alternative				
User Group	Minimum-Control	Alt. A	Alt. B	Alt. C	Alt. D
Fishers	1,948	2,189	1,694	1,157	565
Nonfishers	1,289	2,162	2,661	2,815	2,638
Total	3,237	4,351	4,355	3,972	3,203

Both of these alternatives would result in about $160 million worth of total gross output being added to the 11-county local region surrounding Lake Guntersville. The smallest economic impacts are estimated to result from the minimum-control alternative and management alternative D. These alternatives would result in the addition of about $120 million worth of total gross output to the 11-county region surrounding Lake Guntersville. Management alternative C would contribute about $150 million worth of total gross output to the region.[10]

The economic impact estimates provide a measure of the additional economic activity (e.g., output, income, jobs) in a regional economy that is directly attributable to Lake Guntersville. If reservoir management or changes in visitation patterns result in a reallocation of trips by nonresidents away from Lake Guntersville, the resulting decrease in recreation expenditures and economic activity would represent a loss to the local economy surrounding the lake. Alternatively, if reservoir management or changes in visitation patterns stimulate increased trips by nonresidents to Lake Guntersville, the resulting increase in recreation expenditures and economy activity would represent a gain to the local economy.

The economic impact results reported in this study are subject to several important caveats and limitations. First, it is assumed that residents of the 11-county impact region do not change their allocation of recreational expenditures outside of the impact region as a result of aquatic plant management changes at Lake Guntersville. If residents do change this allocation, then our results could be biased upwards or downwards depending on whether the management changes induce residents to increase or decrease expenditures outside of the impact region. It is also assumed that nonresidents of the 11-county impact region do not reallocate a portion of their recreational expenditures to other sites within the impact region as a result of management changes at Lake Guntersville. If such reallocation does occur, our estimates of the economic impacts of aquatic plant management at Lake Guntersville could be biased upwards or downwards depending on whether management changes induce nonresidents to increase or decrease expenditures at other sites within the impact region. We also assume that changes in aquatic plant management at Lake Guntersville do not induce residents and nonresidents to reallocate expenditures between recreational and nonrecreational commodities and services. Such reallocation, if it occurs, could also bias our results upwards or downwards depending on whether management changes induce residents and nonresidents to decrease or increase per trip recreational expenditures.

We suggest that future studies relax the above assumptions and include an analysis of whether management changes at a particular site within the impact region cause residents and nonresidents to (*a*) reallocate total expenditures between recreation and nonrecreation, and (*b*) reallocate recreational expenditures between sites within and outside of the local impact region.

Conclusions

Management of nonnative aquatic plants in public reservoirs is of considerable interest

[10] Because of the lack of formal statistical tests, comparisons of economic impacts across management alternatives should be viewed with caution. Further research is needed to develop techniques for estimating confidence intervals around economic impact results generated by input-output models so that formal statistical comparisons of impact results across different policy or management alternatives of interest can be conducted.

and concern in the U.S., particularly in the Southeast. In the absence of control efforts, nonnative aquatic plant coverage can rapidly expand in a reservoir. For example, in Lake Guntersville, nonnative aquatic plant coverage reached a high of approximately 30% of total reservoir acreage in 1988, in spite of heavy control efforts. Large amounts of nonnative aquatic plant coverage can have both negative and positive effects on reservoir uses and services. Negative effects include clogging water intake pipes, restricting commercial navigation, restricting access to boat docks and boat launching areas, promoting mosquito production, and interfering with certain recreational activities (e.g., recreational boating, water skiing, and swimming). Positive effects of aquatic plants include provision of food, cover, and oxygen for waterfowl, fish, and other wildlife species, and enhancement of certain recreational activities (e.g., fishing, waterfowl hunting, and wildlife observation).

This study estimated economic impacts associated with recreational spending under five aquatic plant management alternatives at Lake Guntersville, Alabama. Results suggest that there may be large economic impacts associated with differing levels of aquatic plants in reservoirs. Because large reservoirs such as Lake Guntersville support varied recreational activities that are significantly affected in different ways by aquatic plants, plant management strategies could have potentially large effects on local economies. Economic impact information, such as that presented here, is an important input into the management decision-making processes, as indicated by the demand for such information by natural resource managers, local business operators, and other decision makers.

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