



**US Army Corps
of Engineers**

Hydrologic Engineering Center

An Investigation of the Determinants of Reservoir Recreation Use and Demand: The Effect of Water Surface Elevation

November 1972

REPORT DOCUMENTATION PAGE

Form Approved OMB No. 0704-0188

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1. REPORT DATE (DD-MM-YYYY) November 1972		2. REPORT TYPE Research Document		3. DATES COVERED (From - To)	
4. TITLE AND SUBTITLE An Investigation of the Determinants of Reservoir Recreation Use and Demand: The Effect of Water Surface Elevation				5a. CONTRACT NUMBER	
				5b. GRANT NUMBER	
				5c. PROGRAM ELEMENT NUMBER	
				5d. PROJECT NUMBER	
6. AUTHOR(S) William D. Carson, Jr. Department of Economics University of California, Davis Davis, CA 95616				5e. TASK NUMBER	
				5f. WORK UNIT NUMBER	
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) US Army Corps of Engineers Institute for Water Resources Hydrologic Engineering Center (HEC) 609 Second Street Davis, CA 95616-4687				8. PERFORMING ORGANIZATION REPORT NUMBER RD-2	
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)				10. SPONSOR/ MONITOR'S ACRONYM(S)	
				11. SPONSOR/ MONITOR'S REPORT NUMBER(S)	
12. DISTRIBUTION / AVAILABILITY STATEMENT Approved for public release; distribution is unlimited.					
13. SUPPLEMENTARY NOTES .					
14. ABSTRACT This research report summarizes the results of an analysis of recreation use data from five reservoirs in the Little Rock District of the US Army Corps of Engineers. The purposes of the study were: first to determine the effects of certain reservoir operating characteristics on the volume of recreation use and benefits; and second, to relate these results to more conventional analysis of recreation use based mainly on socioeconomic variables. In addition, the study suggests ways that the analysis of recreation use can be applied to benefit estimation for proposed projects. The investigation of relationships between certain operating characteristics of reservoirs and their use for recreation succeeded in finding no quantifiable or empirically relevant relationship except in the case of Greers Ferry Reservoir. In most cases the coefficient of water surface elevation was either of the wrong sign, not significantly different from zero, or both. This conclusion was confirmed by both reservoir and Little Rock District representatives of the Corps of Engineers. They agreed that fluctuation in water surface elevation seemed to have little effect on recreation use of the different reservoirs. The resident engineers indicated that complaints increased with increased fluctuation but most of these come from boat dock owners and concessionaries.					
15. SUBJECT TERMS reservoir, reservoir recreation, recreation benefits, reservoir operation					
16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT UU	18. NUMBER OF PAGES 64	19a. NAME OF RESPONSIBLE PERSON
a. REPORT U	b. ABSTRACT U	c. THIS PAGE U			19b. TELEPHONE NUMBER

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RD-2

FOREWORD

In both the planning and operation of water resources systems, competitive uses of water influence the determination of system configurations and operating criteria. One of the more common conflicts involves the need for a relatively stable water surface elevation for reservoir recreation on the one hand and adequate water releases to meet other needs such as flow augmentation and hydroelectric power on the other. Corps of Engineers planning and operation studies conducted at The Hydrologic Engineering Center have shown the need to identify, if possible, the effect of change in water surface elevation on the reservoir recreation demand function.

This Research Note reports the findings of a study by William D. Carson, Jr., Department of Economics, University of California, Davis, on the determinants of reservoir recreation use and demand. In addition to investigating theoretical relationships, the study utilized extensive Corps of Engineers field data as well as information obtained in interviews with reservoir managers at several reservoir sites. Conclusions are based on an analysis of these data and reflect specific reservoir and recreational characteristics. In other areas, where characteristics differ substantially from those in this study, other conclusions may be justified.

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Preface

The research summarized in this report was supported by Award/Contract DACW05-72-C-0004 from the Hydrologic Engineering Center of the U. S. Department of the Army, Corps of Engineers. Valuable assistance came from a number of people in the Corps, including: A. J. Fredrich and William Johnson at HEC, Richard Brown and William Hansen in the Sacramento District Office, and a variety of people in the Little Rock District. In addition, Victor Goldberg and Leon Wegge of the University of California, Davis made many useful suggestions. Of course, the responsibility for any remaining errors is mine.

AN INVESTIGATION OF THE DETERMINANTS OF RESERVOIR
RECREATION USE AND DEMAND: THE EFFECT OF
WATER SURFACE ELEVATION

Tables of Contents

	Page
Introduction	1
Historical Background	2
Consumer Surplus and the Theory of Consumer Demand	6
The Demand for Reservoir Recreation	13
Application of the Model	23
The Estimated Equations	36
The Regional Demand Equation	37
The Reservoir Demand Equations	39
Conclusions	46

Tables

1	An Example of Distance and Visits	15
2	Visitors at Different Fees	17
3	Characteristics of Reservoirs	27

Figures

1	Hypothetical Demand and Supply	18
2	Location Map	25

AN INVESTIGATION OF THE DETERMINANTS OF RESERVOIR
RECREATION USE AND DEMAND: THE EFFECT OF
WATER SURFACE ELEVATION

Introduction

This research report summarizes the results of an analysis of recreation use data from five reservoirs in the Little Rock District of the U. S. Army Corps of Engineers. The purposes of the study were: first, to determine the effects of certain reservoir operating characteristics on the volume of recreation use and benefits; and, second, to relate these results to more conventional analysis of recreation use based mainly on socioeconomic variables. In addition, the study suggests ways that the analysis of recreation use can be applied to benefit estimation for proposed projects. During the course of the study, a visit was made to the Little Rock District Office of the Corps of Engineers. From this base, visits were made to some of the reservoirs involved in the system studied here. Discussions with a variety of people in the Little Rock Office, and at the reservoirs, generally confirmed the results of the research. The reported results are applicable primarily to the five reservoirs involved, but hopefully the conclusions will be useful in the analysis of proposed reservoirs in the Little Rock District and in recreation analysis in general.

Historical Background

Outdoor recreation, and especially water-based outdoor recreation, has grown tremendously in the last twenty years. Along with this growth has been the growth of recreational use of government built water projects. Growing pressure for provision of recreation facilities and, in some cases, for providing reservoirs for the sole purpose of recreation compelled Congress to recognize the importance of the benefits and costs of recreation in the consideration of new projects. Senate Document 97 [25] first labelled outdoor recreation as a separable purpose of government projects in 1962. This document requires that the benefits and costs of recreation opportunities be measured and accounted for in the justification of public resource projects.

The general standards for the formulation of plans for water resource projects require that:

... Benefits and costs shall be expressed in comparable quantitative economic terms to the fullest extent possible.

2. Comprehensive plans shall be formulated initially to include all units and purposes which satisfy these criteria in quantitative economic terms:

- (a) Tangible benefits exceed project economic costs.
- (b) Each separable unit or purpose provides benefits at least equal to its costs.
- (c) The scope of development is such as to provide the maximum net benefits.
- (d) There is no more economical means, evaluated on a comparable basis, of

accomplishing the same purpose or purposes which would be precluded from development if the plan were undertaken. [25, p. 7,8]

In order to include recreation in these standards the document defines recreation benefits as:

The value as a result of the project of net increases in the quantity and quality of boating, swimming, camping, picnicking, winter sports, hiking, horseback riding, sightseeing, and similar outdoor activities. (Fishing, hunting, and appreciation and preservation of fish and wildlife are included) In the general absence of market prices, values for specific recreational activities may be derived or estimated on the basis of a simulated market giving weight to all pertinent considerations, including charges that recreationists should be willing to pay and to any actual charges being paid by users for comparable opportunities at other installations or on the basis of justifiable alternative costs. Benefits also include the intangible values of preserving areas of unique natural beauty and scenic, historical, and scientific interest. [25, p. 10]

This passage indicates the most important problem plaguing the investigator who attempts to determine the quantity of benefits that can be attributed to recreation on a government project. This problem is "the general absence of market price." The recreation opportunities on most government projects are offered at a zero, or at most a nominal fee. Where fees are charged sites are usually distinguished by some facilities absent at the free sites.

Observations on recreational use of a government built reservoir mean very little in terms of benefits unless there is a value that can be attached to each unit of use. For example, in the case of flood control, a reasonable

estimate of the value of the property saved by avoiding floods can be used as the measure of gross benefits. This is based on existing market prices. In the case of recreation, however, the comparable opportunities which are offered at a price are private facilities and are different products. That is, the services offered by the private and public sites differ in the following ways: first, the private facility is, as its name suggests, private and gives the recreationist a certain amount of seclusion and protection from crowds; second, the private recreation site is usually more improved than the public site; and, third, the private site often provides facilities which the public site does not. Even if the private and public sites offered identical facilities and improvements, the existence of the public sites with free access alongside the private sites would distort the price of the private sites and make them difficult to interpret or use. The absence of market prices for recreation dictates a different approach than the conventional time series approach for estimating a demand curve to determine the recreationists' willingness to pay for public recreation sites.

Another problem of measuring benefits arises due to the multiple purpose nature of most Corps projects. Operation of the reservoir for one purpose may interfere with

other purposes. For example, this study is primarily interested in the effects of drawing down the water surface elevation for electricity generation. Presumably, the change in water surface elevation, and the related changes in shoreline, surface acreage, etc., will change the characteristics of recreation opportunities on the reservoir to such an extent that the recreation use will decrease. The hypothesis of this study is that drawdown will adversely affect recreation use of the five reservoirs: Beaver, Bull Shoals, Greers Ferry, Norfolk, and Table Rock. This hypothesis suggests the necessity for balancing operating revenues from electricity generation against the changes in recreation use caused by the production of those revenues. Certain other physical characteristics of the reservoirs may have an effect on recreation use. The following were investigated in this study: weather, recreational facilities and season. Some of the variables subsumed under these headings proved to have little effect. This study seeks to combine demand estimation procedures with an analysis of the effects of certain physical characteristics, and to indicate how this analysis could be used for estimation of benefits for a proposed project.

Consumer Surplus and the Theory of Consumer Demand

Several recent studies have investigated the measurement of recreation demand and benefits in recent years [for example: 5, 6, 16, 19, and 26]. Most of the researchers argue that the benefits should be measured as all or part of the area under the estimated demand curve for the recreation site. Different analysts give this measure of benefits different names but, in general, the measure can be called consumers' surplus. This is the consumers' surplus originally suggested by Marshall as "the excess of the price which he (the consumer) would be willing to pay for the thing rather than go without it, over that which he actually does pay." [18, p. 124] In the case of the reservoir recreation being studied here (and many other types of publicly provided recreation opportunities) the price the consumer actually pays for the opportunity to engage in recreation is either zero or very small. With a zero price the area of consumers' surplus becomes the entire area under the demand curve. There have been criticisms and rehabilitations of the concept of consumers' surplus but a recent survey of the literature concerning this controversial topic concluded that: "While it is easy to raise objections to the use of the concept of economic surplus for providing answers for policy formulation, it is difficult

to find any workable alternative." [7, p. 791]

This study deals with the estimation of a demand function for existing reservoir recreation sites as a base for the benefit analysis of proposed sites and for indicating any tradeoffs between recreation use and other purposes for operation of the reservoir. Projection of the demand for recreation at a proposed reservoir is usually handled by applying the demand function estimated for an existing "most similar project" [12, p. 61] or by using a demand function estimated for the region in which the proposed project will be built. Values of the independent variables are projected for the area surrounding the proposed reservoir and for the reservoir itself. These values are "plugged" into the estimated function and a demand function for the proposed reservoir is plotted. This demand function can then be used to project benefits for the recreation on this reservoir. Problems involved in this procedure will be discussed below.

Demand functions for various recreation sites have been estimated but often the investigators have failed to note the restrictions placed on the demand equation by the theory of consumer behavior. The exact form of the demand function for any commodity is not known, a priori, but economic theory does give some guidelines which help in the

estimation of the function.

If x_1, \dots, x_n are the quantities of commodities consumed by an individual, then

$$U = U(x_1, \dots, x_n) \quad (1)$$

is a function which indicates the individual's total utility from that consumption. The consumer maximizes his utility subject to the constraint of his budget

$$p_1 x_1 + \dots + p_n x_n = I \quad (2)$$

where p_i is the price of commodity i and I is the consumer's total income for the period. The first order conditions for a maximum of equation (1) constrained by (2) are:

$$U_i - \lambda p_i = 0, \quad i = 1, \dots, n; \quad (3)$$

and

$$I - p_1 x_1 - \dots - p_n x_n = 0 \quad (4)$$

where $U_i = \partial U / \partial x_i$. The system of equations (3) can be rewritten:

$$\frac{U_1}{p_1} = \frac{U_2}{p_2} = \dots = \frac{U_n}{p_n} \quad (5)$$

The combination of equations (3) and (4) or (4) and

(5) can be solved for the x's with given prices and income. These x's will be the quantities of each of the commodities which provide the consumer with the highest level of satisfaction, given his tastes and income, and will be of the form:

$$x_i = x_i(p_1, p_2, \dots, p_n, I) \text{ for } i = 1, \dots, n \quad (6)$$

Any demand equation in this system should have two important properties. First, an individual's demand for any x should be a unique function of prices and income; and, second, each of the functions x_i are homogeneous of degree zero in prices and income [21, p. 111]. That is, if all prices and income change in the same proportion and direction, the quantity demand by an individual will remain constant. It can also be shown that at a constant level of utility if the price of good x_i changes the quantity demanded will respond in the opposite direction of the price change. This and other restrictions can be derived from assumptions concerning the utility function¹ (e.g., quasi-concavity) but in general these are applicable and helpful for

¹These, and certain other conditions, such as Samuelson's reciprocal "integrability" conditions are not testable with a "finite number of point observations." See Samuelson [21, p. 107, footnote].

for estimation of systems of demand equations rather than a single equation. [8]

Under what conditions is the estimation of a single demand equation useful and valid? If it can be assumed that the preferences of an individual are additive and separable, all the cross-partial derivatives of the utility function are zero, i.e.,

$$\frac{\partial^2 U}{\partial x_i \partial x_j} = 0, \text{ for all } i \neq j.$$

This implies that the utility derived from a particular commodity is independent of the quantities of other commodities taken. The assumption of separable utility allows one to analyze one demand function in isolation while retaining the restrictions of uniqueness and homogeneity. A further advantage of an additive preference model is that linear expenditure relationships (demand equations) can be formulated which are easily aggregated across individuals. [17, p. 361]

Two types of demand equations are used in this study. The first is the linear expenditure system equation suggested by Stone [24, 1954]:

$$p_i x_i = p_i \bar{x}_i + b(y - p_j^1 \bar{x}_j^1) \quad (7)$$

where p_i and x_i are the price and quantity of the i^{th} good, \bar{x}_i is the minimum (in some sense) consumption of this good, y is income, $p_j^1 \bar{x}_j^1$ are the prices and minimum consumption of other commodities. On this hypothesis, the consumer's expenditure is allocated to this commodity by first a basic consumption of \bar{x}_i and then in a certain proportion to income left over after making the basic consumption of the other commodities \bar{x}_j^1 , ($i \neq j$). If \bar{x}_i and \bar{x}_j^1 are zero, equation (7) reduces to

$$p_i x_i = bI \quad (8)$$

which implies that the expenditure on the good is proportional to income. Equation (7) can be written in the form:

$$x_i = p_i^{-1} (bI + bc^1 p_j^1 - c_i p_i) \quad (9)$$

to fulfill the homogeneity restriction implied by the theory of consumer behavior. The coefficients c^1 and c_i are $-\bar{x}_i$

¹This demand curve is derived from a utility indicator of the form $U = \Pi(x - \bar{x})^a$ and the implications of additive preference apply because a monotonic transformation of this utility indicator (natural logarithms) is additive.

and $-\bar{x}_j^{-1}$ from above. Again, (9) reduces to equation (8) if the c's are zero. This equation is the most general linear expenditure equation compatible with the conditions imposed by the theory of demand. When equation (9) is aggregated, assuming identical preference functions for all consumers, the equation remains in the same form but x and I become total quantity and income, respectively. [17, pp. 615ff]

The second type of demand equation used in this study is the multiplicative function

$$x_i = c p_i^a y^b \quad (10)$$

where x_i is the demand for commodity i by individual,
 c is a coefficient indicating the individual's
 preference for commodity i,
 p_i is the price of commodity i,
 y is the individual's income,
 and a and b are the respective elasticities which are
 assumed the same for all individuals if equation
 (10) is aggregated to:

$$X_i = C p_i^a Y^b \quad (10a)$$

Capital letters denote aggregate measures. For ease of estimation this equation can be transformed by natural logarithms to:

$$\log X_i = \log C + a \log p + b \log Y \quad (11)$$

This equation is single-valued and homogeneous of degree zero in prices and income if it is divided through by the consumer price index. Although this form of the demand function has been used extensively in empirical studies of demand [for example, 4] it has certain shortcomings. The first is that the utility function which lies behind this demand equation is not easily identified and therefore does not necessarily satisfy the assumptions of utility theory. Secondly, some economists reject the notion of a demand function with constant elasticity throughout. However, some justification for using this demand equation can be found in the fact that utility functions are unobservable, and as such, the empirical analysis of demand must start with the demand function. In addition, the assumption of identical preference functions for all consumers is not necessary when the log-linear equation is used. Only the assumption that the differences in consumers will be washed out in the aggregate analysis so that the elasticities will be the same for all individuals must be made.

The Demand for Reservoir Recreation

Most recreation provided on, or near, reservoirs is

available free or at a nominal fee¹ to all interested recreationists. This characteristic limits the usefulness of the conventional time-series approach to demand analysis because there are no price-quantity observations to use in the estimation of a demand curve. Since the recreationist does not pay for the opportunity to participate in recreation directly, another method is needed to determine his willingness to pay for this opportunity. Marion Clawson [5] suggested a method of estimating the demand for recreation using distance as a proxy for price. This method has been implemented and augmented by subsequent researchers [6, 14, 15, 16, 19, 22, and others] but the elements of the analysis remain the same.

Clawson defines the total recreation experience as consisting of "anticipations before the experience actually begins, the realization of the experience, and recollections afterward." [5, p. 14] To estimate the demand for this total recreation experience, the area surrounding a particular recreation site, or group of sites, is divided into homogeneous distance zones. The number of visitors from each zone is recorded for some period of time. The

¹Scattered user fees of one dollar are charged at improved sites on the reservoirs under study. Apparently these fees were not introduced until after the period of the study and thus are not helpful here.

original suggestion for distance zones came from Hotelling [11], who preferred the use of concentric circles around the park, or site, for dividing the recreationists. Later investigators have used various combinations of zones, counties and groups of counties. The demand curve is estimated by finding the relationship between the average cost of travelling to the site and the number of visitors per 100,000 population from each distance zone, i.e., a cross section regression between travel-cost and visits as a proportion of population. This relationship is called a demand function, a cost response function and a use prediction model. Here the function will be called a demand function because it does relate the consumers' willingness to pay for the recreation ("price") to the quantity of recreation consumed. To illustrate the mechanics of the Clawson procedure the following simple example is offered.

The population surrounding a hypothetical reservoir can be divided into three clearly defined distance zones as follows:

<u>Zone</u>	<u>Average Distance</u>	<u>Visitors/100</u>	<u>Population</u>
I	10	95	200
II	20	90	300
III	30	85	400

An Example of Distance and Visits

TABLE 1

The relation between average distance and visitors per one hundred population is

$$V = 100 - \frac{1}{2}D \quad (12)$$

where V is visits per one hundred and D is average distance. This equation represents the response of consumers of recreation at this site, in terms of use, to increasing difficulty of overcoming distance. Presumably, the further a distance zone is from the reservoir, the fewer visitors there will be per one hundred population, e.g., the demand curve will be downward sloping. The distance response equation (12) can be made more interesting and useful by converting it into monetary terms. If the distance variable is transformed into a variable representing the variable costs of traveling, e.g., four cents per mile, the user response equation becomes:

$$V = 100 - 12.5TC \quad (13)$$

where TC is variable travel cost and V is as before. Equation (13) is the demand for the entire recreation experience and from this equation the demand for the recreation site as a subset of the entire experience can be estimated.

The second step of the analysis requires the following assumption: the reaction of consumers to variable costs, implied by equation (13), would be the reaction of consumers

if entrance fees were instituted at the recreation site. The response of the consumers in the three distance zones to hypothetical entrance fees is recorded in Table 2.

<u>Fee</u>	<u>Visitors by Zone</u>			<u>Total Visits</u>
	<u>I</u>	<u>II</u>	<u>III</u>	
\$1	175	262	350	787
2	150	225	300	675
3	125	187	250	562
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8	0	0	0	0

Visitors at Different Fees

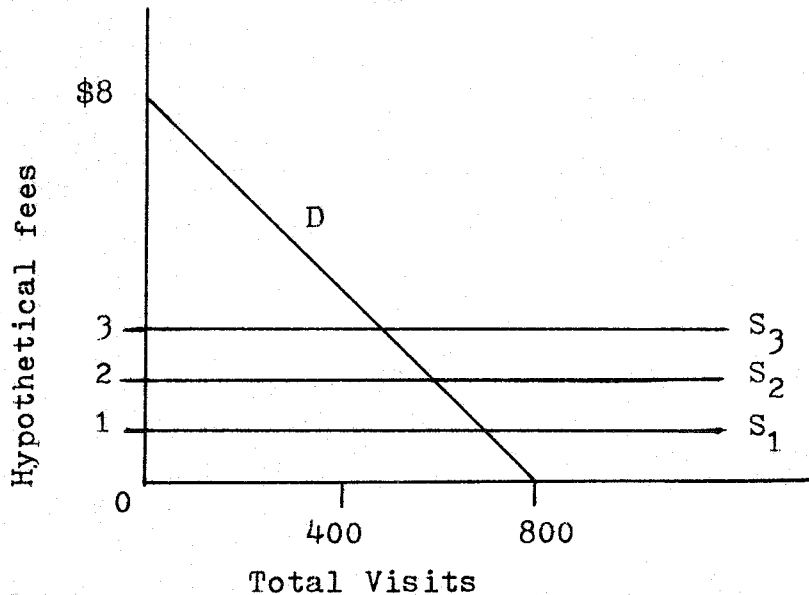
TABLE 2

There was a total of 800 visits at an entrance fee of zero and zero visits at the hypothetical entrance fee of eight dollars. The demand curve for the recreation site in this example can be plotted as in Figure 1. The procedure illustrated here implies a particular form for the supply curve of recreation at a reservoir, or a group of reservoirs. In the estimation of the demand for the entire experience the supply curve corresponds to the horizontal axis because the individual consumer is faced with a zero price and nearly unlimited availability of recreation opportunities.¹ As

¹The phrase "nearly unlimited availability" implies a recognition of the often mentioned problems of crowding and capacity. An unambiguous measure of crowding is difficult

Figure 1

Hypothetical Demand and Supply



the hypothetical entrance fee is imposed and increased, the supply curve would conceptually shift up by the amount of the fee. Supply would remain horizontal, i.e., there would still be unlimited availability of recreation facing the consumer at the new price. For example in Figure 1, S_1 , S_2 and S_3 represent the supply curves for entrance fees of

to formulate and, so far, attempts to measure this factor have been less than fruitful.

one dollar, two dollars and three dollars respectively.

The demand curve posited here represents the consumer's willingness to pay for the recreation site. Since the consumer has only to pay the zero price to get the quantity actually consumed, the entire area above the horizontal axis represents what he would willing to pay to get this quantity but does not have to pay. Therefore, the entire area under the demand curve is the measure of consumers' surplus or gross benefits. As mentioned before, there is some controversy over the use of consumers' surplus to measure benefits but this study has been unable to find a better method. As a result, the estimation of a demand curve using a proxy for price is justified by its usefulness in benefit estimation.

Problems arise when this model is applied to proposed projects rather than existing ones. These problems center around the difficulty of projecting values for the independent variables in the demand equation. Projections of population, cost of operation of an automobile, income of recreationists in a particular location, quality of recreation sites, facilities and other variables which may influence recreation use in the future must be made if recreation use and benefits are to be projected. However, projections such as these are presently made in many fields and since

there are various things that determine which values the variables will take, the best projections possible should be made and updated frequently. In addition, the concept of "most similar project" must be applied. That is, the demand equation that has been estimated for the project which seems to be most similar to the proposed project is used, with the values of variables from the proposed project, to predict the demand for recreation at the proposed site. The choice of the "most similar project" is difficult one that is handled by local offices of the agencies proposing to build the project. Another method to predict use and demand at future projects would be to use the regional demand equation estimated for several projects in the vicinity of the new reservoir rather than the equation for one reservoir. This would have the effect of averaging differences between reservoirs and would take advantage of both the similar characteristics of the recreationists in an area, and the similar characteristics of reservoirs [26].

Subsequent researchers have improved the analysis by adding variables to account for shifts in the demand curve in addition to the movements along the curve caused by changes in "price." Some variables which have been added are: income; educational, racial, sexual and age structure of the population; population and population density;

urban-rural mix of population and other socioeconomic variables that represent characteristics of the populations surrounding the recreation site. [See, for example, 1, 2, 3, 6, 9, 14, 15, 19, 20, 29] One variable which is often mentioned in the context of demand studies for recreation is the value of time. Most researchers have found the measurement of time cost, and separating this cost from the money cost of travelling, to be extremely difficult. Usually they are content to state the direction and possible size of the bias caused when time is excluded from the analysis. [3] One study has posited a trade-off function between time and money costs of travelling to the recreation site. [26] Again, the relationship is difficult to pinpoint and the selection of the tradeoff function is somewhat arbitrary. Since the time costs and travel cost are so closely related a regression analysis that includes both often gives ambiguous results due to multicollinearity.

The theory of consumer behavior suggests that the prices of other goods in the marketplace will have an effect on the demand for the good under study. In the case of recreation, the most important related goods are the substitute sources of recreation opportunities. Since most of these in the vicinity of the reservoirs in the present study are bodies of water (largely reservoirs) and share the

characteristic of lack of market price, a similar approach must be used to provide a proxy for this price. In this study travel cost from point of origin to the alternative will be used as the price of the alternate recreation opportunities. In order to differentiate between the alternate sites of different sizes and qualities, the travel cost will be weighted with the reciprocal of the average size of the recreation pool. Unfortunately, further information on the quality of the various alternate sites was unavailable for this study. (So far, data have only been collected on reservoirs that offer substitute recreation opportunities within one hundred miles of the point of origin counties.) The rationale for weighting the sites by size lies in the assumption that large recreation sites which are near the point of origin should have a lower price because of the relative ease of access at larger sites. In order to limit the number of variables in the actual estimation, the "price of alternative recreation sites" will be weighted average of the form:

$$p_j = \left(\sum_{j=1}^n \frac{d_{ij}}{s_j} \right) / n \quad (14)$$

where n is the number of alternatives available to the i th distance zone or county,

d_{ij} is the travel cost from the i th distance zone to the j th alternative site, and s_j is the size of the recreation pool at the j th alternative site.

More alternatives will lead to a lower price because it is easier to substitute for the site under study. We assume that these are substitutes and we would expect that the consumer would respond positively to a change in the price of the alternatives. That is, an increase in the number of alternatives, a decrease in the average distance to the alternatives or an increase in the size of the average alternative will cause p_j to decrease and lead to a decrease in use of the site under study.

Additional variables to account for the difference in physical characteristics of reservoirs will be included in both types of demand equations estimated below. Other approaches to the problem of assessing the effects of these characteristics on recreation use will also be explored.

Application of the Model

Five reservoirs in the Little Rock District of the U. S. Army Corps of Engineers are used in an application of the Clawson model for estimating recreation demand. The reservoirs are: Beaver Reservoir on the White River in

Benton, Carroll and Washington Counties in Arkansas; Bull Shoals Reservoir on the White River in Boone, Marion and Baxter Counties in Arkansas and Taney and Ozark Counties in Missouri; Greers Ferry Reservoir on the Little Red River in Cleburne and Van Buren Counties in Arkansas; Norfolk Reservoir on the North Fork River in Baxter and Fulton Counties in Arkansas and Ozark County in Missouri; and Table Rock Reservoir on the White River in Stone, Barry and Taney Counties in Missouri and Carroll and Boone Counties in Arkansas. (See Figure 2.)

These reservoirs were selected for this study because of their proximity. All five lie within one hundred miles of Bull Shoals Reservoir. Because of their nearness, all of the reservoirs will serve essentially the same clientele. Beyond this, the five reservoirs are located in a popular vacation and resort area of the Ozark Mountains. There are a variety of tourist related activities in the vicinity of the reservoirs and especially surrounding the four located to the north. These activities have some drawing power for the general area but they are not of the unique type which would bring visitors from long distances; for example, sixty-five to ninety per cent of the visitors to the five reservoirs during the period 1966-69 came from counties within 250 miles of the reservoir.

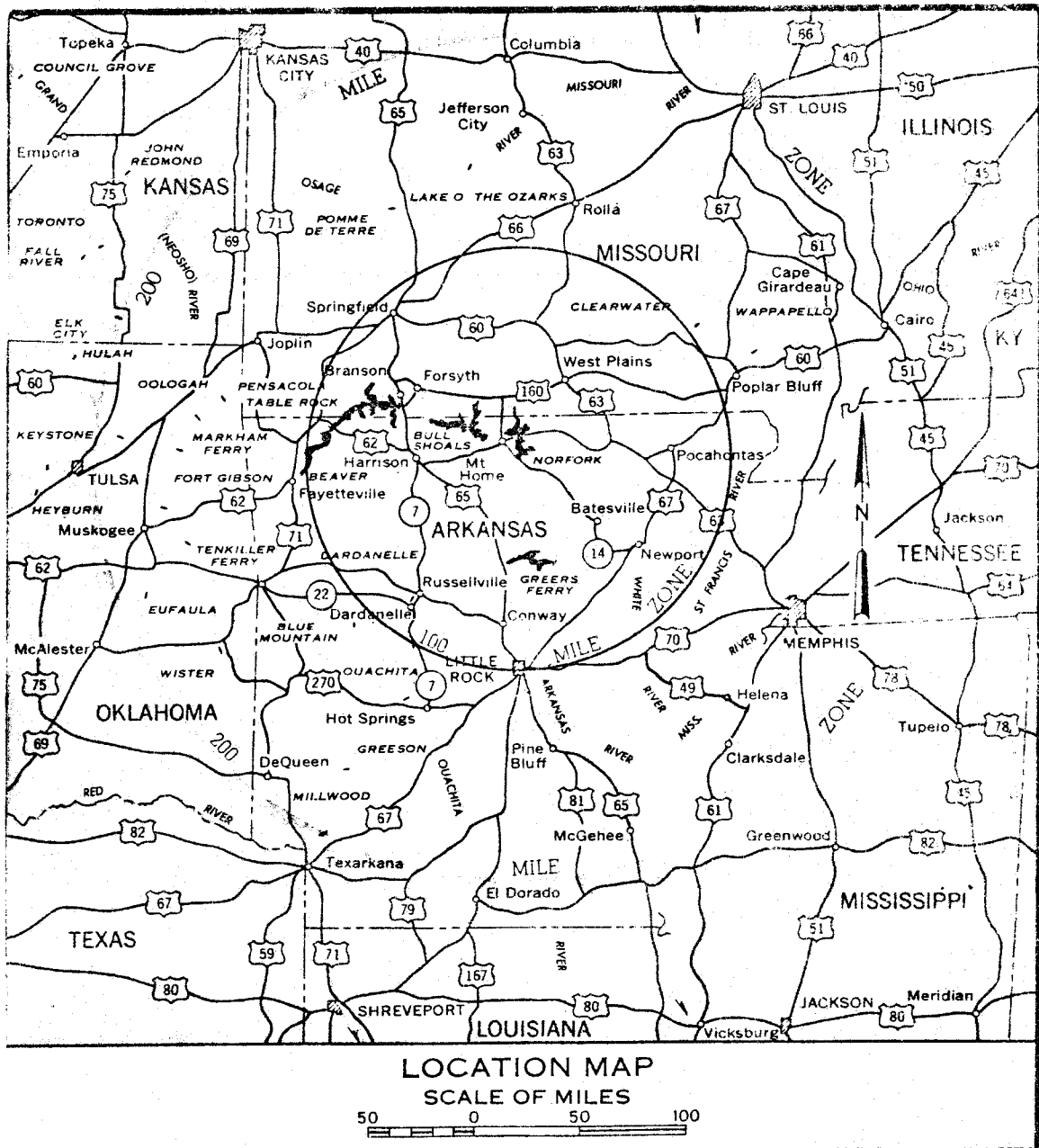


Figure 2
Location Map

The five reservoirs represent a variety of physical characteristics, sizes, facilities and use patterns. All of the reservoirs have excellent access from several different highways and all have excellent water quality. All five are considered adequate for all types of water-based outdoor recreation. Each has facilities for fishing, boating, water skiing, swimming, picnicking, sightseeing and camping. Table 3 illustrates some of the differences between the five reservoirs.

First, the size of the average pool available for recreational use varies from a relatively small Norfolk to a very large reservoir such as Table Rock. In addition, the size of each of these reservoirs changes seasonally and even daily due to operation of the electricity generation process and weather. Beaver and Greers Ferry have relatively more fluctuation in water surface elevation, and therefore in size, than the other three reservoirs. Second, the reservoirs exhibit a variety of facilities. Ease of access is measured by both highways and access areas and varies from seven highway access routes and fifteen access areas on Greers Ferry to twelve highways and twenty-nine access areas on Bull Shoals. Facilities are measured by the number of tent and trailer spaces, estimated day use capacity and number of boat launching lanes. These

Table 3

Comparison of Reservoirs

<u>Characteristic</u>	<u>Beaver</u>	<u>Bull Shoals</u>	<u>Project Greers Ferry</u>	<u>Norfolk</u>	<u>Table Rock</u>
Average Recreation Pool:					
Surface acres ¹	2822	4544	3146	2199	4307
Shoreline miles	449	740	276	380	745
Access Areas:	16	29	15	25	22
Major Highway Access Routes:	7	12	7	8	10
Facilities:					
Tent and trailer spaces	138	489	314	247	869
Day-use capacity	221	230	325	162	727
Boat launch lanes	125	184	56	72	322
Date of Completion:	1964	1951	1961	1943	1958

Source: Department of the Army, Office of the Chief of Engineers, "Estimating Initial Reservoir Recreation Use," Technical Report No. 2, October 1969.

¹In hundreds of acres.

²In thousands of recreation days, i.e., a visit by one recreationist to the reservoir to engage in any of a number of recreation activities for any part or all of one day. The number given as capacity is based on an average weekend day of peak month of use.

measures are important in recreation use prediction because more facilities obviously allow for more recreational use of a given area. As can be seen from the table, the reservoirs display a wide range of facilities. Finally, the reservoirs vary from old, established Norfolk to Beaver Reservoir which was completed the year before the survey began. The heterogeneity of the sample makes the empirical results more meaningful and interesting.

The data on which this study is based have been compiled from surveys undertaken by the U. S. Army Corps of Engineers in each season of the years 1966 through 1969. The seasons are defined as follows: early recreation season is February through May, late recreation season is June through September and the remaining months are off-season. The survey was taken on one weekend day and one week day of each season for the four years. The interviewers tabulated the point of origin of the visitors, the purpose of the visit (fishing, swimming, picnicking, boating, water skiing, sightseeing, or camping), the type of vehicle used and the number of persons in the party. The survey results were used in conjunction with traffic counts at each site to estimate the total use of each reservoir for recreation in each season. The survey results provide a structure for determining the number of persons per

vehicle, purpose of the visit and the locational distribution of the visitors (i.e., the percentage of the total visitation which came from each county in each season). There may be certain biases in the data due to sampling error and sampling problems but these are difficult to identify without a follow-up survey.

In this study, counties are used as the zones into which the visiting population can be divided because of the correspondence with the more recent studies in this field and because of the relative ease of gathering socio-economic statistics for counties rather than distance zones. For application of this procedure counties provide the most inexpensive observation unit. At one stage in the study, groups of counties at similar distances from the reservoirs were used as point of origin zones. This grouping was explicitly to allow the use of a generalized least squares regression model with estimated variance-covariance matrix.¹ This procedure required substantial aggregation of the data for estimation purposes. Even after grouping the data, the results of the estimation were rendered useless by rounding

¹See Appendix A of the January 6, 1972 Progress Report submitted under this contract for a more thorough explanation of this procedure.

errors. Pankey and Johnston [27] found that the difference between counties and distance zones for use prediction is not significant and suggest the use of county zones because of the availability of statistics concerning population density and structure. Unfortunately, observations on the socioeconomic variables are based only on the 1960 Census. Time series analysis of the effects of the socioeconomic variables was not possible because the applicable results of the 1970 Census were not yet available. This would be an area of fruitful future research.

One complication caused by using counties as the observation unit is the large number of zero observations for the use variable. Since the survey was limited to two days in each season the zero use estimates are primarily due to the vagaries of the sampling process rather than being an indication that all of the counties with zero use estimates had no visitors to the reservoir in that season. Several approaches can be used under these circumstances. First, the zero observations can be deleted in the statistical analysis. This is the approach used in this study. The zeros tell us nothing about the effects of reservoir operating characteristics on recreation use unless we assume that the zero was caused by adverse conditions. In addition, the zeros would give a serious downward bias to

the demand estimates generated by the model. If the zeros are allowed to remain in the sample for the statistical analysis they must be incremented by some positive constant to make it possible to estimate the demand function in the log-linear form. This causes biases that cannot be ignored. [See 20, pp. 18, 20] Analysis of the data was undertaken using both data with, and without, the zero use observations. The results were noticeably better using the data without zeros so those are reported here. Grouping the counties to minimize the number of zero observations washes out the effects of the various socioeconomic characteristics of the individual counties.

Second, each observation can be increased by an arbitrary small constant (such as positive one). This allows estimation of logarithmic formulations but leads to a serious downward specification bias [20, pp. 18, 20] and implies a different interpretation of the data than is justified by its construction. That is, this method would imply that the use level from each of these counties was actually zero. Finally, a functional form can be used, for the demand function, which can be statistically estimated with zeros as observations on the dependent variable. This approach is only acceptable if the functional form chosen is in correspondence with the restrictions which were gleaned from demand theory above.

The explanatory variables can be placed into four categories: Physical characteristics of the reservoirs, travel cost from the point of origin to the reservoir, the time or season, and availability of alternative recreation sites. Two types of reservoir characteristics were used: first, those that represent the physical attributes of the site, and, second, those that represent the facilities available for recreation. The first type of statistic includes the size and area of the average recreation pool (where recreation pool is defined to be that part of the reservoir available for recreation), the weather in the reservoir's vicinity, and the amount of fluctuation in the reservoir pool. These could be supplemented with variables representing water quality, fishing potential of the reservoir and natural or environmental attractiveness. In this study there seemed to be little difference in water quality between the five reservoirs and the latter two variables proved beyond quantification. The second type of statistic includes: the number of good access roads to the reservoir; the number of access areas; the number of tent and trailer spaces, the number of boat launching lanes and the estimated day-use capacity of the sites located on each reservoir. The age of the reservoir, from the date of impoundment, is also included in this category of variable. Table 3 lists the values of these variables as of 1969.

The distance variable is defined as the road mile distance from the nearest access area on the reservoir to the most populous city in the county [26]. Distance was converted to travel cost by using a per mile variable cost of 4.68 cents as suggested by a U. S. Department of Transportation study [28]. It reflects only the variable costs of operation of an automobile: repairs and maintenance, replacement tires and tubes, gasoline and gasoline tax, oil and oil tax, and miscellaneous taxes on tires, tubes, etc. Adjustments were made for round trip mileage and for the fact that there is usually more than one person in each automobile. Time was used in two forms in the statistical analysis. First, time was defined as progressing by seasons from one to twelve, beginning with the early recreation season of 1966 to the winter of 1969. Second, dummy variables were used to designate the early recreation and late recreation seasons of each year, and to remove the seasonal variation in the use variable.

Since socioeconomic variables were not of primary importance in this study only two variables were included. Income was measured as the median family income for the county point of origin of each visitor. This procedure has several disadvantages which lead to peculiar results in the statistical analysis (see below). The first disadvantage is that the measure is too aggregated for the corresponding

use observations. That is, each visitor was asked only his county point of origin and not his income level. Using the county measure washes out some of the effects of different levels of income on recreation use and makes the results difficult to interpret. In addition, income data could not be updated (the observations were based on the 1960 Census) because the results of the 1970 Census were not yet available. A further disadvantage was found in the fact that the use variable was measured in terms of individuals while the income measure was in terms of families. The correspondence was not always unambiguous. In order to correctly determine the effects of income on recreation use of reservoirs a question concerning income should be included in the survey. As can be seen below, the results of the regression analysis indicate that as income increases, per capita recreation use of the reservoirs will decrease, i.e., a negative regression coefficient. These results may be valid even though they disagree with some a priori expectations. They may be interpreted to mean that, given a distribution of income, those families with lower income are more likely to engage in reservoir recreation. This interpretation is in agreement with personal observations, i.e., casual empiricism. This does not imply, however, that as incomes in general increase there will be a decrease in

reservoir recreation.

Population is an important determinant of the quantity of recreation use of a reservoir which will come from a particular county. In this study population is used indirectly by defining the dependent variable as per capita use. This implies an assumption that the elasticity of recreation use with respect to population is not significantly different from one.¹ Additional socioeconomic variables were not utilized in this study. Possibilities for future research include (some of which have been investigated by earlier researchers): density of population, educational, racial and sexual composition of the population; ownership of automobiles, boats and other recreational equipment; purchases of fishing licenses; pattern of leisure in the county; and employment in the county. Often these variables prove to have an insignificant effect or are expensive and clumsy to formulate. In addition, they are often overpowered by the variables income or population.

The last group of variables was to have represented the availability of alternative recreation sites to a county. Several forms were used for this variable but

¹Pankey and Johnston tested this assumption and found it acceptable [20, p. 24].

equation (14) proved the most satisfactory from both a priori and a posteriori considerations.

The Estimated Equations

The results reported below are the best in terms of both test statistics, such as R^2 and the Student's t-test, and in terms of non-statistical criteria. Not all of the reported equations have both high R^2 and significant t-values for each variable, but each was chosen as "best" representation of recreation use determination on theoretical and practical bases. In addition to reporting demand functions for each reservoir (in one of the two forms explained above: equation (9) or (11)), equations are reported which purport to explain total seasonal use in terms of facilities and physical characteristics. The variables used in the final analyses are:

- Y_{ijk} = per capita recreation use reservoir k by the residents of county i in period j.
- Y_{kj} = total use of reservoir k from all counties in period j.
- X_{lik} = travel cost, as defined above, from county i to reservoir k.
- X_{2i} = median family income of county i.
- X_{3i} = availability of alternatives (equation (14)) to county i.
- X_{4j} = the consumer price index in period j.

- X_{k5a} = the total range of water surface elevation for reservoir k over one season.
- X_{k5b} = the average water surface elevation for reservoir k for a season.
- X_{k5c} = the average difference between water surface elevation (daily) and the top of conservation pool for reservoir k.
- X_{6k} = difference between normal and actual rainfall in the reservoir basin over a season.
- X_7 = dummy variable representing early recreation season.
- X_8 = dummy variable representing late recreation season.
- X_{9k} = highway access at reservoir k.
- X_{10k} = average size of the recreation pool at reservoir k.
- X_{11k} = the number of access areas at reservoir k.
- X_{12k} = the number of tent and trailer spaces at reservoir k.
- X_{13k} = the estimated day-use capacity at reservoir k.
- X_{14k} = the age of reservoir k from date of impoundment.

The Regional Demand Equation

The log-linear form of the demand equation fits the data much better than the Stone function when all the data were combined. The equation was¹

¹The abbreviation "ln" implies natural logarithms.

$$\ln Y_{ij} = 4.85 + \frac{3.64X_1}{(4.7)Y} + \frac{8.62X_8}{(11.8)8} - \frac{.97\ln X_1}{(-22.4)} / X_4$$

$$- \frac{1.58\ln X_2}{(-16.0)} / X_4 + \frac{.116\ln X_3}{(1.23)} / X_4 \quad R^2 = .45. \quad (15)$$

As expected, the dummy variables proved to be significantly different from zero at a ninety-nine percent level of confidence. The coefficients indicate that recreation use of any reservoir in the system will increase by 3.64 percent in the early recreation season and by 8.62 percent in the late recreation season. Travel cost is the most important variable explaining recreational use patterns, while income is important but in the opposite direction than expected.² The variable representing the availability of alternate recreation sites proved insignificant but positive indicating substitutability rather than complementarity. Water surface elevation and rainfall do not enter this equation in any meaningful way. Apparently, the fluctuation of each reservoir is related to that of all the others and weather patterns do not differ markedly between the reservoirs. The low R^2 is partially due to the large number of degrees of freedom, 2055, and the small number of variables.

²See page 35 for possible interpretations of this result. Hansen and Brown [26] had similar results with California data.

The Reservoir Demand Equations

One estimated equation for Beaver Reservoir is

$$\begin{aligned} \ln X_{ij} = & -.032 + \frac{.024X_2}{(4.45)^2/X_1} - \frac{1050.84X_3}{(-2.46)^3/X_1} + \frac{.207X_4}{(2.49)^4/X_1} \\ & \frac{45.54X_7}{(8.11)^7/X_1} + \frac{86.59X_8}{(15.32)^8/X_1} + \frac{.883X_{5b}}{(.76)^{5b}/X_1} \\ R^2 = & .809. \end{aligned} \quad (16)$$

All of the variables, except the water surface elevation variable X_{5b} , proved to be significantly different from zero at a ninety-five percent level of confidence. The coefficient of income proves to be positive for Beaver Reservoir. Unfortunately, the coefficient of variation in water surface elevation proves neither significant nor of the right sign. The hypothesis that fluctuation in water surface elevation at Beaver Reservoir is an adverse influence must be rejected on the grounds of this investigation. However, a second equation was estimated which proved adequate in terms of explanatory power (R^2).

$$\begin{aligned} \ln Y_{ij} = & 3.85 - \frac{1.16 \ln X_1}{(-15.7)^1/X_4} - \frac{.94 \ln X_2}{(-5.46)^2/X_4} \\ & + \frac{.23 \ln X_3}{(1.32)^3/X_4} + \frac{.15X_7}{(1.12)^7} + \frac{.802X_8}{(6.34)^8} - \frac{.132 \ln X_{5a}}{(-1.5)^{5a}} \\ R^2 = & .62. \end{aligned} \quad (17)$$

In equation (17) X_{5a} is used as the independent variable representing water surface fluctuation. This form of the

variable is reported throughout the remainder of this study. The variable X_{5a} is defined as the total range of water surface elevation for a reservoir over one season. This measure is superior to either X_{5b} , the average water surface elevation for a season, or X_{5c} , the average difference between water surface elevation (daily) and the top of conservation pool for that reservoir. X_{5a} is more representative of the kind of fluctuation that would affect recreation use. A large range of fluctuation will indicate large changes in shoreline and may therefore decrease use. Average water surface elevation, X_{5b} , is an inferior measure because high or low averages give no indication of changes in shoreline or characteristics. Finally, X_{5c} has merits because it measures the difference between daily water surface elevation and a reference point, top of conservation pool. However, X_{5a} gave superior statistical results in addition to being a priori superior. In equation (17) the coefficient of X_{5a} proves insignificant but has the correct sign, i.e., the negative sign indicates that the fluctuation of water surface will have an adverse effect on use. Since the coefficient is not significantly different from zero in either formulation, the hypothesis that water surface fluctuations have a measurable effect on use must be rejected. Again, this equation indicates that

the elasticity of recreation use with respect to income is negative.

For the remainder of the reservoirs the results were not as good in terms of test statistics, but in general, the results are similar. For Bull Shoals the "best" equation is

$$\begin{aligned} \ln Y_{ij} = & 4.59 - 1.13 \ln X_1 / X_4 - 1.14 \ln X_2 / X_4 + 2.39 \ln X_3 / X_4 \\ & \quad \quad \quad (-10.5) \quad \quad \quad (-4.9) \quad \quad \quad (.96) \\ & + .596 X_7 + .89 X_8 - .038 \ln X_{5a} \quad R^2 = .47. \quad (18) \\ & \quad \quad \quad (3.59) \quad \quad \quad (6.0) \quad \quad \quad (-.46) \end{aligned}$$

All of the explanatory variables except availability of alternatives and water surface elevation are significantly different from zero at the ninety-nine percent level of confidence. Again, the coefficient of income is negative and the coefficient of X_{5a} is negative, the correct sign, and insignificant. At Bull Shoals Reservoir the hypothesis that fluctuation in water surface elevation has a measurable adverse effect on recreation use of the reservoir is again rejected.

For Greers Ferry the "best" equation is

$$\begin{aligned} \ln Y_{ij} = & -.52 - .89 \ln X_1 / X_4 - 1.90 \ln X_2 / X_4 - .73 \ln X_3 / X_4 \\ & \quad \quad \quad (-10.2) \quad \quad \quad (-7.7) \quad \quad \quad (-3.7) \\ & + 1.126 X_7 + 1.377 X_8 - .372 \ln X_{5a} \quad R^2 = .41 \quad (19) \\ & \quad \quad \quad (4.8) \quad \quad \quad (7.6) \quad \quad \quad (-2.07) \end{aligned}$$

All of the variables in this equation are significantly different from zero at the ninety-nine per cent level of confidence. As usual, travel cost proves to be the most important variable explaining use. Income remains a negative influence and the coefficient of the variable representing availability of alternatives is negative and significant. This result is difficult to interpret but plausible. Since Greers Ferry reservoir is the closest of the five reservoirs to Little Rock and furthest from the other reservoirs it presents a different situation. Other recreation sites within one hundred miles of the county point of origin may be complements in the sense that fewer available reservoirs may lead to decreased exposure to this kind of recreation and therefore to lower use from that county. The other four reservoirs are clustered together and this would indicate substitutability as does the statistical analysis. The two dummy variables are positive as expected. This is the only equation estimated in this study which shows the coefficient of water surface elevation, in whatever form, to be significantly different from zero. In addition, the coefficient has the correct sign. It must be concluded that changes in water surface elevation have a measurable adverse effect on the recreational use of Greers Ferry Reservoir (however small that effect might be).

The "best" equation for Norfolk Reservoir is

$$\begin{aligned} \ln Y_{ij} = & 9.11 - 1.5 \ln X_1 - 1.17 \ln X_2 + .84 \ln X_3 \\ & \quad \quad \quad (-13.8)^1 \quad \quad \quad (-4.4)^2 \quad \quad \quad (3.8)^3 \\ & + .21 X_7 + .87 X_8 + .158 \ln X_{5a} \quad R^2 = .56 \quad (20) \\ & \quad \quad \quad (.79)^7 \quad \quad \quad (4.4)^8 \quad \quad \quad (.66)^{5a} \end{aligned}$$

Here, travel cost is as expected and income is negative as before. The significant coefficient of the availability of alternatives indicates that the other reservoirs in the system are substitutes rather than complements. At Norfolk, the estimation indicates water surface fluctuation does not significantly affect recreation use.

The best equation for Table Rock Reservoir is

$$\begin{aligned} \ln Y_{ij} = & 20.9 - .876 \ln X_1 - 3.13 \ln X_2 + 1.4 \ln X_3 \\ & \quad \quad \quad (-8.2)^1 \quad \quad \quad (-15.8)^2 \quad \quad \quad (5.9)^3 \\ & + .144 X_7 + .515 X_8 - .158 \ln X_{5a} \quad R^2 = .54 \quad (21) \\ & \quad \quad \quad (.90)^7 \quad \quad \quad (3.6)^8 \quad \quad \quad (-1.1)^{5a} \end{aligned}$$

The results for Table Rock are generally the same as before, with travel cost and income important and negative. Alternatives appear here as substitutes and the effect of water surface fluctuation is negative but insignificant.

Only in the case of Greers Ferry does water surface elevation seem to be an important determinant of recreational use of a reservoir. This may be explained in the following ways: First, Greers Ferry Reservoir is nearer Little Rock, Arkansas than the other reservoirs so it is

visited on a shorter term basis than other reservoirs which are further from major population centers. Less planning and preparation enter the decision making process for short trips than for long ones but satisfaction hinges more on the pleasantness of the short visit. Under these circumstances large fluctuations in water surface elevation will have a definite effect on recreation use. To the extent that short trips are more difficult to undertake to the four other reservoirs (even with good access highways the trip takes a substantial part of a day) visitors are less likely to be discouraged by poor conditions. If conditions are extremely poor (e.g., very large fluctuations) even visitors who plan to travel long distances may be discouraged. Second, larger fluctuations in water surface elevation at peak recreation demand periods may have led to a larger effect on recreational use at Greers Ferry. That is, the water surface elevations of the other four reservoirs move, more or less, in unison while Greers Ferry is somewhat independent.

Several other equations were estimated in an attempt to find some measurable relationship between water surface elevation and recreational use of the reservoirs. These are models of user-response based on a productive relationship between characteristics of the reservoirs and

recreation use [23]. These equations are not demand equations since the price and income variables have been deleted. In general, these equations were no more fruitful in demonstrating a relationship between water surface elevation and recreation use than the equations above. The following two equations are offered as examples:

$$y = 11.88 + \frac{.63X_7}{(7.66)} + \frac{1.43X_8}{(17.2)} + \frac{.022X_{5b}}{(1.08)} + \frac{.04X_9}{(1.57)} + \frac{.001X_{12}}{(5.3)} - \frac{.006X_{15}}{(-1.2)} \quad R^2 = .877 \quad (22)$$

$$\ln y = 8.33 + \frac{.63X_7}{(8.2)} + \frac{1.43X_8}{(18.8)} + \frac{.07 \ln X_{5a}}{(1.25)} - \frac{.008 \ln X_9}{(-.02)} + \frac{.22 \ln X_{13}}{(2.7)} + \frac{.37 \ln X_{14}}{(3.3)} + \frac{.08 \ln X_{15}}{(1.4)} \quad R^2 = .899 \quad (23)$$

The equations have adequate explanatory power, in terms of R^2 , but have little interest because only the dummy variables have coefficients significantly different from zero.

The demand functions estimated in this study would be useful for benefits estimation in the following way. A hypothetical entrance fee is instituted and increased by small increments. At each level of fee the number of recreationists expected from each county is noted. The process is continued until the vertical axis is reached (or approached). The total level of benefits would be the area under the curve traced out by the plot of total users

at each level of fee. Benefits could be easily estimated by multiplying the number of recreationists at each level of fee by that amount of fee and summing over all levels of fee. This estimate would not be exact but as the increments are made smaller and smaller the benefits estimated in this way would approach the area under the demand curve.

Conclusions

The original contract proposal indicated an intent to investigate the relationship between certain operating characteristics of reservoirs and their use for recreation. This exploration succeeded in finding no quantifiable or empirically relevant relationship except in the case of Greers Ferry Reservoir. In most cases the coefficient of water surface elevation was either of the wrong sign, not significantly different from zero, or both. A priori it would be expected that changes in water surface elevation would be negatively related to recreation use but some coefficients proved to be positive. This result came even though several forms of the water surface elevation variable were used. These included: measures of the range of fluctuation over a time period, mean elevation, mean difference between elevation and top of conservation pool,

and several manipulations of fluctuation and mean elevation. The results are also inclusive of several approaches to the problem of finding the relationship between elevation, or drawdown, and recreation use. One approach was to include the variable in one of the different forms of demand equations for recreation estimated for each reservoir. In addition, total recreation use, instead of county point of origin use, was the dependent variable in an estimation of user response to a variety of reservoir specific measures. The conclusion must be that, except in the case of Greers Ferry Reservoir, water surface elevation fluctuation has little, or no, measurable effect on the recreational use of the reservoirs in the Little Rock District.

This conclusion was confirmed by both reservoir and Little Rock District representatives of the Corps of Engineers. They agreed that fluctuation in water surface elevation seemed to have little effect on recreation use of the different reservoirs. The resident engineers indicated that complaints increased with increased fluctuation but most of these came from boat dock owners and concessionaires. In general, it would seem that changes in water surface elevation which did not exceed some limit, say ten feet in one week, would have little effect on recreation use. However, larger and more rapid changes would probably have very perceptible effects. Unfortunately, to find out if

this was true one would need to measure both changes in water surface elevation and recreation use much more frequently than does the survey on which this study is based. In addition, the fluctuations during the survey period would have to be larger. So, on the policy level, the conclusion of this study would be an indication that relatively small changes in water surface elevation will have effects small enough to be ignored. However, in the specific case of Greers Ferry Reservoir the trade off between electricity operating revenues and recreation use should be considered in day-to-day operations.

The availability of alternatives is an important determinant of recreation use at Greers Ferry, Norfolk and Table Rock. At Greers Ferry the statistical analysis indicates that the relationship is complementary while at the others substitutability is indicated. Rainfall, or weather, does not show up as a significant determinant of recreation use. If the survey was taken more often the statistical analysis would probably indicate a definite relationship between recreation use and rainfall.

Two further conclusions stand out. First, the travel cost variable is the most important determinant of the per capita recreation use of reservoirs in the Little Rock District. This result is in agreement with other studies

in other locales. Population is also important but its effect is proportional to size of population and does not seem to affect per capita visitation rates. Second, the effect of income seems to be blurred by the method of obtaining an observation for income of the recreationist. A better way to assess the effects of income would be to include a question concerning the income level of the recreationist in the actual survey. Personal communication with representatives of the Corps of Engineers indicated that a relationship such as the one found statistically is possible. That is, richer recreationists may prefer other types of recreation over reservoir recreation. However, as incomes rise over time it is most likely that recreational use of existing reservoirs will also rise.

Suggestions for improving the sample data would include the following: First, add a question concerning the level of income of the recreationist. This question could be phrased in a variety of ways but best results seem to come from questions asking for a range of income rather than exact income (i.e., \$10 - \$12,000). Second, increase the number of sample days and institute a follow-up survey. Third, include a question such as: "Did you consider the level of the water surface at _____ Reservoir before visiting that reservoir? If so, what

source did you use to find out what the level of the reservoir was?" Such a question might shed additional light on the relationship between water surface elevation and recreation use. Fourth, include a question, or questions, to determine whether alternative recreation sites were considered and if so why the present site was chosen.

To make this particular study more useful, more socioeconomic variables could have been included. In addition, the new information included in the 1970 Census would be valuable in determining the importance of differences in socioeconomic characteristics of counties. Completely correct specification of the model should also include the addition of variables representing water quality, attractiveness of the site, fishing potential and other determinants of popularity. In most cases, the water surface elevation variable and the weather variable could be deleted. This decision would, of course, depend on the characteristics of the site. With these changes, the model presented here would be a useful tool for planning and operating public water projects.

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