RESERVOIR EUTROPHICATION AND THE VALUE OF RECREATIONAL ACTIVITIES: A CASE STUDY OF FLAMING GORGE RESERVOIR

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CHAPTER 1

INTRODUCTION

Flaming Gorge Reservoir is located in southwestern Wyoming and northeastern Utah. (See Figure 1) The reservoir's 42,000 surface acres make it the ninth largest fresh water body in the five-state intermountain region of Idaho, Utah, Colorado, Wyoming and Montana. Its size, and reputation as a trout fishery, attract fishermen from many locations throughout the intermountain region. In the 1970's Flaming Gorge became a nationally renown trout fishery producing a world record brown trout in 1977. In recent years the reservoir has become well known for the large lake trout it produces. A wide variety of other recreationists are also attracted to Flaming Gorge by the scenic beauty of the area, particularly at the southern end of the reservoir.

Flaming Gorge Dam was built in 1962 by the U.S. Bureau of Reclamation to impound water from the Green River. The reservoir serves the purpose of storing water for irrigation and power production. Because of its size, the reservoir is also utilized as a multipurpose recreational area providing a base for such activities as fishing, boating, waterskiing, and swimming. The reservoir is surrounded by 201,114 acres of public land so there is ample space for other types of recreational activities such as camping and hunting. Both the reservoir and the public land surrounding the reservoir constitute a National Recreation Area which is operated by the joint efforts of the U.S. Forest Service and the Bureau of Land Management. Wyoming Game and Fish and Utah Division of Wildlife are responsible for fisheries management in the reservoir.

Flaming Gorge Reservoir has nine major boat ramps, three of which have marinas. (See Figure 2) Six of the boat ramps also have developed camping facilties and there are several other camping facilities near the reservoir. Due to its size, the reservoir is generally divided into three distinct areas

Figure 1. Location of Flaming Gorge Reservoir

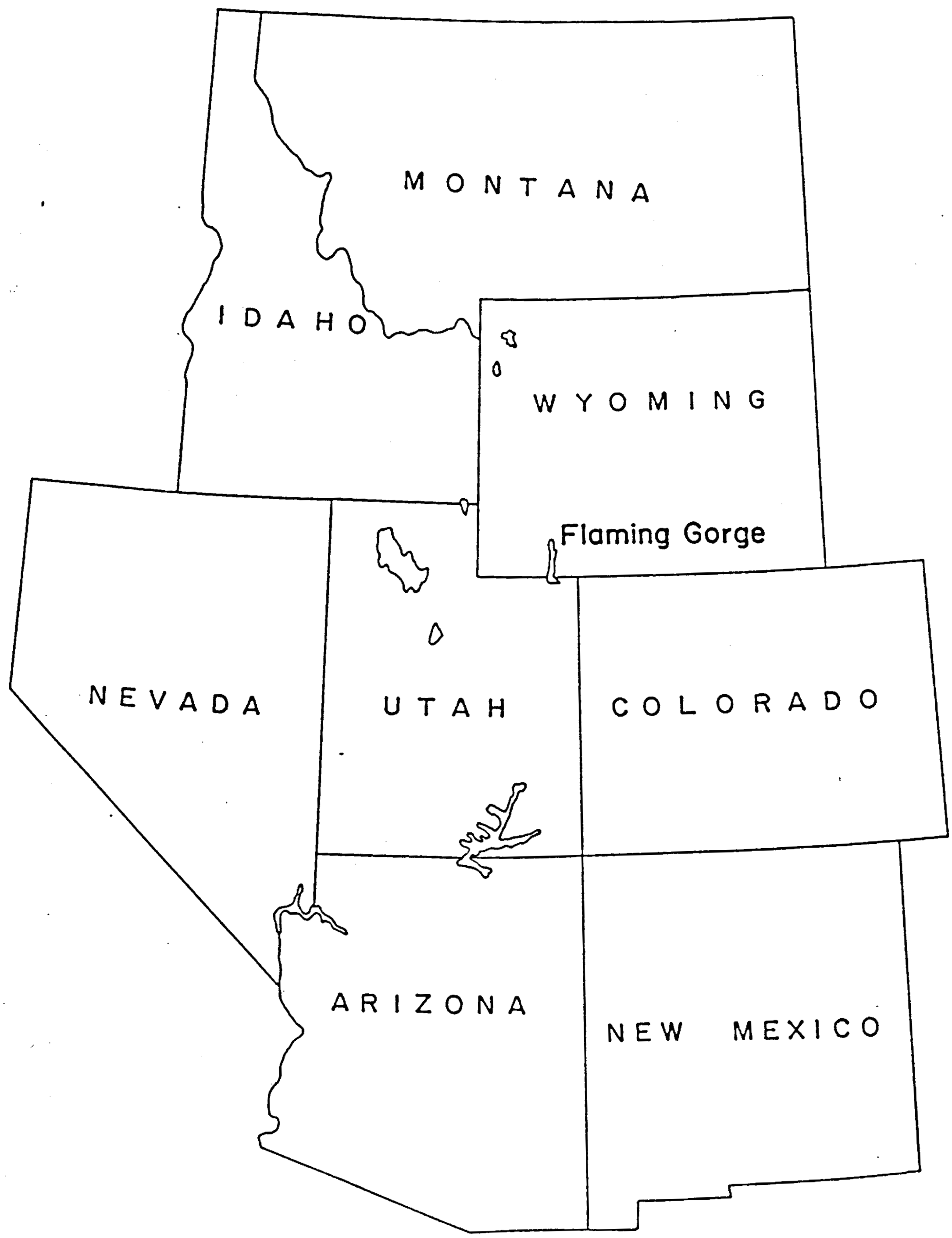
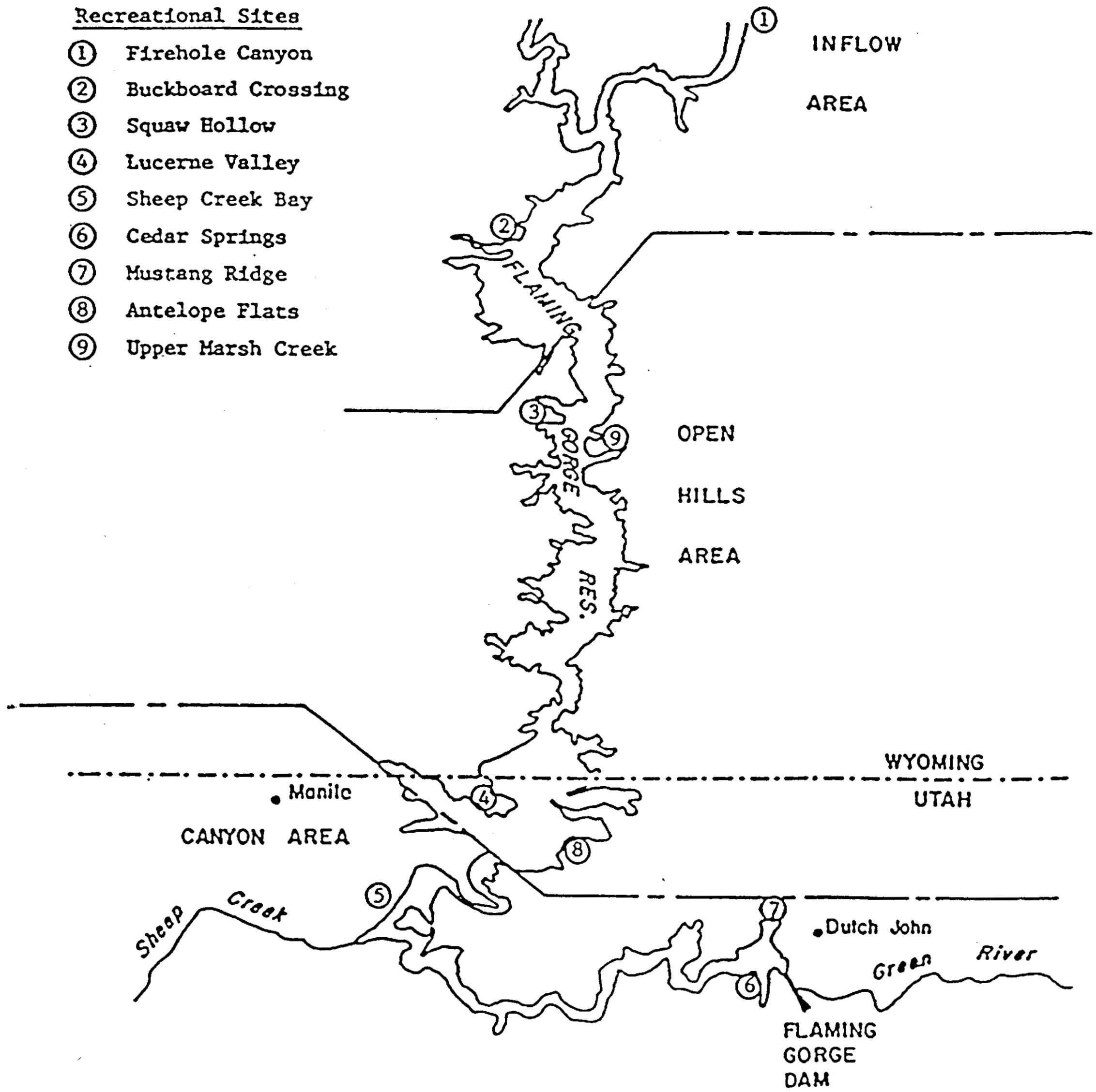


Figure 2. Recreational Sites at Flaming Gorge Reservoir



based upon topography, geology, hydrographic features, limnology, and distribution of fish. These are the Inflow area, Open Hills area, and Canyon area (Wengert 1985). (See Figure 2)

STATEMENT OF PROBLEM

Physical Problem

In recent years, Flaming Gorge Reservoir has experienced eutrophication. Eutrophication is the nutrient enrichment of waters which results in increased algae production. One type of algae produced in the eutrophication process is Aphanizomenon, one of the bluegreen algae. Bluegreen algae is an undesirable algae growth due to its potential impact on a lake or reservoir. Some consequences of bluegreen algae growth are a degradation of fish habitat and risk of fish mortality due to oxygen depletion, an increase in municipal water treatment costs, and a reduction in use of a reservoir for recreational purposes.

In most cases eutrophication of reservoirs has been associated with increased levels of phosphorus; however, nitrogen also has a role in eutrophication. Bluegreen algae blooms are common in late summer and early fall when nitrogen is limited and phosphorus is abundant. Under these conditions, and with the warmer water temperatures during this time of year, bluegreen algae, with its ability to fix atmospheric nitrogen, are able to thrive (Hubert et al 1984).

Phosphorus loading of reservoirs can initiate from both point and non-point sources. Point sources include effluents from municipal and industrial sites, while non-point sources include run-off from agricultural lands and urban areas. The highest percentage of phosphorus loading in most reservoirs is attributable to natural and man-made erosion.

The U.S. Environmental Protection Agency's National Eutrophication Survey (1975, 1978b, 1978c) indicated that most large reservoirs in the United States have encountered nutrient loading. While eutrophic conditions (i.e. excessive nutrients) are relatively common, bluegreen algae blooms in large reservoirs are relatively rare. Among the 170 reservoirs included in the Environmental Protection Agency's National Survey, 69% were classified as eutrophic but only 12% experience large blooms of bluegreen algae. Thus, it appears that factors in addition to nitrogen and phosphorus levels govern the development of bluegreen algae blooms (Hubert et al 1984). Eutrophication is generally more severe in reservoirs than in streams and rivers. The reason for this is that reservoirs retain the water and nutrients for a much longer period, making nutrients more readily available to aquatic plants.

Eutrophication in Flaming Gorge Reservoir has resulted in the undesirable bluegreen algae blooms. Flaming Gorge Reservoir was among the 12% of reservoirs in the National Eutrophication Survey designated as having large blooms of bluegreen algae. Increases in this type of bloom caused the Wyoming Department of Environmental Quality to declare the reservoir the number one surface water quality problem in Wyoming in 1983 and the algal blooms have persisted since that time.

Because the reservoir is surrounded by a large amount of grazing and forest land, the influx of phosphorus is attributed mostly to erosion from these lands. Results of the U.S. Environmental Protection Agency's National Eutrophication Survey in 1979 indicated that 79.3% of the reservoir's phosphorus loading is due to erosion (Hubert et al 1984). The remaining phosphorus comes mostly from effluents generated by municipal and industrial waste disposal in cities at the northern end of the reservoir; however, unpublished results of recent water quality studies indicate the portion from this source has increased in recent years (Parker 1987). The algal blooms that have caused concern for the various agencies managing Flaming Gorge

Reservoir have been concentrated in the northern end of the reservoir (Inflow area) during the late summer months. The shallower waters in this part of the reservoir allow for warmer water temperatures which are conducive to algae growth.

Economic Problem

Hubert et al (1984) stated that eutrophication has negatively affected water based activities at the upper end of Flaming Gorge Reservoir. The thick blooms of algae on the water surface can discourage recreational activities such as boating, waterskiing, and swimming. Also, in a study by Wengert (1985), it was noted that oxygen and temperature measurements taken during the period of 1977-1983 indicated a loss of summer trout habitat in parts of the Inflow area due to lack of oxygen in preferred temperature zones. Thus, there is a potential reduction in fishing activities due to the decreased fish population at this end of the reservoir.

While identifying the connection between eutrophication and recreation activity on Flaming Gorge, Hubert et al (1984) and Wengert (1985) did not attempt to estimate the potential economic losses associated with eutrophication. From a recreational standpoint, economic losses would occur if individuals' recreational activities are altered or reduced as a direct consequence of the eutrophication process.

Measures have been proposed to mitigate eutrophication and its effects on reservoirs. The feasibility of control would be enhanced if further investigation were to find that the costs of control actions are less than the value of recreational activities potentially affected by eutrophication. Estimating the costs imposed by eutrophication is synonymous to estimating the benefits from controlling eutrophication. Thus, determination of the value of current and potential lost water-based recreational activities could expedite the decision-making process regarding actions that may be taken to control eutrophication in Flaming Gorge Reservoir.

OBJECTIVE

The primary objective of this study is to estimate the value of recreational activity at Flaming Gorge Reservoir. With this value the economic loss from any reduction in recreational activity associated with eutrophication can be assessed. In order to estimate the value of recreational activity three secondary objectives must be met. They are:

1) Review and evaluation of alternative valuation methods that have been used to estimate the benefits from recreational activities;

2) Selection of a particular valuation method appropriate for the water quality and recreational situation at Flaming Gorge Reservoir;

3) Development of survey procedures for determining the current and potential impact of eutrophication on water-based recreation (i.e., what activities have been affected by algae, what alternative site would be used if algae precluded use of a particular site?).

Section two of this study provides a review of the literature on valuation methods for estimating the economic benefits of recreational resources. Section three describes the methodology used to estimate the benefits from recreational activity at Flaming Gorge Reservoir as well as the potential loss in benefits stemming from eutrophication. A discussion of survey procedures used to elicit the necessary information from recreational users is also presented in this section. Section four discusses the results of the survey and presents the estimates of the benefits from recreation at Flaming Gorge as well as the loss in benefits due to eutrophication. Finally, section five provides a summary of the results and the conclusions of the study.

This study is concerned only with estimating the value of recreational activities at Flaming Gorge Reservoir and the potential loss in these benefits resulting from eutrophication. Estimation of other costs associated with the eutrophication problem in Flaming Gorge Reservoir is beyond the scope of this study. For example, the blue-green algae do have the potential to become toxic which, if consumed, could result in the loss of animal life. Costs associated with this consequence are not assessed in this study. Also, since eutrophication is prevalent in the northern end of the reservoir, recreation benefit estimates are limited to recreation on the reservoir. The recreation taking place on the Green River below Flaming Gorge Reservoir and along the Canyon Rim, as well as hunting activities on land surrounding the reservoir, are not considered in this study. Thus, the value estimates devised in this study do not represent the value of the total recreation opportunities available in the Flaming Gorge National Recreation Area.

CHAPTER 2

> "The value of recreation offered at a particular facility or site is not what consumers spend each year on travel and on recreation equipment. Rather, it is what the recreation provided by that site adds to our total stock of value or welfare." (Clawson and Knetsch 1966)

VALUATION METHODS

Empirical research on the economic value of outdoor recreation and natural resources has a relatively short history (Walsh 1984). A seminal work on the value of recreation entitled, "Methods of Measuring the Demand for the Value of Outdoor Recreation" was presented in 1959 by Marion Clawson. Public regard for the value of outdoor recreation and natural resources was indicated in 1962 through a Senate document which established benefit-cost methods to be used in planning water and related resource development by federal agencies (U.S. Senate 1962). In 1964, the U.S. Water Resources Council was established to administer the benefit-cost guidelines. Also at this time, a method for establishing economic values for outdoor recreational experiences was authorized for use by federal agencies, a method known as unit day values.

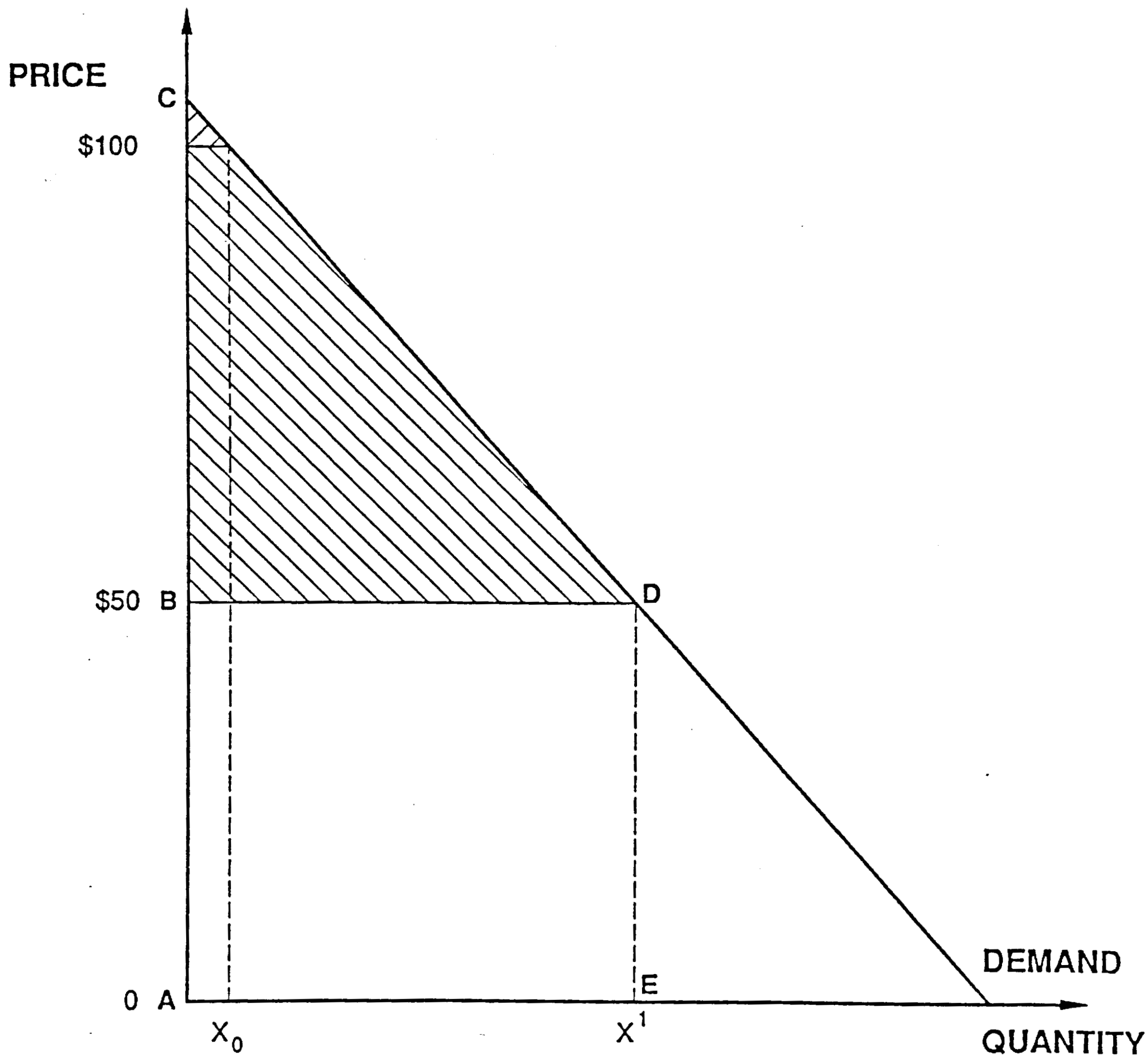
Since 1964 there have been many revisions to the guidelines established. Notable among these revisions is the addition of two other methods of evaluating the economic benefits from outdoor recreational experiences and natural resources. In 1973 the Water Resources Council authorized use of the travel cost method, a method first discussed in Clawson's 1959 study, and in 1979 the contingent value method was approved. Although the U.S. Water Resources Council's (1979, 1983) guidelines are often referred to in discussions of valuing outdoor recreation and resources, other federal agencies (i.e.. Forest Service, Bureau of Land Management) have similar guidelines for valuing recreational experiences and resources under their jurisdiction. The addition of the travel cost and contingent valuation methods to many federal agencies' valuation procedures indicates the growing significance resource agencies have placed on economic measures of natural resource/recreational benefits.

In evaluating recreation/resource benefits, a problem arises because, unlike goods exchanged in the private market, natural resources and recreational activities do not have prices determined by the forces of supply and demand. Prices for these goods are determined by the management agency rather than market forces and in fact, they are referred to as non-market goods. As a consequence, the true value to the consumer of a natural resource or recreational activity may not always be reflected in the user fees established by government agencies.

The value of a good exchanged in the private market is determined from its demand curve which reflects individuals' "willingness to pay" for that good. In economics, the standard measure of value for a good is consumer surplus which is defined as the difference between what an individual is willing and able to pay for a good and what he actually has to pay for the good. This concept is illustrated in Figure 3, which displays a demand curve for a particular good.

In Figure 3 equilibrium is reached at $50 where the supply of good X equals the demand for good X. In a competitive market situation, because the price of a good is assumed constant no matter how many units of the good are purchased, the supply curve, or cost curve for individuals, is horizontal. The equilibrium quantity is X^1. The demand curve shows that some consumers are willing and able to pay $100 for the first unit of good X (X^0). However, since good X only costs $50 they experience a surplus of value of $50 for that unit. Total consumer surplus for the good, or equivalently its economic value, is derived by adding up the individuals' consumer surplus for each unit of the good consumed. This summation is approximately the area under the

Figure 3. Consumer Surplus of Good X



demand curve above the price line, the shaded area of Figure 3 (BCD). The area below the price line (ABDE) is the amount individuals actually pay for the amount of good X consumed.

Consumer surplus then, is a net value figure. It is that part of the total value that reflects people's additional willingness to pay for a good if faced with the possibility of having to forgo use of the good. The total worth of good X would be the entire area under the demand curve (ACDE). Because actual expenditures are a part of the total value of a good, they are important in terms of the impact they have on local economies. Expenditures can be used to calculate the multiplier effects of consumption of the good on local income and employment. However, if individuals had to forgo use of good X, expenditures incurred for the good would either be spent elsewhere or saved. Resources would simply be transferred within the economy. The consumer surplus amount, however, is what would be lost if the good were not available. It is a better reflection of the economic value of a good to society since it represents the "additional" value to society created by having the good available. Consumer surplus is also referred to as the net benefit of a good.

In order to establish a value for recreational activities it is necessary to establish a measure of consumer surplus for a recreational resource. The three methods currently recommended by the Water Resources Council as providing acceptable economic measures of the value of recreation activities and natural resources are the unit day value, the travel cost, and contingent valuation method. The values derived by the three methods are considered to be equivalent to consumer surplus.

In his book Walsh (1984, p. 244) states:

> "While any one of (the three methods) may provide a satisfactory measure of the value of a particular outdoor recreation site (or recreational experience), a problem arises when the results of alternative approaches are compared. Thus far, no standard

approach to estimation of the value of outdoor recreation has been developed that is suitable for all purposes of measurement. Thus, it is important to understand when each measure should be used and how to adjust the results of each to compare it with other measures."

The following will discuss in detail the three valuation methods.

UNIT DAY VALUES

Since the introduction of the unit day value method in 1964 most federal agencies have used the procedure to estimate the value of recreational resources. The unit day value method basically consists of choosing a value for a recreational activity from a range of unit day values, such as those provided in the Principles and Standards of the Water Resources Council, and multiplying that value by an estimate of expected use. The National Forest Service provides similar unit day values as the Water Resources Council.[1]

The Water Resources Council classifies outdoor recreation into two categories, "general" and "specialized". The categories are described in Dwyer et al (1977, p. 22) as:

GENERAL: A recreation day involving primarily those activities attractive to the majority of outdoor recreationists and which generally require the development and maintenance of convenient access and adequate facilities. This includes the great majority of all recreation activities associated with water projects such as swimming, picnicking, boating, and most warm water fishing.

SPECIALIZED: A recreation day involving primarily those activities for which opportunities in general are limited, intensity of use is

[1] Unit day values were intended to be a temporary method for valuing recreation "pending the development of improved pricing and benefit evaluation techniques." It is officially known as the Interim Unit Day Value method. However, it is still currently used by federal agencies despite the development of alternative valuation procedures. The continued use of it is usually attributable to the lower amount of time and resources involved.

low, and which may also involve a large personal expense by the user. Included are activities less often associated with water projects, such as big game hunting and salmon fishing

With the unit day value method, values for recreational sites are assigned based on the type of recreational experience available at the site, general or specialized, and on how well the site meets the five criteria recommended by the Water Resources Council to measure the "quality" of an experience. The five criteria as presented in Walsh (1984, p. 282), are:

1) Quality of the recreational experience as affected by congestion;
2) Availability of substitute areas (in hours of travel);
3) Carrying capacity as determined by level of trail development;
4) Accessibility as affected by road and parking conditions;
5) Environmental quality, including forests, air, water, pests, climate, adjacent areas and aesthetics of the scenery.

Each criteria is given a point value, with the total number of points possible being 100. These points are then translated into appropriate dollar values. The higher the "quality" of the site the higher the value assigned. Also, the more specialized the experience at the site the higher the value assigned.

In 1982, the Council recommended values ranging from $6.10 to $17.90 per day of specialized recreation, including wilderness use. General recreation values were somewhat lower, $1.50 to $4.50 per day (Walsh 1984). Thus, the value of a recreational site that offers a "general" recreational experience would be determined by choosing a value between $1.50 and $4.50, depending on its "quality", and multiplying it by the number of recreation visitor days. A recreation visitor day (RVD) is conventionally considered to be a 12-hour period of recreation. Thus, a visitor day could be measured as one individual recreating for 12 hours or three individuals recreating for four hours.

Initially based on a 1962 survey of entrance fees at private recreation areas, unit day values have been adjusted for changes in the consumer price index to the present. Because they are based on private entrance fees, unit day values are considered a reflection of the value of consumer surplus stemming from use of a site which offers a certain kind of recreational experience.[2]

The use of a recreational site depends on a number of factors. Some of these factors are the distance from an individual's origin to the site, the cost of travel, household income, availability of substitute sites, and the attractiveness of the site. The need to reflect attractiveness in recreation benefit estimation has been one of the major arguments for continued use of the unit day value approach, which places prime emphasis on a planner's judgement. Thus, it is felt by some that a personal assessment of a site's attributes by a recreation expert is the best way to measure the importance of aesthetics when estimating a value for a recreational site or resource.

There has been a good deal of criticism of the unit day value method. Some argue that the problem with this approach is that these measures are based on a "feel" for demand rather than any real measurement of it (Ravenscraft and Dwyer 1978). An additional problem with this approach is that recreation specialists may not reflect the preferences of site users. Empirical studies have indicated that professional recreation specialists may not evaluate sites in the same manner as recreationists. Consequently, what the manager judges to be a pleasing recreational environment may be entirely different from what the recreationists seeks (Ravenscraft and Dwyer 1978).

A couple of other criticisms of the unit day value method noted in Dwyer et al (1977, p. 23) are:

1) The range of unit day values provided is wide and no clear guidance is specified for selecting values within that range. As a result,

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[2] In recent years Forest Service unit day values are based on periodic review of current studies using the travel cost and contingent valuation methods (Walsh 1984).

the value chosen is likely to show little economic reality and will thus almost certainly lead to a misallocation of resources.

2) Procedures for updating the ranges of unit day values are not provided. Adjusting the range upward to account for inflation does not necessarily solve the problem since, over time, the supply and demand may have risen at different rates for recreation activities than for other goods and services.

Because there has been significant criticism of the unit day value method in recent years, alternative methods such as the travel cost and contingent value methods have been encouraged. Although reliance on the unit day value method is expected to decrease in the future, it is still considered a valid means to determine the economic value of benefits from recreation activities and resources (Walsh 1984).

TRAVEL COST

One method available to economists and resource planners as an alternative to the unit day value approach is the travel cost method. The travel cost approach is based on the concept that travel costs to a recreation site can be used as a proxy for price in the derivation of a demand curve for a recreation site.

The theoretical concepts underlying the travel cost method were first introduced in 1947 by Harold Hotelling, a resource economist, in a letter to the National Park Service (Prewitt, 1949). Refinements to the travel cost method were subsequently made by a number of economists most notably: Clawson (1959), Clawson and Knetsch (1966), Cesario and Knetsch (1970), Burt and Brewer (1971), and Knetsch, Brown, and Hansen (1974).

Historically, the travel cost method has been preferred by most economists when estimating recreational benefits since it is based on observed market behavior. The travel cost method is developed by using actual observations on use and user characteristics from various origins (i) to a site (j). The wide range of costs facing individuals at different distances from a site provides considerable information about the influence of costs on participation. This information can be used to generate a demand curve (Dwyer et al 1977). The basic premise of the approach is that the number of trips to a recreation site will decrease with increases in distance traveled, all other things remaining constant. Most current applications of the travel cost approach consider both direct out-of-pocket and time costs of travel.[3]

The travel cost model can be described generally by an expression such as:

$$V_{ij} = f(C_{ij}, P_i, S_{ij}, D_i, A_j)$$

Where:

V_{ij} = the number of site visits or trips from a population center i to recreation site j

C_{ij} = the cost of travel between the origin i and the site j, including time costs of travel and entry fees

P_i = the population of origin i

S_{ij} = an index of the proximity and/or attractiveness of substitute recreation areas available to each population center i relative to site j

D_i = various socioeconomic variables that may influence demand for the recreation for each population center i

A_j = an index of characteristics that account for the attractiveness of the recreation site j

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[3] Direct, out-of-pocket costs include only those costs that would vary with the distance traveled. Thus, major expenses for equipment useful for many trips, or multi-purpose trips, are not charged to travel cost. Also, when cost changes are made, the travel cost model accounts for the differences in time spent driving to a recreation site. Assuming that people place some value on time spent driving, travel time to a recreation site can be considered a cost just like the money expended for gas, oil, etc. When travel time is not accounted for in estimation of a demand curve for a recreation site, the consequence is an overstatement of the reduction in visits when travel costs are increased. This, in turn, results in an underestimate of benefits, assuming there is no positive utility from the time spent driving to the recreation site (See methodology section).

Several assumptions underlie the travel cost method and have been set forth in various studies, most notably Dwyer et al (1977). Most important, is that the distance traveled to a recreation site must vary among users. Without sufficient variation in travel distances to a recreational area statistical estimates of the relationship between the cost of travelling (price) and number of trips (quantity) is not possible, or at least would not yield meaningful results. The other major assumptions of the travel cost model as specified in Dwyer et al. (1977, p. 82) are:

1) Individuals will react to an increase in entry fees in the same manner as to an increase in travel costs;[4]

2) There is no unobserved demand that is unsatisfied due to capacity restrictions (i.e., individuals are not turned away from a recreational area because it is full);

3) All relevant and statistically significant variables which affect trip making behavior are properly specified in the travel cost model

As described previously, the value of a recreational resource is measured by the consumer surplus for that resource. Theoretically, each origin (i) has a demand and supply curve for a particular recreational site (j). Because the cost of a trip is not dependent on the number of trips taken, the supply curve (or cost line), for a given region, is horizontal. Also, because distances vary for different origins, horizontal supply curves will vary in height since those closer in face lower travel costs and vice-versa. (see Figure 4a) This results in origins of varying distances having different amounts of consumer surplus since consumer surplus is the area under the demand curve and above the supply curve, the shaded areas in Figure 4a. The intersection of the demand and supply curve (points A, D and G) is the observed number of visits (trips) to the recreation site for each origin.

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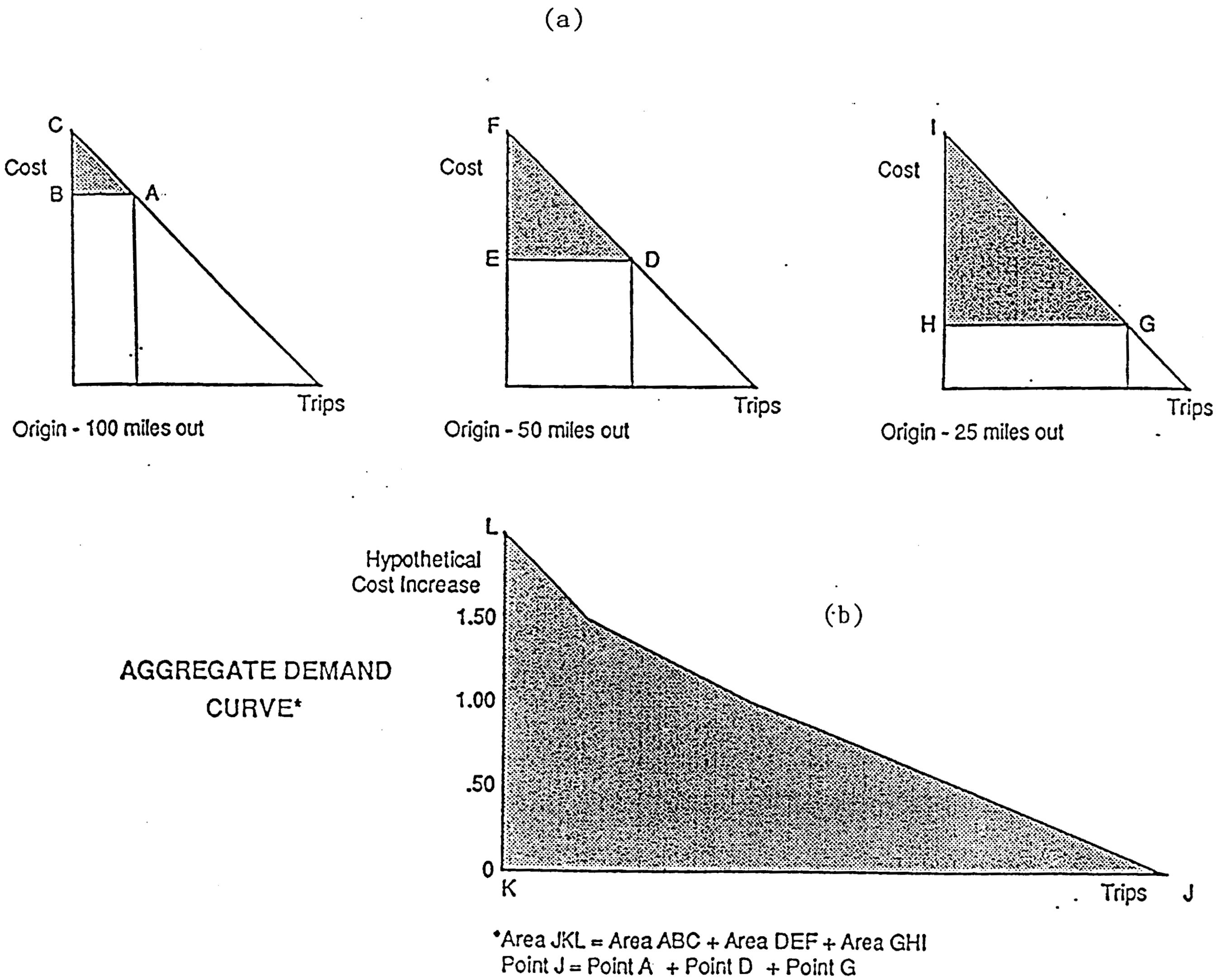
[4] This is necessary in order to derive the second stage demand curve which is the demand curve used to estimate net benefits.

Figure 4. Individual Demand Curve and the Aggregate Demand Curve for a Recreation Site



In order to determine the demand curve for the recreation site, an estimate of the number of trips from each origin is needed. The total number of trips for all recreationists from each origin would be equivalent to the sum of the equilibrium points in Figure 4a (A+D+G). However, it is the measure of consumer surplus that is of interest in estimating the value of a recreation site. In order to obtain a value of consumer surplus the demand curve above the equilibrium point must be estimated.

The travel cost model assumes that individuals across origins behave in the same way in response to changes in travel costs, all other things remaining constant. Thus, if people living 25 miles away from the recreation site were faced with the same travel costs as those living 50 miles away, ceterius paribus, they would take the same number of trips to the recreation site as those living 50 miles away. Having information from a number of origins of varying distances from a recreation site allows for statistical estimation of the demand curve above the equilibrium point for each origin and in turn, the respective amounts of consumer surplus.

The procedure for developing a measure of consumer surplus from the travel cost model is as follows. First the model is applied to all origins (i) using actual data for trip cost (C_{ij}) and other variables of the model. The predicted use from all origins is summed to obtain an estimate of total use at current travel costs.[5] Since it is assumed that participants will react to an increase in fees just as they do to an increase in travel costs, the travel cost for each origin is incremented by fixed amounts (i.e. $0.50) and the model used to estimate use at this new hypothetical fee level. The procedure is repeated and successive estimates of use at each level of fees

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[5] Theoretically, this summation should equal the actual number of trips taken by recreationists.

obtained. With each hypothetical fee increase a new point on each of the origin's demand curve above their equilibrium levels is estimated. These estimates are then added together to create what is known as the second stage demand curve or aggregate demand curve. (See figure 4b) The aggregate demand curve represents the summation of all the individual origins' demand curves above their equilibrium levels and thus, the area under this demand curve is the measure of total consumer surplus for all origins. Total consumer surplus from all origins is equivalent to the value of a recreation site. Consumer surplus estimates per trip are derived by dividing total consumer surplus by total number of trips and thus, represent the average value of a trip.

There is a distinction made in the literature between two types of travel cost models. One model is known as the site specific model and the other is known as the regional model. A site specific model is based on information from only one recreation site while a regional model estimates a demand equation using travel cost information from several different recreation sites in a given geographic area which provide similar recreation opportunities.

Site specific models are appropriate when the objective of a recreation valuation study is to estimate the loss of benefits from the displacement of an existing site, or forecast future use and benefits for an existing site, given all remaining sites stay the same. The advantages of using a single site model to meet these objectives are:

1) Information will be provided at a lower cost due to smaller data requirements and less complex statistical analysis; and

2) On average, it may be a more accurate model of recreation behavior than a regional model due to the ability of the researcher to concentrate on one information source in collecting data (Loomis et al 1986).

Regional models are more appropriate when the objective of a valuation study is to estimate the change in benefits and use resulting from a change in site quality or, to estimate the benefits from a new site. In general, the advantage of using a regional recreation model is that it allows the researcher a broader base whith which to analyze planning issues (Loomis et al 1986). Particularly with the travel cost method, a regional model allows the analyst to evaluate quality changes at a recreation site. Also, planning issues for a new recreation site can be assessed with a regional model.

Another distinction in types of travel cost models is that of the individual versus the aggregate, or zonal model. The individual travel cost model uses data on individual users to generate estimates of consumer surplus. The zonal model groups the data on individual users into origins or zones. Individuals from a certain zone are assumed to have the same travel cost, the same quantity and quality of substitute sites available, and the same demographic characteristics. Variations in visitation rates to a recreation site are explained by variations in these variables among zones rather than individuals.

The individual travel cost model was developed partly in response to statistical problems encountered in estimating zonal demand equations. In particular, it is argued that aggregation of data on such variables as substitute sites and income results in a loss of information. Since these variables serve as demand shifters, the estimated travel cost coefficient will be statistically inefficient (Brown and Nawas 1973). However, the individual approach was not without problems. Two difficulties with the individual observation approach are: 1) if the typical recreationist only takes one trip a year to a recreation site it is difficult to estimate a demand curve since there is not enough variation in the dependent variable, and 2) the probability of participation as a function of distance is ignored (Ward and Loomis 1986). With advances in econometric modeling in recent years, some problems with both approaches have been reduced and in fact hybrid approaches have been employed to combine the best features of both types of models. There does not appear to be a general consensus on the superiority of one approach over the other in the literature.

The travel cost method only evaluates user benefits. If there are significant non-user benefits or loss of benefits arising directly from the site (i.e., increased land values for nearby residents, environmental quality changes, option and existence values) these should be evaluated separately. A problem with the travel cost method is that it will always yield the benefits of the whole travel experience rather than for site use alone. This is particularly a problem when more than one site is visited on a give trip. This problem cannot be corrected without evaluating and separating out the benefits received or lost from intervening opportunities or travel. Except for unusual cases, this should not be a major source of error (Dwyer et al 1977).

CONTINGENT VALUATION

The other method available as an alternative to the unit day value approach in valuing recreational activities is the survey method, also known as contingent valuation. In 1979 the Water Resources Council authorized use of the contingent valuation method to estimate benefits from recreation and natural resources.

The contingent valuation method uses simulated (hypothetical) examples to elicit values from potential users of a recreational resource. A sample of the affected population using a recreational site or engaging in a recreational activity is asked to report their willingness to pay, contingent on hypothetical changes in recreational opportunities or resources. This is the basis for the term "contingent valuation" (Walsh 1984).

As Walsh (1984) notes, the reliability of the estimates depends, in part, on the care with which the interviewer describes the nature of the hypothetical situation; the change in the recreation activities or resources to be valued; the time period for which the valuation applies; the method of hypothetical payment; and the type of value question asked.

The contingent valuation method is considered to yield the best results when an iterative bidding technique is employed. Following a description of the recreation opportunity or resource to be valued and the market area for use of the resource, the respondent is asked to react to a series of dollar values posed by the interviewer. Respondents answer "yes" or "no" to whether they are willing to pay the stated amount of money to obtain a corresponding increment in the recreation opportunity or resource. The interviewer increases or decreases the dollar value until the highest amount the respondent is willing to pay is identified. Thus, in the survey method willingness to pay is obtained by directly asking individuals, while in the travel cost method willingness to pay is derived from data on actual market behavior. Each method has strengths and weaknesses.

The contingent valuation method is predicated on two key assumptions:

1) Consumers can assign an accurate value to the recreation experience; and

2) This valuation can be elicited from them with a properly constructed question or series of questions (Dwyer et al 1977).

The biggest problem with the contingent valuation method is the possible biases than can arise if the question is improperly worded. There can be great variability in responses depending on how the question is asked. One clear advantage of the travel cost procedure over the contingent value method is that the travel cost method does not rely as heavily upon the personal skills of the practitioner in eliciting information from individuals (Dwyer et al 1977).

On the other hand, as Dwyer et al. (1977, p.55) note, the contingent valuation method has significant advantage over the travel cost method in situations that involve:

1) Consideration of the value of small changes in quality at existing sites which would not be expected to affect the travel costs of visitors nor their number of visits, particularly if those changes have implications for recreation experiences at a number of sites;

2) Estimating the value of a site or area that is one of many destinations visited on a trip;

3) Considering the effects of congestion (crowding) on site benefits;

and as Walsh (1984) observes, the contingent valuation method has significant advantage in determining the benefits from preservation of a resource. In regard to the last consideration, the contingent valuation approach provides the only known method to value natural resource quality before degradation occurs. It is the only method recommended by the Water Resources Council when estimating benefits from the preservation of a resource. As Walsh (1984, p. 267) states:

> "To wait until after unique environmental resources are destroyed to measure the change in recreation behavior of users would be an unnecessary costly form of experimentation."

As in the travel cost method, variables other than cost of travel should be considered in the estimation of a demand function for a recreational resource. The way these variables would be used, however, differs in the contingent value approach. Rather than number of visits or participation rates being regressed on such factors as substitutes, income, and qualitative characteristics, in the contingent valuation method the value of willingness to pay would be regressed on these factors. Thus, the variation in willingness to pay responses would be accounted for by differences in such factors as income, availability of substitute sites, and qualitative characteristics of the site. Davis (1963) was the first to use the contingent valuation method to estimate benefits from a recreation site. Other studies that refined the survey approach include Randall, Ives, and Eastman (1974), and Schulze, D'Arge and Brookshire (1981).

Despite some criticism of the contingent valuation approach as to the possibility of eliciting biased answers, the method is gaining broad acceptance. It is generally recognized that if questions are carefully worded and hypothetical situations clearly defined, the contingent valuation approach can yield accurate and meaningful values for benefits from recreational activities. Comparisons have been made between results from travel cost studies and contingent valuation studies, and in general evidence of systematic bias is, at best, inconclusive (Walsh 1984).

CHAPTER 3

METHODOLOGY

CHOICE OF VALUATION METHOD

The method used in this study to estimate the value of recreation at Flaming Gorge Reservoir is the travel cost method. This approach was chosen over the contingent valuation method because it would have been difficult to meet the necessary criteria for using the contingent valuation method, given the recreational situation being evaluated at Flaming Gorge. As stated in Cummings et al (1986, p. 104), these criteria are:

1. Subjects must understand, be familiar with, the commodity to be valued;

2. Subjects must have had (or be allowed to obtain) prior valuation and choice experience with respect to consumption levels for the commodity;

3. There must be little uncertainty.

In evaluating the recreational situation at Flaming Gorge, the difficulty in meeting the three criteria for use of the contingent valuation method is explained primarily by two factors. First, not all recreationists at Flaming Gorge Reservoir are familiar with the eutrophication problem. As was mentioned earlier, eutrophication has been concentrated in the northern end of the reservoir. Because the reservoir is 91 miles long, many recreationists using facilities at southern points do not get up to the northern end on a regular basis or may have only visited when algae was not present. Thus, these recreationists would not know how to assess the indirect effects of algae at the north end on their recreation activities. Secondly, levels of algae in the reservoir vary from year to year. In fact, according to water quality measurements, the level of eutrophication seemed to have peaked in the late summer months of 1978 and has never been as high since that time (U.S. Bureau of Reclamation, 1987). Consequently, people may have a hard time recalling the impact algae had on their recreation experience at Flaming Gorge and thus, would have difficulty making connections between levels of algae and changes in recreation behavior. Also, some recreationists may have started using the reservoir in the last year or two and may not be familiar with algae problems if algae has not been as severe in recent years. Thus, because the criteria for use of the contingent value method could not be met, it was rejected in favor of the travel cost method.

SURVEY PROCEDURE

In order to obtain the necessary information to generate a demand curve a survey of current recreationists at Flaming Gorge was conducted. The survey consisted of both a personal interview with users at the reservoir and a follow-up mail questionnaire. (See Appendices A and B) The personal survey focused on the impact algae may have had on recreational use of Flaming Gorge. Questions concerning what activities had been affected, where on the reservoir activities had been affected, and what time of year algae had affected recreation use were asked on the personal survey. The follow-up mail questionnaire asked more specific questions about recreational use patterns on Flaming Gorge as well as questions regarding socioeconomic characteristics.

A total of 820 interviews were conducted between the months of April and September, 1986. The sample was stratified by the distribution of fishing pressure on the reservoir (Utah Division of Wildlife Resources 1982). Approximately 17% of the surveys were randomly conducted at recreation sites in the Inflow area, 47% at recreation sites in the Open Hills area, and 35% at recreation sites in the Canyon area.

Out of the 820 recreation parties surveyed at the reservoir, 41 refused to participate in the follow-up mail portion of the survey which resulted in a 95% acceptance rate. Those recreationists who agreed to participate in the mail survey were mailed a questionnaire within 14 days of being contacted at the reservoir. If a questionnaire was not returned within 7 days a postcard reminder was mailed. If the questionnaire was not returned within 14 days of the postcard reminder, another questionnaire, identical to the first, was sent along with a letter urging the individual to complete the questionnaire.

Ten surveys out of the 779 mailed out were returned due to wrong addresses leaving 769 valid mail contacts. Of these questionnaires 613 were returned which resulted in an overall response rate of 79.7%. The response rates among the three sections of the reservoir surveyed were uniform.

THE MODEL

This study employs a zonal, site-specific model to estimate the benefits from recreation at Flaming Gorge Reservoir. The single site model was used due to the lack of data on relationships between levels of eutrophication and recreation use for other reservoirs in the region and also, because the change in water quality due to eutrophication was potentially drastic enough to displace recreation at the northern end of the reservoir during certain times of the year. Thus, a regional model did not appear to provide any significant benefit in assessing the impact of eutrophication on recreation at Flaming Gorge.

The general travel cost model used in this study can be given by the expression:

$$V_{ij} = f(C_{ij}, S_{ij}, I_i) \qquad (2)$$

where,

V_{ij} = visits per capita from origin (i) to Flaming Gorge (j)

C_{ij} = the cost of traveling from origin (i) to Flaming Gorge (j) including the opportunity cost of travel time

S_{ij} = a measure of the availability and quality of alternative recreation sites to Flaming Gorge (j) for origin (i)

I_i = median income for origin (i)

Economic theory suggests that the number of visits to a recreation site will be: 1) negatively influenced by travel costs (i.e. an increase in the cost of a trip to a recreation site will lower the number of trips made); 2) negatively influenced by the availability and quality of alternative sites (i.e. the greater the number and the higher the quality of alternative sites for an origin the lower the number of visits); and 3) positively influenced by income (i.e. the higher the level of income for an origin the higher the number of visits).

In a regional model a variable reflecting the "quality" of each recreation site is usually included to account for differences in visitation rates. Measures such as number of camping sites, number of boat ramps, or fish harvest have been used to capture the quality of a site. In a single-site model, however, quality measures can only be incorporated into a model if time series data exists. Otherwise, there would be no variation in the quality variable. Since time series data is rarely available for recreation sites, quality variables are not usually found in single-site models.

DEPENDENT VARIABLE

The dependant variable, trips per capita, is used to capture the effects of population on visitation rates to a recreation site. Measuring visits on a per capita basis accounts for both the number of visits as a function of distance and also, the probability of visiting the site as a function of distance (Brown et al 1983). Thus, if the cost of going to a recreation site fell, not only would present users of the site increase the number of trips they make but also, the lower cost would induce non-users to start making trips to the site. A measure of the dependent variable that is not in per capita units, or does not account for population in the model, ignores the impact a change in costs will have on participation rates by the general population of an origin. Ignoring the effects of population can lead to incorrect consumer surplus estimates (Brown et al 1983).

Trips per capita were estimated by converting Forest Service data on recreation visitor days (RVDs) to the total number of trips to Flaming Gorge based on the average length of stay reported in the user survey. The total trips were then allocated among the various origins according to the sampling distribution. Finally, trips per capita were determined by dividing estimated trips for each origin by the population of each origin.

TRAVEL COST VARIABLE

The travel cost variable C_{ij}, can be defined as:

$$C_{ij} = \frac{d_{ij}(a)}{b} + \frac{d_{ij}(t)}{c} \tag{3}$$

where:

C_{ij} = per person dollar cost of a round trip from the origin (i) to the recreation site (j)

d_{ij} = round trip distance from the origin (i) to the recreation site (j)

a = variable operating cost, in dollars per mile, for a vehicle

b = average number of persons per vehicle

t = hourly opportunity cost of travel time

c = average travel speed in miles

The variable operating cost of a vehicle used in this study was 17 cents. This figure was taken from the U.S. Department of Transportation's (1984) Cost of Owning and Operating Automobiles and Vans. The survey data indicated that 72% of the recreationists drove a 4-wheel drive type vehicle or pickup. Thus, the cost figure is taken from the estimated operating cost for a passenger van since this vehicle most closely resembled the type of vehicle driven by the majority of recreationists.

In calculating the distance from each origin to Flaming Gorge, it was assumed that one of the nine major recreation sites on the reservoir was the primary destination for each origin. This was based on the responses given on the survey to a question asking the primary destination of the trip. Although Flaming Gorge is a large reservoir, the primary destination of users from a particular origin was generally highly concentrated at the site on the reservoir closest to the origin. Also, mileage was calculated from the largest population center of each origin to the primary destination.

The travel cost model accounts for both the direct out-of-pocket and time costs of travel. The time involved in traveling to a recreation site can be considered part of the cost of traveling. Not only does an individual expend money to participate in a recreational activity but also, a certain amount of time is used to get to the recreation site and to stay at the site.

Concern with the impact driving time has on recreation decision-making stemmed from the observation that hours involved in driving to a recreation site varied among visitors. The justification for accounting for differences in time traveled is based on the assumption that time, like income, is a constraint on an individual's or household's budget. In the decision-making process, where time is allocated among competing uses, values for time must be imputed so that time is allocated in accordance with utility maximization. Consequently, different amounts of driving time would create different costs to users of a recreation site.

Cesario and Knetsch (1970, 1976) showed that by omitting the cost of driving to a recreation site, an overstatement in the reduction in visits to the site would result with each hypothetical fee increase since "lower travel frequencies of the centers at greater distances are due not only to the greater monetary costs of making the longer journeys but also the greater time that would be involved." The consequence of an overstatement of the reduction in visits is underestimation of the slope of the demand curve which, in turn, results in a smaller value of net benefits than would be the case if travel time were accounted for.

While theoretical advances in the travel cost model have been made through recognition of the importance of travel time, the empirical modeling of the theoretical concept is still in the experimental stage. There are no definite answers to the question of how to value travel time and how to incorporate the value of travel time into the travel cost model.

The value of time for an individual in a given situation is conditioned by what activities are being traded off. In a recreational demand context usually the trade-off is between participation in a recreational activity and other leisure activities. The question then arises, how much value do people place on time for leisure activities? Cesario (1976) reviewed a number of empirical studies on time-money trade-offs for individuals commuting to work and concluded that the opportunity cost of non-work travel time is somewhere between 1/4 and 1/2 of the wage rate. Research by Smith et al (1983) indicated that the full wage rate may be an appropriate measure of the value of travel time. Consequently, this study utilizes a value of 1/2 the hourly wage rate as the opportunity cost of travel time to Flaming Gorge Reservoir.

In accounting for the opportunity cost of travel time in travel cost models it is usually assumed that the trade-off function between time and money is either linear or multiplicative (convex). A linear trade-off function indicates that time is valued at some constant rate. Thus, at all levels of monetary expenditures time is valued the same. A convex relationship implies there is a diminishing marginal effect on visitation rates to a recreation site for increases in time or money outlays as the size of the time or money expenditure increases. A convex trade-off function results in a less elastic estimate of the demand curve than a linear trade-off function and thus, generates higher benefits than the linear trade-off function (Cesario 1976).

A difficulty with the convex form is that there is a great deal of uncertainty as to how to mathematically model the function. This is due to the lack of empirical evidence indicating the trade-off function between leisure time and money. Although the convex trade-off function has stronger theoretical underpinnings, because of its more conservative benefit estimates, the linear trade-off function may yield better results than an incorrectly specified multiplicative function. Consequently, the linear trade-off function will be used in this study.

The opportunity cost of time used in this study was \$4.34. This value is one-half of \$8.68, the average gross hourly earnings in January, 1986 for the private, non-agricultural sector of the economy (Council of Economic Advisors 1986). Since a linear trade-off function is being employed in this study, the opportunity cost of time is added directly to out-of-pocket expenses incurred by a visitor to Flaming Gorge. Thus, if three hours of travel time are involved in a roundtrip from one's origin to Flaming Gorge \$13.02 would be added to the monetary cost of making this trip.

A related issue to the concern over driving time in recreation demand studies is the consideration of whether the opportunity cost of time spent at a recreation site should be accounted for. Unlike the case of travel time, however, a priori predictions cannot be made about the impact on-site time will have on the coefficients of the demand equation due to the fact that there is no straightforward relationship between distance and on-site time.

Because driving time to a recreation site necessarily increases for more distance origins, and because individuals from an origin must generally drive the same amount of time to a site, it can be shown that omission of travel time costs in a demand equation will underestimate the benefits from use of a recreation site. However, on-site time is not necessarily determined by distance. It is possible to have trips of different lengths (i.e. day vs. multi-day) originate from the same origin. Thus, increased distance could be associated with both longer and shorter time on-site.

The approach taken in this study to account for on-site time costs is to estimate separate demand equations for trips of different lengths. With this approach the problem of variation in on-site time is reduced to one of substitute goods each with a fixed on-site time (Wilman 1980). This is a simpler approach than incorporating on-site time directly into the demand equation, a procedure which usually involves two-stage least squares techniques. The distinction in on-site times was limited to two categories, trips of 12 hours or less in length (day) and trips greater than 12 hours in length (multi-day). In order to estimate the total benefit from the recreation site it is necessary to aggregate the consumer surplus from both types of visits to the recreation site.

SUBSTITUTE SITE VARIABLE

In considering the availability and quality of substitute sites to Flaming Gorge, the general approach used by Brown and Hansen (1974) was followed. The substitute measure used in this study was:

$$S_{ij} = \left(\sum_{k=1}^{n} \ln\left(\frac{a_k}{d_{ik}}\right)\right)^2 \quad \text{for all} \quad \ln\left(\frac{a_k}{d_{ik}}\right) > \ln\left(\frac{a_{ij}}{d_{ij}}\right) \tag{4}$$

where:

a = surface acreage of a reservoir

d = distance

i = origin of visitor

j = Flaming Gorge Reservoir

k = alternative reservoir

As was mentioned previously, finding a criterion to reflect the attractiveness or quality of a recreation site is difficult. Measurable proxies usually are oversimplifications of the attributes of a site since non-tangible elements like scenery are difficult to measure. However, it is reasonable to assume that there is a positive correlation between the size of a lake and its "quality" since larger lakes are likely to have more facilities than smaller ones, offer more space to engage in recreation activities like boating and waterskiing, and may have better fishing opportunities for a larger number of people. As Wennegren et al (1975) have noted, size is a fairly good proxy for the quality of a site because it is highly correlated with other site characteristics. Consequently, surface acreage was used as a proxy for the attractiveness of alternative sites. Attempts to develop an index based on a quality variable such as fishing productivity were unsuccessful due to considerable variation in how creel census data were collected and the years creel census data were available.

The ratio of the reservoir size to distance is essentially a measure of the cost effectiveness of a site k to recreationists from origin i (i.e. the surface acreage available per mile driven). The use of the natural logarithm of the ratio of size to distance indicates that the effect of both size, and the inverse of distance, on the attractiveness of substitute sites increases but at a decreasing rate. This approach differs from the original approach taken by Brown and Hansen (1974) where the natural log was applied only to surface acreage. The result of taking the log of the ratio is that greater weight is given to larger lakes and reservoirs in deriving the substitute index. This approach was taken since it corresponded better with the nature of the substitute sites mentioned in the survey by users. For example, the most frequently mentioned substitute site was Lake Powell, a lake approximately four times the size of Flaming Gorge. The squaring of the index implies that the total effect of all substitutes increases at an increasing rate. Thus, this index measures the substitution effect of the existing reservoirs as a system (Brown and Hansen 1974).

The greater the number of alternative sites that are more cost effective than Flaming Gorge, the larger the substitute index is for a particular origin. The larger the value of the substitute index, ceterus paribus, the lower the number of visits from that origin ought to be. The substitute sites considered in this study included those sites that respondents to the survey indicated as alternatives to Flaming Gorge. Additional sites, not mentioned by respondents, were also included in the index to account for recreation trips by people not using Flaming Gorge. Selection of these additional sites was based on federal and state management agencies' use data for the region. In total 45 alternative recreation sites were considered within an approximate radius of 400 miles of Flaming Gorge.

INCOME VARIABLE

The socioeconomic characteristic thought to have the most potential for explaining differences in visitation rates among origins was income. The size of Flaming Gorge Reservoir and the type of fisheries currently managed for in the reservoir (i.e. lake trout and kokanee salmon) encourage, and almost necessitate, use of boating equipment. Thus, it is reasonable to assume that origins with higher incomes are likely to make more trips to the reservoir due to the greater ability to purchase boating equipment as well as afford travel costs in general. The income figures used in this study were "median household effective buying income" as reported in Sales Marketing Management (1986). This measure of income was used because it is a more reliable indicator of an area's relative income level since it is less likely to be skewed by statistical oddities.

FUNCTIONAL FORM

There has been much discussion in the literature regarding the appropriateness of different functional forms for recreation demand models. A major concern in choosing a functional form is that an untransformed trips per capita variable can lead to heteroskedasticity. The nature of the heteroskedasticity is such that the larger the value of trip per capita, the more error variance there is. Transforming the trips per capita variable appears to often alleviate this problem (Rosenthal et al 1986). Consequently, the semi-log dependent and the double-log forms have been considered by many to be most suitable to recreation demand analysis. Rosenthal et al (1986) also note than when formal tests for functional form have been performed, the semi-log (dependent) or double log functional form appears to be superior to either linear, quadratic, or semi-log (independent).

The semi-log (dependent) form was employed in this study. Along with the advantages of alleviating heteroskedasticity already mentioned, the form was chosen because given the data base for recreation use at Flaming Gorge, it provided the best fit. This result was based on the statistical test provided by Rao and Miller (1965) which allows comparison of R^2's across functional forms. Also, with this form, average consumer surplus estimates are equivalent to marginal consumer surplus estimates which is advantageous in benefit-cost analysis (Sorg et al 1985). The functional form used in this study was:

$$\ln(V_{ij}) = bo + b_1C_{ij} + b_2S_{ij} + b_3I_i \qquad (5)$$

THE MARKET AREA

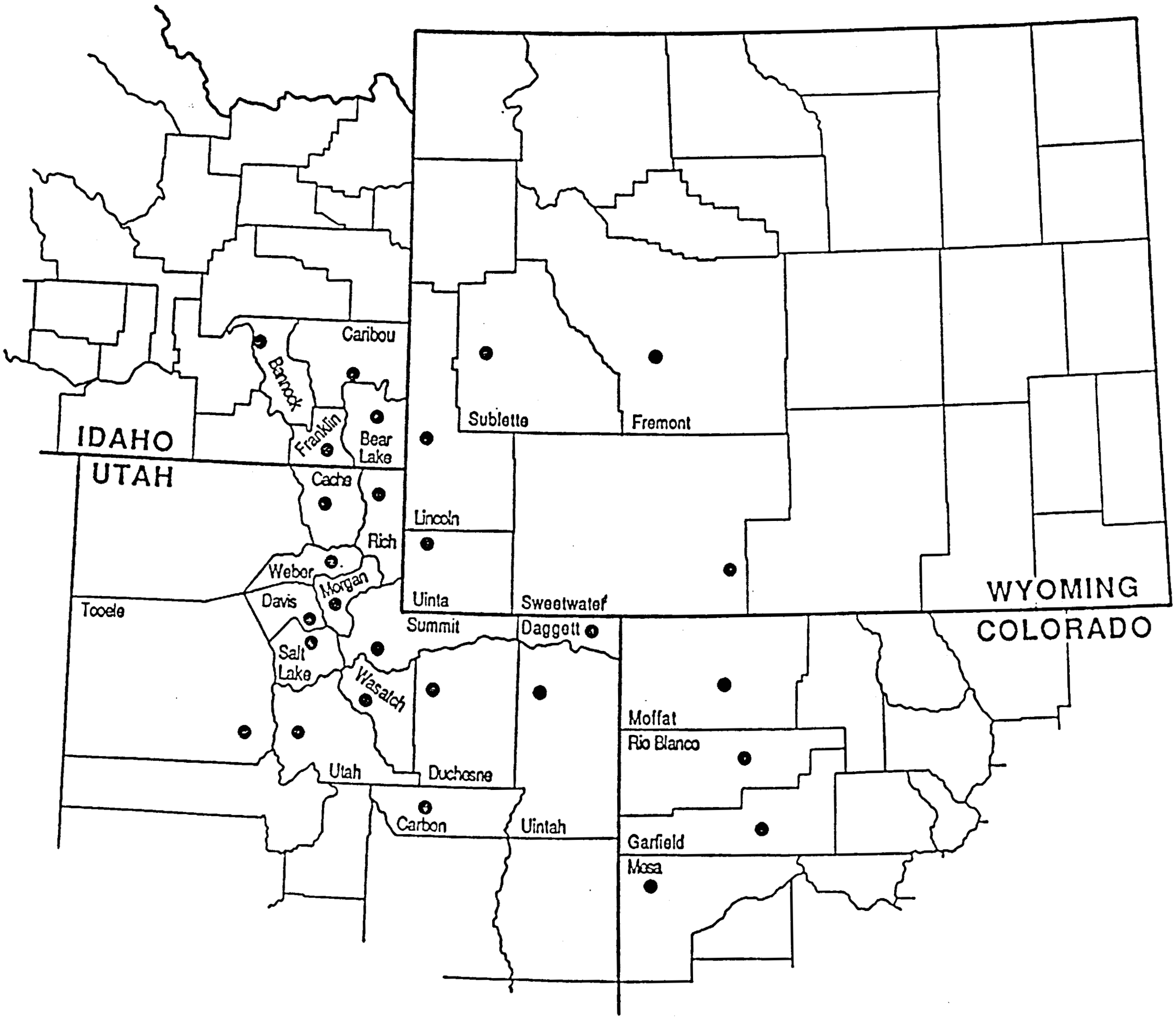
The survey data indicated that 98.2% of the respondents came from a four state area, Utah, Wyoming, Colorado, and Idaho. These are the states that most closely surround the reservoir. The data also showed that 93% of those surveyed come from counties within an approximate radius of 250 miles. It is assumed that these statistics are representative of the entire user population of Flaming Gorge Reservoir.

The counties from which 93% of the users come from make up the market area for Flaming Gorge which is displayed in Figure 5. The market area is the geographical region from which trips to a recreation site are consistently generated. It is assumed in this study that individual counties constitute an origin (i). The demand curve for Flaming Gorge is derived from use data for each of the counties in the market area. The remaining 7% of use originated from such diverse geographical locations that any attempts to include them in the model would likely result in severe statistical problems as there would be numerous counties with zero visitation rates. Also, the number of trips from these areas would be so small, on a per capita basis, that exclusion of them will not significantly affect the results. Designating a market area based on 90% of use is consistent with other travel cost studies such as Brown and Hansen (1974).

ESTIMATING THE IMPACT OF EUTROPHICATION ON RECREATION

In assessing the economic impact eutrophication has on recreation at Flaming Gorge, it would be helpful to have an identifiable relationship between levels of algae and levels of recreation (i.e. what amount of algae in the reservoir leads to a certain amount of change in recreational use?). Such a relationship might be established if time series data provided correlations

Figure 5. The Market Area for Flaming Gorge



between levels of algae and levels of recreational use for sites on Flaming Gorge. However, time series data on the origin of recreational users of Flaming Gorge does not exist so that correlations cannot be established.

Another approach to identifying such a relationship would be to employ a regional model and use data on correlations between levels of algae and levels of recreational use for other reservoirs in the region with eutrophication problems. However, as was mentioned previously, such data does not exist.

A third approach would be to use a form of the regional model based on the various recreation sites on Flaming Gorge rather than different reservoirs in the region. With this method, changes in visitation rates among sites could be analyzed in light of differences in algae levels. The problem with this approach is that use from each origin (county) tended to be concentrated at one site (i.e. the majority of recreationists from Sweetwater County used either the Firehole or Buckboard sites while the majority of recreationists from Salt Lake County used the Lucerne site). Thus, there was not enough of a distribution of use to assess the effect of algae on recreational use patterns using this form of the regional model.

Given the problems with these three possible approaches, the most feasible way to assess the potential impact of eutrophication on recreation at Flaming Gorge using the travel cost method was to assume that the entire northern end of the reservoir (Inflow area), which includes the Buckboard and Firehole sites, would be unusable for the months of July, August, September, and October. According to U.S. Bureau of Reclamation Studies (1987), these are the months during which eutrophication is usually at its worst. Also, the Inflow area is where eutrophication has been concentrated. Since the degree of eutrophication has varied from year to year, a sensitivity analysis was done to consider alternative time frames within the four-month period for the potential impact of algae on recreation. Economic losses due to eutrophication were calculated for the periods of July-October, August-October, and September-October. This sensitivity analysis should be useful in comparing the costs of control measures with the benefits of control once the future course of eutrophication is determined. Results of water quality sampling tests conducted through the joint efforts of researchers at the U.S. Bureau of Reclamation (Salt Lake City, UT), Utah State University (Logan, UT), Western Wyoming College (Rock Springs, WY), and University of Wyoming (Laramie, WY) will provide assessments of the future of eutrophication in Flaming Gorge and should be available in the spring of 1988.

The assumption that the entire northern end of the reservoir would be unusable is, of course, extreme. However, it is not an impossibility depending on the future of eutrophication. If eutrophication significantly affects the trout fishery in this area, and if thick blooms of algae cover a large portion of the water surface, it may be that recreation use would be minimal or non-existent. Making this assumption will result in calculation of the maximum loss in recreation benefits from algae and thus, would serve as an upper bound to the potential loss in benefits from eutrophication. If this figure does not surpass any cost considerations for dealing with less than extreme algae conditions it would not be deemed economical to employ the control measures.

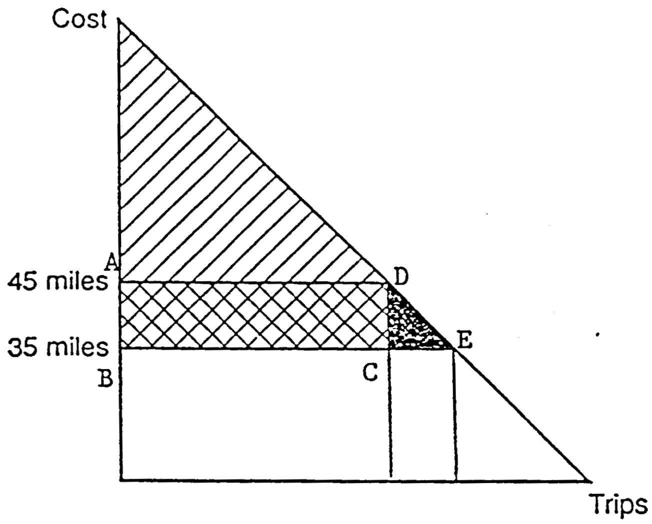
To determine the loss in benefits from eutrophication it is necessary to identify the lost benefits involved in being unable to use the northern end of the reservoir. A loss in benefits occurs if recreationists have to drive further to recreate or if no trip is made. The use patterns on Flaming Gorge indicated that, if the northern end of the reservoir were unusable, the primary loss in benefits would accrue to recreation users from Sweetwater County, Wyoming.

The survey data indicated that approximately 85% of all trips taken to the Buckboard and Firehole sites during the months of July through October originated from Sweetwater County. Also, because of the geographical distribution of the counties in the market area, only recreationists from Sweetwater County, Sublette County (WY), and Fremont County (WY) would have to drive additional mileage to use an alternative site on Flaming Gorge if the northern end were unusable. However, the survey data indicated that, during the months of July through October, no recreationists from Sublette or Fremont County used the Buckboard or Firehole sites and thus, it was assumed that use from these origins, and in turn any loss in benefits, would be minimal. Consequently, only trips from Sweetwater County are considered to be affected by eutrophication and this effect is measured through the increase in mileage necessary for residents of Sweetwater County to access Flaming Gorge Reservoir.

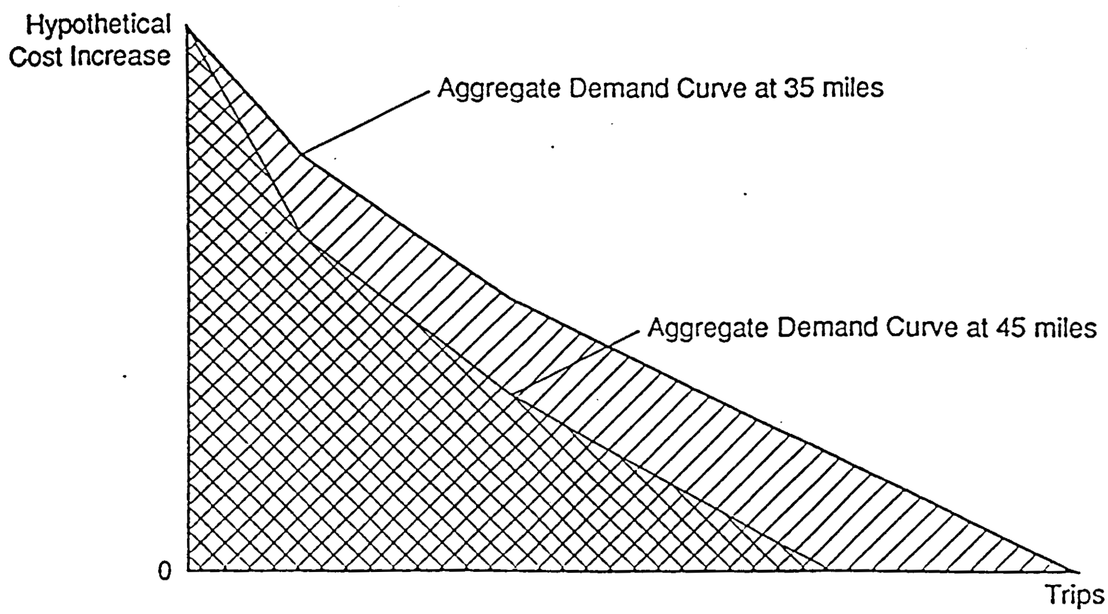
The total loss in benefits to recreational users from an increase in mileage driven is a combination of 1) the reduced number of trips taken as a consequence of higher travel costs (Figure 6, area CDE) and, 2) the reduction in consumer surplus for those trips that are taken at the higher travel cost (area ABCD). Thus, if recreationists from Sweetwater County were unable to use the northern end of the reservoir, the travel cost model indicates that some trips that are presently made would not be made and for those trips that are made at the higher travel cost, benefits that are currently accruing to recreationists would be reduced.

In order to calculate the additional mileage involved in driving to an alternative site as a consequence of eutrophication, it was necessary to: 1) identify the alternative sites that would be utilized if the northern end of the reservoir were unusable, and 2) determine the proportion of trips made to the reservoir from Sweetwater County during the affected period.

Figure 6. Loss in Benefits Due to Eutrophication



Demand Curve for Sweetwater County



Based on the survey data on alternative sites, it was determined that the distance to Flaming Gorge for users from Sweetwater County would increase from an average of 35 miles to an average of 58 miles if the northern end were unusable. The two mileage figures were then weighted according to the proportion of trips occurring during the period when the north end was unusable in order to determine the weighted average distance for Sweetwater County recreationists. For example, for the time period July-October, when 43% of trips by Sweetwater County recreationists are taken to Flaming Gorge, the weighted average distance would be 45 miles, an increase of 10 miles. In order to calculate the loss in benefits due to eutrophication the consumer surplus is calculated for both the 35 mile distance and the weighted average distance. The difference between the two consumer surplus amounts represents the loss in benefits to recreational users of the reservoir. (See Figure 6)

NET PRESENT VALUE

Net present value (NPV) figures of the estimated annual benefits from recreation and loss due to eutrophication will be calculated in this study. The discount rate used to calculate NPV should be representative of the true cost of borrowing or returns to lending. This "true cost" would be equivalent to what is known as the real rate of interest which discounts the effect of inflation on interest rates. The real rate of interest is defined as the nominal rate of interest minus the expected rate of inflation. According to Cecchetti (1986) the real rate of interest between the years 1950 and 1979 averaged 3%. The real rates of interest discussed in Cecchetti's study were based on the monitoring of interest rates on U.S. Government Securities of 3-month, two-year, and five-year maturities. Since 1979 real interest rate levels above 5% have been observed. Consequently, an average value of 4% was used in this analysis. A time horizon of 100 years is used in calculating the NPV which is the standard time basis used by the U.S. Bureau of Reclamation in evaluating large water projects.

CHAPTER 4

RESULTS

USE PATTERNS OF RECREATIONISTS

The survey data indicated that 98.2% of those surveyed came from four states: Utah, Wyoming, Colorado, and Idaho. 54.0% of the respondents were from Utah, 37.4% from Wyoming, 6.0% came from Colorado, and .8% originated from Idaho. The remaining 1.8% of recreationists surveyed came from the states of Arizona, California, Kansas, Nevada, and New Mexico. A study by Collins, et al (1981), surveyed fishermen at Flaming Gorge in 1979 concerning fishery management programs. The results of that survey showed that 40.0% of the fishermen surveyed were from Utah, 35.2% from Wyoming, 13.6% originated from Colorado, and .8% came from Idaho. Thus, 89.6% of those surveyed came from the four state area. The remaining 10.4% of the fishermen surveyed in the study were from the states of Arizona, California, Illinois, Kansas, Massachussetts, Montana, New Mexico, Oklahoma, Oregon, South Dakota, Texas, and Washington. Both sets of use figures are for recreation on the reservoir alone. They are not necessarily representative of use patterns for the entire National Recreation Area.

A comparison of the state use data from the two surveys shows that in the last seven years the geographical distribution of users of Flaming Gorge Reservoir has changed. The proportion of users from the four state area of Utah, Wyoming, Colorado, and Idaho increased by 8.6%. Also, within this four state area, there has been a shift away from Colorado users to Utah and Wyoming users. In fact, the proportion of users from Colorado decreased by 7.6% from 1979 to 1986. The survey data also indicates that there has been a reduction in users from outside the four state area. Thus, in general, the size of the market area for Flaming Gorge has decreased in the last seven years.

The area under a demand curve for a recreation site is a function of: 1) the distance traveled by recreationists; 2) the number of trips made to the site, and 3) the relationship between distance traveled and number of trips (i.e. the slope of the demand curve). A reduction in the maximum distance traveled by recreationists, ceterius paribus, will reduce the area under the demand curve and in turn, the value of recreation at the site. Since a comparison of use data from the two surveys suggests that the market area for Flaming Gorge has decreased in size during the last seven years, the recreational value of the reservoir may have also decreased during this time period. Data limitations for 1979 preclude an exact comparison of the value of recreation between the two years.

It is difficult to attribute the change in use patterns in the last seven years to any one factor. However, the change may be due to a perceived decline in the quality of fishing and recreational facilities at the reservoir. During the past seven years there has been a general decline in the rainbow trout fishery (Wengert, 1985). This fishing is particularly important for "family-type" fishing activities. In addition, facilities at some recreation sites on Flaming Gorge have been closed and maintenance at other sites has been limited due to Forest Service budget limitations. Improvements in the quality of fishing and/or facilities at Flaming Gorge could result in a substantial increase in the benefits from recreation at the reservoir due to an expansion of the market area and/or more trips by existing recreationists.

The survey data also showed that 93% of those surveyed came from counties within an approximate radius surrounding Flaming Gorge Reservoir of 250 miles. Table 1 displays the percent of those surveyed coming from the counties included in the market area.

Table 1. County of Origin of Surveyed Population.

County of Origin	% of Those Surveyed
Salt Lake (UT)	28.8%
Sweetwater (Wy)	26.6%
Davis (UT)	7.5%
Weber (UT)	7.4%
Uinta (WY)	6.9%
Uintah (UT)	3.2%
Utah (UT)	1.9%
Tooele (UT)	1.5%
Lincoln (WY)	1.2%
Daggett (UT)	1.0%
Moffatt (CO)	.8%
Carbon (UT)	.7%
Fremont (WY)	.6%
Summit (UT)	.6%
Mesa (CO)	.6%
Rio Blanco (CO)	.6%
Garfield (CO)	.6%
Morgan (UT)	.5%
Duchesene (UT)	.4%
Sublette (WY)	.3%
Cache (UT)	.3%
Bannock (ID)	.3%
Wasatch (UT)	.2%
Rich (UT)	.2%
Franklin (ID)	.1%
Caribou (ID)	.1%
Bear Lake (ID)	.1%

While the greatest percentage of those surveyed came from Utah the survey data show that Wyoming residents, particularly those from Sweetwater County, make the most trips to Flaming Gorge. In fact, 55% of all trips made to Flaming Gorge, both day and multi-day, originate from Sweetwater County alone. This is due to the fact that Sweetwater County is the origin closest to the reservoir containing a relatively large population center.

The median number of trips made annually to Flaming Gorge by a recreationist from Sweetwater County is 20. In comparison, the median number of trips made by an individual for the entire market area is 8. Of the day trips to the reservoir 75% are made by recreationists from Sweetwater County while only 35% of multi-day trips originate from this county. The median length of a day trip to the reservoir is 7.5 hours. The median length of stay for multi-day users is 48 hours. Thus, Sweetwater County recreationists make more trips to Flaming Gorge than recreationists from other origins but, on average, spend less time at the reservoir during each trip.

Table 2 displays the participation rate of recreationists for various activities at Flaming Gorge Reservoir during the last 12 months. As can be

Table 2. Percent of Surveyed Population Participating in Recreational Activities at Flaming Gorge

Activity	% of Those Surveyed Participating in Activity
Boat Fishing	93%
Shore Fishing	45%
Pleasure Boating	72%
Waterskiing	56%
Sightseeing	56%
Hiking	15%
Picnicking	32%
Camping	67%
Swimming	23%
Ice Fishing	23%

seen boat fishing is the activity that has the highest participation rate. 93% of all recreationists engage in boat fishing on one or more of their trips to Flaming Gorge. Also, the survey data showed that, of these activities, 65% of the respondents indicated boat fishing to be the activity they participated in most often. The data also show that 67% of all respondents camped during one or more of their trips to Flaming Gorge, which suggests significant overnight use of the reservoir.

Table 3 displays use data on a monthly basis. It shows the percent of total trips taken to Flaming Gorge during a particular month. The data

Table 3. Percent of Total Trips to Flaming Gorge by Month.

Month	% of Total Trips Made
April	7%
May	13%
June	16%
July	19%
August	15%
September	9%
October-November	8%
December-March	13%

indicate that 50% of all trips to the reservoir are made during the months of June, July, and August.

Table 4 presents use data for the major recreation sites at Flaming Gorge Reservoir based on both the survey responses and unpublished U.S. Forest Service reports (1986). The survey data measure use in terms of the number of

Table 4. Use Data for Recreation Sites at Flaming Gorge.

Site	% of Total Trips Based on Survey Data	% of Use Based on RVD's
Firehole	6%	3.5%
Buckboard	22%	4.7%
Squaw Hollow	9%	.2%
Lucerne	35%	22.8%
Sheep Creek	8%	11.0%
Cedar Springs	6%	6.6%
Mustang Ridge	3%	15.2%
Antelope Flats	3%	.8%
Upper Marsh Creek	1%	.09%
Other	6%	35.0%

trips taken to a site. The Forest Service data measure use in terms of the amount of hours spent on recreation activities at a site. The hours involved in measuring use by the Forest Service account for a variety of activities including boating, picnicking, and camping. For the survey data the primary sites included in the "other" category were Anvil Draw, Lost Dog, and the

Confluence. These were sites indicated by the respondents. Forest Service data is broken down by many more sites and thus, the percent of use falling into the "other" category is greater.

In comparing use among sites, the distinction between day and multi-day trips must be kept in mind. For example, while respondents indicated that 22% of their trips were to the Buckboard site, since the majority of users of this site are from Sweetwater County, and since the majority of trips from Sweetwater County are day trips, actual hours of use at Buckboard was lower than a site like Cedar Springs because the trips to Buckboard tend to be shorter in length. As can be seen in Table 4, the Forest Service data indicate that only 4.7% of total RVD's is attributable to the Buckboard site. Another significant discrepancy in the use measures is one regarding the Mustang Ridge site. The survey data indicate that 3% of total trips taken to the reservoir have Mustang Ridge as their primary destination while the Forest Service data indicate that 15.2% of all hours involved in recreation at the reservoir are spent at Mustang Ridge. The discrepancy can be explained by the fact that Mustang Ridge has one of the largest camping areas among the recreation sites and thus, a good deal of the use is attributable to trips that were longer in length.

If planning agencies are assessing the need for facilities or changes in facilities at the various recreation sites, it seems important to view use in light of the two different measures in Table 4. Although the Forest Service data does not indicate a significant amount of use at sites at the northern end of the reservoir such as Squaw Hollow, Buckboard, and Firehole, the survey data suggest that these sites do receive a good deal of use, even if it is short-term. Thirty-five percent of all trips taken to Flaming Gorge have these sites as one of their primary destinations. Thus, for these sites, boat ramp and day use facilities may take on more importance than camping facilities although improvements in camping facilities at some sites may generate more multi-day use. As an example, other than restrooms, no camping facilities exist at the Squaw Hollow Site, and yet the survey data show that 9% of all trips made to Flaming Gorge are taken to this site. Alternatively, at sites like Lucerne and Mustang Ridge, Forest Service usage data indicate camping is a significant component of recreational activity. Consequently, camping facilities may take on more importance at these sites than at sites like Firehole and Buckboard where day use is more prevalent.

Finally, since fishing is the recreational activity participated in most at Flaming Gorge, it seemed of interest to measure recreationists' attitudes toward fishing at the reservoir. Table 5 displays the responses of recreationists who were asked to indicate the statement which best described their feeling about fishing at Flaming Gorge. The data indicate that almost

Table 5. Measure of Recreationists' Attitudes Toward Fishing at Flaming Gorge.

Statement	% Response
I would prefer the opportunity to catch a trophy fish even if this meant catching fewer fish.	47.9%
I would prefer the opportunity to catch a lot of fish even if this meant catching smaller fish.	38.9%
I do not care about the number or size of fish caught.	9.4%
I do not care about the fishing on Flaming Gorge.	3.8%

48% of recreationists would prefer to catch trophy fish even it if meant catching a smaller number of fish while approximately 40% place more importance on the number of fish caught rather than the size. This information may be helpful to management agencies in decisions regarding the types of fisheries to cultivate in Flaming Gorge Reservoir.

IMPACT OF ALGAE ON RECREATION

Results of the survey showed that 26% of all users of Flaming Gorge Reservoir were aware of excessive algae in the reservoir but only 13% indicated algae had adversely affected their recreational activity. If users of the northern end are focused upon, the survey data showed that 52% of the recreationists surveyed at the Buckboard and Firehole sites were aware of excessive algae, and 27% had been adversely affected by algae in their recreational activity. In identifying problems with eutrophication, recreationists were not restricted to 1986, the year they were surveyed. If a person responded positively to being adversely affected by algae it could have been for any one, or all, of the years he or she had used the reservoir.

In terms of overall use, the impact of eutrophication on recreational activity does not appear to be significant. This is partly due to the fact that eutrophication is normally concentrated in the northern end of the reservoir, while the majority of recreational use, in terms of hours, takes place in the Open Hills and Canyon areas of the reservoir. However, as was mentioned above, when users of the northern end are focused upon, the effect of algae on recreation more than doubles. If eutrophication were to spread to recreation areas in the southern end of the reservoir, the results of this study suggest that the impact of eutrophication on recreational use could be substantial, particularly since the majority of trips made to the southern end are multi-day trips which are of higher value than day trips. The likelihood of this happening will be discussed in the forthcoming results of water quality sampling studies being conducted by the various state and federal agencies.

Seventy-eight percent of the respondents who had either noticed or been affected by excessive algae said they had encountered it at points north of the Pipeline. (See Figure 7) As has been mentioned, eutrophication is normally concentrated in the northern end of the reservoir, from the Buckboard recreation site up to, and above, the Firehole recreation site. Nineteen-eighty six was not a normal year for eutrophication due to the draining of Fontenelle Reservoir into Flaming Gorge. Fontenelle Reservoir is located about 60 miles upstream from Flaming Gorge. Due to structural problems with the dam on Fontenelle, the reservoir had to be drained and thus, nutrients that contribute to eutrophication were pushed further down Flaming Gorge Reservoir. Most likely, the reporting of excessive algae as far south as the Pipeline by recreationists reflects the movement of sediment further south in Flaming Gorge caused by the extra inflow from the draining of Fontenelle Reservoir.

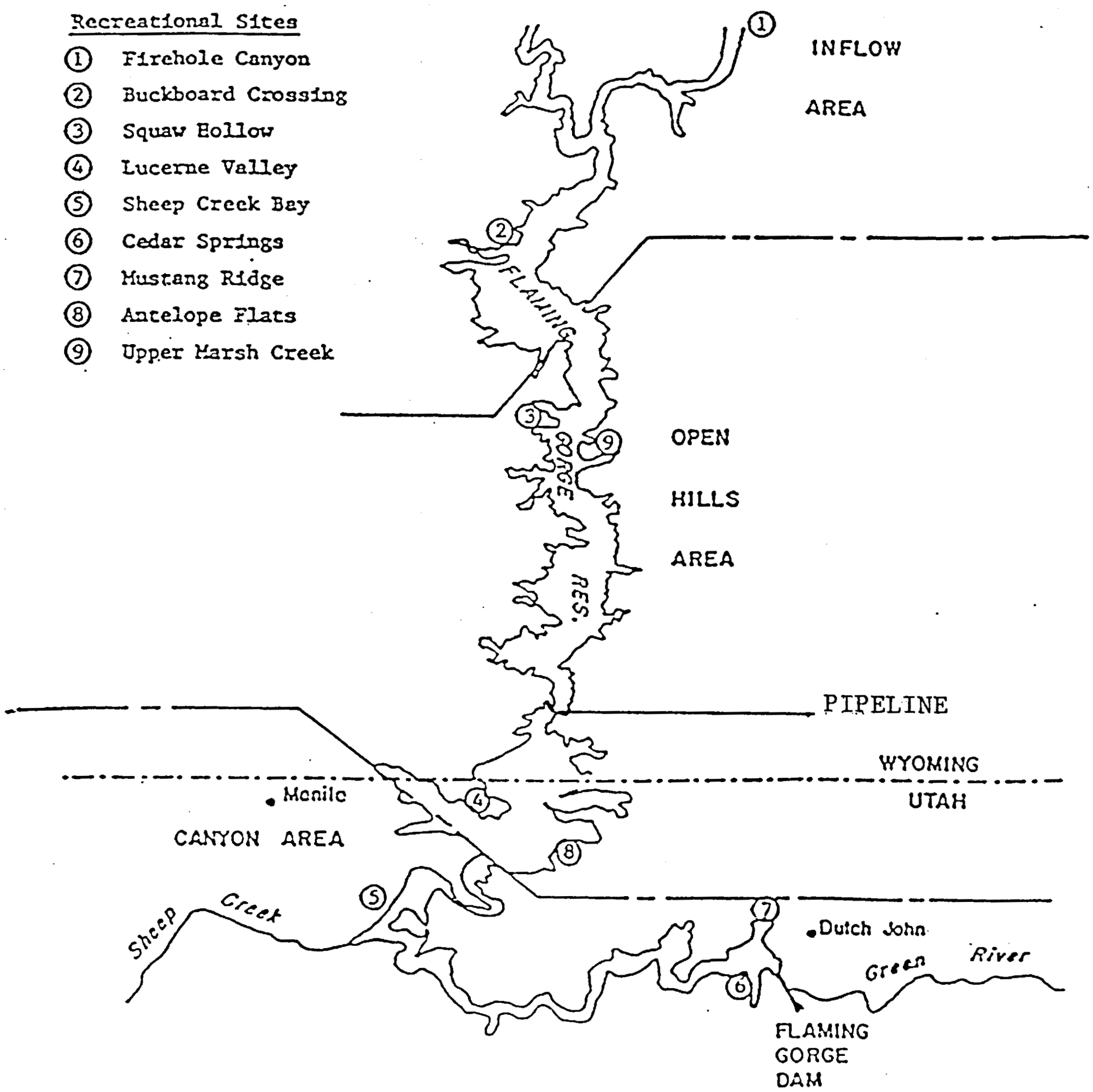
Table 6 presents the percentage of recreationists indicating a particular site as the location where they had encountered excessive algae. The percentage figures do not add up to 100% since recreationists could specify more than one site. As can be seen, the Firehole and Buckboard recreation

Table 6. Percent of Recreationists Encountering Algae at Recreation Sites on Flaming Gorge.

Recreation Site	% of Recreationists Encountering Algae at Site
Firehole	19.3%
Buckboard	33.0%
Squaw Hollow	7.7%
Anvil Draw	8.7%
Pipeline	9.2%
Lucerne	16.4%
Swim Beach	1.5%
Antelope Flats	3.9%
Horseshoe Canyon	1.9%
Sheep Creek	4.4%
Hideout Canyon	2.9%
Cedar Springs	3.4%

sites were identified most by recreationists as locations for excessive algae. The fact that the Lucerne site had almost as many recreationists identifying

Figure 7. Recreational Sites at Flaming Gorge and Pipeline



it as the Firehole site for encountering eutrophication probably reflects the anomaly in water flow from Fontenelle in 1986. Also, the survey data indicated that most people who identified Lucerne as a site for excessive algae were users who were aware of the algae rather than being adversely affected by it. This suggests that algae was not as severe in this area as it was at sites further north.

Table 7 displays the percentage of recreationists indicating a particular year they had either been aware of or been adversely affected by eutrophication. Again, the percentage amounts do not add up to 100% since

Table 7. Percent of Recreationists Indicating Year When Algae Was Excessive.

Year	% of Recreationists Indicating Year When Algae was Excessive
1975-1978	6.3%
1979	4.4%
1980	10.6%
1981	15.0%
1982	21.3%
1983	25.6%
1984	38.7%
1985	46.9%
1986	69.0%

recreationists were allowed to specify more than one year as a problem year. The data show that 69% identified 1986 as the year they had either noticed or been affected by excessive algae. Alternatively, only 6.3% indicated the years 1975-1978 as the time period they had noticed or been affected by algae.

Unpublished data provided by the U.S. Bureau of Reclamation in Salt Lake City (1987), indicate that chlorophyll _a_ concentrations, which are an indicator of the overall quantity of algae in water, were the highest during the periods of 1975-1978 and 1986. Chlorophyll _a_ concentrations have reached problem levels in the area upstream from the Buckboard recreation site in most years between 1975 and 1986 during August through October. Also, the Bureau of Reclamation developed a remote sensing satelite imagery program to partially quantify the magnitude of algal blooms. Remote sensing studies indicated that the algal blooms in 1978 were far greater in concentration and areal extent than during any other year documented. The 1986 algal bloom was abnormally high; however, it was mostly concentrated in the Squaw Hollow area and did not extend to the usual bloom area above Buckboard. The 1978 bloom is attributed to an exceptionally low water level in the reservoir due to drought conditions during 1976 and 1977.

The data provided by the Bureau of Reclamation indicate that there is a good deal of discrepancy between the percent of people identifying a certain year as a problem year for algae and the physical amounts of algae in the reservoir. Such a pattern might be explained by the possibility that those surveyed were relatively new users of the reservoir and were not around when algae was at high levels during the 1975-78 period. However, the survey data indicate that, on average, those surveyed made their first trip to Flaming Gorge in 1973. Thus, the discrepancy in the data is most likely a reflection of the difficulty people have in recalling the impact algae had on their recreational activity. The fact that the percentage amounts progressively increase each year seems to further validate this proposal.

The discrepancy between the survey data in Table 7 and the unpublished Bureau of Reclamation data might also indicate a greater public awareness in recent years of the eutrophication situation in Flaming Gorge Reservoir. Since 1983, when eutrophication in the reservoir was identified by the Wyoming Department of Environmental Quality as the number one surface water quality problem in Wyoming, there has been increased public exposure to the situation through the press. A heightened public awareness of eutrophication in the reservoir may result in more people identifying recent years as a time period when they encountered algae than the years when they were less familiar with the situation through press coverage.

It might also be noted that the majority of recreationists indicated July and August to be the months they had either noticed excessive algae or been adversely affected by it. The fact that July was identified as a month for excessive algae may also be a reflection on the impact the draining of Fontenelle Reservoir had on eutrophication in Flaming Gorge. Fontenelle Reservoir was first drained in 1985 and has been kept at reduced levels since that time. Retention of the added nutrient load in Flaming Gorge from Fontenelle may have precipitated an early bloom of algae.

Of the respondents who had been adversely affected by algae, 73% indicated that fishing was the recreational activity affected. Sixty-seven percent indicated boating had also been affected; 23% said algae had affected their waterskiing activities and 24% said swimming had been adversely affected by algae. The fact that the majority of recreationists indicated fishing had been adversely affected by algae may suggest that degradation of the fish habitat in the Inflow area has occurred as a consequence of eutrophication, particularly since algal blooms have been concentrated in the Inflow area since the early 1970's with the exception of the 1986 bloom. The anomaly of that bloom has already been noted.

RECREATION DEMAND EQUATIONS ESTIMATED

The demand equations estimated for recreation at Flaming Gorge Reservoir with the travel cost model are:

$$\text{Multi-day:}\quad \ln(V_{ij}) = \underset{(2.31)}{-3.69} - \underset{(5.06)}{.0582C_{ij}} - \underset{(1.09)}{.000355S_{ij}} + \underset{(2.82)}{.00014I_{ij}} \qquad (6)$$

$$R^2 = .84 \qquad\qquad \text{F-Value} = 35.69$$

$$\text{Day:} \qquad \ln(V_{ij}) = \underset{(2.45)}{-4.87} - \underset{(7.28)}{.0965C_{ij}} + \underset{(3.48)}{.000202I_{ij}} \tag{7}$$

$$R^2 = .95 \qquad\qquad F\text{-Value} = 90.25$$

All the signs of the coefficients meet a priori expectations. The R^2's indicate that both equations explain a significant amount of the variation in visitation rates. The estimated visits for the multi-day equation were within 90% of actual visits and estimated visits for the day equation were 119% of actual visits. The travel cost variable and the income variable, in both equations, are significant. The travel cost variables are highly significant at the .01% level and the income variables are significant at the 1% level.

Although of the right sign in the multi-day equation, the substitute variable was less significant than the other two variables. Due to its theoretical importance the variable was left in this equation. However, because this variable was of the wrong sign and was not significant at the 20% level in the day equation, it was dropped from the equation. Neither the travel cost coefficient nor the income coefficient was significantly changed by this omission. Also, the day equation in which the substitute site variable was omitted predicted total use better than the day equation that included the substitute variable.

The lack of significance of the substitute variable in both the day and multi-day equations, might be an indication that the substitute index was not a good measure of the quality of the substitute sites. Alternatively, it may suggest that Flaming Gorge offers something unique in terms of a recreational experience and that people perceive that there are no, or few, substitutes for Flaming Gorge. Since it is such a large reservoir, and given its reputation as a trout fishery, it is reasonable to believe that there are few sites readily available to recreationists in the region that can compete with the kind of recreational experience Flaming Gorge offers. This proposal seems validated by the fact that the recreation site mentioned most frequently as an alternative to Flaming Gorge by those surveyed was Lake Powell, a lake almost four times the size of Flaming Gorge located at an average distance from origins in the market area of 375 miles. Also, when asked if they would switch to alternative sites on Flaming Gorge rather than make less trips to the reservoir if algae precluded use of the site they were at, the majority of respondents indicated they would switch to another site on the reservoir.

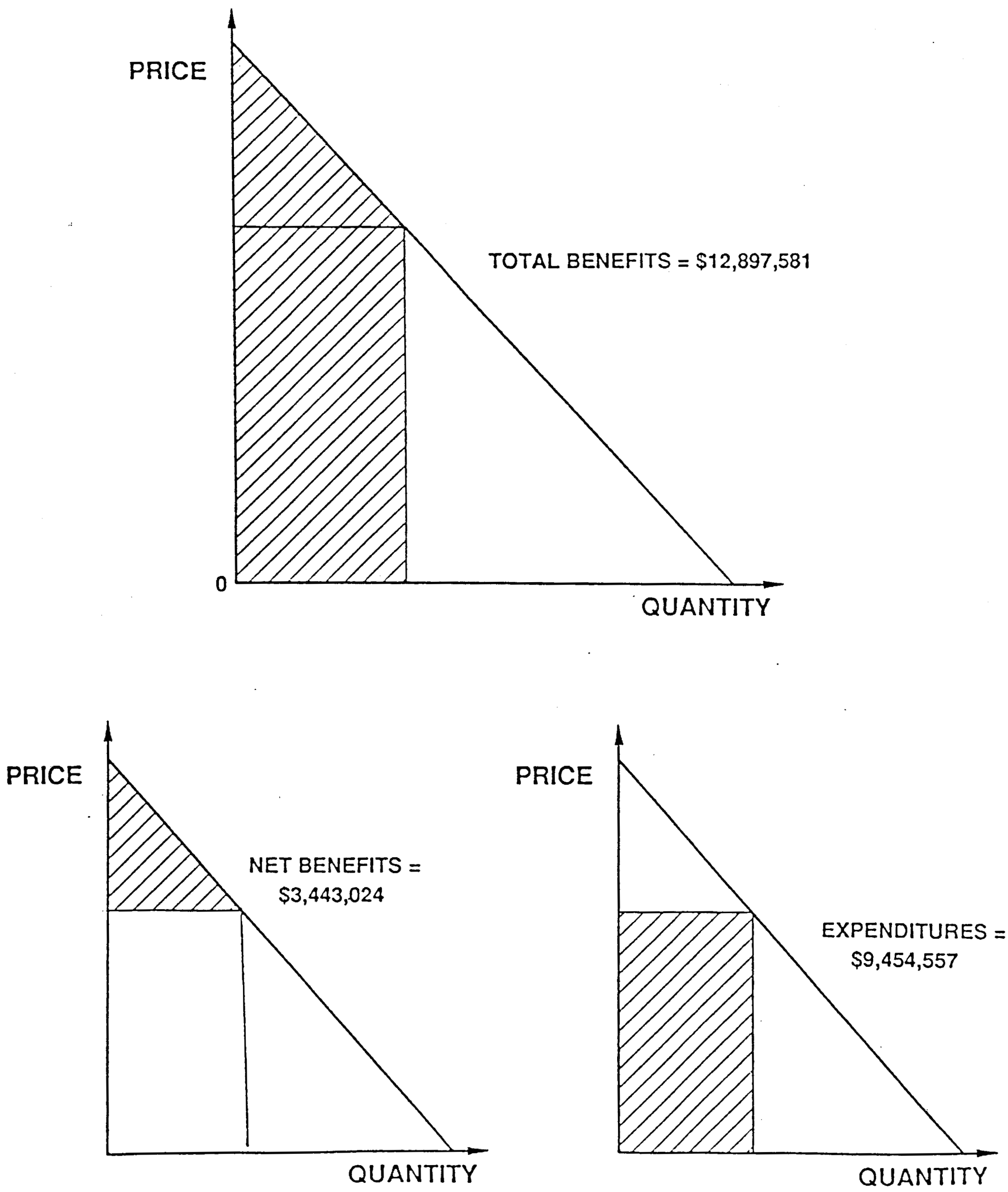
ESTIMATED RECREATION BENEFITS

The total annual benefit from recreation at Flaming Gorge Reservoir was estimated to be $12,897,581. This amount represents the entire area under the demand curve for Flaming Gorge and is equivalent to actual expenditures by recreationists, their opportunity cost of travel time, and the consumer surplus, or net benefit, accruing to recreationists. (See Figure 8) The net present value (NPV) of this total value amount is $315,990,775.

The total annual consumer surplus, or net benefit, estimated for recreation at Flaming Gorge Reservoir from the demand equations was $3,443,024. As has been discussed, it is the net benefit amount that is considered to be the best reflection of the "value" of a good or resource to society. Thus, it is this net benefit amount that would be the appropriate figure in considering any additional costs incurred in the provision of recreation at Flaming Gorge.

Separating the data into multi-day and day trips the total annual net benefit was $2,083,986 and $1,359,038 respectively. This breaks down to a per trip value of $17.65 for multi-day trips and $10.67 for day trips. These per trip figures represent the average amount that an individual would be willing to pay, in addition to present expenditures, rather than forego a trip to Flaming Gorge. For example, on a multi-day trip some people would be willing to pay more than $17.65 and some would be willing to pay less.

Figure 8. Total Benefits, Net Benefits and Expenditures for Recreationists at Flaming Gorge Reservoir.



The NPV of the annual net benefit from recreation at Flaming Gorge is $84,388,518. NPV is the current market value of a future monetary sum. Thus, this NPV figure is the current worth of present and future benefits from recreation at Flaming Gorge for the next one hundred years.

The total expenditures on recreation at Flaming Gorge were estimated to be $9,454,557.[6] This figure represents the difference between the total value figure and the consumer surplus, or net value, figure (see figure 8). The expenditure amount represents what recreationists spend annually on travel, food, and lodging and also, the value of time involved to recreate at Flaming Gorge Reservoir. The out-of-pocket portion of these expenditures represent the impact of recreation at Flaming Gorge on the regional economy (i.e. the market area) since these dollars are transferred to gas stations, grocery and recreation supply stores, and motels. However, there are multiplier effects of these expenditures and thus, the economic impact may be greater than the $9,454,557 figure. Assessing the impact on local economies of expenditures on recreation at Flaming Gorge was beyond the scope of this study.

The average total expenditures per vehicle for a multi-day trip were $178. The average total expenditures per vehicle for a day trip were $83.28. The survey data indicated that the average number of people in a vehicle was 3.35. Thus, on a per person basis, average total expenditures for a multi-day trip were $53.13 and average total expenditures for a day trip were $24.86. If these expenditure figures are added to the per trip consumer surplus amounts (i.e. $17.65 and $10.67), the total value of a multi-day trip to Flaming Gorge, per person, would be $70.78. The total value of a day trip, per person, would be $35.53.

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[6] This figure includes the opportunity cost of time for recreationists and thus direct, out-of-pocket costs would be lower than this value.

ESTIMATED LOSS IN CONSUMER SURPLUS DUE TO EUTROPHICATION

Table 8 presents the results of the sensitivity analysis done in estimating the loss in recreation benefits due to eutrophication. As was mentioned previously, these figures are based on the assumption that

Table 8. Loss in Net Benefits Due to Eutrophication

Period of Non-Use	% of Total Annual Trips from Sweetwater County to Flaming Gorge During Period	Weighted Mileage	Annual Loss in Benefits	NPV of Loss in Benefits
July-October	43%	45	$457,269	$11,203,091
August-October	27%	41	288,323	7,063,914
September-October	12%	38	149,538	3,663,681

eutrophication will prohibit use of the entire northern end of the reservoir during the time periods considered. Thus, the figures represent the maximum loss in benefits from recreation during the months specified. The figures for the annual loss in net benefits represent the difference between the consumer surplus without eutrophication adversely impacting recreation at the reservoir and the consumer surplus amount with eutrophication negatively affecting individuals' recreational activities for both day and multi-day trips.

It is the NPV figures that would be compared to any cost figures for control measures for eutrophication. The loss figures used as a basis of comparison would depend on the predictions of how severe eutrophication will be in the future. At minimum, the NPV of the loss in benefits from recreation due to eutrophication would be $3,633,681. The maximum loss would be $11,203,091. If the cost of possible control measures for eutrophication is greater than the estimated losses in benefits, from an economic standpoint, the control measures cannot be recommended.

If eutrophication were to become even more severe than the "worst case" scenario presented in this study, perhaps limiting recreation as far south as Lucerne, these loss figures would have to be increased. However, since the impact of past and current levels of eutrophication has been less than the worst case scenario level, with only 13% of all recreationists being adversely affected by current levels in eutrophication, the maximum loss figures estimated in this study seem to be a reasonable guideline in making decisions about control measures for eutrophication since they do account for possible increases in the impact of eutrophication on recreational users of Flaming Gorge Reservoir.

CHAPTER 5

SUMMARY AND CONCLUSIONS

The objective of this study was to estimate the benefits from recreation at Flaming Gorge Reservoir and assess the potential loss in benefits due to eutrophication. The travel cost method was employed to meet this objective. The total annual net benefit estimated for recreation at Flaming Gorge from the travel cost model was $3,443,024. Separating the data into multi-day and day trips, the per-trip values were $17.65 and $10.67 respectively. The net present value of the annual net benefit from recreation is $84,388,518. This is based on a 4% discount rate and a 100 year time horizon.

Since most recreation demand studies do not account for on-site time costs through separation of the demand equations, it is somewhat difficult to directly compare the results of this study with values estimated in other studies. However, in general, the estimates from this study compare favorably with results from other regional recreation studies. When values are presented on a per day basis the day value of $10.67 and multi-day value of $8.82 are similar to the values derived for a cold-water fishing trip in Idaho of $13.10 estimated by Gordon (1970), $14.25 estimated by Sorg et al (1985), $16.67 estimated by the U.S. Fish and Wildlife (1980), and to $10.53 for a cold-water fishing trip in Colorado estimated by Walsh and Olienyk (1985).[7]

Because the Idaho and Colorado estimates are average values for the entire state, where a fishing trip can range from small reservoirs to blue-ribbon trout streams, it is reasonable that the values for Flaming Gorge are lower. Also, the values for Flaming Gorge are for a general recreation

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[7] The values for Gordon (1970) and U.S. Fish and Wildlife (1980) have been adjusted to 1985 values. The per-day value of $8.82 for multi-day trips reflects the effect of diminishing marginal returns for recreationists and thus is lower than the day trip value.

trip to the reservoir whereas the values from the Idaho and Colorado studies are for fishing trips alone and thus, it would be expected that values for Flaming Gorge would be lower. However, since the primary recreational activity at Flaming Gorge is fishing, it seems reasonable to use these values as a basis of comparison.

A sensitivity analysis was performed to provide estimates of the loss in recreational benefits due to eutrophication for various time periods. Loss figures were estimated for the periods July-October, August-October, and September-October. These are the months eutrophication is normally at its worst. Since the severity of eutrophication has varied from year to year, and from month to month, alternative scenarios were considered so as to provide a range of values with which potential costs of control measures for eutrophication can be compared. The time period used as a basis of comparison will depend on the predictions made about the future of eutrophication in Flaming Gorge.

The estimated annual loss in net benefits for the period July-October was $457,269. The annual loss in benefits for the period August-October was $288,323. The annual loss in benefits for the period September - October was $149,538. The NPV values of these losses are $11,203,091, $7,063,914, and $3,663, 681 respectively. These loss figures can be compared with the cost of control measures in assessing the desirability of control measures from an economic standpoint.

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APPENDIX A

Personal Survey

Effects of Water Quality on
Flaming Gorge Recreation

ID# ________
SITE ________
INTERVIEWER ________
DATE ________

Q-1) Where do you live?

________ CITY ________ COUNTY ________ STATE

Q-2) Have any of the following water quality problems affected your recreational activities at the reservoir in the past 5 years?

1) Not very clear; murky
2) Strange odors or tastes
3) Algae growth or plant scum
4) Dead fish
5) Irritation to eyes or skin
6) Floating objects
7) Other ________
8) No objection

Q-3) When and where has water quality affected your recreation on the reservoir?

YEAR	MONTH												WHERE	TYPE
19___	1	2	3	4	5	6	7	8	9	10	11	12	___	___
19___	1	2	3	4	5	6	7	8	9	10	11	12	___	___
19___	1	2	3	4	5	6	7	8	9	10	11	12	___	___
19___	1	2	3	4	5	6	7	8	9	10	11	12	___	___
19___	1	2	3	4	5	6	7	8	9	10	11	12	___	___

Q-4) Has the presence of algae affected your enjoyment of recreation on Flaming Gorge?

Yes No

Q-5) What recreational activities have been affected by algae?

1) Fishing 2) Boating 3) Waterskiing 4) Swimming 5) Other ________

Effect on Recreational Activity — Activity

1) Switch to a different site on Flaming Gorge Reservoir? ________

2) Change recreational activities at Flaming Gorge Reservoir? ________

3) Go to a different reservoir? ________

4) Change to other forms of recreation? ________

Q-6) What specific location on the reservoir was the primary destination of this trip to Flaming Gorge?

LOCATION ______________________________
MILES FROM HOME (ONE-WAY) ______________________________
HOURS OF TRAVEL TIME ______________________________

Q-7) If, for some reason, you had been unable to use this site, would you have used an alternative site on Flaming Gorge? Yes No

ALTERNATIVE SITE ______________________________
MILES FROM HOME (ONE-WAY) ______________________________
HOURS OF TRAVEL TIME ______________________________

Q-8) If you were unable to use Flaming Gorge Reservoir, would you use an alternative reservoir or lake? Yes No

ALTERNATIVE AREA ______________________________
MILES FROM HOME (ONE-WAY) ______________________________
HOURS OF TRAVEL TIME ______________________________

Q-9) What is the total number of trips you make to Flaming Gorge in a year ______________?

Q-10) What if the northern end (above Buckboard) of Flaming Gorge Reservoir were unusable in the month of August? Would it cause you to:

1) Make less trips to Flaming Gorge Reservoir? Yes No
   a) By how much? ______________

2) Switch to a different site on Flaming Gorge Reservoir? Yes No
   a) How many trips? ______________

Q-11) Would you be willing to participate further by filling out a more detailed mail survey on your recreation use of Flaming Gorge?

____

1) YES --- NAME ______________________________

2) NO ADDRESS ______________________________

____

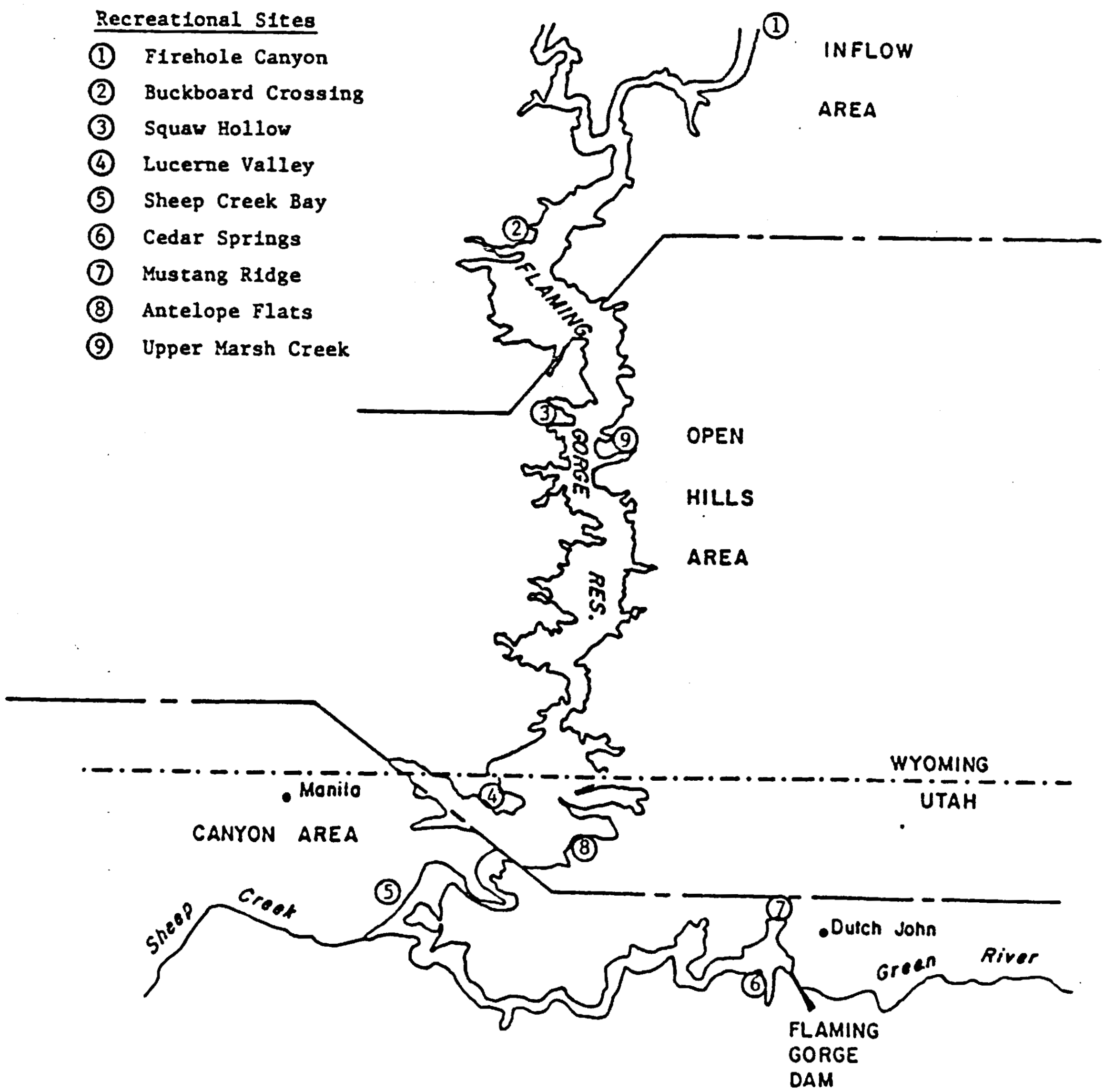
PHONE ______________________________

APPENDIX B

Mail Survey

WYOMING WATER RESEARCH CENTER
The University of Wyoming

SURVEY OF THE RECREATION USERS OF FLAMING GORGE



Part 1. RECREATIONAL ACTIVITIES ON FLAMING GORGE

Q-1 To help us determine the types of recreational use that could be affected by a change in water quality, please indicate the activities that you or your party have participated in when visiting Flaming Gorge during the past 12 months. (Circle any that apply.)

1 BOAT FISHING	7 PICNICKING
2 SHORE FISHING	8 CAMPING
3 PLEASURE BOATING	9 SWIMMING
4 WATERSKIING	10 ICE FISHING
5 SIGHTSEEING	11 OTHER (Please list)________________
6 HIKING	________________

Q-2 Which of the above recreational activities did you do most often? (Put number of item in appropriate box, for example 9 indicates swimming.)

☐	MOST OFTEN-----------	Number of years that you have been doing this activity. _____YEARS
☐	SECOND MOST OFTEN----	Number of years that you have been doing this activity. _____YEARS
☐	THIRD MOST OFTEN-----	Number of years that you have been doing this activity. _____YEARS

PART 2. YOUR TRIPS TO THE RESERVOIR

To determine the frequency of use of Flaming Gorge Reservoir, the following questions ask for some information about your recent visits to the area.

Q-3 Approximately how many recreational trips did you take to Flaming Gorge Reservoir in the <u>past 12 months</u> (including this trip)?

__________ TOTAL NUMBER OF TRIPS

Q-4 Of the total number of trips indicated in Q-3, how many were taken during each of the following time periods?

__________ DECEMBER THRU MARCH	__________ JULY
__________ APRIL	__________ AUGUST
__________ MAY	__________ SEPTEMBER
__________ JUNE	__________ OCTOBER THRU NOVEMBER

Q-5 What was the primary destination of each trip reported in Q-3? The major sites are shown on the map on the cover. (Total should match Q-3)

_________ TRIPS TO FIREHOLE CANYON SITE
_________ TRIPS TO BUCKBOARD CROSSING SITE
_________ TRIPS TO SQUAW HOLLOW SITE
_________ TRIPS TO LUCERNE VALLEY SITE
_________ TRIPS TO SHEEP CREEK BAY SITE
_________ TRIPS TO CEDAR SPRINGS SITE
_________ TRIPS TO MUSTANG RIDGE/DUTCH JOHN DRAW SITE
_________ TRIPS TO ANTELOPE FLATS SITE
_________ TRIPS TO UPPER MARSH CREEK SITE
_________ TRIPS TO OTHER ACCESS SITES (Please list and locate on map)

____

PART 3. THIS TRIP TO THE RESERVOIR

The following questions ask for some specific information about this particular trip to Flaming Gorge Reservoir.

Q-6 How many hours did you spend at the reservoir during this trip?

_________ HOURS

Q-7 What type of vehicle did you travel in on this trip?

Type of Vehicle:

1 COMPACT CAR
2 INTERMEDIATE-SIZED CAR
3 FULL-SIZED CAR
4 TWO-WHEEL DRIVE PICKUP
5 TWO-WHEEL DRIVE VAN
6 FOUR-WHEEL DRIVE VEHICLE
7 SELF CONTAINED RV
8 MOTORCYCLE
9 OTHER (Please list) ____

Did you tow a trailer or another vehicle?

1 YES
2 NO

Q-8 How many people, including yourself, were traveling in this vehicle?

_________ NUMBER OF ADULTS (18 and over)

_________ NUMBER OF TEENS AND CHILDREN

Q-9 This question concerns the amount of money that you spent on this trip.

a. Please estimate the amount spent on transportation on this trip.

_____________ DOLLARS

b. Please estimate the amount spent on food, tackle, etc. on this trip.

_____________ DOLLARS

c. Please estimate the amount spent on lodging on this trip.

_____________ DOLLARS

d. Number in traveling party covered by these expenditures.

_____________ NUMBER OF PEOPLE

Q-10 The previous question asked how much you spent on this trip to the reservoir. Do you feel that this trip was worth more than you actually spent?

1 YES
2 NO -----(If NO, go to Q-11)

Q-10a If YES, suppose that, for some hypothetical reason, the trip to Flaming Gorge became more expensive, perhaps due to increased travel costs or something else. Given that the quality of the reservoir was unchanged, how much more would you be willing to spend on the trip rather than not go to Flaming Gorge.

_____________ DOLLARS

PART 4. INFORMATION ABOUT YOURSELF

The following questions ask for some information about yourself. This information will be summarized to profile typical users of the reservoir. Your answers will be held confidential and you personally will not be identified in reporting the results of the study.

Q-11 In what calender year did you first visit Flaming Gorge Reservoir?

19____

Q-12 How many trips have you taken to lakes or reservoirs other than Flaming Gorge in the past 12 months?

_________ TRIPS

Q-13 Please read the following statements and circle the one which best describes how you feel about fishing on Flaming Gorge.

1 I would prefer the opportunity to catch a trophy fish even if this meant catching fewer fish.

2 I would prefer the opportunity to catch a lot of fish even if this meant catching smaller fish.

3 I do not care about the number or size of fish caught.

4 I do not care about the fishing on Flaming Gorge.

Q-14 What is your age? __________ YEARS

Q-15 How many people, including yourself, are in your household?

__________ PEOPLE

Q-16 What is your principal occupation? ______________________________

Q-17 What is the highest year of formal schooling you have completed? (Circle one number)

1 2 3 4 5 6 7 8	9 10 11 12	13 14 15 16	17 18 19 20+
Elementary	High School	College or Vocational School	Graduate or Professional School

Q-18 To the best of your knowledge, what was your household income last year before taxes?

1 Under $5,000	5 $20,000 to $24,999	9 $40,000 to $49,999
2 $5,000 to $9,999	6 $25,000 to $29,999	10 $50,000 to $74,999
3 $10,000 to $14,999	7 $30,000 to $34,999	11 $75,000 and above (Please list to nearest $10,000)__________
4 $15,000 to $19,999	8 $35,000 to $39,999	

Comments______________________________

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