Reservoir Eutrophication and Recreational Activity on Flaming Gorge Reservoir

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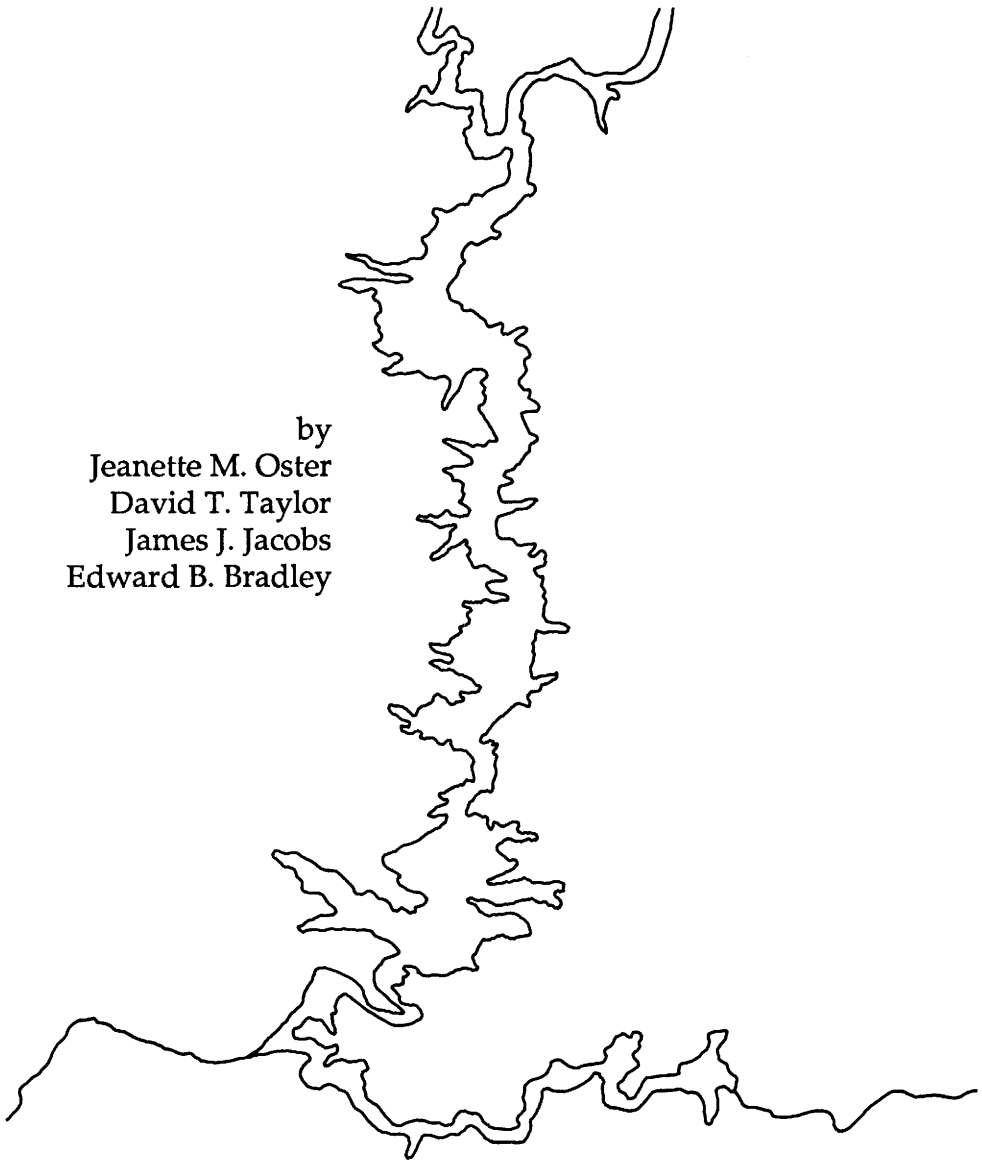

Experiment Station Bulletin No. 908

UNIVERSITY OF WYOMING

College of Agriculture
The University of Wyoming

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5-89/5C/1.30

ACKNOWLEDGEMENTS

This study was conducted with the assistance and cooperation of many state and federal agencies. The activities on which this report are based were financed in part by the Department of Interior, U.S. Geological Survey, through the Wyoming Water Research Center. The authors would like to thank Lee Skabelund and Dave Keddy of the U.S. Forest Service, Dutch John, UT; Steve Brayton and Roger Schneidervin of the Utah Division of Wildlife, Dutch John, UT; Bill Wengert and Dave Dufek of Wyoming Game and Fish, Green River, WY; and Jerry Miller of the U.S. Bureau of Reclamation, Salt Lake City, UT. Appreciation is also extended to Rebecca Taylor, Mike Lindberg, and Al Bath for their assistance in conducting interviews and compiling data. Finally, special thanks to Julie Burton for her skill and patience in typing this report.

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INTRODUCTION

Flaming Gorge Reservoir is located in southwestern Wyoming and northeastern Utah (See Figure 1). The reservoir's 42,000 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 south end of the reservoir.

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

This study was motivated by the concern over eutrophication in the northern end of Flaming Gorge Reservoir. Eutrophication is the nutrient enrichment of water which results in increased algae production. One type of algae produced in the eutrophication process is Apahanizomenon, 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 recreational use of a reservoir.

Figure 1. Location of Flaming Gorge Reservoir.

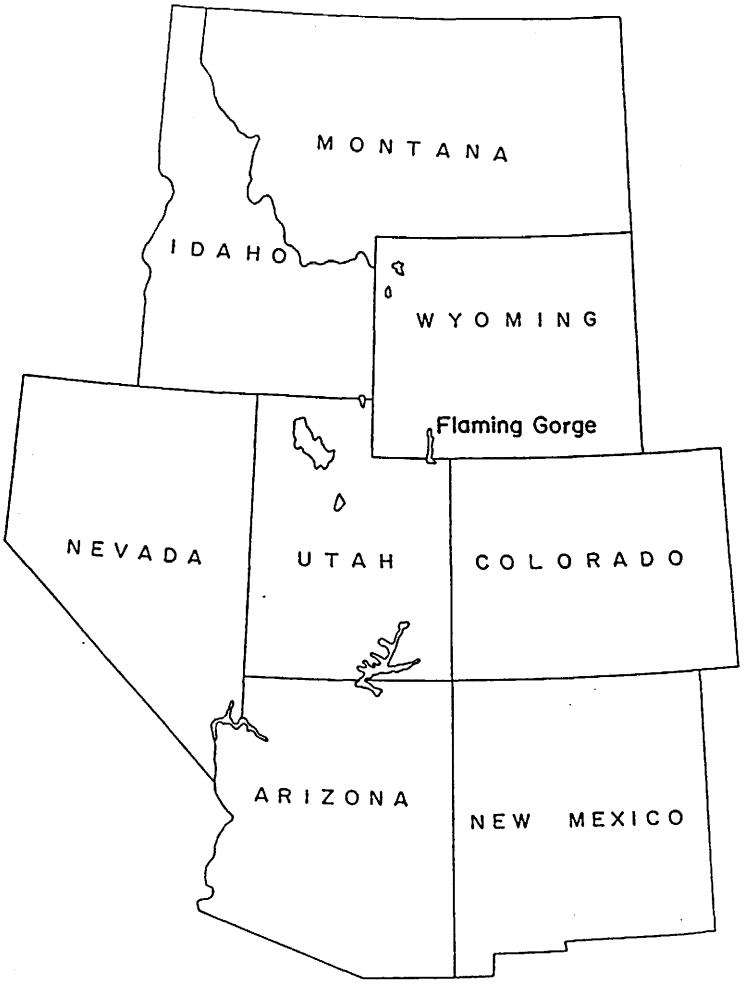
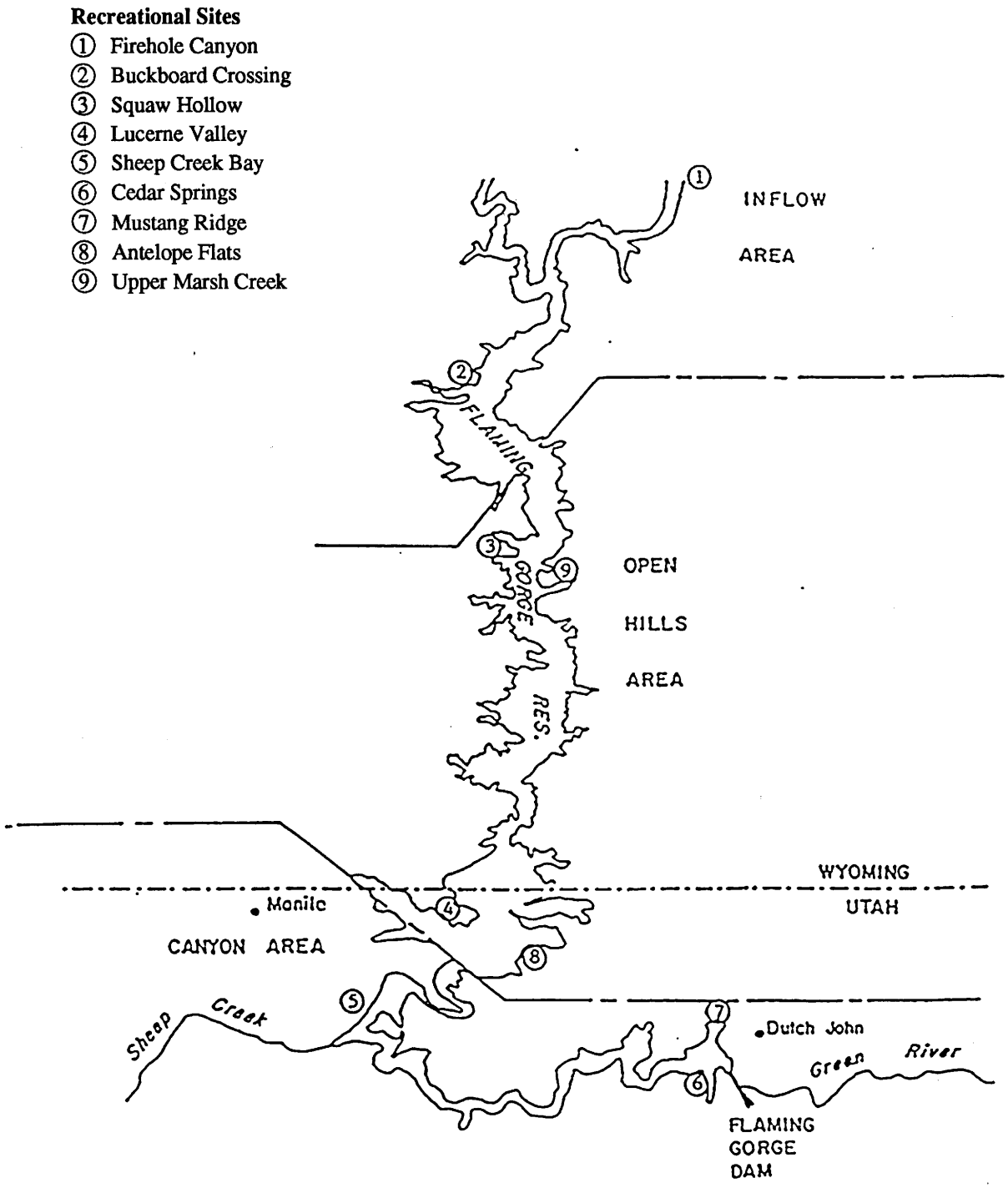


Figure 2. Recreational Sites at Flaming Gorge Reservoir



The U.S. Environmental Protection Agency's National Eutrophication Survey (1975, 1978b, 1978c) indicated that among 170 reservoirs included in the survey only 12% experience large blooms of bluegreen algae. 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. Bluegreen algae blooms have been observed in the northern end of the reservoir since at least 1975.

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. Also, warmer water temperatures during this time of year are conducive to algae growth.

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 rural lands and urban areas. Because Flaming Gorge 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. The remaining phosphorus comes mostly from effluents generated by municipal and industrial waste disposal in cities at the northern end of the reservoir. Unpublished results of recent water quality studies indicate the portion from municipal and industrial sources has increased in recent years (Parker 1987).

From a recreational standpoint, economic losses would occur if individuals' recreational activities were altered or reduced as a direct consequence of the eutrophication process. The thick blooms of algae on the water surface can discourage recreational activities such as boating, water-skiing and swimming. Also, in a study done by the Wyoming Game and Fish (Wengert 1985), it was noted that oxygen and temperature measurements taken during the period 1977-1983 indicated a loss of summer trout habitat in parts of the northern end of the reservoir 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.

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.

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, and the potential loss in this value from eutrophication, 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?).

The second section of this study provides a brief review of the valuation methods for estimating the economic benefits of recreational resources. The third section 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. The fourth section discusses the results of the survey and presents the estimated benefits from recreation at Flaming Gorge as well as the loss in benefits due to eutrophication. Finally, the fifth section provides a summary of the results and the conclusions of the study.

This study is concerned only with estimating the value of recreational activities in Flaming Gorge Reservoir and the potential loss in these benefits from eutrophication. Estimation of other costs associated with the eutrophication problem in Flaming Gorge is beyond the scope of this study. For example, the bluegreen algae do have the potential to become toxic, and thus, 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 Recreational Area.

Finally, this study does not account for non-user benefits. There are benefits to individuals in addition to the values they receive from visiting a site. These benefits are commonly referred to as preservation values. They reflect the value individuals place on just knowing that the possibility of future recreation use is guaranteed and/or that a recreation site or natural resource will be protected. However, since Flaming Gorge Reservoir is not a unique resource with regard to the recreation opportunities available, exclusion of option and existence values should not create any significant bias on the values established from data for current users of the reservoir. As Walsh (1986) notes:

> For less outstanding resources with regional rather than national significance, the proportion of the population who hold preservation values appears to be a declining function of the distance that they live from the resource.

VALUING RECREATIONAL RESOURCES

> 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)

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 individuals are willing and able to pay for a good and what they actually have to pay for the good. This concept is illustrated in Figure 3, which displays a demand curve for a particular good.

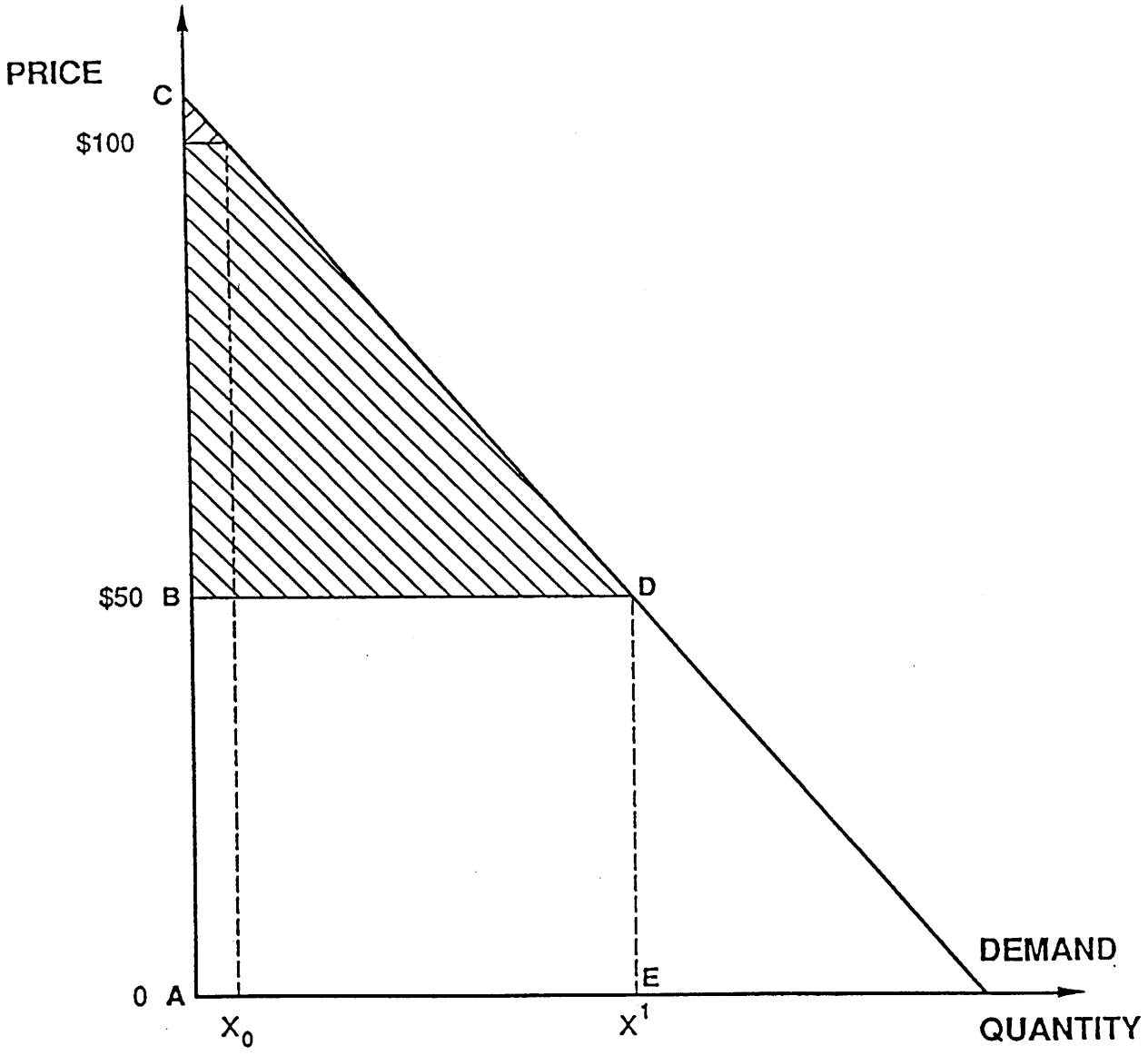
In Figure 3, equilibrium is reached at $50 where the supply of good X equals the demand for good X. In a competitive market situation, because the price of a good is constant no matter how many units of the good are purchased, the supply curve for individuals is horizontal. The equilibrium quantity is 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. Total consumer surplus for the good, or equivalently its economic value, is derived by adding up all individuals' consumer surplus for each unit of the good consumed. This summation is approximately the area under the 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.

The difficulty in valuing natural/recreational resources is that, 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 the market place. As a consequence, the true value to the consumer of a natural resource or recreational activity may not be reflected in the user fees established by government agencies managing these resources. Thus, it would be inappropriate to use the fees charged by management agencies to derive a demand curve for a recreational resource.

As an alternative to user fees as the basis of economic valuation of recreational resources, the U.S. Water Resources Council (1979, 1983) recommends three methods to estimate a measure of the consumer surplus, or net benefit from a recreational resource. The three methods are the unit day value, the travel cost and the contingent valuation method. Many federal agencies, such as the U.S. Forest Service, Bureau of Land Management and Bureau of Reclamation use these methods for valuing recreational resources under their jurisdiction. The following will provide a brief discussion of each valuation method.

Figure 3. Consumer Surplus of Good X.



UNIT DAY VALUES

The Water Resources Council classifies outdoor recreation into two categories, "general" and "specialized". 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 address such factors as congestion, availability of substitute sites, accessibility, carrying capacity and environmental quality.

Each criterion 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. The value of the recreation site is determined by multiplying the day value for the site by the number of recreation visitor days for the site. A recreation visitor day (RVD) is conventionally considered to be a 12-hour period of recreation at a site. Thus, a visitor day could be measured as one individual recreating for 12 hours or three individuals recreating for four hours.

There has been a good deal of criticism of the unit day value method. Some argue that these measures are based on a "feel" for demand rather than any real measurement of it (Ravenscraft and Dwyer 1978). An additional problem 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). 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.

TRAVEL COST

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. The travel cost method is developed by observing the decrease in recreation use of the site as distance from the site increases. The wide range of travel costs facing individuals at different distances from a site provides considerable information about the influence of costs on participation. Also, the travel costs incurred by recreationists are thought to be a good reflection of their "willingness to pay" for use of the recreation site.

The travel cost model assumes that individuals respond to a change in travel costs in the same way they would respond to a change in price, all other things remaining constant. Thus, if people living in town "A" 25 miles away from a recreation site were faced with the same costs as those living in town "B" 50 miles away, they would make the same number of trips to the recreation site as people from town "B". Having information from a number of different origins of varying distances from a recreation site allows for statistical estimation of a demand curve for the site and in turn, the consumer surplus, or net benefit, for the site. Historically, the travel cost model has been preferred by most economists when estimating recreational benefits since it is based on observed market behavior (Dwyer et al 1977).

CONTINGENT VALUATION

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). The "willingness to pay" amounts generated from recreationists are then used to estimate a demand curve for the recreation site.

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 or not 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 contingent valuation 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. The biggest problem with the contingent valuation method is the possible biases that 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 approach over the contingent valuation 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).

METHODOLOGY

CHOICE OF A 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.

The difficulty in meeting the criteria for use of the contingent valuation method is explained primarily by two factors. First, because eutrophication has been concentrated in the northern end of the reservoir not all recreationists at Flaming Gorge are familiar with the eutrophication situation. The reservoir is 91 miles long and many recreationists using facilities at southern points do not use the northern end on a regular basis. Secondly, levels of algae in the reservoir vary from year to year. Consequently, people may have a hard time recalling the impact algae had on their recreation experience and thus, would have difficulty making connections between levels of algae and changes in recreation behavior. 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 for Flaming Gorge, a survey of current recreationists at the reservoir was conducted. The survey consisted of both a personal interview with users at the reservoir and a follow-up mail questionnaire. 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, 46% at recreation sites in the Open Hills area, and 35% at recreation sites in the Canyon area.

Out of 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. 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 a 79.7% response rate.

THE MODEL

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

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

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)

In general, this expression represents the demand curve for Flaming Gorge Reservoir. Economic theory suggests that the number of visits to a recreation site from a particular origin 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).

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 came from counties within an approximate radius of 250 miles. These counties were considered the market area for Flaming gorge which is displayed in Figure 4. 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. The demand curve for Flaming Gorge is derived from use data for each of the counties in the market area. Designating a market area based on at least 90% of use is consistent with other travel cost studies such as Brown and Hansen (1974).

ESTIMATING THE IMPACT OF EUTROPHICATION ON RECREATION

To estimate the potential impact of eutrophication on recreation at Flaming Gorge using the travel cost method, it was assumed that the entire northern end of the reservoir (the inflow area), which includes the Buckboard and Firehole sites, would be unusable for the months of July, August, September and October. According to the 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 algal blooms have 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 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 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 exceed the cost associated with controlling algae, 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 Counties 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. This assumes that no overcrowding or congestion would occur on the reservoir if the north end was unusable.

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 5, 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 are 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 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.

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

Figure 4. The Market Area for Flaming Gorge.

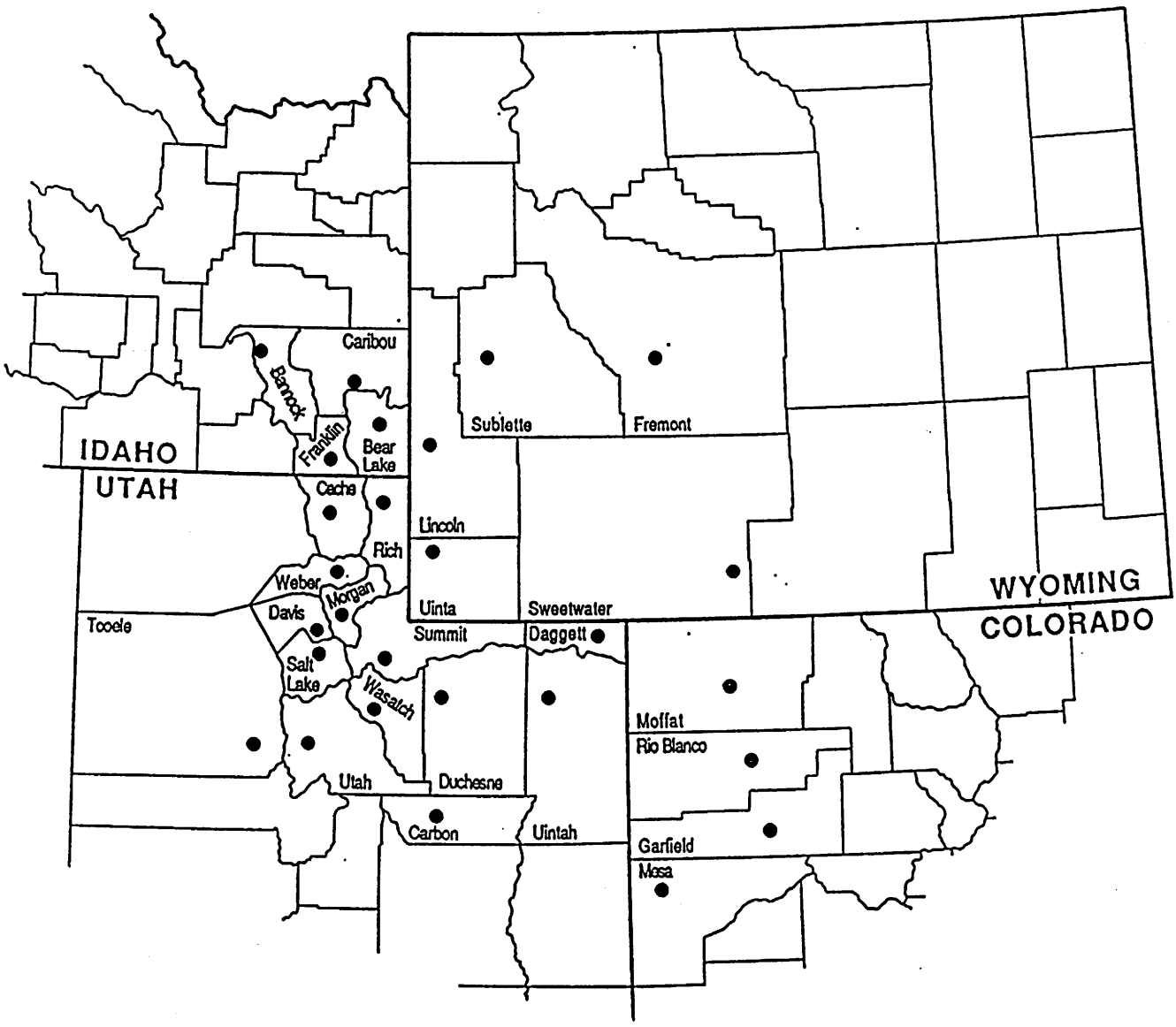
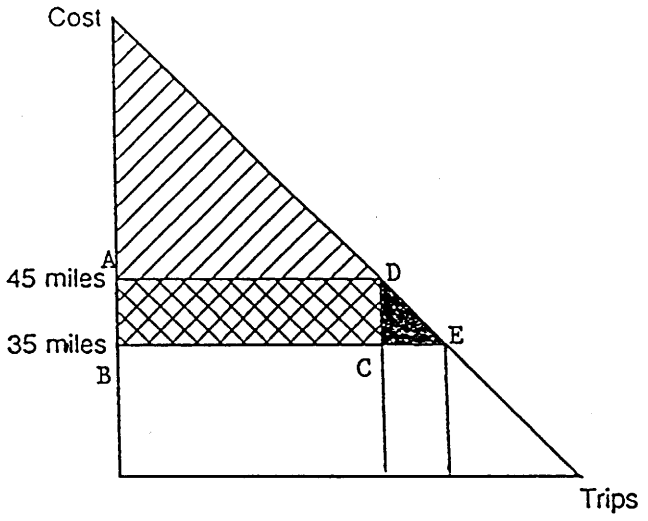
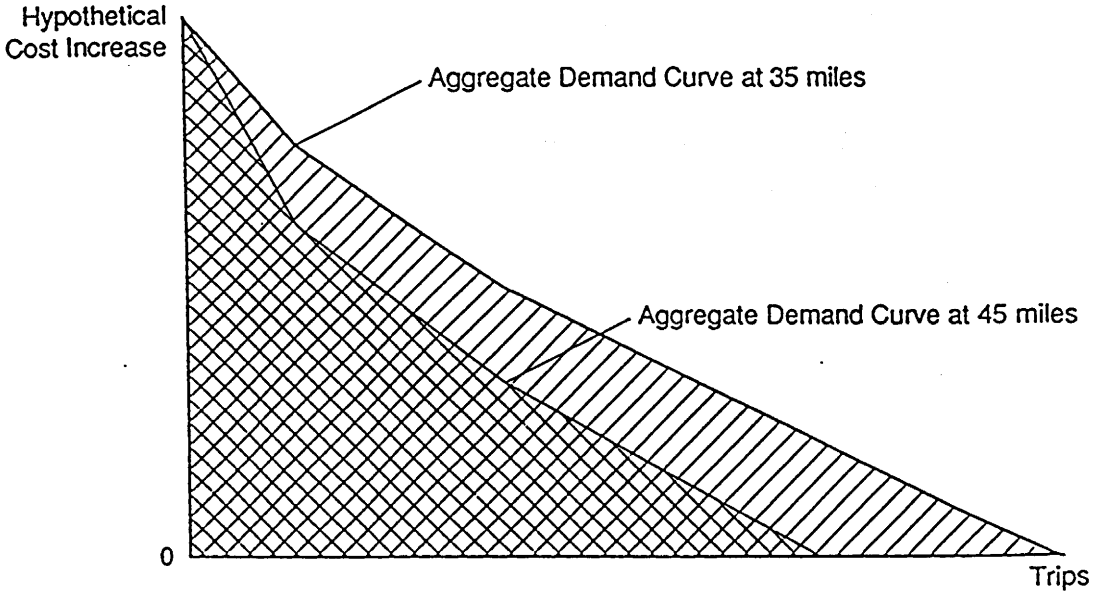


Figure 5. Loss in Benefits Due to Eutrophication.



Demand Curve for Sweetwater County



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 5)

NET PRESENT VALUE

Net present value (NPV) figures of the estimated annual benefits from recreation and loss due to eutrophication were 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.

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, Massachusetts, 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 reductions. 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.

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.

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%

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 and 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 seen, boat fishing is the activity that has the highest participation rate. 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 2. Percent of Surveyed Population Participating in Recreational Activities at Flaming Gorge

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

Table 3 displays use data on a monthly basis. It shows the percent of the total trips taken to Flaming Gorge during a particular month. The data 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 measures use in terms of the number of trips taken to a site. The Forest Service data measures 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.

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%

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%

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 the majority of trips from Sweetwater County are day trips, actual hours of use at Buckboard was lower than a site such as Cedar Springs because the trips to Buckboard tend to be shorter. As can be seen in Table 4, the Forest Service data indicate that only 4.7% of total recreation visitor days (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.

If planning agencies are assessing the need for facilities or changes in facilities at the various recreation sites, it is important to view use in light of the two different measures in Table 4. Although the Forest Service data does not indicate a substantial 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, currently 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 such as 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 such as Firehole and Buckboard where day use is more prevalent.

IMPACT OF ALGAE ON RECREATION

Results of the survey show 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 substantial at current levels. 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

relative 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, since the southern end receives the most use in terms of hours. 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 have encountered it at points north of the Pipeline (See Figure 6). As previously 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 5 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 sites were identified most by recreationists as locations for excessive algae. The fact that the Lucerne site had almost as many recreationists identifying 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 5. Percent of Recreationists Encountering Algae at Recreation Sites on Flaming Gorge.

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

Figure 6. Recreatonal Sites at Flaming Gorge and Pipeline

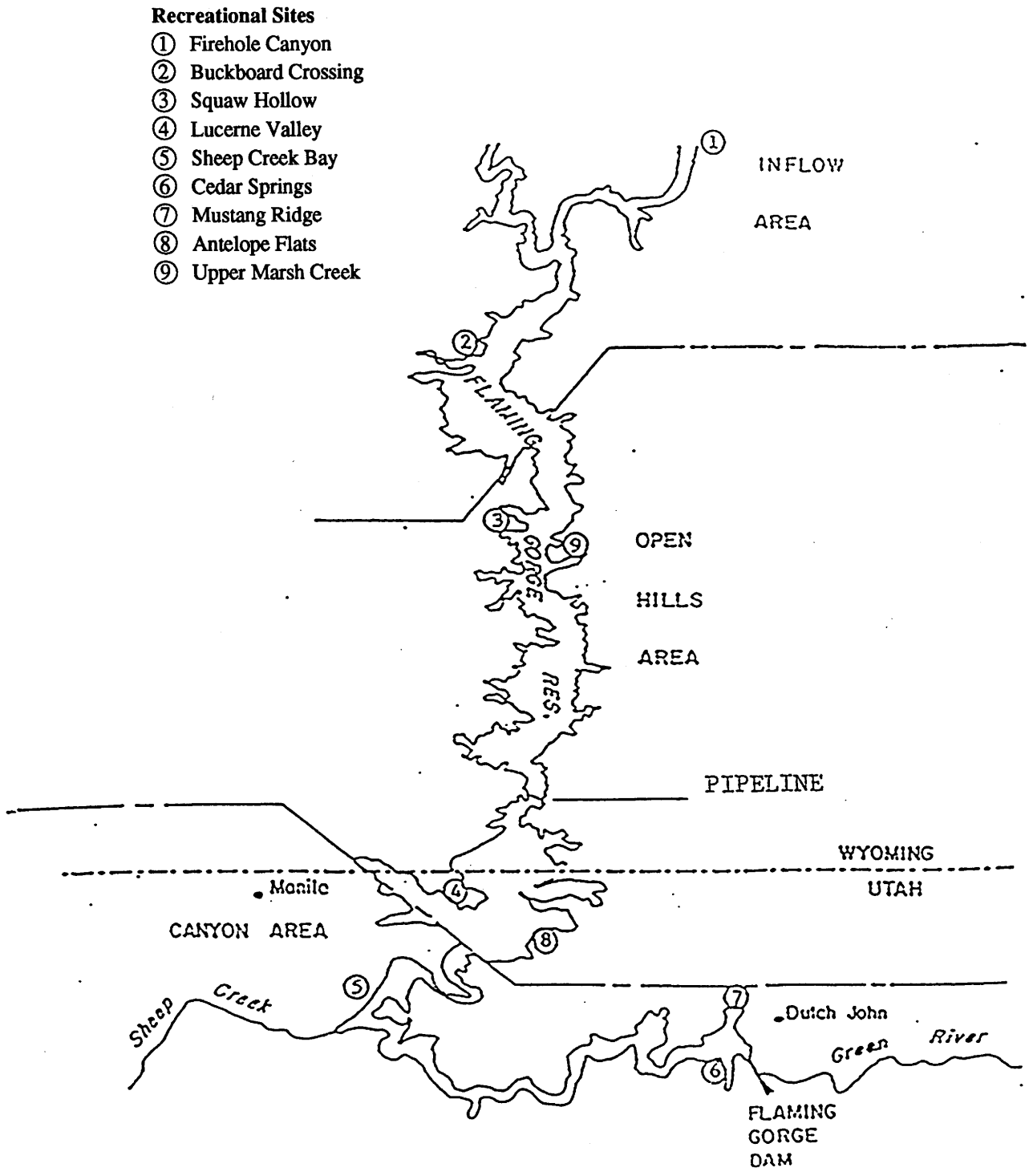


Table 6 displays the percentage of recreationists indicating a particular year they had either been aware of or been adversely affected by eutrophication. Again, the percentage amounts do not add up to 100% since recreationists were allowed to specify more than one year as a problem year. The data show 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.

Table 6. 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%

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 satellite 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 percentage 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 hypothesis.

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 a 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 water-skiing 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.

ESTIMATED RECREATION BENEFITS

The total annual benefit from recreation at Flaming Gorge Reservoir estimated from the demand equations was $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 7). 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 previously 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 by management agencies.

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.

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.[1] This figure represents the difference between the total value figure and the consumer surplus, or net value, figure (see figure 7). 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 local economy since these dollars are transferred to gas stations, grocery and recreation supply stores and motels in the vicinity. 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.

ESTIMATED LOSS IN CONSUMER SURPLUS DUE TO EUTROPHICATION

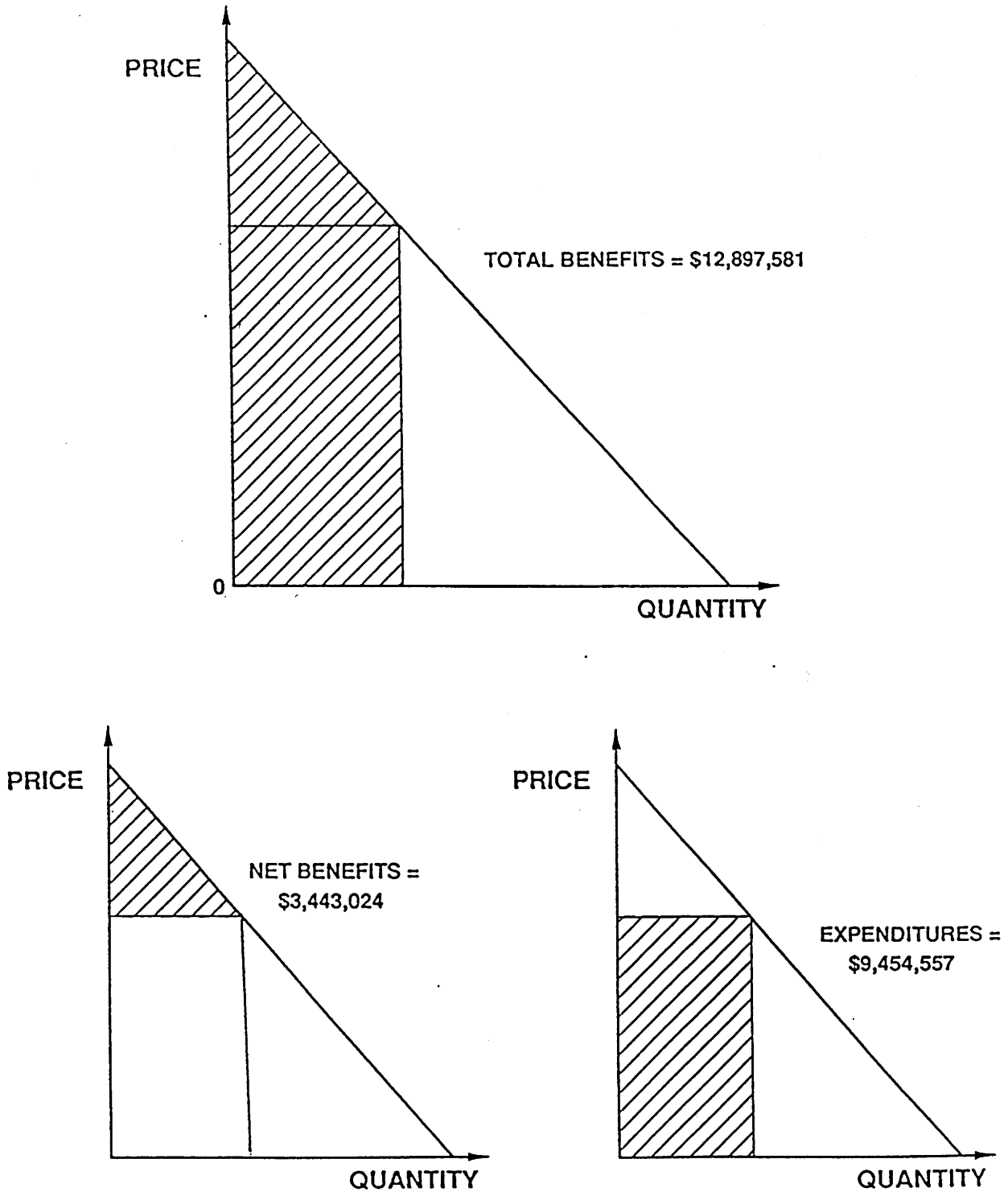
Table 7 presents the results of the sensitivity analysis done in estimating the loss in recreation benefits due to eutrophication. As was mentioned previously, these figures are based on the assumption that eutrophication will prohibit use of the entire northern end of the reservoir during the time periods 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 im-

Table 7. 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

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

Figure 7. Total Benefits, Net Benefits and Expenditures for Recreationists at Flaming Gorge Reservoir



pacting 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, the control measures would not be recommended from an economic standpoint.

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 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 of 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.

SUMMARY AND CONCLUSIONS

The objective of this study is 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.

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 to 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).[2]

Because the Idaho and Colorado estimates are average values for the entire state, including 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 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 somewhat lower. However, since the primary recreational activity at Flaming Gorge is fishing, it is reasonable to use these values as a basis for 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 month to month, alternative scenarios were considered 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.

[2] 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.

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