AN EMPIRICAL APPLICATION OF A MODEL FOR ESTIMATING THE RECREATION VALUE OF INSTREAM FLOW

by

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COLORADO WATER RESOURCES
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ABSTRACT

This report analyzed the public benefits from cold water river fishing, kayaking, and rafting on the West Slope of the Rocky Mountains, Colorado. A representative sample of 206 persons were interviewed at nine river sites during the summer, 1978. Respondents reported willingness to pay contingent on changes in congestion and water level. Recreation benefit functions were related to several important variables, including: instream flow, crowding, characteristics of participants, and costs of management. Policy implications were discussed with emphasis on application of the information to water management decisions.

Benefits from expanding opportunities for fishing would accrue to all individuals who have access to western rivers, because of the reduced congestion which would result at substitute sites. Providing optimum access to 15 percent more miles of river would increase western fishing benefits by an average of $1.25 per user day.

Marginal analysis has shown that while it is true western rivers provide maximum total benefits from excellent white water rapids for kayaking and rafting during spring and early summer when stream runoff is high, instream flow is much more valuable for boating as well as fishing during late July, August, and September to maintain minimum flow. The minimum optimum flow to maximize marginal benefits per acre foot appears to be 35 percent of maximum. At this level, the sum of marginal benefits is estimated as $19.04 per acre foot, including $13.08 fishing, $3.60 kayaking, and $2.36 rafting. This assumes 60 miles of river suitable for each of these recreation activities. An acre foot of instream flow can be used for recreation purposes in subsequent miles of river without diminishing its value to recreation users downstream.

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SUMMARY

The purpose of this study was to develop and apply a procedure to measure the public benefits from cold water river fishing, kayaking, and rafting on the West Slope of the Rocky Mountains, Colorado. Recreation economic benefit functions were related to several important variables, including: instream flow, crowding, characteristics of participants, and costs of management. The information will contribute to an assessment of the economic feasibility of maintaining instream flow to provide recreation opportunities and to protect the natural ecosystem of western rivers. Until recently, most western communities and government agencies welcomed water diversions and related development projects as a source of new income and economic growth. As a result, 30 percent of the 12,500 miles of river in Colorado have been destroyed or substantially altered. Nearly 1,000 miles have been dewatered to provide irrigation, power, and domestic water supply; 300 miles have been inundated by reservoirs; and 2,600 miles have been polluted by mining, industrial, and residential development. Increased attention has focused in recent years on studies to improve western water development policies for the future. Some level of instream flow for recreation use may be compatible with the delivery of water for irrigation, energy, industry, and domestic water supply. Water management agencies are interested in measures of the benefits from recreation use of instream flow comparable to the benefits from alternative uses.

A representative sample of 206 users were interviewed at nine river sites from June 15 to August 15, 1978. The sample was proportional with a minimum of 20 interviews at each river. Three of the nine sites were fishing, three kayaking, and four rafting. One site combined both kayaking and rafting. Thus, 60 fishermen, 60 kayakers, and 86 rafters were interviewed. The sites represent

the range in size and flow of rivers in western Colorado. All sample sites had stream gauge stations. The boating sites accounted for over half of the river boating in the state. The fishing sites provided some of the best trout fishing opportunity, primarily by fly rod while wading the stream bed.

Willingness to pay questions were designed to measure consumer surplus which is the area under the demand curve above the cost of outdoor recreation. Trip cost was selected as a realistic payment vehicle. Payment of trip cost is familiar to all individuals who participate in outdoor recreation and has been applied successfully in other recreation benefit studies. Respondents reported willingness to pay contingent on changes in congestion and instream flow. The stepwise multiple regression procedure was utilized to develop net benefit functions adjusted for congestion. Benefit functions shifted with diversion of instream flow and were constrained by agency costs assumed to be $2.50 per user day.

Individual fishermen who encountered no other persons reported average benefits of about $20 per day. With otherwise identical conditions, benefits declined to zero when nearly 30 other persons were encountered per day. As long as the gains from additional visitors exceeded the loss due to congestion cost, total benefits increased. Beyond some point, congestion costs exceeded the gain experienced by additional visitors and total benefit diminished. For fishing, optimum capacity occurred in the neighborhood of 12 users per mile per day, about 13 percent fewer than currently. For kayaking, optimum capacity was 7.6 users per mile per day, 2.2 times current use levels, and for rafting, optimum capacity was 10.6 users per mile per day, 1.6 times the number of current users, indicating excess capacity was present.

This report has shown that research procedures which measure the effects of congestion improve the resulting estimate of recreation benefits. Without adjusting for congestion, the average recreation benefit of fishing would have been reported as $10.56 per user day which would represent a $1.25 or 10.6 percent under-estimate of the $11.78 average benefit at optimum capacity. Benefits of kayaking would have been over-estimated as $13 per day or $4-$5 more than the $7-$9 at optimum capacity. The benefits of rafting would have been over-estimated as $11 per day or $2-$4 more than the $7-$9 at optimum capacity.

These results have important implications for estimation of benefits from expanding recreation opportunities on western rivers which until recently were closed to public access. Incremental benefits would accrue to all fishermen who use accessible rivers because of the reduced congestion which would result with substitution. Providing access to 15 percent more suitable river miles on the West Slope would increase existing fishing benefits by an average of $1.25 per user day. In the short run, expansion of opportunities for kayaking and rafting may seem less critical although annual growth has been 30 percent in recent years. At this rate, existing capacity would be reached in 1981 and further expansion of opportunities for fishing would be valued as about $12 per user day, and kayaking and fishing would be valued as $8-$9 per user day.

These estimates of congestion adjusted recreation benefits assumed instream flow equal to 70 percent of maximum for fishing and kayaking, and 80 percent for rafting. These were the average flows observed by respondents on the days interviewed. Further diversion of instream flow would have a substantial effect on estimation of total benefits at optimum capacity. Thus, diversion of instream flow to 35 percent of maximum would reduce average fishing benefit to $9.57 per user day and optimum capacity to 8 users per mile. It would reduce kayaking benefits to $5.31 and capacity to 4.8 users per mile. Rafting benefits would fall to $4.93 and capacity to 7.5 users.

Regression results provided demand shift coefficients for individual fishing, kayaking, and rafting, i.e., the change in annual days associated with each one percentage point change in instream flow. This suggests that the capacity constraint curve for kayaking is linear, decreasing at a constant rate over the entire range of instream flow. However, the capacity constraint curves for fishing and rafting tend to be curvilinear, rising at an increasing and then decreasing rate. The capacity constraint curve for fishing is bell-shaped, becoming negative from 65 to 100 percent of maximum instream flow, while rafting continues to rise at a decreasing rate.

This study concluded that the marginal benefit curve for fishing is bell-shaped, contrary to previous research which concluded that it slopes downward to the right with each added unit of flow having a value less than the previous one. The latter would overstate marginal benefits at both high and low levels of instream flow. It represents vertical shifts in the value intercept with constant demand, rather than parallel shifts in both the value and demand intercepts as in this study. The recommended measure of recreation benefits resulting from a change in environmental quality such as instream flow is the area between parallel shifts in the demand curve.

Results were applied to water valuation problems when recreation use is complementary and when it is competitive with other uses. Once capacity of a river basin has been reached, the appropriate measure of the value of recreation as a complementary part of a multiple purpose water development project is the total benefit from the recreation opportunity provided. When recreation becomes competitive with other uses, the appropriate measure of value becomes the marginal benefit of the recreation opportunity provided.

Marginal analysis has shown that while it is true western rivers provide maximum total benefits from excellent white water rapids for kayaking and rafting during spring and early summer when stream runoff is high, instream flow is much more valuable for boating as well as fishing during late July, August, and September to maintain a minimum flow of 35 to 50 percent of maximum. The minimum optimum flow to maximize marginal benefits per acre foot appears to be 35 percent of maximum. At this level, the sum of marginal benefits is estimated as $19.04 per acre foot, including $13.08 fishing, $3.60 kayaking, and $2.36 rafting. This assumes 60 miles of river suitable for each of these recreation activities. An acre foot of instream flow can be used for recreation purposes in subsequent miles of river without diminishing its value to recreation users downstream.

Benefits from river-based recreation would vary to the extent that site specific conditions differ from those considered here. Nonetheless, the information should be of considerable value to water managers who are faced with serious problems in administering the use of basin resources. The contingent valuation approach was successful in meeting the objective of valuing the public benefits from recreation use of instream flow. The findings represent a conservative estimate of possible total benefits of instream flow. There may be long-run ecological benefits which are not included in recreation values.

AN EMPIRICAL APPLICATION OF A MODEL FOR ESTIMATING THE RECREATION VALUE OF INSTREAM FLOW*

Richard G. Walsh, Ray K. Ericson, and Daniel J. Arosteguy
with Michael P. Hansen**

INTRODUCTION

The purpose of this report is to analyze the public benefits from cold water river fishing, kayaking, and rafting on the West Slope of the Rocky Mountains, Colorado. Recreation benefit functions are related to several important variables, including: instream flow, crowding, characteristics of participants, and costs of management. The information will contribute to an assessment of the economic feasibility of maintaining instream flow to provide recreation opportunities and to protect the natural ecosystem of western rivers. This is an important problem. In the past, most western communities and government agencies welcomed water diversions and related development projects as a source of new income and economic growth. As a result, 30 percent of the 12,500 miles of river in Colorado have been destroyed or substantially altered. Nearly 1,000 miles have been dewatered to provide irrigation, power, and domestic water supply; 300 miles have been inundated by reservoirs; and 2,600 miles have been polluted by mining, industrial, and residential development.

Increased attention has focused in recent years on studies to improve water development policies for the future. The people involved in water and energy development in the west are interested in what can be learned about the benefits of river-based recreation use. Some level of instream flow for recreation use may be compatible with the delivery of water for irrigation, energy, industry, and domestic water supply. Water management agencies are interested in measures of the recreation benefits of instream flow comparable to the benefits from alternative uses.

The primary contributions of this study to the literature on economic benefits of instream flow is to apply a procedure for estimating the effects of congestion. Most studies of economic benefits of river-based recreation in the past have dealt with uncongested sites or have assumed that no congestion effects exist. Recently, it has been shown that the resulting estimates of benefits may be biased if there is excess demand or congestion present [Fisher and Krutilla, 1972; Freeman, 1979]. Conceptually, congestion is an external cost perceived as a deterioration in the quality of the recreation experience. Thus, recreation benefits are expected to be a decreasing function of the number of persons encountered per day. Net benefits from recreation use of instream flow are maximized when the gain to the marginal user equals the marginal loss his presence imposes on other users. Given relevant technological and institutional constraints, water resources are allocated efficiently when the net benefits resulting from all uses are maximized. A particular water resource policy is preferred on efficiency grounds when the excess of total benefit over total cost exceeds that which would result from alternative policies. Comparable measurement of the benefit and cost from alternative uses of water in western rivers would be more nearly approached by estimation of recreation benefit at optimum capacity [Krutilla and Fisher, 1975].

The objectives of the study were to measure:

(1) the effect of crowding on the recreation value of instream flow;

(2) the effect of instream flow on recreation value and participation in fishing, kayaking, and rafting;

(3) the effect of distance traveled on per capita participation in river-based recreation.

This report presents the empirical results and conclusions of the project. The following section describes the study sites which represent the range in size and flow of rivers in western Colorado. Section three discusses the theory of a congestion adjusted benefit function. Shifts in the benefit function would result from water diversion associated with other conjunctive uses of instream flow. Section four discusses the study design in which respondents reported willingness to pay contingent upon changes in congestion and instream flow. Section five presents the empirical results with respect to benefits and costs. Finally, policy implications are discussed, with emphasis on application of the information provided by the study to water management decisions.

The following publications and manuscripts were prepared as a result of this project:

Walsh, Richard G., "Estimating the Recreation Value of Water in Reservoirs Compared to Instream Flow," Colorado Water Resources Research Institute Conference, Colorado State University, Fort Collins, April 9, 1980.

Walsh, Richard G., Ray K. Ericson, and Daniel J. Arosteguy, "Congestion Adjusted Recreation Benefits from Instream Flow," Paper submitted for journal publication, October, 1980.

Walsh, Richard G., Ray K. Ericson, and Daniel J. Arosteguy, "An Empirical Application of a Model for Estimating the Recreation Value of Instream Flow," Preliminary Draft of Completion Report, Department of Economics, Colorado State University, Fort Collins, October, 1978.

Papers presented at a recent River Recreation Management and Research Symposium [1977] identified several of the problems unique to the recreation use of mountain rivers. These include: crowding on the river, seasonal variation in stream flow, cold water temperatures, and population growth in the region. Much progress has occurred in the management of rivers for recreation use in other regions [U.S. Department of the Interior, 1978], however, in mountainous areas, there has been resistance to changes in river management for recreation use.

The demand for recreation use of water resources has grown at an accelerated rate since World War II, and is projected to grow at a rate 25 percent greater than other recreation activities to the year 2000 [Cicchetti, Seneca, and Davidson, 1969]. Water-based recreation in the year 2000 is expected to be 2.5 times 1965 levels. Fishing in Colorado, of which 43 percent is river-based, was projected to increase from 7.7 million user days in 1968 to 11.1 million in 1985, by 2 percent or 198,000 user days annually [Arosteguy, 1974]. Boating in the state was projected to increase from 1.4 million user days in 1968 to 2.3 million in 1985, or by an average of 3 percent or 57,000 user days per year. Campbell [1977] estimated that river boating was a small part of total boating in the state, less than 10 percent in 1976, but was growing at a compound rate of 30 percent annually. Since the ability to augment the supply of water resources is severely constrained, diversion of instream flow is now, and will likely continue to be, an important problem.

STUDY AREAS

The study sites are located at elevations of 6,000 to 9,000 feet on the West Slope of the Rocky Mountains, Colorado, an area with increasingly congested recreation resources and competitive demands on instream flow. Figure 1 shows the location of the nine sites in northwest Colorado and Table 1 shows their maximum instream flow. The sites represent the range in size and flow of rivers in western Colorado. They were selected to obtain a representative sample of three distinct types of river-based recreation activities; three were fishing sites, three kayaking, and four rafting. One site was utilized for both kayaking and rafting. The sites accounted for 50 to 60 percent of the estimated 150,000 days total kayaking and rafting in the state of Colorado in 1976 [Campbell, 1977]. They accounted for a much smaller proportion of the total river fishing, primarily with a fly rod while wading the stream bed.

Fishing -- Homestake Creek was the smallest of the three fishing study areas with a width of 30 feet and maximum flow of 460 acre feet per day. It flows northeast and joins the Eagle River near Red Cliff. It provides camping and fishing opportunities near Interstate 70 which is the major east-west route through the Rocky Mountains of Colorado. The Frying Pan River was the second study area with a width of 50 feet and maximum flow of 1,165 acre feet per day. It flows west from the Continental Divide to the Roaring Fork River at Basalt. Its flow is controlled by the Ruedi Reservoir on which the Forest Service provides camping and fishing opportunities. The Eagle River was the largest study area with a width of 120 feet and maximum flow of 4,075 acre feet per day. Interstate 70 follows the stream bed from the Minturn interchange to the Colorado River, and the river is easily accessible for fishing.

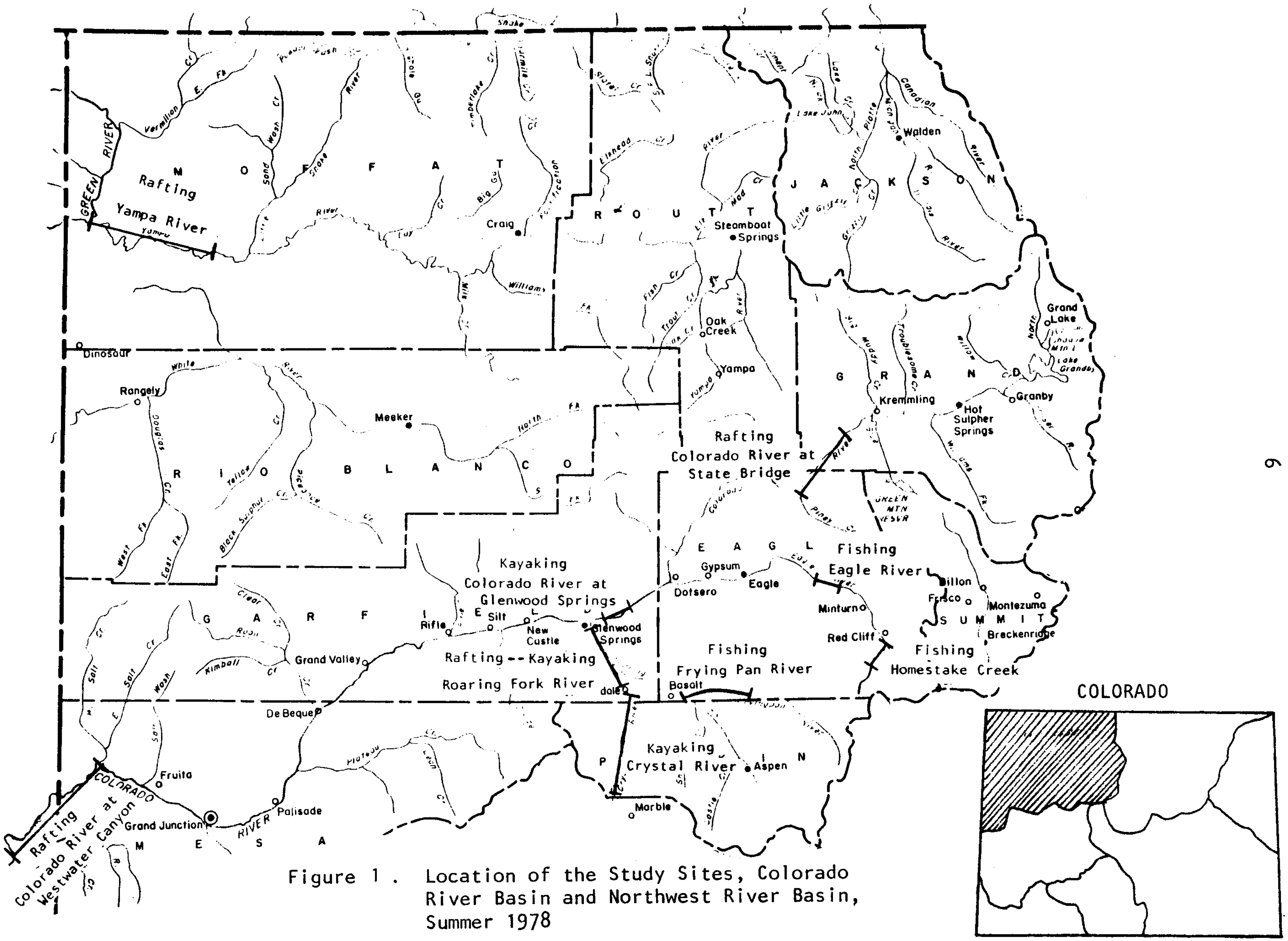

Figure 1. Location of the Study Sites, Colorado River Basin and Northwest River Basin, Summer 1978

Table 1. River Width and Maximum Average Monthly Instream Flow in Acre Feet Per 24-Hour Day at Nine River Recreation Sites in Western Colorado, 1978.

Recreation Site	Recreation Activity	River Width, Feet	Drainage Area, Square Miles	Maximum Average Monthly Instream Flow, Acre Feet Per Day[a/]		
				Long-run Average	Range	1978 High Week
Homestake Creek	Fishing	30	58	460	115-988	456
Frying Pan River	Fishing	50	244	1,165	238-3,115	1,627
Eagle River	Fishing	120	944	4,075	1,591-5,922	9,186
Crystal River	Kayaking	50	167	2,351	744-3,274	2,044
Roaring Fork River	Kayaking & Rafting	80	1,451	7,817	2,260-11,519	13,154
Colorado River at Glenwood Springs	Kayaking	150	6,013	19,116	5,518-26,625	21,229
Colorado River at State Bridge	Rafting	70	2,382	4,031	1,897-8,396	8,396 (est.)
Yampa River[b/]	Rafting	100	7,140	16,926	4,696-27,449	28,351
Colorado River at Westwater Canyon	Rafting	120	17,900	30,698	7,297-57,179	54,758

a. Conversion factor from cubic feet per second to acre feet per 24-hour day is 1.984.

b. Includes the tributary Little Snake River.

Kayaking -- The Crystal River was the smallest of the three kayaking study areas with a width of 50 feet and maximum flow of 2,351 acre feet per day. It flows north from Marble and joins the Roaring Fork River at Carbondale. Its kayaking season tends to be short, as flow becomes a trickle by August. The Roaring Fork River was the second study area with a width of 80 feet and maximum flow of 7,817 acre feet per day. Its upper section, from Aspen northwest to Woody Creek is a difficult kayak run known as "slaughterhouse." It receives more boating use than any other tributary of the Colorado River. The Colorado River at Glenwood Springs was the largest study area with a width of 150 feet and maximum flow of 19,116 acre feet per day. It flows southwest from Dotsero and enters Glenwood Canyon. There, all of the water is diverted for a few miles by the Shoshoni Power Plant and returned to the riverbed below. The stretch from Shoshoni to Glenwood Springs is heavily used by kayakers.

Rafting -- The Roaring Fork River was the smallest of four rafting study areas with a width of 80 feet and maximum flow of 7,817 acre feet per day. Most rafting use takes place from Carbondale northwest to where it joins the Colorado River at Glenwood Springs. The Colorado River at State Bridge was the second study area with a width of 70 feet and maximum flow of 4,031 acre feet per day. It flows out of Lake Granby and traverses the western half of the state before entering Utah west of Grand Junction. The stretch from Radium to Dotsero is heavily used with 36,000 user days in 1976. The Yampa River was the third study area with a width of 100 feet and maximum flow of 16,926 acre feet per day. It flows west from the Continental Divide and joins the Green River in Dinosaur National Monument. It is among the few rivers in the U.S. on which rafters can spend from three to five consecutive days without encountering roads, private land, or other evidence of civilization. With nearly 15,000 user days in 1976, the Yampa provided 10 percent of river boating in the state. The Colorado River at Westwater Canyon was the largest study area with a width of 120 feet and maximum flow of 30,698 acre feet per day. It flows west-southwest from Grand Junction into Utah. Its flow is normally large enough to provide reliable operation by commercial rafting companies.

As instream flow is diverted, there is a loss of surface area and shrinkage of the shoreline. A denuded and discolored rocky area is exposed with water diversion. Yearly stocking may be necessary to maintain a fishery in rivers with no provision for a minimum flow. Diversion must be carefully timed to maintain a wild trout population. After trout have spawned in shallow water with a gravel bottom, diversion would destroy eggs left in gravel above the water line. Other changes may occur with diversion which also lower the quality of recreation experience. They tend to reduce the number of persons willing to use a river for water-based recreation activities, and their willingness to pay for the experience. Thus, total recreation benefits are expected to decrease with the loss of instream water available.

Opportunities for recreation use of rivers normally are provided from a combination of labor, capital, land and scenic resources as well as water [Young and Gray, 1972]. The related inputs may provide such facilities as: access roads and trails, parking areas, observation points, picnic and camp sites, water and sanitation equipment, landscaping, and as appropriate, raft launching and take-out facilities. Other expenses include operation of fish stocking, licensing, and boating use management programs, maintenance, clean-up, and public safety. The costs required to develop, operate, and maintain facilities for recreation use of rivers can be deducted from benefits in order to obtain the recreation value of the natural resources of a site, the water, land, and scenic attributes. Costs of recreation use are especially important when investigating possible water reallocation to recreation use.

West Slope rivers offer the majority of nearly two million residents of Colorado's Front Range metropolitan areas an opportunity to engage in river-based recreation activities within two to five hours drive of their residence. Colorado residents accounted for 83 percent of the fishermen interviewed, 92 percent of the kayakers, compared to 72 percent of the rafters. Tourists from outside the state accounted for nearly 19 percent of all river users, primarily coming from the Northcentral and Western regions of the U.S.

Severely cold surface water temperatures constrained river-based recreation to non-contact activities such as fishing and boating. Swimming accounted for less than one percent of total time at the study sites. The primary activity of fishing accounted for two-thirds of the total time of fishermen. Kayaking accounted for 83 percent of the total time of kayakers. By comparison, rafting was only 58 percent of the total time of rafters. Camping was the second most important activity, accounting for 15 percent of the total time of fishermen and 7 percent of rafters time, compared to only 3 percent of kayakers. Virtually no fishermen engaged in kayaking or rafting nor did kayakers fish, while rafters fished two percent of the time. Other minor activities at the study sites included sightseeing, picnicking, photography, relaxing, hiking, backpacking, driving off-road vehicles, and miscellaneous.

THEORETICAL APPROACH

Congestion of a river recreation site occurs when individual users encounter increasing numbers of other users. This reduces individual satisfaction from the experience of engaging in fishing, kayaking, and rafting. Therefore, willingness to pay diminishes and the consumer surplus measure of individual benefit falls. The presence of congestion has implications for measurement of the effects of instream flow on recreation benefits. In this section, a simple model is developed to analyze the effects of congestion on estimation of river-based recreation benefits at optimum capacity. The model is then adapted to show how the diversion of instream flow shifts the congestion adjusted total benefit function and the estimation of optimum capacity.

An empirical technique for determining the effect of crowding on benefits at a recreation site was developed by Fisher and Krutilla [1972] and applied to wilderness [Cicchetti and Smith, 1973 and 1976] and beach users [McConnell, 1977].[1/] The general procedure is firmly based in the economic theory of consumer demand. Congestion is viewed as one of a number of quality attributes of the recreation site, and enters an individual's utility function as a separate variable. Users are asked to report their maximum willingness to pay with varying numbers of persons encountered per day. Other important demographic information is recorded. A statistical benefit function is specified of the form:

Benefit = f(congestion, income, substitution, days, travel distance, tastes, etc.)

The effects of all other variables are controlled, and an average benefit function is derived in which congestion has a significant negative effect on individual benefit per day.

Figure 2 shows individual benefit per visitor day to be a declining function of number of persons encountered while engaged in recreation activity. The vertical intercept is the amount an individual would be willing to pay if he were the sole user of the river, that is, if the river were uncongested. The horizontal intercept shows the maximum number of users who will eventually choose to participate, if use rates are unrestricted, since an individual user will participate so long as his benefit per day is positive. However, each additional user imposes losses in benefit on all previous users. The gain in benefit enjoyed by additional individuals is represented by the columns. The loss to existing individual users is represented by the rows. Assume that individual benefit per day declines by $1 for each additional person encountered at a recreation site. To find the economic optimum, locate the point where the loss in benefit to existing users from added congestion just equals the benefit gained by the additional user. The gain in benefit enjoyed by the sixth user is $5 represented by the shaded column. At that point, the loss to five existing users is also $5 represented by the shaded row. Thus, the optimum number of encounters is six.[2/] It can be seen that four users would be too few because at that point the loss to existing users would be $3 compared to a gain by the additional user of $7 benefit. Likewise, it can be seen that seven users would be too many because at that point the loss to existing users of $6 would exceed the gain of $4 in benefit to the additional user.

The marginal user considers only his private cost of congestion, namely, the cost imposed upon him by existing users. By ignoring his imposition of congestion cost on existing users, there is created a divergence between private and social costs of congestion. As is generally the case in the theory of externalities, this divergence between social and private costs results in

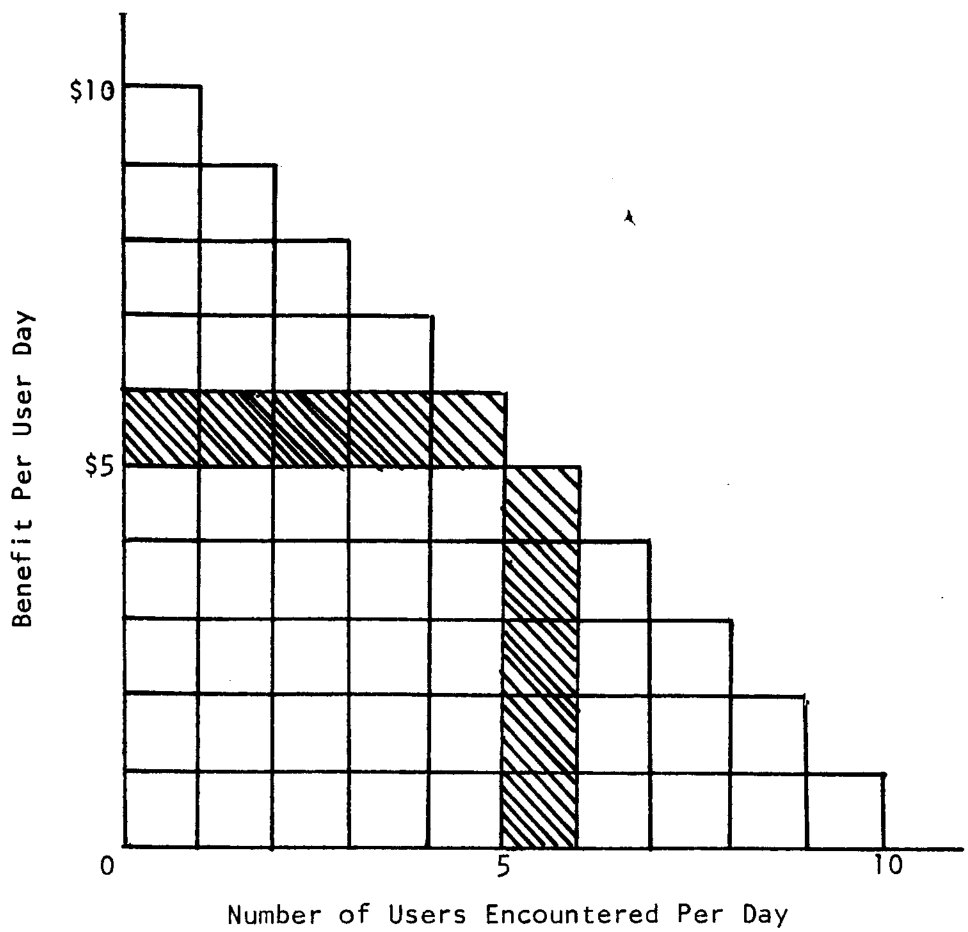

Figure 2. Effect of Crowding on Benefit Per User Day and Optimum Capacity of a Recreation Resource.

over-use of the resource. The economic optimum level of resource use occurs where incremental benefit just equals incremental congestion cost.

That this is so can be easily shown by formal economic analysis. A total benefit function is derived, multiplying the number of users by individual benefits per user day at each level of congestion. Marginal benefit is simply the change in total benefit divided by the change in number of users. Total benefit functions are shown as the top portion of Figure 3 with marginal benefit as the lower portion. As long as the gain from admitting additional users exceeds the loss due to congestion costs, total benefit will increase. Beyond a point where congestion cost equals the gain experienced by the additional recreationist, total benefit diminishes with further admission. If there are no added costs of river management or environmental degradation, optimum use occurs where total benefits are maximized and marginal benefits are zero.

Figure 3 shows a family of total benefit and marginal benefit curves depicting several threshold levels of instream flow.[3/] The largest total and marginal benefit functions shown are expected when instream flow is bankful. Below it are a family of total and marginal benefit curves depicting the expected effect of water diversion. These are based on a shift coefficient derived from a demand function which contains instream flow as an independent variable.[4/] Each diversion level is expected to result in a lower carrying capacity and thus lower total benefit of recreation use.

When there are no costs other than those associated with congestion, optimum capacity will be at the point at which the total benefit is maximized and marginal benefit is zero for each level of instream flow. With the introduction of added costs of river management, fish stocking, providing access, and environmental degradation, adjustments in optimum capacity will occur.

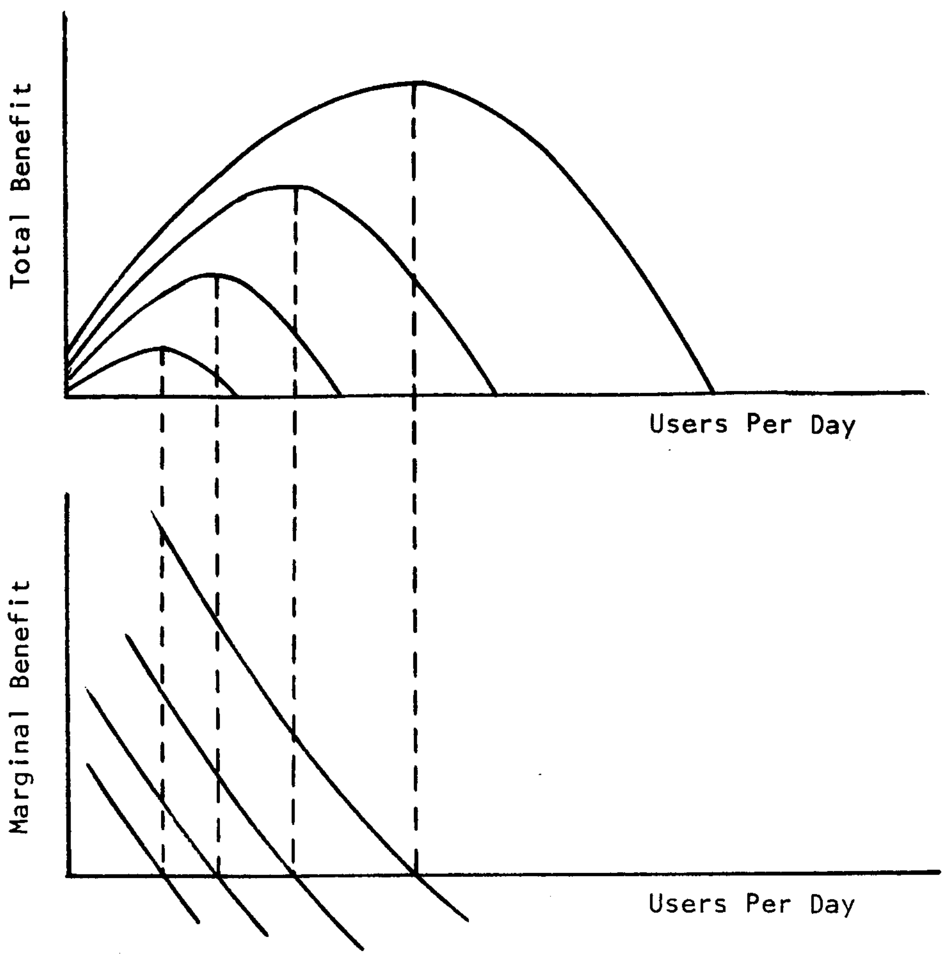

Figure 3. Effect of Instream Flow on Congestion Adjusted Total and Marginal Benefit Functions.

Accordingly, it is desirable to distinguish these costs from the disutilities associated with congestion. We could do so in Figure 3 by introducing a separate marginal cost function (not shown) representing the change in these costs as intensity of use increases. If such costs should occur before the maximum total benefit is reached, marginal costs would intersect the marginal benefit schedule short of the congestion adjusted optimum level. Thus, added costs of river management and environmental degradation would become a constraint, and a perpendicular dropped from the intersection of the marginal cost and marginal benefit functions to the horizontal axis would indicate a new optimum carrying capacity.

STUDY DESIGN

The basic economic data for this study were obtained from interviews with a representative sample of 206 recreation users. The sample was proportional with a minimum of 20 interviewed at each study site. A total of 60 fishermen were interviewed, 60 kayakers, and 86 rafters. Following Knetsch and Davis [1966], the method of valuation was total direct trip costs. Respondents were asked to report the direct out-of-pocket costs of the trip. This was followed by a question which asked respondents to report the maximum they would be willing to pay rather than do without the recreation experience. Willingness to pay was defined as the maximum increase in total trip expenses[5/] above which the individual would decide not to participate, given the level of congestion and instream flow on the day of interview. The direct costs actually paid were then subtracted from maximum willingness to pay so that the resulting value was a consumer surplus measure of benefit from the recreation activity.

Subsequently, respondents were asked to report changes in the maximum amount they would be willing to pay contingent upon changes in congestion and instream flow. Individuals estimated the change in reported willingness to pay with congestion at six threshold levels: with no other person encountered, with 20 percent, 40 percent, 60 percent, 80 percent, and the maximum number of persons acceptable, above which they would discontinue the recreation activity. Individuals also estimated the change in reported willingness to participate at the site with maximum instream flow and diversion of instream flow to five threshold levels: 80 percent, 60 percent, 40 percent, 20 percent, and zero percent of maximum bankful. Maximum water level was obvious from clearly observed water lines resulting from maximum bankful conditions in the past.

The approach was first applied by Davis in a 1963 study of the consumer surplus benefit of recreation activities in the Maine woods. He asked recreationists to report the maximum additional cost they would pay before deciding to discontinue the activities at the study site. The procedure has been successfully applied to value recreation resources in the Maine woods [Knetsch and Davis, 1966], a water basin in British Columbia [Meyer, 1974], water quality in Colorado [Walsh, Greenley, Young, McKean, and Prato, 1978], fishing in Washington State [Mathews and Brown, 1970], the Western Flyway [Hammack and Brown, 1974], wildlife in the Southeastern region [Horvath, 1974], and air quality in New Mexico [Randall, Ives, and Eastman, 1974] and at the Glen Canyon National Recreation Area [Brookshire, Ives, and Schultze, 1976].

The U.S. Water Resources Council [1979] recently recommended this contingent valuation approach to water-based recreation benefit estimation. The Council recommended two types of contingent valuation procedures; the iterative bidding game, and the open-ended direct question. The preferred format for large water projects is an iterative bidding procedure in which respondents answer "yes" or "no" to questions asking if they are willing to pay a stated amount of money to obtain decreased congestion. The value is increased by random amounts until the highest amount that the respondent is willing to pay is identified. The Council recommended this technique on the basis that it has been applied effectively in several surveys [Knetsch and Davis, 1966; Randall, Ives, and Eastman, 1974; Brookshire, Ives, and Schultze, 1976; and Walsh, Greenley, Young, McKean, and Prato, 1978].

The second procedure is a noniterative technique in which the respondent is asked either to select his maximum willingness to pay from a list of stated values or to report his maximum willingness to pay. In this study, respondents were asked the open-ended direct question which the Council recommends for valuation of recreation on small water projects: What is the maximum amount of money the respondent would pay to obtain decreased congestion levels? The Council suggests that at present, insufficient evidence has been accumulated through research to conclude that noniterative bidding questions are as reliable as iterative bidding questions. However, preliminary results of a number of studies suggest that the noniterative technique can provide results comparable to the iterative techniques [Mathews and Brown, 1970; Hammack and Brown, 1974; Walsh, Ericson, McKean, and Young, 1978].

Individual benefit functions are estimated for a representative sample and extrapolated to the population using the recreation site. The purpose of the approach is to estimate the changes in consumer surplus benefits which would result from changes in the quality of resources used at a recreation site. It is important to note that the resulting congestion adjusted benefit function is not a demand curve; it is a direct measure of the change in benefits represented by shifts in the demand curve resulting from increased congestion [Bradford, 1970].

The contingent valuation approach appears to be gaining broad acceptance. It is generally recognized that the method requires careful wording of questions and well-defined situations with which the respondent is familiar. In several of the studies cited above more than one approach was used. No one method has emerged superior in all cases, and there is need for further research to test the effectiveness of alternative willingness to pay formats.

ANALYSIS OF RESULTS

The benefit functions developed in the analysis are shown in Table 2. The proportion of the variation in benefit per day explained by the independent variables included in the three equations ranged from 0.35 to 0.49. All parameters were significantly different from zero at the 5 percent level.[6/] The estimated benefit functions for fishing, kayaking, and rafting are shown in Figures 4, 5, and 6, where individual benefit per day is measured along the vertical axis with number of users per mile measured along the horizontal axis. For illustrative purposes, the regression variable, number of persons encountered per day, was converted to number of users per mile.

Ordinary least squares statistical methods were used to estimate the coefficients and the constant for each model. Each model was then simplified to show the relationship between the two variables of interest. All variables other than the dependent variable, number of persons encountered, were set at their means and added to the constant.[7/] The following regression functions were obtained for average benefits:

$$\text{Fishing benefit} = 20.06 - 0.8868 \text{ Persons} + 0.0050 \text{ Persons}^2$$

$$\text{Kayaking benefit} = 15.20 - 0.2562 \text{ Persons} + 0.0008 \text{ Persons}^2$$

$$\text{Rafting benefit} = 14.89 - 0.1033 \text{ Persons} + 0.0001 \text{ Persons}^2$$

The fishing equation indicates that an average fisherman who encounters no other persons can be expected to have benefits of about \$20 per day. With otherwise identical conditions, individual benefits decline by approximately 60 to 80 cents per day for each additional person encountered while fishing. Fishermen who encounter an average of 12 other persons as reported on the day interviewed, would have average benefits of about \$11 per day. Those who encounter nearly

Table 2. Ordinary Least-Square Equation Estimates of the Effect of Crowding on Net Benefit Per Day of Fishing, Kayaking, and Rafting at 9 River Sites in Western Colorado, 1978.

Variable	Fishing	Kayaking	Rafting	Total
Constant	39.7800	10.0452	81.7326	34.5948
Crowding, Persons	-0.8868 (-4.55)	-0.2562 (-3.63)	-0.1033 (-2.92)	-0.08375 (-3.45)
Crowding Squared	0.00505 (2.73)	0.000798 (2.96)	0.000113 (2.28)	0.000086 (2.40)
Benefit Per Day of This Trip, Dollars	0.7542 (10.08)	0.6603 (14.54)	0.9199 (12.31)	0.7832 (19.94)
Direct Cost Per Day of This Trip, Dollars	-0.5219 (-6.75)	-0.2282 (-4.22)	-0.3498 (-5.43)	-0.3381 (-8.40)
Education, Years	-1.5030 (-1.91)	-1.3546 (-2.54)	-3.5197 (-4.16)	-1.5884 (-3.51)
Maximum Instream Flow				0.00045 (3.39)
Persons Encountered on River Today	0.3041 (4.63)			0.2091 (3.51)
Sex of Respondent Male = 1				-7.5988 (-2.97)
Distance from Home, Miles		-0.01455 (-3.43)		-0.00675 (-2.55)
Member of Sportsman Organization Yes = 1	-12.4960 (-3.28)			-4.9117 (-2.07)
Hours at This Site		0.1168 (2.21)		
Age of Respondent		0.6295 (2.54)	-0.5258 (-2.27)	
Adjusted R^2	.39	.49	.35	.35
F	25.33	36.72	40.10	55.46
Observations	282	317	448	1047

a. Number in parenthesis below each coefficient represents student t-ratios for the null hypothesis. All variables are significant at the 95 percent confidence level.

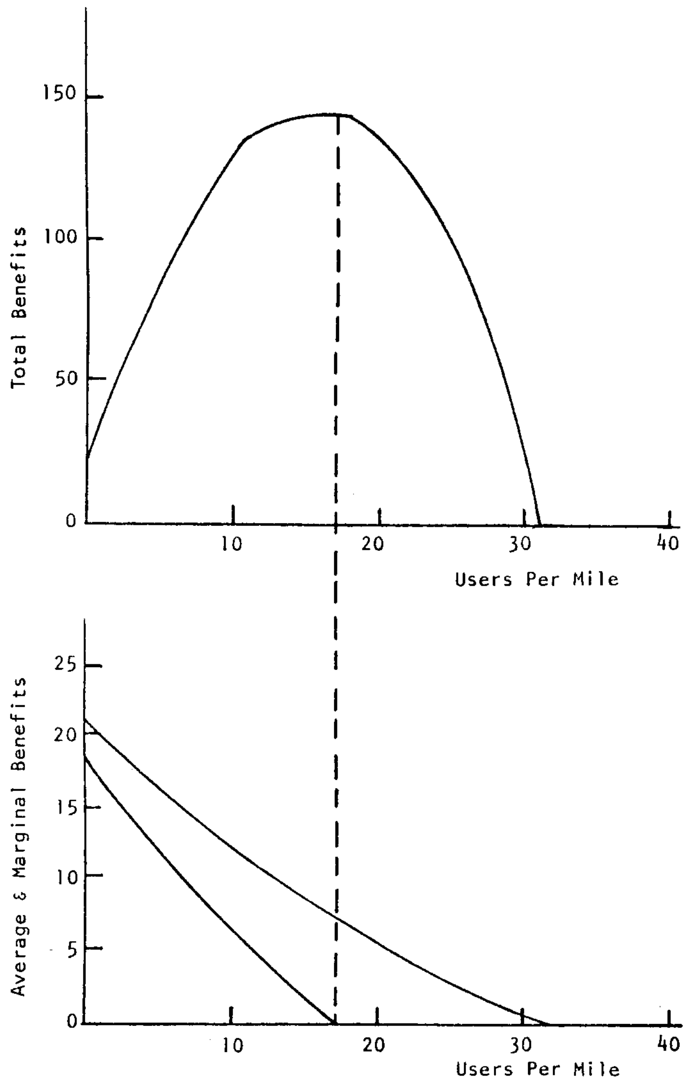

Figure 4. Total, Average, and Marginal Benefit Per Day of Fishing at Three Western Rivers, Colorado, 1978.

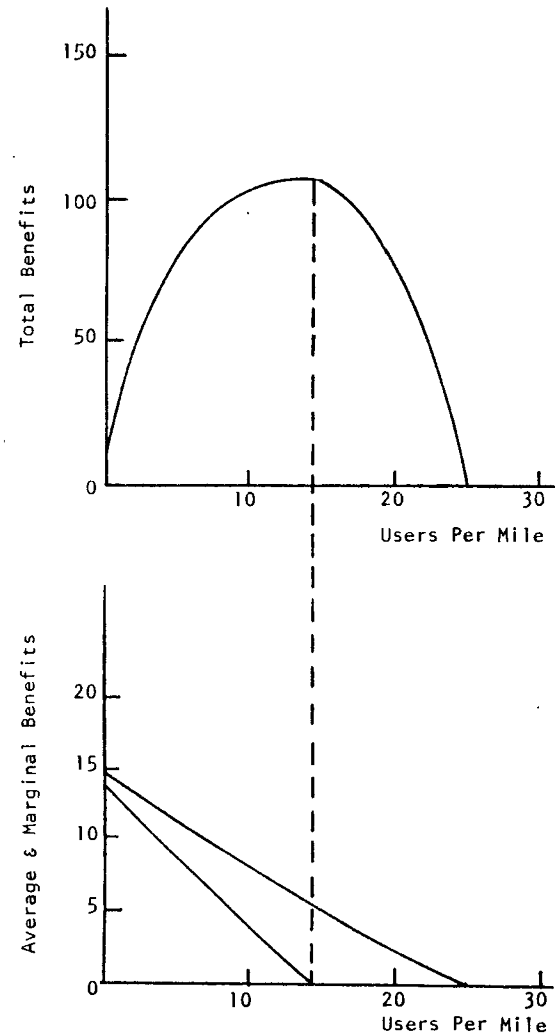

Figure 5. Total, Average, and Marginal Benefit Per Day of Kayaking at Three Western Rivers, Colorado, 1978.

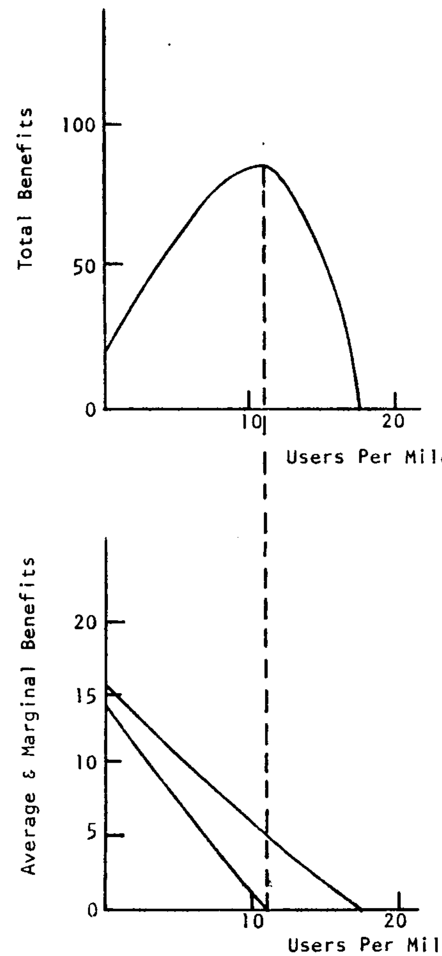

Table 6. Total, Average, and Marginal Benefit Per Day of Rafting at Three Western Rivers, Colorado, 1978.

30 other persons per day would receive virtually no benefits and would be expected to discontinue fishing at these rivers.

The total benefit function takes the same form as the total revenue function based on price times quantity; in this case, it is average benefit times number of encounters plus one, the observer. As long as the gain from additional users exceeds the loss due to congestion cost, total benefit increases. Beyond some point, congestion cost exceeds the gain experienced by additional users and total benefit diminishes. For fishing, this occurs in the neighborhood of 11.7 persons encountered per day. Total benefits are maximized where the cost of incremental congestion equals the benefit of incremental use, hence the marginal benefit function at that point is zero.

If there were no costs other than those associated with congestion, the optimum capacity would be at the point where total benefits are maximized and marginal benefits are zero. With the introduction of costs to provide public access and fishery management, optimum capacity would shift to the left. A review of agency costs on the Western Slope of Colorado revealed that they tend to be site specific depending upon level of management. For illustrative purposes, marginal agency costs of fishing are assumed to be $2.50 per user day, a level which would be seldom exceeded on the Western Slope.[8/] With marginal costs of $2.50, optimum capacity would decline from 11.7 to 9.9 encounters per day. This would be the point where marginal user benefit equals marginal agency cost. At this level of congestion, average benefit from fishing would rise from $10.38 to $11.78 per user day.

APPLICATIONS

This report has shown that research procedures which measure the effects of congestion improve the resulting estimation of benefits from river fishing, kayaking, and rafting. More meaningful comparison of the alternative uses of instream flow is possible if the total benefits from each are estimated at optimum capacity. Table 3 shows that if congestion effects had been ignored, the average benefits of fishing would have been reported as $10.53 per day, and benefits would have been under-estimated. This was the average consumer surplus calculated on the basis of values reported by participants interviewed during the summer, 1978. This would represent a $1.25 or 10.6 percent under-estimate of average benefits at optimum capacity calculated as $11.78 per user day.

Benefit estimates for kayaking and rafting were affected more by congestion than fishing, because boating users experienced considerable under-capacity utilization of the resource. At optimum capacity, average benefits of rafting were calculated as $7-$8 per user day, which was $2-$4 per day lower than the $11 reported by respondents during the summer, 1978, with under-utilization of river capacity evident. Benefits from kayaking were calculated as $7-$9 per user day at optimum capacity. This was $4-$5 lower than the $13 reported by respondents during the summer, 1978, with less than optimum resource use. These results lend support to the U.S. Water Resources Council [1979] unit day standard ranging from $3-$13 benefit per day, with the higher end of the range assigned to more unique experiences and scarce resources such as the rivers on the Western Slope of Colorado. These results suggest that the U.S. Forest Service 1980 Resource Planning Act unit day standard of $6.25 benefit from cold water trout fishing may be an under-estimate. This value was assigned

Table 3. Effects of Congestion and Agency Costs on Carrying Capacity and Individual Benefits Per Day from Fishing, Kayaking, and Rafting at Nine River Recreation Sites in Western Colorado, 1978.

Variable	Fishing	Kayaking	Rafting
Persons Encountered Per Day			
Reported by respondents			
Per Day	11.5	10.3	40.0
Per Mile[a/]	11.5	1.5	2.9
At optimum capacity with congestion costs			
Per Day	11.7	34.5	83.0
Per Mile	11.7	4.9	5.9
At optimum with agency costs of $2.50			
Per Day	9.9	27.6	67.0
Per Mile	9.9	3.9	4.8
Users Per Day Per Mile[b/]			
Summer season, 1978	13.8	3.5	6.6
At optimum capacity with congestion costs	14.0	7.9	11.8
At optimum capacity with agency costs of $2.50	12.0	7.6	10.6
Average Benefits Per Day			
Reported by respondents	$10.53	$12.65	$10.94
At optimum capacity with congestion costs	$10.38	$ 7.32	$ 7.09
At optimum capacity with agency costs of $2.50	$11.78	$ 8.74	$ 8.48
Range of difference	$0.18-$1.25	$3.91-$5.33	$2.46-$3.85

a. Cold water river fishermen used an average of one linear mile of river per day, kayakers seven miles, and rafters fourteen miles.

b. Number of fishermen per mile equaled 1.2 times encounters. Kayakers per mile ranged from 1.5 to 3.0 times encounters and was negative, as was the case for rafters per mile which ranged from 2.0 to 3.0 times encounters.

to a 12-hour visitor day. For a 6-hour fishing day, the derived value would be $3.13 which seems quite low for trout fishing on rivers in western Colorado unless excess demand was much greater than at the study sites.

This paper has demonstrated an empirical basis for estimating optimum capacity of fishing, kayaking, and rafting, as conceived by Fisher and Krutilla [1972] nearly a decade ago. For fishing, the optimum number of users per mile was calculated as 12 persons daily, about 13 percent fewer than currently. This is where marginal benefits would equal marginal costs estimated as $2.50 per user day. For kayaking, the number of users per mile at optimum capacity was calculated as nearly 7.6 persons per day. This was 2.2 times current use levels. For rafting, the number of users per mile at optimum capacity was calculated as 10.6 persons per day, equivalent to 2.1 rafts, about 1.6 times the number of users in 1978. These user-based estimates of optimum carrying capacity tend to support Colorado state capacity standards for river-based recreation [Colorado, 1974]. Following the adoption of the 1970 Colorado Outdoor Recreation Plan, the state adopted a capacity standard of four persons per mile fishing wild trout streams, 16 persons per mile fishing trout streams which are stocked, and eight persons per mile kayaking and rafting. Our user-based capacity of 12 fishermen per mile lends support to the state standard as most rivers studied were stocked on a regular basis, however, some sections were designated as wild trout fishing and were not stocked. Our user-based capacity of 7.6 kayakers per mile was nearly identical to the state standard, and our estimate of 10.6 rafters per mile was about one-third more, reflecting the larger size of rivers studied.

These results have important implications for estimation of benefits from expanding recreation opportunities on western rivers which until recently were closed to public access. Incremental benefits would accrue to all fisherment who use accessible rivers because of the reduced congestion which would result with substitution. For a discussion of conditions under which these benefits would occur, see Freeman [1979] and Cesario [1980]. Providing fishing access to 15 percent more river miles on the West Slope would increase existing fishing benefits by an average of $1.25 per user day, because of reduced congestion at rivers with fishing access. Once increased fishing opportunities equal capacity, however, future expansion to serve increased demand would be valued as about $12 per user day (Table 3). These findings suggest that opportunities for fishing should be increased by provision of public access to western rivers which have been closed. In the short run, expansion of opportunities for kayaking and rafting may seem less critical although annual growth has been 30 percent in recent years [Campbell, 1977]. At this rate, existing river capacity would be reached in 1981 and further expansion of opportunities for kayaking and rafting would be valued as $8-$9 per user day (Table 3).

These estimates of congestion adjusted recreation benefits assumed instream flow equal to 70 percent of maximum for fishing and kayaking, and 80 percent for rafting. These were the average flows observed by respondents on the days interviewed during the summer, 1978. Actual instream flow during the recreation months of July, August, and September may be substantially less. Figure 7 shows a family of total benefit and marginal benefit curves for fishing at several threshold levels of instream flow. The thresholds are based on regression results which provided shift coefficients for individual fishing demand, that is, the change in annual days associated with each one percentage point increase in instream flow. As can be seen, instream flow has a substantial effect on total benefits at optimum capacity.

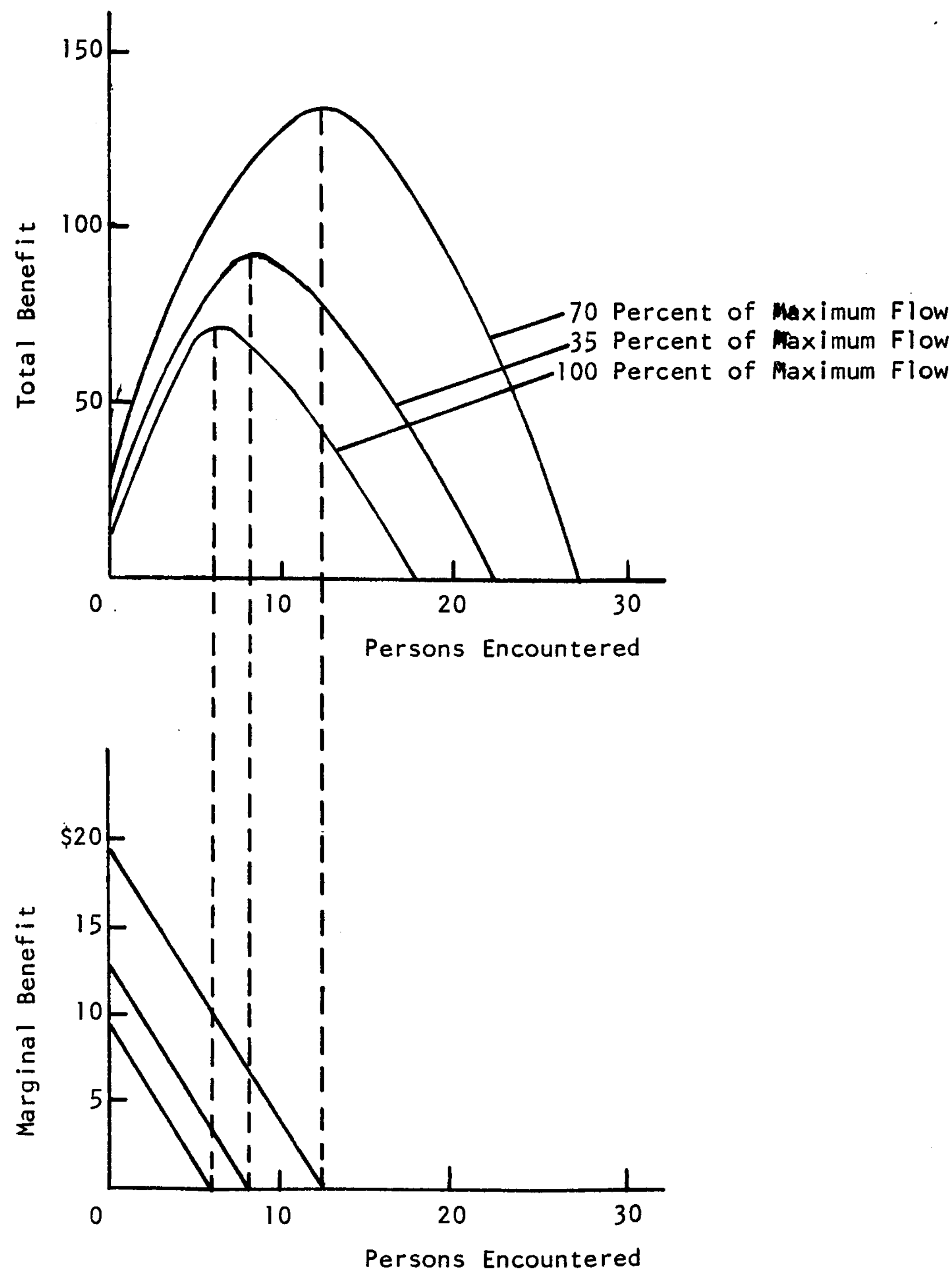

Figure 7. Instream Flow Shifts Total and Marginal Benefits Per Day of Fishing at Three Western Rivers, Colorado, 1978.

Table 4 shows the effect of instream flow on benefit maximizing use levels for fishing. Table 5 shows the same information for kayaking and Table 6 for rafting. Simmons and Lord [1978] defined the relationship between instream flow and optimum recreation use as a "capacity constraint curve." This is shown for western rivers as column four of the tables. The data indicate that the capacity constraint curve for kayaking is linear, decreasing at a constant rate over the entire range of instream flow. However, capacity constraint curves for fishing and rafting tend to be curvilinear, rising at an increasing and then decreasing rate. The capacity constraint curve for fishing is bell-shaped, becoming negative from 65 to 100 percent of maximum instream flow, while rafting continues to rise at a decreasing rate. Actual use of a river may be more or less than the optimum carrying capacity levels shown, however, non-optimum use would result in a loss of total benefits. Optimum total benefits associated with each threshold level of instream flow are shown as column six of the tables. Marginal benefits per acre foot of instream flow per day are shown as columns seven through eleven of the tables.

These results can be applied to water valuation problems when recreation use is complementary and when it is competitive with other uses. Young and Gray [1972] reviewed the concept of the economic value of water and problems in its empirical measurement and concluded that recreation uses of water are most often <u>complementary</u> to other uses. Instream flow which will be diverted later for irrigation, mining, industrial, or municipal purposes often can be used for recreation purposes without diminishing its value in the alternative uses. Once capacity of rivers in the region has been reached, the appropriate measure of the value of recreation as a complementary part of multiple purpose river development is the total net benefit from the recreation opportunity

Table 4. Effect of Instream Flow on Congestion Adjusted Net Benefits from Fishing at Three Western Rivers, Colorado, 1978.

Percent of Maximum Flow	Instream Flow, Acre Feet Per Day	Optimum Encounters Per Mile Per Day	Optimum Users Per Mile Per Day[b]	Optimum Net Benefits Per User Day[c]	Total Net Benefits Per Mile Per Day	Marginal Net Benefits from Fishing: Per Mile for One Percent Change in Maximum Flow	Per Acre Foot of Instream Flow: 15 Miles	30 Miles	60 Miles	120 Miles
0	0	0	0	0	0					
5	80	1.5	1.8	$ 1.82	$ 3.28	$ 0.66	$ 0.62	$ 1.24	$ 2.48.	$ 4.96
10	160	2.9	3.5	3.48	12.21	1.79	1.68	3.36	6.72	13.44
15	240	4.2	5.0	5.00	25.00	2.56	2.40	4.80	9.60	19.20
20	320	5.3	6.4	6.37	40.78	3.16	2.96	5.92	11.84	23.68
25	400	6.3	7.6	7.59	57.68	3.38	3.17	6.34	12.68	25.36
30	480	7.2	8.6	8.66	74.45	3.35	3.14	6.28	12.56	25.12
35	560	8.0	9.6	9.57	91.89	3.49	3.27	6.54	13.08	26.16
40	640	8.6	10.3	10.34	106.49	2.92	2.74	5.48	10.96	21.92
45	720	9.2	11.0	10.95	120.49	2.80	2.63	5.26	10.52	21.04
50	800	9.5	11.4	11.42	130.17	1.94	1.82	3.64	7.28	14.56
55	880	9.8	11.8	11.74	138.50	1.67	1.57	3.14	6.28	12.56
60	960	9.9	11.9	11.90	141.59	0.62	0.58	1.16	2.32	4.64
65	1,040	10.0	12.0	11.91	142.92	0.27	0.25	0.50	1.00	2.00
70	1,120	9.9	11.9	11.78	140.18	-0.55	-0.52	-1.04	- 2.08	- 4.16
75	1,200	9.7	11.6	11.50	133.40	-1.36	-1.28	-2.56	- 5.12	-10.24
80	1,280	9.4	11.3	11.06	124.98	-1.68	-1.58	-3.16	- 6.32	-12.64
85	1,360	8.9	10.7	10.47	112.02	-2.59	-2.43	-4.86	- 9.72	-19.44
90	1,440	8.3	10.0	9.73	97.30	-2.94	-2.76	-5.52	-11.04	-22.08
95	1,520	7.6	9.1	8.85	80.54	-3.35	-3.14	-6.28	-12.56	-25.12
100	1,600[a]	6.8	8.2	7.80	63.96	-3.92	-3.68	-7.36	-14.72	-29.44

a. Maximum weekly instream flow, Frying Pan River, 1978.

b. Cold water river fishermen use an average of one linear mile of river per day. Number of users per mile equaled 1.2 times number of encounters.

c. Net benefits adjusted for agency costs.

Table 5. Effect of Instream Flow on Congestion Adjusted Net Benefits from Kayaking at Three Western Rivers, Colorado, 1978.

Percent of Maximum Flow	Instream Flow, Acre Feet Per Day	Optimum Encounters Per Mile Per Day[a]	Optimum Users Per Mile Per Day[c]	Optimum Net Benefits Per User Day[d]	Total Net Benefits Per Mile Per Day	Marginal Net Benefits from Kayaking: Per Mile for One Percent Change in Maximum Flow	Per Acre Foot of Instream Flow: 15 Miles	30 Miles	60 Miles	120 Miles
0	0	0	0	0	0					
5	100	0.3	0.8	$0.87	$0.87	$0.17	$0.13	$0.26	$0.52	$1.02
10	200	0.6	1.6	1.71	2.73	0.37	0.28	0.56	1.12	2.24
15	300	0.8	2.3	2.51	5.85	0.62	0.46	0.92	1.84	3.68
20	400	1.1	3.0	3.27	9.80	0.79	0.59	1.18	2.36	4.72
25	500	1.4	3.7	3.98	14.52	0.94	0.71	1.42	2.84	5.68
30	600	1.7	4.3	4.67	19.89	1.07	0.81	1.62	3.24	6.48
35	700	2.0	4.8	5.31	25.69	1.20	0.90	1.80	3.60	7.20
40	800	2.2	5.4	5.92	31.68	1.21	0.91	1.82	3.64	7.28
45	900	2.5	5.8	6.48	37.82	1.22	0.92	1.84	3.68	7.36
50	1,000	2.8	6.3	7.01	44.01	1.24	0.93	1.86	3.72	7.44
55	1,100	3.0	6.6	7.50	49.43	1.08	0.81	1.62	3.24	6.48
60	1,200	3.3	7.0	7.96	55.83	1.28	0.96	1.82	3.64	7.28
65	1,300	3.6	7.3	8.37	61.36	1.11	0.83	1.66	3.32	6.64
70	1,400	3.9	7.6	8.74	66.47	1.02	0.77	1.54	3.08	6.16
75	1,500	4.2	7.8	9.08	71.17	0.94	0.71	1.42	2.84	4.68
80	1,600	4.5	8.0	9.37	75.22	0.81	0.61	1.22	2.44	4.88
85	1,700	4.7	8.2	9.64	78.69	0.69	0.52	1.04	2.08	4.16
90	1,800	5.0	8.3	9.88	81.67	0.60	0.45	0.90	1.80	3.60
95	1,900	5.3	8.3	10.04	83.65	0.40	0.30	0.60	1.20	2.40
100	2,000[b]	5.6	8.4	10.19	85.14	0.30	0.22	0.44	0.88	1.76

a. Average trip length of seven linear miles per day.

b. Crystal River maximum weekly instream flow during 1978.

c. Ratio of encounters to users ranged from 1.5 at maximum flow to 3.0 with low flow.

d. Net benefits adjusted for agency costs.

Table 6. Effect of Instream Flow on Congestion Adjusted Net Benefits from Rafting at Four Western Rivers, Colorado, 1978.

Percent of Maximum Flow	Instream Flow, Acre Feet Per Day	Optimum Encounters Per Mile Per Day[a/]	Optimum Users Per Mile Per Day	Optimum Net Benefits Per User Day[d/]	Total Net Benefits Per Mile Per Day	Marginal Net Benefits from Rafting: Per Mile for One Percent Change in Maximum Flow	Per Acre Foot of Instream Flow: 15 Miles	30 Miles	60 Miles	120 Miles
0	0	0	0	0	0					
5	200	0.5	1.4	$0.80	$1.13	$0.23	$0.08	$0.16	$0.32	$0.64
10	400	0.9	2.7	1.57	4.24	0.62	0.23	0.46	0.92	1.84
15	600	1.4	3.9	2.31	8.94	0.83	0.31	0.62	1.24	2.48
20	800	1.8	4.9	3.01	14.86	1.18	0.45	0.90	1.80	3.60
25	1,000	2.1	5.9	3.68	21.70	1.37	0.51	1.02	2.04	4.08
30	1,200	2.5	6.8	4.33	29.26	1.51	0.57	1.14	2.28	4.56
35	1,400	2.8	7.5	4.93	37.08	1.56	0.59	1.18	2.36	4.72
40	1,600	3.2	8.2	5.51	45.13	1.61	0.60	1.20	2.40	4.80
45	1,800	3.4	8.8	6.06	53.15	1.60	0.60	1.20	2.40	4.80
50	2,000	3.7	9.3	6.57	60.86	1.54	0.58	1.16	2.32	4.64
55	2,200	4.0	9.7	7.05	68.19	1.47	0.55	1.10	2.20	4.40
60	2,400	4.2	10.0	7.50	75.02	1.37	0.51	1.02	2.04	4.08
65	2,600	4.4	10.2	7.91	81.02	1.20	0.45	0.90	1.80	3.60
70	2,800	4.5	10.4	8.30	86.52	1.10	0.41	0.82	1.64	3.28
75	3,000	4.7	10.5	8.65	91.14	0.92	0.35	0.70	1.40	2.80
80	3,200	4.8	10.6	8.97	94.72	0.72	0.27	0.54	1.08	2.16
85	3,400	4.9	10.6	9.25	97.65	0.59	0.22	0.44	0.88	1.76
90	3,600	5.0	10.5	9.51	99.46	0.36	0.14	0.28	0.56	1.12
95	3,800	5.0	10.3	9.72	100.43	0.19	0.07	0.14	0.28	0.56
100	4,000[b/]	5.1	10.1	9.93	100.69	0.05	0.02	0.04	0.08	0.16

a. Average trip length of 14 linear miles per day.

b. Colorado River at State Bridge, long-run maximum average monthly instream flow.

c. Ratio of encounters to users ranged from 2.0 at maximum flow to 3.0 with low flow.

d. Net benefits adjusted for agency costs.

provided. Thus, the maximum total net benefits of providing optimum public fishing access to 60 miles of West Slope river with flow at 65 percent of the maximum 1,600 acre feet would be $11.91 per user day or total benefits of $8,575 per day.[9/] This is equivalent to yield of $8.25 per acre foot of instream flow. Capitalized at 10 percent interest in perpetuity, this would represent an investment value of $85,750, which is equivalent to $82.45 per acre foot of instream flow. If the development plan also provides optimum public kayaking and rafting access to 60 miles of West Slope river with flow at 65 percent of maximum, total benefits would increase by 99.6 percent.

If development plans provide that instream water flow will be systematically reduced to 560 acre feet or 35 percent of maximum during the summer months, fishing benefits would fall to $9.57 per user day or total benefits of $5,513 per day. However, this is equivalent to a maximum yield of $9.85 per acre foot of instream flow. Capitalized at 10 percent interest in perpetuity, this would represent an investment value of $55,130, which is equivalent to $98.45 per acre foot. If the plans also provide optimum public kayaking and rafting access to 60 miles of West Slope river with flow at 35 percent of maximum, total benefits would increase by 68.3 percent.

If development plans provide that instream water flow will be systematically reduced to 240 acre feet or 15 percent of maximum, fishing benefits would fall to $5 per user day or total benefits of $1,500 per day. This is equivalent to a yield of $6.25 per acre foot of instream flow. Capitalized at 10 percent interest in perpetuity, this would represent an investment value of $15,000 which is equivalent to $62.50 per acre foot. If the development plan also provides optimum public kayaking and rafting access to 60 miles of West Slope river with flow at 15 percent of maximum, total benefits would increase by 59.1 percent.

When recreation becomes competitive with other uses of instream flow, the appropriate measure of value becomes the marginal benefit of the recreation opportunity. Water managers would maximize the social benefit from water resources where the marginal benefits from water diversion for crop irrigation and other purposes equals the marginal benefit from recreation use of instream flow. Marginal benefit per acre foot of water is the change in total benefit divided by change in instream flow.

In the case of fishing, the marginal benefit function for instream flow had a decided bell shape.[10/] With 60 miles of river suitable for fishing, marginal benefits per acre foot increased from zero with no instream flow to a maximum of $13.08 with instream flow of 560 acre feet per day.[11/] With further increases in flow, marginal benefits from fishing declined. Marginal benefits fell to zero with instream flow of about 1,075 acre feet per day. Beyond this level, added instream flow resulted in negative marginal benefits from fishing. Marginal benefits were negative -$5.12 with instream flow of 1,200 acre feet, and negative -$14.72 with maximum instream flow of 1,600 acre feet per day. A recent study of the Poudre River located on the northern Front Range of Colorado provides a partial replication of this result [Daubert and Young, 1979]. Marginal benefits of fishing on the Poudre River fell to zero at 500 cubic feet per second (cfs) which is equivalent to 992 acre feet per 24 hours, within 8 percent of our estimate of 1,075 acre feet per day for the Frying Pan River on the West Slope of Colorado. The difference may be explained by the fact that fishing on the Poudre River exceeded the optimum capacity estimated as 12 fisherment per mile per day.

The marginal benefit function for kayaking and rafting also exhibited a bell shape.[12/] However, marginal benefits for kayaking and rafting increased at a slower rate and were much lower than fishing with instream flow below 900 to 1,000 acre feet per day. With 60 miles of river suitable for kayaking, marginal benefits increased from zero with no instream flow to a maximum of $3.72 with instream flow of 1,000 acre feet per day. With 60 miles of river suitable for rafting, marginal benefits increased from zero with no instream flow to a maximum of $2.40 with instream flow of 1,600 to 1,800 acre feet per day.

Marginal benefits from kayaking and rafting diminished at a slower rate than fishing, and over a wider range of instream flow. Kayaking marginal benefits declined to $0.88 with maximum instream flow of 2,000 acre feet per day. Rafting marginal benefits approached zero, $0.08, with maximum instream flow of 4,000 acre feet per day. These results indicate that increased flow at high levels provided very little value to boating.

Marginal analysis has shown that while it is true western rivers provide maximum total benefits from excellent white water rapids for kayaking and rafting during spring and early summer when stream runoff is high, instream flow is much more valuable for boating as well as fishing during late July, August, and September to maintain a minimum flow of 35 to 50 percent of maximum. The <u>minimum optimum</u> flow to maximize marginal benefits per acre foot appears to be 35 percent of maximum. At this level, the sum of marginal benefits is estimated as $19.04 per acre foot, including $13.08 fishing, $3.60 kayaking, and $2.36 rafting. Thirty-five percent of maximum is the optimum flow for fishing. At this level, marginal benefits from kayaking are only $0.12 per acre foot less than at 50 percent of maximum flow which is the optimum for kayaking. Also, marginal benefits from rafting are only $0.04 less than at 40 to 45 percent of maximum flow which is the optimum for rafting. Moreover, 35 percent of maximum flow is greatly superior to 65 percent of maximum instream flow with a sum of marginal benefits equal to $5.37 per acre foot, and to 100 percent of maximum flow with a negative sum of marginal benefits estimated as -$13.76 per acre foot. These comparisons assumed 60 miles of river suitable for each of these recreation activities.

Marginal benefits per acre foot would vary among western rivers to the extent that site specific conditions differ from those considered here. For example, recreation benefits of instream flow are sensitive to the size of river and number of miles suitable for fishing, kayaking, and rafting. While some rivers are suitable for two or even all three of these recreation activities, fishermen tend to prefer smaller streams than boaters. A typical river suitable for fishing has maximum instream flow of 1,600 acre feet per day, compared to 2,000 for kayaking and 4,000 for rafting. Some rivers used primarily for kayaking and rafting are considerably larger than this. Increasing size of river reduces recreation benefits per acre foot of instream flow. The number of miles of river suitable for fishing, kayaking, and rafting depends on the characteristics of individual rivers and public access to them. Tables 3, 4, and 5 show that increasing the linear miles of river with public access from 15 to 120 miles increases recreation benefits proportionately. An acre foot of instream flow can be used for recreation purposes in subsequent miles of river without diminishing its value to recreation users downstream.

Information on the marginal benefit of recreation use of western rivers should be of considerable value to water managers who are faced with serious problems in administering the use of water resources. River basins operate efficiently when competitive uses of instream flows are allocated so that the net marginal benefits of flow for crop irrigation and other purposes equals the net marginal benefits of flow for recreation use. If marginal benefits are not equal, the basin is not operating efficiently. For example, if the net marginal benefits from irrigation on the Western Slope are $15 per acre foot in August of a normal year [Daubert and Young, 1979], and the net marginal benefits from fishing and boating are $19 per acre foot of instream flow, as shown, then transferring one acre foot to recreation use would increase output of the river basin by $4. In a drought, this relationship would be reversed; basin output would increase by transferring flow to crop irrigation with net marginal benefits approaching $40 per acre foot [Daubert and Young, 1979].

During certain times of the year, diversion for crop irrigation and other purposes will complement recreation uses. In May, June, and early July, when the average instream flow of western rivers approaches maximum bankful, fishing and boating become complementary basin outputs to irrigation and other diversions. For example, if diversion increases the basin's crop value in May by $1.75 per acre foot, in June by $3.30, and July by $9 [Daubert and Young, 1979] and incremental diversions proceed to a point where instream flow is reduced from 100 to 65 percent of maximum bankful during these months, fishing benefits would be increased by $15.72, kayaking by $2.44, and rafting by $1.72 per acre foot.

One partial solution to the problem of allocating water among competitive uses in a river basin involves changing the timing of water storage in high mountain and plains reservoirs for irrigation and other purposes. In the past, many irrigation companies began filling high mountain reservoirs in the fall and waited until the following spring to fill reservoirs in the plains [Aukerman, Carlson, Hiller, and Labadie, 1977]. Total benefits could increase if high mountain reservoirs were drawn down to a minimum pool sufficient to sustain fish life in October after the high mountain recreation season. Water could be used to fill reservoirs on the plains and the augmented instream flow would increase river fishing benefits in the fall months.[13/] Recreation benefits would increase as the spring runoff fills high mountain storage capacity and reduces early summer (May, June, and early July) instream flow to levels more suitable for recreation use. Net marginal benefits per day of recreation use of high mountain reservoirs have been estimated as $1.20 to $2.60 per acre foot [Walsh, Aukerman, and Milton, 1980] and river recreation at 35 percent of maximum flow as $19 per acre foot, including $13 fishing, $3.60 kayaking, and $2.36 rafting.

CONCLUSIONS

The contingent valuation approach has been successful in meeting the objective of valuing the public benefits from recreation opportunities at western rivers. Contingent valuation techniques have been successfully applied to the valuation of air and water quality in the past. The technique appears to be appropriate for valuation of a wide variety of non-market goods including the effects of congestion and instream flow. It should be remembered, however, that contingent valuation measures the responses of individuals faced with hypothetical situations. Thus, considerable care must be exercised in the design of questions and the conduct of surveys, to insure the results obtained are as realistic as possible.

In addition to the recreation benefits of instream flow, there may be long-run ecological benefits that are not included in recreation values. It is impossible now for biologists to predict what these might be, let alone put a dollar value on them and incorporate them into a benefit estimate. For this reason, it seems that present benefit figures represent a conservative estimate of possible total benefits of instream flow. The inability of economic analysis to place a dollar value on ecological effects should be recognized in applying these results to decisions about instream flow.

FOOTNOTES

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1. An extension of this technique was presented by Freeman and Haveman [1977] and by Freeman [1979]. In its simplest form, an <u>uncongested</u> demand curve for a recreation site is specified and below it a family of <u>constant</u> congested demand curves. The area between the demand curves represents the loss in consumer utility measured in dollars resulting from increased congestion.

From this, a congestion cost function was developed as the difference between the maximum willingness to pay when there are no other users present and when there are an increasing number. Each point on the congestion cost curve represents the most an individual would be willing to pay in order to have congestion reduced to zero. The marginal congestion cost curve equals the congestion cost the marginal user imposes on existing users, plus the congestion cost the existing users impose on the marginal user. Optimum is defined as the point where this marginal congestion cost curve equals the uncongested willingness to pay curve. This formulation yields a solution similar to the procedure applied in this report.

2. Individuals experience congestion as number of encounters. For management purposes, encounters must be converted to persons present. Insufficient resources were available to do a simulation analysis of the relationship between number of encounters and persons present in the study areas. Shichter and Lucas [1978] reported the results of simulation analysis of the Desolation Wilderness Area in California, with numerous rivers and lakes. They reported that the relationship was site specific and linear within the relevant range. The relationship between number of encounters and persons present in the study areas was provided by Wildlife Conservation Officers for fishermen; by kayakers and by commercial rafting companies in a survey by the Colorado Natural Resources Division in October, 1978.

3. Simmons and Lord [1978] adopted the Fisher and Krutilla [1972] model to allow shifts in the congestion adjusted total and marginal benefit function with changes in instream water level. With water diversion, fewer users can be present without interfering with others because there is less area suitable for use.

4. An alternative procedure would be to include the independent variable, willingness to participate, as a shifter in the initial function from which congestion adjusted total and marginal benefit curves were derived. This more efficient approach would yield similar results.

5. Increased trip expense was chosen as a payment vehicle over the alternative entrance fee to avoid protest bids. General trip expenses were familiar to all respondents and were dissociated from specific resource management and commercial fees, which may produce adverse reactions.

6. In this analysis, it is assumed that tastes for congestion avoidance are homogeneous. For a discussion of the ramifications of heterogeneous tastes, see Freeman and Haveman [1977].

7. Other variables which shift the congestion adjusted benefit function include: direct cost, consumer surplus, and level of congestion experienced by respondents, distance traveled, length of stay, education, age, sex, organization membership, and size of river. For example, with each additional $1 of trip cost per day, the fishing congestion adjusted benefit function declined by $0.52. With each 1,000 acre feet increase in maximum instream flow, the total congestion adjusted benefit function increased by $0.45. The empirical results of this study suggest that income was not associated with willingness to pay to avoid congestion. Thus, nonprice rationing of recreation use of western rivers may be efficient. For a discussion of the effects of income distribution on equitable pricing to ration use rates, see Cory [1979-80].

8. Agency costs of $2.50 per user day was considered a reasonable average of several case studies of fish stocking and management costs in 1979. Marginal costs could be as low as $1 per user day, depending on whether the reach of a river is stocked or has natural reproduction. Cost of $2.50 per user

day also was considered a reasonable average of several case studies of agency management of river boating in 1979. Marginal costs of providing river boating opportunities could be as low as $1 per user day, depending on the level of services provided. There is a need for further research on the costs of providing fishing and boating opportunities on western rivers. River costs are comparable to reservoir costs [Milton, 1980].

9. The results of this study have important implications for projection of benefits over a planning period representing the life of a multi-purpose reservoir development project. With a normal growth in number of users from a low base, application of a constant value per visitor day would understate congestion adjusted total benefit during the early years and overstate it during later years of the planning period.

10. This corrects an earlier estimate that the marginal benefits from river fishing slope downward to the right with each added unit of flow having a value less than the previous one, which resulted from an assumption of constant demand across all flow levels [Daubert and Young, 1979]. For an illustration of the difference in estimate, see the Appendix to this report.

11. This estimate is nearly identical to $12.21 fishing benefits during July and August with instream flow assumed to be 496 acre feet per day on the Poudre River [Daubert and Young, 1979].

12. This corrects an earlier estimate that the marginal benefits from kayaking are constant and flat, which resulted from insufficient observations at high flow and an assumption of constant demand across all flow levels [Daubert and Young, 1979].

13. The relative drawdown of high mountain and plains reservoirs during late July and August would depend, in part, on the relative recreation

benefits of water in each. There is a need to study the recreation and aesthetic benefits of water in reservoirs on the plains, which is unknown. In addition, all seepage and evaporation losses must be accounted for.

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Appendix Table 7. Instream Flow Shifts Demand and Benefits from Fishing, Kayaking, and Rafting at 9 River Sites in Western Colorado, 1978.

Percent of Maximum Flow	Fishing		Kayaking		Rafting	
	Demand Shift Factor	Benefit Shift Factor	Demand Shift Factor	Benefit Shift Factor	Demand Shift Factor	Benefit Shift Factor
0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
5	0.1516	0.1528	0.0502	0.0857	0.0946	0.0808
10	0.2902	0.2927	0.0998	0.1677	0.1835	0.1581
15	0.4157	0.4197	0.1501	0.2459	0.2679	0.2322
20	0.5294	0.5348	0.1997	0.3205	0.3477	0.3033
25	0.6314	0.6370	0.2500	0.3910	0.4230	0.3710
30	0.7203	0.7266	0.3002	0.4580	0.4937	0.4356
35	0.7974	0.8034	0.3498	0.5212	0.5598	0.4968
40	0.8627	0.8678	0.4001	0.5806	0.6214	0.5550
45	0.9150	0.9194	0.4497	0.6364	0.6784	0.6098
50	0.9542	0.9584	0.5000	0.6881	0.7309	0.6614
55	0.9817	0.9852	0.5495	0.7363	0.7787	0.7098
60	0.9974	0.9987	0.5998	0.7807	0.8221	0.7550
65	1.0000	1.0000	0.6501	0.8213	0.8597	0.7968
70	0.9908	0.9887	0.6997	0.8581	0.8939	0.8356
75	0.9699	0.9649	0.7500	0.8910	0.9236	0.8710
80	0.9359	0.9281	0.7995	0.9204	0.9475	0.9033
85	0.8889	0.8788	0.8498	0.9460	0.9680	0.9322
90	0.8301	0.8169	0.9001	0.9697	0.9828	0.9581
95	0.7595	0.7427	0.9497	0.9859	0.9942	0.9808
100	0.6758	0.6554	1.0000	1.0000	1.0000	1.0000

Source: Multiple-regression coefficients for instream flow.

DISTANCE TRAVELED, DIRECT COST, AND CONSUMER SURPLUS

Appendix Table 8 shows miles traveled, direct cost per trip and per day at the recreation sites, with consumer surplus per day of participation. Consumer benefit cost ratios were calculated with the average total willingness to pay as the numerator and direct trip cost as the denominator. Kayakers valued the recreation experience relatively more than rafters or fishermen. The consumer benefit cost ratio for kayaking averaged 1.8 compared to 1.3 for rafting and 1.5 for fishing. The direct cost of kayaking was lower, $11.53 per user day, compared to an average of $25.45 for fishing and $30.82 for rafting. This reflects the fact that kayakers traveled an average of 209 miles one way which was less distance than either fishermen with 292 miles or rafters with 375 miles.

These findings are comparable to past studies, even though the definition of direct costs varies. Deviner [1977] reported the direct costs of boating on the Dolores River in Colorado as $14.04 per user day in 1975. This included average expenditures of $1.07 at auto dealers and gasoline stations, $2 at eating and drinking places, $5.97 at other retailers, and $5 for lodging. Michaelson [1977] reported the average direct cost for rafting on the Middle Fork Salmon River in Idaho was $18.50 in 1969. It was reported that direct costs of the average resident fisherman in Colorado were $10.24 and fixed costs were $20.66 for total costs of $30.90 per user day in 1973 [Ross, Blood, and Nobe, 1975]. This compared to total costs of $26.81 per fishing day in 1968. Total costs exceeded direct out-of-pocket costs which is the recommended definition of the price of outdoor recreation.

Appendix Table 8. Miles Traveled, Direct Cost Per Trip and Per Day at Site, With Consumer Surplus Per Day of Participation in Fishing, Kayaking, and Rafting at Nine River Sites in Western Colorado, 1978.

Recreation Activity	Average One-Way Miles Traveled on This Trip	Average Direct Out-of-Pocket Cost For This Trip		Average Consumer Surplus Above Trip Cost Per Day[a]	Average Total Willingness to Pay Per Day	Consumer Benefit Cost Ratio
		Total Cost of Trip	Cost Per Day at Site			
Fishing	292	$175.15	$25.45	$11.78	$37.23	1.5
Kayaking	209	76.98	11.53	8.75	20.27	1.8
Rafting	375	154.35	30.82	8.48	39.30	1.3
Average	301	137.38	23.54	9.67	33.21	1.4

a. With number of users at optimum capacity and instream flow as reported on the days interviewed and agency costs of $2.50 per user day.

Few studies have been made of the consumer surplus of river-based recreation activities. Previous estimates have been considerably higher than the more conservative estimates reported here. Gilbert [1971] calculated the consumer surplus of fishing in Colorado as $17.17 per user day in 1968. He utilized the Pearce approach which is not recommended [U.S. Water Resources Council, 1979]. Michaelson [1977] utilized the individual travel cost approach to calculate consumer surplus of recreation use of the Middle Fork of the Salmon River in Idaho as $76.85 per user day in 1969, of which $20 was attributed to instream flow. These estimates are considerably higher than reported here for West Slope Colorado rivers. A possible explanation of the difference should be noted. The Middle Fork of the Salmon River was the first wild river in the U.S., created by act of Congress (PL 90-542) in 1968. Consequently, national attention was attracted to its uniqueness for river rafting activities. Salmon River demand may be relatively price inelastic, meaning that use would not change much with increases in price (direct cost) and consumer surplus would be quite large.

DISTANCE TRAVELED AND PER CAPITA PARTICIPATION

Appendix Table 9 contains distance decay functions for river fishing, kayaking, and rafting by residents of Colorado. Distance decay coefficients indicate the change in number of recreation days per capita for each one mile change in distance from place of resident to river recreation sites. They are based on origin-destination data in the form of a series of paired observations for distance and number of days. They indicate the number of recreation user days per participant from each hydrological region at river recreation sites of varying distance. Distance decay functions can be used to forecast the effects of changing instream flow on total participation in the recreation activities. Summation of the regional participation rates for given distances would show state participation rates. The integral of the curves could be multiplied by the proportion of the population who participate in the recreation activities and expanded to total population levels.

River fishing by residents of Colorado would decline by -.17 days annually for each 100 mile increase in one-way distance to fishing sites. This is related to where fishermen live, whether on the Front Range or West Slope. Distance decay coefficients are nearly 2 to 5 times greater among West Slope regions (from -.0021 to -.0041) than among Front Range regions (from -.0008 to -.0013). This reflects the attractiveness of fishing in cold water streams on the West Slope, relative to other streams in the state. Fishermen who live in Front Range regions are willing to travel farther to fishing sites. The constant term shows the annual days of fishing in the county of residence. Residents of the West Slope fish more in the county where they live than residents of the Front Range.

Appendix Table 9. Linear Distance Decay Functions for River Fishing, Kayaking, and Rafting by Residents of Colorado River Basins.

Region of Residence or Origin	Sample Size	Estimated Relationship Between Number of Days Per Participant and One-Way Travel Distance[a]	Average Maximum Distance Traveled
Fishing[b]			
State of Colorado	696	$\hat{y}$ = 0.4998 - .0017x	294
Northwest River Basin	14	$\hat{y}$ = 1.0405 - .0037x	281
Colorado River Basin	69	$\hat{y}$ = 1.0625 - .0041x	259
Gunnison River Basin	27	$\hat{y}$ = 0.7864 - .0028x	281
Southwest River Basin	20	$\hat{y}$ = 0.7300 - .0021x	348
Rio Grande River Basin	17	$\hat{y}$ = 0.5962 - .0023x	259
Arkansas River Basin	94	$\hat{y}$ = 0.3677 - .0013x	283
Republican River Basin	5	$\hat{y}$ = 0.3311 - .0008x	414
South Platte River Basin	450	y = 0.3399 - .0011x	309
Kayaking[c]			
Western Slope River Basins	35	$\hat{y}$ = 7.3715*** - .0075x**	983
Front Range River Basins	60	$\hat{y}$ = 4.2216*** - .0034x***	1,242
Rafting[c]			
Western Slope River Basins	23	$\hat{y}$ = 3.2115*** - .0058x**	554
Front Range River Basins	20	$\hat{y}$ = 1.8811*** - .0013x*	1,447

[a] Variable Definitions: $\hat{y}$ = Annual activity days per participant in destination county. x = Travel distance between region of origin and county of destination.

[b] All coefficients are significantly different from zero at the 99 percent level of confidence, except the slope coefficient for the Republican River Basin which has a 95 percent level of confidence.

[c] Levels of confidence coefficients are significantly different from zero: *** = 99 percent; ** = 95 percent; * = 90 percent.

Source: Fishing distance decay coefficients were calculated from data collected for the 1973-74 season for the Statewide Comprehensive Outdoor Recreation Plan (SCORP). Kayaking and rafting distance decay coefficients were calculated from data collected by telephone interviews for the 1977-78 season.

Kayaking by residents of Colorado would decline by about -.49 days annually for each 100 mile increase in one-way travel distance to kayaking sites. Rafting would decline by -.27 days annually for each 100 mile increase in travel distance. This is related to where kayakers and rafters live, whether on the Front Range or the West Slope. The kayaking distance decay coefficient for the West Slope (-.0075) is more than double the decay coefficient for the Front Range (-.0034). The rafting distance decay coefficient for the West Slope (-.0058) is more than four times the coefficient for the Front Range (-.0013). This means that kayakers and rafters who live in the Front Range are willing to travel farther to river boating sites. The constant term shows the annual days of kayaking and rafting in the county of residence. Residents of the West Slope kayak and raft more in the county where they live than residents of the Front Range. Most of the suitable sites for kayaking are located on the West Slope, which is the primary reason for the difference in willingness to travel between residents of the Front Range and West Slope.

A review of the empirical literature on distance decay functions suggested that there has been virtually no previous research on river basins in Colorado or on fishing, rafting, and kayaking. The studies that have been completed show that participation in recreation activities tends to be inelastic with respect to changes in distance traveled. That is, for a given percentage change in distance, there is a smaller change in number of days of outdoor recreation activity. Participants will forego considerable money and time cost of travel before number of days of outdoor recreation will decline appreciably. For example, a study of potential wild river designation of several Idaho streams [Michaelson, 1977] reported that participation declined by -0.12

percent for each 1 percent increase in distance to the St. Joe River. Demand equations were estimated for five other sections of the Salmon River, but the distance coefficient did not enter the estimation equations because of multicollinearity between distance and a user cost specification of the price of recreation. A study by the U.S. Army Corps of Engineers [1976] of the American River Parkway in California showed that the distance coefficient declined when few substitute sites were available for the activity, particularly in the case of river rafting on the upper reaches of the stream where the water was swifter and there were few substitute sites available. Parent and Robeson [1977] estimated the cross-elasticity of demand for rafting on the Snake River in Grand Teton National Park and the Snake River in Targhee National Forest. A 1 percent increase in fee for float trips (with regulation) in the National Park was associated with an increase in participation at the National Forest site of 1.14 percent.

Arosteguy [1974] developed distance decay coefficients in projecting Colorado wildlife related recreation to 1985. Inclusion of socioeconomic variables in this study tended to reduce the effect of distance on recreation activity. The distance decay coefficient for all boating by residents of the Denver metropolitan area was -.0005. For residents of the Colorado River Basin on the Western Slope, the distance decay function for boating was -.001. Thus, boating by Denver residents declined by -0.1 percent for each 1 percent increase in distance to boating sites. Boating by Colorado River Basin residents declined by -0.15 percent for each 1 percent increase in distance to boating sites. This reflects the greater opportunities for substitution by West Slope residents. Distance decay coefficients were developed for number of trips by participants in cold water fishing in the Colorado River Basin and the Northwest River Basin. There were significant differences between distance coefficients of residents and non-residents of the state. Non-resident cold water fishermen represented one-third of fishermen in the Colorado River Basin and 16.8 percent in the Northwest River Basin. For Colorado residents, the relationship between distance and participation was nearly identical for cold water fishing in the two river basins. A 1 percent increase in miles per trip would result in a -0.14 percent reduction in number of trips per fisherman to the Colorado River Basin and a -0.18 percent reduction in trips to the Northwest River Basin. For non-residents of the state, the relationship between distance and participation was much more elastic. a 1 percent increase in miles per trip was associated with a -1.48 percent decline in trips per fisherman to the Northwest River Basin and a -0.58 percent reduction in trips per fisherman to the Colorado River Basin. The increased responsiveness to distance reflects the greater number of substitutes available to non-resident fishermen.

CONTINGENT VALUATION WITH HORIZONTAL SHIFTS IN DEMAND

Contingent valuation is a relatively new approach to measure the recreation benefits of water resources. It was only recently authorized for use by federal agencies in water resource planning [U.S. Water Resources Council, 1979]. As with anything new, it is important to test the effect of alternative procedures used in its early application, so that improvements can be made before general adoption. It is possible to compare the effect of two alternative approaches to the specification of river fishing benefits contingent on changes in instream flow.

Two studies were conducted simultaneously in the Department of Economics at Colorado State University during the summer, 1978. One surveyed a representative sample of fishermen and boaters on the Poudre River which flows through Fort Collins on the Front Range of the Rocky Mountains. The other surveyed a representative sample of fishermen and boaters at nine river sites on the West Slope of the Rocky Mountains in Colorado. Both studies applied the contingent valuation approach. For the most part, the findings of the two studies are similar and provide verification through replication of the basic approach. However, results were significantly different with respect to the shape of curves depicting marginal benefits per acre foot. For example, in the case of river fishing, our West Slope marginal benefit curves were bell-shaped, contrary to the Poudre River marginal benefit curves which sloped downward to the right, with each added unit of flow having a value less than the previous one [Daubert and Young, 1979; 124].

Appendix Table 10 illustrates the effect of the two alternative specifications of the model. First, the Poudre River study held demand constant and calculated the effect of changes in instream flow on willingness to pay.

Appendix Table 10. Congestion Adjusted Net Benefits from Fishing With and Without Effects of Instream Flow on Demand, Three Western Rivers, Colorado, 1978.

Percent of Maximum Flow	Instream Flow, Acre Feet Per Day	Optimum Users Per Mile Per Day	Net Benefits Per User Day	Total Net Benefits Per Mile Per Day		Marginal Benefits Per Acre Foot Per Day For 60 Miles of River	
				With Reported Change in Demand[a/]	Without Change in Demand[b/]	With Reported Change in Demand	Without Change in Demand
0	0	0	0				
5	80	1.8	1.82	$3.28	$21.84	$2.48	$16.38
10	160	3.5	3.48	12.21	41.76	6.72	14.94
15	240	5.0	5.00	25.00	60.00	9.60	13.68
20	320	6.4	6.37	40.78	76.44	11.84	12.33
25	400	7.6	7.59	57.68	91.08	12.68	10.98
30	480	8.6	8.66	74.45	103.92	12.56	9.63
35	560	9.6	9.57	91.89	114.84	13.08	8.19
40	640	10.3	10.34	106.49	124.08	10.96	6.93
45	720	11.0	10.95	120.49	131.40	10.52	5.49
50	800	11.4	11.42	130.17	137.04	7.28	4.23
55	880	11.8	11.74	138.50	140.88	6.28	2.88
60	960	11.9	11.90	141.59	142.80	2.32	1.44
65	1,040	12.0	11.91	142.92	142.92	1.00	0.09
70	1,120	11.9	11.78	140.18	141.36	-2.08	-1.17
75	1,200	11.6	11.50	133.40	138.00	-5.12	-2.52
80	1,280	11.3	11.06	124.98	132.72	-6.32	-3.96
85	1,360	10.7	10.47	112.02	125.64	-9.72	-5.31
90	1,440	10.0	9.73	97.30	116.76	-11.04	-6.66
95	1,520	9.1	8.85	80.54	106.20	-12.56	-7.92
100	1,600	8.2	7.80	63.96	93.60	-14.72	-9.45

a. Net benefits with reported change in demand from Table 3.

b. Net benefits without reported change in demand assumes that optimum number of users per mile per day remains constant at 12.0 persons for all instream levels.

Columns six and eight were calculated holding demand constant at 12 users per mile across all instream flow levels. The result is as expected, a marginal benefit curve which slopes downward and to the right. The approach assumes that a river serves users who are poorly informed and continue to fish under the most unfavorable circumstances as to instream flow, perhaps because they are tourists on vacation and the nearest river to their campground or cabin provides the only fishing opportunity available. Thus, actual use of the river may be at a constant level which is more or less than optimum, however, non-optimum use would result in a loss of total benefits. Second, the West Slope river study included the effect of instream flow on congestion adjusted demand and willingness to pay. Columns five and seven were calculated with demand at optimum across all levels of instream flow. This results in a bell-shaped marginal benefit curve. Congestion adjusted demand for river-based recreation on the West Slope shifts with instream flow. This reflects the fact that diversion of instream flow beyond some level reduces the number of pools available for fishing, riffles suitable for kayaking, and the speed of rafts, thus fewer users can participate without interfering with others.

We conclude that the Poudre River study overstates marginal benefits at both low and high levels of instream flow. It represents vertical shifts in the value intercept of demand curves for changes in instream flow, while holding the horizontal intercept of all demand curves constant. The approach of the West Slope study seems to be more theoretically correct in this respect. Freeman [1979] concluded that the correct approach to estimation of recreation benefits resulting from a change in environmental quality is the area between demand curves whose vertical and horizontal intercepts both shift with changes in the quality of the resource. This effect is illustrated by the near parallel shift of column three, optimum number of users per mile, with column four, net benefits per user day.

It should be acknowledged that this problem was discovered after the Poudre River data had been collected and the analysis was underway. Daubert asked our opinion of the best way to treat the quantity variable, number of user days. To accept the U.S. Forest Service estimate of average daily use seemed to be the only available solution, even though it involved the unrealistic assumption that use does not vary with instream flow. Now with the benefit of hindsight it is apparent that our advice would be to assume that instream flow shifts recreation use at the same rate as willingness to pay. This treatment of demand shifts would be a relatively simple adjustment in the Poudre River data, and it would result in bell-shaped marginal benefit curves for river fishing, similar to the results of the West Slope study. It may not be necessary to ask users about changes in use with instream flow. In future studies, it may be sufficient to assume parallel shifts in demand curves for changes in environmental quality.

AGENCY COSTS TO MANAGE RIVER BOATING

Appendix Table 11 shows the costs incurred by governmental agencies to manage rivers for kayaking and rafting in Colorado. With increased demand for whitewater recreation, a number of public agencies have recently initiated programs to manage rivers to protect user safety and resource quality. The rivers for which cost data were available include: (1) the Poudre River, 25 miles east of Fort Collins; (2) the Colorado River from Kremmling to Dotsero; (3) the Colorado River through Westwater Canyon west of Grand Junction; and (4) the Green and Yampa Rivers through Dinosaur National Monument. These four rivers represent the range of costs incurred which vary from $0.23 to $4.85 per visitor day. Average costs for the 1979 and 1980 fiscal years of $2.29 per visitor day are believed to be a reasonable estimate of boating management costs on western rivers. By comparison, fishery management costs may be somewhat higher. See Note (d) to Appendix Table 11.

The costs of providing boating opportunities vary with levels of demand and management. Poudre River costs of $0.23 per visitor day are minimal with relatively low levels of use, as the boating season is short. While river use permits are required, obtainable at the County Sheriff's office, special facilities are minimal with Highway 14 providing access and existing campgrounds providing parking and sanitation facilities.

Managing boating on the Colorado River at Westwater Canyon costs $4.85 per visitor day with current use equaling the carrying capacity limit of 10,000 visitor days per year. High labor costs are incurred to administer a permit system which limits use to three private and three commercial parties per day. Applications must be obtained two months prior to the trip. Westwater Canyon is remote and the difficult whitewater requires more expensive equipment

Appendix Table 11. Agency Costs to Manage Kayaking and Rafting Use of Western Rivers, Colorado, 1979.

Costs and Use	River Boating Cost Per Visitor Day[a/]				
	Poudre River	Colorado River, Kremmling to Dotsero	Colorado River, Westwater Canyon	Green and Yampa Rivers, Dinosaur National Monument	Average, Four Rivers
Salary and Wages	$0.10	$0.72	$3.24	$1.82	$1.53
Equipment[b/]	0.07	0.07	0.98	0.19	0.22
River Facilities[b/]	0.03	0.57	0.43	0.14	0.31
Buildings[b/]	0.03	0.16	0.20	0.29	0.23
Average Total Cost	0.23	1.52	4.85	2.44	2.29[d/]
Visitor Days[c/]	3,500	36,282	10,440	55,656	26,470
Users	7,000	54,423	7,180	12,976	20,395
Visitor Days per User	0.50	0.67	1.50	4.30	1.30
River Miles Managed	14	42	20	90	42
Visitor Days Per Mile	250	860	522	618	638

a. Poudre River costs from Rick Perkins, Deputy Sheriff, Larimer County, CO. Costs for the Colorado River from Kremmling to Dotsero from Paul Bradley, Glenwood Springs Resource Area, Bureau of Land Management, and Elvin Clap, Kremmling Resource Area. Colorado River-Westwater Canyon costs from Dave Minor, Grand Resource Area, Bureau of Land Management, Moab, UT. Green and Yampa River costs from Earl Perry, Dinosaur National Monument. The assistance of Robert Milton is gratefully acknowledged.

b. Original costs of equipment, facilities, and buildings annualized a 10 percent interest.

c. A visitor day equals 12 hours, as defined by the U.S. Forest Service.

d. With costs of stocking creel-size fish estimated as $1.88 per pound, the costs to stock 14 miles of the Frying Pan River with 2,350 pounds of trout were $2.61 per visitor day. To stock 44 miles of the Poudre River with 20,500 pounds of trout cost $1.07 per visitor day. These costs do not include enforcement of fishing regulations or provisions of facilities such as fisherman parking and sanitation. Including these operating costs and overhead costs of the Colorado Division of Wildlife would increase agency fishing costs to about $4.50 per pound of creel-size fish stocked. The Division estimates the average fishing day is 3.5 hours, thus 3.4 user days equals one visitor day.

and more frequent river patrols for user safety.

Bureau of Land Management costs to administer boating on the Colorado River from Kremmling to Dotsero of $1.52 per visitor day are much lower than at Westwater Canyon. While river use permits are required with fees of $0.30 per commercial user and $1.00 per private user, no carrying capacity has been established and use is not restricted. The agency provides sanitation facilities, road maintenance, signs, potable water, river patrols, cleanup, site and bank protection at major ingress and egress points. Ninety percent of all users enter the river at a common ingress point.

National Park Service costs to manage boating on the Yampa and Green Rivers in Dinosaur National Monument of $2.44 per visitor day are somewhat higher than the average costs of the four rivers studied. With 55,000 visitor days per year, use is restricted by means of a lottery drawn from applications submitted by December 1 of the preceding year. The agency provides access roads, ingress and egress points, primitive camping facilities, sanitation, cleanup, river patrol, and information programs.