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CONGESTION, CARRYING CAPACITY, AND BENEFITS FROM FOREST RECREATION

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ABSTRACT

The purpose of this paper is to show the effect of congestion on the estimation of benefits from low density and high density forest recreation in the Northern Front Range of Colorado, an area with increasingly crowded recreation resources. Most studies of the benefits from outdoor recreation in the past have dealt with uncongested resources or have assumed that no congestion effects exist. Resulting estimates of benefits per day may be biased when measured at non-optimum levels of use. Comparable measurement of the alternative outputs of the National Forests would be more nearly approached by estimation of the benefits of each at optimum capacity.

CONGESTION, CARRYING CAPACITY, AND BENEFITS FROM FOREST RECREATION*

Most studies of the economic benefits from outdoor recreation in the past have dealt with uncongested resources or have assumed that no congestion effects exist. Recently, some observers have suggested that the resulting estimates of benefits may be biased if there is excess demand or congestion [Fisher and Krutilla, 1972; McConnell and Duff, 1976; McConnell, 1977; Freeman 1979]. Conceptually, congestion is an external cost and is perceived as a deterioration in the quality of the recreation experience. Recreation benefits are expected to be a decreasing function of the number of persons encountered. Comparable measurement of the alternative products of the National Forests would be more nearly approached by estimation of the benefits of each at optimum capacity [Krutilla and Fisher, 1975]. The Forest Service is interested in improving measures of the economic benefits of alternative recreation activities in order to compare them with the costs of resource management, such as maintaining stream quality in forest watersheds used for low density versus high density recreation. The purpose of this paper is to show the empirical effect of congestion on the statistical estimation of benefits from low density and high density forest recreation.

The study site is located in the Northern Front Range of Colorado, an area which as been subject to increasing congestion effects. The study area included the 72,622 acre, 113.5 square mile, Indian Peaks Wilderness area and the 3,600 acre Brainard Lake complex which provided the primary access to trails entering the wilderness. Elevations in the study area range from 10,350 to over 14,000 feet. Headwaters of the Colorado, Boulder, and St. Vrain Rivers are within the area, and lakes are numerous. Much of the area consists of open bare rock, and the open landscape is very beautiful. Brainard Lake's 54 developed campsites, 21 picnic sites, and shoreline provided 127,000 recreation visitor days in 1978 [USDA, 1979]. The 76 miles of trail in Indian Peaks provided 176,000 annual recreation visitor days. This equaled 2,300 visitor days per mile of trail.[1/] Indian Peaks has been one of the most heavily used wilderness areas in the nation since its designation in 1978, and growth in demand for forest recreation use seems likely to continue, posing problems of congestion and environmental quality. Located on the south boundary of Rocky Mountain National Park in Arapaho and Roosevelt National Forests, the study area is about 60 miles northwest of Denver. It offers the majority of the over two million residents of Colorado's Front Range metropolitan areas an opportunity to obtain a wilderness experience within 1 to 2 hours drive. It was reported that 70 percent of the Indian Peaks users are from Colorado [Brown, Haas, and Manfredo, 1977], compared to about 30 percent of the users of Rocky Mountain National Park. Almost all visitors are hikers; less than 3 percent use horses. Day use represents 75 percent of total use and overnight use 25 percent. The recreation opportunities provided in the study area include: hiking, backpacking, fishing, picnicking, camping and other activities.

THEORY OF CONGESTION

The theoretical basis of empirical measurement of congestion effects in this paper was developed by Fisher and Krutilla [1972], with further extensions by Freeman and Haveman [1977] and Freeman [1979]. Congestion in forest recreation can be viewed as a negative external effect generated by increasing numbers of consumers at the recreation facility per unit of time. That is, recreationists begin to crowd one another as their numbers increase. Congestion is viewed as one of a number of quality attributes of the recreation facility, and enters the utility function of the recreationists as a separate variable. That is:

$$U_i = U_i(F, C, X)$$

where F = units of the forest recreation experience consumed per unit time;

C = the level of congestion present during consumption of F;

X = a vector of all other goods consumed per unit time;

U_i = utility per unit time for individual i.

While economic theory does not specify the precise manner in which congestion enters the utility function, it is reasoned a priori that, beyond some point, increased congestion will generate a negative marginal effect on utility. Graphically, this is represented in Figure 1.

D_1 represents individual i's uncongested demand curve for consumption of forest recreation, F. D_2 represents individual i's demand curve in the presence of congestion effects. The area between the two curves, ABCD, represents the loss of consumer utility measured in dollars as the result of increased congestion.

Following Freeman and Haveman, congestion cost is measured as:

$$C_i(Q) = P_i(1) - P_i(Q)$$

The congestion cost to individual i when there are Q users of the facility present is equal to the difference between the maximum willingness to pay by i when there are no other users present, $P_i(1)$, and his maximum willingness to pay when there are Q users present, $P_i(Q)$. Alter-

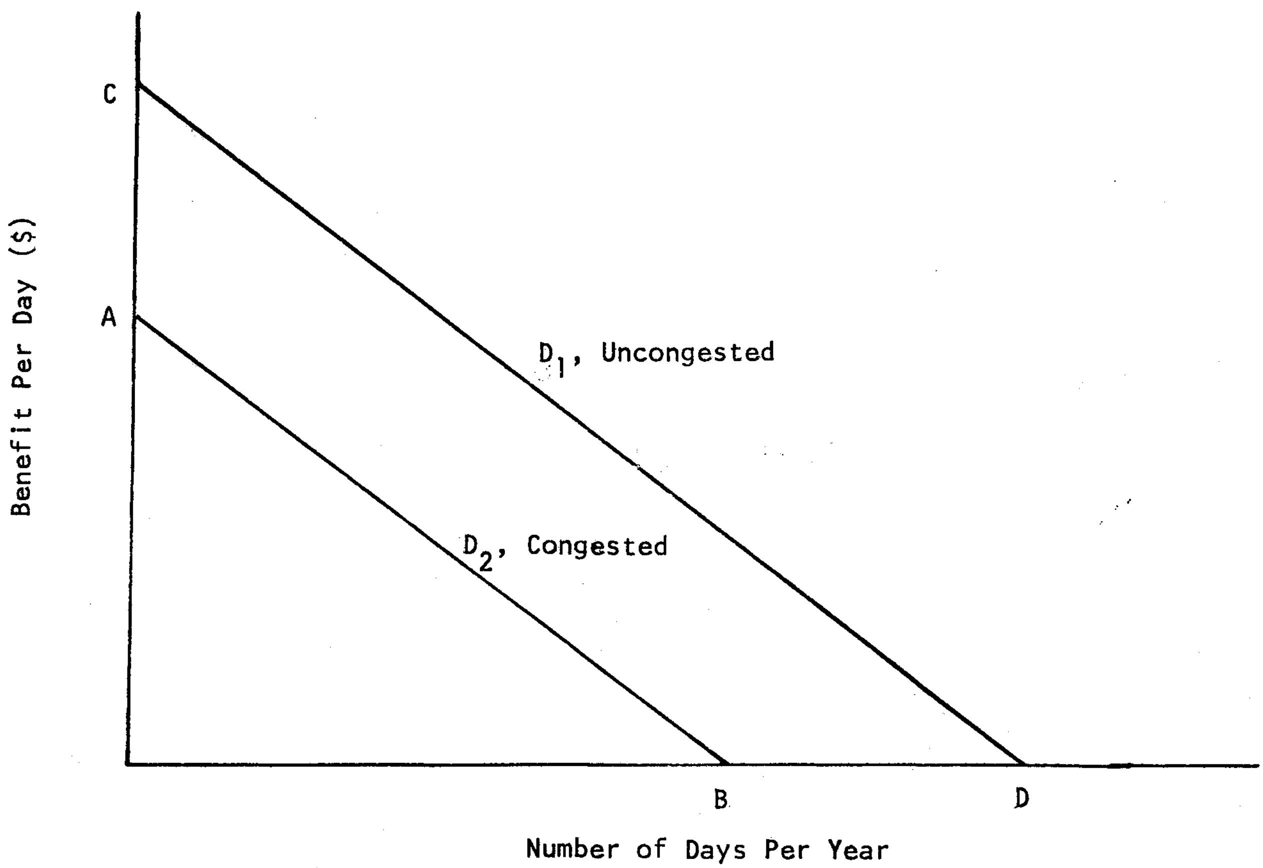

Figure 1. Effect of Congestion on Demand for Forest Recreation.

natively stated, $P_i(1) - P_i(Q)$ is the most individual i would be willing to pay in order to have congestion reduced from that associated with Q to zero.

Aggregating over all individuals reveals a two-part definition of marginal congestion cost. The marginal congestion cost of increased users of a recreation facility equals the congestion cost the marginal user imposes on existing users, plus the congestion cost the existing users impose on the marginal user. It is assumed the marginal user considers only the 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 overuse of the resource. The economic optimum level of resource use occurs where incremental benefit just equals incremental congestion cost. It is the purpose of this paper to illustrate an empirical estimation of optimum capacity in the presence of congestion effects.

STUDY DESIGN

The basic data used in this study were obtained from interviews with approximately 280 recreational users of the Indian Peaks Wilderness and Brainard Lake Recreation areas during August and September, 1979. A representative sample of 190 recreation users were interviewed at the campground, picnic areas, lakes, streams, parking lots, trails, and camp sites in the wilderness area. Recreation use data was obtained from interviews with an additional 90 recreation users who subsequently mailed back questionnaires containing the socio-economic information requested.

Respondents were asked to report the maximum they would be willing to pay for their primary recreation activity in the study area on the day of interview rather than do without the experience. Following Knetsch and Davis [1966], the method of payment was total direct trip costs. Individual direct cost actually paid was subtracted from willingness to pay so that the resulting value is a Bradford [1970] bid curve, or consumer surplus measure of benefit from forest recreation.[2/] This congestion adjusted benefit function is not a demand curve; it is a direct measure of the area between shifts in the demand curve resulting from increased congestion.

The sample was stratified to test the significant difference between recreation benefit using the contingent valuation and direct question approaches. Approximately one-half of the sample was asked the contingency valuation question while the other half was asked the open-ended direct question. Results showed no significant difference in the valuation of benefits from forest recreation at the 95 percent level of confidence, thus the two subsamples were combined in the analysis.

The U.S. Water Resources Council [1979] recently recommended the contingent valuation approach, an iterative bidding procedure successfully applied to the valuation of forest recreation [Knetsch and Davis, 1966], air quality [Randall, et al., 1974; Brookshire, et al., 1976], water quality [Walsh, et al., 1978], instream water flow [Daubert and Young, 1979], wildlife [Brookshire, et al., 1978] and beach recreation [McConnell, 1977]. The preferred format is one in which respondents answer "yes" or "no" to questions asking if they are willing to pay a stated amount of money to obtain an increment or decrement in congestion. The value is increased by random amounts until the highest amount that the respondent is willing to pay is identified.

ANALYSIS OF RESULTS

The benefit functions developed in the analysis are shown in Table 1. The proportion of the variation in benefit per activity day explained by the independent variables included in the four equations varied from 0.14 to 0.46. All parameters were significantly different from zero at the 5 percent level.[3/] The estimated benefit functions are shown in Figures 2 to 5, where benefit is measured along the vertical axis with number of persons encountered measured along the horizontal axis.

Ordinary least squares statistical methods were used to estimate the coefficients and the constant for the model (Table 1). Then the model was simplified to show the relationship between the two variables of interest. All variables other than the dependent variable, average benefit per activity day, and the independent variable, number of persons encountered, were set at their means and added to the constant. This may be illustrated by the following regression function which was obtained for backpacking:

$$\text{Average benefit} = \$23.41 - \$0.2649 \text{ Persons} + \$0.00044 \text{ Persons}^2$$

This indicates that an average backpacker who encounters no other persons can be expected to have benefits of approximately $23 per activity day. With otherwise identical conditions, benefits decline by approximately $0.27 cents per day for each additional person encountered. Backpackers who encounter 50 other persons would have benefits of about $11 per activity day. Those who encounter 100 other persons per day would receive virtually no benefits and would be expected to discontinue the activity at this site.[4/]

Talbe 1. Ordinary Least Square Equation Estimates of Net Benefit Per Day of Recreation Activity at the Brainard Lake Recreation Area and Indian Peaks Wilderness Area, Colorado, 1979.[a]

Variable	Brainard Lake Area		Indian Peaks Wilderness	
	Picnicking	Camping	Backpacking	Hiking
Constant	32.7986	2.4321	-30.4344	42.6840
Crowding, Persons	-0.0708 (-2.05)	-0.0621 (-2.04)	-0.2649 (-3.97)	-0.2052 (-5.41)
Crowding Squared			0.0004 (2.75)	0.0005 (3.05)
Resident, N.E. Region		76.7401 (6.93)		9.0177 (2.04)
Time at Site this Trip, Hours		0.1265 (2.54)		-0.1140 (-3.73)
Nearest Substitution, Miles				0.0296 (1.96)
Average Substitution, Miles		-0.0103 (-2.94)	0.1039 (7.36)	
Distance from Home, Miles		0.0053 (2.30)		-0.0123 (-4.98)
Education, Years	-1.1441 (-2.38)			
Member Sportsman Organization			28.9927 (6.29)	
Colorado Resident				-24.3812 (-5.12)
Household Income Log, Dollars			4.5407 (3.19)	
Adjusted R^2	0.14	0.46	0.30	0.27
F	4.37	29.47	19.37	14.41
Observations	59	180	228	227

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

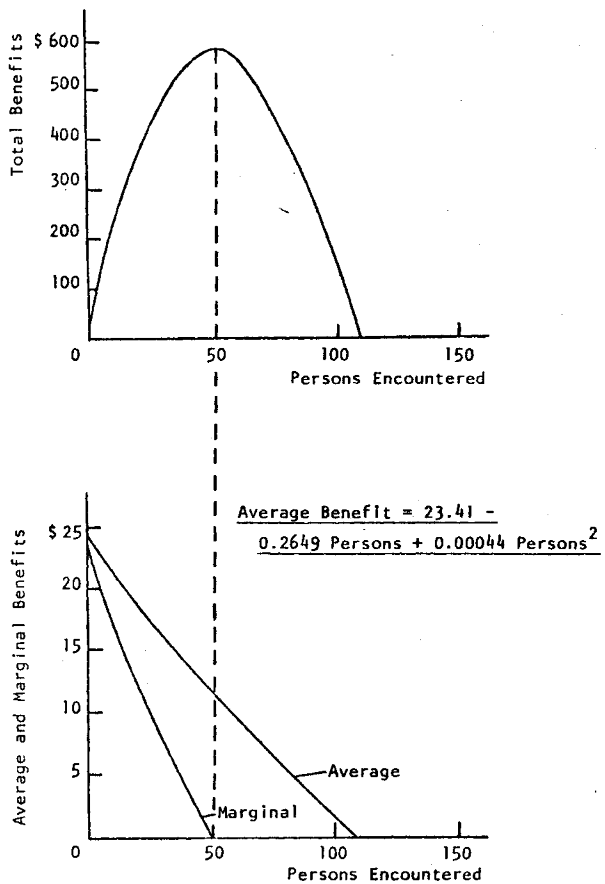

Figure 2. Total, Average, and Marginal Benefit per Day of Backpacking at Indian Peaks Wilderness Area, Colorado, 1979

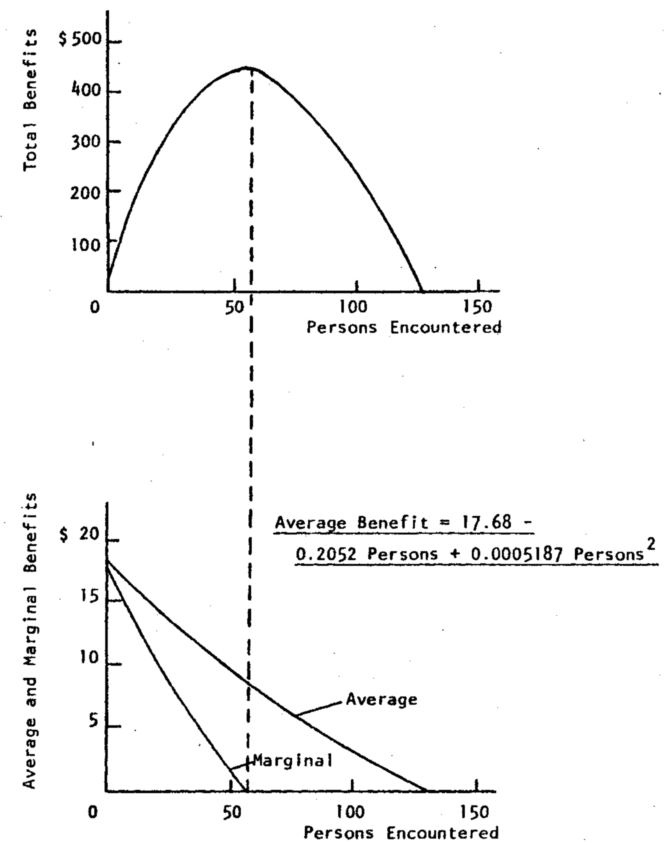

Figure 3. Total, Average, and Marginal Benefit per Day of Hiking at Indian Peaks Wilderness Area, Colorado, 1979

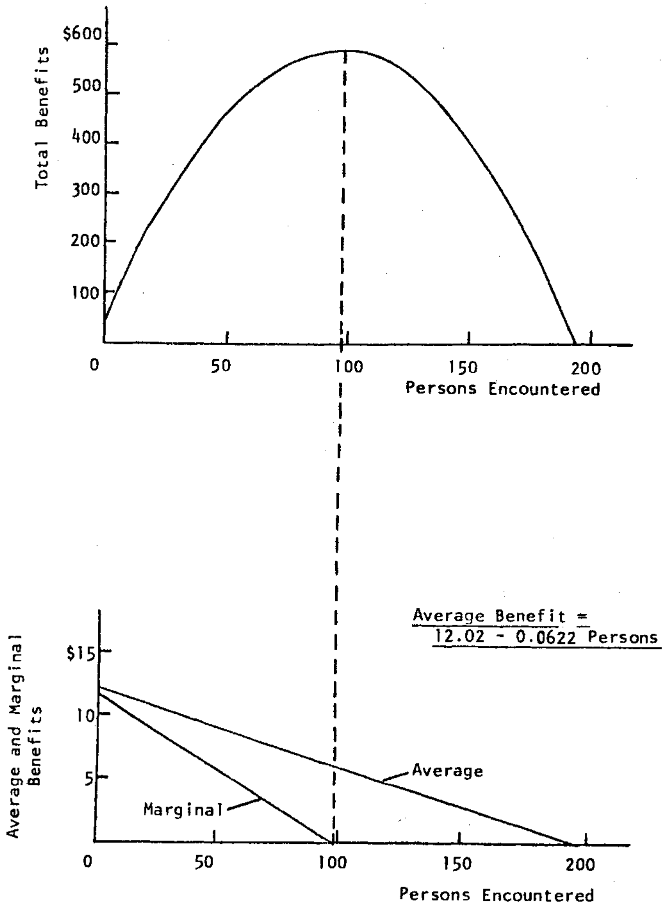

Figure 4. Total, Average, and Marginal Benefit per Day of Camping in Brainard Lake Recreation Area, Colorado, 1979

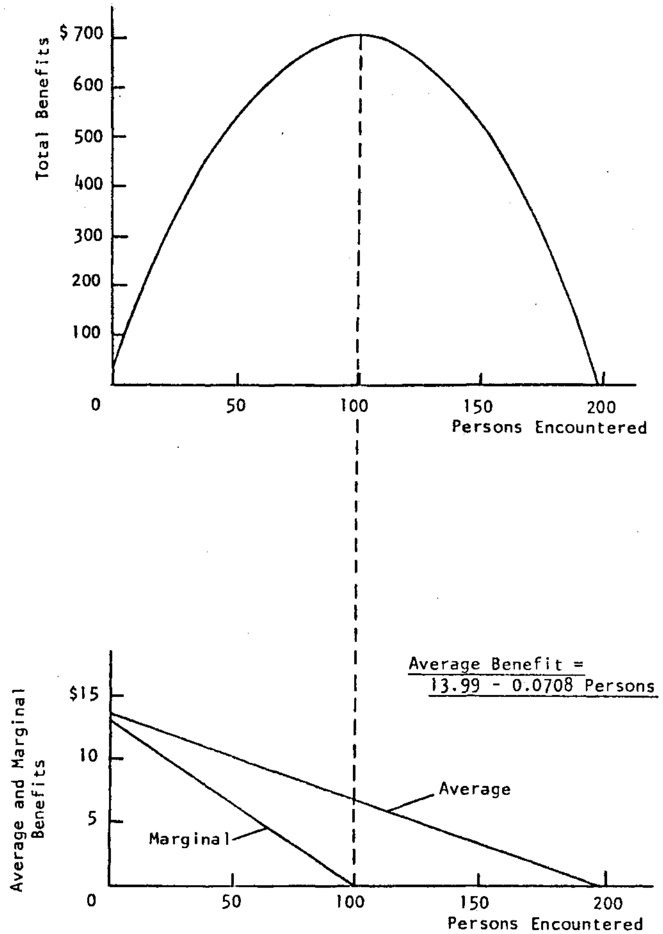

Figure 5. Total, Average, and Marginal Benefit per Day of Picnicking in Brainard Lake Recreation Area, Colorado, 1979

The total benefit function takes the same standard textbook 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 gains from additional numbers of backpackers exceed the loss due to congestion costs, total benefits increase. Beyond some point, congestion costs exceed the gains experienced by additional recreationists and total benefits diminish. For backpacking, this occurs in the neighborhood of 50 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 Forest Service costs of management to prevent environmental degradation, optimum capacity would shift to the left. For Indian Peaks, these costs have been estimated by the Forest Service as approximately $2.50 per visitor day. Thus, optimum backpacking capacity would become 43 encounters per day.[5/] This would be the point where marginal benefits equal marginal costs. At this level of congestion, average benefits from backpacking would rise from $11 previously to $13 per day (Table 2).

CONCLUSIONS

This paper has shown that research procedures which measure the effects of congestion improve the resulting estimation of benefits from forest recreation. More meaningful comparison of benefits from low density and high density recreation activities is possible if the benefits

Table 2. Effects of Congestion and Agency Costs on Carrying Capacity and Benefits from Low Density and High Density Forest Recreation, Brainard Lake and Indian Peaks Wilderness Areas, Colorado, 1979.

	Low Density Forest Recreation		High Density Forest Recreation	
	Backpacking	Hiking	Camping	Picnicking
Persons Encountered Per Day				
Reported by respondents	24.0	38.0	62.0	61.0
At optimum capacity with congestion costs	49.5	53.0	96.0	98.0
At optimum capacity with agency costs of $2.50	43.4	43.5	76.0	80.0
Average Benefits Per Day				
Reported by respondents	$17.31	$10.64	$8.17	$9.67
At optimum capacity with congestion costs	$11.38	$ 8.27	$6.05	$7.05
At optimum capacity with agency costs of $2.50	$13.06	$ 9.07	$7.30	$8.32
Range of difference	$4-6	$1-3	$1-2	$1-2

from each are estimated at optimum capacity. If congestion effects had been ignored, the average benefits of backpacking at Indian Peaks would have been reported as $17 per activity day and hiking as $11. These were average values reported by the participants interviewed during the summer, 1979. This would represent a $1-$6 bias or overestimate of benefits at optimum capacity calculated as $11-$13 per day of backpacking and $8-$10 per day of hiking. These results at optimum capacity lend support to the Forest Service 1980 Resources Planning Act Program unit day standard of $8-$12 benefit from wilderness recreation [Dwyer, 1978]. Krutilla and Fisher [1975] also suggested that benefits per recreation day at White Cloud Peaks Wilderness Area fell within this range.

Benefits from high density recreation activities such as camping and picnicking are less affected by congestion than are low density activities. Average benefits at optimum capacity were calculated as $6-$7 per day for camping and $7-$8 for picnicking. These were only $1-$2 lower than the $8-$9 average benefits reported by respondents engaged in these activities during the summer, 1979. The results at optimum capacity are somewhat higher than the Forest Service 1980 RPA Program unit day standard of $3 benefit per 12-hour visitor day for public developed recreation [Dwyer, 1978]. The higher values are associated with conditions at the study site where: (1) large population centers are nearby; (2) opportunities for developed recreation are scarce; and (3) existing opportunities are heavily used and congested. Potential users with lower benefits than the sample of users interviewed at the study sites may have selected themselves out [Freeman and Haveman, 1977].

This paper has demonstrated an empirical basis for estimating optimum capacity of low density and high density recreation resources, as conceived by Fisher and Krutilla [1972] nearly a decade ago. For hiking and backpacking in the Indian Peaks Wilderness Area, the optimum number of encounters per day was calculated as 43 persons, about one-third more than currently. This is equivalent to 12 parties of 3.6 persons, which is considerably higher than previous studies: Desolation Wilderness Area, approximately 7-8 parties [Shichter and Lucas, 1978]; Spanish Peaks Primitive Area, 5-6 parties [Cicchetti and Smith, 1973]; and a proposed standard for solitude of 2-3 parties [Stankey, 1973]. The higher capacities are associated with nearness to large population centers and scarcity of wilderness resources, thus users have learned to accept higher levels of congestion.

Table 3 shows the relationship between number of encounters and number of users of recreation resources.[6/] The optimum daily capacity of the Indian Peaks Wilderness Area was estimated as about 2,000 visitor days.[7/] This study suggests that in the near future, the number of users should be allowed to increase by one-third over 1979 levels. Some trail head parking lots may be expanded to accommodate this short run growth. In the long run, opportunities for wilderness experience should be provided elsewhere in the National Forest. More Wilderness Areas should be designated in the next few years so that use levels not exceed capacities providing the highest congestion adjusted benefits to wilderness users.

The optimum capacity of developed camping and picnicking facilities was nearly double the capacity of backcountry hiking and backpacking.

Table 3. Relationship Between Number of Encounters and Average Number of Users Per Day and Per Year, Indian Peaks Wilderness Area and Brainard Lake Developed Campground, Colorado, 1979.

Measures of Capacity	Base Case, 1979	Optimum Capacity	
		Without Agency Costs	With Agency Costs
Indian Peaks Wilderness Area			
Persons Encountered Per Day	32	50	43
Parties Encountered Per Day	9	14	12
Users Per Day, Visitor Days	1,467	2,290	1,969
Annual Users, Visitor Days	176,000	275,000	236,000
Brainard Lake Developed Campground, Sites	54	84	66
Persons Encountered Per Day	62	96	76
Parties Encountered Per Day	17	27	21
Users Per Day, Visitor Days	558	864	684
Annual Users, Visitor Days	67,000	104,000	82,000

The number of encounters at optimum capacity was calculated as 76 persons per day for camping and 80 for picnicking. This was about one-fourth more than the average number of persons encountered by respondents during the summer of 1979. So there is some excess capacity in the short run.

Table 3 shows the optimum daily capacity of developed camping at the Brainard Lake Recreation Area. To provide increased camping opportunities in the near future, the number of developed campsites should be increased to 66, one-fourth more than the 54 currently provided. This assumes that some self-contained recreation vehicles would continue to utilize overnight parking facilities adjacent to the campground. In the long run, opportunities for developed camping should be provided elsewhere in the National Forest. This study suggests that medium-sized rather than large campgrounds should be constructed. Medium-sized campgrounds, with approximately 66 campsites per campground, would provide the highest congestion adjusted benefits to developed campground users. This kind of consumer based information should be of considerable value to public land managers who are faced with serious congestion problems in administering the use of forest recreation lands.

FOOTNOTES

*This paper was presented at the Annual Conference, Western Agricultural Economics Association, Las Cruces, New Mexico, July 21, 1980. It benefited from comments by John Loomis, U.S. Fish and Wildlife Service, Fort Collins, Colorado, and by Robert C. Lucas, Wilderness Research Project Leader, Forest Service, USDA, Missoula, Montana. The work was funded in part by the Experiment Station, Colorado State University, Regional Project W-133, and by the Forest Service, USDA, Eisenhower Consortium Project No. 16-891-GR, a joint study with the Center for Research on Judgment and Policy, Institute of Behavioral Science, University of Colorado, Boulder.

1. This compares to annual use of the Rawah Wilderness Area which was one-sixth as great with 380 visitor days per mile of trail. The Rawah is located northwest of Rocky Mountain National Park about 130 miles from Denver, or more than twice the distance to Indian Peaks Wilderness Area.

2. Four benefit-congestion points were estimated by each respondent: (1) consumer surplus and number of persons encountered on the day of the interview; (2) change in consumer surplus with no other persons encountered; (3) change in consumer surplus with the most preferred number of persons encountered; and (4) zero consumer surplus with the maximum number of persons encountered before discontinuing the recreation activity.

3. Other variables which were associated with the level of benefits included income, education, residence, distance traveled, length of stay, substitution, and organization affiliation. For example, with each additional mile backpackers traveled to substitute areas, willingness to pay to backpack at Indian Peaks increased by 10.4 cents.

4. It may be of considerable practical importance to note a general rule: For linear congestion adjusted benefit functions, optimum capacity is equal to one-half the horizontal intercept, and optimum benefit per day is equal to one-half the vertical intercept. We have devoted considerable effort to devising simple questions to estimate these intercepts from direct surveys. Should this prove successful, it may become an easy task for resource managers to estimate carrying capacity and benefits per day for any number of recreation resources.

When first observed, this rule seemed to be a startling new discovery. It should not be so considered. The rule simply reflects the geometric fact that a linear marginal revenue curve intercepts the horizontal axis at one-half the intercept of the average revenue curve. With zero marginal costs, optimum occurs where marginal revenue is zero.

5. Observations of the physical conditions of the study area suggest evidence of additional marginal external costs of environmental degradation, which if quantified, would shift the point of optimum capacity further to the left, at least in the short run, to allow the most severely scarred landscape to recover from past abuse, most of which occurred prior to wilderness designation.

6. Insufficient resources and time were available to do a simulation analysis of the relationship between number of encounters and persons present in the study area. A simulation analysis of the Desolation Wilderness Area in California [Shichter and Lucas, 1978] reported that the number of parties present was 45 times parties encountered and was linear within the relevant range (contrast ski lift line congestion [Gilliam, 1980]). Although this relationship is expected to be site specific, the

Indian Peaks Wilderness was nearly identical to the Desolation Wilderness. The average number of visitor days at Indian Peaks Wilderness Area was 45.6 times person encountered [USDA, 1979]. The average visitor used approximately 5 miles of trail or 6.6 percent of the 76 miles of trail in the wilderness area. With an average of 97 visitor days and 32 encounters daily, there were approximately 3 visitor days for every encounter within each 5 miles of trail in 1979. Resource managers may establish carrying capacity standards for different recreation opportunity spectrum zones within the wilderness area. For example, opportunities for more use may be provided in the transition and semi-primitive zones than in the primitive and pristine zones where solitude may be the primary objective [Brown, Haas, and Manfredo, 1977].

For developed camping at the Brainard Lake Recreation Area, the average number of visitor days was nine times encounters.

7. With net benefits of $10 per visitor day, the annual benefits of the Indian Peaks Wilderness Area at capacity of 236,000 visitor days would be approximately $2.4 million, which is equivalent to an annual yield of $32.50 per acre. Capitalized at 7 percent interest, this would represent an investment value of $33.7 million, which is equivalent to $464 per acre.

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