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CONGESTION AT RECREATION SITES: AN ALTERNATIVE SOLUTION

Lee Huskey
Assistant Professor of Economics

Institute of Social and Economic Research
University of Alaska
Anchorage, Alaska

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The considerable increase in outdoor recreation participation which has occurred during the last thirty years is expected to continue throughout the century. The Outdoor Recreation Resources Review Commission estimated that by 2000 participation in outdoor recreation would be three times as great as in 1960 (ORRRC, 1962). This increase in participation could be viewed as an unquestioned increase in the welfare produced by our recreation resources, unless increases in the use of limited recreation resources leads to congestion which decreases the satisfaction and the welfare derived from these resources.

It may seem that, since approximately one-eighth of the land in the United States is available for outdoor recreation, there is enough land to accommodate any increase in recreation participation. The possibility of future congestion results, not because of a limited amount of land, but because of the location of this land; much recreation land is inaccessible to recreationists. The majority of our recreation land is in the west, while the majority of the population is in the east. This spatial imbalance also occurs on the state level. In most states, the population is urbanized, while the recreation sites are in rural areas. Most recreationists, because of time and money constraints, will spend the greatest portion of their recreation time at recreation sites close to where they live. Because of this, congestion could occur at recreation sites close to highly populated areas even though the total amount of recreation resources is adequate to serve the population.

The possibility of congestion at recreation sites and the impact of congestion on the welfare generated by those sites means that recreation planners and managers must respond in some way to reduce the effects of congestion. Many tools are available to limit the effects of increased use. The spatial imbalance of recreation resources may limit the use of traditional approaches, such as increased acreage in the park system. Park managers may respond to congestion by limiting the use of the park, either by closing the park at certain levels of use or by establishing user fees which reduce park use. The role of the economist should be to provide information which would allow the park manager to choose the most effective tool to use in dealing with congestion. In this paper, a recreation trip demand equation will be used to estimate the cost of congestion, which will be used to estimate the park user fee which would reduce the effects of congestion.

Congestion and Park Capacity

Parks with free access are like public goods in one sense: the consumption of park services by one consumer does not prevent another individual from consuming the services of the park. However, unlike pure public goods, one person's consumption is affected by another's. Bergstrom has defined the "crowded collective good" which describes the recreation facility. The utility a consumer receives from a crowded collective good is affected, not only by the number of times he uses the good, but also by the number of times others use it (Bergstrom, 1971). Congestion of an outdoor recreation facility is the effect of others' use on the services a recreation area provides.

A recreation site is not congested simply because a certain number of recreationists use the park; the effect of use on the services provided by the park depends on the size of the park, the facilities available, and the activities for which the park is used. The level of use at which a park becomes congested can be defined as its optimal capacity. Stankey suggested that congestion and the optimal capacity are not totally physical problems, but depend on the sensitivity of recreationists to increased use by others (Stankey, 1972). Because of this, optimal capacity will differ at each park.

Optimal capacity is affected by the level of use, the type of use, user behavior, user perception of and expectation of quality, and the alternatives available to recreationists. Use levels affect the participants in different activities differently; the same number of participants will affect a recreationist's utility differently if he is hunting rather than swimming. Activities in which solitude is an important characteristic will experience congestion at a smaller number of users. If the predominant types of uses change to those which are more sensitive to level of use, a park system which was previously adequate will no longer be adequate. In areas where there is relatively high demand for recreation and parks are used a great deal, recreationists will expect a great number of people, and their satisfaction from a crowded park will not be decreased by as much as it would if they did not expect crowded parks.

Congestion Costs

The overall effects of congestion at an outdoor recreation site can best be described in terms of the reduced satisfaction derived from the recreation experience. Haveman described the congestion costs at a fixed facility as the utility reductions caused, but not borne, by the marginal user (Haveman, 1973). The effect of the marginal recreationist can be seen by considering a society with a fixed amount of park at a given location where consumers can spend their income on bread, Z_i, or on recreation, A_i. Each consumer's utility depends on the amount of bread he consumes, Z_i, and the amount of recreation activity he consumes, A_i. The recreationist produces A_i with recreation trips to a park and the characteristics of the recreation site,

1) $$A_i = A_i \left(R_i, \sum_j R_j, C\right)$$

where

R_i is the number of trips made to site i by the recreationist

C describes the recreation site's facility and environmental characteristics

$\sum_j R_j$ are the total visits to the park by all other recreationists.

All of the park's characteristics are fixed, except for $\sum_j R_j$, the total number of visits made to the park by other recreationists. The consumer's utility is,

$$2)\quad U_i = U_i(Z_i, A_i) = U_i^*(Z_i, R_i, \sum_j R_j) .$$

The park is a crowded collective good, since the utility a consumer derives depends on the number of visits he makes to it and the number of visits others make to it. More can be determined about congestion and optimal park capacity by examining the allocation of bread and park visits which maximizes social welfare, given by,

$$3)\quad W = \sum_i \lambda_i U_i^*(Z_i, R_i, \sum_j R_j) .$$

Assume the social weights, λ_i, are determined by some omniscient park ranger and W is maximized subject to society's resource constraint,

$$4)\quad G = \sum_i Z_i + \sum_i P_i^* R_i .$$

where G is society's fixed resources, P_i^* is each consumer's transport cost to the park, and the price of bread is the numeraire. Social welfare is maximized when

$$5)\quad W = \sum_i \lambda_i U_i^*(Z_i, R_i, \sum_j R_j) + \theta(G - \sum_i Z_i - \sum_i P_i^* R_i)$$

is maximized, or when for all i = 1.....m,

$$6)\quad \partial W/\partial Z_i = \lambda_i \partial U_i^*/\partial Z_i - \theta = 0$$

$$7)\quad \partial W/\partial R_i = \lambda_i \partial U_i^*/\partial R_i + \sum_{j\neq i} \lambda_j \frac{\partial U_j^*}{\partial \Sigma R_j} \frac{\partial \Sigma R_j}{\partial R_i} - \theta P_i^* = 0$$

It can be seen, by examining 7), that a park visit by recreationist i affects social welfare in two ways. First, it increases social welfare by the marginal utility of the visit for recreationist i. Secondly, the park visit by i will decrease social welfare because of the effect of i's visit on the utility of all other recreationists. This second effect,

$$\sum_{j\neq i} \lambda_j \frac{\partial U_j^*}{\partial \Sigma R_j} \frac{\partial \Sigma R_j}{\partial R_i}$$

is the congestion cost of i's visit; the decrease in utility suffered by others because of increased congestion.

Social welfare will be maximized when the marginal benefits from recreationist i's visit just equal the marginal social cost of the visit; this condition is shown in Equation 8).

$$8)\quad \frac{\partial U_i^*/\partial R_i}{\partial U_i^*/\partial Z_i} = P_i^* + \left(-\sum_{j\neq i} \frac{\partial U_j^*/\partial R_i}{\partial U_j^*/\partial Z_j}\right)$$

Optimal capacity is that level of total use at which the increase in total benefits just equals the marginal social cost of the increase. With open park access, use will exceed the optimum capacity. Recreationists will equate their MRS between recreation trips and bread to their private marginal cost, P_i^*; because $-\sum_{j \neq i} \frac{\partial U_j^*/\partial R_i}{\partial U_j^*/\partial Z_j}$ is greater than zero, the number of trips taken with open access will be greater than the socially optimum number.

This discussion suggests two solutions to the congestion problem. First, optimal capacity could be determined and park use limited to that number of users. The second option would be to find the toll from Equation 8) which could be used to equate private and social cost. However, both the toll and optimal capacity could only be found if the social weights and the parameters of the recreationists' utility functions are known. To provide a useful park management tool, the congestion toll or optimal capacity must be empirically derived.

Krutilla and Fischer suggested that an optimal level of congestion for a recreation area could be determined by reference to an aggregate willingness-to-pay function for the park. Willingness to pay is the inverse of the demand function and measures the maximum amount a consumer would pay for a given number of visits with given conditions. The effect of a visit by recreationist i on both his willingness-to-pay function and the willingness-to-pay functions of all other recreationists could be estimated, and Krutilla and Fischer show in a simple graphical model how the optimal capacity can be found (Krutilla and Fischer, 1972).

Cicchetti and Smith use an estimated willingness-to-pay function to determine the optimal capacity of a wilderness recreation area. The estimated equation relates two measures of congestion, the number of trail encounters and the number of camp encounters, to a recreationist's willingness to pay for the recreation trip. They determine encounter-use relationships which show the expected number of trail and camp encounters for a given level of use of the recreation area. By placing these relations in the willingness-to-pay function and maximizing the aggregate willingness to pay with respect to the number of users, Cicchetti and Smith find the optimal level of daily use (Cicchetti and Smith, 1973).

Congestion Toll

Once optimal capacity is determined, the park would be closed at that level of use. This policy will not guarantee that benefits derived from the park will be maximized. The increase in total benefits derived from a visit will depend on the number of previous trips made by the visitor. A visitor who has made fewer trips will value this visit more and there is no guarantee that when total use is considered, the visitors allowed in the park will be those receiving the greatest benefit from the trip. Controlling congestion through the use of a congestion toll eliminates this problem. A congestion toll is taken into consideration when a consumer makes his marginal decision, so an equilibrium which maximizes total benefits can be obtained through the use of a congestion toll.

The cost of congestion is a welfare cost; it is equal to the loss in total utility which results from the increase in use. Consumer surplus is a measure of welfare, and reductions in recreationists' consumer surplus with increased park use measure the cost of congestion. Although the concept of consumer surplus always has meaning, an empirically observable measure of consumer surplus is needed. Consumer surplus can be measured from a demand curve only when it is adjusted for real income changes, an income compensated demand curve. In order to measure the welfare cost of congestion from a demand curve for recreation trips, it must be shown to be income compensated.

By assuming the consumer takes the location of recreation sites into account when he makes his residential location decision, it can be shown that the demand for recreation trips is income compensated. Alonso defines a residential bid price curve as "The set of prices for land the individual could pay at various distances while deriving constant satisfaction." (Alonso, 1970, p. 59) Alonso assumes a city center to which all commuter trips are made; as consumers move from the city center, commuting costs increase. The bid price for land will decrease with increases in distance from the center, since income decreases by the increase in commuting cost. If rents vary as the bid price curve, the consumer is indifferent between residential locations. Every consumer will try to reach the highest possible level of utility; as long as one consumer is at a higher level of utility, the others will bid up the rent for that location. In equilibrium, everyone with like tastes and incomes will obtain the same level of utility with rents varying across locations to compensate for differences in commuting costs. Alonso considers only a single, centered city and changes in location will affect only the cost of commuting trips. Once it is assumed that the consumer purchases another good, recreation, at a fixed location, changes in residential location will affect the cost of both commuting trips and trips to purchase recreation. Rents should vary to compensate for changes in both these costs. A demand curve for the recreation trips estimated across individuals with like tastes by observing the price paid and quantity purchased at each location would be an income compensated demand curve.

The reduction in consumer surplus of all recreationists at a park which results from increased use can be shown to equal that toll which, if charged, would result in maximum social benefits. Total social welfare is assumed equal to the sum of individual consumer surpluses. Social welfare equals,

$$9) \quad \sum_i B_i = \sum_i \int_{R_i}^{o} f_i\,(t, \sum_j R_j)\,dt - \sum_i P_i^* R_i$$

where B_i is the consumer surplus and f_i ( ) is the inverse of the demand curve, or willingness-to-pay function. Social welfare will be maximized when,

$$10) \quad \frac{\partial \Sigma B_i}{\partial R_i} = \int_{R_i}^{o} \frac{\partial f_i}{\partial R_i}\,dt + \sum_{j \neq i} \left[\frac{\partial R_j}{\partial \Sigma R_j} f_i(R_j, \Sigma R_j) + \int_{R_j}^{o} \frac{\partial f_j}{\partial \Sigma R_j}\,dt - P_j^* \frac{\partial R_j}{\partial \Sigma R_j}\right] - P_i^* = 0$$

or

$$11) \quad f_i(R_i, \Sigma R_j) = P_i^* - \sum_{j \neq i} \int_{R_j}^{o} \frac{\partial f_j}{\partial \Sigma R_j}\,dt$$

The optimal toll will be that toll which allows visits until the marginal gain from the visit equals the marginal social cost of the visit, travel costs plus congestion costs. By assuming that the congestion cost to each consumer is small and does not vary much between consumers, the optimal toll can be approximated by

$$12)\quad T = -\sum_i \int_{R_i}^{o} \frac{\partial f_i}{\partial \Sigma R}\, dt$$

Estimation of Congestion Tolls for Missouri State Parks

The congestion toll, T, found in 12) can be approximated from a recreation trip demand equation similar to those estimated in the Clawson tradition. A series of such demand equations were estimated for recreation trips to parks in the Missouri State Park System using information from a 1971 park-user survey taken in Missouri State Parks. These results were used to approximate the appropriate congestion toll for five Missouri parks.

The following model was assumed to describe recreation decisions. The arguments of the recreationist's utility function were assumed to be activity days spent in each type of outdoor recreation activity. Consumers act as producers; producing standard activity days of each recreation activity using time, goods, and recreation trips to various parks.

The demand for trips to a recreation site then becomes a derived demand for use in the production of a recreation activity. The standard activity days of each activity are defined to account for quality differences in producing the activity. Quality differences can result from using more goods with the same amount of time in the production of an activity, or because different parks affect the production of activities differently. To account for these park differences, parks were assumed to be described by the characteristics they possess, and differences in these characteristics cause the productivity of time in a given activity to differ at each park. The production aspects of consumption and the assumption that goods can be described as bundles of characteristics are concepts from the new consumer theories.

The following activity-aggregated demand equation was used to estimate congestion costs. (A full description is in Appendix A.)

$$13)\quad R_i = P_i^{-.346} \; \Sigma R^{-.182} \; A$$

where

R_i is the number of trips taken by the recreationist to park i

P_i is the full cost of a trip to park i

ΣR is the total weekend use of park i

A is the combined effect of all other variables.

By solving 13) for P_i, an equation for f_i, the willingness to pay, is derived,

$$14)\quad f_i = P_i = \left[\frac{\Sigma R^{-.182} \; A}{R_i} \right]^{-1/.346}$$

The cost of congestion can be found by solving for T in Equation 12); this result is,

$$15)\quad T = -\sum_i \int_{R_i}^{o} \frac{\partial f_i}{\partial \Sigma R}\, dt = \sum_i (.28\ A^{2.89}) \;/\; (R_i^{1.89}\ \Sigma R^{1.53})$$

The quantity inside the summation sign is the cost to an individual recreationist. This cost is smaller, the larger the number of people already using the park. This illustrates the subjective nature of congestion, since one more recreationist will have little effect on satisfaction at an already crowded park. Those park characteristics which increase the productivity of recreation time will also increase the cost of congestion. Recreationists will feel a greater loss in satisfaction from congestion, the better the park. The alternatives available to the recreationist will also affect their perception of congestion and the effect of congestion on their satisfaction. The better the alternatives available to the recreationist, the lower will be the cost of congestion. Equation 15) can be used to find the cost of congestion at existing Missouri parks.

Five Missouri State Parks were chosen to illustrate the use of this equation: Johnson's Shut Ins, Meramec, Pomme de Terre, Babler, and Graham. These parks were chosen because they represent differences in characteristics, use, and market area. The parks and their characteristics are shown in Table 1.

Table 1

PARK CHARACTERISTICS

	Johnson's Shut Ins	Meramec	Pomme de Terre	Babler	Graham
Total Weekend Visits	15,492	29,187	8,978	13,327	1,070
Park Acres	2,460	7,053	365	2,400	251
Wetland Acres	0	0	0	0	0
Water Acres	18	100	7,800	0	0
Acres in High Density Recreation	0	0	0	0	0
Acres of outstanding Natural Features	40	0	0	0	0
Playfield Acres	0	1	0	28	4
Swimming Beach Acres	1	1	2	0	0
Sq. Ft. of Swimming Pool	0	0	0	0	0
Picnic Tables	59	90	4	250	0
Boat Access Sites	0	1	2	0	0
Camp Sites	150	260	27	0	52
Parking Acres	2	3	8	10	0
Road Miles	1	15	2	14	0
Foot Trail Miles	4	12	1	3	2
Marina Slips	0	0	48	10	0
Dominant Feature Woodlands	1	1	1	1	1
Dominant Feature					
flat terrain	0	0	0	0	1
hilly terrain	1	1	1	0	0
rolling terrain	0	0	0	1	0
Reservoir	0	0	1	0	0
Rivers, Streams, Rapids, Springs	1	1	0	0	0
Trout	0	0	0	0	0

Congestion costs were found by summing $\int_{R_i}^{0} \frac{\partial f_i}{\partial \Sigma R}\, dt$ over the total number of weekend visitors. Total weekend visits were distributed between the regions using the distribution found for total trips in the Missouri Park User Survey. The congestion cost of one more recreationist at each park is shown in Table 2.

Table 2

CONGESTION COST

	Cost of Congestion	Percent Reduction in Visits	"Optimal" Capacity
Johnson's Shut Ins	\$2.83	13	13,978
Meramec	1.15	10	26,268
Graham	.77	8	784
Pomme de Terre	1.73	5	8,592
Babler	.94	9	11,128

The other columns of Table 2 show the reduction in total visits which would result from imposing the congestion cost as a toll and the resulting "optimal" weekend capacity. These are just approximations to the correct toll. Since price adjustments affect the price of substitutes, the real solution would be a simultaneous solution. Our model did not allow for this, since an invariant distance was used as a proxy for the price of the substitute parks.

Congestion control is often imposed through the use of the same toll at all parks within the system. The above analysis shows that a uniform toll would not have the desired results, since the toll may be higher than necessary at some parks and not high enough at others. This would have the effect of reducing the use below optimal capacity in some parks and not limiting use enough in other parks.

The second method used for controlling capacity in some park systems is to close the park when use reaches a certain level. If the level is set based entirely on park characteristics, this method will also fail to reach an optimal capacity. Two parks, Johnson's Shut Ins and Babler, have similar capacity-type characteristics, but different optimal capacities. Setting use based on characteristics alone, ignores the effect of the available recreation alternatives on recreationist's determination of congestion. Even if the correct use level was set, there is still no guarantee that this method would maximize the benefits available from the park. Since recreationists, depending on the number of trips they have taken to the park, will value their marginal trip differently, there is no guarantee that the recreationists allowed into the park would be those receiving the highest benefits from the trip.

Conclusion and Future Research

It has been shown in this paper that the cost of congestion can be approximated for recreation trip demand equations estimated in the traditional Clawson method. Previous studies (Cicchetti and Smith, McConnell) have measured congestion costs by asking recreationists their willingness to pay for various recreation experiences. Expansion of the Clawson approach to include observations from many parks, where each park is described by its characteristics, allows the cost of congestion to be estimated from the observed behavior of individuals. The congestion costs derived in this manner provide an approximation to the toll necessary to reduce the impact of aggregate use. Most importantly, this study shows that two solutions to the congestion problem, standard fees and closure, are not the optimal solutions for the congestion problem.

Before the approach suggested in this paper can be applied as a management tool, research is needed in two areas. First, congestion needs to be defined in terms of the relation between use and facilities. In this paper, the average weekend use was used to describe congestion. An alternate approach would be to describe congestion using a series of per capita facility measures, such as people per camp site. Secondly, some account needs to be taken of the effect of activity preferences on congestion costs. It has been shown in other research (Huskey, 1977) that once preference for park characteristics are accounted for, it becomes necessary to account for the activity in which the recreationist participates. Since use by others (not only their numbers but what they do) is hypothesized to affect recreationists differently by activity, account needs to be made of this effect.

Appendix A

RECREATION TRIP DEMAND EQUATION

Variables	Coefficients[1]
Constant	2.675
Full Price	- .346 (741.293)**
County Median Income	.010 (.228)
Day Visits	- .182 (23.537)**
Land Acres	- .200 (14.283)**
Wetland Acres	- .055 (1.395)
Water Acres	- .033 (8.198)**
High Density Acres	- .032 (1.878)
Natural Environment	.005 (.016)
Playfields	.115 (6.019)*
Beach	.397 (112.908)**
Pool	- .002 (.007)
Picnic Tables	.216 (87.383)**
Boat Access	- .070 (17.178)**
Camping Sites	.099 (28.668)**
Parking Acres	- .224 (12.287)**
Road Miles	.148 (7.999)**
Foot Trail Miles	- .076 (3.980)*
Marina Slips (number)	.067 (10.346)**
Substitute Factor #1	- .075 (22.093)**
Substitute Factor #2	.034 (2.310)
Substitute Factor #3	.029 (3.331)
Trout Fishing Available (dummy)	.452 (31.212)**
Woodland Dominant Feature (dummy)	.474 (18.156)**
Flatland Dominant Terrain (dummy)	.469 (15.918)**
Hilly Dominant Terrain (dummy)	.084 (3.233)
Reservoir Present (dummy)	.837 (99.207)**
Presence of Flowing Water (dummy)	.245 (10.803)**

n	4387	$\bar{R}^2$	.323
R^2	.327	F	.7849

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[1]F statistics in parentheses

**Significant at .99 level

*Significant at .95 level

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