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Carrying Capacity, Values, and the Satisfaction Model: A Reply to Greist¹

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ABSTRACT: *David Greist contends that ratio measures of satisfaction are necessary in order to establish carrying capacity on the basis of a model which aims to maximize aggregate satisfaction. While this measurement problem may lead to invalid estimates of carrying capacity in the context of the satisfaction model, it does not in the study criticized because satisfaction does not vary with use level. While satisfaction scores should not be treated as ratio, they may safely be treated as interval so that curves relating satisfaction to density (and other variables) can be estimated. Such estimates may answer questions posed by managers.*

Other conceptual problems with the satisfaction model are noted, which are more serious than the measurement issue noted by Greist. Carrying capacity cannot be established by data from sociological or biological studies alone; value judgments about management goals are also necessary. The lottery procedure proposed by Greist is not a device for establishing carrying capacity but, rather, a creative way to allocate use once capacity has been established.

KEYWORDS: *Carrying capacity, social carrying capacity, satisfaction, measurement, econometric models, values.*

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The wilderness carrying capacity model criticized by David Greist (1976) stems from economic theory (Alldredge 1972; Fisher and Krutilla 1972), and a number of studies have been based upon it, either implicitly or explicitly (Boster 1972; Cicchetti and Smith 1973; Fisher and Krutilla 1972; Godfrey and Peckfelder 1972; Held et al. 1969; LaPage 1963; Lucas 1966; Stankey 1973; and Willard 1971). The primary contention of the model is that visitor satisfaction can be used to determine use limits.

Greist argues that the model is invalid because satisfaction scores are ordinal, not interval, and therefore cannot properly be the object of mathematical manipulation. The present paper will specify more precisely the statistical nature of this problem in the hope that useful aspects of ordinal measures will not be overlooked. We will also present data to show that the general problem does not apply to the specific study Greist chooses to criticize. More serious problems with the satisfaction model will then be discussed, along with Greist's proposed solution.

Ordinal, Interval and Ratio

What Greist points out is that satisfaction is not a ratio variable, with a zero point and negative values which are meaningful. It is unlike income, for example, where zero means "broke" and negative values mean debts, or temperature measured on a Kelvin scale. As a result, the policy implications of an econometric satisfaction model vary with the arbitrary metric chosen.² This criticism, however, should not be taken as a blanket indictment of the use of ordinal satisfaction measures. It is only their use in the "satisfaction" model which is inappropriate; there are other applications where satisfaction scores are valid and useful.

There is much to be gained from using "interval" techniques on ordinal data. Borgatta (1963) has argued that ordinal measures can be treated as interval with no serious violation of assumptions, and Labovitz (1964) has shown that little error is associated with the use of radically different numerical intervals as long as the scale's ordinal character is preserved. Ordinal data on attitudes are regularly treated as interval in the research published in the major sociological and psychological journals (see recent issues of the *American Sociological Review* and *Journal of Personality and Social Psychology*).

As an example, the analysis of ordinal satisfaction scores as interval can be useful in describing the relationship between density and satisfaction. The correlation between satisfaction and density can be compared across studies,

² We would argue that satisfaction is not susceptible to ratio measurement, since it appears impossible to arrive at a valid zero point of no satisfaction/no dissatisfaction. In any case, no studies of which we are aware have utilized a methodology which would approach a ratio measure of satisfaction.

Without a meaningful zero point, the choice of a particular score value corresponding to levels of satisfaction involves an arbitrary constant which determines the distance of any score from zero. This is true for any interval scale, of course, and Greist correctly shows that a "shift of the axis" by two units can cause major changes in the implications drawn from the econometric satisfaction model, as would an arbitrary assignment of different values to the points on an ordinal scale.

even when different metrics are used, since correlations are expressed in terms of standard scores. In addition, this kind of analysis would show the incremental impact of density on satisfaction, so a manager could answer the question, "If I double the number of people, does satisfaction go up or down and by how much?"

Greist himself treats ordinal data as interval in calculating mean satisfaction in Table 1. This is inconsistent with his earlier statement that ". . . satisfaction scores may not be added, subtracted, multiplied or divided."³ He also transforms the satisfaction scores in this table (a linear transformation where $x' = x + 2$), a manipulation appropriate for interval but not ordinal data (Stevens 1946, 1951).

Additional Problems with the "Satisfaction" Model

It is not possible to establish carrying capacity on the basis of the satisfaction model when there are no mean differences in satisfaction at different use levels. This is the case in the particular research Greist has chosen to criticize (Haas and Nelsen 1974). Among those who floated the Colorado River in the Grand Canyon, satisfaction is the same at different density levels (Tables 1 and 2). Regardless of the metric selected, then, a satisfaction-based carrying capacity cannot be identified within the variation of current use levels, since satisfaction is not correlated with use. While the satisfaction model will not be misleading under these circumstances, it will be no help either.

It can be argued that use levels have not been high enough to show a negative effect on satisfaction. But we think the model itself is unrealistic. The simplistic contention that carrying capacity can be determined on the basis

TABLE 1
SATISFACTION AT DIFFERENT USE LEVELS IN THE GRAND CANYON

Use level People per week leaving Lee's Ferry	Mean ^a Satisfaction	N
80-400	4.138 ^b	135
401-700	4.058	334
701-950	4.087	515
overall	4.084	984

^a Satisfaction was scored on a 5-point scale where perfect = 5; excellent, only minor problems = 4; very good, but could have been better = 3; good, but I wish a number of things could have been different = 2; fair, it just didn't work out very well = 1.

^b If these are rounded to one significant digit they become exactly equal at 4.1.

³ Lord (1953) in his humorous discussion of football numbers points out that the numbers themselves, even on football jerseys, may be manipulated quantitatively. There is nothing inherent in satisfaction scores that technically prevents the mathematical calculations to which blanket statements such as Greist's seem to refer.

TABLE 2
ANALYSIS OF VARIANCE TABLE FOR SATISFACTION OF GRAND CANYON
VISITORS UNDER DIFFERENT USE LEVELS

Source	Sum of Squares	Degrees of Freedom	Mean Squares	F	P
Between	.62	2	.31	.51	.60
Within	601.77	981	.61		
Total	602.40	983			

of satisfaction alone is, in our opinion, a more serious problem than the measurement issue Greist discusses. Specifically, the satisfaction model has a number of additional weaknesses.

First, recreation behaviors are largely voluntary and therefore self-selected. As a result, users choose activities which are in accord with their normative idea of a "good time." They will thus tend to show high satisfaction levels, as they do in the Grand Canyon (Shelby and Nielsen 1976). That people have voluntarily selected the activity and made a substantial investment of money and vacation time might also lead to a positive evaluation of the experience, as dissonance theory suggests.

Second, again because recreation activities are self-selected and voluntary, those dissatisfied with crowding may move on to less crowded areas, and those with norms more tolerant of higher densities will "displace" them.

Third, increasing densities may cause a change in the definition of the experience. Increased use alters the character of the experience from, for example, zero contact wilderness to moderate contact semi-wilderness. As this happens, people probably change their normative definition of appropriate contact levels. Changes in the experience, then, cause individual normative changes, and satisfaction remains high. This subtle "product shift" would again mean that satisfaction continues to climb as use increases (Stankey, personal communication 1976).

Fourth, satisfaction is related to a number of other factors, including expectations, personal benefits, social interaction, and the wilderness character of the experience (Shelby and Nielsen 1975a, 1975b, 1976). In this multivariate world, the simple bivariate impact of density on satisfaction, when it exists, is likely to be small and possibly obscured by other variables. This means that if a resource is being managed for satisfaction there are variables other than density which should receive management's attention. For example, Stankey (1973) found wilderness visitors reporting that seeing litter was more disturbing than seeing too many people.

A management policy aimed at maximizing aggregate satisfaction leads to some interesting possibilities. For example, a Grand Canyon Parkway along the Colorado River would certainly increase the number of satisfied Canyon visitors. Dissatisfied seekers of wilderness might go elsewhere, the influx of people more tolerant of crowding would cause contact norms to change, and

the new "product" (the Grand Canyon by automobile) would be defined in terms of higher contact rates.

Carrying Capacity and Value Judgements

The reason that a parkway sounds so out of place is that it would dramatically change the character of the "Grand Canyon experience." Visitors and managers think of the Canyon in terms of undeveloped wild country and the wilderness experience (Shelby and Nielsen 1976; Boster 1972). A highway is antithetical to that experience. The satisfaction model is beguiling in its apparent "objectivity," but it is based on the assumption (or value) that aggregate satisfaction should be maximized. When we see that maximizing satisfaction may lead to a Grand Canyon Parkway, the value judgement becomes more obvious.

Likewise, biological studies can establish carrying capacities only on the basis of a value premise. For example, a carrying capacity for predators can be established under management objectives which value a diversified eco-system, with no species eliminating another. With different values, such as "no lambs or calves ought to be eaten by wolves," a different carrying capacity will be selected. It often *appears* that expert judgement can establish biological or physical capacity, but this is so only because the value premise is more likely to be shared than it is for sociological carrying capacity (where there are many competing interests).

Any carrying capacity, then, is based on values. This is why the political process, as Greist notes, must always be involved in some fashion. Sociological research can best serve resource managers by specifying as clearly as possible the consequences, in terms of the character of the experience, of different management alternatives. Managers can then choose the experience and corresponding use level which best fits the values in question.

The final report of the study Haas and Nielsen proposed does specify the consequences of different use levels. Although much of the proposal is couched in terms of satisfaction, the study did far more than measure satisfaction and correlate it with density, as would be required by the econometric model. The specifications in the call for proposals (Kilgore 1973) were followed, resulting in measures of (1) visitor contacts on the river, at attraction sites, and in camping areas; (2) visitor perceptions of crowding; and (3) visitor satisfaction. A certain number of trips leaving per week is thus associated with an average of 10 minutes of river contact per day and a low probability of encounters at visitor attractions (e.g., Redwall Cavern), while a different use level results in 2-3 hours of river contact and a high probability of meeting 40-60 people at attraction sites. These data also allowed a test of the assumption that density influences current visitors' satisfaction.

Selecting any use level alternative involves values. Managers will have to decide what they are trying to provide in the Canyon (either wilderness or "something else," such as an excursion experience or a parkway). This decision should be made on the basis of input from the political process, the legal and ethical mandates of the Park Service, and managerial expertise. An "appropriate" experience in terms of contact levels can then be selected, with a corresponding

use level in terms of trips per week. Multiplying the weekly level by the number of weeks in the season will give the capacity figure.

Greist's Lottery Technique

Greist's comment concludes by proposing a voluntary lottery as means of solving the ". . . problem of measuring carrying capacity." This is a creative management tool which allows visitors to choose the density level they find most acceptable. This, however, is not so much a solution to the carrying capacity problem as a way of allocating use once limits have been set. To use Greist's lottery, one must divide the area into zones (temporal or spatial) having ". . . various use intensity limits." In other words, it is necessary to know the carrying capacity of different zones before using the technique. In addition, the demand for different experiences must be known; this in itself is a notorious problem in outdoor recreation (National Academy of Science 1975). A lottery for different density zones, then, can be used only after selecting carrying capacities. Consequently, Greist's solution will not help the manager with his most difficult problem—selecting a use figure.

Conclusion

Ratio manipulations of ordinal data represent a general problem in the satisfaction model. But the lack of mean differences in satisfaction at different use levels neutralizes this particular criticism of the study proposed by Haas and Nielsen. In addition, ordinal satisfaction measures may usefully be treated as interval for some purposes. Beyond these statistical issues, there are other serious problems with the satisfaction model which make it nearly unworkable for management. Research can be most useful when it specifies, in terms of the character of the experience, the consequences of different alternatives. Greist's suggestion of a lottery for different density zones is creative, but the technique can only be used after determining capacities.

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