

EVALUATING MULTIPLE DIMENSIONS OF VISITORS' TRADEOFFS BETWEEN ACCESS AND CROWDING AT ARCHES NATIONAL PARK USING INDIFFERENCE CURVE ANALYSIS*

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*The authors would like to acknowledge the assistance William A. Valliere, Benjamin Wang, Kathleen Liang, and the staff of Arches National Park provided us in conducting this research.

Abstract: Tradeoffs are an inherent part of many of the decisions faced by outdoor recreation managers. For example, decisions concerning the social carrying capacity of popular attraction sites involve tradeoffs between limiting visitor use to ensure a high quality experience and allowing high levels of visitor use to ensure that large numbers of visitors retain access to park and outdoor recreation resources. This study uses indifference curve analysis to evaluate the tradeoffs visitors are willing to make between access and visitor use levels at Delicate Arch, Arches National Park. Differences in the evaluation of tradeoffs between access and crowding are examined for first time visitors versus repeat visitors; local visitors versus non-local visitors; and across questionnaire formats. The results of the indifference curve analysis allow Arches National Park managers to make informed evaluations of alternative management options for visitor use at Delicate Arch.

Introduction

Tradeoffs are an inherent part of many of the decisions faced by outdoor recreation managers. One of the more challenging and pervasive issues outdoor recreation managers face concerns the appropriate level of use, or social carrying capacity, of popular attraction sites. Decisions about appropriate levels of visitor use involve inherent tradeoffs between limiting visitor use to ensure a high quality visitor experience and allowing high levels of visitor use to ensure that large numbers of visitors retain access to park and outdoor recreation resources (Manning, Valliere, & Jacobi 1997).

A number of frameworks have been developed to provide park and outdoor recreation managers with a basis for making decisions about the social carrying capacity of outdoor recreation settings. These frameworks include Visitor Experience and Resource Protection (VERP) (National Park Service 1997), Limits of Acceptable Change (LAC) (Stankey et al. 1985), and Visitor Impact Management (VIM) (Graefe, Kuss, & Vaske 1990).

Common to these approaches is the formulation of indicators and standards of quality. Indicators of quality are measurable, manageable variables that serve as quantifiable proxies for management objectives. Standards of quality define the minimum acceptable condition of indicator variables (Manning, 1999).

While a number of studies have been conducted to define the social carrying capacity of various outdoor recreation settings, there have been few attempts to explicitly consider the inherent tradeoffs between quality and access. There is evidence that social carrying capacity may be significantly affected when management implications are explicitly considered by study respondents (Manning, Valliere, Wang, & Jacobi 1999). That is, visitors may be more tolerant of higher levels of visitor use when they are aware that their standards of quality may result in limitation or regulation of visitor access to attractions and facilities.

This paper describes techniques used to apply indifference curve analysis to evaluate the tradeoffs associated with the social carrying capacity of Delicate Arch, Arches National Park. Specifically, this study examines the tradeoffs visitors are willing to make between the number of visitors at one time at Delicate Arch and the percentage chance of receiving a hypothetical permit to hike to Delicate Arch.

Indifference Curve Theory

Indifference curve theory, developed in economics, provides a model representing the tradeoff decisions an individual makes in allocating a fixed level of income between two consumer goods (Nicholson 1995). There are two primary components to the indifference curve model, the individual's indifference curves and his/her budget constraint. A single indifference curve represents all possible combinations of two goods (e.g. A and B) that provide the individual with the same level of utility (Pindyck & Rubinfeld 1995). The curves labeled IC₁ and IC₂ in Figure 1 are examples of indifference curves. The budget constraint represents the possible combinations of goods A and B the individual can purchase, assuming the individual spends all of his/her income (Pindyck & Rubinfeld 1995). For example, the budget constraint labeled BC in Figure 1 represents all possible combinations of the two consumer goods A and B, for a fixed income level.

According to indifference curve theory, the optimal combination of goods A and B for a given level of income is located where the budget constraint is tangent to one of the individual's indifference curves (Nicholson 1995). This represents the highest level of utility the individual can achieve from the consumption of goods A and B, given a fixed level of income. In Figure 1, the optimal combination of goods A and B is represented by point X. A more complete discussion of indifference curve theory is presented in Lawson and Manning (2000).

Methods

Indifference curve analysis was applied to the evaluation of social carrying capacity at Delicate Arch by substituting

lack of crowding at Delicate Arch and accessibility to Delicate Arch for consumer goods (i.e., goods A and B in Figure 1). Specifically, the number of people at Delicate Arch was substituted for good B along the y-axis, and the percent chance of receiving a hypothetical permit to hike to Delicate Arch was substituted for good A along the x-axis.

Indifference Curves

Indifference curves were estimated following a procedure adapted from MacCrimmon and Toda (1969). In this procedure, respondents are presented with a series of pairs of crowding and accessibility conditions. The first component of each pair of conditions is a fixed reference condition, against which respondents evaluate an alternative condition. Respondents are asked to indicate their preference within each pair of conditions they evaluate. For example, respondents were asked to express their preference between a first set of conditions – having a 100 percent chance of receiving a permit to hike to Delicate Arch and seeing 108 people at Delicate Arch – and a second set of conditions – having a 50 percent chance of receiving a permit to hike to Delicate Arch and seeing 36 people at the Arch. See Lawson and Manning (2000) for a graphical description of the methods used to estimate indifference curves.

Regression analysis was used to estimate an indifference curve for each respondent based on the data points derived from his/her evaluation of a series of access and crowding conditions at Delicate Arch. For each respondent, a hyperbolic, semi-log, and quadratic curve was fit to the data points. The functional form for each individual indifference curve was selected based on the goodness of fit (R-square) of the regression equation, and the explanatory significance of the access variable (chance of receiving a permit) on the number of people at Delicate Arch.

Budget Constraint

A simulation model of visitor use at Arches National Park was used to estimate points along the budget constraint representing the possible combinations of visitor use levels and accessibility at Delicate Arch. Computer simulation models have been successfully applied to a variety of park and outdoor recreation areas (e.g., Potter & Manning 1984; Wang & Manning 1999; Schechter & Lucas 1978). Additional information about the inputs used to develop the simulation model can be found in Lawson and Manning (2000).

The simulation model was run at three levels of daily visitor use. The first level of use represented the Park's average daily use in the summer, which was used as a proxy for a 100 percent chance of receiving a permit to hike to Delicate Arch. The second level of use was 50 percent of the Park's average daily use, which was used as a proxy for a 50 percent chance of receiving a permit to hike to Delicate Arch. The third level of use was 25 percent of the Park's average daily use, which was used as a proxy for a 25 percent chance of receiving a permit to hike to Delicate Arch.

For each use level, the model was run 12 times to account for variability in model parameters. The outputs from the simulation model runs were used to estimate the maximum number of people seen at Delicate Arch at one time by at least one visitor per day, for each of the three accessibility conditions. A linear budget constraint was estimated from the three data points. Given the scope of this paper, a linear budget constraint was assumed for the purposes of simplification. Subsequent research should investigate the validity of this assumption.

Indifference Curve Analysis

Lastly, each individual's indifference curve was mathematically adjusted by adding a constant term to the equation for the indifference curve, to find the point where the indifference curve is tangent to the budget constraint. The point of tangency between the adjusted indifference curve and the budget constraint reveals the respondent's preferred combination of visitor use and accessibility, given the possible conditions at Delicate Arch.

Visitor Survey

Two versions of the indifference curve questionnaire were administered to visitors during the summer of 1999 as they returned from their hike to Delicate Arch. One version of the questionnaire included photographs depicting the number of visitors at Delicate Arch associated with each pair of conditions that respondents were asked to evaluate. The second version of the questionnaire included narratives describing each pair of conditions that respondents were asked to evaluate. Photographs of the number of visitors at Delicate Arch were not included in the second version of the questionnaire. Both versions of the questionnaire were administered on laptop computers. A total of 124 individuals responded to the questionnaire with photographs and 113 individuals responded to the questionnaire with narratives.

Results

For those individuals who responded to the questionnaire with photographs, results are presented for the estimation of each respondent's indifference curve. The budget constraint, constructed from the output of the simulation model of visitor use at Arches National Park is reported. Additionally, the preferred combinations of access and visitor use at Delicate Arch derived from the indifference curve analysis are presented for respondents to the questionnaire with photographs. Finally, the results of three chi-square tests are reported. The first test examined differences in the evaluation of tradeoffs between access and crowding for first time visitors versus repeat visitors. The second test examined differences in the evaluation of tradeoffs between access and crowding for local visitors to Arches National Park versus non-local visitors. The third test examined differences in the evaluation of tradeoffs between access and crowding for respondents to the questionnaire using photographs versus respondents to the questionnaire using narratives.

Indifference Curves

Indifference curves were derived for 123 respondents to the questionnaire with photographs, based on their evaluation of the tradeoffs between access and visitor use levels at Delicate Arch. Data from one respondent were excluded from the analysis because the data did not conform to the expected properties of indifference curves.

Analysis of sample data revealed 16 unique indifference curves. Respondents were categorized into one of three groups based on the characteristics of the preferences they revealed. The first group includes individuals whose preferences are "access oriented". In other words, these respondents would tolerate seeing relatively large numbers of people at Delicate Arch to help ensure they would be granted access to the Arch. The second group includes individuals whose preferences are "low use oriented". These respondents would tolerate a lower chance of being granted access to Delicate Arch to help ensure that if they received access to the Arch they would see relatively few people. The third group includes individuals whose preferences are "tradeoff oriented". In other words, these respondents would be more likely to negotiate or make tradeoffs between accessibility and visitor use levels than respondents in the other two groups.

Figure 2 illustrates indifference curves representative of individuals with "access oriented", "low use oriented", and "tradeoff oriented" preferences. The values on the y-axis represent the maximum number of people seen at Delicate Arch at one time by at least one visitor per day. The values along the y-axis are inverted to represent increasingly desirable "crowding" conditions, based on the assumption that respondents would prefer to see fewer people at Delicate Arch. The values on the x-axis represent the percentage chance of receiving a permit to hike to Delicate Arch. The percentage chance of receiving a permit to hike to Delicate Arch serves as a proxy for total use at Delicate Arch. Current total use at Delicate Arch is represented as a 100% chance of receiving a permit to hike to Delicate Arch. The values along the x-axis extend beyond a 100% chance of receiving a permit to hike to Delicate Arch to represent total use levels that are greater than current total use levels. However, respondents were not asked to evaluate any conditions in which the percent chance of receiving a permit to hike to Delicate Arch was greater than 100%.

Nearly half of all respondents revealed preferences characterized as "low use oriented" (48.8%), compared with just one-fifth of respondents having preferences characterized as "access oriented" (20.3%). Just under one-third of respondents had preferences that were characterized as being "tradeoff oriented" (30.9%).

Budget Constraint

The budget constraint defining the possible combinations of accessibility and visitor use for Delicate Arch was derived from output generated by a simulation model of visitor use at Arches National Park. Output from the simulation model resulted in three data points for the budget constraint. Regression analysis was used to

estimate a linear budget constraint based on the three data points. Figure 3 presents the budget constraint defining the possible combinations of access and visitor use levels at Delicate Arch.

Indifference Curve Analysis

An indifference curve was estimated for each respondent to the questionnaire with photographs. Each respondents' indifference curve was then adjusted to find the point of tangency with the budget constraint. Figure 4 presents the percent of respondents with each of the preferred combinations of access and visitor use at Delicate Arch. The budget constraint for Delicate Arch is represented by the line labeled BC. Each point noted along the budget constraint represents a preferred combination of access and crowding at Delicate Arch for at least one respondent. The number beside each point indicates the percent of respondents with the corresponding preferred combination of access and crowding.

Comparisons of Tradeoff Evaluations by Visitor Type and Questionnaire Format

An analysis was conducted to determine the potential effect of visitor type and questionnaire format on the findings from the indifference curve analysis. The first chi-square test examined differences in the evaluation of tradeoffs between access and crowding at Delicate Arch for first time visitors versus repeat visitors. Repeat visitors were defined as any individual who reported that they had visited Arches National Park on a previous trip. The results of the statistical test indicate that the distribution of first time visitors among the three preference categories ("access oriented", "low use oriented" and "tradeoff oriented") is not significantly different than that of repeat visitors ($\chi^2 = 0.361$, $p = 0.84$).

The second chi-square test examined differences in the evaluation of tradeoffs between access and crowding at Delicate Arch for local visitors versus non-local visitors. Local visitors were defined as residents of any of the "four-corners" states (i.e., Colorado, New Mexico, Arizona and Utah). Non-local visitors were defined as residents of any state other than one of the "four-corners" states. The results of the statistical test indicate that the distribution of local visitors among the three preference categories is significantly different than that of non-local visitors ($\chi^2 = 5.864$, $p = 0.05$). About half of both local visitors (49.2%) and non-local visitors (48.4%) revealed preferences characterized as "low use oriented". However, local visitors (27.9%) are more likely to be "access oriented" than non-local visitors (12.9%). Additionally, more than one-third of non-local visitors (38.7%) indicated "tradeoff oriented" preferences, compared with just under one-quarter of local visitors (23.0%).

The third test examined differences in the evaluation of tradeoffs between access and crowding at Delicate Arch for respondents to the questionnaire using photographs versus respondents to the questionnaire using narratives. The statistical test revealed significant differences between the preferences of respondents to the two questionnaire formats ($\chi^2 = 11.246$, $p = 0.00$). Specifically, nearly half of all

Figure 1. Theoretical Indifference Curves
and Budget Constraint

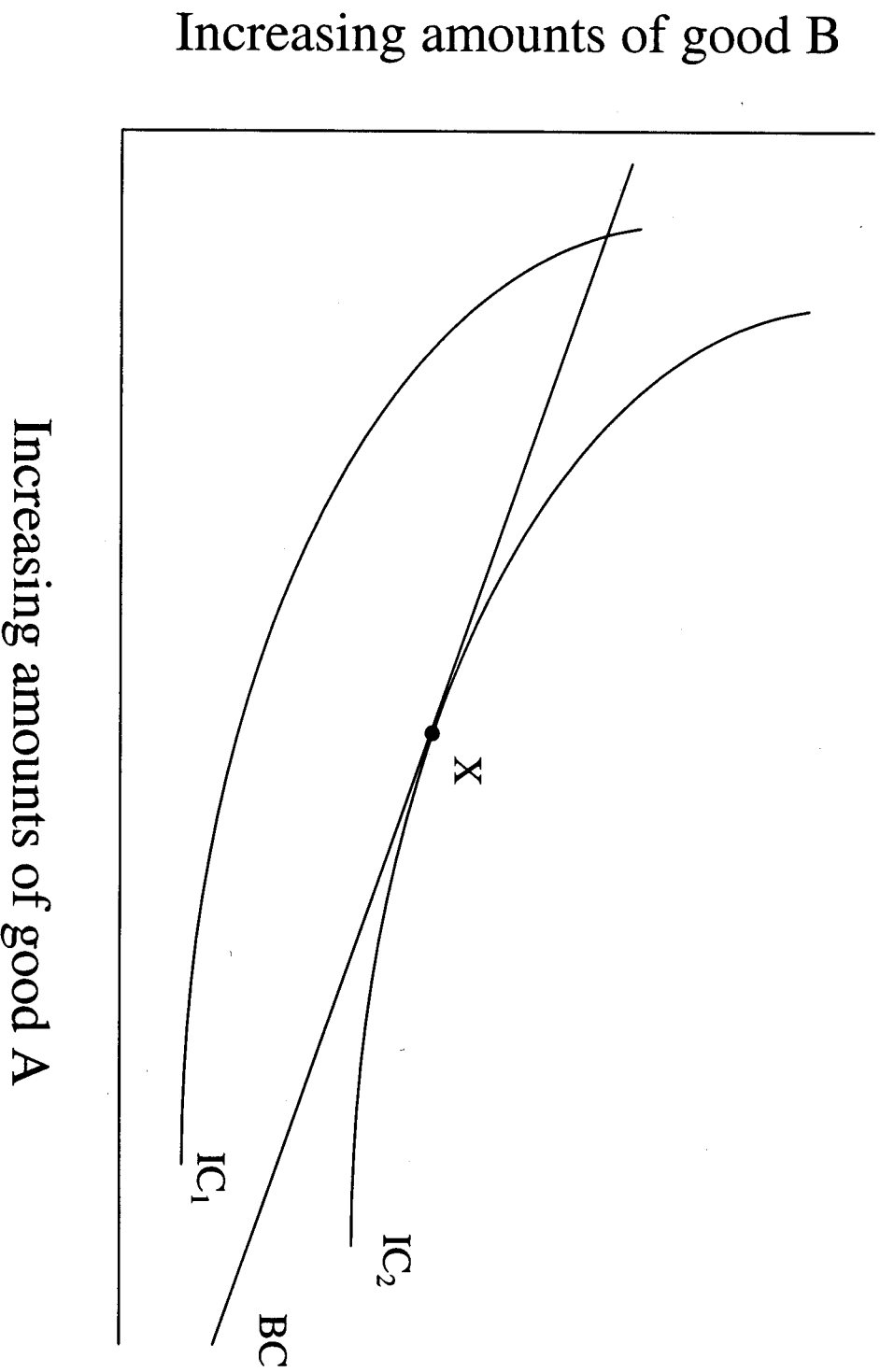
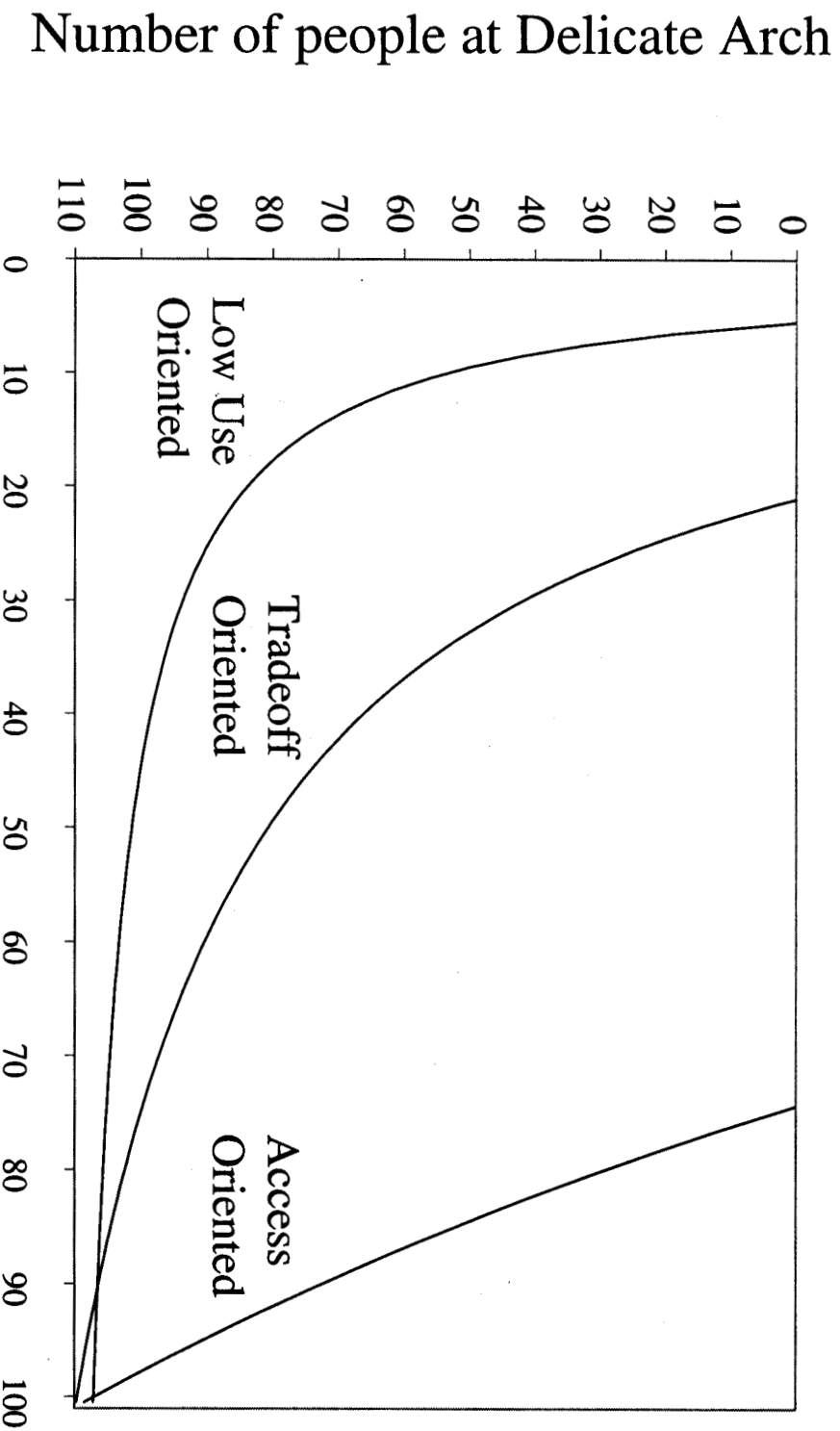
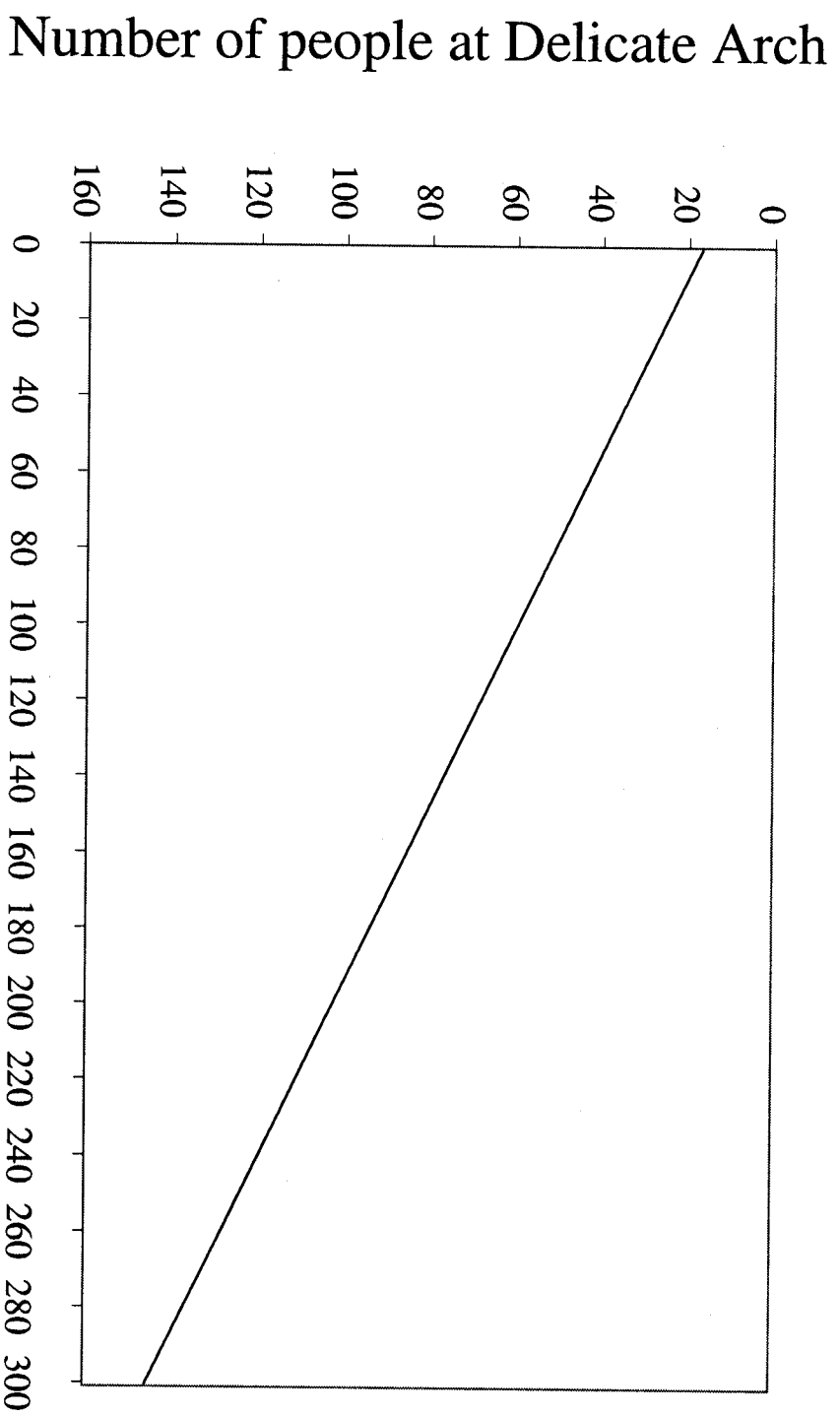


Figure 2. Indifference Curves – Access, Low Use, and Tradeoff Oriented Visitors



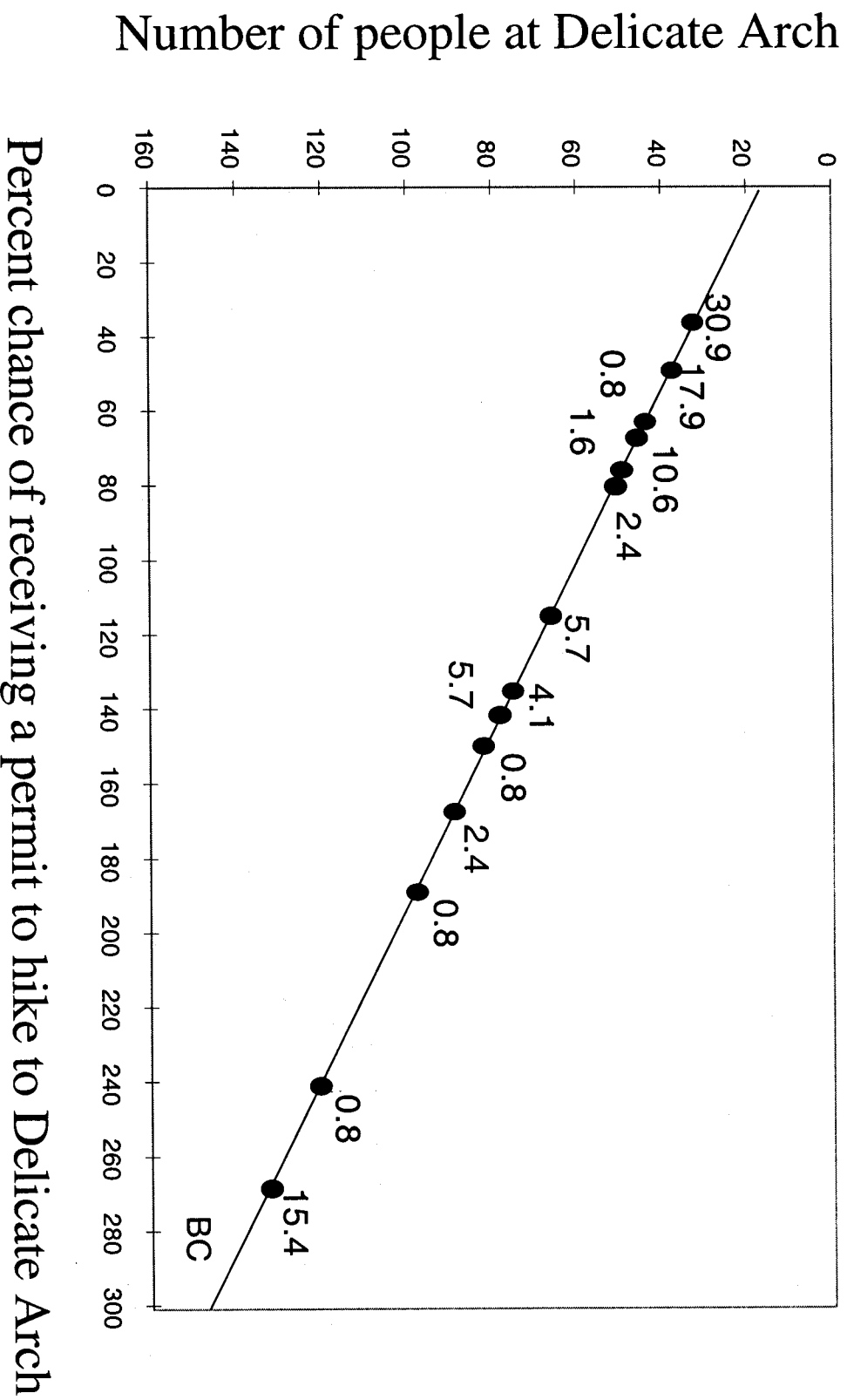
Percent chance of receiving a permit to hike to Delicate Arch

Figure 3. Budget Constraint for Delicate Arch



Percent chance of receiving a permit to hike to Delicate Arch

Figure 4. Preferred Combinations of Access and Visitor Use at Delicate Arch



respondents to the questionnaire using photographs (48.8%) revealed preferences characterized as "low use oriented", compared with just under one-third of respondents to the questionnaire using narratives (32.0%). Respondents to the questionnaire using narratives (40.0%) were more likely to reveal preferences characterized as "access oriented" than respondents to the questionnaire using photographs (20.3%). Just under one-third of respondents, regardless of questionnaire format, revealed preferences characterized as "tradeoff oriented" – 30.9% of respondents to the questionnaire using photographs and 28.0% of respondents to the questionnaire using narratives.

Conclusions

The results of this study suggest that indifference curve analysis provides a useful tool for park managers to evaluate the tradeoffs inherent in decisions about appropriate levels of visitor use at popular attraction sites. Indifference curve analysis allows managers at Arches National Park to make more informed evaluations of alternative management options for visitor use at Delicate Arch.

One of the management alternatives Arches National Park managers have is to freeze visitor use at Delicate Arch at current levels. The budget constraint indicates that if park managers continue to manage Delicate Arch at current use levels, visitors would see no more than 62 people at one time at the Arch. The results of the indifference curve analysis suggest that rather than allowing current use levels at Delicate Arch to persist, about two-thirds of the sample (64.2%) would prefer park managers to reduce visitors' chances of hiking to Delicate Arch to ensure that those who do go to the Arch see fewer than 62 people at one time. About one-third of the sample (35.7%) would prefer that park managers increase visitors' chances of seeing Delicate Arch, rather than maintaining current visitor use levels at the Arch.

A second alternative is to manage Delicate Arch in a manner that reflects the preferences of "low use oriented" visitors or "access oriented" visitors. Management actions taken to reduce the number of visitors seen at one time at Delicate Arch would be favored by about half of all respondents (48.8%). For example, these "low use oriented" visitors would prefer to see park managers initiate a permitting system to reduce the number of visitors seen at one time at Delicate Arch. About one-fifth of respondents (20.3%) have preferences characterized as "access oriented". Management actions that increase visitors' chances of seeing Delicate Arch (e.g. increasing the number of parking spaces at the Delicate Arch trailhead) would be favored by these "access oriented" visitors. Just under one-third (30.9%) of the sample have preferences characterized as "tradeoff oriented". These visitors would not necessarily favor management actions that reflect the preferences of either "low use oriented" visitors or "access oriented" visitors.

As the indifference curve data indicate, there are a substantial number of visitors with preferences

characterized by each of the three preference categories. In light of these findings, Arches National Park managers might choose to manage visitor use levels by zones. Certain zones within the park could be managed to meet the preferences of "low use oriented" visitors. Visitors' access to these zones would be restricted through the use of a permitting system, or some other mechanism, in order to ensure a relatively "uncrowded" visitor experience. Other zones could be managed to meet the preferences of "access oriented" visitors. Visitors' chances of seeing attractions in these zones would not be restricted or limited by a permitting system. Virtually anyone who wanted to visit these zones would be able to. "Tradeoff oriented" visitors could choose among the various zones to meet their preferences for accessibility and visitor use levels at park attractions. Indifference curve data can help quantify choices about managing the park by zones.

Managers at Arches National Park may want to provide a visitor experience that targets the preferences of local visitors or non-local visitors. The results of this research inform Park managers about how various visitor use management alternatives will serve local and non-local visitors' preferences for access and crowding conditions. For example, management actions that increase visitors' chances of seeing Delicate Arch would be more consistent with the preferences of local visitors than non-local visitors. Additionally, Park managers can use these study results to make more informed decisions about how to designate management zones within Arches National Park that target local visitors or non-local visitors based on the chance of receiving access to the attractions in the zone and the number of other people visitors would see while visiting the attractions.

The results of this study suggest that the type of questionnaire format used to elicit evaluations of tradeoffs between access and crowding at Delicate Arch may influence study results. Further research should be conducted to investigate the effect of questionnaire format on the indifference curve analysis of tradeoffs in outdoor recreation management. Generating larger sample sizes for alternative questionnaire formats and controlling for the access and crowding conditions experienced by respondents to the indifference curve questionnaires would provide more insight into this issue.

Additional research might investigate the temporal consistency of individuals' preferences for access and lack of crowding. For example, respondents to an on-site survey like the one in this study could be recruited to participate in a follow-up mail survey. The mail survey would ask respondents to evaluate the same combinations of access and crowding conditions that they were asked to evaluate in the on-site questionnaire. Each individual's responses to the mail survey could be compared to his/her responses to the on-site survey to examine if preferences for tradeoffs between access and lack of crowding change over the full duration of the recreation experience.

Further research might focus on the effect on social carrying capacity of shifting the budget constraint

associated with an attraction site. Shifting the budget constraint might be accomplished through visitor management or site design. For example, the budget constraint representing possible combinations of accessibility and visitor use levels at Delicate Arch could be shifted by scheduling the departure times of visitors hiking to Delicate Arch (Manning and Potter 1984). By scheduling visitors' hiking trips to Delicate Arch, park managers could potentially lower the number of people seen at one time at Delicate Arch while holding total use levels constant. Such a shift in the budget constraint would influence the outcome of the indifference curve analysis.

References

- Graefe, A., Kuss, F., & Vaske, J. (1990). Visitor Impact Management: The Planning Framework. Washington, D.C.: National Parks and Conservation Association.
- Lawson, S., & Manning, R. (2000). Crowding Versus Access at Delicate Arch, Arches National Park: An Indifference Curve Analysis. Proceedings of the Third Symposium on Social Aspects and Recreation Research.
- MacCrimmon, K., & Toda, M. (1969). The Experimental Determination of Indifference Curves. Review of Economic Studies, 36, 433-451.
- Manning, R. (1999). Studies in Outdoor Recreation: Search and Research for Satisfaction. Corvallis: Oregon State University Press.
- Manning, R., & Potter, F. (1984). Computer Simulation as a Tool in Teaching Park and Wilderness Management. Journal of Environmental Education, 15, 3-9.
- Manning, R., Valliere, W., & Jacobi, C. (1997). Crowding Norms for the Carriage Roads of Acadia National Park: Alternative Measurement Approaches. In W. Kuentzel (Ed.), Proceedings of the 1996 Northeastern Recreation Research Symposium (139-45). USDA Forest Service General Technical Report NE-232.
- Manning, R., Valliere, W., Wang, B., & Jacobi, C. (1999). Crowding Norms: Alternative Measurement Approaches. Leisure Sciences, 21 (2), 97-115.
- National Park Service. (1997). VERP: The Visitor Experience and Resource Protection (VERP) Framework - A Handbook for Planners and Managers. Denver, CO: Denver Service Center.
- Nicholson, W. (1995). Microeconomic Theory: Basic Principles and Extensions (6th ed.). Fort Worth: The Dryden Press.
- Pindyck, R., & Rubinfeld, D. (1995). Microeconomics. Englewood Cliffs: Prentice Hall.
- Potter, F., & Manning, R. (1984). Application of the Wilderness Travel Simulation Model to the Appalachian Trail in Vermont. Environmental Management, 8, 543-550.
- Schechter, M., & Lucas, R. (1978). Simulation of Recreational Use for Park and Wilderness Management. Baltimore: Johns Hopkins University Press.
- Stankey, G., Cole, D., Lucas, R., Peterson, M., Frissell, S., & Washburne, R. (1985). The Limits of Acceptable Change (LAC) System for Wilderness Planning (General Technical Report INT-176). USDA Forest Service.
- Wang, B., & Manning, R. (1999). Computer Simulation Modeling for Recreation Management: A Study on Carriage Road Use in Acadia National Park, Maine, USA. Environmental Management, 23, 193-203.