Computer Simulation as a Tool for Developing Alternatives for Managing Crowding at Wilderness Campsites on Isle Royale

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Abstract: Isle Royale National Park is experiencing increased backcountry visitation, resulting in crowded camping conditions during peak periods. For example, during July and August, backcountry campground capacities are commonly exceeded and visitors are required to share sites with other groups. During the summers of 2001 and 2002, two phases of research were conducted to assist Park managers in addressing this issue. In the first phase of research, computer simulation modeling was used to test the effectiveness of alternative management practices designed to reduce or eliminate campground crowding. The simulation results provide numerical estimates of campground crowding (i.e., campsite sharing) under alternative management approaches, including permit quotas, trailhead quotas, campsite development, and fixed itineraries. The second phase of research used stated choice analysis to evaluate visitors' attitudes toward alternative management scenarios developed with the simulation model. Results of the stated choice analysis suggest that visitors are willing to tolerate some campground crowding in order to avoid "heavy-handed" management practices. Together, findings from the two phases of research assist Park managers in estimating the outcomes of alternative management practices and anticipating the likelihood that visitors will support those outcomes.

Introduction

Since the establishment of the National Wilderness Preservation System in 1964, recreation use of wilderness has grown steadily and continues to be on the rise today, particularly in the National Parks (Cole, 1996). In the face of burgeoning public demand for outdoor recreation, national park and wilderness managers must make decisions that integrate a broad array of public values. For example, wilderness recreationists value, to varying degrees, opportunities for solitude, pristine resource conditions, and recreation opportunities unconstrained by management restrictions. Decisions about how to integrate these diverse values are complex and involve tradeoffs among potentially competing values (Lawson & Manning, 2002b).

This study uses computer simulation modeling to quantify tradeoffs associated with management options for improving backcountry camping conditions at Isle Royale National Park. The results of this study are assisting park managers in understanding current crowding-related conditions in campgrounds, comparing current conditions to proposed standards of quality for camping-related indicators, testing the effectiveness and implications of alternative management strategies, and informing the public about the implications of various management alternatives.

Isle Royale National Park

Isle Royale National Park is located in the northwest corner of Lake Superior, approximately 75 miles from Houghton, Michigan and 20 miles from Grand Portage, Minnesota, USA. Approximately 99% of the park's land base is designated wilderness. The park has a system of 36 campgrounds, with a total of 244 designated tent and shelter sites dispersed along lakeshores and a network of 165 miles of trails. Primary recreation activities at the park, which is open to visitors from mid-April until the end of October, include hiking and camping. During the 1990's, visitation to Isle Royale National Park grew at a rate of 4–5% annually, and, on a per acre basis, the park has one of the highest number of backcountry overnight stays in the National Park System (Farrell & Marion, 1998).

Visitors interested in backcountry camping at Isle Royale National Park are required to obtain a permit. As part of the permitting process, visitors are asked to report their anticipated itinerary, identifying the number of nights they plan to be in the park and the

campground they intend to stay at each night of their camping trip. However, visitors are not required to follow their proposed itinerary and there are no restrictions on the number of permits issued for camping in the park. While visitors do have the option to obtain special permits for off-trail hiking and camping, the vast majority choose to camp at the designated campground sites (Farrell & Marion, 1998).

Isle Royale National Park's approach to backcountry camping management is designed to maximize public access to the park and to maintain visitors' sense of spontaneity and freedom. However, recent research suggests that this management approach, coupled with increased backcountry visitation at the park, has resulted in campground capacities commonly being exceeded during peak periods of the visitor use season. Campers who arrive in full campgrounds are asked to share campsites with other groups, and most campers surveyed indicated that having to double-up with other camping groups detracted from the quality of their experience (Pierskalla, Anderson, & Lime, 1996, 1997).

Park managers have decided to address this backcountry camping issue by formulating a standard for campsite sharing (Manning, 1999). As park staff attempt to identify an appropriate and feasible standard for campsite sharing, they are faced with a number of difficult questions. For example, to what extent would use limits or fixed itineraries need to be imposed in order to reduce sharing to achieve alternative standards? Could efforts to provide public access, visitor freedoms, and reduced campground crowding be optimized by redistributing use temporally and/or spatially? Could alternative standards for campsite sharing be achieved by adding new campsites to the park, rather than by limiting use? If so, how many additional campsites would be needed, and where would they need to be located? Answers to these questions can assist managers in more precisely describing what the alternatives are and how they affect visitor freedoms, spontaneity of visitor experiences, public access, facility development, natural resource protection, and opportunities for camping solitude. This paper shows how computer simulation modeling of visitor travel patterns can assist managers in answering such questions.

Methods

Data Collection

Backcountry camping permits issued by park staff during the 2001 season provided the primary source of data needed to construct the travel simulation model. Information from the permits concerning the starting and ending date of each group's trip, camping itinerary, and group size were used as inputs to the simulation model. Data needed to test whether the simulation model outputs are valid estimates of on the ground conditions were gathered through a series of campground occupancy observations conducted throughout the park's 2001 visitor use season. For a more detailed discussion of the data collection and validation processes see Lawson and Manning (2003a).

Computer Travel Simulation Model

The travel simulation model developed in this study was built using Extend software (Extend, 1996; Lawson & Manning, 2003a, 2003b; Lawson et al., 2003; Wang & Manning, 1999). The structure of the simulation model consists of objects called hierarchical blocks that simulate various aspects of the Park's camping system. Entrance blocks generate simulated visitor groups and assign values for a set of attributes to groups (e.g., group size, camping itinerary) designed to direct their travel through the simulated backcountry camping trip. The model contains entrance blocks for each of the primary entry points to the Park. Entrance blocks allow the user to control the simulated amount and spatio-temporal distribution of backcountry camping use by specifying the simulated average daily number of trips starting from each of these locations. Routing blocks direct simulated visitor groups to the next (or first) campground on their itineraries, at the beginning of each simulated day, and direct groups that have completed their itineraries to exit the park. Campground blocks record the number of groups camping at each campground and the number of groups sharing campsites on each night throughout the simulation period.

Model Runs

Simulation runs were conducted to estimate the extent of campsite sharing in the Park under status quo conditions. Model runs were also conducted to estimate the effectiveness of management actions at reducing or eliminating campsite sharing, including a permit quota, fixed itineraries, and increasing the number of campsites on the Island. In addition, a workshop was conducted to instruct park staff how to use and modify the simulation model to continue meeting their planning needs. The park staff's use of the simulation model is ongoing, allowing them to evaluate management strategies as new ideas emerge throughout the Park's backcountry and wilderness planning process.

Results

Backcountry Camping Permit Data

All 3,810 backcountry camping permits issued by the park during the 2001 season were used as inputs to the computer travel simulation model. These data include permits issued to backpackers, kayakers, canoeists, powerboaters, and sailboaters. Data reported in Table 1 indicate that, on average, 27 more permits were issued per day during July and August than during the remainder of the season (referred to throughout the remainder of the paper as the July/August peak and the low use period of the

Table 1. Mean Number of Permits Issued per Day, by Trip Starting Location – 2001 Visitor Use Season.

	Windigo	Rock Harbor	All Other Locations	All Locations Combined
July/August weekdays	12.8	19.0	2.3	34.2
July/August weekend days	17.9	29.8	4.3	52.1
July/August all days	14.2	22.0	2.8	39.1
Low use period weekdays	2.4	5.0	1.4	8.7
Low use period weekend days	6.4	9.5	2.6	18.5
Low use period all days	3.6	6.3	1.7	11.6

season, respectively). The permit data indicate that substantially more visitor groups started their backcountry camping trips on a weekend than on a weekday. Most visitors access the Park by commercial boat, landing at either Windigo (on the west end of the Park) or Rock Harbor (on the east end of the Park). Consequently, the vast majority of backcountry camping trips started at Windigo or Rock Harbor.

Model Output

Table 2 summarizes the results of simulation runs conducted to estimate the current extent of campsite sharing in the Park and to estimate the effectiveness of alternative strategies for reducing or eliminating campsite sharing. The alternatives outlined in Table 2 were selected for analysis with the simulation model because they reflect a range of management approaches that emphasize campsite solitude, visitor freedoms, public access, and facility development to varying degrees.

Park managers have the option of managing backcountry camping to maintain status quo conditions. Under this alternative, an average of about 39 permits would be issued per day, there would be no new campsite construction, and visitors would not be required to follow prescribed itineraries. Simulation results for the "Status Quo" alternative suggest that under the Park's current management approach, an average of about 9% of groups are required to share campsites per night during July and August, with 24% sharing during the busiest two weeks of this period. Less than 1% of groups are estimated to share sites during the low use period of the season.

Simulation runs were conducted to assess the effectiveness of a permit quota at reducing or eliminating campsite sharing. Under the "Permit Quota" alternative, there would be no new campsite construction and visitors would not be required to follow prescribed itineraries. However, the average number of permits issued per day during July and August would be reduced to ensure that an average of no more than 5% of groups share campsites per night (a standard for campsite sharing that the Park is considering). Such an approach would continue to emphasize visitor freedoms and place limits on facility development in wilderness, while allowing for greater camping solitude than the status quo for those groups able to obtain a permit. However, some individuals who wanted to take a backcountry camping trip during July or August would not be able to obtain a permit to do so. The simulated "Permit Quota" alternative suggests that the Park would need to reduce visitor use during July and August by nearly 25% to ensure that an average of no more than 5% of groups share campsites per night.

Decisions to limit public use of national parks and wilderness are inherently controversial. To avoid this controversy, Park managers could institute a fixed itinerary system, rather than a permit quota, to reduce or eliminate campsite sharing,. Under this approach, everyone who wanted to take a backcountry camping trip would be able to obtain a permit to do so and no new campsites would be constructed. However, visitors would potentially have fewer choices of itineraries and would lose the freedom to spontaneously alter their camping itinerary during the course of their trip. The results of the simulated "Fixed Itineraries" alternative suggest that, by requiring visitors to follow prescribed camping itineraries, the Park could issue approximately 30% more permits than they did during the 2001 visitor use season, while at the same time virtually eliminate campsite sharing.

Rather than institute a permit quota or require visitors to follow prescribed itineraries, Park managers could try to reduce or eliminate campsite sharing by building new campsites. The park's recently adopted General Management Plan allows for construction of up to 13 additional campsites in specific campgrounds. If the Park were to adopt this "Campsite Construction" alternative, the simulation results suggest that, without instituting any limits on use, the

park could reduce campsite sharing by about 2%, resulting in an average of approximately 7% of groups sharing campsites per night.

As the results of the simulated "Status Quo" alternative indicate, campsite sharing is a problem primarily during the months of July and August, while there is virtually no campsite sharing during the low use period of the season. Further, results of the "Permit Quota" alternative suggested that Park managers would need to reduce the number of permits issued during July and August by about 25% to ensure that an average of no more than 5% of groups share sites per night. However, rather than turning those visitors away completely, Park managers could shift "surplus" peak season use to the low use period of the season. This "Temporal Redistribution" approach would allow managers to maintain season-wide visitor use levels, reduce campsite sharing during July and August, avoid building new campsites, and maintain visitors freedom with respect to camping itineraries. Results of the simulated "Temporal Redistribution" alternative suggest that campsite sharing would increase from an average of approximately 0.4% of groups per night during the low use period of the season, to just over 1% of groups per night.

Simulations conducted to estimate the effect of redistributing visitor use evenly across the two primary starting locations for backcountry camping trips (i.e., Windigo and Rock Harbor) or evenly across the days of the week suggest that neither strategy would reduce campsite sharing. Therefore, the results of these simulations are not included in Table 2.

Results of simulation runs conducted to test the validity of the model indicated no statistically significant differences between observed campground occupancies collected by park staff during the 2001 season and travel simulation model output. More importantly, there were no *substantive* differences between the observed campground occupancies and the corresponding model output. This suggests that the travel simulation model accurately represents backcountry camping conditions at the park during the 2001 season. For more information about the validation of the simulation model see Lawson and Manning (2003a).

Park staff's use of the simulation model is ongoing. For example, park staff have used the model to estimate the effect of shifting some use to secondary entry points, differentially altering the visitation levels of hikers, paddlers, and powerboaters, and setting alternative standards for campsite sharing at different times of the season. In addition, park staff have used the model to estimate where and how many new campsites would need to be added to the Park to eliminate campsite sharing during peak season demand. Using simulation results as a guide, park staff conducted site visits to determine the feasibility and desirability of campground development needed to meet peak camping demand, based on considerations of physical constraints of wetlands, fragile habitats and topography as well as appropriate size of campgrounds in different areas of the park. In Isle Royale's case, the number of new sites the simulation model estimates would be needed to accommodate peak demand is greater than the number of sites that could be added to the Park, given the constraints listed above. However, the new sites could mitigate campsite sharing to some extent.

Discussion and Management Implications

The findings from this study have implications for management of backcountry camping use at Isle Royale National Park in particular, and for management of visitor use in parks and wilderness in general. Isle Royale National Park managers have made a commitment to adopt campsite sharing-related indicators and standards of quality and to develop and implement strategies to improve social conditions in campgrounds while also protecting park resources. To do this in an informed manner, park managers not only need to identify feasible manage-

Table 2. Management alternatives quantified based on simulation model output.

Wilderness Values	Status Quo	Permit Quota	Fixed Itineraries	Campsite Construction	Temporal Redistribution
Public Access	Current use	22% reduction in July/August use	30% increase in July/August use	Current use	Current use (shift 22% of peak)
Facility Development	No new campsites	No new campsites	No new campsites	13 new campsites	No new campsites
Visitor reedom	No fixed itineraries	No fixed itineraries	Fixed itineraries	No fixed itineraries	No fixed itineraries
Camping Solitude July and August	9% of groups share sites/night	5% of groups share sites/night	<1% of groups share sites/night[1]	7% of groups share sites/night	5% of groups share sites/night
Camping Solitude Low Use Period	0.4% of groups share sites/night	0.4% of groups share sites/night	<1% of groups share sites/night[1]	<1% of groups share sites/night	1.4% of groups share sites/night

[1]Assumes permits are issued to achieve 80% occupancy rate to adjust for non-compliance

ment options, they must also understand the effects of alternative options on a diverse array of wilderness values (Cole, 2002). This study assists park managers in defining and assessing management alternatives not only in terms of how effective they are at reducing or eliminating campsite sharing, but also in terms of their consequences with respect to visitor freedoms, public access, and resource impacts associated with facility development. Consequently, the simulation modeling results aid managers in better informing the public of the costs and benefits of different management options, resulting in more effective public involvement in the planning process.

Results from this study are consistent with findings from previous research at Isle Royale National Park, suggesting that campsite sharing is prevalent during certain periods of the visitor use season. Although it would be possible to reduce campsite sharing through backcountry camping use limits alone, results from the travel simulation model suggest that the park would have to issue approximately 22% fewer permits during July and August to ensure that an average of no more than 5% of groups share campsites per night.

The outdoor recreation literature generally suggests that use limits should be considered a last resort for managing crowding, and that less intrusive alternatives should be considered first (Behan, 1974, 1976; Dustin & McAvoy, 1980; Hall, 2001; Hendee & Lucas, 1973, 1974). The computer simulation model developed in this study helps managers identify effective management actions with relatively low "costs" to visitors and avoid those that are less effective or that come at a relatively high "costs" to visitors. In Isle Royale's case, modeling suggests that the extent of use limits necessary to achieve certain standards for campsite sharing could be minimized by also redistributing use and/or modifying campground capacities.

Although this study provides managers with descriptive information related to backcountry camping at Isle Royale National Park, managers are still faced with difficult judgments concerning the most appropriate strategies for managing backcountry camping. These judgments require managers to reconcile tradeoffs among potentially competing wilderness values. For example, do the costs in visitor freedoms and spontaneity associated with a fixed itinerary system outweigh the benefits of increasing use and eliminating or substantially reducing campsite sharing? Is it in the public's interest to limit backcountry camping use during the peak period of the season in order to minimize campsite sharing? If so, to what extent should use be limited to achieve a greater degree of camping solitude? Is it acceptable to shift a percentage of peak season use to the low use period of the season, or does the historically low use period of the season offer a type of wilderness experience that should be preserved? While these judgments must ultimately be made by managers, a growing body of recreation research has been conducted to provide managers with a more informed basis for making such judgments (Lawson & Manning, 2001a, 2001b, 2002a, 2002b; Manning & Lawson, 2002).

The simulation results from this study formed the basis of a visitor survey conducted at Isle Royale National Park during the 2002 visitor use season (Lawson & Manning, 2003b). The visitor survey was designed to assess public attitudes toward management alternatives derived from the simulation model. Results of the visitor survey provide managers with estimates of the proportion of current visitors that support alternative strategies for managing backcountry camping (Table 3). Each alternative in Table 3 is defined in terms of the amount of backcountry camping use permitted, the number of new campsites constructed, whether visitors are required to follow a prescribed itinerary, and the extent of campsite sharing during July and August. The last row of Table 3 reports the proportion of visitors estimated to support each alternative.

The results suggest that the greatest support among visitors is for the "Status Quo" and "Permit Quota" options, with 36% and 39% of visitors estimated to support each of these alternatives, respectively. While the "Campsite Construction" alternative is less popular than the "Status Quo" and "Permit Quota" alternatives, nearly 20% of visitors are estimated to support this option. The "Fixed Itineraries" alternative is substan-

Table 3. Preference proportions for management alternatives.

Status Quo	Permit Quota	Fixed Itineraries	Campsite Construction
Current use (39 permits/day)	22% reduction in use (31 permits/day)	30% increase in use (52 permits/day)	Current use (39 permits/day)
No new campsites	No new campsites	No new campsites	70 new campsites
No fixed itineraries	No fixed itineraries	Fixed itineraries	No fixed itineraries
9% of groups share campsites/night	5% of groups share campsites/night	<1% of groups share campsites/night[1]	<1% of groups share campsites/night
36%	39%	6%	19%

[1]Assumes permits are issued to achieve 80% occupancy rate to adjust for non-compliance

tially less favorable to visitors than any of the other alternatives, with just over 5% of visitors estimated to support this option. These findings suggest that visitors would prefer to tolerate some amount of campsite sharing in order to ensure that the park does not build a large number of new campsites or require visitors to follow prescribed, fixed itineraries. In this way, the simulation model provides managers with information about the consequences and benefits of alternative management strategies, and the visitor survey assists managers in evaluating public acceptance of the consequences and benefits associated with those management alternatives.

This paper describes how simulation modeling can be used as a tool to contribute to improved management of parks and wilderness. In particular, simulation modeling can more precisely describe the "packages" of attributes (social, environmental, managerial) that are the real management alternatives from which one future must be selected. The simulation results can be used to focus visitor surveys and other public input processes on assessing public support for real management options. In these ways, simulation modeling can be a very effective way of communicating with the public and informing decisions throughout the planning process.

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