EXPLORATION OF OPTIMAL BACKCOUNTRY TRAVEL PATTERNS IN GRIZZLY BEAR HABITAT

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Abstract: Trade-offs among backcountry management objectives were explored for the northern half of Glacier National Park, Montana. Parametric linear programming was employed to quantify the trade-offs among 5 objectives, consisting of 3 measures of trail-related contact between grizzly bears (*Ursus arctos*) and humans (dangerous, nondangerous, total), a measure of solitude at the backcountry campsites, and the volume of backcountry overnight use. Contact indices were developed for these measures of contact for 3 time periods for each of 85 trail segments in the study area. Optimal patterns of backcountry overnight use were identified for various combinations of objectives within 2 management models. The first model minimizes all trail-related contacts between humans and grizzlies. The second model minimizes only dangerous contacts. Parametric linear programming is shown to be a powerful technique for dealing with multiobjective problems of the size and complexity considered in this study.

Researchers who have considered human use of grizzly bear habitat have suggested that management be directed towards controlling the volume and/or distribution of this use (Craighead and Craighead 1967, Herrero 1970a, Mundy and Flook 1973). Managers, however, have found it difficult to implement these management recommendations for several reasons. They have lacked the means to assess the number of contacts between humans and grizzlies likely to occur with alternative volumes and distributions of use. Moreover, the several goals typically pursued by management further complicate the task of evaluating the relative desirability of alternative use patterns.

Effective management of human use of grizzly habitat is important for several reasons. It not only serves to protect people from injury and death but also helps protect the bears. Grizzly populations are imperiled by the sentiment that periodically surfaces suggesting they be removed from national parks (Moment 1970). Grizzlies warrant special management attention, having been declared a threatened species in the continental United States (45 FR 31734-31736) under the Endangered Species Act of 1973 (PL 93-205).

Work conducted from 1974 through 1977 quantitatively assessed the trade-offs among management objectives relating to human use of grizzly habitat. In effect, the work has been an attempt to find optimal patterns of backcountry travel for various combinations of management objectives. Thus, the research empirically explored the suggestion that the distribution and/or volume of human use of grizzly habitat should be managed.

The type of information generated by this work is intended to be an input to backcountry management planning. The objective has been to enhance the manager's role as a decision maker by quantifying the trade-offs among management objectives so that more informed decisions can be made.

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STUDY AREA

The study was conducted in Glacier National Park in Montana. The Going-to-the-Sun Road, which runs east-west, divides the park into 2 parts (Fig. 1). The study area was the backcountry north of the Going-to-the-Sun Road. This area comprises approximately 215,000 ha, or slightly more than half the total area of the park. The study area contains 39 designated backcountry campsites. Access to these campsites is facilitated by 22 trailheads and 461 km of backcountry trails (Fig. 2).

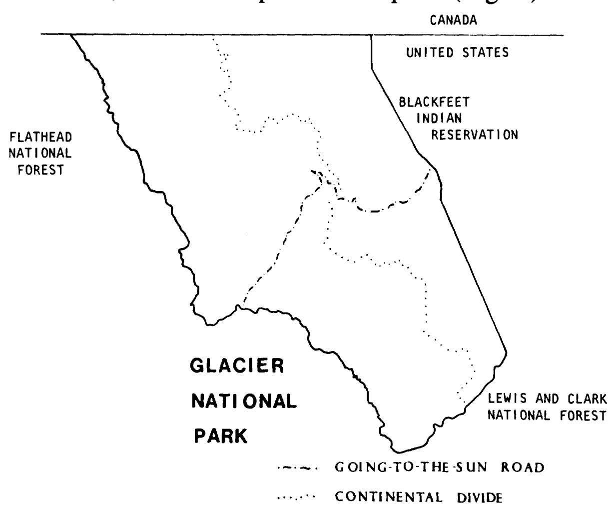

Fig. 1. Map of Glacier National Park and surrounding lands.

Martinka (1974a) has estimated that during the years

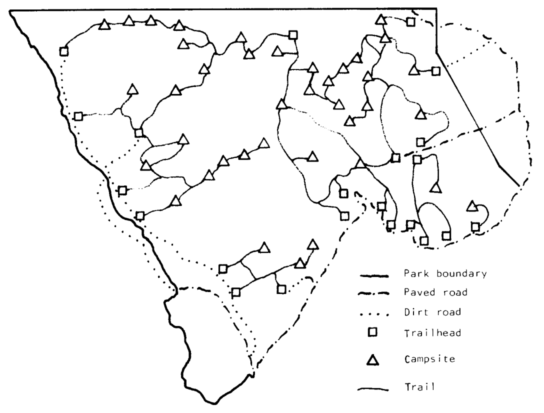

Fig. 2. Map of the trails, trailheads, and designated backcountry campsites in the study area.

1967-73, the size of the grizzly population in Glacier was stable, with a mean of 194 animals. The area inhabited by these bears has seen significant backcountry use in recent years. In 1975, 4,502 parties composed of 11,464 people camped overnight in Glacier's backcountry. The entire park had 8,206 party-nights of backcountry use, with more than three-fourths of it occurring in the study area.

There have been 3 fatalities caused by grizzlies in Glacier National Park. In 1967, 2 women died as a result of separate attacks by grizzlies in the backcountry. A third woman died after an encounter with a grizzly at a developed campground in 1976. In addition, grizzlies have caused a number of injuries of varying severity in recent years.

Glacier's backcountry is managed under a system of designated backcountry campsites and mandatory backcountry permits. The research has been carried out within this management framework, exploring the capabilities of the current system to accommodate human use of grizzly habitat more effectively.

CONTACT INDEX DEVELOPMENT

Effective management of the volume and distribution of human use requires knowledge of human-grizzly contact rates or probabilities specific to locations and time periods. Although there are several ways to estimate these values, data were available only from sightings of bears. It had been anticipated that estimates of human use on various trail segments by time period could be obtained. These estimates would have permitted conversion of the absolute number of grizzly contacts in an area during a time period into a contact rate. Thus, some of the biases known to be associated with observation data (Mundy and Flook 1973, National Academy of Sciences 1974, Singer 1976) could be eliminated. Obtaining reasonable-quality estimates of human use proved to be impossible, so the decision was made to use contact indices rather than contact rates.

Three contact indices were developed. The first related to dangerous contacts; the second dealt with nondangerous contacts. The third index pertained to all contacts between humans and grizzlies. These contacts included everything from direct physical contact to seeing a bear at a distance of a kilometer or more. For these purposes, dangerous and nondangerous contacts were considered to be both mutually exclusive and collectively exhaustive. Therefore, the total contact index was the sum of the danger and nondanger contact indices.

Indices were defined in terms of time periods. The backcountry use season was considered to extend from 1 June to 15 September and was divided into the early season (1 June-5 July), the midseason (6 July-10 August), and the late season (11 August-15 September).

Contact indices related factors associated with grizzly observations in the study area to data for the various trail segments. The focus on trails excluded consideration of off-trail travel and backcountry campsites. Off-trail travel is uncommon in the study area, and excluding it from consideration kept the problem to a manageable size. Contact indices were not calculated for campsites because campsite encounters with grizzlies can be more effectively handled through management actions directed toward camping practices and campsite locations than by manipulating the pattern of use.

Contact indices incorporated data from grizzly observations recorded in park files. For the years 1968-75, a total of 585 observations from the study area between 1 June and 15 September were located. Of these, 191 were observations of sows with young. The 585 observations included 598 adults and 362 additional grizzlies classified as cubs, yearlings, and 2-year-olds.

The observations were divided into the 3 time periods mentioned above to take into account the noted differential habitat use by grizzlies over the course of the season (Martinka 1972, Mundy and Flook 1973). The observations were further categorized by the habitat type and elevation zone in which each observation occurred. Five habitat types and 6 elevations zones were used. The 5 habitat types — alpine, forest, shrub, slide, and grassland — were those used by Martinka (1972) in his work on grizzlies in Glacier. The 6 elevation zones covered elevations in the study area ranging from approximately 945 to 3,200 m (Stuart 1977).

The percentage of the total number of observations in a time period was computed for each habitat type-elevation zone combination. Not all potential combinations existed in the study area, with only 20 having reported observations. The observations were further partitioned as to whether or not sows with young were involved. This distinction was based on the work of Herrero (1970a, 1970b, 1976), which showed that sows with young are disproportionately involved in aggressive contacts with humans. For each time period, similar calculations by habitat type-elevation zone were carried out for sows with young and for all other grizzlies.

Each of the 85 trail segments in the study area was systematically sampled at approximately 0.17-km intervals. Data were obtained for 2,682 sampling points. At each of these points, the following data were recorded: the length of unobstructed visibility on the trail in both directions, the habitat type(s) of the adjacent area, and a rating of the difficulty of off-trail travel in the vicinity of the trail. Combining elevation data from topographic maps with the habitat type data for each sampling point allowed estimation of the percentage of a trail segment in each combination of habitat type and elevation zone.

Rating the difficulty of off-trail travel and measuring trail visibility helped in assessing the likelihood that an encounter with a grizzly on a trail segment would, or would not, be dangerous. All else being equal, the chance of a dangerous encounter with a grizzly is much higher if a hiker meets the animal on the trail than if the grizzly is seen off the trail. In addition the more difficult the off-trail travel, the greater the likelihood that an encountered grizzly will be on the trail. A grizzly encountered on the trail, however, need not be considered dangerous if the hiker is aware of the grizzly soon enough to respond. An encounter is assumed to be dangerous any time a person is not aware of a grizzly until they are so close that the outcome will be determined by the bear.

The trail visibility data indicate that in many parts of the study area an unobstructed view of the trail is restricted to a short distance. Nearly 80 percent of the time, unobstructed trail visibility is limited to 30 m or less; over 90 percent of the time it is restricted to less than 61 m. Trail visibility is particularly important since Herrero (1976) indicated that injuries occurred when people were not aware of the grizzly's presence until a short distance separated them. This distance never exceeded 100 m and was often much less.

For each trail segment, computations were carried out to construct a danger contact index, a nondanger contact index, and a total contact index, for each time period. The danger contact index for a trail segment and time period was the weighted average of 2 values. Herrero (1976) reported that sows with young were involved in 80 percent of the major injuries attributable to grizzlies on the North American continent from 1970 through 1973. The danger contact index used the values 0.8 and 0.2 for these weights. The former was associated with the pattern of habitat use observed for sows with young, the latter for the pattern of habitat use for all other grizzlies.

The *sows with young* element of the danger contact index for a trail segment going from point *e* to point *f*, for time period *k*, was calculated as follows:

$$SWK^k_{ef} = \frac{\sum_{i=l}^{5} \sum_{j=l}^{6} (S^k_{ij})(T_{ij})}{\sum_{i=l}^{5} \sum_{j=l}^{6} (S^k_{ij})^2}$$

where,

S^k_{ij} = the percentage of observations of sows with young during time period *k* recorded in habitat *i* and elevation zone *j*,

T_{ij} = the percentage of the trail segment estimated to be in habitat type *i* and elevation zone *j*.

Note that this element is constructed so that if a trail segment went through terrain and vegetation with the same pattern as that for observations of sows with young during that time period, its value would be *1*.

For the same trail segment and time period, the element for *all other grizzlies* was calculated as follows:

$$AOG^k_{ef} = \frac{\sum_{i=l}^{5} \sum_{j=l}^{6} (O^k_{ij})(T_{ij})}{\sum_{i=l}^{5} \sum_{j=l}^{6} (O^k_{ij})^2}$$

where,

O^k_{ij} = the percentage of observations of all other grizzlies during time period *k* recorded in habitat type *i* and elevation zone *j*.

After computing these 2 elements, the value of the *danger contact index* for the trail segment from *e* to *f* during time period *k* was determined as follows:

$$DCI^k_{ef} = [(0.8)\ (SWY^k_{ef}) + (0.2)\ (AOG^k_{ef})]\ [(D)\ (V_{ef})(L)(B^k)]$$

where,

DCI^k_{ef} = the danger contact index for time period k for the trail segment from e to f,

D = the estimated proportion of the trail segment with a rating of average or greater for off-trail travel difficulty,

V_{ef} = the estimated proportion of the trail in the direction of travel with visibility restricted to 61 m or less,

L = length of the trail in miles,

B^k = the ratio of the mean number of grizzlies seen per day during time period k to the mean number of grizzlies seen per day during the entire season.

The *nondanger contact index* was calculated in a related manner. For the same trail segment (from e to f) and time period (k), the nondanger contact index calulations were as follows:

$$NDCI^k_{ef} = \frac{\sum_{i=l}^{5} \sum_{j=l}^{6} (A^k_{ij})\ (T_{ij})}{\sum_{i=l}^{5} \sum_{j=l}^{6} (A^k_{ij})^2} [(1 - (D)(V_{ef}))\ (L)(B^k)]$$

where the terms previously used are defined as above and

A^k_{ij} = the percentage of observations of all grizzlies during time period k recorded in habitat type i and elevation zone j.

In the danger contact index calculations, the product $[(D)(V_{ef})]$ is used as a proxy for the probability that a contact with a grizzly on a particular directed trail segment would be dangerous. Since dangerous and nondangerous contacts are considered mutually exclusive and collectively exhaustive, the term $[1 - (D)(V_{ef})]$ is employed in the nondanger contact index calculations.

For a trail segment and time period, the total contact index is the sum of the danger contact index and the nondanger contact index. In other words:

$$TCI^k_{ef} = DCI^k_{ef} + NDCI^k_{ef}\ .$$

MANAGEMENT MODELS

For any particular volume of use, the backcountry management problem is essentially to find the pattern of use, across the various time periods comprising the backcountry use season and throughout the backcountry within each time period, that best accomplishes the relevant management objectives. Hence, a variable in the management models is an overnight backcountry trip that can be taken during a given time period. The solution for a management model reveals the number of parties needed to undertake the backcountry trip during the time period represented by each variable, if an optimal pattern of use is to be achieved.

To find an optimal pattern of backcountry use, it was necessary to know all the backcountry trips possible in the study area. These trips represent various sequences of trail segments and campsites that meet a set of criteria. The most significant of these criteria are (1) that a trip involve camping only at designated backcountry campsites and (2) that each day's travel not exceed a maximum distance. Through the use of techniques from the field of network and graph theory, it was possible to identify all such theoretically possible trips (Stuart 1977).

A total of 2,116 trips were available for consideration by the models in determing optimal patterns of use. Due to the impassability of some trails at the beginning of the season, every trip cannot be undertaken in each time period. Only 833 of these trips can be undertaken in the early season of a typical year, but all 2,116 are feasible in both the midseason and the late season.

Each variable has a value for the danger contact index, the nondanger contact index, and the total contact index. These values are the sum of the index values for each trail segment traversed in the course of the trip and the time period implied by that variable.

Linear programming is the mathematical optimization technique employed in the management models. Solution of these models was carried out while parametrically varying one or more constraints, thus permitting identification of the trade-offs among various management objectives. The linear programs contained 5,065 variables and nearly 200 constraints.

Linear programming determines the optimal value for each variable in a model. This optimality is in terms of a linear objective function being maximized or minimized subject to linear equality and inequality constraints. For these management models, the variables are backcountry trips during specified time periods. The value of a variable is the number of parties recommended for the journey implied by that trip and time period. Constraints in the models limit the amount of overnight use at each backcountry campsite and the level of parking at each trailhead. Other contraints insure that any pattern of backcountry use identified will have additional desirable properties. These properties include reasonable distributions across the 3 time periods, among average daily travel distances, and among trips of various durations (Stuart 1977). Two alternative objective functions were used, giving rise to a pair of management models — Model 1 and Model 2. The difference between the models involves the implicit view a manager might have toward human-grizzly contacts.

Model 1 minimizes the value of the total contact index as its objective function. The underlying rationale for use of this model is that efforts should be made to prevent all contact between visitors and grizzly bears. A suggestion that prevention of all contacts ought to be the management objective for the National Park Service is in the literature (Craighead and Craighead 1967). In minimizing this objective function, the model minimizes the sum of the total contact index for each variable times the number of parties suggested for the trip during the time period represented by that variable. The value of the objective function for this model relates to the total number of trail-related contacts (of all kinds) between backpackers and grizzly bears that would arise over the course of the entire season.

Model 2 has as its objective minimization of the danger contact index. With use of this model, the goal is to prevent contacts with grizzlies in areas of the backcountry where the contacts are likely to be dangerous. This objective function relates to the total number of dangerous trail-related encounters between backpackers and grizzlies over the course of the season.

In generating values for constraints in the linear programs, 5 alternative definitions of backcountry campsite capacity were used. By comparing solutions for model runs that differ only with respect to the definition of campsite capacity, the implications of providing greater or lesser degrees of solitude at the backcountry campsites can be seen. This is an important feature of the models, since several researchers suggest that campsite solitude is an important element in a wilderness experience (Stankey 1973, Lucas 1973, 1974).

These 5 definitions of campsite capacity included the one actually used in the park. These actual capacities for the various campsites range from 1 to 10 parties per evening, with 3.9 the mean. The distribution of these values is presented in Table 1 under ACTUAL. Distributions of capacities under the other 4 definitions are also in Table 1. For each of these definitions, the capacity of a campsite is the minimum of the campsite's ACTUAL capacity and the integer value of the name of that capacity definition. Thus, each of the other 4 definitions is more restrictive than ACTUAL.

Table 1. Number of campsites with various maximum limits of nightly party use for alternative definitions of campsite capacity.

Capacity definition	Maximum number of parties per night										Mean capacity
	1	2	3	4	5	6	7	8	9	10	
ACTUAL	2	7	11	5	7	5	0	1	0	1	3.9
FOUR	2	7	11	19	-	-	-	-	-	-	3.2
THREE	2	7	30	-	-	-	-	-	-	-	2.7
TWO	2	37	-	-	-	-	-	-	-	-	1.9
ONE	39	-	-	-	-	-	-	-	-	-	1.0

RESULTS

The goal in Model 1 is to find the pattern of backcountry use that keeps the value of the total contact index as small as possible, for a given volume of use. One way of pursuing this goal would be to solve the model for one or several selected volumes of use, but the question of which volumes to use would then arise. By employing parametric linear programming, this aspect of the management problem can be treated in a more elegant and more comprehensive fashion. The linear programs were solved while parametrically varying the volume of use. In other words, for each capacity definition, an optimal pattern of use was identified for every volume of use (in party-nights) from zero to that level at which the backcountry is used to its capacity (Stuart 1977). A summary of these solutions is graphically presented in Fig. 3.

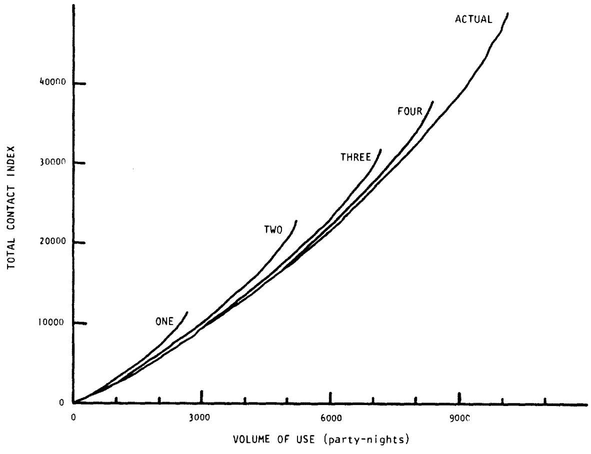

Fig. 3. Model 1 trade-off possibility frontiers for alternative campsite capacity definitions.

Fig. 3 presents 5 trade-off possibility frontiers, 1 for each of the 5 alternative definitions of campsite capacity. They show the trade-offs, given an optimal pattern of backcountry use, between the total contact index and the volume of use for each capacity definition. All points on these curves have a special property. The value of the total contact index associated with the volume of use for any point on a curve is the minimum attainable total contact index value for that campsite capacity definition and volume of use. There is, in addition, a specified pattern of use associated with each point on these curves (Stuart 1977).

This type of information can be employed by managers in several ways. For instance, for any volume of use, say 6,000 party-nights (in the range of recorded use in the study area during the 1975 season), the relationship between the total contact index and solitude at the backcountry campsites can be explored. For capacity definition ACTUAL, the total contact index value is 21,754. The more restrictive definition of FOUR raises the total contact index value to 22,252, an increase of 2.3 percent. Capacity definition THREE, even more restrictive, results in an index value of 23,379, 7.5 percent higher than that for ACTUAL.

In this way the manager is able to see the trade-offs between a measure of all trail-related contacts with grizzlies and a measure of solitude at the backcountry campsites, for all feasible volumes of use. The degree of solitude to provide and the level of contact between visitors and grizzlies to be endured is a judgement to be made by a manager. The data show how much of one objective the manager foregoes to achieve given levels on the other.

Information presented in this fashion also permits a quantitative assessment of the relationship between changes in the volume of use and the level of contacts with grizzlies. It has been suggested that increasing use levels are likely to bring higher levels of contact between people and grizzlies (Martinka 1974b, Merrill 1976). Here we see that even if these higher volumes of use are distributed optimally, a measure of total contacts is an increasing function of use. Now only does this measure of contacts increase with additional use, but it also increases more than proportionally. For example, at 6,000 party-nights of use with capacity definition ACTUAL, a 1 percent increase in use would produce a 1.35 percent increase in the total contact index. At 7,000 party-nights, a 1 percent use increase would raise the total contact index 1.38 percent.

Model 1 allows a manager to explore the trade-offs among 3 objectives in backcountry management: the volume of use, a measure of solitude at the campsites, and a measure of all trail-related encounters with grizzlies.

Model 2 explores the trade-off between the danger and nondanger contact indices for specified volumes of use and campsite capacity definitions. The results of

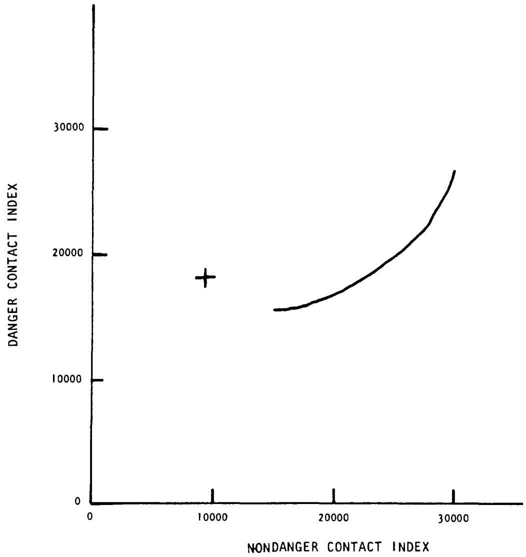

Fig. 4. Model 2 trade-off possibility frontier for campsite capacity definition THREE and a volume of use equal to 7,000 party-nights.

solutions for this model can also be presented as trade-off possibility frontiers. Fig. 4 shows this relationship for 7,000 party-nights and the ACTUAL campsite capacities. This curve is again a set of points with valuable properties. Any point on the curve is simultaneously the lowest level of the danger contact index for that level of the nondanger contact index *and* the highest level of the nondanger contact index for that level of the danger contact index. Each point on the curve has associated with it a particular pattern of backcountry overnight use.

The point at the left of the curve is the minimum attainable value for the danger contact index. Other points on the curve are the minimum danger contact index values for progressively higher levels of the nondanger contact index. The problem was solved by parametrically varying the nondanger contact index over all pertinent values (Stuart 1977).

The + symbol in Fig. 4 represents the minimum feasible sum of the danger and nondanger contact indices, which is precisely the definition of the total contact index. The + is thus the minimum total contact index value found in Model 1. This illustrates that *if* a manager feels comfortable about distinguishing between dangerous and nondangerous contacts, substantial differences in the properties of optimal travel patterns result.

For the example presented in Fig. 4, the total contact index value from Model 1 is 26,932. This value is composed of a danger contact index value of 17,801 and a nondanger contact index value of 9,137 (differences are due to rounding in the original data). By minimizing the danger contact index in Model 2, its value was reduced to 15,552, a decrease of nearly 13 percent. The level of the associated nondanger contact index if 15,005, a 64 percent increase over the value from Model 1.

A manager need not prefer the point at the left end of the curve, the point for which the danger contact index is minimized. A manager might favor another point on the curve, tolerating a higher level of the danger contact index to achieve a higher level of the nondanger contact index. In more practical terms, a manager might choose a pattern of use that has a higher probability of people seeing grizzlies in nondangerous situations. The price for this decision, however, would be more chances of encounters with grizzlies in dangerous situations. As can be seen from the shape of the curve, the trade-off is reasonably attractive over a range but becomes progressively less attractive along the curve to the right. By examining these types of figures, a manager can see the trade-off between 2 management objectives (measures of dangerous and nondangerous contacts), holding constant the volume of use and campsite capacity definition.

Even more valuable information can be displayed for the manager by plotting several related curves on the same axes, holding only 1 thing constant. Fig. 5 shows trade-off possibility frontiers for capacity definition THREE with alternative volumes of use (6,000 and 7,000 party-nights). Fig. 6 shows comparable results for capacity definition FOUR. Of course, there is no need to hold the capacity definition constant. Fig. 7 presents curves for alternative campsite capacity definitions for a constant volume of use (6,000 party-nights). In any of these multiple-curve figures for Model 2, a manager can explore the trade-offs among 3 objectives. By examining 2 or more related plots iteratively, trade-offs among 4 objectives can be evaluated.

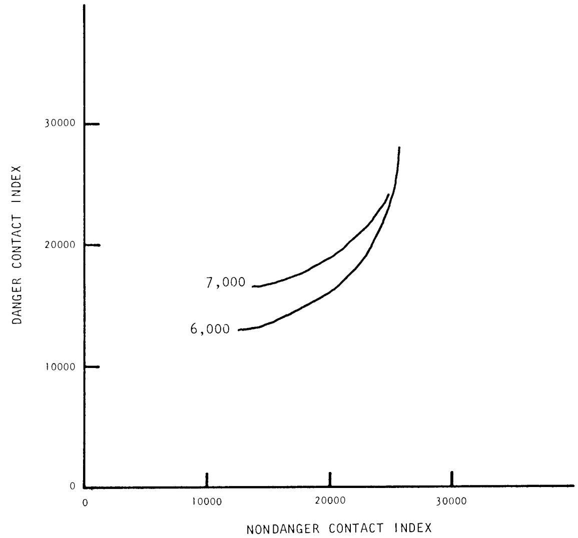

Fig. 6. Model 2 trade-off possibility frontiers for campsite capacity definition FOUR and alternative volumes of use.

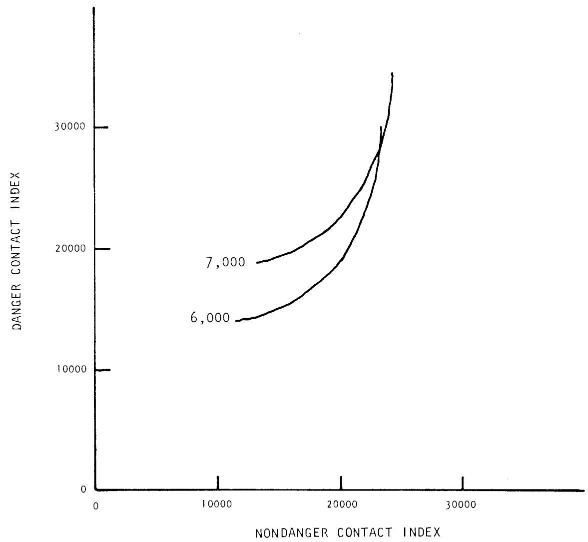

Fig. 5. Model 2 trade-off possibility frontiers for campsite capacity definition THREE and alternative volumes of use.

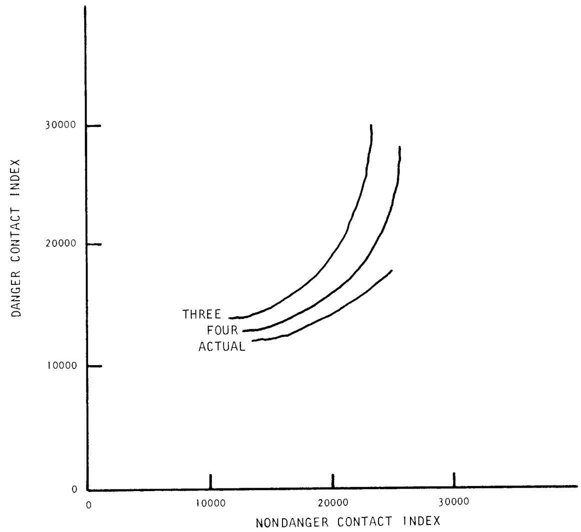

Fig. 7. Model 2 trade-off possibility frontiers for alternative campsite capacity definitions and a volume of use equal to 6,000 party-nights.

DISCUSSION

The results presented above show some of the information that these management models can provide. Other information available includes the pattern of use by season for each trailhead, campsite, and trail segment. The change in the objective function that would result from altering the capacity of any campsite or trailhead is also determined. Modification of the models would permit consideration of such topics as the impact of changes in the trail network or in the set of designated backcountry campsites and evaluation of backcountry day use.

Contact rates that are specific to locations and time periods are clearly a critical element for models of this type. Use of contact indices had the advantage of exploring the feasibility of various mathematical management models as well as demonstrating the kinds of information these models can provide. The indices included in one fashion or another most factors that are suspected to be related to encounters between humans and grizzlies. Nevertheless, indices are no substitute for contact rates. Estimation of these rates would be a significant step forward in providing managers with information they could use in helping visitors plan their backcountry journeys. In this way, people can be advised of possible trips that would meet their objectives while simultaneously encouraging a pattern of use that poses fewer problems for the grizzlies.

The capacity to explore trade-offs among objectives would remove neither the opportunity nor the obligation for a manager to exercise professional judgement in considering alternative volumes and distributions of use. It would, however, allow necessary and difficult decisions to be made with much more relevant information than is currently available.

LITERATURE CITED

CRAIGHEAD, J. J., AND F. C. CRAIGHEAD, JR. 1967. Management of bears in Yellowstone National Park. Report to the Office of Natural Sciences, National Park Service. 113pp. (Mimeogr.)

HERRERO, S. 1970a. Man and the grizzly bear (present, past, but future?). BioScience 20(21):1148-1153.

———. 1970b. Human injury inflicted by grizzly bears. Science 170(3958):593-598.

———. 1976. Conflicts between man and grizzly bears in the national parks of North America. Pages 121-145 *in* M. R. Pelton, J. W. Lentfer, and G. E. Folk, Jr., eds. Bears — their biology and management. IUCN Publ. New Ser. 40.

LUCAS, R. C. 1973. Wilderness: a management framework. J. Soil and Water Conserv. 28(4):150-154.

———. 1974. Forest Service research in the Rockies, what we've learned so far. Western Wildlands 1(2):5-12.

MARTINKA, C. J. 1972. Habitat relationships of grizzly bears in Glacier National Park, Montana. Natl. Park Serv. Prog. Rep. 19pp. (Mimeogr.).

———. 1974a. Population characteristics of grizzly bears in Glacier National Park, Montana. J. Mammal. 55(1):21-29.

———. 1974b. Preserving the natural status of grizzlies in Glacier National Park. Wildl. Soc. Bull. 2(1):13-17.

MERRILL, E. 1976. Factors affecting depredations on backcountry campgrounds by bears in Glacier National Park. Glacier Natl. Park Proj. Compl. Rep. 12pp. (Mimeogr.)

MOMENT, G. B. 1970. Man-grizzly problems — past and present implications for endangered species. BioScience 20(21):1142-1144.

MUNDY, K. R. D., AND D. R. FLOOK. 1973. Background for managing grizzly bears in the national parks of Canada. Can. Wildl. Serv. Rep. Ser. 22. 35pp.

NATIONAL ACADEMY OF SCIENCES. 1974. Report of the committee on the Yellowstone grizzly. 61pp. (Mimeogr.)

SINGER, F. J. 1976. Seasonal concentrations of grizzly bears and notes on other predators in the North Fork of the Flathead River. Glacier Natl. Park Res. Note 2. 19pp.

STANKEY, G. H. 1973. Visitor perception of wilderness recreation carrying capacity. USDA For. Serv. Res. Pap. INT-42. 61pp.

STUART, T. W. 1977. Multiobjective analysis of wilderness travel in grizzly bear habitat using parametric linear programming. Ph.D. Dissertation. Univ. of California, Berkeley. 241pp.