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# A RECREATIONAL VISITOR TRAVEL SIMULATION MODEL AS AN AID TO MANAGEMENT PLANNING

by

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## SUMMARY

A simulation model for dispersed recreation areas has been developed that provides a means for experimenting with modifications of use or area conditions to determine effects on use patterns and encounters between visitor groups. The model, the results of a test of it, and potential future applications are discussed.

Un modèle de simulation du comportement des usagers de sites de loisirs donnant des façons d'expérimentations avec les modifications dues aux diverses utilisations ou aux conditions de terrain permettant de déterminer des patterns d'usage et de rencontres entre groupes d'usagers a été mis au point.

Le modèle, les résultats du test afférant et ses futures applications possibles sont en discussion.

Es wurde ein Simulationsmodell für verstreut liegende Erholungsgebiete entwickelt welches die Möglichkeit bietet mit veränderten Nutzungen oder Verhältnissen im Gebiet zu experimentieren mit dem Ziel Auswirkungen auf Verwendungsart und Zusammentreffen von Besuchergruppen bestimmen zu können. Das Modell, die Ergebnisse der Modell-tests und künftige Anwendungsmöglichkeiten werden besprochen.

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[1]Dr. Shechter was a visiting scholar at Resources for the Future, of Washington, D.C., when he was associated with the project described in this paper.

# INTRODUCTION

Numbers of people visiting most kinds of outdoor recreation areas continue to grow. This growth often creates problems for management, with the nature of the problems depending on the type of area and the management objectives established for it. In the United States, growth in use of dispersed recreation areas has been rapid (Lloyd and Fischer 1972) and the resulting problems of congestion and resource damage have been difficult for managers to solve. These problems have been particularly severe on lands established as wilderness. Wilderness, by law, is to be managed to permit natural ecological processes to operate without alteration by modern man and also to provide visitors with "outstanding opportunities for solitude."

Growth in the number of visits to wilderness increased about 15-fold from 1950 to 1975, threatening both natural ecosystems and the experience of solitude. Poor distribution of use, both in space and time, is common and accentuates the problems of congestion and ecosystem damage. Studies of the distribution of wilderness use show that very uneven use patterns are the general rule; use is heavily concentrated on certain portions of each area while larger portions receive little use. Similarly, a few summer weekends usually experience sharp peaks in use. Redistribution of some use seems to offer considerable hope for reducing the adverse effects of heavy use.

In addition to the legal objectives for wilderness, research has shown that visitor satisfaction is influenced substantially by the types of encounters with other visitors and that visitors report strong preferences for low levels of encounters (Stankey 1973). Therefore, managers of wildernesses receiving heavy use are beginning to take actions to modify or control use. Both the National Parks and the National Forests are rationing use of some areas. In some cases this is done by limiting the numbers of visitors permitted to enter each day at various access points. In other areas, managers set nightly capacities for all camping areas and require visitors to establish and adhere to rigid itineraries that will not result in the campsite capacities being exceeded. If this is impossible, the party is not permitted to visit the area at that time. In a few other areas, managers have attempted to influence visitors to voluntarily shift their use to other areas or times through educational pamphlets and personal contacts.

However, all the managerial actions, except the establishment of rigid itineraries (which have other problems discussed below), suffer from a major flaw. The manager's objective is to reduce use at overused locations, and to avoid excessive levels of various types of encounters (on trails, at campsites, etc.). However, there has been no way to relate changes in total use or redistribution of use to the number of encounters per party or to the amount of use of particular places within a wilderness. The complexity of travel routes, which characteristically overlap and intertwine, and the variability in travel decisions are so great that neither intuition nor analytic solutions are useful predictors of the variables of interest for a given amount of use.

The rigid itineraries do provide a more determinate result, at least for use of key locations and encounters between camping parties, but not for encounters between parties while traveling on the trails. For many reasons (weather, illness, over-ambitious planning, etc.) not all parties adhere to their itinerary, so results are not as determinate as they seem. More important, such close control of movements seems to detract from the visitors' experiences of adventure, exploration, and spontaneity, and to transplant the structure of modern urban life to the wilderness setting intended to offer release from civilization's pressures. In general, research has indicated that a desire to escape civilization is a major motivation for wilderness visits. Furthermore, most visitors feel assigning itineraries is a highly undesirable approach to use control (Stankey 1973).

If use pressures and encounters resulting from any given use level and pattern cannot be predicted, experimentation through trial and error is an apparent alternative. However, trial and error is not an effective approach. It is very time consuming; managers would have to try a policy for a year or more to see how it worked. Results for any 1 year could be heavily influenced by uncontrolled outside factors such as weather. Detailed information on use patterns and encounters would be available only if special studies monitored the area. It would not always be possible to create the use pattern the managers desired to test. For example, if managers wanted to know the effect of a doubling in use, there probably would be no practical way to cause this much use in the short run. At least three sorts of high costs could also result from a trial and error approach to use management. First, serious long-lasting or even irreversible damage to resources might result from tests of heavy use. Second, many visitor benefits could be sacrificed, either through testing excessive use levels that seriously reduced the quality of visitors' experiences or through testing low levels of use that resulted in many people being denied entrance. Finally, frequent, major changes in use policies could lead to controversy and severe public relations problems.

Systems that are too complex for analytic solutions and not suited to real-world experimentation are often approached by simulation modeling (Shechter 1971). Therefore, a wilderness travel simulation model was developed to provide a better way to formulate and evaluate use management policies. The simulation model provides a practical way to test use patterns quickly. Variability in visitor behavior is incorporated in the model, but, in just a few minutes use can be simulated for an entire season or a number of seasons. The model records and displays in appropriate formats all the desired information on use and encounters. Because the experimentation takes place in the computer instead of the real world, we avoid the high social costs. Even the most extreme patterns can be tested without damage to precious resources.

Travel simulation models are common, but the requirements for the wilderness model were quite different. In particular, the interest in encounters was unique. Therefore, the United States Department of Agriculture, Forest Service, entered into a cooperative research agreement with Resources for the Future, complementing ongoing research at RFF, to develop a general use simulation model for wilderness-type areas. Resources for the Future involved specialists from International Business Machines, Inc. in the project.[2] The model has been developed, modified and refined, and has been field tested.

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[2]Dr. Kerry Smith of Resources for the Future and David Webster and Norman Heck of IBM constructed and programed the original version of the model. Dr. John V. Krutilla of RFF initiated the project and he, Smith, Dr. Charles Cicchetti, and Dr. Anthony Fisher all contributed to the initial conceptualization. See Fisher and Krutilla 1972; Smith, Webster, and Heck 1974; Smith and Krutilla 1974.

This paper will briefly describe the model, some results of the field tests, and present our conclusions about future applications.

## A GENERAL DESCRIPTION OF THE SIMULATOR

All simulation models are simplified abstractions of complex, real-world processes. However, the wilderness travel simulator quite realistically embodies the main characteristics of wilderness visitor movements and interactions.

The computer program for the model generates visiting parties who arrive at the area at various simulated dates and clock times, enter at particular access points, select routes of travel and move along them. The simulated parties may overtake and pass slower parties moving in the same direction (overtaking encounters), pass parties moving in the opposite direction (meeting encounters), or pass by parties camped in areas visible from trails or other travel routes, such as rivers (visual encounters). Parties that stay overnight select campsites which they may or may not share with other camping parties (camp encounters are recorded when they occur). On an ensuing day, camping parties leave the campsite and continue on their chosen routes, and eventually leave the area.

There are four important components to the model implicit in this description. They are:

1. Route network.--This consists of entry points, segments of trails or other travel routes, and camping areas.

2. User characteristics.--Simulated parties have been differentiated by size and method of travel (hiking or horseback in one application and by boat type in another). Arrival timing patterns, travel speed, etc., can vary depending on the type of party.

3. User-route interactions.--Route selection can vary between party types, as can travel time in each direction over different trail segments.

4. User-user interactions.--These are the four types of encounters described above.

To make the model operational, data are needed on the area and its use. The travel network must be known, and something about how different types of visitors behave within it--their patterns of arrival, various routes followed and relative popularity of each, travel speeds, and so on. This information is supplied to the model in probabilistic terms.

The simulator provides detailed output information for each individual simulation of a particular use situation or "scenario." Since part of the input data is of a probabilistic nature, the model has the facility of producing summaries of a series of replications of any such "scenario," providing average values of various performance measures, such as the amount, character, distribution, and timing of use. For example, the number of parties of each type using each trail segment is provided (if desired, even on a daily basis in one of the three versions of the model). Additional information is available on the number of encounters by type of encounter, by type of party (classified by mode of travel or by length of stay), and by individual trail segments and campsites (again, in one version, on a day-to-day basis).

The model is coded in the IBM-originated language GPSS, version V. (GPSS stands for General Purpose Simulation System.) The model to date has been successfully operated on IBM's 360 and 370 series of computers as well as Control Data Corporation's 6600 computer. A version adapted to the Univac 1108 computer should be completed soon. A Users Manual (Shechter 1975) is available.[3]

## RESULTS OF FIELD TESTS

The model has been field tested in two areas, the Desolation Wilderness on the Eldorado National Forest in California, and Dinosaur National Monument (a National Park Service area) in Colorado and Utah.[4] The Desolation Wilderness is a high, mountainous, lake-dotted area of about 26,000 hectares, that is very heavily visited.[5]

The Green and Yampa Rivers in Dinosaur National Monument are fast-flowing, "white-water" rivers that visitors float in boats, kayaks, and rafts. Use is much lighter than in the Desolation Wilderness.

Special sample surveys provided the needed input information on use and visitor behavior. In the Desolation, visitors kept travel logs while in Dinosaur, visitors and professional boatmen on commercially guided trips kept logs to supplement National Park use data. In both studies, information was recorded on encounters.

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[3]Single copies are available from Robert C. Lucas, Forestry Sciences Laboratory, Drawer G, Missoula, MT 59801, USA, until the manual and all programs become available from the National Technical Information Service, United States Department of Commerce, 5258 Port Royal Road, Springfield, VA 22151, USA.

[4]The application to the Desolation Wilderness was a joint venture of USDA Forest Service Research and National Forest managers and Resources for the Future, including the present authors. The Dinosaur National Monument application involved the National Park Service; Dr. David W. Lime of Forest Service North Central Forest Experiment Station, St. Paul, Minnesota; and Professor Stephen F. McCool, Utah State University, Logan, Utah. A paper by McCool and Lime, "The Wilderness Area Travel Simulator: Applications to River Recreation Management," 1976, is available from them.

[5]A monograph describing the results of the Desolation Wilderness application is being written by Shechter and Lucas and should be available in 1977.

In both areas, the first scenario was the existing situation, or "base case." One week of peak use was simulated. A 1-week initialization period achieved a realistic starting condition. Simulation results were compared to data from the user surveys as one check on model validity, both for use patterns and encounters. Agreement was good, particularly in Dinosaur National Monument where more precise information on use characteristics and travel routes was collected and used in the model. In the Desolation, encounters were somewhat higher for the model than reported by visitors, for a variety of reasons. Several minor simplifications or departures from reality had compounded effects, but probably the most important cause was that the limited number of visitor travel routes used in the model (210 different routes) fell short of reflecting how variable visitor movements really were and resulted in slight over-concentrations of parties which increased encounters. On the rivers, where there were fewer entry points and possible variation in routes was less, this problem decreased.

Next, a variety of scenarios were tested. Use was increased and decreased by varying amounts and uneven distributions were made more even by shifting use from popular entries to less-used access points, and from heavily used weekends to weekdays.

Some clear relationships, not all expected, emerged. Changes in total use (all other things remaining the same) produced proportionate results. That this would be true for use patterns is probably obvious; if total use doubles, use of any specific location doubles, on the average. Encounters, expressed in per-party-per-day terms, also would double in this example, which was not entirely expected.

This predictable, proportional relationship provides a convenient base for comparing results of more complex scenarios in which use is redistributed with an across-the-board change with the same total use. The use redistribution scenarios produced lower average encounters per-party-per-day than the same total use without redistribution. This was especially true for trail encounters (up to one-third fewer encounters than comparable across-the-board total use). Camp encounters dropped only a little below comparable unmodified use, persumably because campsites were somewhat limited and most parties camped in about the same areas out of necessity even though they arrived by different routes or at different times.

Average encounters do not tell the whole story, however. The frequency of extreme encounter levels (very high levels, especially, but, sometimes also very low and zero levels) changed substantially. A manager probably would be more concerned about reducing or eliminating experiences of unsatisfactory quality than altering averages. In addition, changes at key trouble spots were even more pronounced. This also would probably be more relevant to a manager's evaluation of the results of a scenario than overall averages.

## CONCLUSIONS FOR POTENTIAL FUTURE APPLICATIONS

We conclude that the simulator is a useful tool for the manager of a wilderness or similar area. The model does not, of course, make decisions for the manager. It does, however, enable the likely results of various possible alternatives to be compared carefully before any decision to implement a use management plan is made. This makes it much more likely that the plan chosen will achieve management objectives and that public benefits will be maximized.

It also appears to us that it provides a practical way to achieve desired conditions in terms of the amount of use of key areas and the quality of visitor experiences in terms of congestion or solitude but without requiring tight control of visitor itineraries.

We feel that the simulator should be applicable to many other sorts of dispersed recreation systems besides U.S. wilderness. In fact, we suspect imaginative applications to some very different situations might be possible and useful. The elements in the model are perfectly general. For instance, what we have named "trail segments" are, in general, "transportation linkages" and could represent any type of movement; for example, traffic on park roads or bicycle paths. The model provides for six types of "transactions" (the general GPSS term for the entities whose behavior is simulated). We have usually named them large, medium, or small hiking or horseback groups of visitors, but any designation is possible. Perhaps one type might even represent some kind of wildlife (say, elephants) if their movements could be described in probabilistic terms, and "encounters" would become "wildlife observations," and the managers' goal might be to increase, rather than decrease, encounters.

Certainly, the model is clearly applicable to any type of dispersed recreation area where visitor flows are of concern, where there are capacity constraints, where visitor encounters are significant, and where it is desired to allow visitors substantial freedom to move about flexibly. In such situations, the model is particularly well-suited to management planning to modify use, that is, to alter numbers of visitors entering at different places and times. The model can also be used to test effects of alterations within the area, such as new access points, closure of some travel routes, addition of campsites, and so on. However, to simulate such changes, a basis for specifying how visitors will respond to the new conditions is needed. Observation of current behavior cannot directly provide this basis, and other kinds of special information or assumptions based on expert judgment would be required.

The use of computer-based simulation modeling in outdoor recreation management planning may arouse fears of depersonalization. On the contrary, it may help make it possible to maintain the traditional values of recreational visitor independence, flexibility, and spontaneity as well as to protect resources and experience quality in the face of growing demands on limited resources.

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