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Simulation of Recreational Use for Park and Wilderness Management

Mordechai Shechter and Robert C. Lucas

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Publisher's note

The publisher has made every effort to ensure the quality of this reprint, but points out that some imperfections in the original copies may be apparent.

This work was begun in the natural environments program at RFF under the direction of John V. Krutilla. This program is now part of the quality of the environment division, Walter O. Spofford, director. The research was conducted under a Forest Service-Resources for the Future Cooperative Research Agreement. Robert C. Lucas is project leader, USDA Forest Service, Intermountain Forest and Range Experiment Station, Missoula, Montana. Mordechai Shechter is associate professor and chairman of the department of economics, University of Haifa and a senior researcher at the Center for Urban and Regional Studies, Technion-Israel Institute of Technology, Haifa, Israel. The book was edited by Ruth B. Haas.

RFF editors: Joan R. Tron, Ruth B. Haas, Jo Hinkel, Sally Skillings

The Buddha, the Godhead, resides quite as comfortably in the circuits of a digital computer or the gears of a cycle transmission as he does at the top of a mountain or in the petals of a flower.

Robert M. Pirsig
Zen and the Art of Motorcycle Maintenance: An Inquiry Into Values

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FOREWORD

Resources for the Future's interest in the problem of defining the optimal capacity for low density, wilderness recreation resources began with the problem Clifford Russell and I confronted in attempting to compare the value of the Hells Canyon reach of the Snake River as a source of electricity with its value as a source of amenity services incompatible with hydroelectric development. Some constraints on use are necessary if the amenity value of a given wilderness tract is to be maximized. In the course of developing a cost-benefit analysis for the Hells Canyon hearings, we arrived at these constraints pragmatically, through "expert opinion," a method often used in adversary proceedings.

Later an invitation to spend the summer of 1970 as visiting scientist at the Forestry Sciences Laboratory of the USDA Forest Service in Missoula gave me the opportunity to meet with George Stankey and Bob Lucas of the Forest Service's Wilderness Research Project for long talks on the nature of wilderness recreation, its purpose as defined by statute, and the character of those users of wilderness amenity services whose values are consistent with the values and objectives of the Wilderness Acts. Benefiting from these discussions, Tony Fisher and I attempted to conceptualize the problem of determining the optimal capacity of a low density recreation resource. If the recreational services associated with a wilderness environment are to compete on equal terms with demands for other services of such land (for example, extraction of primary commodities, or high density recreational use), it is important that the intensity and character of recreational uses be managed in a way that maximizes the yield of the wilderness area so that it can be compared fairly with the optimal yield of other uses that may permanently alter the character of the area.

We found that the benefits of a wilderness outing were a decreasing function of expected frequency of encounters, by type, place, and circumstance. Two research tasks then became apparent. One was the empirical evaluation of the relation between the benefits enjoyed by a wilderness recreation party and the frequency with which they encountered other parties. Lucas and Stankey kindly lent us their list of surveyed users of the Spanish Peaks

Primitive Area and helped Charles Cicchetti and Kerry Smith design a questionnaire and pretest it in order to develop the data that would permit an estimation of the relationship between benefits and expected frequency of encounter by type, place, and circumstances.

The complementary task consisted of developing a model that would simulate the travel behavior of wilderness users so that we could estimate expected frequency of encounters as a function of increased intensity of use. This model was developed and implemented in a prototype application in the Spanish Peaks.

The Forest Service was then approached to determine whether the National Forest System, that is, the management, as contrasted with the research branch, would be interested in a large-scale test of the results in the field. In this the Forest Service was as forthcoming as it had been in assisting with funding of the basic research and simulator development.

A Forest Service team was formed under the leadership of Bob Lucas to test the simulator in the Desolation Wilderness of California. It included RFF and Forest Service research personnel and the staff and the "on the ground" management personnel of Region 5. What started out to be an "extension service," or simple technology transfer project to acquaint management personnel with research tools, became a combination management application and R and D project in its own right.

The Desolation Wilderness is one of the most densely used areas in the National Forest Wilderness System. It is used so heavily that the number of parties which were to be tracked exceeded the core capacity of the computer as the simulator was then programmed. This problem was solved ingeniously by Mordechai Shechter, who partitioned the wilderness trip by day, carrying over the relevant information, yet beginning anew each day the cumulative recording of encounters by party and type. A second innovation introduced during this field application was the addition of an algorithm to record an overlooked type of encounter in the Smith-Krutilla simulator, that is, the encounter experienced when parties are visible to each other although they are not occupying the same facility (trail segment or campground). Accordingly, what was naively perceived at the outset as a routine "extension" service turned out to involve the further development and expansion of the simulator's capacity and versatility.

This study by Lucas and Shechter is notable not only for its ingenuity in handling previously unanticipated difficulties when extremely high densities (for wilderness recreation tracts) were encountered, but also for the authors' conscientious efforts to present the material in a didactive mode for benefit of the ultimate users, that is, the managers of wildlands and low-density recrea-

tion resources, rather than for fellow researchers or colleagues in academe. In this, as well as other aspects, I am confident their success will be apparent to the reader. Indeed, the simplicity and clarity of their writing commends itself to students, whether they be managers of wildlands recreation or members of recreation curricula taught in association with forestry, wildlife, resource management, or outdoor recreation programs.

Nearly ten years have elapsed since attention was first drawn to concerns about "carrying capacity" and "optimal use density" of low-density recreational resource facilities and the publication of this study by Lucas and Shechter. It is gratifying to observe how ideas which have grown out of practical resource management problems have progressed through conceptual models to operational tools and finally to application in actual public land management settings. It is similarly rewarding to see the work being adapted for use by the National Park Service and other agencies at home and abroad. This experience over a decade may be a prototype in continuing private and government research collaboration and further collaboration between the research and the practicing community. It demonstrates that a congenial and productive association can be developed between the specialists of several disciplines and members of different organizations who have a contribution to make to a complex public land management problem.

January 1979

John V. Krutilla
Resources for the Future

ACKNOWLEDGMENTS

The wilderness use simulation model that is the subject of this book was a cooperative effort by the Forest Service of the U.S. Department of Agriculture, and Resources for the Future, and we gratefully acknowledge the contributions of people associated with both organizations.

John Krutilla of Resources for the Future initiated the development of the simulator and provided the encouragement, advice, and stimulation necessary to complete the project. He played the central role in coordinating at RFF a complex and lengthy undertaking that has as its basis a conceptual model of wilderness recreation that bears his mark, and those of Kerry Smith, Charles Cicchetti, and Anthony Fisher.

Kerry Smith also participated actively in the development of the first prototype simulation model, and together with John Krutilla, in its application to the Spanish Peaks Primitive Area. Both Kerry Smith and John Krutilla helped teach recreation managers about the use of the model at several workshops and reviewed this book in manuscript.

We wanted the simulator to be used in management planning if it proved to be valid and useful. Therefore, a pilot test application was carried out on a complex, real management problem—the preparation by the Forest Service of a revised management plan for the Desolation Wilderness in California. The field test and the further development of the simulator were made possible by the financial support of the Washington office of the Forest Service. Further support from the California Region of the Forest Service made it possible to gather detailed data on the recreational use of the Desolation Wilderness. Alan Lamb, director of recreation for the California Region, was instrumental in providing this support and other essential cooperation.

David Webster with Norman Heck of International Business Machines, Inc. worked with RFF to program the prototype model. Dave also consulted on revisions incorporated into the version of the model reported on here, and taught at the simulation workshop in San Francisco. Pathana Thananart of the computer services section at RFF developed the output summary programs that are a new feature, making the simulator a more useful management aid.

Martin Wefald of the California Region carried out many of the computer runs and helped develop the summary programs. He served on the field test team, which included Carl Westrate, Philip Corson, Robert Jensen, Clyde Carter, and Michael Goggin from the Forest Service, and Jan van Wagtendonk from Yosemite National Park, who also wrote an appendix to this book. All of these team members contributed greatly to the effort. They helped gather use data, plan use policy scenarios for simulation, conduct simulations, and discuss results. They even coded information and punched computer cards well into the night. They provided suggestions for further improvements in the simulator. A suggestion by Jan van Wagtendonk led to the development of a new output table that related areas of visitor congestion to the access points where the visitors originated and aided in the development of corrective policies. All of the team members also served as instructors in the San Francisco simulator workshop, and all reviewed the manuscript for this book.

MaryAlice Taylor, forestry research technician, oversaw the field work and supervised data tabulation. She hiked most of the trails in the Desolation Wilderness to help estimate visitors' travel times.

David Lime and Dorothy Anderson at the North Central Forest Experiment Station, St. Paul, Minn., and Stephen McCool, University of Montana, prepared the chapter on applying the simulator to a river setting.

In addition to the reviewers listed above, the manuscript was reviewed by John Schomaker, Gary Elsner, David Lime, Stephen McCool, Dorothy Anderson, George Stankey, Richard Griswold, Wendell Beardsley, William Watson, and Ronald Cummings.

Bryan Owen prepared all of the illustrations in the book with skill, promptness, and good humor, which are much appreciated. Cynthia Crane typed the manuscript accurately and quickly and always was a pleasure to deal with. Ruth Haas edited the book and let the light shine through much of our more opaque writing.

Finally, we thank the thousands of visitors to the Desolation Wilderness who took the time, while trying to temporarily escape the hectic demands of urban life with all of its paperwork, to provide the information about their trips that we requested.

January 1979

Mordechai Shechter
Robert C. Lucas

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CHAPTER 1

INTRODUCTION

THE ISSUES

Wilderness remains wilderness only as long as man and his traces are few. Two conditions are necessary for an area to qualify as wilderness—essentially unmodified natural ecosystems and outstanding opportunities for solitude.

Both of these qualities are specified in the two Wilderness Acts in the United States, and are also prominent in public attitudes and perceptions. The policies of the agencies responsible for managing these wilderness areas stress these conditions, and management plans for individual areas focus on ways of protecting both.

By early 1978, 175 areas and 16.6 million acres (6.7 million hectares) had been legally designated as wilderness. For these areas, which are located in 39 of the 50 states, the threat of degradation of natural ecological conditions and loss of opportunities for solitude comes almost entirely from recreational visitors. Many other areas, although not officially established as wilderness, also are valuable for low-density recreation. Maintaining natural conditions may not be a critical management goal in all these areas, but some desired level of solitude is, and, again, overuse is the threat.

It is widely recognized that a wilderness has a limited carrying capacity which cannot be exceeded without destroying the qualities that characterize it. Management of recreational use is essential to protect wilderness qualities, but such management is a difficult challenge. The Wilderness Use Simulation Model presented in this book (usually referred to hereafter simply as "the simulator" or by the initials "WUSM") is one tool for strengthening management of wilderness use.

For readers unfamiliar with American wilderness, some background may be helpful. Starting in the 1920s, areas in the national forests were administratively designated as primitive areas, wild areas, or wilderness. Later, legislation (Public Law 88–577, 1964) endorsed and extended wilder-

ness classification to include national parks and wildlife refuges. Wilderness areas were designated in the longer settled and more extensively developed eastern states still later (Public Law 93-622, 1975). Many wilderness areas are large—often from 100,000 to over 1 million acres or about 40,000 to 400,000 hectares—and most are in mountainous regions in the western United States. These areas serve as nature preserves but have always also had great importance as recreation areas. They are most commonly used for hiking, often just for the day, but other times for several days or a week or two, which involves overnight camping, usually at campsites with little or no development. Simple trails wind through the areas. Some visitors travel on horses, and, in a few areas, by boat, raft, kayak, or canoe. There is some winter use on skis or snowshoes. Generally, roads, commodity production, permanent residences, and use of mechanical devices are prohibited. For a good description of many of these areas, their use, and some of their management problems, see *Wilderness U.S.A.*, published by the National Geographic Society (1973). Many other countries have roadless recreation areas, often in national parks or nature reserves, which share many of these features and problems.

THE NEED FOR WILDERNESS USE MANAGEMENT

The recreational use of wilderness has been growing steadily for many years. Figures for national forest wilderness, which includes most U.S. wilderness, show an average annual increase in use of just over 7 percent for 1960–75. From 1946 to 1959, the average annual increase was almost 15 percent.[1] Figures available for the wild backcountry of some national parks for various periods also show rapid increases in use. For example, backcountry use of Rocky Mountain National Park increased over 700 percent in the past ten years.[2] Shenandoah National Park's backcountry use quadrupled from 1967 to 1974.[3] A continued growth in the numbers of people visiting wilderness and similar areas is expected in the future, and even if the growth rate is less spectacular than in the past, it will intensify the need for management of use. Even if use should level off, as it eventually will, the need for skillful, professional management will still exist.

[1] From annual reports on "Use of National Forest Units, National Wilderness Preservation System," USDA Forest Service, Washington Office.

[2] From *National Parks and Conservation Magazine*, February 1976, p. 21.

[3] From presentation by Superintendent Robert R. Jacobsen at 20th meeting of the Appalachian Trail Conference, June 22, 1975.

Use of individual wildernesses varies greatly. Visitor-days[4] per acre for national forest wildernesses vary from a low of 0.01 to a high of 7.59, a 750 to 1 range. (See table 4-1 in chapter 4 for some examples of use intensities for various wildernesses.) In many areas, use pressures are high, and there is general agreement that excessive use is damaging natural conditions or eliminating solitude, or, in most cases, harming both. The distribution of recreational use within a particular wilderness is also usually very uneven. Many of the areas not heavily used in total still have parts that are crowded, with resulting loss or reduction of wilderness qualities.

Research on how visitor use affects ecosystems leaves no doubt that damage to natural conditions is a problem. Studies so far show that a small amount of use usually has a large initial impact on soils and ground cover vegetation, but that additional use has proportionately less and less impact (Merriam and coauthors, 1973; Frissell and Duncan, 1965; Bell and Bliss, 1973; Dale and Weaver, 1974). Damage can occur quickly, but recovery is slow. Water quality may be affected by recreational use in a more linear manner, although changes appear small, but research is scanty (Merriam and coauthors, 1973; McFeters, 1975). The effect of recreation on wildlife is virtually unstudied (Stankey and Lime, 1973). Current knowledge identifies no obvious, critical use level or naturally occurring threshold on which to base ecological carrying capacities. Professional managerial judgment will be needed to determine how much change in natural conditions can be accepted as consistent with wilderness management objectives (Frissell and Stankey, 1972). The severity of impacts and the ability of the ecosystem to recover are the main issues. Much of the potential management response to visitor impacts probably will involve closing trails and campsites located on fragile lands and relocating them to more durable settings where possible (Helgath, 1975). Water quality may be managed by changing methods for disposal of human wastes. Still, for many specific places, managers will need to set upper limits on use to keep environmental impacts to acceptable levels.

Studies of wilderness visitors' desires and attitudes concerning solitude also support the conclusion that overuse can damage wilderness experiences. Solitude, or more precisely, meeting few other parties, is an important appeal of wilderness for most visitors (Stankey, 1973). More use and more encounters with other groups result in less expressed satisfaction, but many factors interact to modify the effect of encounters on the quality of the

[4] A visitor-day is defined as one visitor present for 12 hours, continuously, or intermittently, or two persons for 6 hours each, or any equivalent combination.

experience. Most visitors prefer a campsite out of sight and sound of other visitors, but tolerate a few encounters on the trail before their reported satisfaction drops much. Encounters are more acceptable close to entry points than in the interior of a wilderness. Large parties disrupt solitude far more than small groups do. Some hikers object to meeting visitors traveling with horses.

Wilderness visitor studies indicate there is a sort of tradeoff between quantity (number of visitors) and quality (satisfaction with the experience). We can think of this in terms of diminishing returns. Total benefits would rise as use increased at low levels, because more people would enjoy the area, and enjoyment or benefits per visitor would remain high. But, at some point, increasing use would result in congestion and enough encounters to reduce the benefits per visitor so much that total benefits level off. Continued increases in use would lower total benefits (Fisher and Krutilla, 1972).[5]

Perhaps a simple, numerical example will clarify the idea. Imagine a wilderness where the value or benefits of a visitor's experience can be measured for a variety of possible use levels. How it is measured or what the units are, we can leave to the imagination (of course, it could even be how much people would be willing to pay to enter):

Number of visitor-days	*Value of a visitor-day*	*Total value (No. of visitor-days times value)*
1,000	10	10,000
2,000	9	18,000
3,000	8	24,000
4,000	7	28,000
5,000	5	25,000
6,000	3	18,000
7,000	2	14,000
8,000	1	8,000

[5] This is true for a given population of recreationists at a particular time. However, over time, increasing use and encounters also can be associated with continuing high satisfaction as visitors seeking solitude abandon the area and are replaced by visitors who are more tolerant of heavy use. Although expressed satisfaction might remain high, the recreation experience provided has shifted to a different category, one which may be inconsistent with the established objectives for the area, and one which serves a different clientele. Assuming that an overall recreation policy provides a system of recreation areas, offering a broad, balanced spectrum of different types of opportunities related to public needs, this displacement process seems undesirable. If use is to be managed to preserve the opportunities called for by existing objectives, especially for low-density areas such as wilderness, then the concept of benefits declining beyond some level of use seems valid and relevant to management decision making.