Recreational Impact on Wildlands

Conference Proceedings
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Contains 57 papers concerned with perceptions of impact, research findings, experiences in preventing and remedying impacts, and approaches to future management, research, and role of the wildland user. Emphasis is on physical and biological changes resulting from recreation on wildland.

KEY WORDS: Recreational use, research, dispersed recreation.

Drawings at the end of selected papers
by Ramona Hammerly
from
Northwest Trees
The Mountaineers Books
Seattle, Washington

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This conference and its proceedings were conceived from the thought that solutions to wildland impact problems could be defined and identified by bringing together land managers, recreation users and natural resource researchers.

This was an ambitious goal. The reader will not find in these proceedings any magic panaceas or even a definitive answer as to what constitutes an impact or what level of impact is unacceptable. Conference participants did learn that there are no simple, single answers to these questions, that the only single answer is one that says, "It depends..." Impacts and their acceptance depend upon physical, biological and social factors. And what is acceptable depends to a considerable extent on the management objectives for an area.

The spirit and intent of the conference were well expressed by a 4-wheel drive enthusiast when he confessed that "this is the first time that I have been with other recreationists and managers that I haven't been made to feel the total blame, the bad guy for wildland problems." Recreationists representing diverse activities, resource managers from several different public agencies and researchers working in public agencies, universities and private consulting firms recognized that the first step in identifying, isolating and solving resource damage problems was for everyone to accept responsibility for a share of the problem.

The specific conference objectives were no less ambitious than the goal. These proceedings are dedicated to:

- Understanding different perceptions of impact and their meaning to management.
- Integrating research findings into management practices regarding soil, wildlife, vegetation and changes caused by recreation activities.
- Examining first-hand experiences in efforts to prevent and remedy recreational impacts.
- Suggesting direction for management, research and the user.

The scope of discussion was limited for practical reasons. For example, winter and water-based recreation as well as developed campsite recreation were not featured. Emphasis was placed on the physical and biological changes resulting from wildland recreation. Access methods included foot, horse, trailbike and 4-wheel drive. "Wildlands" included wilderness, backcountry, roadless and roaded areas used for dispersed recreation.

These proceedings reflect the conference objective to approach the issue of recreational impacts on wildlands from a variety of perspectives. The reader will find an introductory philosophical paper followed by the pragmatic experiences of two land managers and a representative of the land-using public. Researchers present technical papers featuring perceptions of recreational impacts and specific findings from studies on soil, vegetation, water/noise and wildlife. No less important are the experiences reported by user and user groups as well as techniques used by field managers for preventing and...
correcting recreation impact on wildlands. The role of education and facility design is explored. These papers focus either on prevention or rehabilitation for dealing with recreational impacts. Finally, an idea exchange treated in the proceedings as papers with extended discussions provides many fruitful suggestions.

It has been the object of the editing process to retain the uniqueness of each author's style while maintaining technical accuracy. We apologize to authors and readers for any shortcomings in reaching this goal.

Many people were responsible for the successful production of the conference and the publication of these proceedings. The steering committee chaired by Dr. David R. M. Scott of the University of Washington worked hard for over a year. Rick Ells, University of Washington graduate student, developed the slide-tape program "Impacts" that so ably set the tone of the conference. Thanks are also due to the many individuals who donated their time and experience during the conference and preparation of proceedings. These people are listed by name in the following pages.

Also deserving particular appreciation are the coordinating agencies and co-sponsors shown on the inside back cover.

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# TABLE OF CONTENTS

## PERCEPTIONS OF RECREATION IMPACTS ON WILDLANDS

David R. M. Scott, Chairman

A philosophical look at recreational impacts on wildlands  
Valerius Geist .................................................. 1

Wildland recreation impact from the National Park Service land manager’s perspective  
Daniel J. Tobin .................................................. 8

Wildland recreational impact from the U.S. Forest Service land manager’s perspective  
Richard F. Buscher ............................................. 11

Recreational impact on wildlands--the user's perspective  
Thomas S. Deans ............................................... 14

Users' and managers' perceptions of dispersed recreation impacts:  
a focus on roaded forest lands  
Kent Downing and Roger N. Clark  .................................. 18

Perceptions of non-motorized recreational impacts:  
a review of research findings  
Robert C. Lucas .............................................. 24

Determining the acceptability of recreational impacts:  
an application of the Outdoor Recreation Opportunity Spectrum  
Roger N. Clark and George H. Stankey .............................. 32

## RESEARCH FINDINGS

Introduction to research findings: summary session  
James K. Agee, Moderator .......................................... 43

### SOIL: Charles C. Grier, Chairman

Role of soil reconnaissance surveys in predicting use-impact susceptibility of wildlands  
T. M. Ballard ................................................... 45

The use of soils information for dispersed recreation planning  
Raymond Leonard and H. J. Plumley ................................... 50

Research on wildland recreation impact in the Canadian Rockies  
Bruce F. Leeson .................................................. 64

Soil factors influencing the quality of wilderness recreation impact  
G. O. Klock and P. D. McColley .................................. 66

### VEGETATION: Jan van Wagendonk, Chairman

Reducing the impact of hikers on vegetation:  
an application of analytical research methods  
David N. Cole .................................................. 71

Experiments on the effects of human urine and trampling on subalpine plants  
Daniel O. Holmes ................................................ 79
An assessment of damage caused by off-road vehicle traffic on subarctic tundra in the Denali Highway area of Alaska
Frank J. Wooding and Stephen D. Sparrow ......................................................... 89

The relationship of trail condition to use, vegetation, user, slope, season and time
Tad Weaver, Donn Dale and E. Hartley ................................................................. 94

Vegetation disturbance by natural factors and visitor impact in the alpine zone of Mt. Rainier National Park: implications for management
Ola M. Edwards ........................................................................................................ 101

WATER AND NOISE: Richard H. van Haagen, Chairman

Human use in a dispersed recreation area and its effect on water quality
Harriet H. Christensen, Robert E. Pacha, Kevin J. Varness and Robert F. Lapen. . . . 107

Predicting off-road vehicle acoustic impact on forest recreation--a simplified method
Robin T. Harrison .................................................................................................... 120

WILDLIFE: Jack Ward Thomas, Chairman

Assessing human impacts in two national park areas of western Texas
David J. Schmidly and Robert B. Ditton ................................................................. 139

Human-wildlife conflicts in backcountry: possible solutions
Catherine H. Ream .................................................................................................. 153

Man-caused mortality of coyotes marked in Grand Teton National Park
Walter M. Tzilkowski and Frederick F. Knowlton .................................................. 164

Management and impacts of roads in relation to elk populations
Richard J. Pedersen ............................................................................................... 169

USER AND USER GROUP TECHNIQUES FOR PREVENTING AND CORRECTING RECREATION IMPACT ON WILDLAND
William B. Beyers, Chairman

Guidebooks -- for better or for worse?
Peggy Ferber ......................................................................................................... 175

An educational alternative: practices for users
Peter Simer .......................................................................................................... 180

Wildland impacts and business responsibility
Ben Hayes ........................................................................................................... 185

Sierra Club wilderness impact study: conclusions and specific findings
John Stanley .......................................................................................................... 189

Efforts of equestrians to protect wildlands
J. Earl Flick ......................................................................................................... 195

Responsible off-road/off-highway vehicle user impact on wildlands
Garrell E. Nicholes ............................................................................................... 199
## EDUCATION AND DESIGN

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<table>
<thead>
<tr>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Human impact inventory and management in the Olympic National Park backcountry</td>
<td>203</td>
</tr>
<tr>
<td>Edward S. Schreiner and Bruce B. Moorhead</td>
<td></td>
</tr>
<tr>
<td>Guidelines for the rehabilitation and preservation of the Appalachian</td>
<td>213</td>
</tr>
<tr>
<td>trail system using the principles of landscape architecture</td>
<td></td>
</tr>
<tr>
<td>William King</td>
<td></td>
</tr>
<tr>
<td>A successful campaign to reduce trail switchback shortcutting</td>
<td>217</td>
</tr>
<tr>
<td>Sandy J. Matheny</td>
<td></td>
</tr>
<tr>
<td>A human approach to reducing wildland impacts</td>
<td>222</td>
</tr>
<tr>
<td>Jim Bradley</td>
<td></td>
</tr>
<tr>
<td>Information and education techniques to improve minimum impact use</td>
<td>227</td>
</tr>
<tr>
<td>knowledge in wilderness areas</td>
<td></td>
</tr>
<tr>
<td>James R. Fazio</td>
<td></td>
</tr>
<tr>
<td>Mt. Rainier backcountry plan: a case study</td>
<td>234</td>
</tr>
<tr>
<td>John Dalle-Molle</td>
<td></td>
</tr>
</tbody>
</table>

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<table>
<thead>
<tr>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mission Mountains: planning for a tribal wilderness</td>
<td>241</td>
</tr>
<tr>
<td>Robert R. Ream, David Rockwell and Richard Flichtler</td>
<td></td>
</tr>
<tr>
<td>Without a trace--a wilderness challenge</td>
<td>248</td>
</tr>
<tr>
<td>Elizabeth L. Horn</td>
<td></td>
</tr>
<tr>
<td>Successful methods of design and construction for managing impact on</td>
<td>250</td>
</tr>
<tr>
<td>trailbike trails</td>
<td></td>
</tr>
<tr>
<td>Joseph J. Wernex</td>
<td></td>
</tr>
<tr>
<td>Visitor access over coastal waterways</td>
<td>253</td>
</tr>
<tr>
<td>J. Thomas Ritter</td>
<td></td>
</tr>
<tr>
<td>Alternative transportation systems for reducing natural resource</td>
<td>257</td>
</tr>
<tr>
<td>impact</td>
<td></td>
</tr>
<tr>
<td>Gary Brown</td>
<td></td>
</tr>
<tr>
<td>McKinley's shuttle bus system and the management of traffic impact on</td>
<td>263</td>
</tr>
<tr>
<td>wildlife</td>
<td></td>
</tr>
<tr>
<td>Frederick C. Dean and Diane M. Tracy</td>
<td></td>
</tr>
</tbody>
</table>

## REHABILITATION

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<table>
<thead>
<tr>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Revegetating the forest zone of North Cascades National Park</td>
<td>271</td>
</tr>
<tr>
<td>William Lester and Sue Calder</td>
<td></td>
</tr>
<tr>
<td>Six years of site restoration at Lyman Lake</td>
<td>276</td>
</tr>
<tr>
<td>Donald L. Mann and Ken Dull</td>
<td></td>
</tr>
<tr>
<td>Image Lake rehabilitation project, Glacier Peak Wilderness</td>
<td>280</td>
</tr>
<tr>
<td>Bernard A. Smith</td>
<td></td>
</tr>
<tr>
<td>Off-road vehicle site restoration</td>
<td>284</td>
</tr>
<tr>
<td>Thomas J. Spolar</td>
<td></td>
</tr>
</tbody>
</table>
Soil and vegetation restoration at the Sunrise developed area, Mt. Rainier National Park
Joseph C. Van Horn ........................................ 286

Predicting human impact on high elevation ecosystems
Roger del Moral. ........................................... 292

Propagation of plant material for subalpine revegetation
Joseph W. Miller and Margaret M. Miller. .................. 304

THE IDEA EXCHANGE
Charles J. Gebler, Moderator

Reaching your publics through television
Charles J. Gebler ........................................ 312

Management problems in off-road-vehicle recreation
Russell Shay. ............................................. 314

Establishing a volunteer wilderness host program
Bernard A. Smith. ....................................... 318

The responsible trail user
Ruth Ittner ............................................... 320

The use of interpretive structural modeling in the context of recreational impact management
James Wise and William Cole .......................... 322

Backcountry horsemen
Loy Robinson, Bob Caldwell and Ken Wilcox .......... 326

Water quality ........................................... 329

Educational programs to reduce impact on wildland
David Timothy Kneeland. .............................. 332

CREATING THE FUTURE: Closing General Session
James Wise, Moderator ............................... 337
A PHILOSOPHICAL LOOK AT RECREATIONAL IMPACT ON WILDLANDS

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ABSTRACT--The overuse of wildlands is a special case of Hardin's tragedy of the commons, in that technical means can ameliorate the effects of this social problem. Technical solutions do not eliminate the causes of overuse, but can only buy time to develop an appropriate political solution. Technical solutions to overuse carry inherent dangers such as distancing users of wildlands from nature by encasing them in a technological cocoon, alienating the constituency of users via overregulation, trivializing recreation and depriving recreationists of the health benefits of recreation, and contrasting the fact that on private lands the economic and social elite can have frustration free recreation. Political solutions to overuse are to expand the available wildlands and to encourage alternatives to wildland recreation. Here a liaison with planners and policy analysts is required.

The National Parks present another instance of the working out of the tragedy of the commons. At present, they are open to all, without limit. The parks themselves are limited in extent--there is only one Yosemite Valley--whereas population seems to grow without limit. The values that visitors seek in the parks are steadily eroded. Plainly, we must soon cease to treat the parks as commons or they will be of no value to anyone.

Garrett Hardin
The Tragedy of the Commons

There has developed in the contemporary natural sciences a recognition that there is a subset of problems, such as population, atomic war, and environmental corruption, for which there are no technical solutions. There is also an increasing recognition among contemporary social scientists that there is a subset of problems, such as pollution, atomic war, environmental corruption, and the recovery of a livable urban environment, for which there are no current political solutions.

Beryl L. Crowe
The Tragedy of the Commons Revisited
The objectives of our conference are to discuss technical solutions to recreational impact on wildlands. We have gathered to do something constructive about the problem of many diverse users each maximizing his utility on lands that are held in the public domain, that is in the "commons". As each user enjoys the land he leaves a trace and the traces of many users avalanche into a pattern of abuse that detracts from the land as wilderness, and from the experiences each visitor rightfully expects. As the damage increases, as the landscape becomes "hominized", as elk trails change to horse trails, which change to cycle trails, which change to jeep trails, the very nature of wildlands is called into question. For wilderness supreme is a land void of the traces of modernized man. As the users multiply, as measures are implemented to reduce recreational impact, so the wilderness disappears increment by increment and the tragedy of the commons is complete.

A major point of Garrett Hardin's famous essay on the tragedy of the commons, was to draw to the attention of scientists the observation that problems are not amenable to technical solutions. He was chided by a social scientist, Beryl L. Crowe, not for his conclusion, but for reinventing the wheel. The tragedy of the commons is old hat, very old hat to social scientists. Even sophisticated mathematical models exist to simulate it. Indeed, no technical solutions exist for the tragedy of the commons, one such tragedy being--so Hardin pointed out--the over use of national parks by an increasing crowd of visitors. To intensify the tragedy Crowe points out that for the subset of problems that have no technical solution there are no current political solutions either. Crowe referred to the United States specifically, although his conclusions are likely applicable to the liberal democracies as a whole.

Is it possible that recreation on wildlands is not a problem in the sense of the tragedy of the commons? Did Hardin make a mistake in identifying park use as a type problem? I do not think so. True, the "resource" is not consumed akin to grass being eaten by cattle, so that the impact of each user is relatively small. However, the problem meets all criteria of the tragedy of the commons: a fixed land area in the public domain, an open access to all users, and great accelerating demand by all users, and an increasing evidence of that use in degraded landscapes. There is no escape from it: wildland recreation on public wildland is an example of the tragedy of the commons, since unlimited recreation and wildland conservation ultimately are two incommensurable goods.

My thesis will be that wildland recreation is a somewhat unusual use of the commons, and one which has the makings of a tragedy far greater than perceivable at first glance. Unlike a cow on the commons which removes a relatively fixed amount of fodder, the amount of resource despoiled by a recreationalist can indeed be reduced. No technical solution exists to reduce the share required by each cow, but technical solutions do exist to reduce the impact of each recreationalist. Herein lie some hope and some very great dangers, which if unperceived will destroy wilderness as surely as the sun will rise.

The hope lies in the fact that the technical solutions buy time. They postpone, but do not circumvent, the necessity of finding social solutions to the tragedy of the commons. Technical solutions buy precious time, very precious time to search for, formulate, implement and test policies that will safeguard both wilderness, and the individual's right to experience wilderness. The responsible pursuit of technological solutions to a social problem implies only the promise of buying time, and of making good use of the time so freed toward a social solution, that is, some acceptable means of increasing the commons or reducing its users. If the time freed is not used, if it is squandered in the vain hope that techniques of reducing recreational impact will somehow prevent destruction of wilderness, then our society would have been better off without the technological solution in the first place. Here lies one dimension of the deeper tragedy: the technological solution may detract from efforts to solve the tragedy of the commons by social means, and thereby contribute not to the salvation but to the destruction of wilderness. We must ask ourselves whether the problem would not be solved quicker if we scientists did not offer our services, if we did no research at all and would thus force a political decision. There is no doubt that today wilderness has a very large and politically powerful constituency. That constituency would probably force political decisions favorable to wilderness even in our absence. There is a real danger that we scientists oversell the technical solutions, and that we detract from the efforts, time and monies required to find and implement social solutions.
This, however, is not all of the tragedy vested upon wildlands: it runs deeper still. To understand it we must understand the utility of recreation. What is recreation good for? Traditionally our society has encouraged the notion that work is vital, while recreation is tolerable, albeit frivolous. This emphasis of values is derived from our dominant economic pursuit, based on a more or less free market. Work, that is, activity that generates a monetary return, that contributes to the Gross National Product, is a dominant, if not the dominant value. What contributes to work output by the individual—education, health, recreation, personal freedom of choice, specialization of skills, freedom from family responsibilities—are all secondary values, but important in that context. Non-monetary economic activities such as gardening, hunting, fishing, building one's own house or an extension thereto, receive relatively little acclaim. Work is required to keep the means of production as fully occupied as possible to produce the greatest amounts of good and salable services. Moreover, economics dictates that work produced now is of more value than work produced later. This is one reason why work is so readily traded off against health. If it were not so, would we in the Western World tolerate the severe loss of health and years of life suffered by unskilled, and especially night-shift, workers? For instance, a recent study prepared for the Labour Ministry of the State Northrhein-Westphalia, Germany, and reported on in Der Spiegel showed that industrial workers on night-shift not only suffer from irritants such as disrupted sleep and concomitant family quarrels, or have much higher rates of debilitating illnesses than day time workers, but also suffer a reduction in life expectancy of some 14 years. They die on average at 63 years of age compared to 77 for the occupations with the longest life expectancies, independent entrepreneurs, senior civil servants and the clergy.

There are two consequences of work's having a higher value than recreation. First, wildlands which today are held from economic development because they receive heavy use from recreating people, are not secure. Should these wildlands lose their amenity value, then they will lose the political support that keeps them today as wildlands. The resources these wildlands contain are coveted by entrepreneurs which will move in to stake their claim upon the mere sign of erosion of support for wildland recreation. All resources of the commons (though not on private land) are open to negotiation and the claim for wildland preservation must be maintained very strong at all times. Otherwise the land will change uses from wildlife to cattle production, from timber for scenic and watershed values to pulp and lumber, and from wild rivers to hydroelectric power, while the freedom of the hills will be curtailed by "No Trespassing" signs. We must ask ourselves whether the technical solutions we seek will not only buy time for a search for social solutions, but also create time to permit people to habituate to hominized wildlands, to become insensitive to eroded wildland values, or maybe become disenchanted with overregulated wildland use. If so then buying time courts the danger of losing one's constituency.

The second consequence of work's having a higher value than recreation in the conventional wisdom of today, is that we remain less than well informed about the value of recreation. What does recreation do to us? What is it good for? The answer that we must have it because people want it is not good enough, not for professional decisionmaking. For reasons I elaborated elsewhere (Geist 1978), user's choice is a very dangerous criterion for action by professionals. We must know the tangible benefits of recreation to individuals; knowing that it increases work output on the job is nice, but not relevant. My research on the question of how to maximize health via lifestyle (Geist 1978) suggests the following answer: recreation in natural settings appears to be vital to increasing the individual's physical, intellectual and social competence, which in turn maximizes health, develops a sense of mastery and increases life span. From a physiological and morphological perspective, recreation, by forcing diversity of activities and exertion on the individual, reflects itself in increased body size, enlarged brain, superior capacity to heal wounds, heavier bones, slower heart rate and leaner body mass. It reflects itself in more liters of tidal volume, greater speed of impulses along nerve fibers, reduction of rate of body deterioration past middle age, greater endurance and physical strength.

At first glance this may all seem unimportant. But at second glance it is not. Great diversity in mastering physical, intellectual and social skills appears to lead during ontogeny to a distinct phenotypic body form. It is a body form characterized by relatively luxurious development and
great health. It is the body form both of our upper Paleolithic ancestors—and of the upper social classes in our society. It is the phenotypic body form associated with the "life of kings", with affluence, power, privilege and longevity. What are the ingredients of a life style that maximizes individual development? They are besides material security and access to nature, freedom, power, high ideals, adventure, travel, tutoring, sports, family support, and intense learning of many skills, social and economic functions, and knowledge. It is a life style which in individuals develops the diversity of competencies we humans are capable of. It is not an "easy" life style; on the contrary, it is a very demanding one (see Geist 1978). From the above perspective, recreation is not a frivolous activity but the very essence of a life style that makes for sound bodies and minds.

Let me dwell on this point a little longer. There is a very real need to develop a life style conducive to health since not only have medical expenditures risen to vie for second or third place in the Gross National Product (Kristein et al. 1977, Lalonde 1972), but above all our society carries a heavy burden of individuals which, as Ford (1970) has put it, are "casualties of our times". It is difficult to estimate the number of these victims but a conservative estimate would place the proportion at no less than 20 percent (see Geist 1978, Chapter 15). No wonder that governments grope to change by regulation and public education how we live (Lalonde 1972), health fads abound and preventive medical fields proliferate (we have today besides the older disciplines of preventive medicine and epidemiology, prescriptive medicine, predictive medicine, constitutional medicine, orthomolecular medicine, environmental health and public health). Moreover, no accepted scientific theory of health is yet available. I have made an attempt of such a theory which shows that health is related to phenotype development, which in turn is a function of resource abundance and diversity of activities performed by individuals. Health appears to be more prevalent in the upper classes than lower classes, and the phenotype of people from upper classes is that expected from the theory of health I developed (Geist 1978). This latter relationship is ancient; even in the bronze age we find a correlation between the amount of grave goods and body stature (Huber 1968). It cannot be emphasized enough: humans are incredibly sensitive to environmental factors during ontogeny.

School children may fail to grow physically in some schools, except during holidays (see Tanner 1962 p. 137); parental dislike may stunt the growth of a child (see Timiras 1972 p. 315, Parke and Collmer 1975); birth order and family size affect body size and intellect (Tanner 1962 p. 138, Belmont and Moralla 1973, Zajonk 1976); brain size, head shape, body size and proportion are greatly affected by motor and intellectual exercises (see Greenough 1975, Geist 1978). Differences in physical types between populations and classes appear to reflect differences in life style (Deutsch 1973).

The above excursion into health and life style was not done for the sake of advocacy. Rather it was to give notice of some new and as yet insecure developments that suggest recreation is a major and integral part of a life style that maximizes health. This is a life style that comes close to that of people with power and affluence and recreation far from being frivolous may well be the essence of what generates health, competence and a long life. The above excursion should indicate that we must become much, much better informed on what the value of recreation is to the individual. Here we need penetrating new research. If recreation in the out-of-doors is that great, life-giving good that I suggest it may be, then we have a just claim to maintain and expand the land for recreation as well as non-monetary economic activities.

One can even make a case that wildland held in the public domain is an attempt by America's middle class to partake of the "good" life. The affluent can have it by buying their own "wildlands" in which they can practice relatively unregulated, frustration-free recreation, on their ranches, islands or exclusive clubs. From that perspective national parks and forests are the counterpart of the hunting preserves of kings and nobility of diverse nations and cultures. National parks are then a part of the traditional American drive to distribute privilege so that many have the opportunity to lead the "good life". The environmental movement can be viewed as an attempt by the middle class to preserve for themselves what the upper class can readily acquire privately, namely to live and recreate on unpolluted, unspoiled, beautiful land.

If the technical solution to the tragedy of the commons only buys time to search for and implement a social solution, what then is the nature of the social solutions? There
are three basic solutions: to increase the commons, to restrict the uses but not the access of users to the commons, and to regulate the number of users. All other solutions are combinations of the above. None of these solutions is appealing. The first extinguishes the rights of some citizens to economic activities on privately held land, before the land is transferred for recreational purposes into the public domain. The third raises the whole difficulty of deciding who shall enjoy wildland recreation as a privilege. The second has all the ingredients of deepening the tragedy of the commons. This is the route of regulating use and enforcing regulations, as well as of reducing the value of recreation; the route of estrangement of users from wildlands and of placing the rights of the "have's" on private land in contrast to those of the "have not's" on public lands.

Please note: technological means to reduce user impact on wildlands increasingly put the individual into a technological cocoon that isolates him from the very wildlands he visits whether he like it or not. He who uses a propane camp stove instead of a campfire, loses the knowledge and skills needed to find the proper kindling and wood, know how to coax a fire when the elements conspire against it nor will develop a pioneer's eye for selecting his nightly camp spot. He who is confined to trails laid out by others fails to develop a keen eye for landscapes or a sound appreciation of his bodily skills. In short, the camp stove, the tent, the foamy, the sleeping bag, the dehydrated food - great conveniences - all conspire to lessen the interaction between the human being and nature. They rob a person of knowledge, skills and insights. The visitor of wildlands is less and less interacting with nature, but becomes a platonic visitor that drifts past. Does that not defeat and trivialize the very essence of recreation which is adventure and a test of oneself, nature perceived as an adversary or romantically as a nurturing, supporting mother? Add to all this the regulations, "thou shalt not . . .", and the interpretive services that tell you where to look and what to appreciate. Is this the life of kings? Is this how the upper classes live on their ranches, estates, islands and exclusive clubs? Is this the way to a sense of mastery, power, health and longevity?

The only two social solutions that do not trivialize recreation are to increase the land held in the commons, or to somehow reduce the number of persons seeking recreation on public lands. The former solution requires a justification for recreational activities superior to the justifications by those that presently use the land. A long-term policy of opportunistic purchase of land is likely to be a relatively painless way to increase the commons. The next solution, reducing the number of visitors to the public wildlands, need not be draconian. Such solutions would be a lottery system to limit access, or long-term applications for a visit, or a limit for example on the visits per life-time. There is a better way. This is to search for and implement policies that somehow deflect visitors from wildlands by offering a most acceptable alternative. For instance, we can work towards a policy of:

1. Increasing scenic rivers and river trails that lead through developed land. At the cost of some land acquisition, landscaping and promotion a challenging and satisfying recreational experience can be had.

2. Taking agricultural lands from intensive use towards fish and game production. The means to achieve it may be diverse and dependent on local politics. The aim here is to provide particularly close to urban centres opportunities for recreational fishing and hunting.

3. Increasing the opportunities for second homes or weekend cottages that give individuals a stake in a piece of land that must be managed.

4. Making allotment gardens available very close to within urban centers, while encouraging gardening. Good gardening is a task requiring knowledge and skill, and first-rate recreation.

5. Increasing guest ranches and moderately priced resorts to replace presently favored alternatives such as trailers and campers.

6. Increasing fish stocking and fish production by giving it high priority in regional plans.

7. Shifting from capital-intensive agrobusiness to labor-intensive small-scale farming with emphasis on natural rather than industrial control of weeds and pests. The outcome here is an increase in cover and field borders that houses wild-
life, a reduction in field size and greater heterogeneity of the land surface. That in itself would humanize much of our hominized landscape.

8. Zoning land use so as to segregate recreationists in order to cluster the more compatible activities; cross country driving by all-terrain vehicles and hiking do not mix too well.

9. Helping to make cities, where the bulk of our population must live, into more livable, attractive places by whatever means, including the availability of natural recreation areas in close proximity.

10. Pursuing a policy of maximizing individual development as a policy taking priority over the one we follow today, namely maximizing economic activity, or "economic health". An integral part of that policy would be one of reducing population size.

As scientists or managers with scientific training we are not equipped to handle policy issues. We depend here on those who are specialists in such areas as land and urban planning, economics and political science. While we as scientists pursue technical solutions to visitor impact on wildlands, we also must put some effort into finding out how policies can affect our goal of wilderness preservation and promoting wholesome recreation. We could, for a start, devote a session of a conference similar to this to policy issues and to opening a dialogue with professions of very different perceptions from our own. To use the time gained by the technical solutions to sophisticate technical solutions would be a misuse of that time. Technical solutions do not ultimately solve the tragedy of the commons, and we must not be guilty of pretending that they do. What would happen should we refuse to develop knowledge of how to "harden" trails and campsites, help restore wilderness by rehabilitating land, refuse to educate the public about low-impact camping technology? What would happen if we did not offer technical solutions to the tragedy of the commons" It would bring the problem of incompatible uses on wildlands very quickly to a head and force some political decisions.

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ABSTRACT--What we often define as "impact" is a narrow concept of what is usually a larger, more complex problem. We must understand these larger problems to solve most of the narrowly defined ones. The National Park Service has a mandate to (1) manage parks for resource preservation and (2) for visitor use and enjoyment. This dual mandate creates continuing problems for managers: how much use can a resource absorb before permanent damage exists? Understanding where this balance exists starts with accurate cost-effective ways to measure impact. Public involvement is an essential part of the whole process. The park manager must seek out as wide an audience as possible, and include other agencies and levels of government. Recent legislation, such as the Wilderness Act and National Environmental Policy Act, have helped refine our procedures for dealing with and perceptions of impact. Enlightened, flexible management can provide answers to questions about wildland impacts.
that they are preserved for posterity.

Obviously, too much impact on the parks will mean that the heritage of parks would be passed on in damaged or debased condition. That is something we cannot tolerate. So we are faced with one of the perpetual questions that plague park managers. Just how much impact of any kind can a park tolerate and still be kept in shape for future users? As in most decisions, it is not a question of either/or but of how much.

And just as we must understand impact in the broadest possible sense, we must be capable of measuring impact in efficient and understandable ways. Our measuring must be efficient in several ways. Obviously, it must provide an accurate indication of what is going on, and it must be cost effective. There are many examples of problems where more time and money was spent in trying to identify and define the problem than was spent in correcting it. Sometimes this is unavoidable, but we should be cautious about large investments in super-sophisticated measuring techniques. We should be reasonably certain that the end product will be worth the cost.

A computer, properly used, will provide measurements ranging from the super-sophisticated to something impossible to distinguish from good common sense. Our job, and one that a professional should be able to handle, is to determine which problems can be defined and measured with common sense and which require the application of modern technology. We should not be afraid to try either the clip board or the computer.

When we do get measurements, they must be understandable. The information that has meaning to a scientist should be capable of being translated into words that mean essentially the same thing to the rest of us.

It is almost axiomatic in today's world that the public gets involved in the government decisionmaking process, and the public's decisions will be only as good as the public's understanding of the problem. Among those who must understand the measurements are the managers. They must be able to understand and correctly interpret measurements and analysis if they are to respond with the decision that will meet the problem.

A key question in this entire analysis is who gets involved in measuring and reacting to impacts on natural recreational resources. In philosophical terms, everybody is involved. One of the patron saints of the National Park System, John Muir, once said that "when we try to pick out anything by itself, we find it hitched to everything in the Universe."

A public trust cannot be selective. We must manage for those who actively use the parks and forests and we must manage for those who are content to know that parks and forests are there and are being protected. And, finally, we must manage for those who at this point in time don't really care whether the parks and forests are there or not. They may not care right now, but later on they may become interested or perhaps their children will be interested and active outdoors people.

However, in direct and everyday management terms, we tend to relate to those who appear on our doorstep. Some are easy to identify as members of special-interest groups. These people are the easiest to work with because their interest is obvious and their concern reflected in the fact that they are there on your doorstep.

Many of these people have the interest and enthusiasm to be active participants in impact measuring and concerned critics of your application of remedies. They also have a willingness to set standards for your performance that appear always to be slightly beyond reach. Nonetheless, these dedicated people are a major force in problem solving in park and recreation areas.

Most of the people who come to parks are less well organized. They come because they enjoy the park but don't have the degree of commitment that leads them into special-interest organizations.

The problem in dealing with them is that their concerns and attitudes are very hard to measure. I believe, however, that an honest effort must be made to involve as wide a segment of the population as is possible when seeking public input on issues as difficult as those involving impact.

I mentioned earlier the need for public involvement in the decisionmaking process. In some cases, the push for public participation is a reaction to life in the post-Watergate era. Managers use it because they can't afford not to. But I would strongly suggest that the bottom line in this area is that honest and full-scale public
participation in the decisionmaking process produces better decisions.

And just as we should be sensitive to the need for public involvement, so we should be concerned that all other agencies and institutions that have concerns over impact be a part of the process of analyzing and adjusting to those impacts.

For many years the various components of the park and recreation field tended to go their own way. Their interests seemed to stop at the boundary of their jurisdiction.

Well, we are all in John Muir's "universe" and lack of concrete jurisdiction cannot be an excuse for ignoring responsibility. It has become clear that impacts in other areas are really impacts on us too, and it should be equally clear that only with a completely cooperative and universal effort will we solve the problems of impact -- or of anything else for that matter.

In many, many areas there are just not going to be enough of our basic commodities to go around. To determine the wisest and best use of our resources will require open, honest cooperation among all concerned. Once we have determined who is involved we have to address the question, "Who is responsible?" Well, in most cases the answer is the same -- everybody.

Those who are "responsible" for the management of a specific park, forest or other outdoor recreational resource are indeed responsible for the management of that area. But they also have a responsibility to cooperate effectively with other area managers. And they have a responsibility to involve the public in impact decisions in their areas.

In our system of government, a major responsibility for decisionmaking rests, ultimately, with the public. And, unfortunately, the trends seems to be government by as minority as fewer and fewer people go to the polls at each election. It is hard to assess the number of people--as a percentage of park users--who become actively involved in park decisions but it certainly is not large. If we believe in our system, I think it behoves all of us to encourage the maximum citizen participation in our affairs at every level of activity.

Until recently our perceptions of impact were very subjective. We all tend to look at impact and the resulting problems in terms of our own direct responsibilities and our individual or organizational values. We rated impacts as good, bad or indifferent depending upon those individual values. But some changes have been made. For one, our horizons have been expanded along with our consciousness so that we tend to have a broader perspective. Some of this process has been brought about by new legislation and accompanying implementing regulations. Certainly the two most important pieces of legislation in this regard are the Wilderness Act and the National Environmental Policy Act (NEPA).

The first defined in a very significant area just what were acceptable and unacceptable impacts. The Wilderness Act also helped to raise the national consciousness of the concept of and benefits derived from the wilderness. Sometimes, however, it also raised the level of public controversy.

It all comes down to the fact that there is no substitute for enlightened, flexible management. We must develop in all of us a willingness to look beyond the superficial and the obvious, to consider what has been overlooked and to ask questions that don't have ready answers.

Only then will we have an impact on the problem of impact on the wildlands.
WILDLAND RECREATIONAL IMPACT FROM THE U.S. FOREST SERVICE LAND MANAGER'S PERSPECTIVE

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ABSTRACT--The Forest Service manager's perspective of recreation impacts on wildland is influenced by his possessory interest in the land he manages, his resource management training and experiences, the historic role of protection responsibilities, and the mandate to provide a wide spectrum of recreation opportunities.

The management of National Forest recreation use and the attendant impacts is complicated by the multiplicity of recreation uses that occur, the variety of consumptive recreation uses permitted, the dispersed recreation mission for the National Forests, and the interrelationships with the other forest resource values and products.

Several positive influences that are reducing the impacts of recreation use will offset the experienced increases in kinds and amount of recreation use.

The appropriate response of Forest Service managers to the challenge of recreation impacts is the establishment of an environmental ethic in users and managers through cooperative research and education rather than increased regulation of the user.

I find this opportunity to address you a personal pleasure and professional satisfaction for one simple reason - I believe in the vital need to achieve the objectives of this conference which will be an important step in minimizing impacts of recreation use on wildlands.

If you are to understand the Forest Service manager's perspective of recreation impacts, I believe it is necessary that you have some knowledge of the influences that form it - in short, "where we're coming from."

Most of you know that we take pride in the fact that the Forest Service is a decentralized organization with the District Ranger being the key in accomplishing the "doing" job of land management. The placement of considerable authority and responsibility on the line officer closest to the land has had the effect of establishing a strong possessory interest for "their districts." Add to this our organizational heritage of a strong mandate to protect the forests from natural and man-caused damage and you will understand why Forest Service managers seem to perceive recreation impacts somewhat personally or subjectively.

But there are other significant influences on our perceptions of what is an impact. Most of us have a direct experience in timber management in our career background. Perhaps that explains why some 30 Forest Service recreation specialists I once accompanied could walk across a meadow disturbed by a logging tractor without critical comment, to look at the "impact" of a narrow motorbike trail and find it unacceptable damage. They recognized the track of the tractor as transitory impact but interpreted the bike trail as permanent damage. We are, like yourselves, biased by our training, experiences, and personal preferences.

One last important influence is that
Congress has mandated that National Forests be managed to produce multiple uses and benefits. As a result, the Forest Service manager has a strong sense of responsibility to accommodate the full spectrum of recreation uses.

With this understanding of the influences affecting the Forest Service manager's perception of recreation impacts in mind, let us turn to the present situation in National Forest recreation and the resultant impacts on the land.

Since the National Forests are managed to produce the widest possible recreation opportunity for the public that owns them, the potential for impact is high. In addition to the great variety of recreation uses we permit and encourage, the National Forests have a primary mission among federal land management agencies to provide for dispersed recreation. By definition, this includes types of recreation that allow the user a high degree of freedom of choice. This often results in the development of user-built conveniences that are perceived by managers as impacts.

We also provide opportunities for consumptive recreation. Hunting and fishing quickly come to mind as examples; however, there are many more such as rockhounding, Christmas tree cutting, mushrooming, tree and shrub transplanting, and fire-wood cutting. All of these legitimate recreation activities have an obvious potential for impacts when we fail to communicate the conditions of proper use, or they are abused.

The other resources protected, managed and produced on the National Forests including timber, livestock forage, wildlife, and water are often impacted by recreation use. We believe the key to management of the several resources is to seek harmony of use within a given land area and not to establish exclusive use areas. While I believe this philosophy is easily defended, it increases the complexity of the management job. This interrelationship between recreation impacts and the other forest resources will be discussed in depth during the the next two days of this conference.

Before we become trapped in the negative tone of the word impact, let's all agree that any use of a natural resource has attendant impacts. The key to responsible land and resource management is to establish the acceptable impact levels. The scope of this conference has placed emphasis on the physical and biological changes resulting from recreation use on wildlands and we will concentrate on these. There are, of course, aesthetic, social, or psychological impacts that are perhaps even more difficult to define and manage.

To find the acceptable level of recreation impacts of the physical or biological resources, early recreation planners and managers adopted a well developed range management concept - carrying capacity. This is defined as the number of cattle that can graze a given area for a planned period of time without causing deterioration. While there is some value in using this approach in recreation management, we have learned that the behavior of recreating people is not as simplistic or predictable as that of grazing cattle. We need far more sophisticated approaches to defining and measuring impacts or more specifically - environmental damage. The technical sessions of this conference will report on the progress being made to satisfy this need.

My perception of the present trend in National Forest recreation use is that ever-increasing numbers of people are spending more time in a widening variety of recreation activities while the agency's recreation budget is declining. However, I do not believe this necessarily signals an inevitable increase in recreation impacts. There are several positive indicators that support this belief:

The behavior of many types of recreationists on National forest land has improved through education efforts.

Volunteerism by recreation groups is working to correct past and prevent future damage.

There is an increasing national awareness of environmental values and concern for our finite wildland resources. Recreation and conservation organizations have accepted the responsibility to educate their members and the public on the principles and methods of minimum impact recreation use.

I will end with this comment on Forest Service management's response to recreation impacts now and in the future. We have a choice before us between an increase in regulatory control of recreation use or an increase in a cooperative education program.
between managers and users. I will let the following words I wrote several years ago for the introduction of the Alpine Lakes Study brochure indicate my preference:

"Whether or not legislative action is taken, the enduring protection, utilization, and enjoyment of these resources will be accomplished only through the sensitivity and the cooperation of the public and private owners and the land managers serving them.

When an environmental ethic is developed in all of us that respects the basic land values while enjoying the benefits, the wildland will be fully protected."

This conference of managers, researchers, and users is a major step toward developing that environmental ethic that will permit minimum impact recreation to be achieved with a minimum of government regulation.
ABSTRACT—The Appalachian Mountain Club is the oldest and one of the largest outdoor recreation organizations in the United States. The author shares his personal observations of recreational impacts on wildlands. He investigates the reactions of the manager to recreational impacts and the meaning of those actions to the user. The effects of the tremendous recent increase in outdoor use on users, managers and recreation systems are reviewed.

The prime point stressed is that the best solutions to problems of recreational impact lie with the users themselves. It is the author's conviction that a majority of impacts can and should be corrected by the users with active encouragement from wildland managers.

Recreational impact has recently begun to receive a much higher degree of attention from managers, researchers, and users. I would like to share with you some of my experiences and observations on this issue with the hope of generating some thoughts for further discussion during the conference.

First of all, let me give you a brief description of the organization that I represent. The Appalachian Mountain Club (AMC) is a volunteer, nonprofit organization of over 23,000 members. With headquarters in Boston, its membership is centered in the northeastern United States but stretches worldwide. The AMC is the oldest, and one of the largest outdoor recreation organizations in America. Through its 102 years of existence, the AMC has been committed to conserving, developing and managing dispersed outdoor recreational opportunities for the public in the northeast.

Ten regional chapters, from Maine to Pennsylvania, 55 committees, hundreds of volunteers, and a professional staff all join in administering the Club's wide-ranging outdoor programs. These programs include an intensive schedule of outing activities, trail and shelter construction and maintenance, conservation, outdoor education, research and backcountry management. In addition, the Club organizes leadership workshops, mountain search and rescue, and a youth opportunities program for urban young people. The Club publishes a number of books addressing a wide spectrum of interests. Since 1876, the AMC has published America's oldest mountaineering journal. The organization's unique hut system in the White Mountains of New Hampshire provides hospitality, food and lodging to more than 200,000 hikers, ski tourers, and snowshoers every year.

The Appalachian Mountain Club endeavors to promote wise planning for the use of the backcountry, its rivers, forests, mountains and lakes, and has committed itself to working cooperatively with other managers and recreational users in the effort.

My personal experience is as a backpacker in the mountains of New England over the past 30 years. I have also had the pleasure of hiking on a number of occasions in the western part of the United States, Canada, and in Europe. The views I will share with you today are based on these experiences and are from the eyes of a pedestrian user of our wildlands. As I think you can well imagine, I find it very difficult, if not impossible, to try to represent the "typical" user's perspective. What one person considers to be an extremely impacted area may well be another's paradise.
One of the terms used in the title for this conference I feel would present a real challenge to the typical user. The term "wildlands" can, and certainly does mean many different things to different people. Can you blame the poor user for being confused? We seem to dream up a new term for wildlands every year; we have had "Wilderness" with a capital "W", with a small "w", "wildlands," "backcountry", "open space," "solitude areas," "Management Areas 1 through 4," "primitive areas", "scenic areas," "pristine areas," "threatened areas", "urban wilds" -- and many more. I have been very close to the capital "W" Wilderness issue in the East for the past ten years. I have to admit that I am still confused as to what is an acceptable level of recreation and impact in a Wilderness area, even given all my experience with the issue.

In order to understand impact from the user's perspective, we must know more about our users. What do people seek in wildlands? What needs are being satisfied? What motivates them? The answers to these questions, I am certain, vary greatly from user to user, day to day, and even within the same person from one age to another. It has been my observation that users' perceptions of impacts and expectations from wildlands vary a great deal with their level of experience. The inexperienced user is most comfortable when there are many developments around and signs of man's "impact" are apparent. As the user becomes more experienced he will look for a purer and purer environment for his recreational activities. In this stage, I find people quite selfish. Here the user is likely to object strongly to impacts that he encounters in the wildlands and equally to responses employed by managers to correct those impacts. Some users mature to an understanding of the variety of needs of users and the different techniques that managers can apply to the tough question of recreation impacts.

In general terms I think there are three kinds of impacts on wildlands to which most pedestrian users react negatively. These would be roads built into our wildlands, off-road vehicles using trails in the backcountry, and timber cutting. Here we encounter the problem that most users have a perception that all wildlands are protected and therefore not subject to the multiple use concept.

The user is also served or dis-served by the hundreds of new "how to" books that have been published on wildland and outdoor recreation. I believe these books have had a great deal to do with conjuring up a perception of what users should expect of their backpacking or recreation experience. Even Madison Avenue has gotten into the game. Every new car, even cigarettes and soap, have had a wildlands setting.

These thousands, if not millions, of new wildland seekers have descended upon a system of lands and management systems designed for a much different level of use. The results have been chaos. Horror stories poured out of the woods. Old timers wished for the "good ole days", managers ran for cover, and many of the new users were turned off by the mess and problems of mismanagement they encountered.

Yes, there was a great deal of impact on our wildlands--trails eroded, campsites were hard hit, overuse occurred at many sites, criminal acts began to occur in the backcountry.

Managers and users reacted to these new conditions. Cries for tough controls rang out. Managers started to use the term "carrying capacity" and began to employ police powers. Most outdoor organizations ran stories in their publications of impacts that ran shivers up the outdoor user's back. Scientists stepped up recreational impact research (limited as it was). Having painted this picture of the scene, I think I would be wasting your time to go through the list of impacts that I have seen and how other users might react to them.

The theme that I would like to develop today, and caution us all on, is not to overreact as managers and researchers to the impact issue. The medicine has the potential of being worse than the illness. I have personally been as guilty as any of you of overreacting to this issue, if I may put on my manager's and researcher's hat for a moment. Even this conference and workshop might, though I hope not, lead to the perception that conditions in our wildlands are pretty desperate. In a nutshell, I would prefer some degree of impact on our wildlands to the alternative of land managers over-reacting and restricting our present "freedom of the hills". I think we have a tendency to make mountains out of molehills. I do not for a minute want to deny that there are serious recreational impacts on wildlands that should be researched and studied carefully or that managers should take action to correct
these problems. However, reviewing the list of distinguished speakers at this conference this week I feel certain that these matters will be adequately covered.

Another issue that has plagued both the user and the manager is the question of overuse. I would not deny that there are areas of overuse and serious recreational impacts but I do believe in general that they have been overstated. It is my observation that hardly any of our users want to do anything that will have a negative impact on our wildlands. The problems that have occurred are due in large part to the fact that until recently users have not had meaningful facts and information on which to make their backcountry decisions. I would suggest that many of our problems have been a result of misuse and mismanagement rather than overuse. In New England, we are now in the process of changing a century of backcountry camping traditions.

In the Northeast, as I believe is true here, most management systems were developed during an era of much lower use. A large majority of facilities and trails were built 50 to 100 years ago. When these systems do not work properly we have a tendency to blame the outcomes on overuse.

I may be a blind optimist, but I do not feel conditions in our wildlands are as bad as many users and managers would have you believe. The AMC has had great success with its carry-in carry-out campaign -- trails and rivers are much cleaner now even with record numbers of users. I find managers of our wildland recreation areas and facilities much more aware, sensitive, and responsive to backcountry users now than formerly. Another very significant point is that even though we experienced tremendous increase in use from 1965 to 1975, many of the most popular areas in the White Mountains of New Hampshire, the Green Mountains of Vermont, and the Adirondacks of New York, have not experienced much of an increase since 1975. I have heard the same reports from places here in the West.

I suggest that the best solution to the issue of recreational impact on wildlands lies with the users themselves. I believe that a majority of the documented impacts can, and should, be corrected by the users with encouragement from the managers. In my estimation, managers have made far too little use of this approach. Where we have problems, let's get the users actively and directly involved and I feel strongly we will see dramatic results. The worst thing that could happen is that responsible officials over react to what they perceive as deteriorating conditions of our wildlands and therefore take all the fun and challenge out of the user's outdoor experience. I would caution all of us, on behalf of my fellow users, not to move the pendulum too far as we sometimes have a tendency to do. Let's steal a page from the current energy debate and take the "soft path" in researching and managing wildland impacts. And, most importantly, let's have the users play a major role in the real problems we do have. I might go out on the limb and say, "We had a problem".

In conclusion, I would like to cover briefly two other issues of importance to managers, researchers, and wildland users. The first of these issues is the current drive of Americans to curb the growth of government spending.

At the recent National Recreation and Park Association's annual congress, I participated in two panels on "Political and Professional Response to Tax and Expenditure Limits". Needless to say, the recreational professionals gathered at the conference were very concerned with the current public mood toward public expenditures and the potential impact on the programs they administer.

I would suggest that managers, researchers, and outdoor users should be considering many of the possible impacts of this current trend. As people concerned with the protection of our wildlands, we should be searching for ways to maintain quality management programs during what seems sure to be a period of fiscal stress.

The second item I wanted to bring to your attention is a report the AMC played a major role in preparing as part of the U.S. Department of Interior's 1978 Nationwide Outdoor Recreation Plan. The report entitled, "Role of Non-Profit Organizations in Providing Outdoor Recreation Opportunities", was completed this past May.

The principal conclusion of the task force was that volunteer non-profit organizations fulfill a vital role in the provision of recreational opportunities and wherever possible these contributions should be fostered and encouraged at all levels of
government, federal, state and local. In providing these opportunities, non-profit organizations offer the advantages of substantial public involvement, cost effectiveness, flexibility and diversity.

This approach seems sure to be viewed as a viable option by those responsible for recreational services within the government as they move to fill the void left by the financial crunch I noted above. I believe that non-profit organizations, and their thousands of volunteers, are ready and equipped to accept an expanded role.

Alders
ABSTRACT--A 1976 study compared users' opinions, attitudes and recreation patterns on roaded Forest lands in the Pacific Northwest with managers' perceptions of dispersed recreation. Users prefer a very low level of development or none at all and value privacy, freedom, peace and quiet - the opportunity to do their "own thing." Developed sites are not substitutes for dispersed road settings. Dispersed recreationists return to favorite sites and have been returning for many years. Many dispersed recreationists are not disturbed by logging and fewer are disturbed by even grazing of cattle and sheep. Users are receptive to some forms of management control to reduce impacts but not to others. Forest land managers, particularly those with public agencies, are generally favorable toward dispersed road recreation. Because of concern with possible impacts, managers support or encourage some dispersed road recreation activities more than others. When manager and user perceptions are compared, managers tend to rate recreation impacts as more serious than do users: litter and garbage, vandalism and theft, danger of fire, danger of accidents from logging traffic, conflicts with other recreationists, and human waste.

Awareness of impact from recreation use spans many decades. Written evidence of managers' concern appears as early as 1913 when the transient visitor was described as a formidable menace, posing a threat to forests from man-caused fires and introducing problems of sanitation in community watersheds (USDA Forest Service 1913, 1915). This paper focuses on impacts associated with dispersed road recreation activities--activities which commonly occur outside of developed recreation sites along forest and other resource management roads. The perspective, however, is on comparing how impacts are perceived by resource managers and recreationists, rather than on direct measures of change or impact in the physical setting.

Past research within diverse types of recreation environments (from wilderness areas to highly developed campgrounds) has shown that resource managers and users do not necessarily have the same views about what constitutes a pleasing or satisfying recreation experience. Managers may seriously misjudge what users are seeking from their recreation outing, as well as how they are likely to respond to management controls (Clark et al. 1971; Hendee and Harris 1970). In part this is due to differences in values and expectations. As compared with most users who are from urban places, managers have a close personal orientation toward natural environments and have formed more traditional views concerning activities and behaviors appro-
propriate in such settings. To many managers of highly developed campgrounds, for example, it seems inconsistent that campers who bring along many of their urban conveniences and expectations (radio, TV, bicycles, camper vans, desire to socialize) may also be seeking more traditional values such as isolation and contact with natural environments. Furthermore, to many managers it is inconceivable that users are able to achieve such values in developed settings (Clark et al. 1971).

Given differences in perspective and past experience, it is not too surprising then that managers and users may vary in their sensitivity to recreation impacts.

Users may be less disturbed than managers at conditions in developed sites that are similar to their urban environment—litter or noise in campgrounds, for example. In fact, many may not even perceive the existence of environmental impacts resulting from their recreation activities which annoy and distress managers.

But it is management concerns with impacts which have frequently led to constraints on users in the past. Emphasis of the past half century on providing developed recreation sites is an example of action taken to concentrate recreation use where it could be more easily controlled. Unfortunately a dilemma exists. On the one hand, if managers allow some recreation activities to occur there may be potential for user conflict or, from the traditional resource protection viewpoint, undesirable resource impacts. On the other hand, carried to an extreme, management control can have the effect of limiting the spectrum of opportunities available to meet the wide range of preferences for recreation opportunities existing among the public. Failing to recognize and provide for diversity and diverse public tastes "invites charges of favoritism, elitism, discrimination (Clark and Stanley 1978)." At the same time, it should be noted that for various reasons, including legislative or administrative requirements, ecological constraints, or desires to protect the diversity of recreation opportunities for future as well as present use, management of areas cannot be based solely on popular preferences. Considerable latitude, however, is often possible within such constraints, and this is where user desires can influence policy to some degree (Hendee and Harris 1970).

THE STUDIES

In the following discussion we describe two studies which identify user and managers' concerns about impacts from recreation activities.

Users

The opinions, attitudes and recreation patterns of dispersed recreationists along roads in three forest areas in the Pacific Northwest were examined with a combination of short on-site interviewing and a mail questionnaire during the summer and fall of 1976. Three drainages—the Greenwater on the White River Ranger District of the Mt. Baker-Snoqualmie National Forest, Washington; the Taneum-Manastash area on the Ellensburg Ranger District of the Wenatchee National Forest, Washington; and the Upper-Clackamas area on the Clackamas and Estacada Ranger Districts of the Mt. Hood National Forest, Oregon—were selected as representing a range of dispersed recreation environments in the Pacific Northwest. They were characterized by minimal or no recreation developments, intermingling public and private ownership, current or imminent road closures, a spectrum of nearby recreation opportunities, ORV use, different methods of timber harvest including clearcuts, and general conditions typical of large categories of national forest land administered under multiple use. All were easily accessible from a large metropolitan area and contained road systems which include blacktop highway, mainline logging roads, and many miles of dirt spur roads.

Though differences in use patterns exist among the three study areas, a general pattern can be described as follows. Both overnight camping and day use occur in the dispersed areas. Use peaks on weekends and holidays, though bad weather can suppress weekend activity considerably. Most respondents live within two hours of the site, participate in parties of four people or more, and engage in a diverse range of activities while in the area. Pickup campers and trailers are the most common types of camping units observed, and use tends to concentrate along river bottoms, at midslope stream crossings and at ridgetop vantage points (Hendee, Hogans, and Koch 1976).

Managers

Managers' views about benefits and
problems with dispersed recreation and their predisposition toward management actions are based on a 1975 mail questionnaire survey of personnel of the Bureau of Land Management, USDA Forest Service, Oregon Department of Forestry, and Washington Department of Natural Resources. Supervisory personnel as well as staff with responsibilities for timber, recreation, wildlife, range and watershed management, fire control and engineering were included. Foresters employed with private companies and private forest landowners were surveyed with a slightly modified version of the public agency questionnaire in April, 1975. The results of this study are based on returns from 483 public agency personnel and 180 forest landowners and privately employed foresters from Washington to Oregon.

RESULTS

Before comparing managers’ and users’ perceptions of recreation impacts, it is necessary to understand their more general orientation and expectations which help define individual perceptions of what constitutes an impact. This topic is discussed in more detail in the paper by Clark and Stankey elsewhere in this volume.

What are Users Saying?

Dispersed recreationists along forest roads prefer a very low level of development or none at all. Just over one-third of the respondents feel no improvements are needed. For those who do, however, the most frequently mentioned additions included trash cans (45% of respondents), toilets (38% of respondents), and drinking water (24% of respondents). There is a potential inconsistency here, however, one that was evident to some of the people interviewed. While some people may prefer additional facilities, it seems clear from their choice of where to camp that they accept places where no facilities exist. And, during casual conversations with some users, interviewers noted that these recreationists quickly changed their minds about the desirability of improvements when they considered that such change might tend to increase use or change the type of users of the area. While respondents would prefer a few conveniences they are more than willing to accept the unimproved conditions in order to protect the type of opportunities they are seeking. Moreover, it should be noted that most hardened sites developed in response to increased use or concern for site protection were once undeveloped like those in the study areas.

Users value privacy, freedom, peace and quiet—the opportunity to do their "own thing". Dispersed road recreation was preferred by 85% of users because they could camp away from others not in their party and have few encounters with other people. Nearly 3 out of 4 indicated that freedom from regulation and control in a dispersed setting as well as the opportunity to alter sites to accommodate their needs--move fire rings or construct rustic tables, for example--are important values. And almost half choose dispersed recreation because they can engage in activities not allowed or appropriate in developed recreation areas. It is in this category of values where perhaps the largest potential exists for conflict between management concerns and user goals.

Developed sites are not substitutes for dispersed road settings. For reasons listed previously, as well as for many others mentioned less often, it is evident that when users choose dispersed settings they seek an experience which is different from that available at developed recreation sites. Three out of four of agreed that lack of developed campgrounds was not a reason for preferring dispersed road recreation. Thus, dispersed recreation opportunities appear to occupy a unique place on the outdoor recreation opportunity spectrum, and efforts to harden dispersed sites will reduce the range of choice for these users.

Dispersed recreationists return to favorite sites and have been returning for many years. Three out of four respondents said they have favorite places to recreate and return to them again and again. It follows then that management actions that would alter sites (or allow deterioration to continue from uncontrolled use--the management dilemma again) or that would modify the surroundings significantly are very likely to be noticed by and may even be disruptive to a large percentage of users.

Efforts to close or restrict use of favored areas may even lead to rule violations by users who re-open access to these areas by removing barriers or closure signs. Previous research further suggests that without understanding reasons for restrictive management actions, users may be able to rationalize this rule violation (Clark, Hendee and Campbell 1971; Clark
Many dispersed recreationists are not disturbed by logging and even fewer are disturbed by grazing of cattle and sheep. One-half of the users indicated that the impact of logging does not detract from their enjoyment of dispersed recreational areas, although 65% regard large clearcuts as unacceptable compared with only 18% who are disturbed by small clearcuts. Nearly half (46%) believe clearcut logging should be hidden from roadside view, although 25% believe there is no need to hide them. In general we would conclude that although dispersed road recreationists would prefer some modification of timber harvest practices, most (in contrast to visitors to wilderness) are willing to accept timber management activities in dispersed settings.

The Taneum-Manastash study area is the only one of the three where grazing of cattle occurs, and only about 20% of the respondents in that area believe grazing should be excluded. This is nearly 10% less than the proportion opposed to grazing in the other two areas where users presumably have had less contact and experience with impacts from grazing. Evidently grazing has not severely interfered with people’s ability to enjoy themselves in the Taneum-Manastash area.

Users are receptive to some forms of management control to reduce impacts but not to others. There is a rationality underlying users' responses to potential management controls. For example, most would support road closures to reduce fire hazard (81%), for road maintenance or repair (80%), to protect sensitive wildlife (75%), or to improve hunting quality (53%). Furthermore, over 80% would agree with requiring campers to carry a shovel, axe and bucket as a fire prevention measure. Almost half would support controls to reduce crowding.

Conversely, a much smaller proportion would back management controls such as requiring fire permits (15%) or total closure of areas during high fire danger. User's perceptions of the need for and the legitimacy of management actions, as well as possible inconvenience or infringement of their personal freedom, seem to be important values involved in their receptivity to controls.

What Are Managers Saying?

Forest land managers, particularly those with public agencies, are generally favorable toward dispersed road recreation. Over 9 out of 10 public managers, two-thirds of foresters with private companies and one-third of private land-owners favor dispersed recreation on lands owned or administered by their organization or on tracts they own personally. Opportunities for people to achieve privacy and to participate in activities as they wish without restrictions are viewed by managers as well as users as primary benefits to recreationists.

On the other hand, fewer than half of the public managers (47%) and only 18% of the private managers and landowners believe that benefits to managers or to the organization, such as reduced pressure on developed sites, increased public awareness of forest practices, or better public relations, outweigh the problems that result from dispersed recreation.

Because of concern with possible impacts, managers support or encourage some dispersed road recreation activities more than others. Although favorably disposed toward dispersed recreation as a general concept, most managers are more supportive of traditional recreation pursuits such as hiking, fishing, hunting and picnicking than they are of activities such as camping outside of campgrounds, target shooting (which may be associated with hunting), and most forms of off-road vehicle use. Extended living or squatting would be prohibited by nearly all managers. We found evidence that differences in support for activities depend on managers' perception of the social and administrative problems, as well as environmental impacts that may result.

What Can We Conclude by Comparing Users and Managers Perceptions of Impact?

The major finding when manager and user perceptions are compared is that managers tend to rate recreation impacts as more serious than do users (Table 1). We discuss each of these impacts below.

Litter and garbage. As compared with managers dispersed road users are much less likely to regard litter and garbage as a problem at dispersed sites being used now. Differences in sensitivity to litter may be a reflection of managers' and users' dissimilarities in values, living environments, previous experiences and expectations, discussed earlier in the paper. By way of comparison, it is
Table 1. Managers' and users' perceptions of impact

<table>
<thead>
<tr>
<th>Impact</th>
<th>Percent of respondents who believe impact is serious, somewhat serious, or becoming more of a problem</th>
</tr>
</thead>
<tbody>
<tr>
<td>Litter/garbage</td>
<td>Managers</td>
</tr>
<tr>
<td>Vandalism</td>
<td>92</td>
</tr>
<tr>
<td>Danger of Fire</td>
<td>86</td>
</tr>
<tr>
<td>Theft of Equipment</td>
<td>86</td>
</tr>
<tr>
<td>Danger of accidents with logging traffic</td>
<td>81</td>
</tr>
<tr>
<td>Conflicts between recreationists</td>
<td>55</td>
</tr>
<tr>
<td>Presence of human waste near sites</td>
<td>64</td>
</tr>
<tr>
<td>Water quality problems from human waste</td>
<td>44</td>
</tr>
<tr>
<td>Human health problems from human waste</td>
<td>39</td>
</tr>
</tbody>
</table>

interesting to note that dispersed wilderness/backcountry users are quite concerned about litter in the wilderness environment. Ninety-nine percent of respondents in a study of users in three wilderness areas of the west and the Boundary Waters Canoe area were annoyed at finding litter along trails or in campsites. In fact, two-thirds felt litter at a campsite was more disturbing than seeing too many people (Stankey 1973).

**Vandalism and theft.** Nearly all managers in the study expressed concern with theft and vandalism associated with dispersed road recreation. Whether they believe the problems would be less severe in and around developed sites cannot be determined from the data. But, far fewer of the users regard vandalism and theft as a problem; no doubt because they normally would not encounter this type of impact during the course of their recreation activities in dispersed areas. Most (84%) indicated they feel safe when picnicking or camping in dispersed areas.

**Danger of fire.** Managers expressed strong concern with the potential for fire caused by dispersed recreationists. Far fewer users, however, think there is great danger of recreationists accidentally starting a forest fire. Whether users' or managers' perceptions more accurately reflect the role of recreation in past fire history needs to be examined.

**Danger of accidents with logging traffic.** A high percentage of managers believe there is danger of log-truck accidents with recreationists on forest roads. Users, on the other hand, are much less concerned, perhaps because they have had few encounters with logging traffic. Most dispersed road recreation activity occurs on weekends and holidays when few, if any trucks are hauling.

**Conflicts with recreationists.** As compared with managers users seem relatively unconcerned about conflicts with other recreationists. Users who are concerned regard conflicts as a growing problem to be dealt with in the future rather than a major issue now.

**Impacts of Human Waste.** While managers express concern with aesthetic problems of human waste near recreation sites, few users regard it as a problem now. About the same percentage of both groups (40%) tend to believe there is a hazard to water quality and human health from waste located close to recreation sites. But, over half of the users (55%) either have no opinion or believe that human waste is not really an important threat in dispersed recreation areas; nature quickly takes care of it. Moreover, over half are not concerned about water pollution in dispersed areas and indicated that they drink from main streams. The implications of these data are further discussed in the paper.
by Christensen and Pacha elsewhere in these proceedings.

CONCLUSIONS

People appear to be expressing a desire for something quite specific when they engage in recreational activities along forest and other resource management roads. Some of the values and opportunities they are seeking, however, may lead to a wide array of impacts that will require a planned management response. While users don't want to get far away from roads and the conveniences and opportunities made possible by having their vehicles close at hand, they do appear to be seeking privacy and freedom from restrictions commonly imposed in developed sites. For many, this freedom involves recreating away from persons not in their party, being able to alter sites in ways to accommodate their needs, and engaging in activities not customarily allowed in developed recreation areas.

They certainly do not want highly developed sites -- dispersed road recreation and developed sites are not substitutes. As a result, managers who opt for site hardening, more intensive development and increased regulation in response to dispersed recreation use will, more than likely, find themselves serving a different clientele as the dispersed users move on to find areas that better meet their desires.

Where impacts might be mitigated by cooperation on the part of the users, their awareness of problems as well as their perceptions of the seriousness of the situation will certainly influence their willingness to assist. It is evident from the information presented, that in dispersed recreation areas many impacts which distress managers are not regarded as serious by recreationists.

REFERENCES CITED


Clark, Roger N., Hogans, W. Russell and H. H. Christensen. A profile of dispersed recreationists along forest roads in three forest areas of the Pacific Northwest: their recreation patterns, opinions and attitudes. Forthcoming from the Pacific Northwest Forest and Range Experiment Station, Seattle.


ABSTRACT--Recreational use of wildlands will inevitably change the environment. Change perceived as undesirable constitutes damage and requires corrective action. Managers and visitors perceive recreational impacts differently, based upon different training, background, responsibilities, and time frames. Studies reviewed indicate visitors' perception of recreational impacts is limited. Visitors' satisfaction is not strongly affected by severity of impacts on trails and campsites. Management of recreational impacts on wildlands must be based mainly on: (1) professional recognition of long-term consequences of impacts; and (2) legal and policy goals that set standards for acceptable impact levels.

INTRODUCTION

Any recreational use of wildlands will produce some environmental change. "No change" or "unmodified natural conditions" may sound noble but neither can be achieved in areas visited by recreationists and therefore both are unrealistic management objectives.

The word "change" (or "impact") is a neutral term. It refers to an objective description of the environmental effects of recreational use. "Damage", (or similar terms, such as "deterioration" or "degradation"), in contrast, reflects a value judgement that the amount, type, or rate of change is undesirable. As such, damage is defined by individual perceptions that vary among observers in response to many factors.

A key question, essentially unanswered to date, is: At what point does change become damage? Management of impacts must be based on a clear, objective description of what is and is not acceptable impact. This question has several parts: Who will decide what constitutes unacceptable impact--managers or visitors? At what point will managers intervene to prevent or correct damage? How will the severity of damage be evaluated as a basis for determining intensity of managerial response? In this paper, I will attempt to answer these questions based on the limited research that is relevant to the problem. I will offer some conclusions to guide wildland managers. The research cited deals mainly with non-motorized recreational use of roadless wildlands and may not be applicable elsewhere.

FACTORS AFFECTING PERCEPTION OF WILDLAND IMPACTS

Importance and Desirability

There are two aspects to recreational impact perception: (1) the perceived importance of impact conditions relative to all other aspects of the wildland recreational setting (such as scenic appeal, fishing, solitude, freedom); and (2) the evaluation of any given physical-biological condition in desirable/undesirable terms. An example of the second is the degree to which a campsite with a specific level of vegetation change is perceived as appropriate and desirable or deteriorated and undesirable.
Origins

Impact perceptions are influenced by factors in addition to site conditions and the individual observer's background and personality. As Lowenthal pointed out (1962), "the genetic vision," that is, what an observer assumes to be the origin of something in the landscape, powerfully modifies perception. His example is a discolored stream, which is perceived as ugly if it is assumed to result from pollution caused by careless mining, but much more acceptable if the turbid water was caused by a natural sulfur vent or spring runoff. As another example: How might we variously perceive erosion on a steep slope if it is believed to be the result of 4-wheel drive or motorcycle recreational use, of hikers shortcutting a trail, of careful logging, or of elk movements?

Settings

Perceptions are modified also by the observer's beliefs about the setting. For example, an impact perceived as appropriate and acceptable in a developed, road-accessible area may not be considered appropriate in a wilderness.

Influences on Managers' and Visitors' Perceptions of Impacts

Perceptions of both aspects of impacts (importance and desirability standards) probably differ between managers and visitors, although research on this issue, to be reviewed later, is scarce and indirect. It is clear, however, that managers and visitors relate to impacts and damage in basically different ways. Each group has different responsibilities, different backgrounds and viewpoints, different objectives, and different time perspectives.

Managers have a professional, stewardship obligation to control recreational damage to wildland environments. They operate under legal and policy goals and constraints. They must consider impacts both at individual sites and throughout an entire management unit, such as a park or wilderness. As Hendee and Pyle (1971) point out, wilderness (and similar lands) are generally a work environment for managers, and many live in rural settings. Most managers are trained in the biological sciences and observe the environment accordingly. They usually recognize major plant species and ecological processes. Some managers have observed particular areas for many years, giving them a base for noticing trends. Their awareness of likely future changes is fairly high, and they tend to take a long-term view of changes. Origins of impacts influence perceptions; for example, some managers view recreation impacts as unacceptable, while tolerating similar impacts from logging or road building as an inevitable part of even careful management.

Recreational visitors probably vary more than managers in perception of environmental change. Visitors' relationship to the environment is primarily aesthetic, although they may also have utilitarian demands, such as gathering firewood and grazing pack and saddle stock. Visitors relate mainly to impacts at individual sites, rather than over large management units. For visitors, wildlands are a play environment (Hendee and Pyle, 1971). Visitors are also directly affected by management actions taken to control environmental impacts. Visitors are usually poorly informed on legal directives, and have varying senses of stewardship. Most visitors, I am sure, feel concern for wildlands and want to help protect them, although often they may not know how. Visitors' educational levels are typically high, with professional - technical occupations most common (Wildland Research Center 1962; Lucas 1964; Hendee and others 1968), but most visitors do not have training in biological sciences. Species recognition and awareness of processes of ecological change are usually limited. For example, as West (1975) indicates, few visitors recognize the replacement of native willow and cottonwood by Asiatic tamarisk along the Colorado River. Similarly, exotic grasses introduced at campsites by man's activities would probably not be noticed, nor early signs of loss of tree vigor or absence of tree reproduction. A few recreationists have visited the same area for years and have an opportunity to compare past and present. (In some areas with high turnover of managers, old-time visitors may be in a better position to notice changes than managers.) However, time frames are mainly limited to the present, and awareness of likely future change is usually low. Visitors' perceptions of impacts probably are influenced by assumed origins and depend on their own style of use. For example, horsemen or motorcyclists may accept their own impacts more readily than do hikers.

Managers and visitors not only view recreational impacts from differing bases,
they also differ in their perceptions of the acceptability of management actions designed to control impacts. The following review includes research on attitudes about management actions as well as perceptions of impact.

Area Characteristics and Activities

Wildlands fall along a continuum from roadless to roaded. There is no sharp dichotomy, except under arbitrary definitions in terms of road character and spacing. RARE I and II (the Forest Service's two Roadless Area Reviews and Evaluations), both faced this fact, and different definitions were used with different resulting inventories of "roadless" lands.

The characteristics of wildlands, their use, problems, and management also are arrayed along a continuum. Roger Clark elaborates on this point in his symposium paper dealing with the recreation opportunity spectrum concept. This paper focuses on the impact issue for the relatively roadless wildlands, and will emphasize the unmechanized types of recreation, in contrast to the paper by Downing at this symposium.

The roadless lands tend to have a narrower mix of recreational uses compared to more accessible lands, and the variety of impacts is thus reduced. This is especially true in wilderness, where mechanized recreation is legally prohibited (with some exceptions).

Roadless wildlands probably draw different types of visitors than roaded areas, in socio-economic terms although comparative knowledge of the range of recreationists is incomplete. We are planning a nationwide survey to attempt to fill the gaps in knowledge. It seems probable that visitors to roadless areas have different experience expectations and have different standards for evaluating user impacts, than those who visit more developed, more accessible areas.

Management is more constrained in dealing with impacts on roadless lands than roaded lands. In wilderness, law and policy impose special constraints. Outside wilderness, limitations of access make some management actions impractical or too expensive and require modifications in other practices.

RESEARCH RESULTS

Research on perception of recreational impacts is scarce. Hardly any studies focus specifically on how much visitors or managers recognize recreational impacts or how they react to the impacts they recognize. A few studies touch on the topic, usually peripherally, and all relate to the visitors' perceptions, not the managers'.

Visitors' Perception of Campsite Impacts

Studies generally suggest that campsite conditions resulting from visitors' impacts are not a major influence on visitors' choice of campsites or their satisfaction with them.

Frissell and Duncan (1965) asked Boundary Waters Canoe Area (Minnesota) visitors what factors had influenced their choice of campsites; campsite impact conditions did not appear among the reasons given. Satisfaction was apparently also little affected by site conditions. "The most frequent complaint pertained not to the physical characteristics of the site itself, but to the trash and debris left by previous campers." This was despite the fact that the study campsites had lost an average of 85 percent of their original ground cover.

Merriam and Smith (1974) also reported that campers seldom commented on site impact conditions but often mentioned littering. They reported no correlation between visitor ratings of campsite physical condition and the "site impact stage" that they assigned to sites based on the severity of impacts. Comments related to campsite appearance were weakly correlated with impact stage.

The Outdoor Recreation Resources Review Commission (ORRRC) wilderness study (Wildland Research Center 1962) combined "littered and rundown campsite conditions" in one question. Together, among the factors visitors were asked about, they were the leading cause of reduced enjoyment in the three study areas -- the Boundary Waters Canoe Area in Minnesota, the High Sierras Wilderness in California, and the Mt. Marcy Area, a wilderness-type area administered by the state of New York. However, campsite conditions still were not very strong influences on satisfaction (Table 1). Depending on the area, motorboats, effects of horses (another type of recreational
Complaint

Littered or rundown campsites
Too few campsites
Difficulty of finding isolation from other camping parties
Very large parties traveling or camping together
Effects of too many horses or mules on trails or new campsites
Motorboats or jeeps in the area
Helicopters or airplanes in the area
Large number of insects
Poor fishing

A study by Stankey (1973) sheds some light on the preceding results. Stankey did not study perceptions of physical impacts, but he reported strong negative reactions to litter. This suggests the ORRRC results may be more indicative of visitor concern with littering than with visitor impacts on the environment.

In a study of the Cranberry Backcountry in West Virginia, Echelberger and Moeller (1977) did not list site impact conditions among the responses to an open-ended question about most-and least-liked characteristics of the area.

In an unpublished study (cited by West 1975), Godfrey and Peckfelder found that less than 1% of the floaters on Idaho's Middle Fork of the Salmon River felt man's imprint on campgrounds was noticeable.

Lee (1975) examined Yosemite National Park backcountry campers' satisfaction (overall satisfaction, satisfaction with the "social atmosphere," and satisfaction with physical appearance of the camping area) and also the feeling of being crowded as related, first, to expert assessments of 15 camping area physical and social conditions, and, second, to the campers' perceptions of the same conditions. Satisfaction with both social and physical aspects was moderately high, 6.6 to 6.8 on a 9-point scale (with 9 "absolutely" satisfied). Visitors rated amount of litter, ground-cover impact conditions, and damage to trees all close to the scale value corresponding to "moderately close to what you would prefer," although expert assessments rated litter conditions better than ground cover, which, in turn, was slightly better than damage to trees. This would seem to imply greater visitor sensitivity to litter than vegetation impacts.

Little of the variation in visitors' satisfaction with campsite physical conditions could be explained by expert assessments. Using multiple regression, less than 8% of the variation in satisfaction was accounted for ($R^2=0.0773$). The attributes contributing most to the equation (based on beta coefficients) were almost all related

Table 1. Reactions of campers in three areas to various environmental factors in wilderness (percent of users)¹

<table>
<thead>
<tr>
<th>Complaint</th>
<th>Mount Marcy (N = 90)</th>
<th>BWCA (N = 82)</th>
<th>High Sierra (N = 154)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Littered or rundown campsites</td>
<td>Noticed 32% 12% 2%</td>
<td>Noticed 51% 39% 18%</td>
<td>Noticed 50% 40% 21%</td>
</tr>
<tr>
<td>Too few campsites</td>
<td>Found 22% 19% 7%</td>
<td>Found 31% 33% 17%</td>
<td>Found 38% 33% 11%</td>
</tr>
<tr>
<td>Difficulty of finding isolation from</td>
<td>Reduce 12% 9% 5%</td>
<td>Reduce 15% 1% 1%</td>
<td>Reduce 17% 2% 1%</td>
</tr>
<tr>
<td>other camping parties</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Very large parties traveling or camping</td>
<td>Noticed 37% 16% 6%</td>
<td>Noticed 27% 15% 5%</td>
<td>Noticed 33% 16% 6%</td>
</tr>
<tr>
<td>together</td>
<td>Found 1% 1% 1%</td>
<td>Found 4% 3% 8%</td>
<td>Found 12% 3% 8%</td>
</tr>
<tr>
<td>Effects of too many horses or mules on trails</td>
<td>Reduce 1% 1% 1%</td>
<td>Reduce 4% 3% 8%</td>
<td>Reduce 12% 3% 8%</td>
</tr>
<tr>
<td>or new campsites</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Motorboats or jeeps in the area</td>
<td>Noticed 8% 6% 1%</td>
<td>Noticed 20% 4% 4%</td>
<td>Noticed 17% 3% 1%</td>
</tr>
<tr>
<td>Helicopters or airplanes in the area</td>
<td>Found 7% 3% 1%</td>
<td>Found 27% 15% 5%</td>
<td>Found 14% 8% 3%</td>
</tr>
<tr>
<td>Large number of insects</td>
<td>Reduce 19% 3% 1%</td>
<td>Reduce 11% 7% 4%</td>
<td>Reduce 18% 12% 2%</td>
</tr>
<tr>
<td>Poor fishing</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

more to people than environment—in order of importance they were park facilities, litter, user-constructed facilities, water purity, and camper friendliness(!). Ground cover (as evaluated by experts) was among the 5 most important variables related to overall campsite satisfaction, however.

Analysis of the relationship between satisfaction with physical conditions and visitor perceptions of conditions were surprising. The equation explained 20 percent of the variation in satisfaction ($R^2=0.2010$), but the four most important independent variables were all social factors. Furthermore, none of the perceived impact variables had any important relationship to overall satisfaction.

In general, Yosemite visitors' recognition of environmental impacts seemed low and the impacts' effect on satisfaction appeared minor. "Deterioration of the physical environment had far less effect on campers than did the presence of 'unnatural' objects left by previous visitors."

My own current studies of eight wilderness and similar areas in Montana and Idaho and one in California separate reactions to litter and site conditions. Site conditions were rated as "good" or "very good" by 70 to 80% of the visitors to all areas except the heavily used Desolation Wilderness in California, where ratings dropped to 55%. Litter conditions were rated as worse than site conditions in all areas.

Visitors who had previously visited each area were asked how area conditions (of all kinds) had changed, that is, whether conditions were better, worse, or about the same as before. In most areas, over half said "the same", while "worse" responses outnumbered "better" 2 to 1. In the Desolation Wilderness, although nearly half said "same", "worse" outnumbered "better" over 4 to 1. In the Jewel Basin Hiking Area in Montana, where horses and motorcycles were banned beginning in the study year, "better" responses equaled "worse" (each group accounted for about 21% of the total).

Visitors were asked why they rated conditions as they did; about 10% cited littering and less than that mentioned other impacts.

Visitors' perceptions of wear and tear were negatively correlated with their reported overall satisfaction with the trip. Values for Gamma, a type of correlation statistical measure, ranged from -0.18 to -0.44. This means from about 18 to 44 percent of the variation in visitors' satisfaction was accounted for by their rating of impact conditions, and suggests a weak to moderate loss of satisfaction with increased wear and tear. This is stronger than the correlation between visitors' ratings of litter conditions and satisfaction (although they rated littering conditions as worse than impacts), and it is about the same as the correlation between satisfaction and ratings of crowding/solitude. However, I have no data on how visitors' perceptions and ratings of "wear and tear" related to the actual site conditions.

This same study shows only limited support for facilities and developments in wilderness, including some that might help protect sites, such as hitching rails, corrals, fireplaces, outhouses, and so on.

Some indirect indications that many campers do not perceive campsites as excessively impacted comes from a current Master's thesis study by Beth Ranz of the University of Montana. She found that 16% of the camper parties around a large, popular lake in the Selway - Bitterroot Wilderness used campsites posted as closed because of camping damage (as perceived by the managers). At least a part of this camping probably is because the sites looked acceptable to visitors ("What's wrong?") or because they did not recognize the impacts they would cause ("What am I going to hurt?").

**Visitors' Perceptions of Trail Impact**

Very little research deals with visitors' perceptions of trail conditions. Trahan (1977) reports that trail users in Rocky Mountain National Park, Colorado, rated trail conditions very high -- 85% said "excellent" or "good".

In Yosemite National Park, satisfaction with trails was moderately high (Lee 1975). Satisfaction with physical conditions was lower than overall satisfaction, which was about the same as satisfaction with the social atmosphere. This seems to suggest a secondary role for physical conditions in visitors' satisfaction with trails.

Visitors ranked horse manure on the trail the most objectionable condition, followed by physical deterioration and litter. Expert observers rated litter as vir-
tually absent, and manure and trail condition about the same. This implies visitors reacted more sensitively to manure than eroded, rutted trails.

Almost none of the variation in satisfaction with trail physical conditions was accounted for by expert observations ($R^2=0.0387$). Loose rock on trails and numbers of people (a social factor) were the most important variables. More of the variation in satisfaction with trail physical conditions was accounted for by visitor perceptions ($R^2=0.2013$). Physical deterioration and horse manure were the most important variables in this equation.

Overall trail satisfaction was largely unexplained by the regression equation ($R^2=0.0524$), but litter and trail deterioration appeared to be the most important variables.

In my study of 9 wilderness-type areas, visitors were asked why they rated general wear and tear as they did. Only about 10% gave trail erosion as a reason.

In two study areas (the Selway-Bitterroot Wilderness in Idaho and Montana and the Desolation in California), visitors were asked their evaluation of trail conditions. More than 70% said they were well-satisfied with trails. This was despite the fact that some of the Selway-Bitterroot trails were severely eroded (Helgath 1975). Trail complaints rarely referred to erosion (less than 5% mentioned it) and almost never to manure (1%). The erosion complaints came mainly from hikers; down-tree complaints were largely from horse travelers.

In all areas, support for low standard trails was much stronger than for high-standard trails.

Visitors' Perceptions of Other Impacts

I am not aware of any studies on recreationists' perceptions of air pollution in recreation settings. Backcountry campers in Yosemite National Park rated water quality fairly high, as did expert observers (Lee 1975). The expert ratings of water quality were a relatively important variable in multiple regression equations relating site conditions to overall satisfaction and to satisfaction with social and physical conditions in camp sites. Visitors' perceptions of water purity were relatively unimportant in accounting for variation in the campsite satisfaction measures.

There are a few, indirect indications that visitors almost totally fail to perceive impacts on wildlife by themselves and other visitors. Ream (1976) found loon nesting suffered due to disturbances by canoeists and campers. Hunt (1972) reports reduced nesting success by gulls in Maine as a result of recreationists. Hudnall (1977) describes adverse effects on whales. Weeden (1976) mentions harrassment of hawks, plover, terns, and elephant seals. Glinski (1976) describes harassment of birds in Arizona by bird watchers. Most of the visitors in these cases were unaware of any impact they were causing. (See the paper by Ream at this conference for a discussion of recreationists' impacts on wildlife.)

Managers' Perceptions of Impacts

Managers' perceptions have been studied very little and not specifically in relation to impacts, except Downing and Moutsinas (1978) study of managers' attitudes about dispersed road recreation, which is discussed further in Downing's paper at this symposium. It might be interesting if someone analyzed the content of impact-related statements in management plans and other documents prepared by managers as one way of describing their perceptions of different types of impacts.

Hendee and Harris (1970) found that Forest Service wilderness managers and visitors had similar attitudes about wilderness. However, when managers predicted visitors' opinions, three major misperceptions appeared, all of which have implications for impact management: (1) Visitors were less in favor of facilities and developments than managers expected; (2) visitors were more willing to accept regulation than managers expected; (3) visitors were more willing to permit managers flexibility and use of mechanized equipment for wilderness management than managers expected.

Peterson (1974) also found that managers and visitors in the Boundary Waters Canoe Area shared most perceptions. However, visitors were less aware of "the deprecatory consequences of recreational use" than managers. He also reported a similar discrepancy for water quality, i.e., visitors thought water quality was better than the managers did. In contrast to other studies, Peterson found a greater proportion of
visitors in favor of facilities than managers.

Even more indirect, but perhaps offering some insight into the differences between managers' and recreationists' perceptions, is a study of road-accessible recreation areas on two national forests in Michigan (Lucas 1970). Recreation resource evaluations by Forest Service planners did not correlate with visitors' evaluations of the same resources at the same sites, nor with the amount of recreational use the sites received. This suggests problems in managerial judgements of site attractions, which has implications for programs of trail or campsite closure or relocation.

CONCLUSIONS

Management of recreational impacts on wildlands apparently must largely depend on factors other than the effect of impact conditions on visitors' experiences and satisfaction. Environmental impacts do affect visitors and confirm the urgency of the problem but visitors' limited perception of impacts and the resulting weak-to-moderate reductions in satisfaction suggest that management of recreational impacts be based mainly on: (1) professional recognition of longer-term consequences of impacts; and (2) legal and policy goals that set standards for naturalness and acceptable impact levels.

This conclusion is consistent with West's (1975) position, but it rests on a slim research base. The problem of defining environmental damage in recreation settings, and of understanding impact perceptions by visitors and managers is sorely in need of more research. The definition of acceptable impacts needs a clearer conceptual framework. It appears to be a complex, multifaceted concept. For example, the amount of ecological change resulting from recreation impacts and the kinds of changes visitors notice and dislike may not be closely correlated.

Managers also need to be cautious in reacting to visitor evaluations of impact conditions. It is possible that visitors who object to impacts could abandon an area and be replaced by visitors who are less sensitive to impacts, and, thus, for visitor acceptance to remain high. However, if management objectives remain unchanged, this shifting clientele may mislead managers.

Education of visitors to increase their awareness of the impacts they cause appears to be necessary to help motivate their adoption of lower-impact techniques. Education is also a management action that is very acceptable to visitors.

Structural or engineering solutions, in effect "site hardening", need to be very carefully evaluated. At least in wilderness, the research results suggest that visitors may find such facilities worse than the impacts corrected. In other words, obvious human manipulation may reduce satisfaction more than the less-easily recognized ecological changes these managerial actions are attempting to minimize. Here again, more research is badly needed. For example, how do visitors view the trade-offs between bogs on trails, log corduroy, or soil cement? How do visitors' standards of acceptability vary with the setting, e.g., between wilderness and various other types of roadless wildlands?

Relocation of campsites and trails from fragile to more durable sites is a management action that could fit in well with visitor perceptions and attitudes. It can avoid or reduce the need for engineering approaches that many visitors view as over-development, as well as reducing the need for regulations on use. More research is needed, however, to enable managers to assess fragility and durability of different locations, and, also, visitors' perceptions of the attractiveness and acceptability of alternative sites, especially campsites.

Finally, where necessary, visitors by and large will accept and generally comply with well-founded, well-explained regulations and controls designed to reduce impacts.

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DETERMINING THE ACCEPTABILITY OF RECREATIONAL IMPACTS: AN APPLICATION OF THE OUTDOOR RECREATION OPPORTUNITY SPECTRUM

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ABSTRACT--Impacts from recreational activities on wildlands are of increasing concern to resource managers and recreationists. Determining the acceptable level of recreation impacts is difficult because there are no absolute standards of acceptability. In this paper the Outdoor Recreation Opportunity Spectrum is used to describe the role recreation impacts play in defining recreation opportunities. Noise is used as a case example.

INTRODUCTION

Throughout the United States, increasing numbers of people are going into wildlands in search of outdoor recreation. Growth in recreation whether in highly developed and intensively used forest campgrounds or in wilderness has brought with it an increasing concern about associated impacts. Managers, users, and researchers alike have become increasingly conscious of the potential adverse consequences of recreation use on vegetation, soil, water, wildlife, and other resources (for specific examples, see Downing and Clark, and Christensen et al. elsewhere in the proceedings).

Although there is a growing concern about recreation impacts, it is also clear that substantial disagreement surrounds what constitutes unacceptable impacts. The presentations and discussions at this conference clearly indicate that definitions of acceptability depend upon the values and expectations of the person making the judgment. A conflict in values seems unavoidable because so many Americans use our wildlands for so many diverse purposes.

In this paper we describe how the concept of the Outdoor Recreation Opportunity Spectrum (OROS) can be used in making judgments about the acceptability of recreational impacts. First, we will briefly describe the factors that help define recreation opportunities, followed by a discussion of the role which expectations play in a judgment of acceptability. In the last section of this paper, we show how the OROS framework can be applied to minimizing noise problems in recreation areas.

THE OUTDOOR RECREATION OPPORTUNITY SPECTRUM

The task of assessing potential consequences of a variety of recreational impacts begins with a definition of recreational opportunities. When considering outdoor recreation opportunities, people must make choices about the types of setting in which to recreate, the sorts of activities in which to engage, and the kinds of recreation experiences to seek. In this paper we focus on the setting in which recreation occurs. It is our belief that if recreationists have information describing the
factors which influence or define the range of possible settings, they will be in the best position to make choices in keeping with the experiences they desire to find. We define a recreation opportunity setting as the combination of social, physical, biological, and managerial conditions that give value to a place. Consequently, the role of values is central in understanding recreation. Different values producing different tastes, interests, and preferences lead to diverse demands for recreation opportunities that array themselves along a continuum or range. We and others (for example, Driver and Brown 1978 and Brown et al. 1978), have found this continuum useful for dealing with a wide range of value-related management issues such as carrying capacity, depreciative behavior, and recreation impacts. We refer to this continuum as the Outdoor Recreation Opportunity Spectrum (OROS). It is distinguished by varying conditions ranging from modern and developed to primitive and undeveloped, or as Nash (1973) succinctly phrased it, "from the paved to the primeval."

To make practical order out of this, we have broken the OROS down into six factors (setting attributes) which influence recreation behavior and have management significance. A more detailed description of these six factors may be found in Clark and Stankey (manuscript in preparation). These factors include:

1. **Access** into and within the area, the level of difficulty associated with access, and the permitted means of conveyance.

2. **Other non-recreation resources uses** (timber, mining, etc.). The extent to which they are compatible with various outdoor recreation activities.

3. **On-site management** -- the extent, apparentness, and complexity of modification, including the use of exotic vegetation, landscaping, traffic barriers, facilities (tables, toilets, water supplies) and others.

4. **Social interaction** -- the relative intensity of use per-unit area, including the level of intergroup contact and the space requirements associated with different opportunities.

5. **Level of regimentation** -- the nature, extent, and level of control over recreation use exercised by management.

6. **Level of visitor impacts** acceptable in different opportunities.

Each of these factors is characterized by a range of conditions. For example, access ranges from areas where mechanical access on wide, paved highways is appropriate and in keeping with the opportunity provided, to areas where no trails exist and only foot travel is permitted. Similarly, the level of social interaction varies from where high-density use is present (as well as appropriate and expected, such as in some modern campgrounds) to places where maximum solitude occurs. The point is, these conditions by any single or absolute standard of appropriateness; rather, the appropriateness varies along the spectrum. Well-developed roads and large numbers of people with frequent contact between parties are not appropriate in wilderness, yet they can be very appropriate in places like beach areas near an urban area and highly developed campgrounds.

A recreation opportunity setting is the result of a specific combination of these factors in a particular location. The setting may also include a variety of other natural features (scenery, landscape, wildlife, mountains, lakes for example). Alternative combinations of the factors lead to different types of opportunity settings which give recreationists many options from which to choose, in keeping with the experience they desire. Considerations about appropriate criteria to apply for any one of the factors are largely judgmental; there are seldom any absolute standards. But use of the OROS in making decisions about opportunity settings forces one to make all conditions explicit, which should maximize the possibility for all recreationists to find the types of opportunities they desire.

**DEFINING ACCEPTABLE VISITOR IMPACTS**

Factor 6, visitor impacts, is an aspect of the OROS that is especially critical in recreation management. Recreation activities can disturb soil stability, vegetation, wildlife, water, scenery, and the natural quietness of many outdoor environments. In many cases in the past, the management response has been for example, to regulate, restrict, or prohibit use (or the type of equipment), harden sites or install protective facilities. But the meaning of these management changes is often unclear to recreationists. Such actions may have con-
sequences as disruptive of recreation opportunities and recreationists' experiences as do the impacts they are meant to control.

The assumption implicit in management actions to minimize or eliminate impacts from recreation activities is that the impacts are unacceptable. What has not been adequately resolved, however, is what, in fact, defines acceptability and to whom. It often appears that while impacts of varying degrees are expected and acceptable in other resource uses (for example, timber management, mining, grazing), a "no impact" standard has been prescribed for the management of many outdoor recreation opportunities (Burch 1970). But a no impact philosophy may be impossible without drastic reductions in use in many areas.

In considering what constitutes appropriate or inappropriate impact, it is helpful to distinguish between the magnitude of the impact and its importance. Magnitude refers to the quantitative aspects of the phenomenon under study such as its frequency and extent. Magnitude can be measured reliably by independent observers and there will be typically little disagreement about these measurements. Often however, an ex post facto approach to establishing magnitude is required and is typically less reliable.

Importance, on the other hand, reflects the value one assigns to some phenomenon such as sound, water pollution, soil compaction. Importance will vary among individuals and over space and time. For example, two individuals observing the same impact with predetermined magnitude can differ greatly in the importance they assign to that impact, a difference reflecting their personal value system and expectations. The role which values and expectations play in defining the importance of recreation impacts (or any other type of impact for that matter) is described below.

Our view of the world around us is shaped by deeply imbedded orientations that we call values. Values provide an estimation of the worth of some object to an individual or in a particular situation (Andrews and Waits 1978). Although values often are not explicitly recognized, they form the base from which we develop our concepts of what is right and wrong, appropriate and inappropriate, acceptable and unacceptable. Many of these notions "go without saying," that is, we don't really stop and think about them, where they come from, or what they imply, because they are general and, in a sense, vague, they are difficult to change. In general, we tend to seek out and accept those things that we perceive as consistent with our particular values.

In addition, we choose to do things and go to places likely to meet our expectations. These expectations are a function not only of the values we hold, but also of our experience and knowledge. These expectations will influence what people define as acceptable or unacceptable actions on the part of others. Expectations are formed by many factors which are either internal or external to the individual. These include the influence of family and/or friends, the media, schools, available information, personal values, personal experience in similar situations, and the norms (informal rules) which govern appropriate actions in a particular place.

People have expectations regarding what they will find in any particular location. And, in a specific situation, people will judge the importance of impacts based on those expectations. The judgment has two possible outcomes: Either the impact in this context is acceptable and does not detract from their satisfaction; or the impact in this context is unacceptable and may lead to a decline in user satisfaction and, perhaps, a decision not to return to that location in the future. A given individual may judge the same impact acceptable in one situation but unacceptable in another—the judgment depends on the context within which the impact occurs.

In addition, people's expectations may be either realistic or unrealistic for a particular situation. Realistic expectations are based on accurate knowledge of the purpose of an area and the norms operating there. Expectations may change as one gains new information and experiences. Generally, we might expect to find that people with greater experience in an area would have more realistic and strongly held expectations than the novice.

Fortunately, the relative importance people attach to impacts does not vary randomly along the ORS. That is, people who choose a particular type of opportunity (modern or primitive, for example) probably hold somewhat similar notions of what is appropriate and in keeping with these kinds of places. Some of these notions become widely and strongly held norms that govern behavior and set standards of appropriateness and acceptability in a specific
opportunity setting far more effectively
than any agency-promulgated rule ever will.
In other cases, it is less clear what
specific criteria are appropriate,
acceptable, or expected. Here our estimates
must be tentative and open to revision.

The challenges are then to (1) set
standards on acceptable impact levels for
recreation areas, taking expectations into
account along with other spectrum factors and
concerns such as other resource values and
long term goals for the area; (2) provide
adequate information about what one will find
there so that users can make choices about
where to go in keeping with their preferences
and expectations; and (3) manage and monitor
the activities and impacts to ensure that the
situation doesn't change inadvertently,
thereby adversely affecting the quality of
the recreation environment.

We can illustrate the relative nature of
impacts by considering the issue of noise in
recreation areas—or more correctly, sound.
Sound is a physical phenomenon susceptible to
accurate measurement. Thus, the magnitude of
sound can be assessed using the physical
model outlined by Harrison elsewhere in these
proceedings. But "noise" is an inter­
pretation that the magnitude of the sound
(such as those listed below) has reached
unacceptable levels; and no absolute
standards define this level, with the
possible exception of the threshold of pain,
a condition generally not present in recre­
ation areas. Yet, recreationists' com­
plaints about noise are familiar to most
managers; and there are clearly some common,
albeit not universally shared notions, as to
what constitutes noise in certain settings.

In the following discussion, we offer an
example of how managers can use the OROS to
integrate the data supplied by Harrison's
physical prediction model, so as to keep
sound within acceptable levels in recreation
areas. The approach we describe is based on
state-of-the-art judgments from the best
knowledge available (from research and
management experience) at the present time.
Additional research will be necessary to de­
terminate how well the concepts we present fit
reality.

Some potential sound sources in recrea­
tion environments are as follows:

**Mechanical**

Vehicles (autos, trucks, motorcycles)

Airplanes, helicopters
Other motors (chain saws, generators)

**Non-mechanical**

Human
Voices (talking, singing, yelling)
Camp tending (clanging dishes, wood
chopping)

Domestic animals (stock, pets)

Other (radios, gun shots, musical
instruments)

**Noise Impacts--an Example**

Noise in recreation areas is a concern
to managers and users alike (Dailey and
Redman 1975). The rejection of noise is
characteristic in all types of recreation
areas—noise is as inappropriate in a modern
campground as it is in a remote wilderness.
The difficult problem, however, is that one
individual's definition of noise may not be
another's. Furthermore, definitions of
noise are a function of more than just
decibel level; some types of sounds con­
stitute noise (that is, inappropriate sound)
regardless of the magnitude. Even the faint
sound of a machine might constitute noise in
a wilderness. In a developed, modern camp­
ground the same sound might not be noticed.

Noise is a characterization of sound in
a particular context or setting. The appro­priateness of a sound depends upon expec­
tations for a particular setting (although we
recognize one's expectations may themselves
be inappropriate or unrealistic). Con­sequently, standards regarding the loudness,
frequency, or duration of the sound, or the
type of sound that exists, may be inappro­
priate if they ignore the setting. There­fore,
standards for appropriate sound levels in
recreation environments should be estab­lished only in terms of specified situations.

The concepts of magnitude, importance,
and the OROS provide a useful framework in
determining when sound becomes noise in
recreation areas. Present technology allows
us to determine the magnitude (how loud
different sounds are at various distances and
across different terrain). The physical
model developed by Harrison is an application
of this technology. The physical model
provides valuable data because it informs
managers about the physical consequences of
sound sources under a variety of conditions
and the distances required to buffer one area
from another. Determining the importance of these sounds, however, is not as easy. We offer the following approach as a way to utilize the opportunity spectrum in this task.

We assume that most people would prefer to have a relatively quiet environment, whether they favor modern or primitive recreation opportunities. But, we also assume that people expect that opportunities towards the modern end will have a greater variety of human-related sounds than opportunities toward the primitive end. The OROS framework suggests that a variety of human-related sounds are not only consistent with opportunities towards the modern end of the spectrum, but that they are acceptable (and perhaps not even noticeable) to most people who prefer those opportunities. Following is a proposed typology of appropriateness for sounds in recreation areas for four types of recreation opportunities. The labels used (e.g., modern, semi-modern) are arbitrary. Other labels, such as urban, rural, natural, could be used depending on individual preference.

**Modern.** "Noisy" relative to the full range of recreation opportunities. A variety of both mechanical and nonmechanical sounds are acceptable at levels close to that found in urban residential environments. The sounds may be of long duration, occur frequently, and occasionally be heard during late hours of the night. Sounds are acceptable well beyond the source.

**Semi-modern.** May have the same sound sources as in modern opportunity areas; the loudness, frequency and duration of the sounds are noticeably less. Sound impacts are occasionally evident beyond the general area of their source.

**Semi-primitive.** Have primarily natural sounds. Human-related sounds are less frequent than in the semi-modern category, last for a shorter period of time, and are infrequent during the night. Sound impacts are generally confined to the general area of their source.

**Primitive.** Generally free from human-related sounds; the primary sounds are natural background sounds such as wind or water. Both mechanical and non-mechanical sounds are inappropriate in the most primitive opportunity areas. Sounds do not extend beyond the immediate area of their source.

Even though the presence of a variety of sounds may be acceptable, there are norms or standards regarding the duration, frequency, and timing of such sounds. For some "modern opportunities," for example, the sound of a chainsaw or motorcycle may be entirely appropriate. But either sound can be too long or occur too often or at the wrong time. That is, hearing a motorcycle or chainsaw may not be bothersome during the day, but if they occur outside your tent at 11:00 p.m. they're noise! At the primitive end of the spectrum, however, even the faintest sound of a chainsaw or motorcycle at any time will probably be defined as noise and be a serious disruption of the recreation experience. Sounds, then, only become noise according to the criterion of appropriateness within a specified opportunity, rather than at any absolute level. Figure 1 combines the characteristics of sound sources (frequency of occurrence, loudness, and duration) and the four opportunity types in a hypothetical relationship.

The following example should be helpful in demonstrating how one might evaluate sound impacts in recreation areas. For illustrative purposes, we use U.S. Environmental Protection Agency standards for urban residential noise as a baseline (see Harrison elsewhere in these proceedings). We have suggested how standards for four possible recreation opportunity types might be established (see Figure 2). For example, one might propose that for "modern opportunities," standards for mechanical and non-mechanical sounds would be the same as regular urban residential standards. However, for "semi-primitive opportunities," the standard for mechanical sounds (largely inappropriate in such a setting) would shrink to 10% of the urban baseline, while non-mechanical sounds would be 40% of that same baseline. In primitive settings, at least ideally, mechanical sounds would be nonexistent and non-mechanical would perhaps be no more than 10%. Table 1 summarizes the characteristics of acceptable sounds across the four opportunity types.

To determine whether a sound from a specific source will affect a receiver in a particular recreation opportunity setting, the following steps are suggested. The procedure can be used to evaluate both existing and potential source and receiver locations.

1. Define the recreation management objectives for the area in question in terms
Figure 1. An hypothesized relationship of appropriate sound source characteristics and the opportunity spectrum.

High

Number, loudness, duration and frequency of sound sources

Moderate

None

Modern Semi-modern Semi-primitive Primitive

Type of Opportunity
Figure 2. Acceptable level of sounds (hypothetical)

Percent of EPA urban residential limit

Type of Opportunity
Table 1. Proposed characteristics of acceptable sounds as heard by other parties

<table>
<thead>
<tr>
<th>Opportunity</th>
<th>Type of sound</th>
<th>Loudness (% urban resident limit)</th>
<th>Frequency of occurrence</th>
<th>Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Modern</td>
<td>mechanical</td>
<td>100</td>
<td>very common</td>
<td>long during the day</td>
</tr>
<tr>
<td></td>
<td>nonmechanical</td>
<td>100</td>
<td>very common</td>
<td>short at night</td>
</tr>
<tr>
<td>Semi-modern</td>
<td>mechanical</td>
<td>50</td>
<td>common</td>
<td>short during the day and night</td>
</tr>
<tr>
<td></td>
<td>nonmechanical</td>
<td>75</td>
<td>common</td>
<td>long during the day short at night</td>
</tr>
<tr>
<td>Semi-primitive</td>
<td>mechanical</td>
<td>10</td>
<td>infrequent</td>
<td>short during the day and night</td>
</tr>
<tr>
<td></td>
<td>nonmechanical</td>
<td>40</td>
<td>common</td>
<td>short during the day short at night</td>
</tr>
<tr>
<td>Primitive</td>
<td>mechanical</td>
<td>0</td>
<td>never (ideally)</td>
<td>N/A</td>
</tr>
<tr>
<td></td>
<td>nonmechanical</td>
<td>10</td>
<td>infrequent</td>
<td>short during the day short at night</td>
</tr>
</tbody>
</table>

1/ These relative limits are used for illustrative purposes only and are based on state-of-the-art judgments including past research and management experiences.

of the recreation opportunity spectrum (that is, determine the opportunity type—modern, semi-modern, semi-primitive or primitive—for which the area is to be managed). Once this decision has been made, standards specifying acceptable sound levels must be developed, such as shown in our Table 1.

2. Identify existing or potential locations of sound sources and receiver locations. Figure 3 shows a schematic drawing relating examples of sound source and receiver locations to opportunity settings.

3. Using Harrison's physical model, determine the sound levels at various receiver locations in the area(s) in question—that is, determine whether sounds from source locations S1-S4 will be heard in receiver location R1-R4 in Figure 3. (Care must be taken to identify critical problem spots so that hundreds of calculations are not needed to characterize an area).

4. Determine whether the magnitude of the sound (loudness) exceeds the standard for the opportunity level set by the area's management objectives.

- If not, then no unacceptable impacts will occur.
- If yes, then unacceptable impacts will occur. The nature of the impact should then be further examined to determine
Figure 3. Example of a management area showing potential recreation opportunities, in relation to planned and existing sound sources, and receivers' locations.

Sound sources:
S1 = trucks, highway traffic
S2 = cycle on road, logging truck
S3 = rock crusher
S4 = cycle on trail

Receivers:
R1 = recreationist expecting primitive opportunity at mountain lake
R2 = recreationist expecting semi-primitive opportunity camped along trail
R3 = recreationist expecting semi-modern opportunity camped along road
R4 = recreationist expecting modern opportunity camped in campground
how severe the impacts may be. One should determine:

1. the duration of the sound,
2. the frequency of occurrence, and
3. its timing (day, night, season for example. Such an analysis might point out that although the sound standards will be exceeded, this would occur only during periods when most recreationists are not present.

5. After this has been done and the nature of the impacts have been described in terms of their variability in time and space, then one or more of the following options can be considered.

a. Eliminate or move the source.

b. Mitigate the sound source by buffering, engineering modifications of the source, or regulation.

c. Redefine the area's management objectives, thereby changing the opportunity level to make it consistent with the sound source.

d. Do nothing, thereby accepting the consequences of the impact. This might change the nature of opportunity, at least in terms of sound impacts.

The manager's decision will require judgment as to the consequences and feasibility of each option.

CONCLUSIONS

The OROS does not represent a good-to-bad or quality-continuum. Quality recreation experiences can be derived from along the entire spectrum; they are not restricted to those which conform to values traditionally embraced by professionals in resource management or by any one interest group. Quality is a value judgment; what represents a quality experience for one person is not necessarily the same for another.

The basic rationale underlying the Outdoor Recreation Opportunity Spectrum is that quality in outdoor recreation is best assured through provision of a diverse set of opportunities. A wide range of tastes and preferences for recreation opportunities exists among the public. For those preferring solitude and a minimum of contact with others, primitive opportunities are appropriate. For others who seek a chance to meet and visit with friends in convenient and comfortable surroundings, modern auto campgrounds are preferable. Providing a wide range of settings varying in use density, level of development, access, and other respects ensures that the broadest segment of the public will find quality recreational experiences they seek, both now and in the future.

It is equally important to understand that impacts from recreational activities constitute only one of many factors that define opportunity settings. In some instances, recreation impacts may be the limiting factor in determining what recreation activities are possible and in what amount for certain places. In other cases, other factors may take precedence. Planners and managers must make these judgments on a case-by-case basis.

When evaluating the meaning of impacts, determine their magnitude as well as their importance. Although an objective method can be used to determine the magnitude of impacts (for example, the decibel level for sound, and the coliform count for water quality), estimating the importance of the impact is not as easy. Here, value judgments enter into the question, and considerable differences of opinion can occur between managers and recreationists as to what constitutes unacceptable impacts (for example, see Clark et al. 1971). When making these judgments, use of the Outdoor Recreation Opportunity Spectrum is useful because it recognizes that impact is a relative rather than an absolute concept and that what constitutes unacceptable damage in one opportunity setting may be acceptable and appropriate elsewhere along the spectrum.

RESEARCH NEEDS

The approach for determining the meaning of recreation impacts described in this paper is based on state-of-the-art judgment and combining findings from past research with management experience. As such, the guidelines described are tentative; further research is required to determine how well they can be generalized. Some questions needing additional study are:

1. What impacts are most disruptive to recreationists' experiences?
magnitudes? Do these vary across the opportunity spectrum?  

2. Are specific sounds equally annoying at the same magnitude across the opportunity spectrum? Or does annoyance vary by the type of source and recreationist?  

3. What specific standards are appropriate for each opportunity type? For various sound sources?  

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INTRODUCTION TO RESEARCH FINDINGS: SUMMARY SESSION

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A Research Findings Summary Session was held at the conference immediately after the research findings sessions on Vegetation, Soil, Wildlife, and Air-Water-Noise.

The purpose of the session was two-fold: to summarize the findings of the individual sessions, and to provide a forum specific to the research portion of the conference. Most of the discussion, however, concentrated on the role of the scientist in a research-manager-user context.

This summary precedes the specific research papers in the Proceedings because of its significance in interpreting the role of research and researchers in wildland recreation impact solutions.

Two introductory comments are in order. Because the Conference focused on biological and physical impacts, there is an unfortunate but unavoidable concentration on the natural sciences. Social science information is necessary to fully understand impact patterns, and, as this session indicated, to clarify the relationship between researchers, managers, and users. This summary was compiled from a transcript of the tape-recorded dialogue, and the ideas are those of the participants. Because the concepts and ideas have been edited and rearranged for a more coherent presentation, specific participants have not been identified.

The liveliest discussion of the Session revolved around how recreational impact scientists relate or fail to relate their findings to managers and users. This topic is certainly not a new or unusual one and could have been expected to surface here. The discussion identified two researcher weaknesses: (1) a failure to successfully communicate findings to managers, and (2) a lack of ability or unwillingness to generalize from findings.

The failure to communicate was characterized by the concentration of research information in the written word: bulletins and professional papers, for example. There was general agreement that publication, in and of itself, is not a sufficient communication device. Though, for a variety of reasons publications are an essential part of the research process, they must be supplemented by an interpretation of findings in manager or user languages. This interpretive function works best if the people involved shed their institutional roles and deal with each other on a personal level. Managers often are viewed as crisis oriented, operating by "seat-of-the-pants" logic, while researchers are incapable of seeing beyond their "ivory towers." Researchers and managers communicate best when these stereotypic impressions of each other are left behind.

Three ideas were presented as a positive approach to bridging the various gaps and occasional chasms between the conduct of research and its application in a manager-user context. The first was that researchers should allocate a proportion of their time, perhaps between one-third and one-fifth, to interpreting the results of research. Secondly, managers and users should go to researchers familiar with their subject area of interest and ask questions. This active, personal approach is viewed as the best way to stimulate researchers to communicate in understandable terms. If the questioner is persistent, he or she can usually obtain an excellent state-of-the-art interpretation. Finally, managers should use communication specialists to translate research findings from the management plan phase to the application phase. Most land management agencies are not currently using people who are trained professionals in communication, and often the failure to apply recreational impact research findings can be traced to ineffective communication to the user level.

The lack of generalization of research results was the other problem recognized in the recreational impact research discussion. Managers are often forced to deal with a variety of environments and an excess of day-to-day problems. They cannot afford to do research on administrative problems, and even if they could, interim management decisions still would be necessary. User and manager comments tended to favor a heavily
weighted management orientation to research. Researcher comments stressed the variability of systems as a barrier to gross generalizations, and the fact that basic research will define principles from which the best generalizations can be drawn. These attitudes at first glance reinforce the stereotypic characteristics of researchers, managers, and users, but perhaps more importantly they reflect a significant underutilization of research information that now exists.

There is a tremendous amount of unconnected research on recreational impacts that is impossible to digest in its present form. However, if a researcher begins to catalog this material in some sort of conceptual framework, consistent relations will often appear in the information. This consistency, if it exists, may require cataloging several hundred pieces of information. There was no agreement in the discussion on an appropriate conceptual framework. Habitat types were suggested as a framework by one participant, but were noted by another person to be much more floristically than edaphically consistent and, therefore, not a sufficiently uniform framework from which to generalize. The framework may differ from area to area or agency to agency, but its purpose is clear: to allow the analysis of existing information and provide a means of identifying where future research should be concentrated. Conceptual models can often evolve to predictive models.

The generalization of research findings is closely related to the interpretive role of the scientist. If a state-of-the-art generalization can be coherently defined by the scientist for the manager or the user, this communication can create a supportive atmosphere for future basic or applied research by the scientist. It tells the people who will use or be affected by this information why new research is needed, and how it will fit into the existing information matrix which serves as the biological basis for management.

The following papers illustrate the range of physical and biological research projects that are attempting to find answers to wildland recreation impact issues. They range from conventional to highly innovative approaches to problems. The completion of such studies, however, is only one link in the process of finding solutions to impacts. The Conference audience indicated that a mutual interaction between researchers, managers, and users was a high priority item for resolution in recreational impacts.
research findings

SOIL

[Image of a tree root system]
ROLE OF SOIL RECONNAISSANCE SURVEYS IN PREDICTING USE-IMPACT SUSCEPTIBILITY OF WILDLANDS

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ABSTRACT--Examples from Kluane National Park, in southwestern Yukon Territory, illustrate the uses of a soil reconnaissance survey in a wildland recreation area. Such information as slope, mode of deposition of material, organic versus mineral soils, soil organic-matter content, and occurrence of wet soils, salinity, thin soils over bedrock, loess, and permafrost can have considerable interpretive value in terms of recreational suitability and impact susceptibility. Reconnaissance surveys are inexpensive, but yield maps of limited detail, inappropriate for highly site-specific application to a very small area. They are of value in planning the broad outlines of recreational development and management, identifying sites or routes where collection of more detailed soil information may be appropriate, and identifying areas where specific recreational uses should be limited.

Soil properties influence both the suitability of sites for specific recreational uses and the susceptibility of sites to recreational impacts (Montgomery and Edminster 1966). Information about soil properties and their geographic distribution can assist in development planning as well as management of a recreation area. Such information is contained in soil survey reports. Detailed surveys are too expensive for large wildland areas. The practical alternative is a low-intensity survey, commonly called a "reconnaissance survey".

The objective of this paper is to illustrate the nature and information content of a soil reconnaissance survey and its interpretations for predicting recreational suitability and impact susceptibility. Although such surveys may vary in many respects, a single example will serve the purpose of illustration.

The example considered here is the soil survey of Kluane National Park (Ballard and Otchere-Boateng 1977), in the St. Elias Mountains of southwestern Yukon. Most of the park area is occupied principally by rock and ice, and is too remote for heavy recreational use and significant recreational impact to be anticipated except along a few popular climbing routes. A portion of the park--about 3000 square miles--contains a considerable area of soil and vegetation. It provides important wildlife habitat and may be locally subject to intensive recreational use in the future.

A soil reconnaissance survey of this 3000-square-mile area was carried out by a 2- to 3-man crew over two 10-week field seasons, and soil maps were produced at a scale of 1:50,000. Map units were initially differentiated and characterized as terrain units. Major terrain factors, interpreted from aerial photographs, included topography (slope, aspect, and elevation), landforms and erosion features (indicating texture, mode of deposition, and depth to bedrock of soil materials), and vegetation type (indicating, for example, drainage, local climate, successional stage). Occasionally, such factors as lithology and the presence of calcareous materials could be inferred. The air-photo information was supplemented by such other information (e.g., geologic survey reports) as could be obtained for the survey area.
Each kind of terrain unit was field-checked. The first part of a field check consists of verifying the characterization of the terrain unit. Ground observation is used to improve the quality of photo interpretation. The second part of the field check consists of characterizing the soils of the terrain unit so that it can serve as a soil map unit. In the mountainous terrain of Kluane National Park, the smallest unit mappable at 1:50,000 inevitably contains more than one kind of soil. Thus the soil-map unit represents a complex of associated soils which forms a repeating element in the landscape pattern. Ideally, the field check is repeated several times elsewhere to confirm the soil characterization of a particular kind of map unit. However, the low intensity of a reconnaissance survey severely limits such verification. Thus it can only be inferred that similar map units, not subject to field checking, possess a similar complex of soils.

Such an inference assumes that the characteristics of a soil complex are very strongly correlated with the terrain features used in differentiating the map unit. The underlying rationale is that soil properties are known to reflect the interaction of environmental factors, such as climate, organisms, topography, and parent (geologic) material acting over time (Jenny 1941; Buol et al. 1973). Thus, where such factors, indicated by terrain features, are similar, soils can be expected to be similar. Where any such factor changes substantially, as at a landform boundary, there is likely to be a significant soil boundary.

Compromise is inevitable in the choice of map scale and in the symbols which label each map unit. The park planner interested in an overview of a large area may be overwhelmed if detail is excessive; the park manager concerned with problems at a single campsite will be disappointed if detail is scanty. To some extent, such conflicts can be resolved with different maps, and at different scales containing different amounts of detail. However, maps produced in reconnaissance surveys seldom provide site-specific interpretations for small areas. Their information content seldom justifies scales larger than 1:50,000. Map-unit symbols for the Kluane soil survey convey only a minimum of detail (Figure 1). Soils of dominant and subdominant materials are included, separated by a horizontal line. The first letter symbol describes the kind of material, e.g., "M", morainal; "C", colluvial. Numerals broadly describe soils in terms of pedogenetic classification, according to the recent Canadian system (Canada Soil Survey Committee 1974). For example, the numeral 1 designates Regosols (mineral soils lacking a B horizon); 2 designates Alpine Eutric or Dystric Brunisols, which possess a weakly developed B (cambic) horizon. The minor soils are in parentheses. Lower-case letters are modifiers, connoting additional soil characteristics. The final symbol, following a sloping line, is an upper-case letter denoting the broad slope class which applies to that material in the map unit. The "M" represents 9-30% slopes, "S" represents 30-60% slopes.

A soil scientist could provide the land manager with several interpretations if the soils could be more closely defined taxonomically. The modifier symbols make this possible. Table 1 shows the taxonomic significance of some modifiers which might be used with the numeral 1, the Regosols. The "n" signifies that the Regosols contain little organic matter near the surface, "h" signifies more abundant organic matter, "k" signifies the presence of calcareous materials, and "c" signifies that permafrost is present. As seen in Table 1, the modifiers often permit classification at soil subgroup level in the U.S. taxonomy (Soil Survey Staff 1975) and in the Canadian system.

The map-unit symbols also enable more direct interpretations related to recreational suitability and recreational impacts. For example, the kind of material conveys information concerning particle-size distribution of soils, information which can...
Table 1. Regosol taxonomy in relation to "modifier symbols" used on soil maps of Kluane National Park

<table>
<thead>
<tr>
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<tbody>
<tr>
<td>n, kn</td>
<td>Orthic Regosol</td>
<td>Cryorthent</td>
</tr>
<tr>
<td>h</td>
<td>Orthic Regosol</td>
<td>Entic Cryumbrept</td>
</tr>
<tr>
<td>hk</td>
<td>Orthic Regosol</td>
<td>Cryic Rendoll</td>
</tr>
<tr>
<td>cn, ckn</td>
<td>Cryic Regosol</td>
<td>Pergelic Cryorthent</td>
</tr>
<tr>
<td>ch</td>
<td>Cryic Regosol</td>
<td>Pergelic Entic Cryumbrept</td>
</tr>
<tr>
<td>chk</td>
<td>Cryic Regosol</td>
<td>Pergelic Cryoboroll</td>
</tr>
</tbody>
</table>

be used for engineering purposes in planning trail and road systems. For example, morainal materials (Table 2) are somewhat variable, but normally fall within a certain limited range of classes in the Unified Classification System, used by engineers (U.S. Waterways Experiment Station 1953).

Table 2. Some engineering interpretations for morainal materials, Kluane National Park

<table>
<thead>
<tr>
<th>Common Unified Classes (U.S. W.E.S. 1953)</th>
<th>As subgrade material</th>
<th>For road surfacing</th>
<th>Drainage</th>
<th>Frost-heave susceptibility</th>
</tr>
</thead>
<tbody>
<tr>
<td>GW-GM, GW-GC, GM, GC.</td>
<td>Most are good.</td>
<td>GW-GM, usually good; GW-GC, usually excellent; GM and GC, poor.</td>
<td>Poor in some areas</td>
<td>High for GM</td>
</tr>
</tbody>
</table>

At Kluane Park, the silty and clayey gravel classes and their intergrades with well-graded gravel are especially common among morainal materials. For road construction, these are usually good as subgrade material; the intergrades are good to excellent for surfacing unpaved roads, but the silty and clayey gravel classes are poor. Morainal materials pose drainage problems in some areas, and the silty gravels are particularly susceptible to frost heaving. Of course, additional engineering interpretations could be made from other map-unit symbols, such as those denoting organic soils, permafrost, and slope class. Although the material symbol alone conveys some useful information, the example given here shows that it lacks precision in distinguishing some of the Unified classes. The engineer looking at alternative transportation corridors may use the reconnaissance survey to identify clearly unsuitable routes, and thus trim the list of candidate routes for which more detailed survey information might be obtained before making a final choice.

Soil erosion is sometimes an impact of heavy recreational use. The map-unit symbols designating kind of material and slope class permit an approximate estimate of erosion risk. For example, most morainal soils on slopes of 9-30% (M.../M map units) may be assigned a low erosion risk. Some exceptions to this generalization are associated with certain modifier symbols (Table 3). Where permafrost occurs, erosion risk is higher because meltwater is perched over the frozen layer, contributing to the likelihood of
solifluction and/or surface runoff. A superficial loess layer is more erodible than most morainal materials. Soils with low organic-matter content are likely to be poorly aggregated and hence less erosion resistant.

The numerals in the Kluane map-unit symbols, which denote major taxonomic groups of soils, have some significance in relation to recreational suitability and impact susceptibility. For example, certain numerals represent the Gleysolic and Organic soil orders. These soils occupy wet sites, so that trafficability is poor and deteriorates reducing soil aeration and impairing growth of the natural vegetation of such soils. However, the trafficability problem is less severe than on Organic or Gleysolic soils, so gleyed soils can usually withstand very light traffic, e.g., dispersed backcountry recreation, without perceptible impact.

An "r" modifier denotes occurrence of bedrock near the soil surface (lithic soil subgroups) within the map unit. (However, because of the scale of mapping, there may also be large areas of deeper soils included in the map unit.) Bedrock near the surface suggests limitations in terms of road and trail locations, campsite suitability, sewage disposal, erosion following site disturbance, and slow and incomplete recovery from the impacts of over use.

The "c" symbol, indicating presence of permafrost, and the "h" and "n" symbols, denoting presence versus absence of significant soil organic matter, have already been mentioned. Except in early primary succession on recently deposited materials (e.g. Dryas drummondii on new alluvial fan deposits) an absence of vegetation is usually well correlated with the "n" symbol. A well-drained soil designated "cn" (which might be found in a high alpine area) may be very resistant to recreation impact. There is little or no vegetation to be disturbed, and the permafrost is unaffected by recreational use. A soil designated "ch" (which might occur under meadow vegetation in a low alpine area) is likely to be very susceptible to recreational use. The vegetation and the soil organic-matter content protect the soil from deep summer thawing. Vegetation damage from use (e.g., as a campsite) may allow substantial thawing, turning the soil to a muck, forcing recreational activity onto adjacent

### Table 3. Erosion risk ratings for morainal soils on 9-30% slopes, Kluane National Park

| Modifier Symbol | Erosion Risk Rating  
<table>
<thead>
<tr>
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<tbody>
<tr>
<td>c (permafrost)</td>
<td>high</td>
</tr>
<tr>
<td>e (loess cap)</td>
<td>moderate</td>
</tr>
<tr>
<td>n (low organic content)</td>
<td>high</td>
</tr>
<tr>
<td>other</td>
<td>low</td>
</tr>
</tbody>
</table>

/1 If more than one modifier symbol characterizes a map unit, the highest of the corresponding ratings is applied to the map unit.

rapidly under use. Such soils should normally be avoided for roads, trails, and structures and are poor for sewage disposal. If they would tend to attract very much use, it may be desirable to avoid developing or encouraging access to them.

Some modifier symbols are particularly useful in relation to impact susceptibility. For example, an "s" symbol denotes saline soils. In some places, these develop white surface crusts of salt during dry periods. Recreational traffic can be esthetically undesirable because of the tracks which develop on the salt crusts; it can also be ecologically undesirable because of impacts on the sparse and rather unique vegetation of the saline soils. The impact problems are aggravated by the poor trafficability of the fine-textured soils during wet periods.

A "g" symbol designates occurrence of gleyed subgroups of various mineral soils, e.g., Regosols or Brunisols. These occur on moderately wet sites which normally should be avoided by roads and trails because of poor trafficability. Traffic on these moderately wet soils may break down soil structure, trail locations, campsite suitability, sewage disposal, erosion following site disturbance, and slow and incomplete recovery from the impacts of over use.

An "r" modifier denotes occurrence of bedrock near the soil surface (lithic soil subgroups) within the map unit. (However, because of the scale of mapping, there may also be large areas of deeper soils included in the map unit.) Bedrock near the surface suggests limitations in terms of road and

48
undisturbed sites, and quickly spreading the area of impact. Traffic can have a similar, but more serious effect. A trail along a slope where soils are characterized by "ch" symbols is likely to become a deeply incised streambed after thawing and subsidence.

The map-unit symbols used in the soil survey of Kluane National Park are unique to that survey. But the information content of the soil maps and survey report is comparable to that of other surveys of very low intensity. With increasing survey intensity, the maps and reports would contain more kinds of information and greater precision, and thus facilitate interpretation for more varied application.

The examples given illustrate that susceptibility to recreational impacts and limitations on recreational suitability can often be predicted from soil-reconnaissance survey information. Such surveys, being inexpensive to produce and suitable for large areas, are particularly appropriate for recreational wild lands. Yielding maps of limited detail, they lack the information needed for highly site-specific application to a very small area. For wildland recreation, their greatest value is in planning the broad outlines of recreation development and land management, in identifying sites or routes where collection of more detailed information may be appropriate, and in identifying areas where certain uses should be limited.

REFERENCES CITED


U. S. Waterways Experiment Station, 1953. Unified Soil Classification System. Technical Memorandum 3-357. Vicksburg, MS.

REFERENCES CITED


DISCUSSION

Comment: Have you considered the possibility of correlating your soil units with vegetation units and then proceeding in more intensive or more detailed surveys without the pick and shovel, but using only vegetation?

Ballard: In fact, the survey program of Parks Canada does involve a reconnaissance survey of plant communities (and wildlife and aquatic systems) as well as soils. Because of the low intensity of the soil survey, vegetation units, along with landforms and other features, serve as important indicators of soil units. In the long run, as one develops familiarity with the area, one becomes better able to use vegetation units as an indicator of soil conditions. However, vegetation may not be an adequate indicator of some soil properties which may be of interest in a detailed soil survey.

Comment: After your paper, you showed a couple of slides illustrating the effect of nutrients on soils of the Polar Desert. Have you given any thought to why such an impact should be prevented, other than on a purely theoretical basis of keeping things the way they are?

Ballard: One of the attractions of the Polar Desert is its uniqueness. If people travel thousands of miles to see it, they presumably want to experience it free of the artifacts of occupation by modern man: free of the artifacts of recreational use. The slides showed that nutrients from a muskox carcass enabled abundant vegetation to grow on a site which previously lacked plants. More is involved than vegetation. Birds and grazing animals are attracted to such a site, and predators such as foxes are attracted by the lemming population which the vegetation supports. Analogous changes can be expected where nutrients are introduced in litter, garbage, and sewage on a recreation site.
THE USE OF SOILS INFORMATION FOR DISPERSED RECREATION PLANNING

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ABSTRACT—Planning for dispersed recreation areas requires information on soil conditions. However, these conditions vary and are often site-specific, and available soil inventories and mapping techniques may not be adequate. Various soil properties and their application to planning for dispersed recreation areas are discussed.

INTRODUCTION

All land use activities, from highway construction to farming, require consideration of the earth's soil material. Soils differ in suitability for various land uses because they react differently to various physical stresses. Consequently, soil conditions may pose specific design requirements for specific land uses. Though their effect is slight compared to highway development, dispersed recreational activities interact with soil conditions and require consideration of soil limitations.

Under the Resources Planning Act of 1974, Forest Service managers were given the responsibility of providing more wildland areas for dispersed recreational use, and protecting forest resources from physical degradation.

Unfortunately, there is little information on the capacity of forest lands to endure the impacts of recreational use; thus, forest managers have been wary of developing design requirements for dispersed sites. As a result, the past use of wildland areas has not always been compatible with the durability of the land.

Physical degradation of campsites and trails has been documented for many regions of the United States. The forest floor is trampled within concentrated areas, and the soil undergoes compaction. Part of the vegetation overstory is lost to root damage and firewood scavenging. Groundcover vegetation and litter is almost totally removed after light to moderate use of campsites and trails (Frissell and Duncan 1965; Dotzenko et al. 1967; Merriam et al. 1973; Bogucki et al. 1975; Legg and Schneider 1977; Young 1978). The bare soil has a greater potential for soil erosion by rainfall impact and runoff.

Campsites located on shallow soil, such as those near mountain summits or near pond shores, have recently been plagued by problems of human waste disposal. Heavy use at such sites has created more human waste than can be assimilated by the soil.

Profile measurements have been made on trails in the Northeastern United States by a transect method that measures changes in ground surface (Leonard and Whitney 1977). Net soil losses from erosion can be estimated from changes in trail depth and width. Moderately heavy-use trails ascending mountain slopes have been found to have significant soil losses. For example, after three years of transect measurements on moderately steep trails (15 to 45 percent) in the Green Mountains of Vermont, average trail cross-sectional area change (soil loss) was found to be 120 cm² per year (this is an average depth loss of 1.7 cm per year). These losses are of mineral soils from unvegetated trails having minimal natural litter cover.

In the Adirondack Mountains of New York, the change in trail depth was 1 inch (2.5 cm) per year on midelevation trails of moderate slope gradients (14 and 21 percent) in a paper birch or a spruce-fir forest (Ketchledge and Leonard 1970). For
comparison with soil erosion losses from other nonurban land uses, the measured trail changes have been converted to average soil losses per acre per year:

- Average annual erosion rate for Eastern United States -- 0.5 to 0.6 ton/acre/yr\(^1/\)
- Forest land, unharvested -- 0.04 ton/acre/yr\(^2/\)
- Forest land, harvested in a well-managed eastern forest -- 0.05 to 0.10 ton/acre/yr\(^1/\)
- Forest land, harvested (national average) -- 18.8 tons/acre/yr\(^2/\)
- Cropland (national average) -- 7.5 tons/acre/yr\(^2/\)
- Moderate use trail in the Green Mountains, Vermont (average trail cross-sectional 120 cm\(^2\) per year) -- 1.4 tons/acre/yr\(^3/\)
- Heavy-use trail in Adirondack Mountains, New York (Average trail soil lowering of 2.5 cm per year) -- 2.8 tons/acre/yr\(^3/\)

Gully erosion from a heavily used wildland trail is not as great as sheet or rill erosion from agricultural lands, but it is much higher than normal erosion from unharvested forest lands. Even greater trail erosion has been measured on the combined horse and foot trails in the Rocky Mountains in Wyoming. Forest trails have lost 11.7 cm per year and meadow trails have lost 7 cm per year (Dale and Weaver 1974).

Where interest or time and money have been available to forest districts and private mountaineering clubs, some very energetic maintenance projects have been initiated to reduce degradation on existing recreation sites. For example, in the White Mountains of New Hampshire, heavily used trails ascending steep slopes have been abundantly rock-stepped to retain loose soil and keep the hikers off the bare soil. Overnight sites that showed signs of severe compaction and destruction of vegetation have been closed and revegetated or "hardened" to withstand continued use. Human waste at some of the popular high-elevation shelter sites is no longer buried in the shallow soils, but is composted at the site or flown out by helicopter.

As the costs of maintaining some of the older campsites and trails rise, the desire for more sophisticated site planning information also increases. Factors affecting site tolerance to recreational impacts need to be identified more clearly. One of the factors that plays a role in site tolerance is soil condition.

Soil condition may not be a limiting factor in site selection but it may restrict the type of use that can be allowed or the types of facility and maintenance that may be required to handle the use. In this paper we define soil behavior criteria relevant to dispersed recreation needs, and discuss soil properties that affect these soil behaviors.

SOIL RESOURCE

To geologists, botanists, and soil scientists, the term "soil" has different meanings and encompasses different layers of the earth's surface. Soil is formed from mechanical and chemical weathering (or breaking apart) of rock materials. Some of this material remains in place over the parent rock; some is transported by gravity, water, ice, or wind to new locations. All of the loose material above the bedrock is called "regolith." The upper layers of loose material, which are a mixture of weathered minerals and rock and decaying organic matter, are called "soil." It is this material that supplies mechanical support and nutrients for plant growth (Figure 1).
Figure 1. Soil profile layers
Soil composition varies considerably among regions of the country. Five major factors affect the type of soil which is formed.

1. Climate, through temperature and precipitation, affects the type of weathering that occurs and the type and amount of minerals that are leached through the ground.

2. Topographic condition, for example, slope aspect, gradient, and position, affects the amount of moisture in the ground and the velocity of surface runoff of water and soil.

3. Rock material and mineral composition affect the mineral content of soils, the physical properties of soil, and the plant nutrients available.

4. Vegetation and other living organisms affect nutrient and moisture availability as well as soil structure.

5. Time—modifies all of these processes.

The regolith material undergoes continual modification and the soil profile that is formed is a reflection of the types of physical processes that have been active. Distinct soil layers and sublayers (called horizons) develop in many soils. Soils of the cool-humid regions have the most mature or distinct horizon developments (Bridges 1970). In general, most soils have four layers.

1. An upper layer of organic material which is dark and includes litter, fermented litter, and decomposed organic matter (humus). This layer is absent in polar and arid regions, which support little vegetation.

2. A layer of mineral soil in which nutrients from the organic material and minerals from the soil rock fragments are leached downward (called "zone of leaching" or eluviation). The types and quantities of minerals and nutrients that are leached out depend on the climate of the region. Greater precipitation causes more leaching; higher temperatures promote greater decomposition of organic materials.

3. A layer of mineral soil in which the minerals leached from above accumulate (called the "zone of accumulation" or illuviation). Again, the types of minerals here are determined by the climate of the region.

4. A zone of maximum leaching depth and least weathering, which is the transition zone between the lower mineral layer of high clay content and the underlying bedrock.

SOIL CAPABILITIES FOR DISPERSED RECREATIONAL IMPACTS

Soils differ in texture, structure, and physical-chemical composition, and respond differently to forces of gravity, surface and subsurface water flow, wind, and compaction. The ability of soil to support plant growth also varies widely.

The ability of the soil to support certain activities must be assessed for any land use development. For dispersed recreation activities, including trails and overnight camping, some soil conditions withstand the impacts of trampling, scuffing, and human waste disposal better than others. The physical capabilities of soils that should be considered for wildland site planning can be categorized as follows:

1. The ability of the soil to drain. This affects the extent of potential damage and, thus, maintenance needs at campsites and trails. Hikers tend to seek drier grounds; in so doing, they wear down trail edges and enlarge campsite areas. Soil drainage also is important for human waste disposal. Poorly drained soils inhibit the activity of soil organisms that is necessary for the aerobic decomposition of human waste.

2. The ability of the soil to resist erosion. Eroded soil affects the condition of trails and overnight sites. Soil erosion alters the soil profile as it wears away the surface organic matter and humus, and exposes the mineral soil to the forces of erosion (raindrops and trampling). The subsurface mineral soil will become nutrient deficient. The vegetation that can be sustained on the surface will be adversely affected (Wilde 1958).

3. The ability of the soil to support plant growth. The ease with which soil can be stabilized at campsites and adjacent trail edges is strongly affected.
4. The ability of the soil to promote decomposition of human waste. At dispersed overnight sites where special human waste facilities are not provided and the cathole method of waste disposal is used, the soil must be able to decompose the waste fairly quickly.

Site characteristics that affect the four soil capabilities have been summarized in Tables 1 through 4. The information in the tables was compiled from soil texts and research studies of changes in soil from recreational use. The information is not intended to address soil conditions for a specific region of the country. Rather, it is meant to provide an overview of the kinds of soil information that managers and recreation researchers need for analysis in their particular region.

Agricultural soils have been studied extensively, particularly for erodibility and fertility. Civil engineers have studied soils for properties affecting highway and urban development needs. The research in these disciplines has provided most of our current knowledge of soils. The physical processes at work on forest and mountain soils--soils characteristic of most of our wildland areas--are similar; however, the soil composition and texture are often quite different. Few quantitative studies have been made on the response of forest soils to recreation activities. Where some studies have measured the change in one or two soil variables, the amount of change has not been related to a quantifiable change in soil behavior. Given these limitations, the tables provide qualitative relationships between soil characteristics and expected soil behavior.

FACTORS AFFECTING SOIL CAPABILITIES

The soil capabilities for dispersed recreational use are affected by (1) various soil properties; (2) the climate of the region; (3) the topographic location of the soil; and (4) the vegetative cover. In many cases, the latter three factors have an over riding influence on soil behavior, and differences in soil characteristics are inconsequential.

Numerous studies of soil erosion on agricultural lands indicate that ground vegetation and litter cover have the greatest effect on reducing soil loss (Wischmeier and Smith 1965). The erodibility of loam soils on high-elevation rangelands in Utah was found to be affected primarily by the percent of ground covered by plants and litter.

The effect of cover was greatest on steeper slopes (Meeuwig 1971). Severe trail erosion in Idaho and Montana seemed most highly correlated with vegetation habitat and slope. Steep trails through subalpine fir on coarse, dryish soils showed the highest soil loss, and low-gradient trails through western red cedar stands on boggy soils showed severe gully erosion (Helgath 1975).

On barren soils, conditions typical of trails and campsites, the erodibility of mountain soils has been found to be affected most by slope gradient and rainfall intensity. Simulated rainfall studies on coarse, gravelly, sandy soils and a clay soil taken from high-elevation Rocky Mountain forest areas, showed that 90 percent of the variance in soil erosion loss was due to slope and rainfall intensity (Farmer and VanHaveren 1971).

The effect of slope gradient and length on soil erosion during rainfall has been studied using controlled situations of barren soil over uniform slopes. Slope gradient has been found to have the most significant effect on soil loss. For soils of medium texture, doubling slope increases soil loss by two to three times. Increasing slope length also increases soil loss, but the effect is less significant (Baver 1956).

Soil properties

Four soil properties that seem to have a significant effect on soil capabilities for dispersed recreation are texture, structure, organic content, and depth to pan layer.

Soil texture. This is defined as the relative proportions by weight of different sizes of particles in a soil. Soil particles have been classified by diameter size. The broadest classes from large to small are gravels, sands, silts, and clays. The coarse sands are irregularly shaped or spheroidal and the fine clays are platelike in shape.

Soil textures differ in physical behavior. Finer textured soil can hold more water and mineral elements (called cations), which are essential to plant growth (Brady 1974). As particle size decreases: (1) the total surface area of the soil increases, for example, the surface area of colloidal clays...
## Table 1. Ability of the soil to drain

<table>
<thead>
<tr>
<th>Factors affecting soil drainage</th>
<th>Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Nonsoil factors</strong></td>
<td><strong>Poor drainage</strong></td>
</tr>
<tr>
<td>Precipitation pattern</td>
<td>Soils where rainfall is infrequent but intense, especially after soils are frozen or saturated.</td>
</tr>
<tr>
<td>Vegetative cover</td>
<td>Soils with sparse vegetative cover.</td>
</tr>
<tr>
<td>Topographic location</td>
<td>Soils in small topographic depressions or channels may be poorly drained due to subsurface drainage from adjacent slopes.</td>
</tr>
<tr>
<td></td>
<td>Soils on N-facing slopes are moister than those on S-facing slopes. (Moist soils do not drain as rapidly as dry soils.)</td>
</tr>
</tbody>
</table>

### Soil properties affecting infiltration capacity

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low bulk density soils show changes in compaction and greater decreases in infiltration rates. (Organic peat or muck soils; fine-texture soils such as clay loams and clays.)</td>
<td>Higher bulk density soils (coarse to medium-texture soils) show smaller changes in compaction and smaller decreases in infiltration rates.</td>
</tr>
<tr>
<td>Massive, nongranulated soil structures. Compacted granular soils can become nonporous and poorly drained.</td>
<td>Granular, porous structured soils; columnar subsurface structure is very permeable if soil can dry between rainfalls.</td>
</tr>
<tr>
<td>Absent or thin organic layer.</td>
<td>High content of the mineral soil. (Increases pore space and water-holding capacity; also shows smaller maximum compaction.)</td>
</tr>
<tr>
<td>Low organic content in the mineral soil.</td>
<td>Deep soil depths (&gt;3 feet).</td>
</tr>
<tr>
<td>Shallow soil depth (&lt;1 foot).</td>
<td>Soils that are not too moist before rainfalls.</td>
</tr>
<tr>
<td>Water-saturated soils, especially organic soils such as peat or muck.</td>
<td>Surface layer of cobbles-gravel (at least 2 inches thick) protects soil from compaction.</td>
</tr>
<tr>
<td>Low cobble-gravel content at surface.</td>
<td></td>
</tr>
</tbody>
</table>
is 1,000 times greater than that of fine sands; (2) the amount of large pore space diminishes, and the permeability of the soil decreases; (3) the cohesiveness, or plasticity, of the soil increases with increasing clay content; this can act to increase the resistance of soil to dispersion and erosion.

Research studies on sheet and rill erosion of bare agricultural soils on moderately low slopes of 9 percent have determined that soils high in silts or very fine sands are more erodible than either coarse, sandy soils or clay-type soils (Wischmeier and Smith 1965; Wischmeier and Mannering 1969; Wischmeier et al. 1971). Soil survey interpretations are often made for land use planning. A summary report on soils suitable for camping and trails showed that the soil textures of moderately coarse loams (sandy loams to loam) are most suitable, while silty-clay, clay, sandy or organic soils are least suitable (Montgomery and Edminster 1966). Loose, sandy soils are unstable when dry. Soils high in clay are poorly drained and sticky when wet.

Fine-soil particles of silt and clay do not lie as close together as sands. Fine-texture soil has a lower bulk density than coarse-texture soil. As a result, the fine silt and clay particles may be compacted tightly into dense, impermeable material (Brady 1974).

The impact of recreationists trampling campsites and trails is a compacting of the soil. This can result in a decrease in porosity, aeration for plants, and infiltration rates, and a greater potential for surface runoff and soil erosion (Speight 1973; Wilde 1958, p. 187).

In a study of forest picnic sites, Lutz (1945) found that compacted soils of coarser texture exhibited higher infiltration rates than compacted, fine-texture soils, though both soils experienced lower rates (the infiltration rate of sandy-loam soil was 1/20 the rate of the untrampled soil). And Ripley (1962) found that drainage was better over soils of coarser texture at southern Appalachian campsites.

More recent studies have attempted to relate campsite use and soil properties to soil compaction (measured by bulk density or penetrometer), but have not related degree of change in soil compaction to an associated change in soil behavior. In the Boundary Waters Canoe Area of Minnesota, campsites with various medium-texture soils showed no significant differences in compaction between soils of different textures, but all sites reached maximum compaction after 2 years of moderately heavy use (Merriam and Smith 1974). Similar results have been reported by Liddle (1975) for chalk grasslands, and by Young and Gilmore (1976) for loessial soils (predominately silts) and pan soils at Illinois campsites.

Soils on lower mountain slopes tend to be of finer texture, that is, they have less sand and more silt and clay particles. Soils on the upper slopes are of coarser texture, with much gravel and sand. Soil texture may vary widely, however, because of variations in the mountain topography (Willen 1965; Hoyle 1965). Compared to agricultural soils of the plains, the texture of mountain soils is much coarser, regardless of slope location. The texture of soil on the lower toeslopes of the White Mountains of New Hampshire was coarse at all soil horizons, with 50 to 70 percent sand content and less than 4 percent clay content (Hoyle 1973).

Soil structure. Individual soil particles combine into soil aggregates which assume different geometric shapes or structures, depending on the soil-forming forces, especially those that promote contacts between soil particles. The structure of the soil affects the porosity of the soil and, hence, the permeability of water-and nutrient-holding capacity of the soil. It also affects the soil stability.

Soil structures commonly found in surface soils of forests are "granular" or "crumbly." If a surface is compacted or the soil poorly drained, the soil structure may be "massive" or "puddled" with no distinct arrangement of particles. Large, blocky, or columnar-shape soil structures are usually found in the subsoils of arid regions (Wilde 1958).

Soils with a granular structure have several desirable properties. They are very porous and have a high water-and nutrient-holding capacity. The soils are better able to support plant growth and drain surface water than the more impermeable, massive, platey, or blocky structures. Structure affects the erodibility of unvegetated soils. Studies of erosion of wildland soils have determined that soils with a high content of either water-stable aggregates (soil aggregates that do not break down under
Table 2. Ability of the soil to resist erosion (soil dispersal and movement downslope)

<table>
<thead>
<tr>
<th>Factors affecting soil erodibility</th>
<th>Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Nonsoil factors</strong></td>
<td></td>
</tr>
<tr>
<td>Precipitation pattern</td>
<td>Infrequent but intense rainfalls.</td>
</tr>
<tr>
<td>Slope gradient and length</td>
<td>Soil on steep slopes (&gt;25% for temperate-humid regions) especially, moist silty soils.</td>
</tr>
<tr>
<td>Vegetative cover</td>
<td>Long, unvegetated slopes allow more rapid surface runoff of water and soil.</td>
</tr>
<tr>
<td></td>
<td>Soils under sparse groundcover vegetation. (Dense overstory, especially of conifers, retards groundcover growth.)</td>
</tr>
<tr>
<td><strong>Soil factors</strong></td>
<td></td>
</tr>
<tr>
<td>Ability of soil to absorb water</td>
<td>Low percent (by weight) of soil particles and water--stable aggregates &gt;2 mm diameter.</td>
</tr>
<tr>
<td>(soil infiltration capacity)</td>
<td>Soil texture--high percent of silts or very fine sands.</td>
</tr>
<tr>
<td>Ability of soil to resist dispersion</td>
<td>Low organic content of mineral soils, especially with high-clay content.</td>
</tr>
<tr>
<td>(soil structural stability)</td>
<td>Wet, granular soils, especially organic peat or muck soils.</td>
</tr>
<tr>
<td>Texture-structure</td>
<td>Shallow soil depth to pan or soils over a frozen subsurface layer.</td>
</tr>
<tr>
<td>Moisture-holding capacity</td>
<td>Low cobble content.</td>
</tr>
<tr>
<td>Organic matter content</td>
<td></td>
</tr>
<tr>
<td>Soil moisture level before rainfall</td>
<td></td>
</tr>
<tr>
<td>Surface cobble content</td>
<td></td>
</tr>
</tbody>
</table>
water movement) or soil particles larger than 2 mm are the most resistant to erosion (Farmer and VanHaveren 1971). Wildland soils with larger water-stable aggregates tend to be surface soils that are high in organic matter content and clay and that have a low bulk density (Wooldridge 1964).

Studies of agricultural soils have shown that the more finely granular the soil structure, the less erodible the soil (Wischmeier et al. 1971). Under conditions of long, intense rainfall, however, the granular soils may be less resistant to surface erosion than massive clay soils. Once granular soils have become saturated with water, the soil has less resistance to dispersion under the impact of raindrops and can be more easily transported or eroded down slope. The more impermeable soils that have a high clay content may be more resistant. Initially, the dry, loose aggregates of clay on the surface are dispersed by the rain. But once the soils are saturated, the soil is very cohesive and resists dispersion. Surface-water runoff increases over the smooth, tightly held soil particles, but soil is not eroded (Baver 1956, pp. 455-458).

Organic matter content of the mineral soil. The organic matter in soil is derived from plant and animal tissues which decompose and leach through the soil. Soils that have high organic content tend to be:

1. In cool, humid environments. Organic matter decomposes less rapidly in these environments.
2. Under grasslands which provide the soil with more organic materials than forest vegetation.
3. Of finer texture. Fine-texture soils retain more moisture and are less aerated, which retards rapid oxidation of the organic materials.
4. Poorly drained.
5. Surface soils, especially under forests. Organic matter decreases rapidly where the soil depth is less than 2 inches.

High organic content of soils contributes to an increase in granular structure, which, in turn, provides an increase in porosity and lower bulk density, and an increase in the nutrient- and water-holding capacity. This improves the drainage ability of the soil and its capacity to support plant growth. Decomposed organic matter (humus) has at least twice the nutrient-adsorbing power of clay (Brady 1974, p. 148). Studies of medium-texture (loamy) agricultural soils show that soil erosion decreases appreciably when organic matter increases from 0 to 4 percent (Wischmeier et al. 1971).

A high organic content of the soil does not always ensure beneficial soil properties. The erodibility of soil under rainfall is partially influenced by the interaction of soil texture and organic content. In a comparison of soil losses at high-elevation Utah rangeland, it was found that sandy soils high in organic content were more erodible than sandy soils low in organic content. The organic material may have acted to disaggregate the soil. However, soils high in clay content were less erodible when organic content was high (Meeuwig 1971).

Although soils with high organic content tend to have a lower bulk density, they show lower maximum compaction than soils of low organic content (Dotzenko et al. 1967). Also, the recovery rate (as measured by increases in infiltration rates and decreases in water runoff) for compacted grazing land was quicker in soils with higher organic content (Orr 1975).

Depth of soil to an impervious layer. A layer of material beneath the soil which is impervious to water could be bedrock or a pan layer. A pan layer is a soil high in clay content or a caliche layer of cemented calcium carbonate, or just a very compacted, dense soil layer through which water can barely penetrate.

The soil depth to pan affects:

1. The infiltration capacity of the soil and, consequently, the ability of the soil to drain.
2. The amount of soil available for filtration of organic human waste left buried at dispersed campsites.

SOIL INVENTORY

A major problem with soils information for forest managers is the lack of useful soil surveys for wildland areas. Surveys have not been completed for undeveloped, high-elevation regions, especially at the scale the manager may need.
Table 3. Ability of the soil to support plant growth

<table>
<thead>
<tr>
<th>Factors affecting plant growth</th>
<th>Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soil water-holding capacity</td>
<td></td>
</tr>
<tr>
<td>affected by:</td>
<td></td>
</tr>
<tr>
<td>Soil texture</td>
<td>Low water-holding capacity</td>
</tr>
<tr>
<td>Organic content of mineral soil</td>
<td>Coarse-texture soils (sands, gravels, cobbles)</td>
</tr>
<tr>
<td>Depth of pan/bedrock</td>
<td>Low organic content in mineral soil.</td>
</tr>
<tr>
<td></td>
<td>Shallow depth to pan, especially on sloping terrain.</td>
</tr>
<tr>
<td></td>
<td>Good (not excessive) water holding capacity</td>
</tr>
<tr>
<td></td>
<td>Medium-texture soils (mixture of fine, sandy loams to sandy-clay loams).</td>
</tr>
<tr>
<td></td>
<td>Organic soils of peat or muck have excessive water-holding capacities for recreational use.</td>
</tr>
<tr>
<td></td>
<td>Well-aggregated and granular-structured soils.</td>
</tr>
<tr>
<td></td>
<td>High organic content in mineral soil.</td>
</tr>
<tr>
<td></td>
<td>Deep soil depth to pan.</td>
</tr>
<tr>
<td>Soil nutrient availability</td>
<td>Low nutrient availability</td>
</tr>
<tr>
<td>affected by:</td>
<td>Soils in areas that receive abundant precipitation (nutrients are leached through the soil).</td>
</tr>
<tr>
<td>Nonsoil factors</td>
<td>Soil under coniferous small forests are low in Ca, Mg and K nutrients and are acidic, which tends to reduce nutrient availability to plants.</td>
</tr>
<tr>
<td>Precipitation</td>
<td>Calcareous soils (limestone derived) are deficient in iron and are very alkaline.</td>
</tr>
<tr>
<td>Vegetative cover</td>
<td>Soils with high content of coarse particles or silts.</td>
</tr>
<tr>
<td>Bedrock type</td>
<td>Low organic content in the mineral soil.</td>
</tr>
<tr>
<td>(mineralogical composition)</td>
<td>Water-saturated soils retard soil organisms that decompose organic matter.</td>
</tr>
<tr>
<td>Soil factors</td>
<td></td>
</tr>
<tr>
<td>Texture</td>
<td></td>
</tr>
<tr>
<td>Organic content of mineral soil</td>
<td></td>
</tr>
<tr>
<td>Soil water-holding capacity</td>
<td></td>
</tr>
</tbody>
</table>
A meaningful soil survey could be very expensive. Often, soil conditions of mountain lands vary widely, especially in the midslope sections. Soil rockiness and depths vary, depending on the topography, so the resulting soil drainage and erodibility are quite varied.

This situation should not preclude the survey of soils at proposed wildland sites. Managers are concerned primarily with trails and overnight sites. An analysis of the soils over a potential trail corridor and at certain points (or potential overnight sites) could be satisfactory. Forest Service soil scientists usually can predict with accuracy the types of soil at particular locations by studying the topography, vegetation, and climate of the region. However, where pit privies are under consideration, field measurements should be made to check the depth of soil to pan and the permeability of the soil.

USING SOILS INFORMATION FOR DISPERSED RECREATION PLANNING

There are two facilities for dispersed recreation that require planning and management by the forest manager: trails (circulation links between roads and hiker destinations) and designated overnight sites (sites where hikers frequently cluster for camping). For each of these the manager must select locations and provide special facilities and maintenance where needed to prevent physical degradation. Poor soil conditions limit the ways in which a site can be managed.

The management or facility requirements, or both, for poor soil conditions, corresponding to Tables 1 through 4, are listed below:

Trails

On poorly drained soils
- Additional management is needed to prevent trail widening and soil compaction around fragile vegetation.
- Trail tread, such as wood bridging or rock paving, should be required where hiker use is moderate to heavy.
- Hikers should be discouraged from using trails during periods of frequent or heavy rainfall.

Over erodible soils
- Additional management is needed to reduce soil loss and trail gullying.
- Trail stability structures should be required, for example, waterbars to reduce surface waterflow down the trail, and steps and cribbing to retain loose soil.
- Trails ascending steep slopes should have sufficient switchbacks to maintain a moderate trail grade (less than 25 percent).

Over nutrient-deficient soils
- Vegetation growing around the trails must be protected from trampling. The vegetation is growing in poor soil conditions and may be easily destroyed, especially alpine tundra. Trail delineation, such as scree walls, may be needed to encourage hikers to stay on the trail tread. In small areas of concentrated use, a trail patrol might be effective in informing hikers about fragile vegetation.

Overnight sites

On poorly drained soils
- These are generally poor areas in which to locate campsites as compaction potential is high and human waste disposal is difficult.
- Facilities to "harden" the site would be required, for example, shelters or tent platforms to minimize ground trampling and compaction. These structures can encourage more centralized camping and cooking activities. Circulation paths around the site require trail tread structures.
- Where facilities are not provided, overnight use limits must be enforced.
- Human waste must be removed from the site or composted at the site. Areas where the soil is well drained, but shallow (less than 5 feet beneath the bottom of the privy pit) limit the use of pit privies because the soil is not deep enough to filter the waste.
Table 4. Ability of the soil to promote decomposition of human waste

<table>
<thead>
<tr>
<th>Soil factors affecting soil organism activity</th>
<th>Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vegetative cover</td>
<td>Low organism availability</td>
</tr>
<tr>
<td>Soil acidity</td>
<td>Soils under sparse vegetative cover.</td>
</tr>
<tr>
<td>Soil moisture</td>
<td>Acidic soils.</td>
</tr>
<tr>
<td>Soil temperature</td>
<td>Wet soils for long durations (blocks soil aeration needed for aerobic decomposition). Organic soils of peat or muck usually are too wet. Cold soils. At soil depths 6 inches below surface. Arid soils for long durations inhibit soil organism growth.</td>
</tr>
</tbody>
</table>

- The roots of ground vegetation growing in poorly drained soils are often suspended in a water pocket. Compaction of the soil easily crushes the roots, resulting in a decrease in the porosity of the soil. Foot traffic should be kept off areas where ground vegetation is desired.

On highly erodible soils

- Facilities to minimize foot traffic on the ground surface would be required (similar to those for poorly drained soils).
- Bare, erodible soil areas should be revegetated with durable ground covers, for example, grasses.
- The revegetation of highly erodible areas should include soil stability structures to retain loose soil. Foot traffic must be kept away from revegetation areas. Thinning overstory plant cover might improve light conditions on the ground and promote more rapid growth of ground vegetation.

On soils of limited ability to support plant growth

- The rehabilitation of eroded or compacted soils may require shallow tilling (the top 2 inches) and an application of organic matter (sawdust or ground bark) to improve the water-holding capacity of the soil.
- Revegetation of nutrient-deficient soils requires fertilization. However, the nutrient availability of the soil must be determined to know what fertilizer and what quantities are needed. Fertilizer should not be applied before periods of heavy rainfall. Excessive quantities of fertilizer should be avoided, especially near streams and ponds, to prevent eutrophication.

On soils with low availability of soil organisms

- In areas where much dispersed tenting is likely and the catholing method for human waste disposal is used, soils
should be those in which surface-soil organisms are readily available. Soils that are always cold and wet or that have little vegetative cover would be poor choices as dispersed tenting sites where frequent use is expected. At sites with a low availability of organisms, overnight use should be limited to avoid unesthetic site conditions.

Forest sites with poor soil conditions require a greater expense of time and money for management for recreational use. Where management resources are limited, the selection of trail routes and overnight sites should be made for maximum benefit.

A management decision to close, relocate, or alter a site can be made and justified by comparing physical and management resource capabilities. An understanding of soil abilities and limitations provides an additional component to the decision-making process.

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RESEARCH ON WILDLAND RECREATION IMPACT
IN THE CANADIAN ROCKIES

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ABSTRACT--An increasing interest in recreating in undisturbed natural settings has attracted large numbers of people to hike and camp in the wildlands of Canada's Rocky Mountain National Parks. Deteriorating environmental conditions precipitated wildland recreation impact research designed to guide better land-use decisions in future planning and management. Soils high in either fine-grained, coarse-grained or organic materials are least desirable for trails and campsites. The degree of impact is directly related to the soil drainage characteristics. Low-growing, herbaceous, alpine plants are the most susceptible to damage from trampling.

Substantial changes in visitation and recreational activities have occurred in Canada's Rocky Mountain National Parks in the 1970s. Growing regional population, increasing concern for environmental integrity, technology and the attractive national park landscapes are some of the factors influencing the pattern of use and objectives of visitors to the national parks. Widespread interest in recreating in undisturbed natural settings encouraged a great number of park visitors to hike and camp in the backcountry areas. The availability of lightweight equipment has placed all areas of the mountain national parks within reach of determined hikers. Overcrowding, deteriorating environmental conditions and conflicts with traditional users and outdated practices precipitated studies of the environmental effects of wildland recreation. The effects of hikers and horses on trails, group campsites and primitive campsites with respect to soils, vegetation, water quality and wildlife have been examined. In many cases, it has been found that the degree of impact is largely related to improper location of facilities. Construction techniques and upkeep have been inadequate to overcome inherent environmental hazards. The persistence of traditional but undesirable practices by both users and managers has aggravated many of the avoidable circumstances.

A number of resource parameters, including soil, vegetation, hydrology, active geomorphic processes, faunal habitats, climate and topographic characteristics are important in the allocation of land uses in wildland settings, and the location and design of facilities. Soil characteristics, will, to a large degree, determine the difficulty of developing and the performance of many wildland facilities such as trails and campsites. A large amount of pedological and edaphological information can be produced about any soil. While any or all of the possible pieces of information may be important in making certain comparative statements, a relatively small amount is critical to the wildland planner who is designing low-intensity recreational facilities. The soil properties of texture, structure, organic matter content, depth, stoniness and drainage characteristics are the most important soil facts in making decisions about trails, campgrounds, disposal sites and activity areas.

Fine-grained soils tend to become compacted and density increases under use. Infiltration and permeability decrease and puddling results. Clays are slippery and sticky when wet, but become hard and cloddy when dry. When wet, silty soils promote needle ice which complicates rehabilitation. When dry, however, silty soils cause dusty
trail and camp conditions. Sandy soils are loose and droughty. Consequently they are easily displaced and do not hold cover vegetation well. Favorable soil textures include sandy loams and loams.

Organic matter promotes favorable soil structure by imparting soil aggregate stability and soil porosity. Up to a point, increasing organic matter promotes productivity in mineral soils; however, it intensely complicates the use of soils for recreational purposes. Organic material is easily broken and disintegrated by foot traffic. Trails which cross organic areas become churned quagmires of perpetually wet, slippery ooze. Concerted attempts to avoid organic soil must be exercised in trail location.

Although construction of wildland facilities will normally not require disturbance of more than the upper 15 cm of soil, it is desirable to have at least 30 cm of soil material over bedrock. The presence of some stones and rocks within the soil matrix (up to 25% by volume) is desirable in that they impart stability to subgrade materials and resistance to traffic. When surface rocks and stones occupy more than 20% of the soil surface, moderate to severe limitations for trails and campsite are encountered.

Internal soil drainage is affected by texture, structure or other soil-layer features which may influence permeability. Most medium and fine-grained soils experience decreasing load-bearing capacity as soil moisture increases, frequently with resultant compaction, disaggregation and muddy conditions. Severe constraints for trails and campsites are posed by imperfectly and poorly drained soils. Trails are best located on well-drained soils and campsites on no poorer than moderately well-drained soils.

The science of managing natural vegetation is less well developed than soil science. Seed or plant materials of many native species are generally not commercially available. Furthermore, the physiology and reproductive processes of many native plants are largely unknown. The fragility of individual species is greatly influenced by phenotypic variability and the nature of the impact source. While a great many factors can affect site-specific vegetative fragility, it appears likely that plant fragility to trampling from least to most fragile would be trees, grasses, sedges, shrubs, tree seedlings, forbs, mosses, and dry lichens. In all, the soils supportive the vegetative cover will to a considerable degree determine the degree of sensitivity.

DISCUSSION

Comment: Is there any difference in the rehabilitation difficulties of an impacted forested site compared to an impacted meadow site?

Leeson: Yes, given similar altitudinal and macro-climatic characteristics, the meadow site will recover more quickly. Meadow soils generally present more favourable growing medium because the soils have more incorporated organic material as a result of increased soil microbiological activity. Increased light levels also assist more rapid rehabilitation.

Comment: In order to minimize impact, should an agency concentrate camping at designated sites, or attempt to disperse campers?

Leeson: Where Parks Canada intends to accommodate comparatively large numbers of visitors, designated campsites will be provided. Nearly 90% of the total impact at continuously used sites occurs in the first two years, so there is little merit in moving the new sites after absorbing most of the expected impact. Other wildland portions of the parks will be managed for low levels of visitation, and in these places dispersed camping will be permitted. Travelers will be allowed to select their own camping sites, subject to regulations dealing with shoreline setback, waste disposal and forbidding fires.

Comment: Are you having problems with increasing numbers of backcountry travellers developing trails where none ever existed before?

Leeson: New trails occur impromptuously only where travelers attempt to avoid bad stretches of trail which may be muddy or rutted. In these situations multiple trailing will develop. Visitors do not develop completely new trails because almost all valleys and passes have trails of some sort, originally created by horse travelers, which hikers simply follow. Many of our present trail problems exist because these original horse and game trails were never created with any thoughts of scientific land-use planning or the aspirations of hikers.
SOIL FACTORS INFLUENCING THE QUALITY OF WILDERNESS RECREATION IMPACT

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ABSTRACT--Limited soil information is readily available to help wilderness managers or land-use planners. However, four dominant soil factors influence recreational-use impacts: trafficability, depth, drainage, and erodibility. These major factors are interrelated, and an evaluation of each can help in location of trails and waste disposal.

INTRODUCTION

There is little information readily available to help wilderness managers or land-use planners identify soil factors that influence the kind and extent of impact from recreational use. We also do not have any current formal research studies within wilderness areas to develop such information. We are, however, active in identifying soil-related problems and assisting in providing soil management interpretations in wilderness areas. Most of our experience has been in the Pasayten, Glacier Peak, and Alpine Wilderness Areas. All of these areas are set upon varied and complex geologic formations and show a wide diversity of plant communities and soil types. Our discussion will relate predominantly to the soil factors affecting impact from wilderness recreational use.

Most visitors to wilderness areas quickly realize the esthetic value of plant communities, particularly in the subalpine environment. Disruption or destruction of these plant communities by wilderness "users" may leave other visitors with an unpleasant experience and the soil in an exposed unprotected condition subject to erosion and other damage. The soil component is the basic support of nearly all terrestrial plant communities within ecosystems found on the North Cascade Range. External factors that modify the soil component can often have a serious impact on the plant communities, thereby affecting an area's quality for wilderness use.

Soil is the unconsolidated life-supporting material forming a complex three-phase system above the mantle rock. A given volume of soil consists of solid, liquid, and gaseous materials. The solid material may be mineral or organic, the mineral portion consisting of particles of varying sizes, shapes, and chemical composition and the organic fraction including residues in different stages of decomposition as well as live active organisms. The liquid phase is the soil water which fills all or part of the open spaces between the solid particles. The soil water varies in chemical composition and the freedom with which it is able to move. The gaseous phase, frequently identified as air space, is that part of the pore space between the soil particles that is not filled with water. The dynamics of the soil-supported plant communities are affected not only by the properties of each phase, but also by temperature, pressure, and solar radiation. Therefore the effect of visitors on the soil is an important consideration in any wilderness land management program.

SOIL FACTORS

Our soils research experience and ob-
servation within the Cascade Range has shown us that there appears to be four dominant soil factors influencing wilderness quality for recreational use. They are:

1. Trafficability
2. Depth
3. Drainage
4. Erodibility

Obviously, all of these major factors are interrelated. For example, both soil depth and drainage influence trafficability. Although our discussion is limited to soil factors influencing quality in wilderness areas, these four soil factors are also important in influencing the quality of other wildlands for recreational use.

Trafficability

Trafficability is defined as the capacity of a soil to bear a moving load. In wilderness areas it is related to the resistance of soil to displacement or compaction by the foot of man or animal. This resistance is highly dependent upon the strength of the soil which, in turn, is influenced by the physical characteristic of texture, structure, and the ability to retain and transmit soil water. Soils with low strength are less suitable for trails and campsites because they are easily compacted or displaced.

Compaction makes the soil particles pack more closely together (increased dry weight/unit of volume), so that water will run off rather than infiltrate the soil. Because of increased surface water runoff, compaction can lead to both droughty conditions for plant growth and increased erosion potential. Though the ability of roots to survive or grow is severely affected by soil compaction, the degree of compaction that will adversely affect plant growth is difficult to define. A soil density greater than 1.4 grams per cubic centimeter has been shown to reduce the root growth of many agricultural crops, and soils formed in volcanic ash may exhibit restricted root growth at somewhat lower density levels because they are so light in weight.

Potential soil displacement by the passage of human or animal is an important aspect of soil strength. This factor is important to an understanding of how a soil's ability to resist the effect of a human foot differs from its resistance to the foot of a horse. Often soils will be little affected by the passage of a large number of people, but will be severely compacted and/or displaced by the passage of several horses. Regardless, however, of the type of traffic, rates of both trail and campsite deterioration increase greatly with intensity of use (Legg and Schneider 1977). The physical properties of soil affected by intensity of use are bulk density, permeability, and porosity (van Wijk, Verhaegh and Beuving 1977).

There appears to be a marked difference in trafficability among areas developed on contrasting geologic formations. In an evaluation of six different soil parent materials in the Selway-Bitterroot Wilderness of Idaho and Montana, Helgath (1975) found trail deterioration, as evidenced by soil displacement and compaction, most serious on soil material from hornblende gneiss. Generally, soils weathered from granitic formation show greater strength—greater resistance to displacement and compaction—than soils weathered from volcanic ash as in the Cascade Range.

Depth

Depth of the unconsolidated soil material above the mantle rock is highly influential on the moisture and nutrient pool available for the support of plant growth. Plants on shallow soils are therefore most sensitive to disturbance. Shallow soils are also most susceptible to erosion following disturbance.

Soil depth is an important factor in waste disposal. Waste disposal units and pit toilets are not functional in areas with shallow soils and the potential for contaminating water supplies is also considerably greater than in areas with deeper soil.

Drainage

Drainage, or the characteristic of the soil within an area to retain groundwater or water of the capillary fringe, is an extremely important factor in determining the potential impact of trail or campsite use. Visitors to wilderness areas should be strongly encouraged to avoid areas with poorly drained soil. The vegetative species composition in areas with poor drainage generally shows a greater and more long
lasting impact from disturbance than in areas that are well drained. Drainage conditions have a marked influence on trafficability and waste disposal. Soils that have a fluctuating water table or poorly drained soils, are not suitable for waste-disposal sites.

Erodibility

When evaluating the potential impact of soil displacement or compaction by wilderness use, it is necessary to know the soil erodibility or the resistance quality of a soil to displacement by the action of wind or water. Any activity reducing the natural rate of water infiltration from rainfall or snowmelt can result in overland flow. If the soil surface has been disturbed, this overland flow can lead to erosion. Considerable research is currently in progress to measure the erodibility factor for many agricultural and forest soils. Generally, soils showing evidence of single-grain properties and/or a fine texture (high clay and silt with low sand-size particles) are most susceptible to erosion. Soils with good aggregation and intermediate texture appear to be less susceptible to erosion.

Parent material, the weathered aggregates from which soil is formed, often highly influences soil erodibility. Soils developed on volcanic ash would be expected to have high erodibility. With the exception of alluvial deposits, Helgath (1975) pointed out that "accumulation and retention of materials such as loess and volcanic ash indicate a very stable, non-erosive surface condition; therefore these sites do not erode as a result of natural site qualities." Wilderness visitor use leading to soil disturbance and compaction, however, has the potential to reduce natural stability.

Management skills are generally available to prevent accelerated erosion on wildlands including wilderness areas. Skills are also available to reduce erosion on areas where visitor "users" have previously had a serious impact (Klock 1973; Klock, Tiedemann and Lopushinsky 1975). The best method of managing the soil erodibility factor is erosion prevention through land-use planning.

REFERENCES CITED


DISCUSSION

Comment: If you have a trail forming, have to build or reroute a trail because of a lot of moisture in the trail, and you're not a soils expert, how do you go out there and look at it, and determine from a practical standpoint whether or not this is a well-drained area?

Klock: Color of the soil is often a good indicator of the drainage conditions, even if you are out in the field during the dry season and the trail and surrounding area is dried up. If the soil color has a dark bluish or dark organic appearance, it usually indicates poor drainage. If one sees bright yellow to red soil colors—and we must not be confused by some of the bright-colored volcanic ashes found in the Cascade Range—it usually indicates a well-drained soil.

Comment: In the Cascades where we have a lot of moisture, especially snowmelt early in the season, you get a lot of subsurface flow. Let's say you are locating a new trail location in the fall after the snow has melted from the previous winter and the soil is dry.

At this time people are locating the trail line when the soil is dry. Would it be
better to look at this area earlier in the season, maybe digging some pits to determine any subsurface flow rather than just depend on soil color and structure?

Klock: Yes, your observations need to cover different seasons. You should be looking for soil and vegetation conditions as well as use patterns. Thus, if you are concerned about the movement of people through an area during the wet season, you should see the area during that period of time. I should also point out that there are many options for improving trafficability besides rerouting. Log puncheons as well as natural rock material can be used. In our slide presentation we showed the use of rocks to increase the trafficability of an area in the Enchantment Basin. That material has worked very well.

Comment: When the Forest Service reroutes a trail or builds a new one, do they call on soil specialists to help with location or are they like a lot of the rest of us where the trail foreman goes out and locates the trail and doesn't really look at some of these factors that you people have been talking about?

Klock: That question should really be addressed to my co-author; however, he is not here today. As the Wenatchee National Forest soil scientist, this type of work is part of his job. When the District Ranger is made aware of a need or problem, he can call on the soil specialist to assist trail locators in the review of proposed trails. The forest soil specialist is available as a resource and will assist in developing site-specific prescriptions when called upon by the District Ranger.

Comment: I am interested in the trafficability amenities, such as the stepping stones over wet areas that you showed in the Enchantments. It is a marvelous technique, but I think that it was grossly misapplied in that instance. Being familiar with that area, recognizing that it is a destination and not a through way, why would we take people across the middle of a wetland just because we have the capability?

Klock: I was aware that this question might come up because that is a controversial situation. I think your question is valid. May we take the question step by step? First the trail is a through way. Visitors move through in large numbers. This trail is a major pathway between Asgard Pass and the Snow Lakes region. The second thing is that this particular section of trail coming around the north end of Perfection Lake is the shortest distance between the upper and lower basins. This is a hiker-located trail. It is a natural trackway, so the Forest Service is armorin the tread with the rock rather than trying to change human nature. Hikers could go up on the ridge and go around the wet area, but it is not natural for people to go the long way when they can see a shorter route. Without armorin on this section of trail, the muddy area will continue to grow, thus degrading the entire area. Armoring the trail may offend some people but it increases the trafficability without causing soil or water resource damage.

Comment: I work with trail maintenance and trail construction and what bothers me is that your experience and knowledge does not get to the people on the ground or to the decision making managers. For instance, the ranger goes out to reroute a trail around the lake or over the ridge because we have decided an area is over-used. The trail crew goes to work, but nobody is really getting together on these things.

Klock: Your comments are of real value and you are speaking to the timeless question of information transfer from research to the user. This information transfer problem is not limited to wilderness recreation per se; the land manager always has the problem of becoming aware of the latest research information. There is a problem of how much we as scientists can afford to look at the basic problems and how much time we can afford with information transfer. However, there are some projects coming along within the National Forest Administration to use highly trained people for information transfer. These people can talk with both the researcher and the people in the field. Until we have a number of these people in the field, we are not going to come close to solving the problem we have discussed here today.

Comment: So it is sort of like extension agents from the Forest Service?

Klock: Right. We need them. And let's not stop with the Forest Service because Forest Service Research is applicable to wild lands in general. The application of our research doesn't stop at the boundaries of the national forest.
ABSTRACT—After a brief review of several approaches for studying the impact of hikers on backcountry vegetation, this paper describes a study of vegetation alteration along trails located in different vegetation types. Results show that in Eagle Cap Wilderness, Oregon, hiker impact on vegetation is more pronounced in dense forests than in meadows or open forests. Similar investigations of impacts on environmental characteristics (other than vegetation) would help managers locate recreational facilities where undesirable ecological change would be minimized.

INTRODUCTION

In recent years there have been dramatic increases in the number of recreationists entering backcountry areas. Recreational use of most wilderness areas, for example, has increased at a rate of 10% per year or more (Frissell & Stankey 1972). This essentially unrestricted recreational use has already destroyed the integrity of natural plant communities in many areas where management objectives call for preservation and protection. Anticipated increases in use threaten to accelerate this destruction unless managers can effectively resolve the conflict between use and preservation.

Impacts resulting from this conflict are inevitable because even light use produces some ecological change. The basic problem, then, is to define the "limits of acceptable change," the maximum amount of deviation from pristine conditions consistent with the management objectives for the affected area (Frissell and Stankey 1972). Management, not research, must ultimately establish these limits. The role of research is to study user/environmental...interactions in sufficient detail to suggest management actions that can confine recreational impacts within these established limits.

To limit recreational impacts on vegetation, researchers must be able to predict the effects of various use configurations on different vegetation types. Use configuration incorporates differences in the absolute amount of use; the type of use, whether by hikers, packstock, or some other type; the season of use; and the frequency of use by parties of various sizes. Differences in any of these use variables will result in different types and intensities of impact on the vegetation. Vegetational changes resulting from use will also vary with vegetation type due to differences in the susceptibility of habitats and species assemblages to alteration.

RESEARCH APPROACHES

Accurate prediction of the effect on vegetation of a change in use configuration will depend on careful experimentation. This is the most practical means of controlling use and environmental variables so that the effect of a change in one of these variables can be assessed.

Unfortunately, this type of study often requires many years to complete. Most researchers to date (e.g., Wagar 1964, Bell and Bliss 1973, Liddle and Greig-Smith 1975, and Holmes and Dobson 1976) have only investigated short-term responses to trampling. This limits conclusions to initial deterioration of vegetation and ignores long-term deterioration processes, recovery rates, and vegetative reestablishment. Longer-term experimental studies should be given high priority and initiated as soon as possible.
In the interim, however, vegetation will continue to deteriorate as a result of recreational use, and management responses will remain largely intuitive because of poor data.

Non-experimental research methods such as the analytical approach described by Liddle (1975), can also provide valuable input. The analytical approach investigates sites already subjected to recreational use. Long-term analytical studies are possible and have been undertaken (LaPage 1967, Merriam et al. 1973), but more significantly, short-term analytical studies can provide information useful to managers before the completion of long-term experimental work.

The analytical approach compares adjacent used and unused areas with similar environmental characteristics. The implicit assumption is that any difference between the two areas is the result of recreational use.

There are two major advantages to this approach: first, long-term responses to recreational use can be identified in a short-term study because the plant populations selected for study have had time to adjust to use; and secondly, investigations of this type deal with real situations. The vegetation along trails, for example, is affected by soil changes resulting from trampling, site development such as tree removal and drainage alteration, and new vectors of plant dispersal, in addition to the direct mechanical effect of trampling on plants (Cole 1978). These changes can not all be realistically simulated in an experimental study.

The major disadvantage of the analytical method is the difficulty in unraveling cause and effect. There is no means for effectively controlling the large number of ecological and human-use variables which affect the existing conditions of any recreation site. Furthermore, accurate assessments of the past use history of any site are rarely possible, even if information on current use configurations can be obtained.

Nevertheless, analytical studies provide several types of valuable information. Assessments of the relative susceptibility of vegetation types to changes resulting from recreational use are particularly useful because they contribute to the rationale behind locational decisions.

Most research shows that above relatively low threshold values, amount of use is not highly correlated with amount of ecologic change. Most change on a recreational site results from initial, light use and continued or increased use results in little additional change (Frissell and Duncan 1965, LaPage 1967, Merriam et al. 1973, Young 1978). This suggests that site impact could be more effectively managed by facility location and design than by regulations on the amount of use and that ecologic change could be minimized by concentrating use on particularly resistant sites rather than dispersing use in space. Furthermore, because recovery rates can be many times slower than deterioration rates, most closure and rest-rotation schemes to allow site rehabilitation seem merely to increase the area of alteration without significantly reducing the intensity of alteration (Merriam et al. 1973). These research findings emphasize the importance of locating facilities permanently in places where undesirable change is minimized and the value of collecting information that contributes to more objective locational decisions.

VEGETATION CHANGE ALONG TRAILS IN EAGLE CAP WILDERNESS

Methods

An attempt by Cole (1978) to assess the susceptibility of vegetation types to trailside alteration serves as an example of the analytical technique. In this study the change in understory species composition and amount of plant cover was investigated along trails in the eight most common vegetation types of the Eagle Cap Wilderness Area in northeastern Oregon. Within each vegetation type, ten pairs of quadrats - each measuring 0.5 m x 1 m - were established. One quadrat of each pair was located immediately adjacent to the trail; the other quadrat was 10m from the trail in essentially undisturbed vegetation. Percentage cover of each understory species was estimated in each quadrat. Total cover in the paired quadrats was compared using the formula

$$CR = \frac{C_1 - C_2}{C_2} \times 100\%$$

where CR is percentage cover reduction, $C_1$ is the cover in the trailside quadrat, and $C_2$ is the cover in the quadrat 10m from the trail. This provides a measure of cover loss along the trail in each vegetation type.

The species composition of the quadrats was compared using the formula
FD = 0.5\sum|P_1 - P_2|

where FD is a coefficient of floristic dissimilarity, the difference in species composition between two quadrats, \( P_1 \) is the importance value (see Cole 1978 for discussion) for a given species in the trailside quadrat, and \( P_2 \) is the importance value for the same species in the quadrant 10m from the trail. This provides a measure of the change in species composition that occurs along trails in each vegetation type.

For this study, use configuration at the sample points was considered constant because sampling was confined to the West Fork of the Wallowa River trail, a transportation route to high-elevation lakes. Most trail users hike the entire trail so that use is relatively evenly distributed.

Results

As Table 1 illustrates, there are significant variations in the amount of cover loss and change in species composition along trails in the vegetation types of the Eagle Cap Wilderness. These changes are greatest in the three most densely forested vegetation types: Pseudotsuga menziesii/Physocarpus malvaceous (Douglas-fir/ninebark), Picea engelmannii/Thalictrum occidentale (Engelmann spruce/meadowrue), and Abies lasiocarpa/Vaccinium scoparium (subalpine fir/grouse huckleberry) forests. These forests have understories dominated by woody shrubs and erect forbs, growth forms poorly suited to trampling survival (Wagar 1964, Dale and Weaver 1974, Holmes and Dobson 1976). In comparison to heliophytes (sun-loving plants), these shade-tolerant species usually have more supportive and conductive tissue (Treshow 1970), greater leaf areas, and thinner cuticles, cell walls, and stems (Daubenmire 1959) - morphological characteristics that make them extremely susceptible to breakage. In addition, light intensities along trails are increased by trail construction in dense forests and this increase can result in significant shifts in species composition.

In contrast, vegetation change in the three open vegetation types, the Pseudotsuga menziesii/Calamagrostis rubescens (Douglas-fir/pinegrass) open forest, the Stipa occidentalis (needlegrass) grassland, and the Carex (sedge)-forb subalpine meadow, is relatively insignificant. These vegetation types have understories dominated by grass-like plants (graminoids). The trampling tolerance of this growth form has been consistently noted (Bates 1935, Dale 1973, Liddle 1975, Liddle and Greig-Smith 1975) and derives from such preadaptations to

<table>
<thead>
<tr>
<th>Vegetation type</th>
<th>Cover reduction</th>
<th>Floristic dissimilarity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pseudotsuga menziesii/Physocarpus malvaceous forest</td>
<td>73</td>
<td>82</td>
</tr>
<tr>
<td>Picea engelmannii/Thalictrum occidentale forest</td>
<td>64</td>
<td>64</td>
</tr>
<tr>
<td>Abies lasiocarpa/Vaccinium scoparium forest</td>
<td>57</td>
<td>67</td>
</tr>
<tr>
<td>Pinus contorta/Vaccinium scoparium forest</td>
<td>53</td>
<td>41</td>
</tr>
<tr>
<td>Pinus albicaulis/Vaccinium scoparium open forest</td>
<td>22</td>
<td>62</td>
</tr>
<tr>
<td>Pseudotsuga menziesii/Calamagrostis rubescens open forest</td>
<td>37</td>
<td>36</td>
</tr>
<tr>
<td>Stipa occidentalis grassland</td>
<td>38</td>
<td>44</td>
</tr>
<tr>
<td>Carex-forb subalpine meadow</td>
<td>12</td>
<td>37</td>
</tr>
</tbody>
</table>
trampling stress as basal meristems, small protected flowers, tough and flexible vegetative parts, basal leaves, underground stems, and the ability to reproduce vegetatively.

Additionally, site manipulation associated with trail construction, particularly tree and brush removal, is often unnecessary. Consequently, environmental alterations that lead to changes in species composition are less profound than in dense forests.

The indices of vegetation change in the two remaining vegetation types respond in opposing manners. The Pinus contorta/Vaccinium scoparium (lodgepole pine/grouse huckleberry) forests lose a considerable amount of cover, but the change in species composition is slight. This results from reductions in the cover of Vaccinium scoparium, a brittle shrub highly susceptible to damage from trampling, and a lack of invasion by other species. In the Pinus albicaulis/Vaccinium scoparium (whitebark pine/grouse huckleberry) stands, cover loss is slight but change in species composition is high. In these forests, Vaccinium cover is reduced but open areas are colonized by species from adjacent alpine openings.

Vegetational responses along trails are confined to a zone seldom more than several meters wide. Cover loss and change in species composition only 2 m from the Eagle Cap trails are negligible when compared to trailside changes (Cole 1978). Trail width differs between forested and open areas, however, with open areas having wider trample zones since hikers can easily walk abreast or leave the trail. For example, in forested areas researchers have found that impact is usually confined to 1 m on either side of the trail (Bayfield 1971, Dale and Weaver 1974). In the alpine meadows of Glacier National Park, the zone of greatest change occurred within 2 m of the trails' edge, but some vegetational response was noted more than 5 m from the trail (Hartley 1976). Similarly, along meadow trails in Yosemite National Park, noted severe disturbance was confined to 2 m on either side of the trail center some changes were noted at a distance of 7 m from the center.

**Discussion**

On the basis of these results it must be concluded, for the Eagle Cap Wilderness at least, that the vegetation of meadows and open forests changes less following the construction and use of trails than the vegetation of dense forests. Ecologically this makes sense, because open vegetation types have understories dominated by species with growth forms and organ structures that facilitate trampling survival. Moreover, these types are less altered by trail construction and they have evolved in conjunction with trampling stress from native animals.

In a study of campsites in the Eagle Cap Wilderness Area (Cole 1977), the use of a paired-plot method similar to that used in the trail study illustrated that the understory vegetation on campsites in forested areas is also more highly altered than the vegetation on campsites in meadows. With the inclusion of the frequent elimination of downed wood and mutilation of live trees in and around forested campsites, this greater impact becomes even more obvious.

As supportive evidence for these conclusions, Foin et al. (1977) concluded that visitor impacts on forested areas in Yosemite National Park are much greater than impacts on meadow trails. Their rationale was that forests regenerate slowly and that thorough destruction of the understory increases the probability of accidents affecting the canopy. Dale (1973), in a study in the Madison Range, Montana, also noted that trails in meadows recover from use more rapidly and completely than trails in forests. Thorneburgh (1970), working in North Cascades National Park, noted severe disturbance on campsites in mountain hemlock/silver fir forests and a relative lack of disturbance on campsites in alpine Carex nigricans meadows. One of the most heavily used sites in his study area, a Carex spectabilis meadow near the sign at Cascade Pass, retained an 88% vegetative cover.

**Merriam et al. (1973)** studied campsites in the Boundary Waters Canoe Area of Minnesota. Although only two campsites in open areas were investigated, it is significant that after five years of use, the non-vegetated area on these open sites was only 3% and 13% of the original campsite area, while the lowest value for any of the 21 forested campsites was 26%.

In a study of backcountry campsites in Banff National Park, Lesko and Robson (1975) concluded that subalpine meadows provide much better campsites than forested areas because of thicker organic horizons, deeper effective rooting mediums, and a higher proportion of trampling-resistant species.
Finally, in a study conducted in Finland, Kellomaki and Saastamoinen (1975) suggested that camping is less destructive to meadows than to forested areas, although this greater tolerance of meadows is not apparent in short-term experimental studies. They illustrate the need for long-term experimental studies by noting that grasses are heavily damaged by short-term trampling and relatively resistant to prolonged trampling.

**MANAGEMENT IMPLICATIONS**

These results imply that vegetation alteration could be minimized by locating trails and camps in meadows and open forests where understories are dominated by graminoids and heliophytic plants. Densely forested areas should be avoided, particularly where understories are dominated by woody shrubs and erect forbs.

This is a surprising conclusion, considering the common practice of encouraging camping and routing trails into forests rather than meadows. Although the justification for this practice is usually that it reduces ecological damage, this conclusion may be based more on evident visual deterioration than on actual ecological deterioration. Human impact on meadows is much more obvious to visitors than impact is on forests, even if meadow impact is less severe. This emphasis on visual criteria would be justified if it were consciously recognized that management actions were minimizing visual impacts at the expense of maximizing impacts on the vegetation. The concern is that this trade-off situation has not been recognized, and that this visual emphasis has occurred by default because of the lack of comparative data for different ecosystems.

Ultimately, locational decisions must be based on an understanding of the susceptibility of many environmental variables—not just vegetation—to changes resulting from recreational use. Although locating trails and campsites in meadows may minimize vegetation alteration, such an action may maximize soil erosion, wildlife disturbance, visual changes and the likelihood of seeing other parties. For example, many subalpine meadows have fine-textured soils and a perennially high water table, so that trails often become knee-deep in mud when subjected to heavy use.

The following procedure is suggested for backcountry managers who need to make decisions regarding locations of trails and campsites. Determine for each major ecosystem type the changes in environmental characteristics associated with the construction and use of trails or campsites. Both the biophysical nature of the backcountry area and the inclinations of the area's manager will determine the parameters to be considered. Vegetative cover, species composition, wildlife populations, soil compaction, soil texture, soil depth, and organic-matter content consistently change along trail corridors and on camp-sites.

Ideally, a paired quadrat method, similar to that described above should be used to generate the type of quantitative data presented in Table 1. This information on susceptibility to change could be gathered in only a few field seasons. If objective, empirical results of this type are not obtainable due to financial constraints or manpower shortages, managers could assess the susceptibility of ecosystems on the basis of personal observations and previous experience. As funding becomes available, these "educated guesses" could be confirmed or rejected by an improved data base.

This information, regardless of the data-collection method, could be arrayed in a matrix similar to Table 2. The number of susceptibility categories is not important as long as the number remains manageable.

At this point the manager must assign priorities to each environmental parameter. For example, a manager might decide that wildlife disturbance and soil depth change are particularly undesirable because they are difficult to reverse. Weighting factors, based on these priorities, can then be assigned to each parameter (Table 3) and multiplied by the relative susceptibility ratings (1 for low, 2 for moderate, and 3 for high). Summing all of these weighted susceptibility ratings for an ecosystem type provides an overall rating. In the case shown in Table 3, ecosystem types C and D are particularly susceptible to undesirable changes; ecosystem types A and E are relatively resistant. Therefore, trails should be concentrated in ecosystems A and E, and ecosystems C and D should be avoided.

The elements of subjectivity in this system must be kept in mind. Overall susceptibility ratings will vary with the measures taken, the accuracy of the individual susceptibility ratings, and the weighting factors used. This subjectivity is
Table 2. A hypothetical matrix of the relative susceptibility of ecosystems to changes resulting from trail construction and use

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Ecosystem type</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A</td>
</tr>
<tr>
<td>Vegetative cover</td>
<td>3</td>
</tr>
<tr>
<td>Species composition</td>
<td>2</td>
</tr>
<tr>
<td>Wildlife disturbance</td>
<td>1</td>
</tr>
<tr>
<td>Soil compaction</td>
<td>1</td>
</tr>
<tr>
<td>Soil texture</td>
<td>1</td>
</tr>
<tr>
<td>Soil depth</td>
<td>1</td>
</tr>
<tr>
<td>Organic matter content</td>
<td>2</td>
</tr>
</tbody>
</table>

Susceptibility: 3=high; 2=moderate; 1=low

Table 3. Overall susceptibility ratings of the ecosystem types in Table 2

<table>
<thead>
<tr>
<th>Parameter and Weighted factor</th>
<th>Ecosystem type</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A</td>
</tr>
<tr>
<td>Vegetative cover (IX)</td>
<td>3</td>
</tr>
<tr>
<td>Species composition (IX)</td>
<td>2</td>
</tr>
<tr>
<td>Wildlife disturbance (3X)</td>
<td>3</td>
</tr>
<tr>
<td>Soil compaction (IX)</td>
<td>1</td>
</tr>
<tr>
<td>Soil texture (2X)</td>
<td>2</td>
</tr>
<tr>
<td>Soil depth (3X)</td>
<td>3</td>
</tr>
<tr>
<td>Organic Matter content (2X)</td>
<td>4</td>
</tr>
</tbody>
</table>

Overall Susceptibility Rating 18 25 33 32 19

Weighted ratings are calculated by multiplying the susceptibility ratings in Table 2 by the weighted factor assigned to each type of change. The overall susceptibility rating for the ecosystem type is the sum of these values.
unavoidable because the ratings reflect both environmental conditions and management objectives; they are not absolute and unchangeable. Nevertheless, this method provides a framework for integrating various types of human impact, displaying trade-offs to be made, and summarizing the overall susceptibility of ecosystem types to particularly undesirable changes.

This illustrates how analytical methods can generate information capable of guiding locational decisions. The technique involved is simple and the information can be gathered quickly. With the resulting data base, locational decisions would have a scientific foundation that could constantly be improved, particularly when long-term experimental results become available.

REFERENCES CITED


DISCUSSION

Comments: Your evaluations show percent cover reduction. Is this relative cover? Our results in Olympic National Park substantiate what you've shown, but I've often wondered about the importance of noting that percent cover reduction is less in meadows. In terms of actual plant loss, have we lost more total plants in a dense meadow community than in a forested community with a sparse shrub layer?

Cole: That's a good point. I used a relative measure, expressing cover loss as a percentage of the vegetation that you started with. The alternative is absolute cover loss which is highly dependent on the amount of original cover.

Let's say you have an undisturbed community with a cover of 20%. If you lose all the cover, that's a 100% cover loss using my system. Otherwise, it would be only a 20% absolute cover loss. Compare that to a community with 60% initial cover and 30% cover after use. In this case, there has been a greater absolute cover loss, 30%, but you have only lost half of the cover. In my opinion, this is less significant and that is why I chose relative cover. As I've said before, this is a subjective decision based upon a management decision as to which is better or worse. Maybe we need both.

Comment: Did you try applying the overall susceptibility rate to your own studies?

Cole: No, I only measured cover loss and change in species composition. I have not had a chance to use the expanded susceptibility rating system.

Comment: Off the top of your head, what ecosystem do you think would come out most susceptible? The forest type?

Cole: I'm not really in a position to say because, as I have stressed, susceptibility can only be defined in terms of management priorities. Forests are probably least susceptible if visual impact is given overriding importance, while meadows are least susceptible to vegetation alteration. Before this question can be answered, we need to know more about wildlife disturbances and soil changes and managers need to assign priorities to the various types of change. The answer will vary from place to place due to differences in environment and management objectives.

Comment: I'm one of the land managers for the Eagle Cap Wilderness and I really enjoyed your comments. We're really concerned about lake shores and the vegetation changes there. I was wondering if you noticed in your studies if these same patterns held true at lake shores--are forested lake shores more impacted than open lake shores?

Cole: Many of the areas I studied were around lakes, such as Horseshoe Lake. I did find that forested areas around these lakes were more highly impacted by camping than subalpine meadows. On the other hand, trails through perennially wet meadows around lakeshores may be particularly damaging to soils. In terms of vegetation change, however, even under these conditions, trails cause less change in meadows than in forests.
EXPERIMENTS ON THE EFFECTS OF HUMAN URINE AND TRAMPLING ON SUBALPINE PLANTS

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University of California
Berkeley, California

ABSTRACT--Human trampling is shown to have detrimental effects on low-growing vegetation. Measurements of the vulnerabilities to experimental tramplings and subsequent recoveries of 21 perennial plant species near 2,900 m (9,600 ft) in the Sierra Nevada are given.

The trampling effects are evaluated in terms of a survival rate based on the percent of the original cover surviving 100 standard steps. Trampling impact on plants is viewed as the collective result of several distinct trampling effects: shearing, crushing, gouging, grinding, and ripping.

Herbaceous plants with basal leaves generally exhibited the greatest resistance to trampling. Plants were usually found to be more vulnerable to trampling damage in the late summer (September) than in the early summer (end of July to mid-August). Layered communities, thick or revolute leaves, or moist peaty soil with a dense root content and a stable surface, tended to cushion plants from damage. Plants most sensitive to trampling were those with woody stems above the ground and those with tall, entirely herbaceous and caulescent shoot stems.

Recovery rates in subsequent seasons vary widely between plants of the same growth form. Extreme differences are noted between the survival and recovery rates of the same plant species.

Human urine was applied by several methods to 22 low-growing plant species. The effects are found to vary greatly between species. Leaf contact with urine is determined to be the principal cause of plant damage. Animals show a preference to feed upon such plants. The extent of urine damage to plants in backcountry camp areas appears insufficient to be considered important in management.

INTRODUCTION

Our experiments, conducted near an elevation of 2930 m (9600 ft) in Yosemite National Park, tested the relationships of human urine and trampling to changes in low-growing, subalpine vegetation. The plant species studied (Table 1) are distributed in varying degrees throughout the mountainous regions of Western North America (Dean Taylor, personal communication). Even those species whose distribution is limited are representative, in terms of growth forms, of plants found throughout the western part of the continent. Growth form is especially important in studies of trampling vulnerability. In addition, since the Yosemite plants must withstand the rigors of montane environments, it seems reasonable to conclude that their physiological processes are representative of other species in similar ecosystems.

URINE EXPERIMENTS

We poured 200 ml doses of urine over
Table 1. Recognized western North American distribution of plant species examined in trampling and urine impact studies, Yosemite National Park

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<tr>
<th>Lat.</th>
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each plant, much as campers might do it. (Gershenfeld 1943). Control plants received 200 ml of water. The results are shown in Table 2.

All of the plants which showed any tissue damage due to urine application, except for Vaccinium nivictum in a sunny location, began to deteriorate within six days from the time of application. Damage from urine, if any, occurred consistently only to the leaves. Their contact with the salt-laden urine may cause the onset of the osmotic movement of water out of the plant tissues, causing dessication. Most of the plants susceptible to direct urine damage were also eaten. The extremely irregular lengths of the remaining stems indicated that they were probably eaten one at a time by rodents that were probably seeking the salts. There was no visual evidence of plants benefitting from urine.

Two species exhibited particularly interesting symptoms. Oryzopsis kingii, a fine-bladed grass, showed small, whitish and crystalline deposits near the tip of each leaf two days after the urine was applied; salt glands may be involved. The leaves of Salix Eastwoodiae turned brown from their edges or tips inwards, an unusual pattern of browning which does not occur under normal

Table 2. Results of urine application, August 13-15, 1975

<table>
<thead>
<tr>
<th>Genus species</th>
<th>Results 1/</th>
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<tr>
<td>Antennaria alpina (L.) Gaertn. var. media (Greene) Jeps.</td>
<td>U</td>
</tr>
<tr>
<td>Aster alpigenus spp. Andersonii (Gray) Onno</td>
<td>U</td>
</tr>
<tr>
<td>Calyptridium umbellatum (Torr.) Greene</td>
<td>Ds,E</td>
</tr>
<tr>
<td>Carex festivella Mkze.</td>
<td>U</td>
</tr>
<tr>
<td>Castilleja Lemmonii Gray</td>
<td>E</td>
</tr>
<tr>
<td>Ericaglomum incanum T. &amp; G.</td>
<td>U</td>
</tr>
<tr>
<td>Juncus Parryi Engelm.</td>
<td>U</td>
</tr>
<tr>
<td>Kalmia polifolia Wang. var. microphylla (Hook.) Rehd. (moist)</td>
<td>Ds</td>
</tr>
<tr>
<td>Kalmia polifolia Wang. var. microphylla (Hood) Rehd. (dry)</td>
<td>U</td>
</tr>
<tr>
<td>Lupinus Covillei Greene</td>
<td>Ds,E</td>
</tr>
<tr>
<td>Lupinus Lyallii Gray var. danaus (Gray) Wats.</td>
<td>Ds,E</td>
</tr>
<tr>
<td>Mimulus primuloides Benth.</td>
<td>S</td>
</tr>
<tr>
<td>Oryzopsis kingii (Bol.) Beal.</td>
<td>U</td>
</tr>
<tr>
<td>Phyllococe Breweri (Gray) Heller</td>
<td>T</td>
</tr>
<tr>
<td>Pinus Murrayana Grev. &amp; Balf.</td>
<td>Ds</td>
</tr>
<tr>
<td>Polygonum bistortoides Pursh.</td>
<td>U</td>
</tr>
<tr>
<td>Salix Eastwoodii Ckll. (?)</td>
<td>Ds,E</td>
</tr>
<tr>
<td>Senecio Scorzonella Greene</td>
<td>Es</td>
</tr>
<tr>
<td>Senecio triangularis Hook.</td>
<td>U</td>
</tr>
<tr>
<td>Sphenosciadum capitealeatum Gray</td>
<td>Es</td>
</tr>
<tr>
<td>Stipa occidentalis Thurb.</td>
<td>U</td>
</tr>
<tr>
<td>Vaccinium nivictum Camp. (sunny)</td>
<td>D</td>
</tr>
<tr>
<td>Vaccinium nivictum Camp. (shady)</td>
<td>U</td>
</tr>
<tr>
<td>Veratrum californicum Durand.</td>
<td>Es</td>
</tr>
</tbody>
</table>

1/ U = unaffected
    S = seasonal change preempted experimental results
    T = temporary change, but recovered by September 15
    Ds = slightly damaged
    Es = slightly eaten, but recovered by September 15
    D = more than 50% severely damaged
    E = more than 50% eaten
circumstances. The leaves also were very shiny for a couple of days after the urine was applied to their surface; this was probably caused by salt crystallization, which could be the result of salt-gland secretion or of salts being left behind as the urine was evaporated from the leaves.

Numerous additional experiments and detailed observations of changes in each plant species due to urine application allowed us to recognize when a plant's leaves were damaged by urine (Holmes and Dobson 1976). Armed with this knowledge, the vegetation in and around dozens of campsites in Yosemite was examined for evidence of direct urine damage. The only case observed was in Vaccinium niviculum, and it recovered in a couple of weeks. Therefore, it appears that direct effects from urinating on plants are rarely a problem in wilderness campsites. However, indirect effects of urine, such as concentrating the activities of salt-craving animals, can be fairly serious (Bruce Moorhead, personal communication).

TRAMPLING EXPERIMENTS

In the trampling study, the relative and absolute rates of defoliation of 21 different plant species were determined (Holmes and Dobson 1976). Several important variables were analyzed: differences between individual trampers, the constitution of the standard step, the nature of trampling impact, and the relationship of different growth habits, morphologies, seasons, slopes, and habitats to plant survival rates (Figure 1). Plot recovery rates were also determined.

Substantial differences in sizes of trampers, as well as the sizes of their loads, make it necessary to consider differences in their relative impacts. It was found that an individual's impact is closely tied to body weight, and we used this conclusion to derive a standard step considered representative of the typical Yosemite back-country user (Harper et al. 1961, Scott 1942, and Steindler 1955). Since our primary concern was with campsite deterioration and because backpack weights are very variable, we used trampers without packs. The typical backcountry user weighed 66 kg (145 lbs). This weight, when concentrated on a lug sole of the appropriate size, was about .83 kg/sq cm (12 lbs/sq in). In our group of fifteen experimental trampers, the coefficients for an individual's step to the standard step ranged from 0.7 to 1.3. Due to the short length of the study plots, it was not necessary to consider variations in stride length.

Each subdivision of the gait has its own particular pressures and motions in regard to affecting vegetation (Figure 2).

Shearing occurs during the swinging phase of the leg; the front edge of the boot, and to some extent the sole, move rapidly forward a few centimeters above the ground or vegetation surface, pushing over and lightly abrading or clipping off the taller stems. The shorter plants (those less than 3 cm high) are usually spared from any contact. Those which are slightly higher (that is from 3 to 5 cm) may or may not be touched, depending on the trampler's inclination to lift his feet. Plants from 5 cm to 30 cm high are almost always struck. Tender leaf blades and flowering stems are usually torn or broken by this movement.

Crushing is the principal effect on vegetation when the body's weight is applied downward. Any plant underfoot subject to this pressure is flattened. Plants with upright leaves, brittle petioles or stems, or stalks with unipliable and erect leaves are particularly vulnerable to this force. Crushing appears to be the most extensively destructive of the trampling impacts. Its damaging effects may be lessened by the presence of cushioning, as found in a layered plant community, or where the leaves are thick or revolute.

Gouging, or digging, occurs as the foot first contacts or leaves the ground. The small boot area in contact with the ground and the great pressure exerted make this a very damaging motion, although it does not compare in the extent of its effect with crushing. Gouging can lead to the rapid removal of soft soil from around and beneath plants, exposing subterranean parts to crushing and removing soil support under prostrate plant parts.

Grinding, twisting the foot while it is supporting the body, usually occurs when making a sharp turn, especially from a stand-still position. It contributes significantly to the total defoliation which is common in the center of campsites.

Ripping is the downward sliding of the boot due to inadequate friction between the boot and the ground surface. Pressure is accentuated at the uphill edge of the boot in
Figure 1. Individual hiker heftiness, plant species characteristics, and environmental factors combine to create trampling vulnerability.
an effort to cut into the surface and reach a more stable, as well as a more comfortable (flatter) footing. Repeated gouging in this manner creates a contoured trail when it occurs across slope and a depressed, unstable channel when up-and-down slope. Ripping and topographically induced gouging play a small role in trampling impact in the normally flat camp areas; however, their impact is substantial on slopes or at embankments such as
near the edges of streams or lakes.

It is clear that the overall amount of impact upon vegetation in a given area is closely tied to these motions of the boot. But equally important are environmental factors and the characteristics of each plant species.

The plants we chose to study are fairly common in the lodgepole-subalpine ecosystem of Yosemite. They are all perennials and between them represent the growth forms found in alpine, subalpine, and lower meadows throughout the west. Some of the plants are forest-floor residents, others occupy riparian habitats, and others are typical of open meadows. Most of the species have a broad elevation range. It should be noted that the same species generally becomes increasingly diminutive with higher elevations. Differences in plant size, such as occur with elevation changes, can noticeably influence trampling vulnerability.

Twenty-one plots of nearly pure or pure stands of the different species were laid out. In addition, there were five plots of extremely mixed composition. All plots were 1 m wide with one-half of that meter being a control area not subjected to trampling. The plot was trampled repeatedly over a few days' time and the rates of defoliation were noted. Full descriptions of the methodology are to be found in Holmes and Dobson (1976).

A survival rate was calculated for each plant species, representing resistance to trampling. The survival rate is the percentage of original absolute cover surviving 100 standard steps on an area of one-half square meter. Survival rates ranged from over 95% for very resistant plants, to less than 1% for extremely vulnerable species.

The plants were trampled during either the early season (end of July into early August) or the late season (September). For each species, a comparison was made of vulnerability during the two periods. When the plants were vigorous and green in the early season, they were usually more resistant to trampling damage than in the late season, when they were past flowering and often somewhat dried and more brittle.

Senecio triangularis typifies the most vulnerable plants, those with tall, entirely herbaceous, and caulescent shoot systems (Figure 3). One or two steps are adequate to do substantial amounts of damage. Its survival rate is only 10% in the early season and less than 1% in the late season.

Another very vulnerable plant is Calyptidium umbellatum. Several factors are involved: its being only a few centimeters across, its very sparse density of cover, the fact that its habitat is sandy, often dry soil, and its having only a taproot incapable of binding the soil (Figure 3). These factors combined to allow it to be easily buried by gouging; the soil, especially when dry in the late season, readily shifted over the plant.

Vaccinium nivicum, bilberry, is a common woody-based brittle groundcover with thin, tender leaves, weak petioles and nodes, and very short stature (Figure 3). In having erect leaves, it is more vulnerable than many woody-stemmed plants, although its short stature provides some protection in that stems cannot be crushed down very far before they are supported by the ground. We measured vulnerability of this plant when it was growing on different slopes. On level ground the survival rate was 10%. On a 13 degree slope, the survival rate was 5%. On a 32 degree slope, the survival rate was less than 1%. These differences are primarily due to ripping.

The arrangement of the leaves in a basal rosette often increases survival rates. Senecia Scorzonella (Figure 3) has very tough and pliable leaves which are highly resistant to abrasion and tearing. Its early season survival rate was 90%; later it was 30%.

As a group, the most resistant growth forms are the so-called bunch grasses. Juncus Parryi has the same growth form (Figure 3). They are characterized by tough, wiry, densely bunched blades. The blades arise from sheaths clustered just above the ground. Their survival rates typically exceed 80%.

Table 3 shows the average of early and late season survival rates for a number of plant species in relation to their growth forms and morphological characteristics. Clearly we must know a great many things in order to decide the vulnerability for an entire plant community, not the least of which is the influence of community members in providing cushioning and protection for one another.

The survival rate give us only an index
Figure 3. Growth forms of five exemplary plant species

Senecio triangularis Hook.

Senicio Scorzonella Greene

Calyptridium umbellatum (Torr.) Greene

Juncus Parryi Engels.

Vaccinium nivictum Camp.
of the rate of damage being sustained during the present season of use. However, there is as wide a variation in recovery rates (one year after trampling) as there is in survival rates. The factors involved in accounting for differences between the species probably include such items as the amounts of root carbohydrate reserves, degree of damage due to trampling, location of regenerative buds, extent of interconnecting root systems with untrampled areas, weather, amount of later trampling, aspect, season of initial trampling, and rodent activity (Bates 1938, Billings and Mooney 1968, Burcham 1957, and Davies 1938). The recovery rates were often over 90%. Probably this is because the virgin sites were only trampled over one brief period and the trampling was not repeated, as would often occur in camp areas, but there are also some low rates of recovery. A table of the recovery rates has not been included because they are still under investigation.

Plants of the same community or same growth forms tend to have different survival or recovery rates. Sometimes similar growth forms have similar survival rates, but these are dependent upon none of the species having a particular morphological weakness, such as weak petioles or tender leaves. In general both survival and recovery rates are highly specific to each individual species. And the rates may vary for each environmental factor such as community composition, slope or weather.
CONCLUSION

The direct effects of urine on plants probably need no further attention. Trampling effects, however, are substantial and need considerable additional study.

In the face of an overwhelming number of variables affecting trampling vulnerability, we must monitor the change in vegetation in use areas and seek to manage wilderness users in response to that observed change. Over an extended period, this will provide an idea of long-term effects of repeated trampling, and thus guide us, ever so slowly, into predictive management.

ACKNOWLEDGMENTS

Without the tremendous assistance of Ms. Heidi Dobson of the Department of Botany at the University of California at Berkeley, this research would have been impossible. Drs. Jan W. van Wagendonk and John R. Parmeter provided their enthusiastic support, an essential element. Special thanks to Ms. Lou Ellyn Mills and Ms. Andrea Thrams, freelance artists, for their illustrations which brighten the text and enlighten the reader. Finally, my appreciation to Dr. Dean Taylor for the use of his data on plant distributions.

REFERENCES CITED


DISCUSSION

Weaver: You have described strong effects of human urine on high grasslands. In contrast, I see little effect of cow urine in high Idaho fescue grasslands. I had always imagined that spots of unusually bright bluegreen grass were due to the fertilizer effect of cow urine, but when I applied 500 ml of cow urine to each of thirty-five quadrats (225 square cm) I observed no effect in the first or in any of the following five years. On the other hand, cow manure "pats" applied at the same time eliminated existing vegetation and have allowed few plants to reestablish themselves in the following five years. T. Weaver, Montana State University, Bozeman, MT 59717.

SUMMARY SESSION COMMENTS noted little direct impact of urine on plants, but added that a significant indirect impact may exist due to the salt attraction for insects and mammals. Ungulates, especially deer, elk, and goats, will consume vegetation or soil that has been urinated upon, and some animals may even follow people around waiting for such an event. Elk have been known to collar themselves with old toilet seats as they nose down into old makeshift privies.
AN ASSESSMENT OF DAMAGE CAUSED BY OFF-ROAD VEHICLE TRAFFIC ON SUBARCTIC TUNDRA IN THE DENALI HIGHWAY AREA OF ALASKA

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ABSTRACT--The impact of ORV traffic on vegetation in the Denali Highway region of Alaska varied from little noticeable effect to drastic alterations. The amount of traffic, plant habitat type, and soil stability properties are the most important factors influencing the degree of plant injury that occurs. These factors are closely interrelated, and any one often influences the other. All of the heavily used trails are denuded of vegetation. Less used trails have no vegetation remaining in the tracks but have good plant cover in the middle of the trail. All ORV traffic causes some injury to the tundra vegetation. The weight of the vehicle causes the plants to bend and break. Under favorable soil conditions, however, the injury to the low growing plants, a result of a single pass of a vehicle is usually slight to moderate and the plants recover without any long-term effect. The taller shrubs, such as willow and shrub birch, are more susceptible to damage than the low-growing plants. Sedges appear to be most resistant to sustained ORV traffic. The sedges are the first plants to reinvade the wet areas; whereas, the grasses are usually the first to revegetate the drier sites. Vegetation on shallow, gravelly, or cobbly soils is more subject to injury than on deeper, well-drained soils.

INTRODUCTION

In 1975, a multidisciplinary research proposal was funded by the Bureau of Land Management (BLM) to develop baseline data on resources and recreational activity in the Denali Highway area. Two distinct efforts were implemented during the summer field season. One component involved gathering of information on recreational activity in the study area. Survey research was employed to obtain data on the types, amounts, and patterns of outdoor recreation activity (Johnson 1976, 1977).

The other component sought information about soils and vegetation in the study area. The investigators focused their attention on effects of off-road vehicle (ORV) activity on the resource base. Revegetation test plots were also initiated in a heavily used area of a campground. The results of the soils and vegetation analysis were reported to the Bureau of Land Management. (Sparrow 1976). A portion of the report, emphasizing soil classification and soil compaction has recently been published in the Journal of Soil and Water Conservation (Sparrow et al., 1978). This paper will deal primarily with an assessment of ORV damage to tundra vegetation and with plant-soil relationships which determine the degree of damage.

DESCRIPTION OF DENALI HIGHWAY AREA

The Denali Highway is a two-lane, gravel
road which runs 217 km east-west from Paxson to Cantwell, Alaska, and parallels the south side of the Alaska Range at about 63 degrees north latitude (Figure 1). The elevation is approximately 800 m at Paxson about 670 m at Cantwell. The highest point along the highway is 1,245 m at Maclaren Summit. The highway generally follows the ridges, which are glacial moraines and eskers. The area is geologically young. The underlying stratum in most of the region is glacial drift which was deposited during the last glacial advance about 8,000 years ago. There is little permanent development in the region, and the highway is usually open and maintained only from mid-June to the end of September.

At higher elevations and on exposed slopes, the vegetation is characteristic of alpine tundra of which the major plants are low-growing shrubs such as white-mountain avens, alpine bearberry, crowberry, bog blueberry and lowbush cranberry; herbaceous plants such as moss campion, black oxytrope, and bistort; mosses; and lichens.

There are sparse stands of white spruce at lower elevations and in the river valleys. Many species of shrubs can be found in the spruce forests.

On the north side of the highway, the mountains are close to the road (5 to 8 km). Several large lakes are within hiking distance. Except near Cantwell, most of the area south of the highway is flat to rolling, often boggy, tundra interspersed with many lakes. The entire area is popular for sight-seers, hikers, and hunters (both on foot and in ORV's). There are many trails leading away from the highway to fishing or hunting areas. Many of these areas are accessible only by ATV's (all terrain vehicles), although some of the trails are good enough...
during dry weather to be driven across with conventional highway vehicles.

The lands along the Denali Highway are administered by the Bureau of Land Management (BLM). According to the provisions of the Alaska Native Claims Settlement Act of 1971 (ANCSA), most of this area has been designated as national interest (D-1) lands. It is anticipated, therefore, that the BLM will continue its administrative responsibilities here, and that outdoor recreation will continue to receive primary consideration in decisions related to resource allocation and land use.

**APPROACH**

Several representative ORV trails were selected for study of the effects of traffic on vegetation and soils. We hiked these trails and took notes on the general condition of the vegetation and soil in the trails. Sites along each trail were selected for more detailed descriptions.

The predominant plant species, both in the trail and in the undisturbed areas, were listed. Changes in composition and damage to individual plants were noted. Plant samples were collected and brought into the laboratory for positive identification. Photographs were taken of the vegetative cover in the undisturbed area and of the trail so that different sites could be compared and so that changes with time could be observed.

**ASSESSMENT OF DAMAGE**

The impact of ORV traffic on vegetation and soils in the Denali Highway region of Alaska varied from little noticeable effect to drastic alterations. The degree and type of impact was dependent on certain soil and terrain characteristics, plant habitat type, type of vehicle, and time and amount of use. These factors are closely interrelated, and any one often influences the other. Amount of traffic, plant habitat type, and soil stability properties are the most important factors influencing the degree of plant injury that occurs. Soil depth, texture, and drainage are the most important factors influencing the impact of traffic on soils, although slope, vehicle type, vegetative cover, and amount and time of use can be significant.

All the heavily used ORV trails are denuded of vegetation. Less-used trails have no vegetation remaining in the tracks but have a good plant cover in the middle of the trail. All ORV traffic causes some injury to the tundra vegetation. The weight of the vehicle causes the plants to bend and break. Under favorable soil conditions, however, the injury to the low-growing plants as a result of a single pass of a vehicle is usually slight to moderate and the plants recover without any long-term effect (Table 1). The taller shrubs, such as willow and shrub birch, are more susceptible to damage than the low-growing plants. Sedges appear to be most resistant to sustained ORV traffic. The sedges, especially Eriophorum sp., are the first plants to reinvade the wet areas; the grasses, especially Calamagrostis sp., are usually the first to revegetate the drier sites.

Time and type of traffic can be an important factor influencing both soil and plant damage. Many soils become unstable when wet, at spring break-up or during a rainy period, for example. A single pass with a vehicle may cause deep ruts in the soil and kill the vegetation. Very little effect would be noticed if the soil were in a dry or frozen state. Conventional wheels usually cause deep ruts and more complete vegetation removal than do track vehicles. Track vehicles cause deep ruts only under very unstable soil conditions. However, the total area affected is greater with track vehicles than with conventional wheels.

Poorly drained soils are often the most damaged soils in the trails, especially if subjected to heavy use. These trails usually have a thick mat of moss and undecomposed organic matter on the surface. This thick cover acts as an insulator that protects the soil from temperature extremes. The soil usually does not thaw below a few centimeters, even during the warmest summer months. The protective covering of organic material helps cushion the weight of passing vehicles. It also acts as a sponge and absorbs water. When this mat of organic material is destroyed by repeated traffic, the soil absorbs more radiation, warms faster, thaws faster and deeper during the summer and usually becomes soggy. Also, the warming and the tilling effect of vehicles churning the soil causes an increase in the decomposition rate of organic matter. This, in combination with compaction, reduces the soil porosity. With the absorptive organic layer missing, water becomes ponded and the area becomes a quagmire. A major problem with many trails is that in trying to avoid the quagmire caused by previous use, ORV drivers widen the
Table 1. Some common plants identified in the Denali Highway area and relative damage resulting from light ORV traffic under favorable soil conditions

<table>
<thead>
<tr>
<th>Scientific name</th>
<th>Common name</th>
<th>Degree of Injury</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arctostaphylos alpina</td>
<td>alpine bearberry</td>
<td>Moderate</td>
</tr>
<tr>
<td>Betula glandulosa</td>
<td>shrub birch, resin birch, glandular birch, bog birch, dwarf birch</td>
<td>Severe</td>
</tr>
<tr>
<td>Betula nana</td>
<td>dwarf arctic birch, dwarf alpine birch, dwarf birch</td>
<td>Moderate</td>
</tr>
<tr>
<td>Calamagrostis sp.</td>
<td>reedgrass</td>
<td>Slight</td>
</tr>
<tr>
<td>Carex bigelowii</td>
<td>bigelow sedge</td>
<td>Slight</td>
</tr>
<tr>
<td>Drayas octopetala</td>
<td>white mountain-avens</td>
<td>Moderate</td>
</tr>
<tr>
<td>Empetrum nigrum</td>
<td>crowberry</td>
<td>Moderate</td>
</tr>
<tr>
<td>Eriophorum sp.</td>
<td>cottonsedge, cottongrass</td>
<td>Slight</td>
</tr>
<tr>
<td>Ledum decumbens</td>
<td>narrow-leaf Labrador tea</td>
<td>Moderate</td>
</tr>
<tr>
<td>Ledum groenlandicum</td>
<td>Labrador tea</td>
<td>Moderate</td>
</tr>
<tr>
<td>Poa sp.</td>
<td>bluegrass</td>
<td>Slight</td>
</tr>
<tr>
<td>Polygonum bistorta</td>
<td>meadow bistort</td>
<td>Severe</td>
</tr>
<tr>
<td>Rubus chamaemorus</td>
<td>cloudberry</td>
<td>Moderate</td>
</tr>
<tr>
<td>Salix sp.</td>
<td>willow</td>
<td>Severe</td>
</tr>
<tr>
<td>Vaccinium uliginosum</td>
<td>bog blueberry</td>
<td>Moderate</td>
</tr>
<tr>
<td>Vaccinium vitis-idaea</td>
<td>lowbush cranberry, mountain cranberry, lingonberry</td>
<td>Moderate</td>
</tr>
</tbody>
</table>

With heavier traffic or wet soil conditions, virtually all vegetation, with the exception of a few scattered grasses and sedges, were destroyed.

Soils which are gravelly or cobbly or very shallow soils which have a good gravel or cobble base are less susceptible to erosion than deep, gravel-free soils. Even on steep slopes, these soils are only slightly eroded whereas deep, loose soils, may be severely eroded when the vegetation is removed even on gentle slopes. However, vegetation on shallow, gravelly, or cobbly soils is more subject to injury than on deeper, well drained soils because it is growing in a more stressful environment and has a weaker root system.

ORV trails do make visible scars on the tundra landscape and because the vegetation is low growing, these scars are sometimes visible for great distances. To some extent this is unavoidable if trails are to exist, but many specially unsightly features of the trails could be avoided. Many trails have several branches leading off the highway but eventually coming together to form one main trail. Also, there are often several
branches rather than one trail going around obstacles such as a steep hill, small lake or boggy area. In boggy areas the trail becomes a wide quagmire.

RECOMMENDATIONS

The effect of ORV's on plants and soils alters the aesthetic quality of the landscape. While aesthetic judgments are subjective and dependent on the values of the individual, it must be recognized that some changes in the environment may be necessary for an area to meet its recreational potential. To preserve the wilderness character in an area, these changes should be kept to a minimum.

At the present time, ORV traffic is a significant part of the recreational use of the Denali Highway region. ORV traffic will likely increase in the area unless it is regulated. As it is unlikely that ORV traffic will be eliminated, certain preventive measures can be implemented to minimize its impact.

To encourage ORV drivers to use the main trails rather than making several branches, all but one main entrance to each trail from the highway should be closed and the closed trails revegetated. In some instances where trails pass through areas with soils which are highly susceptible to damage, trails may need to be rerouted. If trails are rerouted, or if new trails are built, they should follow ridgetops and avoid, as much as possible, areas which are steep, boggy, or have erodible soils. In many cases, it may not be feasible to reroute existing trails and when building new trails it is impossible to avoid all areas that are susceptible to soil damage. Where trails pass through bogs, the widening of the trail should be prevented. In extreme cases of soil damage, trail improvement by hauling in gravel, diverting water flow or building corduroys may be necessary.

In areas where severe erosion has already begun, erosion control measures should be taken as quickly as possible. Revegetating the areas with sod-forming plants is often sufficient but where gullies are forming, damming with bales of straw, brush or logs will likely be required. More research is needed to determine the best methods and materials to use for revegetation and erosion control.

To determine which areas are susceptible to damage and which are suitable for trail, detailed soil surveys should be done in areas of existing trails or in areas where future trails may be built.

REFERENCES CITED


THE RELATIONSHIP OF TRAIL CONDITION TO USE, VEGETATION, USER, SLOPE, SEASON AND TIME

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Associate Professor of Botany

Donn Dale

E. Hartley
Biology Department
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Bozeman, Montana

ABSTRACT--The following conclusions are drawn from experimental trampling of natural vegetation. Trampling impact increases as numbers of passes increase. Grassy vegetation is more resistant to trampling than are tree seedlings, shrubs, or forbs. Impact increases from hiker to motorcycle (12 MPH) to horse traffic. Trampling impact is greater on slopes than on level sites; it tends to be greatest for hikers and horses moving downslope and for motorcycles moving upslope. Five years after the experiment, recovery of vegetation cover is 65% in an alpine meadow, 50% in the shrubby understory of a forest, and nearly 100% in a grassland; though some recovery of soils is apparent most trail sites are still deeper and more compact than adjacent untrampled sites.

INTRODUCTION

This paper reviews quantitative studies of trampling made in the Pacific Northwest with the object of relating trail condition to amount of use, vegetation used, type of user (hiker, motorcycle, or horse), slope, and season of use. New data are presented on rates of recovery of two trampled sites. Trail condition has also been related to site conditions such as vegetation type, land form, and substrate (Helgath 1975, Cole 1978).

METHODS

Studies relating trail condition to the quantity of use have been based on measurements along preexisting trails with known amounts of use (Dale and Weaver 1974, Helgath 1975) or on purely experimental trails with known use levels. Other experimental studies as well as this paper have considered a variety of variables: number of passes, vegetation types (Table 2), different trampers (Weaver and Dale 1978), various slopes (Weaver and Dale 1978), different seasons (Foster 1977), and after different recovery times (Bell and Bliss 1973, Hartley 1976). In some studies the trampling was concentrated in a period as short as two weeks (Weaver and Dale 1978) while in others it was spread evenly through seasons as long as six weeks (Bell and Bliss 1973, Landals and Scotter 1974, and Hartley 1976). Although comparisons of the two methods have shown relatively little difference between them (Cieslinski and Wagar 1970, Landals and Scotter 1974) we doubt the generality of this conclusion.

RESULTS AND CONCLUSIONS

Though the principal impact of travelers is on the trail itself a broader corridor is affected. Transect data show
that some plants common in the forest understory, especially shrubs and taller herbs, disappear at the edge of trails—perhaps because they are unable to tolerate trampling. Other plants, especially introduced and native meadow plants are most common at the trail's edge—perhaps because of increased light, precipitation, fertilization, and seed supply at the trail's edge. The affected area apparently extends only 1 m beyond the trail's edge in Agrostis-Agrogyron-Trisetum meadows (Foin et al. 1977), 1-2 m beyond the trail's edge in forests (Dale and Weaver 1974), and 2-5 m beyond the trail's edge in heavily used alpine meadows (Hartley 1976). Scanty data suggest that some animals may increase or decrease—according to species—as one approaches a trail or campground (Chester 1976 and Foin et al. 1977).

Impact generally increases with increased user number whether hiker, motorcycle or horse (Table 1, Bell and Bliss 1973, Landals and Scotter 1974, Schreiner 1974, Hartley 1976, Weaver and Dale 1978):

1) Percent bare ground is expected to equilibrate at 100% when use levels become sufficiently high.
2) Trail widths continued to increase slowly through 1000 passes in our experiment due to the natural tendency of tramplers to wander (Weaver and Dale 1978). This tendency will be aggravated if obstacles such as stone, roots, mud, or manure appear in the trail as well as near the beginning or end of a trail where tramplers often walk abreast. In Rocky Mountain forests and meadows, trail width seems to increase with the logarithm of user visits per year from a meter with 1000 visits per year to 2 meters with 10,000 visits per year (Dale and Weaver 1974).
3) Trail depth continued to increase up to and after 1000 passes (Table 1 and Weaver and Dale 1978). Well-established trails used by 1,000 to 5,000 individuals per year average 4-5 cm deep for hikers and 7-11 cm deep if both hikers and horses were included (Dale and Weaver 1974).
4) Soil bulk density (compaction) also increases steadily through at least 1000 hiker passes (Table 1, Weaver and Dale 1978).

Vegetation dominated by graminoids usually tolerates more trampling than vegetation dominated by more easily broken forbs or shrubs (Table 2). Some plants may largely avoid the direct effects of trampling by growing in non-trampling seasons; for example, Erythronium grandiflorum may complete much of its life cycle before trampling begins in many Rocky Mountain vegetation types (Dale and Weaver 1974 and Hartley 1976). Trample-avoiders may be benefited more by release from competition than they are inhibited by compaction of soils in which they grow. In high meadows (wet to dry) of the Olympic Peninsula, Schreiner (1974) found that 500 tramplings reduced grass cover by 5-47%, forb cover by 65-68%, dwarf shrub cover by 85%, moss cover by 6-44%, and lichen cover by 44-85%.

User impact generally increases from hiker to cycle to horse. (Table 3 and Weaver and Dale 1978).
1) On a level site, for example, 50% bare ground is reached after 1000 hiker, 1000 cycle and 600 horse passes on a grassy site, and after 300 hiker, 50 cycle, and 50 horse passes on a forested site.
2) Trail width probably increases from hiker to cycle to horse because trampler width increases in this order.

<table>
<thead>
<tr>
<th>Number of passes</th>
<th>0</th>
<th>300</th>
<th>600</th>
<th>900</th>
</tr>
</thead>
<tbody>
<tr>
<td>bareground (%)</td>
<td>2+ 2</td>
<td>8+ 3</td>
<td>18+4</td>
<td>45+8</td>
</tr>
<tr>
<td>width (cm)</td>
<td>0+ 0</td>
<td>12+ 5</td>
<td>24+ 4</td>
<td>26+ 3</td>
</tr>
<tr>
<td>depth (mm)</td>
<td>16+ 2</td>
<td>37+11</td>
<td>39+ 3</td>
<td>40+ 4</td>
</tr>
<tr>
<td>bulk density (gm/cc)</td>
<td>1.01+</td>
<td>1.09+</td>
<td>1.11+</td>
<td>1.18+</td>
</tr>
</tbody>
</table>

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2) Trail widths continued to increase slowly through 1000 passes in our experiment due to the natural tendency of tramplers to wander (Weaver and Dale 1978). This tendency will be aggravated if obstacles such as stone, roots, mud, or manure appear in the trail as well as near the beginning or end of a trail where tramplers often walk abreast. In Rocky Mountain forests and meadows, trail width seems to increase with the logarithm of user visits per year from a meter with 1000 visits per year to 2 meters with 10,000 visits per year (Dale and Weaver 1974).
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2) Trail width probably increases from hiker to cycle to horse because trampler width increases in this order.
3) Trail depths increase from hiker to cycle to horse because of tendencies of each trampler to compact and/or move soil. We have not documented the relative tendencies to move soil but soil compaction is demonstrated by our bulk density data (Weaver and Dale 1978).

4) Soil bulk density clearly increases from hikers with relatively light weights and large bearing surfaces to horses with relatively heavy weights and smaller bearing surfaces.

The impact of trampling increases with increasing slope (Table 4 and Weaver and Dale

Table 2. Number of hiker tramplings necessary to remove 50% of the cover of nine Rocky Mountain vegetation types

<table>
<thead>
<tr>
<th>Dominant species</th>
<th>Tramplings</th>
<th>Life form</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valeriana sitchensis</td>
<td>25</td>
<td>tall moist site forb</td>
<td>Landals and Scotter 1974</td>
</tr>
<tr>
<td>Vaccinium membranaceum</td>
<td>30</td>
<td>medium forest shrub</td>
<td>Landals and Scotter 1974</td>
</tr>
<tr>
<td>Carex tolmei-</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Erigeron peregrinus</td>
<td>30</td>
<td>dry alpine meadow</td>
<td>Hartley 1976</td>
</tr>
<tr>
<td>Carex phaeocephala</td>
<td>60</td>
<td>stone stripe meadow</td>
<td>Bell and Bliss 1973</td>
</tr>
<tr>
<td>Cassiope mertesiana</td>
<td>100</td>
<td>dwarf alpine shrub</td>
<td>Landals and Scotter 1974</td>
</tr>
<tr>
<td>Luetkea pectinata</td>
<td>180</td>
<td>sub-alpine shrub</td>
<td>Landals and Scotter 1974</td>
</tr>
<tr>
<td>Vaccinium scoparium</td>
<td>300</td>
<td>dwarf forest shrub</td>
<td>Weaver and Dale 1978</td>
</tr>
<tr>
<td>Carex nigricans</td>
<td>40</td>
<td>snowbank meadow</td>
<td>Bell and Bliss 1973</td>
</tr>
<tr>
<td>Carex nigricans</td>
<td>200</td>
<td>wet alpine meadow</td>
<td>Hartley 1976</td>
</tr>
<tr>
<td>Carex nigricans</td>
<td>750</td>
<td>wet alpine meadow</td>
<td>Landals and Scotter 1974</td>
</tr>
<tr>
<td>Festuca idahoensis-</td>
<td>1100</td>
<td>mesic grassland</td>
<td>Weaver and Dale 1978</td>
</tr>
<tr>
<td>Poa pratensis</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 3. The effects of 1000 user passes on level forest or grassland

<table>
<thead>
<tr>
<th>Trampler</th>
<th>Hiker</th>
<th>Cycle</th>
<th>Horse</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bare ground (%)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>grassland</td>
<td>47+8</td>
<td>50+10</td>
<td>72+7</td>
</tr>
<tr>
<td>forest</td>
<td>98+1</td>
<td>98+2</td>
<td>100+0</td>
</tr>
<tr>
<td>width (cm)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>grassland</td>
<td>28+1</td>
<td>34+6</td>
<td>84+4</td>
</tr>
<tr>
<td>forest</td>
<td>34+1</td>
<td>62+2</td>
<td>68+3</td>
</tr>
<tr>
<td>Depth (mm)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>grassland</td>
<td>42+4</td>
<td>49+4</td>
<td>68+7</td>
</tr>
<tr>
<td>forest</td>
<td>23+3</td>
<td>36+7</td>
<td>64+10</td>
</tr>
<tr>
<td>Bulk density (gm/cc)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>grassland</td>
<td>1.2+0.0</td>
<td>1.3+0.0</td>
<td>1.3+0.0</td>
</tr>
<tr>
<td>forest</td>
<td>1.1</td>
<td>1.0</td>
<td>1.2</td>
</tr>
</tbody>
</table>
Table 4. The effect of slope on trailwear after 1000 passes in a grassland. Standard errors are available in Weaver and Dale 1978.

<table>
<thead>
<tr>
<th></th>
<th>Hiker</th>
<th>Cycle</th>
<th>Horse</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Level</td>
<td>Slope</td>
<td>Level</td>
</tr>
<tr>
<td>Bare ground %</td>
<td>47</td>
<td>66</td>
<td>50</td>
</tr>
<tr>
<td>Width (cm)</td>
<td>28</td>
<td>44</td>
<td>34</td>
</tr>
<tr>
<td>Depth (cm)</td>
<td>4.2</td>
<td>6.2</td>
<td>4.9</td>
</tr>
<tr>
<td>Bulk density (gm/cc)</td>
<td>1.15</td>
<td>1.28</td>
<td>1.26</td>
</tr>
</tbody>
</table>

1978) whether the trampler is a hiker, a cycle or a horse. Rates of vegetation destruction probably increase on slopes because shearing increases: force applied and slippage increase while area of application may decrease. Trail width probably increases because the trampler is under poorer control moving downslope than on level or upslope trails. Increases in trail depth with slope may be due to greater compaction and/or movement of the soil followed by greater water erosion of the bared surface. Bulk density increases indicate application of greater forces to the surfaces of sloping trails.

Motorcycles tend to be more destructive when moving up than down a 25% slope while horses and hikers tend to be most destructive when moving downslope (Table 5). Foster (1977), however, recorded no significant differences in wear of a trail whether moving up or down a 6-8% slope in Stipa-Agropyron rangeland in a truck. The probability of spinning a wheel when moving upslope is apparently greater than sliding (via braking) when moving downslope, in spite of the fact that the force applied in accelerating upslope should equal that applied in resisting acceleration by gravity downslope. Animals and especially bipeds, i.e., people, plant their feet carefully and control acceleration upslope carefully to minimize energy output; when they move downslope, on the other hand, they accelerate (via gravity) and decelerate (via bones, elastic connective tissue and muscles) sharply because this requires less energy than a smoother descent under greater muscular control.

Table 5. The effects of uphill vs downhill traffic in a grassland. (The larger of each pair of values is underlined when the values differ significantly.)

<table>
<thead>
<tr>
<th></th>
<th>Hiker</th>
<th>Horse</th>
<th>Cycle</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Up</td>
<td>Down</td>
<td>Up</td>
</tr>
<tr>
<td>Bareground, %</td>
<td>7</td>
<td>66</td>
<td>63</td>
</tr>
<tr>
<td>500 passes</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Width, CM</td>
<td>38</td>
<td>49</td>
<td>83</td>
</tr>
<tr>
<td>100 passes</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Depth, cm</td>
<td>4.4</td>
<td>7.9</td>
<td>6.8</td>
</tr>
<tr>
<td>1000 passes</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Both soil and vegetation responses may change with season (Foster 1977). Use in the spring tended to increase soil bulk density, penetration resistance, infiltration rates and cracking of soils trampled when they were moist; these effects grew smaller as the season progressed and soils dried. Trampling in the spring had smaller immediate effects on vegetation than at later dates and plants trampled in the spring recovered more completely than those trampled later in the season. Landals and Scotter (1974) and Hartley (1976) also observed a tendency of herbaceous vegetation trampled in the spring to recover as the season progressed.

Little-used trails are more sharply defined when they pass through forests than when they cross meadows because portions in meadows are so quickly overgrown by grasses. For example, on experimental plots bare ground at the trail's center was reduced by plants appearing there; in a grassland, bareground was scarce after two years and essentially absent after five years, while in a forest recovery was only 50% on a foot path and 26% on a horse trail (Table 6 and Weaver and Dale 1978). After six years, cover in dry alpine meadows trampled 200 times was 64% recovered (Hartley 1976); Bell and Bliss (1963) reported slow recovery in a

Table 6. The recovery of a grassland (Festuca-Poa) and a forest (Pinus-Vaccinium) from one thousand tramplings applied five years earlier (1973-1978)

| Bareground (%) | Grassland level | | | Grassland 25% slope | | | | |
|---|---|---|---|---|---|---|---|
| | Hiker | Cycle | Horse | Hiker | Cycle | Horse | |
| Before | 0 | 0 | 0 | 0 | 0 | 0 | |
| After | 47+8 | 50+10 | 72+7 | 67+10 | 99+0 | 99+0 | |
| 5 yr | 0 | 0 | 0 | 0 | 0 | 0 | |
| Width (cm) | | | | | | | |
| Before | 0 | 27+4 | 0 | 0 | 44+7 | 68+12 | 83+3 | |
| After | 0 | 34+5 | 0 | 0 | 0 | 0 | 0 | |
| 5 yr | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| Depth (cm) | | | | | | | |
| Before | 2.0+0.3 | 2.0+0.3 | 2.0+0.3 | 2.2+0.3 | 2.2+0.3 | 2.2+0.3 | |
| After | 4.2+0.2 | 4.9+0.4 | 6.8+0.7 | 6.2+0.8 | 7.0+0.8 | 8.6+0.8 | |
| 5 yr | 2.1+0.4 | 2.3+0.4 | -- | 4.0+0.7 | 5.4+0.7 | 8.5+0.4 | |
| B Density (gm/cc) | | | | | | | |
| Before | 1.0+0.0 | 1.0+0.0 | 1.0+0.0 | 1.1+0.0 | 1.1+0.0 | 1.0+0.0 | |
| After | 1.2+0.0 | 1.3+0.0 | 1.3+0.0 | 1.3+0.0 | 1.4+0.1 | 1.5+0.0 | |
| 5 yr | 1.0+0.0 | 1.1+0.0 | -- | 1.1+0.0 | 1.3+0.1 | 1.3+0.1 | |

| Bareground (%) | Forest level | | | Forest 25% slope | | | | |
|---|---|---|---|---|---|---|---|
| | Hiker | Cycle | Horse | Hiker | Cycle | Horse | |
| Before | 19+4 | 19+4 | 19+4 | 29+4 | 29+4 | 29+4 | |
| After | 98+1 | 98+2 | 99+0 | 98+2 | 99+0 | 99+0 | |
| 5 yr | 58+5 | 67+4 | 77+3 | 59+3 | 89+6 | 96+2 | |
| Width (cm) | | | | | | | |
| Before | 0 | 33+1 | 0 | 0 | 0 | 0 | 0 | |
| After | 0 | 62+2 | 0 | 0 | 43+1 | 62+3 | 124+6 | |
| 5 yr | 30+2 | 41+3 | 47+3 | 28+1 | 45+4 | 89+3 | |
| Depth (cm) | | | | | | | |
| Before | 1.2+0.2 | 1.2+0.2 | 1.2+0.2 | 2.0+0.3 | 2.0+0.3 | 2.0+0.3 | |
| After | 2.3+0.3 | 3.6+0.7 | 6.4+1.0 | 2.5+0.3 | 5.6+0.7 | 13.9+1.7 | |
| 5 yr | 2.5+0.3 | 3.1+0.4 | 4.1+0.4 | 1.8+0.5 | 4.9+0.6 | 6.6+0.7 | |
| B Density (gm/cc) | | | | | | | |
| Before | 0.9+0.1 | 0.9+0.1 | 0.9+0.1 | 0.8+0.0 | 0.8+0.0 | 0.8+0.0 | |
| After | 1.1+0.0 | 1.0+0.0 | 1.2+0.0 | 1.3+0.0 | 1.3+0.0 | 1.6+0.0 | |
| 5 yr | 0.9+0.0 | 1.1+0.0 | 1.1+0.0 | 0.9+0.0 | 1.3+0.0 | 1.3+0.0 | |
stonestripe community and more rapid recovery in a snowbank community. Species composition in forest and grassland plots was essentially normal after five years but compositional changes in Hartley's (1976) alpine meadows were still clearly evident after six years. Trail width decreases as plants invade from the trail's edge; grassland trails were indistinguishable after five years while forest trails were still 70% of their maximal width. Trail depth may decrease as burrowing, trampling and erosion refill a trail or as frost heaving and burrowing relieve compaction; recovery after five years on our sites ranged from 0 to 100% with no consistent difference between vegetation types, slopes, or tramplers. Compaction is still evident after five years at both sites; foot trails on both sites are 80-100% recovered, cycle trails are 0-60% recovered, and horse trails are 30-50% recovered.

RECOMMENDATIONS

In trail management the following points might be considered:
1) Intensive use areas, such as trails and campgrounds, should be permanently designated and, to the extent possible, use should be concentrated on them; vegetation is destroyed too easily and recovers too slowly to permit rotation of use.
2) The visitor who stays on trails sees essentially undisturbed vegetation if he looks beyond the trail's edge. Occasional forays into level dry grasslands do relatively little damage; damage increases with increasing slope, tall shrub or forb vegetation, and soil water content.
3) The impacts of both horses and motorcycles are significantly greater than those of hikers with respect to physical damage (destruction of vegetation, erosion and compaction), trail-side grazing, manure, air pollution, and noise. If an area is to receive multiple use, it seems especially important to keep horse and cycle traffic moving on trails with gentle slopes (less than 15°) and at low speeds (less than 20 km/hr = 12 MPH). If one area is to be used by hikers, motorcycles, and horses, transportation carrying capacity should be allocated according to the reciprocal of damage done by each mode of transport.
4) Since hikers and horses tend to be most destructive when moving downslope, traffic should be directed, where feasible, so steep slopes are ascended and gentle slopes are descended. For motorcycles the opposite is true.

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VEGETATION DISTURBANCE BY NATURAL FACTORS AND VISITOR IMPACT IN THE ALPINE ZONE OF MOUNT RAINIER NATIONAL PARK: IMPLICATIONS FOR MANAGEMENT

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ABSTRACT--The heather meadow and fellfield communities of Mount Rainier are unique because they represent an isolated and specialized plant habitat at much higher elevation than the nearby Cascade Range. Most of the individual areas of vegetation are 50 m or less across, and resemble patches or ribbons rather than typical meadows. Trampling and camping have initiated and accelerated natural erosion processes. Once heather community canopies have been disturbed, an irreversible phase of erosion can remove the soil of the entire site, which may be 6,000 to 10,000 years old. Campsite construction in fellfields removes stones which serve as favorable microhabitat for fellfield plants. A 1978 management plan recognizes the vulnerability of these communities. Restricting campsites to adjacent snowfield areas preserves the vegetated areas while allowing visitation to continue.

INTRODUCTION

Before we can hope to preserve ecosystems from human perturbations, let alone restore damaged ones, we must understand how they work: the environmental constraints, and plant-community dynamics and physiology of the plants themselves. We should also be able to distinguish between natural and man-induced disturbances. This does not imply that management decisions can be postponed until all experimental results are in, because that never happens, but does imply that rational management must recognize the available facts.

Contrary to popular belief alpine plants are relatively durable. They must be able to cope with the rigorous alpine environment. However, the community is fragile in the sense that it cannot tolerate many kinds of human impact, and there are few species available to replace any that succumb to impact. There are no invaders, no weeds and all native species have become specialists.

The heather meadow and fellfield communities in the alpine zone of Mount Rainier provide an example of how management decisions may be based on ecological input. The individual areas of vegetation are usually 50 m or less across and resemble patches or ribbons rather than typical meadows. But it is their very limited extent and high elevation that make them especially interesting and ecologically valuable.

Study Area

Mount Rainier National Park is in southwest Washington State. The study area is
HEATHER MEADOWS

Three species dominate in the heather meadows within the study area; Cassiope mertensiana, Phyllodoce empetriformis and P. glanduliflora. Each species has its own ecological requirements and limitations and dominance interrelationships change along the elevation gradient; nevertheless they form a distinct and easily recognizable community. From observations and measurements of floristic composition, seedling establishment and soil characteristics, evidence was found for a cyclic pattern of succession.

Alpine heather meadows only persist where there is a continuous and reliable winter snowcover followed by a continuous supply of moisture during summer (Edwards 1978). Thus, their habitat is strictly delimited. Seedlings are never found in old established meadows but only in appropriate stony areas. From this initiation, a mature meadow develops by the washing and blowing in of fine textured stone-free soil which stimulates vegetative growth until individual plants can no longer be identified. The developmental stage reached in a recently deglaciated area suggests that this stage may take at least 100 years. The process of accretion may continue until the fine soil profile is a meter deep.

Evidence for this manner of buildup comes from various sources: the presence of heather pollen throughout the soil profile, similar levels of organic matter throughout the profile, and the presence of marker volcanic ash layers and radiocarbon dating of old stem remains from the base of one profile (Edwards, 1978).

Observations show that the plant canopy of an established meadow may be broken open by various natural events as well as by visitor trampling. During one winter season (1975-1976) for instance, over-grazing by heather voles (Phenacomys intermedius, Merriam) reduced the canopy in some localized areas from 98% cover to less than 50%. An exceptional snow-free winter (1976-1977) caused desiccation and death of shoots and extensive canopy loss, especially of Cassiope. But these natural catastrophes presumably are of infrequent occurrence and affect limited areas compared to the frequency, extent and severity of pedestrian traffic which in a single spring season (1978) can drastically reduce the plant cover and expose eroding bare soil.

Figure 1. Phyllodoce empetriformis biomass at different elevations on Mount Rainier
Once the canopy has been opened, the heathers are unable to close the gaps by vegetative growth or by seedling establishment. Instead, several physical processes set in and initiate an irreversible phase of erosion. Needle ice raises the bare soil which quickly dries out and is blown away, exposing the shallow heather roots. Some herbaceous species invading from the nearby fellfields temporarily colonize the bare patches but eventually are unable to prevent the erosion phase which continues until the entire profile is lost back to the stony pavement base.

Implications for Management

The meadows are most vulnerable to trampling damage in early spring during the snowmelt period before the established trails are fully cleared. The soil is water-saturated and new season shoots are unhardened. Because of the absence of stones in the soil, the erosion that follows is rapid and uncontrollable. There is no evidence of repair or recovery once the protective canopy is broken open. The meadows have taken a long time to develop to their present state. At 2,000 m elevation using C horizon Mazama ash as a marker one meadow is estimated to be at least 10,000 years old. In another meadow at 2,400 m elevation radiocarbon dating has given an age of 6,730 ± 250 years. If these ancient meadows are to be preserved visitor traffic must be kept to levels that will not initiate irremediable erosion. Once the degradation part of the cycle begins it will take many generations before they will return to their present condition.

FELLFIELDS

The Mount Rainier fellfields constitute a plant community restricted both in elevation and geographic distribution. Of the forty-two vascular plant species which grow in the fellfields, twenty do not occur below 2,000 m elevation. Thirty have geographic ranges limited to the western United States and nine are restricted to the Pacific Northwest. Four are on the proposed Washington State list of rare, threatened and endangered species.

Physical Environment

The fellfields occur along gentle convex slopes and ridge tops (12 ± 6% slope) along the entire elevation gradient between 2,100 m and 2,700 m elevation. Their low-statured perennial vegetation is typically clumped around stones. With an average canopy cover of 20+-2% they closely correspond to the North Cascades fellfield community types described by Douglas and Bliss (1977). Most of the fellfield study sites have been observed to be snow-free during periods between winter storms so that bedrock and surface stones are subjected to prolonged frost splitting.

Because of their topographic position, the fellfields are typically windswept and accumulate less snow during winter months than other nearby community types; consequently, they are bared earlier during the spring thaw. Morainal and lava flow debris and pyroclastic deposits originating from a number of recent volcanic eruptions have been reworked to form a heterogeneous stony surface interspersed with areas of silt to gravel-sized fines. In some areas these form patterned ground features, sorted as the result of long-term frost activity. These may be described as a gradational series from sorted nets in horizontal areas to debris islands and sorted steps on slopes. (Washburn 1956).

The areas consisting of stone-free fines in unperturbed sites may be overlain by a stabilizing layer of gravel which protects the underlying finer fractions from wind or snowmelt erosion. In heavily trampled sites or where the gravel component is lacking these areas are subjected to diurnal frost activity. Such activity includes both extensive needle ice formation and shallow homogeneous soil freezing, but there is no evidence of permafrost. These phenomena are absent in the stony portions of the pattern.

The microtopographical differences produced by the frost action result in a vegetational pattern associated with the positioning of stones. These observations confirm the report by Bryant and Scheinberg (1969) that stones alter surface wind patterns and velocities which in turn affect local snow distribution. The soil next to stones is both insulated and protected from aeolian erosion while the sandy stone-free areas are blown clear and consequently subjected to repeated diurnal freeze-thaw cycles.

The fellfield soils typically have a loamy sand texture and are well drained. They show no profile development except for the presence of unincorporated organic debris beneath clumps of vegetation.
Midsummer drought-period temperatures were recorded in vegetation next to 20-100 cm diameter stones and in stone-free sandy frost-prone areas. Analysis of variance indicates significantly different temperature regimes at these locations (P <.001) and also close similarity between a natural frost-induced barren sandy area and one created by visitor campsite construction (Figure 2). Douglas and Bliss (1977) found similar temperature trends in alpine fellfields of the North Cascades and concluded that decrease in temperature resulted from insulation afforded by increased plant cover.

Gravimetric soil moisture determinations made during the same summer drought period indicate that the upper 5 cm soil layer is significantly (P <.01) drier than at the 5-20 cm depth. Moisture content under vegetation (Penstemon davidsoni Greene) adjacent to stones at 5-10 cm depth is significantly higher (P <.01) than in comparable stone-free, unvegetated frost-prone areas.

**Fellfield Vegetation**

The fellfields appear to sustain long-lasting and self-perpetuating communities in spite of the environmental severity restricting the number of species that can establish themselves. Seedlings and young plants, while not abundant, appear to maintain a regular replacement of the community in unperturbed sites.

Only five species can establish successfully into stone-free sandy or frost-prone areas. The remaining thirty-seven species are restricted to microhabitats adjacent to stones of more than twenty cm diameter.

Reasons for the observed plant-stone association may include any of the following phenomena all of which may be found in the study area:

1) Snowmelt runoff washing away fine-textured soil from seedling roots.
2) Modification of the soil physical environment whereby soil temperature and moisture levels influence seedling survival.
3) Creation of microtopographic patterns by stone arrangements, altering wind speed (Warren Wilson, 1959) and thereby affecting evaporation rates and available radiant heat from stone surfaces. Stone-sheltered plants leaf out and flower earlier than others of the same species growing just a few centimeters away from stone protection.
4) Trampling on areas reticulated by social trails, resulting in total confinement of all vegetation to stone-protected microhabitats.

The long snow-free period of the fellfields makes them vulnerable to visitor traffic for a great part of the year. User groups include hikers, climbers, cross-country skiers, snowshoers and campers. Two main types of usage impact can be recognized: trampling and camping.

Detrimental effects of trampling involve mostly breakage to vegetation and disruption of the natural frost patterned ground features.

Campsite construction is much more destructive of the fellfield habitat than trampling. Historical evidence suggests that camping in this area is a modern phenomenon which has arisen along with recent development in lightweight equipment and increase in visitor numbers to the Alpine zone. The campers typically set up two-man tents and their visit is usually for only one night. Each year new campsites are made as illustrated by Figures 3 and 4. The site is leveled, vegetation scraped off and as many as 300 stones moved. Because the fellfields are windswept and offer no shelter, the stones are typically piled into a surrounding wall (Figure 3). The more elaborate of these contain stones brought from the surrounding...
Potential sites for seedling establishment, as well as present plant habitats, are destroyed by the stone moving. The rate of plant establishment is unknown but periodic monitoring of new campsites constructed during the past four years fails to show any evidence of either recovery of damaged vegetation or of seedling establishment. Soil temperature measurements (Figure 2) indicate that instead, an environment closely resembling a naturally barren and frost-prone area has been created. The evidence suggests it will remain as a permanently barren feature.

**Figure 3.** A typical fellfield campsite at 2,200 m showing an enclosing wall built with stones carried from the surrounding area.

**Implications for Management**

There has been a continuing, perhaps even accelerating degradation of the fellfield areas accompanied by what appears to be a permanent loss both of existing vegetation and of potential microsites for future establishment. As pointed out earlier, the vegetation consists of restricted high alpine specialist species, including Polemonium elegans Greene, which is endemic to British Columbia and Washington State, grows only above 2,000 m elevation, is on the proposed Washington State list of rare, threatened and endangered species, and co-dominates in the highest patch of extensive vegetation in the study area (100x50 m) at 2,600 m elevation. Figure 4 shows one of six tent platforms leveled from the fellfield during July 1978, destroying 20 square meters of habitat.

**Figure 4.** One of six tent platforms leveled from a 2,600 m fellfield (the highest elevation in the entire study area) where Polemonium elegans, endemic to British Columbia and Washington State and on the proposed Washington State list of rare, threatened and endangered species is a co-dominant species. Flowering P. elegans is at the bottom right.

Mount Rainier can be regarded as an alpine island; it provides an isolated and specialized plant habitat at much higher elevations than the nearby Cascade Range. Growth rates are considerably less than those measured at lower elevations (Figure 1) so presumably any natural or assisted attempts at recovery or restoration will be similarly slow.

These special attributes of Mount Rainier, combined with its easy accessibility from metropolitan Puget Sound, and the National Park Service mandate to preserve natural ecosystems, suggest that the Alpine zone of Mount Rainier be given some appropriate measure of protection. There is no ecological evidence for recovery following visitor perturbation.

**CONCLUSION**

As a result of the investigations outlined above, it has proven possible to develop a rational plan for visitor use of this alpine region. A management plan adopted in 1978 recognizes the susceptibility of the heather meadows and of the fellfields to specific types of damage as described. Limitation of campsites to adjacent snowfield areas denies no visitor the
opportunity to experience the alpine environment and yet preserves the vegetation of the area from damage.

REFERENCES CITED


DISCUSSION

Comment: Would you suggest graveling?

Edwards: Yes, either stone paving or graveling, but the gravel must be deep enough to stabilize the surface and prevent the runoff that is so destructive after summer rainstorms.

Comment: Do you remain pessimistic about those tent platforms?

Edwards: There has been no re-vegetation in any of these tent platforms, I think they will remain permanently barren unless the stones are put back in place.
research findings
ABSTRACT--Potential problems are associated with increases in dispersed outdoor recreation. The lack of facilities at remote locations appeals to many users, but the potential exists for unfavorable impacts on the ecology and on users' health and enjoyment of the area. This paper summarizes part of a two-year social and biological study and describes the effects on water quality of use of two camping areas (established by users) for weekdays and weekends (including 2 holiday weekends) from May 1975 through July 7th, 1976.

INTRODUCTION

Millions of acres of wildland are accessible to recreationists by the National Forest road system. The roads, developed primarily for timber sale activity, allow access to remote locations. Often found at these locations are recreationists engaged in camping, berrypicking, cycling, fishing, horseback riding, target shooting, hiking, mushroom gathering, wood collecting, rock-hounding, and other assorted activities. Dispersed recreation, such as day activities and camping at informal, undeveloped sites, accounts for more use and is growing faster in the National Forests than concentrated recreation at developed sites (Hendee et al. 1976, Lloyd and Fisher 1972, U.S. Department of Agriculture 1975).

Resource managers, planners, and researchers are becoming increasingly concerned with environmental impacts produced by recreationists in dispersed recreation areas (Moutsinas 1976, Downing and Moutsinas 1978, Burt and Gentry 1974, Barton 1969, Douglas 1969, Bay and Krammes 1975, Alford and Binkley 1977). One problem of specific concern to managers and users is the impact of human waste disposal (meaning the excrement and urine of people) on water quality. Lack of sanitary facilities in dispersed recreation areas may be part of the appeal to the user but may contribute to conditions having the potential for producing impacts that could affect users' health and esthetic experience. These
concerns are also discussed in the paper in these proceedings by Downing and Clark.

From past studies, it is difficult to ascertain the impact that people have on water quality; that is, not all water pollution in wild lands is caused by humans. Research on water quality has shown the presence of pathogenic microorganisms in areas undisturbed by man. Fair and Morrison (1967) found Salmonella from wild or domestic animals in Colorado stream water. Stuart et al. (1971) studied a municipal watershed in Montana, closed to the public since 1917, which contained four to six times the coliform count found in a nearby mountain watershed open to public use. Bissonnette et al. (1970) traced microbial pollution to wild animals in both a closed and an open watershed in Montana. Other watershed studies have demonstrated the presence of bacterial indicators of pollution even though the argas were undisturbed by human use (Goodrich et al. 1970, Walter and Bottman 1967, Doty and Hookano 1974).

Some studies undertaken in areas with human use show no substantial increase in water pollution (Aukerman and Springer 1976, Carswell et al. 1969, Rosebery 1964, U.S. Department of Health, Education, and Welfare 1969, Surgenor 1977). Lee et al. (1970) studied the effect of three levels of human use on water quality in the Pacific Northwest. They found that 3 man-days (1 man-day is equivalent to 24 hours) per river mile on the Cedar watershed, 10 on the Green watershed, and 45 on the Clackamas watershed were insufficient to influence water quality. Other studies have also demonstrated little or no influence on water quality from human use (Skinner 1974). McFeters (1975) concluded people were not responsible for any large-scale contamination of water in Grand Teton National Park.

In contrast, other studies have suggested that pollution increases when people use an area: (Varness 1976, Barbaro et al. 1969, Wagenet and Lawrence 1974, King and Mace 1974, Ching and Frick 1974, Murphy 1973). A cursory review of the literature has led to the conclusion that human use in a watershed may or may not be directly related to water quality. Most researchers have not closely studied the relationship between people and water quality; specifically the effects of self-contained parties (meaning people using recreational vehicles with built-in toilet facilities), number of people, style of camping, and so forth, on water quality. Furthermore, most studies have not included intensive water sampling during periods of human use.

This paper is part of a 2-year study summarizing the effects of dispersed recreation on water quality for weekdays and weekends (including 2 holiday weekends) for the period of May 1975 through July 7, 1976. (Unpublished data are being prepared for publication and are on file at Pacific Northwest Forest and Range Experiment Station, Seattle, WA.)

STUDY OBJECTIVE

The overall objective of this study was to determine the effect of recreational use on water quality. Specifically, what effect did the number of people, style of camping, self-contained parties, human waste disposal and rain have on water quality? Research questions were:

1. What are the densities of total coliforms, fecal coliforms, and fecal streptococci upstream and downstream from campsites before, during, and after recreational use?

2. What are the nature and extent of recreation use and human waste disposal? For instance, what is the amount of human use? Where did users camp? When did they camp? What is the style of camping--how many tents, trailers, pickup campers, motorhomes, and so forth? What proportion of users are self-contained and have recreational vehicles with toilet facilities? How many toilet tissues are observable? How far from the water is there evidence of human waste disposal? Are pit toilets present? What kind of weather occurred during the sampling periods?

Major features of this study were intensive sampling of water upstream and downstream before, during, and after use by recreationists, and intensive measurement of human behavior during periods of use. (For the original publication of the study, see Varness et al. 1978.)

STUDY AREA

The study area was the Greenwater watershed, located about 96 km (60 miles) southeast of Seattle, Washington, on the White River Ranger District, Mt. Baker-Snoqualmie National Forest (Figure 1). The
watershed runs in an east-west direction, and elevations range from 580 to 1830 m (1,900 to 6,000 feet). Ownership is "checkerboard": even-numbered sections belong to the USDA Forest Service and odd-numbered sections belong to a commercial timber company. For a detailed description of the study area, see Williams et al. (1975).

A total of 72 campsites established by users are located on the river bottom road (Hendee et al. 1976a, 1976b). Two areas were selected for study—the Loop and the Pyramid Creek road units.

Six campsites are located at Pyramid Creek and 16 campsites at the Loop. Criteria for selection were that campsites be close to the water with high frequency and heavy concentration of human use and have no formal, sanitary facilities.

The Greenwater River flows mostly northwest for 34 km (21 miles), joining the White River at the town of Greenwater. Principal tributaries include Pyramid, Whistler, Burns, Slide, Twentyeight Mile, and Midnight Creeks. The Greenwater River originates in a high mountain valley with four lakes, then flows through coniferous forest in a relatively narrow, steep-sloped valley for 16 km (10 miles) to Pyramid Creek. The width of the channel ranges from 2 to 5 yards and through this stretch numerous cascades and small falls are found. The stream bottom is predominately bedrock and boulder. Streamside cover is dense. The valley floor is narrow and the soil is moist. Intensive camping occurs at Pyramid Creek.

Below the campsites, Pyramid Creek joins the Greenwater River. For the next 2 to 3 miles to Burns Creek, the gradient remains steep, and the width ranges from 3.6 to 7.2 km (4 to 8 yards); banks are sharp and rock cut, covered by dense overgrowth. After Greenwater River joins Burns Creek, the valley floor widens and narrows for about 6.4 km (4 miles), and side slopes remain steep and densely forested. Intensive camping occurs at the Loop below the junction with Twentyeight Mile Creek where the valley floor is wide and the soil is dry. The gradient then decreases, and the channel becomes more winding toward the town of Greenwater. Stream banks consist of natural earth or rock cuts or rubble-gravel side beaches. Side cover is sparse to dense. Cover where clearcutting has not taken place consists of coniferous forest with some mixed deciduous trees and shrubs.

Figure 1. Location of the Greenwater watershed, Mt. Baker-Snoqualmie National Forest: campsites were established by the users.

Peak flows generally occur between December and June. Lowest flows normally occur from mid-July through November. The flow rates taken at Greenwater during the study period ranged from a low of 1.3 kl (48 cubic feet) per second to a high of 85 kl (3000 cubic feet) per second (U.S. Geological Survey 1975, 1976). Rainfall averages about 1.9 m (75 inches) per year. Snow depths vary from 6 dm (2 feet) in the lower elevations to 46 dm (15 feet) in the upper elevations.

Approximately 400 deer, 200 elk, and a variety of small game species are present in the study area.

METHODOLOGY

Information was collected on water quality, weather, and human use. The procedures are described below.

Water Quality

The sampling design was based on a purposeful systematic sample of observed human use periods in an attempt to determine if human use changed the quality of water (Hendee et al. 1976a) Upstream and downstream from the Loop and Pyramid camping areas 210 water samples were collected for
bacteriological examination from May to September 1975 and from May to July 7th, 1976. Samples were taken biweekly during 1975 except for the Labor Day weekend when they were taken daily. In 1976, samples were collected biweekly during May, and multiple samples were collected during the Fourth of July weekend.

Water collected at each site was immediately placed on ice and transported to the laboratory within 6 hours to insure that when the microbes were examined in the laboratory they would be representative of those in the stream. Total coliforms, fecal coliforms, and fecal streptococci were measured by the membrane filter technique as described in Standard Methods for the Examination of Water and Wastewater (Greenberg et al. 1976). Total coliforms are aerobic or facultatively anaerobic gram-negative, nonspore-forming, rod-shaped bacteria that ferment lactose with the production of gas within 48 hours at 35°C. These organisms serve as primary indicators of the bacteriological quality of potable water and public water supplies.

Fecal coliforms are gram-negative, nonspore-forming rods that ferment lactose in 24 hours at 44.5°C. These organisms are part of the total coliform group and are used as indicators of fecal pollution.

Fecal streptococci are found in the feces of human and other warm-blooded animals. These organisms are in serological groups D and Q.

Samples were plated in triplicate for each indicator organism. The sample size of each replicate varied from 100 to 250 ml depending on the turbidity of the water. The results are reported as the number of organisms per 100 ml and were calculated by averaging colony counts on 3 replicate membranes.

Weather Characteristics

Weather information was collected during the Labor Day weekend 1975 and the Fourth of July weekend 1976 during the periods of water sampling. Categories were clear, broken clouds, overcast, drizzle, and rain.

Human Use

Informal, conversational contacts were made with users from all parties at the campsites. Data on human behavior were collected from July 3, through September 3, 1975, and from July 2 through July 7, 1976. A total of 33 parties were contacted during the Labor Day weekend 1975 and Fourth of July weekend 1976. For the entire 1975 study period, 111 parties were contacted.

Number of Users. Conversations with users helped us to obtain information on the total number of people in a party at a campsite. A party was defined as one or more people camping together overnight at a site or visiting the area for the day.

Style of Camping and Recreational Vehicles with Toilets. Observation was systematically used to determine number of vans, tents, and pickup campers, motorhomes, and trailers with toilets (self-contained) and those without. A recreational vehicle (RV) was determined to be self-contained if it had a hose-connecting valve on the rear side or under the rear trunk of the vehicle.

Presence of Domestic Animals. Information was gathered to determine the presence of horses, dogs, and cats that users brought with them. The type and number of animals were recorded.

Human Waste Disposal. Observation was used before and after recreational use to trace the presence of human waste tracks within a 91 m (300-foot) radius of the fire ring. Toilet tissues were used as indicators of human waste tracks. The types of information collected were: (1) number of toilet tissues, (2) presence of pit toilets, and (3) distance of toilet tissues from the water source.

DATA ANALYSIS

Geometric means were calculated from bacterial analyses conducted during the summer of 1975. Geometric means are the nth root of the product of the n values in a series. Geometric means were used to reduce variations in counts due mainly to differences in flow rates, and to enable us to compare our data with data from similar studies (Stuart et al. 1971, McFeters 1975). During Labor Day weekend 1975 and Fourth of July weekend 1976, simple values of indicator densities were used to compare bacterial counts on different days or at different hours (Barbaro et al. 1969, McFeters 1975,
RESULTS AND DISCUSSION

What is the Effect of Recreational Use on Water Quality?

The potential for impacts on water quality from recreational use does exist. The quality of the surface waters in the watershed varied substantially. Total coliform densities ranged from <1 to 105 per 100 milliliters of surface water. Fecal coliforms ranged from <1 to 91 per 100 milliliters, and fecal streptococci ranged from <1 to 52 per 100 milliliters. The bacteriological standards established by the State of Washington, Department of Ecology (WAC 173-201-030) for Class AA water state that total coliform organisms shall not exceed median values of 50 per 100 milliliters with less than 10% of samples exceeding 230 per 100 milliliters when associated with any fecal source (Washington Department of Ecology 1978). Based on these criteria, the Greenwater River would be classified as AA—acceptable for general recreation and esthetic enjoyment. Water used for drinking, however, should contain less than 2 total coliforms per 100 milliliters.

Table 1 summarizes total human use and geometric means of indicator densities on weekends and weekdays at the Loop and Pyramid Creek campsites during 1975. Over 90% of the human use occurred on weekends. Weekend use may be overnight camping whereby users arrive Friday night or Saturday morning and leave Sunday afternoon or evening. Weekend use also includes day use on Saturday or Sunday where users visit the area for mushroom gathering, berry picking, or other activities.

Geometric means were calculated from bacterial analyses conducted in 1975 for both weekend and weekday determinations of total coliforms, fecal coliforms, and fecal streptococci. At Pyramid Creek, indicator densities were consistently higher on weekends than on weekdays. The geometric mean densities immediately upstream and downstream from human use were uniformly low on weekdays. On weekends, the upstream densities remained low but downstream densities increased. This correlated directly with greater recreational use at Pyramid Creek during the weekends. The most dramatic increase was detected on August 16 when fecal coliforms increased from 2 per 100 ml upstream to 91 per 100 ml downstream from Pyramid Creek. Peak human use at Pyramid during summer 1975 was 47 people on August 16. No one was using recreational vehicles with toilet facilities.

At the Loop, water quality during periods of recreational use did not deteriorate as dramatically as at Pyramid Creek. The main impact was a slight increase in total coliforms on the weekend at the downstream site. Fecal coliform and fecal streptococcus levels on the weekend were essentially the same as on weekdays. The fecal coliform and fecal streptococcus levels immediately upstream and downstream from the Loop also were essentially equivalent. To better understand the relationship between recreational use and water quality, we sampled the water and observed human behavior more frequently during two holiday weekends.

What was the Quality of Water at the Loop and Pyramid Creek during Two Holiday Weekends?

Table 2 summarizes the indicator densities upstream and downstream from recreational use during the Labor Day weekend 1975 and the Fourth of July weekend 1976. At the Loop campsite during Labor Day, total coliforms increased during the weekend at the downstream sample site; however, fecal coliforms and fecal streptococcus densities of upstream and downstream samples were similar. At Pyramid Creek the same weekend, indicator densities downstream from human use increased dramatically during the period of human use. Densities remained low upstream from the camping area. The downstream indicator densities peaked during the weekend and subsequently declined to preweekend values.

To characterize water quality before the Fourth of July weekend 1976, we collected and analyzed 35 water samples for densities of bacteria during May 1976. These samples indicated that bacterial densities were low at all sites for the entire month. This included samples collected over the Memorial Day weekend. Total coliform and fecal streptococcus densities did not exceed 6 per 100 ml, and fecal coliforms did not exceed 3 per 100 ml.

Indicator densities were measured for a 7-day period that included the Fourth of July 1976. At the Loop, total and fecal coliform
densities for the upstream and downstream samples approximated each other in most instances (Table 2). The highest densities of bacteria appeared in the morning and evening hours and the lowest in the afternoons.

During the afternoon periods, however, the majority of users were riding bikes away from the campsites, possibly accounting for the low densities.

At Pyramid Creek during the Fourth of July weekend, data suggest three synchronous increases in total and fecal coliforms downstream and one increase upstream, all occurring in afternoon samples. In contrast to the Loop, low densities appeared to be in morning hours, increasing in the afternoons and decreasing in the evenings. The increase upstream on Monday occurred from a sampling point which was downstream from a fisherman.

The Greenwater watershed was sampled during high-use weekends for enteric bacterial pathogens. As a result of these studies, Salmonella arizonae was isolated from the watershed during both the Labor Day weekend 1975 and the Fourth of July weekend 1976.

Table 1. Total human use and geometric means of indicator densities on weekends and weekdays, upstream and downstream from user-established campsites at Loop and Pyramid Creek, 1975

<table>
<thead>
<tr>
<th>Sampling sites and use</th>
<th>Total use by people</th>
<th>Indicator densities</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N</td>
<td>Percent</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Loop:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Weekend</td>
<td>414</td>
<td>93.9</td>
</tr>
<tr>
<td>Weekday</td>
<td>27</td>
<td>6.1</td>
</tr>
<tr>
<td>Total</td>
<td>441</td>
<td>100.0</td>
</tr>
<tr>
<td>Pyramid Creek:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Weekend</td>
<td>277</td>
<td>95.8</td>
</tr>
<tr>
<td>Weekday</td>
<td>12</td>
<td>4.2</td>
</tr>
<tr>
<td>Total</td>
<td>289</td>
<td>100.0</td>
</tr>
</tbody>
</table>

What was the Nature and Extent of Recreational Use and Waste Disposal During Two Holiday Weekends?

Recreational Use. Table 3 summarizes characteristics of human use at the Loop and Pyramid Creek campsites during Labor Day weekend 1975 and the Fourth of July weekend 1976.

During the Labor Day weekend, the amount of human use at Pyramid Creek was similar to that at the Loop (Table 3). The maximum number of people observed at the Loop and Pyramid during the weekend were 52 and 40, respectively. Numbers of parties camping were similar in the two areas. More tents (80%) but fewer trailers (33%) were observed at Pyramid Creek than at the Loop campsites. Numbers of pickup campers were similar at
both areas.

Pyramid Creek did not have any recreational vehicles with toilets; this implies that human waste might be disposed in the surrounding area. In contrast, the Loop had some self-contained RV's. If we assume people use their toilets, we would expect to observe less waste at the Loop. Similar numbers of dogs were observed at both areas which implies dog excrement and potential pollution to the water source.

On the Fourth of July weekend 1976, characteristics of use were different. The Loop had 40% more human use than Pyramid Creek, but the Loop had more parties (92%), tents (72%), pickup campers (91%), and trailers (57%). The Loop also had more self-contained RV's, but Pyramid Creek had a

Table 2. Indicator densities upstream and downstream from user-established campsites during Labor Day weekend 1975 and Fourth of July weekend 1976

<table>
<thead>
<tr>
<th>Time and day of measurement</th>
<th>Loop</th>
<th>Pyramid Creek</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Total coliforms</td>
<td>Fecal coliforms</td>
</tr>
<tr>
<td>Labor Day weekend</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Thurs., Aug. 28</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>Sat., Aug. 30</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>Sun., Aug. 31</td>
<td>9</td>
<td>20</td>
</tr>
<tr>
<td>Mon., Sep. 1</td>
<td>4</td>
<td>12</td>
</tr>
<tr>
<td>Wed., Sep. 3</td>
<td>7</td>
<td>6</td>
</tr>
<tr>
<td>Fourth of July weekend</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Thurs., July 1, 4 a.m</td>
<td>8</td>
<td>12</td>
</tr>
<tr>
<td>12 p.m.</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>7 p.m.</td>
<td>8</td>
<td>20</td>
</tr>
<tr>
<td>Fri., July 2, 4 a.m</td>
<td>12</td>
<td>12</td>
</tr>
<tr>
<td>9 a.m.</td>
<td>10</td>
<td>4</td>
</tr>
<tr>
<td>2 p.m.</td>
<td>11</td>
<td>9</td>
</tr>
<tr>
<td>7 p.m.</td>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td>Sat., July 3, 4 a.m</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>9 a.m.</td>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td>2 p.m.</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>7 p.m.</td>
<td>5</td>
<td>3</td>
</tr>
<tr>
<td>Sun., July 4, 4 a.m</td>
<td>6</td>
<td>8</td>
</tr>
<tr>
<td>9 a.m.</td>
<td>6</td>
<td>10</td>
</tr>
<tr>
<td>2 p.m.</td>
<td>2</td>
<td>5</td>
</tr>
<tr>
<td>7 p.m.</td>
<td>9</td>
<td>13</td>
</tr>
<tr>
<td>Mon., July 5, 4 a.m</td>
<td>11</td>
<td>6</td>
</tr>
<tr>
<td>9 a.m.</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>2 p.m.</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>7 p.m.</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Tues., July 6, 4 a.m</td>
<td>13</td>
<td>21</td>
</tr>
<tr>
<td>12 p.m.</td>
<td>10</td>
<td>29</td>
</tr>
<tr>
<td>7 p.m.</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Wed., July 7, 4 a.m</td>
<td>14</td>
<td>19</td>
</tr>
<tr>
<td>12 p.m.</td>
<td>4</td>
<td>6</td>
</tr>
</tbody>
</table>

Bacteria/100 ml
higher proportion. It might be expected, therefore, that less human waste tracks would be observed at Pyramid since there were fewer campers and 4 of 10 RV's had toilets. Dogs were present at both areas but one-third more were at the Loop than at Pyramid Creek. One horse was observed.

**Human Waste Disposal.** During Labor Day weekend at the Loop, we expected to find fewer toilet tissues because more users camped with their own toilet facilities. Use at Pyramid Creek was not self-contained so more human waste tracks were expected. Table 3 suggests that our expectations were met. The Loop, indeed, had fewer tissues --14, suggesting less human waste disposal; Pyramid Creek had 22 tissues. The distance of waste from the water source varied. All waste at Pyramid Creek was 15.5 m (51 feet) or more from the water; at the Loop it was at least 8 m (25 feet) from the water. Only one user-built pit toilet was observed and that was at the Loop, located 15.5 - 23 m (51-75

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Loop</th>
<th></th>
<th>Pyramid Creek</th>
<th></th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Labor Day weekend 1975:</td>
<td>N</td>
<td>Percent</td>
<td>N</td>
<td>Percent</td>
<td>N</td>
</tr>
<tr>
<td>Total human use</td>
<td>52</td>
<td>56.5</td>
<td>40</td>
<td>43.5</td>
<td>92</td>
</tr>
<tr>
<td>Number of parties</td>
<td>9</td>
<td>56.2</td>
<td>7</td>
<td>43.8</td>
<td>16</td>
</tr>
<tr>
<td>Style of camping:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tent</td>
<td>1</td>
<td>20.0</td>
<td>4</td>
<td>80.0</td>
<td>5</td>
</tr>
<tr>
<td>Pickup camper</td>
<td>5</td>
<td>50.0</td>
<td>4</td>
<td>50.0</td>
<td>12</td>
</tr>
<tr>
<td>Trailer</td>
<td>8</td>
<td>66.7</td>
<td></td>
<td>33.3</td>
<td></td>
</tr>
<tr>
<td>Recreation vehicles with toilets (excludes tents):</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No</td>
<td>10</td>
<td>52.6</td>
<td>9</td>
<td>47.4</td>
<td>19</td>
</tr>
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<td>3</td>
<td>100.0</td>
<td>0</td>
<td>0.0</td>
<td>3</td>
</tr>
<tr>
<td>Total amount of toilet tissues and distance from water:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1-25 feet</td>
<td>0</td>
<td>0.0</td>
<td>0</td>
<td>0.0</td>
<td>0</td>
</tr>
<tr>
<td>26-50 feet</td>
<td>12</td>
<td>100.0</td>
<td>0</td>
<td>0.0</td>
<td>12</td>
</tr>
<tr>
<td>51-75 feet</td>
<td>21</td>
<td>100.0</td>
<td>0</td>
<td>0.0</td>
<td>21</td>
</tr>
<tr>
<td>76 feet or more</td>
<td>2</td>
<td>66.7</td>
<td>1</td>
<td>33.3</td>
<td>3</td>
</tr>
<tr>
<td>Pit toilets:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No</td>
<td>7</td>
<td>70.0</td>
<td>3</td>
<td>30.0</td>
<td>10</td>
</tr>
<tr>
<td>Yes</td>
<td>3</td>
<td>30.0</td>
<td>0</td>
<td>0.0</td>
<td>3</td>
</tr>
<tr>
<td>Domestic animals:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dog</td>
<td>5</td>
<td>50.0</td>
<td>5</td>
<td>50.0</td>
<td>10</td>
</tr>
<tr>
<td>Fourth of July weekend 1976:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total human use</td>
<td>120</td>
<td>69.8</td>
<td>52</td>
<td>30.2</td>
<td>172</td>
</tr>
<tr>
<td>Number of parties</td>
<td>14</td>
<td>82.4</td>
<td>3</td>
<td>17.6</td>
<td>17</td>
</tr>
<tr>
<td>Style of camping:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tent</td>
<td>13</td>
<td>72.2</td>
<td>5</td>
<td>27.8</td>
<td>18</td>
</tr>
<tr>
<td>Pickup camper</td>
<td>10</td>
<td>90.9</td>
<td>1</td>
<td>9.1</td>
<td>11</td>
</tr>
<tr>
<td>Van</td>
<td>12</td>
<td>57.1</td>
<td>9</td>
<td>42.9</td>
<td>21</td>
</tr>
<tr>
<td>Recreation vehicles with toilets (excludes tents and vans):</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No</td>
<td>17</td>
<td>73.9</td>
<td>6</td>
<td>26.1</td>
<td>23</td>
</tr>
<tr>
<td>Yes</td>
<td>5</td>
<td>55.6</td>
<td>4</td>
<td>44.4</td>
<td>9</td>
</tr>
<tr>
<td>Total amount of toilet tissues and distance from water:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1-25 feet</td>
<td>0</td>
<td>0.0</td>
<td>9</td>
<td>100.0</td>
<td>9</td>
</tr>
<tr>
<td>26-50 feet</td>
<td>0</td>
<td>0.0</td>
<td>10</td>
<td>100.0</td>
<td>10</td>
</tr>
<tr>
<td>51-75 feet</td>
<td>21</td>
<td>78.5</td>
<td>3</td>
<td>21.5</td>
<td>24</td>
</tr>
<tr>
<td>76 feet or more</td>
<td>35</td>
<td>100.0</td>
<td>0</td>
<td>0.0</td>
<td>35</td>
</tr>
<tr>
<td>Pit toilets:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No</td>
<td>8</td>
<td>72.7</td>
<td>3</td>
<td>27.3</td>
<td>11</td>
</tr>
<tr>
<td>Yes</td>
<td>1</td>
<td>100.0</td>
<td>0</td>
<td>0.0</td>
<td>1</td>
</tr>
<tr>
<td>Domestic animals:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dog</td>
<td>12</td>
<td>66.7</td>
<td>6</td>
<td>33.3</td>
<td>18</td>
</tr>
<tr>
<td>Horse</td>
<td>1</td>
<td>100.0</td>
<td>0</td>
<td>0.0</td>
<td>1</td>
</tr>
</tbody>
</table>
feet) from the water.

During the Fourth of July weekend the Loop had twice the amount of use as Pyramid Creek. And proportionately, the Loop had fewer vehicles with toilets. Consequently, we expected to find more waste at the Loop and less at Pyramid Creek. Results shown in Table 3 do not meet these expectations. More tissues (50) were found at Pyramid Creek; not fewer, as expected. At the Loop, 43 tissues were found. All observed tissues at Pyramid Creek were found close to the water. Tissues observed at the Loop were farther away from the water. No pit toilets had been built by users at Pyramid; one had been built at the Loop.

Most of the toilet tissues were located away from the campsites and trails. Fecal matter was generally not found with toilet tissues. The question is, what happens to it? It is possible that dogs, dung beetles, coyotes, or other wildlife remove fecal matter. We found that the majority of the users had dogs with them. It is not known, however, whether dogs are disturbing the excrement; if they are, potential health hazards to animals and humans could be significant.

Weather. Table 4 summarizes the weather during sampling periods. During the Labor Day weekend, it rained on Saturday, August 30; during the Fourth of July weekend it rained on July 3 at 4 a.m. and July 4 at 9 a.m. If runoff had an effect on concentrations of bacteria, we would expect indicator densities to increase during these periods.

Results of the study suggested that during periods of rain, July 3 and 4, indicator densities remained low at the Loop and Pyramid Creek. In contrast, during periods of rain on Saturday, August 30, indicator densities increased at Pyramid Creek but not at the Loop.

What Effects Do Number of People, Self-Contained RV's, Human Excrement, and Rain Have on Water Quality?

What, then, can be said from these results in terms of potential impacts of recreation use and human waste disposal on water quality? What are the effects of number of people, self-contained RV's, human waste disposal, and rain on water quality?

Differences between the Loop and Pyramid Creek in response to recreational use cannot be explained entirely by the number of people camping in a given location. Twice as many people camped at the Loop, but only a slight increase in total coliform density was noted and no evidence of increased fecal pollution was detected. At Pyramid Creek, however, increases occurred in both total coliforms and fecal coliforms, indicating fecal contamination of the surface waters.

The number of self-contained RV's does not clearly explain increases in fecal coliforms. At Pyramid Creek, fecal coliforms increased whether users were in self-contained RV's or not. Results were different at the Loop. Fecal coliforms remained similar regardless of the number of self-contained vehicles.

Results of this study suggest that human waste disposal does have an effect on water quality. More tissues were observed at Pyramid where increases in bacteria were found. Fewer tissues were found at the Loop where fecal indicator densities did not generally fluctuate.

Rain and surface runoff did not seem to have a major effect on the level of indicators in the stream. The increases in indicator densities did not correlate consistently with periods of rain. Furthermore, water samples taken at the Loop and Pyramid Creek during periods of rain on August 30, 1975, and on July 3-4, 1976, did not show appreciable differences in indicator densities.

CONCLUSIONS

Surface waters in the Greenwater River watershed were found to be AA--acceptable for general recreation and esthetic enjoyment. But evidence of fecal pollution and the isolation of Salmonella from the relatively clean water of the watershed suggests that potential health hazards exist. The deterioration of water quality that was detected occurred intermittently and in localized areas.

The study did suggest, however, a potential relationship between increased human use and increased densities of bacteria, particularly at Pyramid Creek. This was shown by indicator density increases during weekends when campsites were occupied by recreationists. When human activity decreased during weekdays, indicator
densities decreased.

Results also suggest that human waste has an effect on water quality. More tissues were observed at Pyramid Creek where densities of bacteria increased. The effects of number of people, self-contained RV's, and rain are inconclusive and require further study.

Site differences could also play a part in the effects of recreational activity on water quality. Increases in bacteria at the Loop were less dramatic than those at Pyramid Creek and were restricted to a slight increase in total coliforms. One obvious difference between the sites is the dilution effect of the surface waters. The Loop is farther down the watershed, and the adjacent river contains more water than the creek at Pyramid.

The rapid increase in bacterial indicators poses an interesting question of how the bacteria entered the surface water so quickly. Even though rain and surface runoff

Table 4. Weather characteristics during the Labor Day weekend 1975 and the Fourth of July weekend 1976

<table>
<thead>
<tr>
<th>Time of measurement</th>
<th>Weather characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Labor Day weekend 1975:</td>
<td></td>
</tr>
<tr>
<td>Thurs., Aug. 28</td>
<td>Overcast</td>
</tr>
<tr>
<td>Sat., Aug. 30</td>
<td>Rain</td>
</tr>
<tr>
<td>Sun., Aug. 31</td>
<td>Drizzle</td>
</tr>
<tr>
<td>Mon., Sep. 1</td>
<td>Broken clouds</td>
</tr>
<tr>
<td>Wed., Sep. 3</td>
<td>Clear</td>
</tr>
<tr>
<td>Fourth of July weekend 1976:</td>
<td></td>
</tr>
<tr>
<td>Thurs., July 1, 4 a.m.</td>
<td>Clear</td>
</tr>
<tr>
<td>12 p.m.</td>
<td>Clear</td>
</tr>
<tr>
<td>7 p.m.</td>
<td>Clear</td>
</tr>
<tr>
<td>Fri., July 2, 4 a.m.</td>
<td>Rain</td>
</tr>
<tr>
<td>9 a.m.</td>
<td>Overcast/drizzle</td>
</tr>
<tr>
<td>2 p.m.</td>
<td>Broken clouds/clear</td>
</tr>
<tr>
<td>7 p.m.</td>
<td>Broken clouds/clear</td>
</tr>
<tr>
<td>Sat., July 3, 4 a.m.</td>
<td>Overcast</td>
</tr>
<tr>
<td>9 a.m.</td>
<td>Rain</td>
</tr>
<tr>
<td>2 p.m.</td>
<td>Overcast/drizzle</td>
</tr>
<tr>
<td>7 p.m.</td>
<td>Overcast/drizzle</td>
</tr>
<tr>
<td>Sun., July 4, 4 a.m.</td>
<td>Clear</td>
</tr>
<tr>
<td>9 a.m.</td>
<td>Clear</td>
</tr>
<tr>
<td>2 p.m.</td>
<td>Clear</td>
</tr>
<tr>
<td>7 p.m.</td>
<td>Clear</td>
</tr>
<tr>
<td>Mon., July 5, 4 a.m.</td>
<td>Clear</td>
</tr>
<tr>
<td>9 a.m.</td>
<td>Clear</td>
</tr>
<tr>
<td>2 p.m.</td>
<td>Clear</td>
</tr>
<tr>
<td>7 p.m.</td>
<td>Clear</td>
</tr>
<tr>
<td>Tues., July 6, 4 a.m.</td>
<td>Clear</td>
</tr>
<tr>
<td>12 p.m.</td>
<td>Clear</td>
</tr>
<tr>
<td>7 p.m.</td>
<td>Clear</td>
</tr>
<tr>
<td>Wed., July 7, 4 a.m.</td>
<td>Clear</td>
</tr>
<tr>
<td>12 p.m.</td>
<td>Clear</td>
</tr>
</tbody>
</table>
was minimal, organisms entered the surface water rapidly. Bacteria may be surviving in sediments and stirred up by people playing in the water—although this did not happen on Saturday at 2 p.m. on the Fourth of July weekend in 1976 when two jeeps were observed in the river hauling logs from one bank to the opposite side. During this activity, indicator densities did not fluctuate. Direct deposits of human waste in the water are another possible reason for contamination. However, direct contamination to the water was not observed during the study.

Many questions still remain to be answered about the impact of recreational use on water quality. More work is needed by soil specialists, water quality specialists and human behavioral specialists to determine the effect of dispersed recreation and waste disposal practices on water quality and potential solutions for mitigating adverse impacts. Of particular importance are studies to determine the mechanisms by which bacteria enter the surface waters so quickly. It is also important to determine survival rates of bacteria in soil and in water sediments. Further work is needed on the human behavior aspect of the problem—the effects of the number of people, self-contained RV's, and human waste disposal. Such studies would help determine the implications of long-term recreational use of the area.

ACKNOWLEDGEMENT

Research reported in this paper was conducted under a cooperative agreement between the USDA Forest Service, Pacific Northwest Forest and Range Experiment Station, Recreation Research, Seattle, and Forest Hydrology Laboratory, Wenatchee; and the College of Forest Resources, University of Washington, Seattle; and Department of Biological Sciences, Central Washington University, Ellensburg, Washington.

REFERENCES CITED


Aukerman, Robert and William T. Springer.


ABSTRACT—A simplified mathematical model (Acoustic Impact Prediction Method) has been developed for the prediction of the impact of off-road vehicle noises on forest recreation situations. The concept of signal detection is used to assess probable impact as a function of recreationists' expectations.

INTRODUCTION

This paper presents the Acoustic Impact Prediction Method (AIPM) in its simplified version (see appendix). AIPM allows recreation planners to predict the impact of various noise sources on forest-recreation values. The version presented here is applicable only to off-road vehicles. More sophisticated versions, applicable to the general problem of acoustic impact on forest recreation, are available (Harrison and Clark, 1979). The method predicts how loud a noise source will be at a distance remote from its source, and also sets noise criteria for various recreational experiences and assesses the impact of remote sources on the recreator.

The underlying assumption is that the impact of recreational noise is proportional to detectability. This hypothesis has been shown, in limited psychoacoustic testing, to be applicable to forest noise backgrounds and noise sources with spectra similar to those of most off-road vehicles (Horonjeff, 1978a). For a thorough discussion of the concept of signal detection see Green and Swets (1973) and Swets (1964).

DESCRIPTION OF THE ACOUSTIC IMPACT PREDICTION METHOD

As we are aware, the farther away from a noise source a listener is, the fainter the source seems until, at a sufficient distance, the source is no longer audible. The steps taken in AIPM reduce the sound level of an off-road vehicle at a measurement distance of 50 feet by factors that exist between the source and the listener, such as the distance and wind condition. The effects taken into account by the model are:

<table>
<thead>
<tr>
<th>Factors</th>
<th>Parameters</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inverse Square</td>
<td>Distance</td>
</tr>
<tr>
<td>Atmospheric Absorption</td>
<td>Distance</td>
</tr>
<tr>
<td>Atmospheric Shadow Zones</td>
<td>Distance, wind speed, wind direction, and lapse rate (sky condition)</td>
</tr>
<tr>
<td>Ground Cover Loss</td>
<td>Ground cover type</td>
</tr>
</tbody>
</table>

The mathematical model utilized in AIPM is basically a simplification of the model developed by Fidel and Bishop (1974). Their model dealt with the problem of the acoustic detectability of combat vehicles. Modifications to both the physical portion of the model and the psychoacoustic criteria are incorporated in the current work.
Barrier Shadow Zones

Height of barrier

Distance from barrier to source and receiver

**Inverse Square Radiation**

The mechanism of inverse square radiation is shown in Figure 1. At some distance X from a source, a certain amount of energy is passing through a given area A. At 2X the same amount of energy is passing through an area four times as great, or 4A. Thus at X, the wave will have one amplitude; at 2X its amplitude will be one-fourth of that. Since the decibel is a logarithmic unit, one-fourth of the amplitude equals -6 dB. This is an illustration of the well-known "6 dB per doubling of distance" rule of thumb.

**Figure 1. Spherical spreading**

---

**Atmospheric Absorption**

Air absorbs some of the energy of sound waves. The amount of energy absorbed depends on temperature, pressure, relative humidity, spectral content of the sound, etc. The method of Sutherland (1974) was used in this model.

**Short-Distance Ground and Foliage Effect**

The effects of ground reflection, ground absorption, and absorption by foliage have been combined in one simplified coefficient. The contribution of ground absorption is based on the work of Thomassen (1977) and Piercy and Embleton (1974). The experimental work of Embleton (1963) and Aylor (1972) is the basis of the estimate of foliage and ground cover absorption. Note that while Cook (1969) has shown that carefully engineered plantings of trees and shrubs can bring about significant attenuation of vehicular noise sources, Harrison (1974) has confirmed that, as arranged by nature, growing things are very poor noise absorbers. Nevertheless, the estimates provided by the model are probably conservative; i.e., they underestimate the effects of ground and trees.

**Shadow Zone Effects**

If noise rays cannot propagate directly from the source to the receiver, a shadow zone is created. The shadow is not as sharp as an optical shadow because of refraction around the obstruction (Figure 2). Shadow zones may be created by barriers or by refraction because of changes with altitude in the speed of sound (Figure 3). Shadow zones normally form upwind of noise source (Figure 4). The analysis of Delany (1969) is followed in the estimates of atmospheric refraction and the resulting shadow zones. Maekawa's method (1966) is used to estimate shadow zones created by barriers. Since the total attenuation due to all combined shadow zone effects has been observed to be about 25 dB, the method contains such a 25-dB limitation.

**Hearing Threshold**

Since a noise will not be detected if it falls below the hearing threshold at the listener's location, the model checks the reduced level against the human hearing threshold and provides an answer of no impact, as appropriate.
CALCULATION OF DETECTABILITY ($d'$)

If the reduced noise level at the listener's location exceeds the human threshold of hearing, the next step is to calculate the detectability ($d'$) of the source at the listener's location. The following equation defines $d'$:

$$d' = \frac{S}{N} / \sqrt{\eta}.$$  

$S$ is the signal level in the 1/3 octave band with the greatest $S/N$. $N$ is the background sound level in the same 1/3 octave band, and $W$ is the 1/3 octave bandwidth. $\eta$ is an expression of the efficiency of a human observer with respect to an ideal energy detector. For most listening situations, a value of $\eta = 0.4$ has been determined to be appropriate (Fidel and Bishop, 1972).

Work by Horonjeff (1978b) has indicated that for off-road vehicle detectability, in a background of forest noise, the detectability calculated in the 500-Hz 1/3 octave band consistently shows high correlation with actual detectability. So, for simplicity's sake, detectability is calculated only in the 500-Hz band.

PERMISSIBLE VALUES OF $d'$

Recognizing that most users of AIPM will have only acoustic instruments capable of measuring A-weighted level, the AIPM document (see Appendix) provides an estimated 500-Hz band level for various types of off-road vehicles at a distance of 50 feet, and 500-Hz background sound levels based on an A-weighted measured level at the listener's location. This last level is given for various forest types and conditions in Table A-4 of AIPM. The difference between the reduced 500-Hz source level and background level is directly related to $d'$ at the listener's location. The maximum appropriate difference for various forest recreation conditions is given in Table A-5.

CONCLUSION

The method described in this paper is, at best, an estimator. Its particular weakness is in a lack of substantiation of Table A-5, the estimates of the maximum
acceptable acoustical impact as a function of recreation experience. Also, it must be recognized that a priori information and biases of the listener are extremely important in the perception of the appropriateness of off-road vehicle noise intrusion, and thus its impact.

POST SCRIPT

Little data exists in this area, and the author would be grateful for feedback and additional data. AIPM is currently being tested in several dispersed recreation situations in the National Forests, and improvements and refinements are expected.

ACKNOWLEDGMENTS

The author gratefully acknowledges the help of Drs. Fidel and Bishop. This work was supported by an interagency agreement between the Forest Service-USDA and the U.S. Environmental Protection Agency, Office of Noise Abatement and Control.

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Cook, David I., and David F. Van Haverbeke. 1971. Trees and shrubs for noise abatement. Univ. of Nebraska, College of Agriculture, Lincoln, Nebraska.


Harrison, Robin T. 1974. Sound propagation and annoyance under forest conditions. USDA, Forest Service, Equipment Development Center, San Dimas, California.


APPENDIX
SIMPLIFIED VERSION
ACOUSTIC IMPACT PREDICTION METHOD
(AIPM)
Worksheet
(Note: Do not use for source-listener distances of less than 200 ft. This version is applicable only to motorcycles, snowmobiles, ATV's and chainsaws.)

Date___________________ Time___________________ By___________________

Site ____________________

I. Fill in the following noise source information:
Description of noisemaker ____________________________________________

Select the most appropriate ORV type from Table A-1. Write the type here __________________. If you know the sound level of the noisemaker at 50 ft, when it is being operated wide open throttle, write it here. __________ dBA. From Table A-1, select the closestmost appropriate Ai value. If you do not know the 50-ft level of your noise source, select the Ai value circled in Table A-1 for the most appropriate vehicle. Write the value here . . . . . .

\[ A_i = \] __________

II. Fill in the distance from noise source to listener, feet . . . .
Look at Figure A-1. From Figure A-1, find \( a_1 \). Write it here: \( a_1 = \) _______ dB. Subtract it from \( A_i \). \( (A_i - a_1 = A_2) \). Write \( A_2 \) here . . . . .

\[ A_2 = \] __________

If \( A_2 \) is less than 6, the listener will not hear the noise source. Go no farther with the calculation. If \( A_2 \) is 6 or more, go on to step III.

III. Fill in the following atmospheric data:
Temperature = _______\(^\circ\)F Humidity = _______% RH

From Table A-2, find \( a_2 \). Write it here \( a_2 = \) _______ dB/100 ft. Divide the source-listener distance by 100. Write the quotient here _______. Multiply the quotient by \( a_2 \). Subtract from \( A_2 \). \( (A_2 - \frac{x}{100} a_2 = A_3) \). Write \( A_3 \) here . . . . .

\[ A_3 = \] __________
If $A_3$ is less than 6, the listener will not hear the noise. If $A_3$ is more than 6, go on.

IV. Do you have a steady wind? (That is, the wind is 5 mph or greater, and flows from the same direction, within plus or minus 15°, at least 75% of the time. Yes or No. If no, enter a 0 for $a_3$ below, and go on to step V. If yes, find $\theta$. Refer to Figure A-2. Draw a line on a map through both the noise source and listener. Draw an arrow representing the wind direction through the source. Measure the smallest angle between the lines. This is $\theta$. $\theta = \ldots$.

Refer to Table A-3. Based on your sky condition and time of day, select $\theta$. $\theta = \ldots$.

Subtract $\theta$ from $\theta$. Write the difference here $\theta - \theta = \ldots$.

From Figure A-3, find $a_3$. Write it here. $a_3 = \ldots$. Skip to step VI.

V. Refer to Figure A-4. Knowing the distance from noise source to listener, find $a_4$. Write it here. $a_4 = \ldots$ dB. Go on with step VI.

VI. Circle the most appropriate ground cover type:

- Grass or open brush
- Dense broadleafs
- Sparse broadleafs or conifers
- Dense conifers

Refer to Figure A-5. Find $a_5$, write it here $a_5 = \ldots$ dB.

VII. Are there land forms or other solid, substantial barriers in the line of sight between the noise source and the listener? If not, skip this step. If so, fill in the following:

- Straight line distance from source to listener, $X$, feet
- Height of barrier above line between source and listener, $h$, feet
- Distance from receiver to barrier, $R$, feet

Find the quantity $N$ where

$$N = 0.91 \left[ \sqrt{h^2 + R^2} + \sqrt{h^2 + (X-R)^2} - X \right]$$

Write $N$ here. $N = \ldots$.

From Figure A-6, find $a_6$. Write it here $a_6 = \ldots$ dB.

VIII. Add up $a_3 + a_4 + a_5 + a_6$. Write the sum here $a_3 - a_6 = \ldots$ dB.

If $\sum a_3 - a_6$ is greater than 25 dB, subtract 25 dB from $A_3$. If $\sum a_3 - a_6$ is less or equal to 25, subtract the $\sum a_3 - a_6$ from $A_3$. ($A_3 - \sum a_3 - a_6 = A_4$).

$A_4 = \ldots$

If $A_4$ is less than 6, the listener will not hear the noise. If $A_4$ is greater than 6, go on to step IX.

IX. Find the most appropriate background value $A_b$ from Table A-4. Write it here $A_b = \ldots$ dB. Subtract $A_b$ from $A_4$. Write the difference here.

($A_4 - A_b = \ldots$ dB.

Refer to Table A-5. For your closest appropriate recreational use, find the maximum acceptable $A_4 - A_b$. If your calculated $A_4 - A_b$ is greater, the
Acoustic impact of the noise source is unacceptable. If your calculated $A_4 - A_b$ is less, the impact is probably acceptable.

Table A-1. $A_1$-Values

<table>
<thead>
<tr>
<th>Vehicle Type</th>
<th>50-ft Wide Open Throttle Levels</th>
<th>$A_1$-Values</th>
<th>50-ft Wide Open Throttle Levels</th>
<th>$A_1$-values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Motorcycles</td>
<td></td>
<td>75 79 83 86 92</td>
<td></td>
<td>69 73 (77) 80 86</td>
</tr>
<tr>
<td>All-terrain Vehicles</td>
<td></td>
<td>73 78 83</td>
<td></td>
<td>62 (67) 72</td>
</tr>
<tr>
<td>Snowmobiles</td>
<td></td>
<td>70 75 78 83</td>
<td></td>
<td>66 (71) 74 72</td>
</tr>
<tr>
<td>Chain Saws</td>
<td></td>
<td>81 86</td>
<td></td>
<td>69 (74)</td>
</tr>
</tbody>
</table>

Table A-2. $a_2$, dB/100 ft

<p>| Temperature, °F | Relative Humidity, |</p>
<table>
<thead>
<tr>
<th></th>
<th>0-30%</th>
<th>31-50%</th>
<th>50-100%</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>.21</td>
<td>.11</td>
<td>.06</td>
</tr>
<tr>
<td>32</td>
<td>.13</td>
<td>.06</td>
<td>.04</td>
</tr>
<tr>
<td>50</td>
<td>.08</td>
<td>.06</td>
<td>.06</td>
</tr>
<tr>
<td>70</td>
<td>.08</td>
<td>.09</td>
<td>.08</td>
</tr>
<tr>
<td>90</td>
<td>.12</td>
<td>.11</td>
<td>.08</td>
</tr>
</tbody>
</table>

Table A-3. θ

<table>
<thead>
<tr>
<th>Sky</th>
<th>Day or Night</th>
<th>θ</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clear</td>
<td>Day</td>
<td>130°</td>
</tr>
<tr>
<td>Clear</td>
<td>Night</td>
<td>65°</td>
</tr>
<tr>
<td>Cloudy</td>
<td>Day &amp; Night</td>
<td>90°</td>
</tr>
<tr>
<td>Measured Level dBA</td>
<td>$A_b$</td>
<td>Comments</td>
</tr>
<tr>
<td>-------------------</td>
<td>-------</td>
<td>----------</td>
</tr>
<tr>
<td><strong>Coniferous Forests</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>16</td>
<td>Deep snow-covered. No wind.</td>
</tr>
<tr>
<td>25</td>
<td>20</td>
<td>No wind, no snow.</td>
</tr>
<tr>
<td>30</td>
<td>24</td>
<td>Light wind, no snow.</td>
</tr>
<tr>
<td>35</td>
<td>28</td>
<td>Most common - 5-10 mph wind.</td>
</tr>
<tr>
<td>40</td>
<td>32</td>
<td>Wind over 10 mph.</td>
</tr>
<tr>
<td>45</td>
<td>36</td>
<td></td>
</tr>
<tr>
<td>50</td>
<td>40</td>
<td></td>
</tr>
<tr>
<td><strong>Broadleaf Forest, Grassland, Brush, Tropical Forest</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>16</td>
<td>Very quiet. No wind or insects.</td>
</tr>
<tr>
<td>25</td>
<td>18</td>
<td>Very quiet. No wind or insects.</td>
</tr>
<tr>
<td>30</td>
<td>20</td>
<td>Quiet, green broadleaf forest.</td>
</tr>
<tr>
<td>35</td>
<td>22</td>
<td>Most usual in open grassland, no wind.</td>
</tr>
<tr>
<td>40</td>
<td>24</td>
<td>Most usual in brush &amp; chaparral.</td>
</tr>
<tr>
<td>45</td>
<td>26</td>
<td>5-10 mph wind.</td>
</tr>
<tr>
<td>50</td>
<td>33</td>
<td>Wind over 10 mph, Aspen groves.</td>
</tr>
<tr>
<td><strong>Desert</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>10</td>
<td>Completely calm.</td>
</tr>
<tr>
<td>25</td>
<td>14</td>
<td></td>
</tr>
<tr>
<td>30</td>
<td>18</td>
<td></td>
</tr>
<tr>
<td>35</td>
<td>22</td>
<td></td>
</tr>
<tr>
<td>40</td>
<td>26</td>
<td></td>
</tr>
<tr>
<td><strong>Running Water, Dunes within 1 mile of Ocean</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>40</td>
<td>28</td>
<td>Calm wind, calm sea.</td>
</tr>
<tr>
<td>45</td>
<td>33</td>
<td></td>
</tr>
<tr>
<td>50</td>
<td>41</td>
<td>Wind 10 mph, 3-ft surf.</td>
</tr>
<tr>
<td>55</td>
<td>47</td>
<td></td>
</tr>
<tr>
<td>60</td>
<td>55</td>
<td>Loud waterfall.</td>
</tr>
</tbody>
</table>
Table A-5. $A_n - A_b$ for Various Recreational User Expectations

<table>
<thead>
<tr>
<th>Condition</th>
<th>Max. Occurrences per Day/Night</th>
<th>Max. Acceptable $A_n - A_b$ of Intruding Noise</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;True&quot; wilderness</td>
<td>10/$\infty$</td>
<td>0.2</td>
</tr>
<tr>
<td>Remote, dispersed recreation situation</td>
<td>15/$\infty$</td>
<td>0.6</td>
</tr>
<tr>
<td>Trail camps</td>
<td>20/20</td>
<td>1.2</td>
</tr>
<tr>
<td>Undeveloped road campgrounds</td>
<td>30/10</td>
<td>2.3</td>
</tr>
<tr>
<td>Roadside campgrounds</td>
<td>$\infty$/50</td>
<td>4.7</td>
</tr>
<tr>
<td>Highly developed campgrounds</td>
<td>$\infty$/$\infty$</td>
<td>9.3</td>
</tr>
</tbody>
</table>

Note: $\infty$ = No limit to number of occurrences.

Figure A-1. $a_1$
Figure A-2. Determination of Wind Angle

Figure A-3. $a_3$
Figure A-4. a₄
Distance from source to listener $X$, ft

Figure A-5. $a_5$
SIMPLIFIED VERSION
ACOUSTIC IMPACT PREDICTION METHOD
Texas Instrument SR-50 Program

Definitions:
Enter your values here

- \( A_1 \) = Noise source level at 50 ft, dB in 500-Hz band, Table A-1
- \( X \) = Distance from noise source to listener, feet
- \( a_1 \) = From Figure A-1
- \( a_2 \) = From Table A-2
- \( \theta \) = From Figure A-2
- \( \theta \) = From Table A-3
- \( a_3 \) = From Figure A-3
- \( a_4 \) = From Figure A-4
- \( a_5 \) = From Figure A-5
- \( h \) = Height of barrier above line of sight, feet
- \( R \) = Distance from receiver to barrier, feet
- \( a_6 \) = From Figure A-6
- \( A_b \) = Background sound level @ listener, dB in 500-Hz band, Table A-4

To enable programming on programmable calculators, the equations of the parameter given in the figures, where possible, are shown. Use actual tabulated values for \( A_1, a_2, \theta, a_3, a_5, a_b \).

\[ a_1 = -20 \log \left( \frac{X}{50} \right) \]

\[ a_4 = 0 \text{ for all } X < 800, \quad a_4 = 10 \log X - 29 \text{ for all } X \geq 800 \]

\[ a_6 = 10 \log (N + 0.1) + 13 \]
Enter

\( A_1 \)  
\( a_1 \)  
\( a_2 \)  
\( X \)  
100

Press

STO  
+/-  
\( \Sigma \)  
\( \Sigma \)  
RCL  
RCL

Write the display

Source inaudible

> 6

no  
yes

no  
yes

Steady wind

Enter

\( a_4 \)
or
\( a_3 \)
Enter

\( a_5 \)

+/-  
\( \Sigma \)  
+/-  
\( \Sigma \)  
+/-  
\( \Sigma \)  

Landforms Barriers

no  
yes

Source inaudible

> 6

no  
yes

Enter

\( A_b \)

=  

Write the display

Compare with Table A-5
DISCUSSION

Comment: Is the method applicable to aircraft? Locally that is a bone of contention. There are areas closed to aircraft in the alpine lakes of Washington which float planes have used historically. The question is whether it is now closed to aircraft over-flights. Is this a reasonable regulation or an unreasonable one? Does it have some features that could allow mitigation?

Harrison: The general method is applicable to aircraft. The simplified method presented
here is not. The reasonableness of the regulation is subjective... whether or not the people surrounding the lakes are willing to give up the advantage of having airplanes come in and out to get rid of the noise. As far as mitigation, there are no practical engineering ways to quiet existing small airplanes, partly because Federal Aviation Regulations prohibit any modifications without prohibitively expensive testing.

Comment: I'm here to represent the Seaplane Pilots Association. We've done studies on methods to reduce aircraft noise. We've proven that simply by reducing revolutions per minute you can significantly reduce the noise-you can't eliminate it, of course. The major noise source on a float plane is the propellor. As the propellor tip approaches supersonic speed, the noise becomes very objectionable. By reducing engine speed (in some cases, by only 100 rpm) the tip speed becomes significantly lower than supersonic and then the noise is greatly reduced. This is something that the Seaplane Pilots Association is trying to educate all pilots to be aware of, rather than run with their prop control full forward when it's unnecessary.

Another aspect: The shadow effect which you touched on is a very prominent factor when flying in the mountains --because an airplane that's down in a canyon adjacent to a listener is not going to be detected, whereas one that is flying overhead will be detected.

The request that seaplane pilots have presented is to have a few landing sites designated in the mountain lakes. We recognize that there are objections to aircraft noise. The noise will always be there due to the high-flying aircraft: airline traffic, military traffic, and Forest Service fire patrol airplanes. These high-flying aircraft generate more noise to the person on the ground near alpine lakes than an airplane that's over in the next canyon.

Van Haagen: In response to this gentleman's statement about the canyons, there are problems with temperature inversions which carry the sound over the hills and this is one of the severe problems one cannot predict. It means that you have sound propagating quite some distance at times. Particularly in the morning and evening.

Comment: Clouds also reflect the sound. Am I correct?

Harrison: No. I think what happens is that clouds represent a rather marked change in the lapse rate and the temperature, so a very sharp refraction exists.

Comment: So it's actually the temperature change rather than the presence of water vapor?

Van Haagen: Well, it can act as a mirror; if the refractive index is greater at that point it can actually reflect the sound. But the cloud has to be fairly uniform.

Harrison: The effect is complex, and impossible to predict in a field situation. I think we agree.

Van Haagen: Yes, definitely.

Comment: I've noticed departing aircraft, as they gain elevation, if above the cloud layer, don't seem to be as loud as they are on a clear day.

Harrison: I suggest that that major factor is that you don't see them.

Van Haagen: Thank you Rob. We also wish to thank Harry Levinson of Bowel and Kjaer Instruments, Inc. for bringing and demonstrating sound level equipment. To summarize: One of the most important factors to the recreational user is solitude and getting away from people and perhaps civilization! (That's a personal interjection). Noise represents all of these things the recreationist is trying to escape. I think the author's point is very well taken that noise is the objectionable part of sound. To avoid these sound sources is one of the purposes of the person going where he goes. It isn't only the visual aspect. Another one of the speakers this morning (the Appalachian Mountain Club representative) spoke of the fact that by spacing campsites around so you couldn't see each other, you wouldn't be affected by them. That may very well be for some people - out of sight, out of mind. And this is pointed out in this paper. Part of your perception is actually what you see and what you expect, as well as what you actually hear.
ABSTRACT--This paper presents some of the results of human impact research conducted under contract with the National Park Service in Big Bend National Park (BBNP) and Amistad Recreational Area (ARA) in 1976 and 1977, respectively. Two types of impact, livestock grazing and recreational impact resulting from human use at designated campsites and their effects upon two biotic components (terrestrial rodents and vegetation), were monitored in the riparian habitats of BBNP and ARA. Our results suggest that present levels of recreational usage in the Rio Grande River System have had little significant impact on these biological parameters in riparian habitats. Comparison of our findings with those of other workers suggests that an assessment of the cause (quantification and classification of users) as well as the effect (measurement of environmental changes) of visitor impacts is necessary to provide managers the information needed to cope with these problems. Management implications of the research are discussed.

INTRODUCTION

As use of selected national park areas increases and as related conflicts emerge, the National Park Service (NPS) has sought to limit use based on resource-carrying capacity. On the Colorado River, for example, the NPS placed restrictions on the number of people outfitters can carry during the year (Boster, 1972). Use regulations and limitations have also been imposed (Roggenbuck, 1975) in Canyonlands National Park and Dinosaur National Monument. In Grand Teton National Park, where floating use has increased sharply in recent years, river use is limited to the number of rafts that can be physically accommodated at entrance and departure points (Jubenville, 1976). Outfitters expect regulations to be imposed on the Buffalo National River in coming years (Whisnant, 1978). While these are offered only as examples, they are indicative of a trend which shows the NPS imposing restrictions on use of riverways and backcountry areas (Butts, 1976).

Most of these restrictions have been tied to the NPS statutory concern for preventing resource deterioration. In some cases, restrictions have been based on recreational impacts. In other cases, restrictions have been imposed as a preventative measure. Graefe (1977) points out, "Because it is managing non-renewable resources of national importance and because such dramatic increases in use are unprecedented, the NPS has apparently opted to play it safe environmentally--to restrict use before irreversible damage to resources might occur." Given increasing recreational use, this is a reasonable approach. Unfortunately, it has not proven to be legally or politically safe. Without any evidence of resource degradation, some members of the public view the resultant limitations as arbitrary and capricious (Butts, 1976). Several suits have been brought that have challenged the basis for the limitations. In response to such actions, the NPS declared that regula-
tions would not be changed "except for just cause or through benefit of fresh scientific knowledge" (National Park Service, 1975). So as to avoid the approach of documenting damage after it has occurred, the NPS initiated research to establish "the level of use that each river can sustain" (National Park Service, 1975). This research will provide the scientific base for the management plans developed for each NPS area and for subsequent decision making.

Other forces are at work in support of research efforts that document recreational use and its impact on the natural resource base. The National Environmental Policy Act (NEPA) requires that decisionmakers understand and predict the environmental impacts of their actions. They are charged with analyzing the environmental impact of proposed actions and adverse effects which cannot be avoided as well as alternatives to the proposed action, the relationship between short-term use of natural resources and their long-term productivity and the irreversible aspects of the proposed action. Regulations which seek to restrict use so as to minimize impact on park resources must be supported by an environmental impact statement which provides concise analysis and support for the regulations. A concern for endangered species and their habitats has also reinforced both the need for regulating recreation use and the need for scientific studies that establish the extent of impacts associated with recreational use.

All of these forces have led NPS officials to seek to prevent unacceptable resource deterioration. Their focus is primarily on physical and biological resources. The research task has fallen primarily to physical and biological scientists. Increasingly, we have recognized that it is difficult to understand the impact of recreational use and its managerial implications without some knowledge and understanding of the extent, character, and timing and patterns of recreational use. Again, we find support in NEPA's charge to agencies to utilize "a systematic, interdisciplinary approach which will insure the integrated use of the natural and social sciences ... in decisionmaking which may have an impact on man's environment." The design of the research reported here uses such a systematic interdisciplinary approach to understanding man's impact on the flora and fauna of two study areas within the Rio Grande River System in western Texas.

This paper presents some of the results of recreational impact research conducted under contract in Big Bend National Park (BBNP) and Amistad Recreational Area (ARA) in 1975 and 1977, respectively. While both are within the same river system, they are different with regard to management objectives. The management categories for BBNP and ARA are "natural" and "recreational," respectively. Management objectives for the two areas, however, are not clearly differentiated. According to the BBNP Master Plan (NPS, 1973), the resources of Big Bend will be managed so as to maintain the ecological processes of the area. Further, the plan recognized that some areas can accommodate moderate to heavy usage with only local impact while other areas can absorb little or no recreational use. At ARA, on the hand, recreational use is encouraged but not to the detriment of scenic, scientific, natural, historic, and other values found there (NPS, 1974). The Amistad Natural Resources Management Plan recognizes the need for a visitor-use analysis to obtain data on visitor-use activities and to develop monitoring programs to protect the environment.

The two areas also differ sharply in terms of annual park visitation as shown in Table 1. It should be remembered that the data presented in this table are for the entire park and are intended for purposes of perspective. Data on use of specific riparian habitats will be presented later in the paper where it will be correlated to impact data.

DESCRIPTION OF THE STUDY AREAS

Big Bend National Park

Created in 1944, BBNP is located in Brewster County, Texas, on the southwestern part of the great bend in the Rio Grande between El Paso and Laredo. Three major physical features (the Chisos Mountains, the Chihuahuan Desert, and the Rio Grande) dominate the landscape of BBNP. Our studies were conducted entirely in the floodplain or riparian vegetation which exists wherever periodic flooding occurs along the Rio Grande. Many of the popular campgrounds in BBNP are located in close proximity to these riparian communities.

Amistad Recreation Area

ARA was created in 1968 by the construction of Amistad Dam at the junction of the Rio Grande, Devils River, and Pecos
River in Val Verde County, Texas. At the 340.5 meter (m) contour elevation, which is considered conservation level, the impounded water extends 119.1 kilometers (km) up the Rio Grande, 40.2 km up the Devils, and 22.5 km up the Pecos River. The maximum flood stage for the reservoir is at the 348.0 m contour level which, except at developed sites, defines the boundary of the recreation area. Several hundred acres of land, representing wildlife habitat and natural area, lie between the 340.5 and 348.9 m contour levels.

The habitats on the recreation area have been altered somewhat since the construction of the dam. Inundation by water destroyed most of the "true" flood-plain riparian habitats in the area, and these have been replaced by a flood-zone type of riparian habitat along the edge of the reservoir. The size of the latter varies seasonally and yearly depending upon the water level of the lake. The vegetation of the surrounding hillsides is basically of a desert scrub type with a sparse cover of grasses and forbs.

**METHODS**

There are basically three approaches to measuring recreation-induced changes in biological parameters (Settergren, 1977). The first, and probably the most desirable method is the before/after method in which biological data are obtained prior to opening up an area and then the area is again inventoried after some period of use. A second method is to establish a set of sampling plots and transects in the used areas and locate a similar but undisturbed area nearby for an identical set of control points.

### Table 1. Annual visitation to Big Bend National Park and Amistad Recreation Area

<table>
<thead>
<tr>
<th>Year</th>
<th>Total Visits BBNP</th>
<th>Percent Change of Previous Year Total</th>
<th>Total Visits ARA</th>
<th>Percent Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>1977</td>
<td>402,433</td>
<td>-11.8</td>
<td>993,577</td>
<td>-9.2</td>
</tr>
<tr>
<td>1976</td>
<td>456,201</td>
<td>+37.4</td>
<td>1,094,605</td>
<td>+3.3</td>
</tr>
<tr>
<td>1975</td>
<td>331,913</td>
<td>+74.0</td>
<td>1,059,534</td>
<td>+11.3</td>
</tr>
<tr>
<td>1974</td>
<td>191,252</td>
<td>-44.0</td>
<td>951,961</td>
<td>-3.0</td>
</tr>
<tr>
<td>1973</td>
<td>341,200</td>
<td>+18.0</td>
<td>982,916</td>
<td>+1.4</td>
</tr>
<tr>
<td>1972</td>
<td>290,247</td>
<td>+17.0</td>
<td>969,746</td>
<td>+42.0</td>
</tr>
<tr>
<td>1971</td>
<td>247,401</td>
<td>+43.0</td>
<td>682,921</td>
<td>+0.6</td>
</tr>
<tr>
<td>1970</td>
<td>172,648</td>
<td>...</td>
<td>678,972</td>
<td>+51.6</td>
</tr>
</tbody>
</table>

Third, recreation areas may be surveyed, without employing controls, to obtain impact comparisons between sites receiving different types and intensities of use. We were unable to use method 1 in either of our studies along the Rio Grande; instead we used method 2 at ARA and method 3 at BBNP.

**Big Bend National Park**

Sixty-four major riparian sites were identified. For purposes of statistical analysis each site was treated as a distinct sampling entity although in practicality the riparian communities tend to form a continuum along the river (a map depicting the exact location of the 64 sites is given in Ditton et al., 1977, Figure 1, page 257). Most of the riparian areas are accessible only by floating the river. However, 26 riparian sites are accessible via roads, and most of these may be reached via a dirt road.
called the River Road. Use data (1975) at BBNP were derived from backcountry permits that visitors are required to obtain prior to camping at any backcountry area or floating the Rio Grande. Permit data were used first to establish the extent, character and patterns of Rio Grande corridor use. Secondly, permit data were totaled to provide a monthly description of use at each of the designated primitive campsites along the River Road. Use data for the remaining riparian sites were not available as these areas were not identifiable.

The interrelationships between human impact and biotic resources of the riparian habitats in BBNP were investigated at selected designated campsites which represent a continuum of human use varying from sites which receive little impact to those receiving heavy impact. Impact was assessed by means of a subjective site-evaluation sheet in which eight different variables were assigned ordinal ranks to determine the magnitude of human and livestock impact (Ditton et al., 1977). The species composition and density of the terrestrial rodents was monitored at 11 sites using a modification of the Calhoun and Casby (1958) method. The canopy-coverage method of Daubenmire (1959) was used to analyze vegetation (trees, shrubs, and grasses) at the rodent-trapping sites. The exact methodology for these studies is described elsewhere (Ditton et al., 1976; Schmidly and Ditton, 1976; Schmidly et al., 1977; and Boeer, 1977) and will not be detailed here.

Amistad Recreation Area

Analysis of human impact and biotic resources in the lakeshore habitats of ARA was conducted using three primary study sites, each reflecting different intensities of human or livestock impact. The first site, Governor's Landing, is an overnight campground with primitive facilities. This campground currently receives continuous use; it was selected as a study site that experienced considerable human impact. Data regarding overnight camping use of Governor's Landing were derived from voluntary registration forms. Additionally, we relied upon visual on-site counts made by NPS personnel and mechanical counts made by pneumatic tube traffic counters deployed at entrance points. Personal observation and time-lapse photographic techniques were used to identify on-site recreational use patterns at Governor's Landing.

Two study sites were located at Long Point, an area across the lake from Governor's Landing. These were established on each side of a fence; one site represented an overgrazed area and the other a non-grazed, lightly impacted control site. These sites received very little human visitation due to their relatively inaccessible location and limited recreational opportunities. The overgrazed study site has been under grazing pressure by sheep, cattle and goats intermittently since 1900.

Small mammals were sampled using 100 Sherman live traps set in standard trapping grids for five consecutive nights each month from January through June at the three study sites. This trapping regime resulted in 3000 trapnights at each site. All mammals captured were marked by toe clipping and released after species identification, sex, approximate age, and reproductive condition were noted. Trap records permitted estimation of species population density, home range, and distribution in the habitat. Species densities were estimated by calculating capture frequency, which is an indication of catch per unit effort or total captures per trap-night. Indices of general diversity, richness, and evenness were generated for each study site using the Shannon Index formula for general diversity (Odom, 1971).

The white-ankled mouse (Peromyscus pectoralis) was the most abundant small rodent recorded during the live-trapping studies. Several aspects of its population characteristics (including home range, sex, and age structure) were analyzed at the Governor's Landing and Long Point-ungrazed study sites. Animals were aged on the basis of pelage characteristics as follows: (1) juveniles, pelage short and gray along lateral flanks and dorsum; (2) subadults, pelage brownish-gray with obvious molt lines across the dorsum; (3) adults, pelage a rich cinnamon-brown coloration. All animals captured were weighed to the nearest 0.5 gram (g) with a 30 g-capacity hand-held Pesola scale graduated in 1 g intervals.

Two different techniques were used to assess the vegetation at the three study sites. The point-centered-quarter technique (Cottom and Curtis, 1956) was used to measure change in shrub growth, and the grass and-forb stratum was sampled for percent cover using the point-quadrant method (Brown, 1954). The sampling points in the campground were randomly located and not
restricted to pathways or picnic areas.

RESULTS

Big Bend National Park

The detailed results of the Big Bend study are reported elsewhere (Ditton et al., 1976; Schmidly and Ditton, 1976; Schmidly et al., 1976; Boeer and Schmidly, 1977; and Boeer, 1977) and only the relationships among human use, subjective impacts, and biological parameters will be discussed here.

A distribution (in man-days) of total River Road camping by individual designated sites is presented in Table 2. These data reveal that camping at designated primitive River Road campsites was concentrated at a very few sites. Two River Road sites (Gravel Pit and Solis) accounted for 39% (in man-days) of total annual River Road use. Four more sites (San Vincente Crossing, Talley, Black Dike, and Johnson Ranch) accounted for an additional 32% (man-days) of total annual River Road site use. Thus, in terms of man-days of camping provided, six sites account for 71% of the total annual River Road use. Alternatively, eight of the remote River Road sites received less than 2% each of the total river oriented backcountry camping. These data suggest that, for most sites at most times, use is extremely low.

Table 2 also includes the results of 7,920 trap nights of collecting small rodents at 11 different riparian sites (720 trap nights per site) along the Rio Grande. The riparian rodent fauna of BBNP is less diverse than that of the desert-shrub, grassland, or woodland habitats. Eight species of small terrestrial rodents occupy riparian habitats in BBNP. Perognathus pen-
Table 2. Annual campsite use, total human impact, rodent densities, and percent cover for trees, shrubs, and grasses at River Road campsites in Big Bend National Park

<table>
<thead>
<tr>
<th>River Road Site</th>
<th>Use $^1$</th>
<th>Human Impact $^2$</th>
<th>Heteromyid Catch $^3$</th>
<th>Cricetid Catch $^3$</th>
<th>$^4$ Trees</th>
<th>$^4$ Shrubs</th>
<th>$^4$ Grasses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gravel Pit</td>
<td>1,426.5 (20.0)</td>
<td>16.0</td>
<td>67 (3)</td>
<td>15 (3)</td>
<td>9.8</td>
<td>5.3</td>
<td>14.0</td>
</tr>
<tr>
<td>Solis</td>
<td>1,377.7 (19.3)</td>
<td>18.0</td>
<td>74 (1)</td>
<td>58 (3)</td>
<td>8.0</td>
<td>3.0</td>
<td>21.9</td>
</tr>
<tr>
<td>San Vincente</td>
<td>677.9 (9.5)</td>
<td>16.0</td>
<td>70 (2)</td>
<td>36 (3)</td>
<td>12.0</td>
<td>1.2</td>
<td>12.0</td>
</tr>
<tr>
<td>Talley</td>
<td>577.3 (8.1)</td>
<td>17.0</td>
<td>74 (1)</td>
<td>58 (3)</td>
<td>8.0</td>
<td>3.0</td>
<td>21.9</td>
</tr>
<tr>
<td>Johnson Ranch</td>
<td>545.9 (7.6)</td>
<td>18.0</td>
<td>21 (1)</td>
<td>12 (4)</td>
<td>6.0</td>
<td>3.0</td>
<td>5.3</td>
</tr>
<tr>
<td>Black Dike</td>
<td>475.5 (6.6)</td>
<td>28.0</td>
<td>23 (2)</td>
<td>12 (4)</td>
<td>9.8</td>
<td>2.4</td>
<td>16.0</td>
</tr>
<tr>
<td>La Clocha</td>
<td>273.0 (3.8)</td>
<td>20.0</td>
<td>37 (2)</td>
<td>23 (2)</td>
<td>9.8</td>
<td>3.0</td>
<td>8.0</td>
</tr>
<tr>
<td>Woodson's</td>
<td>264.8 (3.7)</td>
<td>14.5</td>
<td>37 (2)</td>
<td>23 (2)</td>
<td>9.8</td>
<td>3.0</td>
<td>8.0</td>
</tr>
<tr>
<td>Rooneys</td>
<td>229.7 (3.2)</td>
<td>9.5</td>
<td>5 (2)</td>
<td>9.8</td>
<td>3.0</td>
<td>8.0</td>
<td>8.0</td>
</tr>
<tr>
<td>Buenas Aires</td>
<td>224.0 (3.1)</td>
<td>6.0</td>
<td>5 (2)</td>
<td>9.8</td>
<td>3.0</td>
<td>8.0</td>
<td>8.0</td>
</tr>
<tr>
<td>Casa Piedra</td>
<td>167.7 (2.3)</td>
<td>14.5</td>
<td>37 (2)</td>
<td>9.5</td>
<td>2.4</td>
<td>8.0</td>
<td>4.7</td>
</tr>
<tr>
<td>Other</td>
<td>164.7 (2.3)</td>
<td>14.5</td>
<td>37 (2)</td>
<td>9.5</td>
<td>2.4</td>
<td>8.0</td>
<td>4.7</td>
</tr>
<tr>
<td>Pettit's</td>
<td>136.7 (1.9)</td>
<td>8.5</td>
<td>55 (2)</td>
<td>27 (4)</td>
<td>4.7</td>
<td>1.2</td>
<td>18.0</td>
</tr>
<tr>
<td>Gauging Station</td>
<td>120.2 (1.7)</td>
<td>14.0</td>
<td>79 (2)</td>
<td>10 (4)</td>
<td>9.8</td>
<td>2.4</td>
<td>16.0</td>
</tr>
<tr>
<td>Smokey Creek</td>
<td>118.0 (9.5)</td>
<td>8.5</td>
<td>37 (2)</td>
<td>9.5</td>
<td>2.4</td>
<td>8.0</td>
<td>4.7</td>
</tr>
<tr>
<td>Jewel's Camp</td>
<td>105.7 (1.5)</td>
<td>8.5</td>
<td>37 (2)</td>
<td>9.5</td>
<td>2.4</td>
<td>8.0</td>
<td>4.7</td>
</tr>
<tr>
<td>Compton's</td>
<td>98.0 (1.4)</td>
<td>7.5</td>
<td>41 (2)</td>
<td>16 (3)</td>
<td>9.8</td>
<td>1.8</td>
<td>3.5</td>
</tr>
<tr>
<td>Loop Camp</td>
<td>76.7 (1.1)</td>
<td>8.0</td>
<td>41 (2)</td>
<td>16 (3)</td>
<td>9.8</td>
<td>1.8</td>
<td>3.5</td>
</tr>
<tr>
<td>Sierra Chino</td>
<td>65.6 (0.9)</td>
<td>7.0</td>
<td>41 (2)</td>
<td>16 (3)</td>
<td>9.8</td>
<td>1.8</td>
<td>3.5</td>
</tr>
<tr>
<td>Hot Springs</td>
<td>26.0 (0.4)</td>
<td>7.0</td>
<td>41 (2)</td>
<td>16 (3)</td>
<td>9.8</td>
<td>1.8</td>
<td>3.5</td>
</tr>
</tbody>
</table>

1. Man-days of use per site (percent use given in parentheses).
2. Median value of man's impact parameter (see Fig. 2, p. 260, Ditton et al., 1977).
3. Total individual animals captured per 720 trap-nights per site (number of species in parenthesis).
4. Estimated percent cover using the Daubenmire (1959) method.
The only information available regarding recreational use of this site is taken from traffic counter data gathered by NPS personnel. The number of cars entering and leaving Governor's Landing was recorded as follows for the study period: August, 1976 - 2,829; September, 1976 - malfunction; October, 1976 - 557; November, 1976 - 703; December, 1976 - 461; January, 1977 - 247; February, 1977 - 1,253; March, 1977 - 1,109; April, 1977 - 1,310; May, 1977 - 907; June, 1977 - 1,165 and July, 1977 - 1,207.

All live-trapped mammals were small rodents. Six different species belonging to two families were trapped on the study sites as follows: Family Heteromyidae (Perognathus flavus, P. hispidus, P. melsoni); Family Cricetidae (Peromyscus pectoralis, Sigmodon hispidus, and Neotoma micropus). The number of different animals captured, total captures, and capture frequency (captures per trap-night) are presented in Table 3. Indices of diversity, richness, and evenness for each study site are given in Table 4. Demographic features analyzed for P. pectoralis included sex ratios, age-class and weights (see Table 5). So few individuals were captured at the Long Point-grazed site that virtually nothing about population demography of P. pectoralis could be assessed.

Grazing Impacts

Vegetation. The point-quadrat analysis was used to detect differences in amount and total cover of forbs and grasses. The amount of cover available on the grazed site was less than on the ungrazed site. The type of cover also differed between the two areas. Hall's panicum (Panicum hallii), threeawns (Aristida sp.), hairy tridens (Erioneuron pilosum) and fairy-duster (Calliandra conferta), three of the more common species providing cover on the ungrazed site, were relatively uncommon on the grazed site. The rarity of fairy-duster, which is a desirable browse plant, on the grazed site is directly attributed to overgrazing. The cover on the grazed site was composed of species such as hairy tridens (Erioneuron pilosum), red plantage (Plantage rhodosperma) and cudweed (Gnaphalium falcatum). The aerial parts of these plants did not extend as far above the ground as did those plants providing cover on the ungrazed site. The point-centered-quarter analysis revealed some differences in species composition of shrubs between the grazed and ungrazed site. Blackbrush acacia (Acacia rigidula) was more abundant on the ungrazed sites, whereas ceniza (Leucahyphylum frutescens) was more common on ungrazed sites.

Small mammals. In comparing the grazed and ungrazed study sites at Long Point, some marked differences were noted in the species composition as well as density of the rodent fauna (Table 3). The rodent fauna on the grazed site was composed primarily of heteromyid rodents (65.8% of the total catch), whereas the kinds of rodents were rare on the ungrazed site (1.4% of the total catch) where cricetid rodents dominated the total catch. Capture frequencies were over four times greater on the ungrazed than on the grazed site, reflecting the higher density of rodents on the former area. The grazed site had higher indices of diversity, richness, and evenness than the ungrazed site (Table 4). The greater richness value was a result of the occurrence of more species on the grazed site. The lower evenness value on the ungrazed site was due to the fact that one species, P. pectoralis accounted for more than one-half of all small rodents captured on the ungrazed site, whereas small rodents captured on the grazed site were more evenly distributed among all species captured.

Human Impacts

Vegetation. There were no great differences in total cover provided by grasses anf forbs at the campground or the unused control site. Threeawns (Aristida sp.), leatherstem (Jatropha dioica), hairy tridens (Erioneuron pilosum) and fairy-duster (Calliandra conferta) were common at both sites. Certain areas at Governor's Landing were covered with a denser, grassy vegetation than was found at Long Point. No significant differences in shrub height or canopy diameter were detected for any species at either study site. Common shrubs at all three sites included blackbrush acacia (Acacia rigidula), guajillo (Acacia berlandieri), and prickly pear (Opuntia engelmanii).

Small mammals. Rodent densities, as related by capture frequencies (Table 3), were slightly greater at the campground (Governor's Landing) than at the control site (Long Pointungrazed). The control site had higher diversity and richness values in the Shannon-Weaver formula (Table 4) reflecting a greater number of species (5) taken here than at Governor's Landing (3). The rodents captured at Governor's Landing were more evenly distributed among several
Table 3. Number of small mammals marked, total captures, and recaptures at the three study sites

<table>
<thead>
<tr>
<th>Species</th>
<th>Long Point-Ungrazed (3000)</th>
<th>Long Point-Grazed (3000)</th>
<th>Governor's Landing (3000)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peromyscus pectoralis</td>
<td>48</td>
<td>176</td>
<td>128</td>
</tr>
<tr>
<td>Sigmodon hispidus</td>
<td>18</td>
<td>44</td>
<td>26</td>
</tr>
<tr>
<td>Neotoma micropus</td>
<td>13</td>
<td>17</td>
<td>4</td>
</tr>
<tr>
<td>Perognathus flavus</td>
<td>1</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Perognathus hispidus</td>
<td>2</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>Perognathus nelsoni</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td><strong>TOTALS</strong></td>
<td>82</td>
<td>240</td>
<td>158</td>
</tr>
<tr>
<td>Capture Frequency 2</td>
<td>8.00%</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1. Trap-nights for study site.
2. Calculated as total captures divided by total trap-nights.

Table 4. Shannon-Weaver index of diversity for the terrestrial rodent fauna at the three major study sites

<table>
<thead>
<tr>
<th></th>
<th>Long Point Ungrazed</th>
<th>Long Point Grazed</th>
<th>Governor's Landing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diversity (H)</td>
<td>1.083</td>
<td>1.445</td>
<td>.878</td>
</tr>
<tr>
<td>Evenness (e)</td>
<td>.673</td>
<td>.803</td>
<td>.799</td>
</tr>
<tr>
<td>Richness (d)</td>
<td>.908</td>
<td>1.456</td>
<td>.427</td>
</tr>
<tr>
<td>No. of Species</td>
<td>5</td>
<td>6</td>
<td>3</td>
</tr>
</tbody>
</table>
Table 5. Number and percent of *Peromyscus pectoralis* in each age class and mean weights as reflected by live-trapping studies at Long Point-Ungrazed and Governor's Landing

<table>
<thead>
<tr>
<th>Month</th>
<th>Long Point-Ungrazed</th>
<th>Governor's Landing</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>adults (AD)</td>
<td>sub-adults (SA)</td>
</tr>
<tr>
<td>Jan.</td>
<td>4 (-)</td>
<td>7 (-)</td>
</tr>
<tr>
<td>Feb.</td>
<td>8 (21.51)</td>
<td>7 (17.33)</td>
</tr>
<tr>
<td>Mar.</td>
<td>12 (20.04)</td>
<td>6 (17.00)</td>
</tr>
<tr>
<td>Apr.</td>
<td>8 (20.36)</td>
<td>8 (18.29)</td>
</tr>
<tr>
<td>May</td>
<td>13 (20.50)</td>
<td>3 (19.08)</td>
</tr>
<tr>
<td>Jun.</td>
<td>7 (20.25)</td>
<td>0</td>
</tr>
<tr>
<td>Totals</td>
<td>52</td>
<td>31</td>
</tr>
</tbody>
</table>

% of total population
- Long Point-Ungrazed: 58.43%
- Governor's Landing: 34.83%

Mean Weight
- Long Point-Ungrazed: 20.49 g
- Governor's Landing: 17.78 g

1. Numbers in parentheses are mean weights in grams.

Several aspects of the population demography of *P. pectoralis* were compared between the control site and the campground. More male than female *P. pectoralis* were taken at both Governor's Landing and Long Point-ungrazed, but these deviations were not significantly different from the expected 50:50 ratio at either site. At both sites, adult *P. pectoralis* compromised a greater percentage and juveniles a smaller percentage of the populations than any other age class (Table 5). However, adults made up a significantly greater percentage of the total population at Long Point-ungrazed than at Governor's Landing, and, conversely, juveniles made up a significantly greater percentage of the total population at Governor's Landing than at Long Point-ungrazed. Mean weights of subadult and adult *P. pectoralis* were significantly less (Student's t-test; p < 0.05) at the Long Point-ungrazed site than at Governor's Landing.

**DISCUSSION**

Although two types of impact, livestock grazing and recreational impact resulting from human use at designated campsites and their effects upon two biotic components (terrestrial rodents and vegetation), were monitored in the riparian habitats of BBNP.
and ARA, this discussion will focus on recreational impacts.

Some possible recreational impacts on vegetation in riparian habitats include the following (after Settergren, 1977): (1) mechanical injury to trees on heavily used areas; (2) total elimination of trees in the younger age classes (seedlings and saplings) which results in a reduction in under-story vegetation; and (3) trampling which results in the reduction in the native ground cover both in amount and the number of species represented. Examples of a few kinds of these impacts were observed in our studies at BBNP and ARA. Mechanical injury to trees (such as wood cutting) was observed at several camping sites in BBNP. Furthermore, the occurrence of trees was negatively and significantly correlated with human impact, indicating that as impact increases the frequency of trees (especially the smaller seedlings and saplings) decreases. Our observations at the Governor's Landing campground at ARA indicate that recreationists do not use the entire site uniformly. Rather, they tend to congregate at and move along specific sites and routes, such as picnic benches, sanitary facilities, and the straight-line paths between. The impact of use on the vegetation is almost exclusively limited to these obviously impacted locations. In fact, assessment of vegetation at random points throughout the campground did not reveal any significant differences in ground cover (grasses, forbs, and shrubs) between the campground and the unimpacted control site at Long Point.

Visitor use impacts other than the obvious effects on vegetation and soil compaction (such as seen along trails) are extremely difficult to detect. A number of studies (summarized by Settergren, 1977) have examined changes in vegetation and soil as a result of recreational use, but very little literature is available concerning the impact of concentrated recreational activity on wildlife populations, especially non-game wildlife. The few available studies (Foin et al., 1977; Aitchison, 1977) suggest that human use of a campground could affect, either positively or negatively, the density and diversity of wildlife populations as well as the population structure of individual species, and that different species may exhibit totally different responses to human uses depending on their ecological requirements. A complicating factor in studies of visitor impacts on wildlife populations is the difficulty in separating visitor effects from environmental effects.

Our studies at BBNP and ARA suggest that present levels of recreational usage in the Rio Grande River System have had little significant impact on density of rodent populations. At BBNP there was no significant correlation between subjectively evaluated human impact and density of any rodent species or taxonomic category (i.e., cricetid rodents and heteromyid rodents). Total rodent densities were higher at the campground in ARA than at the unused control site, although some differences in the densities of individual species were apparent between the two study sites. The density of P. pectoralis was about the same at the campground as at the control site, but cotton rats (Sigmodon hispidus) were more common at the campground and woodrats (N. micropus) were more common on the control plot. These differences are probably related to microhabitat differences at the two study sites rather than any component of human impact. Cotton rats are known to prefer dense, grassy vegetation and more of this habitat type was available at Governor's Landing than at Long Point. Woodrats were generally captured in association with prickly pear (Opuntia engelmannii) which occurred in approximately equal abundance at both sites. The differential response of these rodents illustrates the importance of understanding the ecological requirements of species in determining whether or not they may be affected by visitor impacts.

The results of our studies contrast somewhat with those of Foin et al. (1977) and Aitchison (1977) who studied the effects of visitor impacts on wildlife at campgrounds in California and Arizona, respectively. Foin et al. (1977) noted that deer mice (Peromyscus maniculatus) occurred in greater densities at campgrounds in Yosemite National Park than at other places in the park, and they regarded this difference as a clear response to supplemental food sources. These authors also noted that another rodent, the montane vole (Microtus montanus), showed no relation to visitor use. Aitchison (1977) studied the effects of a campground on breeding birds in Arizona over a three-year period and observed that bird breeding densities were similar between a constructed campground and a relatively natural area when the campground was closed to campers. However, bird species composition differed between sites, the campground having relatively heavier bodied birds ($\bar{x} = 48.5$ g) than the control area ($\bar{x} = 38.2$ g).
Once the campground was opened for human use, the breeding bird population decreased in density and diversity; on the control site, the population either remained the same or increased (Aitchison, 1977).

There was no obvious relationship between species diversity and human impact in BBNP, but fewer species (3) occurred at the campground in ARA than at the unused control site (5). However, the two species that occurred at the Long Point control site in ARA and not at Governor's Landing campground were rare at the former site (only 3 individuals captured), and we feel that the differences in species diversity between the two sites was probably not the result of human presence.

Definite differences were observed in the population structure of Peromyscus pectoralis at the campground in ARA as compared to the control site. Significantly more juveniles were in the population at the campground, and the animals of all age classes weighed significantly more at the campground than at the control site. Foin et al. (1977) also noted that populations of Peromyscus maniculatus in campgrounds had a higher preponderance of juvenile individuals than did other populations. These observed differences in population structure could result from secondary or indirect effects of human presence, although it is difficult to conclusively prove this point. For example, one could postulate that animals in the campground weigh more because of the supplemental food source (in the form of food scraps) available to them. Similarly, the preponderance of juveniles in the population at the campground could indirectly result from human presence. Rodents, as primary consumers in the food chain, are preyed upon by various predators such as rattlesnakes, hawks, and coyotes. Because of man's continued presence at campgrounds predators should not be as common there as in other places. Theoretically, younger less wary animals should be more susceptible to predation than the more experienced adults. Consequently, one might expect younger animals to comprise a greater percentage of the population at the campground, where predator populations are probably lower, than at the control site where predators are more common.

The implications of our research at BBNP and ARA are that overgrazing by domestic livestock (particularly cattle) has had a much more devastating effect on vegetation and rodent populations than have recreational impacts. Livestock are attracted to these riparian zones because they prefer the quality and variety of forage available which, because of its moisture content, is more palatable (Ames, 1977). The impact of livestock is more generalized and less concentrated than that of human users. As mentioned earlier, people do not use a campsite uniformly but tend to restrict their activities to well defined trails, showing an obvious reluctance to pioneer new routes through unknown territory. Livestock, on the other hand, do not restrict their movements to predefined paths, and they tend to exert a more generalized disturbance on the ecosystem.

**MANAGEMENT CONSIDERATIONS**

Research has demonstrated that concentrated recreation can alter soil and vegetation in a campground, but the effects on wildlife populations seem to be of a secondary or indirect nature and not primarily related to the presence of visitors. These secondary or indirect effects are difficult to detect and distinguish from environmental effects which are presumably independent of visitors. And, as has been mentioned, impacts of recreationists are greatest, if not exclusively, on the sites where their activities are concentrated. The question of how much of the total resource is adversely impacted is seldom addressed.

Recreation management agencies must consider the cause as well as the effect of visitor impacts, and they must attempt to relate changes in environmental parameters to the number of visitors and the type of use. Therefore, studies are needed which incorporate an assessment of the cause (quantifying and classifying users) as well as the effect (measuring environmental changes) to provide management the necessary information to cope with these problems.

Ecological changes, resulting from visitors may take a long time to become apparent. Furthermore, it is possible that, following an initial change in environmental parameters, very little additional impact will result with increased use. Unfortunately, funds and/or time for impact research are often short, and investigators are unable to adequately answer questions concerning visitor cause and ecological effect. Without time to develop and carry out a research program, management decisions will be based on inadequate information.
This is particularly true of studies relating to wildlife populations, in which the effects of visitor use are often secondary and may require several years of data to detect. Additionally, many wildlife populations undergo cyclic fluctuations and short-term studies can lead to erroneous conclusions about population characteristics.

Several past studies focusing on the impact of recreational activity have sought to identify a recreational carrying capacity, a level beyond which further use is unacceptable. As Schreyer (1976) points out, however, such a single figure is unlikely, even for a particular area under a specific management policy. He suggests that a range of values or thresholds is likely to emerge from which decisions must be made. The research reported here does not seek to establish a carrying capacity. Instead the paper focuses on documenting changes in the ecosystems studied. Any recreational use of a resource will result in some change in resource conditions. The critical task for management is to decide what is an acceptable level of physical-biological change. This requires a value judgment (on the part of management) as to the desirability of changes that are anticipated or have already occurred, i.e., whether there is excessive deviation from the accepted standard for resource quality as specified in the area's management objectives (or their interpretation).

This paper focuses on relationships between human use and environmental impacts; however, in no way intends to ignore the research efforts probing the socio-psychological components of carrying capacity. As suggested by Settergren (1977), recreation managers should also consider how the public perceives the deterioration in terms of the total resource. In response, some managers may argue that since they have the statutory management responsibility, it is their perception, not the visitor's, that counts. Other managers realize that knowing what visitors consider important will also be useful to them in their decisionmaking relative to the "significance" of impacts. For example, visitor sensitivity to some of the human and livestock impacts, investigated by Schmidly and Ditton (1976) were probed by Ditton, Graefe and Mertens (1977). This was done by asking survey respondents the extent to which they were disturbed by identified impacts. The study group did not appear disturbed by any of the impacts considered earlier as the modal response was "not at all disturbed". This can have two meanings. It may be that the specific objects of impact on the riparian zone as measured is in fact not a serious problem or that the impact parameters selected and studied by Schmidly and Ditton, while relevant to managers and researchers as indicators of resource conditions, were not particularly important to visitors and their recreational experiences.

Understanding elements of recreational experiences provided at an area may be just as important as understanding biological components in determining sustainable levels of use. For example, in addition to the impact studies conducted in BBNP reported earlier in this paper, Graefe (1977) found that relatively high levels of satisfaction were found to persist across all identifiable subgroups of visitors who floated the Rio Grande in BBNP. In fact, no identifiable groups of dissatisfied visitors were found. These findings, when taken together with earlier findings dealing with physical impacts, should provide management with a clearer understanding of the existing situation in BBNP. Numerous social scientists are doing research relative to achieving a greater understanding of the complexities of human behavior so the dynamics of the recreational experiences desired can be considered by management. At the least, managers should have knowledge of the extent, timing and patterns of visitor use. Beyond this they need to have an understanding of visitors' perceptions, attitudes and behaviors if they are to be effective managers.

ACKNOWLEDGMENT

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DISCUSSION

Comment: In your paper you indicate that horses have a major impact. Is the situation going to be like the Grand Canyon, where man's impact added to that of horses is going to require one or the other to be severely controlled?

Schmidly: The major problem the National Park Service faces in those riparian habitats in Big Bend are trespass livestock--not just horses but also cattle. They've tried some things, none of which have been politically acceptable, like rounding up all the cattle. But the wealthy Mexican landowners across the river, of course, didn't care for that. I suspect that management will have to do something about these trespass livestock.

Comment: You commented that fewer predators lived in the campground at ARA than at the unused control site. Did you actually take a census of predators at the two sites?

Schmidly: We were not in a position to undertake estimates of predator populations given our budget for the project. So in our constant, everyday activities around the campground, we kept track of the number of predators observed as well as any sign of their presence. We had visual quantification in that sense. We saw more rattlesnakes, for example, at the Long Point site than we did at the campground. We never saw one there. We saw ring-tailed cats, coyotes, and foxes at the Long Point area, but none of these were seen at the campground. Admittedly these are not accurate density estimates, but it is the only way we can quantify our statement.
HUMAN-WILDLIFE CONFLICTS IN BACKCOUNTRY: POSSIBLE SOLUTIONS

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ABSTRACT—Wildlife is increasingly threatened by growing numbers of backcountry recreationists and diminishing wildlands. Biological, sociological, managerial, and popular literature was reviewed to identify the extent of human impacts as well as possible solutions to them.

Although intentional harassment does occur, the major impact results from recreationists who innocently produce stressful situations for wildlife.

Possible solutions to the problem include: people management (spatial, temporal, and behavioral); wildlife management, in the sense of modifying wildlife behavioral responses to certain recreational activities; and habitat modification to affect the spatial distribution of wildlife. These approaches can be used individually or in combination.

INTRODUCTION

The existence of some species of wildlife requiring remote country is being threatened. Wildlands are being consumed by development, logging, and mining. The number of recreationists on the remaining wildlands is increasing at a rate that surpasses the population growth of the nation. The result is a greatly increased potential for the interaction of man and wildlife. This interaction is often detrimental to wildlife, and since the impact is difficult to document, severe or irreversible damage may occur before the problem is recognized.

The problem is harassment of wildlife by recreationists. Harassment, as used here, refers to events which cause excitement and/or stress, disturbance of essential activities, severe exertion, displacement, and sometimes death. Well-fed, healthy animals with ample refuges from disturbance can withstand more harassment than wildlife already under stress from severe weather, malnutrition, parasite loads, birth or nesting, or inadequate security areas. Predators can also produce stress, but predators and prey have evolved together and achieved a level of accommodation.

Intentional harassment is vandalism. Enforced regulation and public (peer) pressure are the only means of controlling willful, destructive activities.

Innocent or uninformed harassment by recreationists is common. It is what photographers, skiers, and bird watchers do—"the good guys." Nevertheless, this harassment may be critical if it occurs when animals are already under stress.

Possible solutions to harassment include people management, wildlife management, and habitat manipulation. Because of the complexity of factors in man/wildlife interactions, managers, using background information, must formulate unique solutions to particular situations.

PERTINENT PUBLICATIONS

Published information concerning man-wildlife interactions can be divided into three categories: popular, sociological and biological. The information cited here was chosen for its applicability to the interaction problem.
Popular Articles

Popular articles include adventure stories from sports magazines, which may provide insights, but cannot be considered authoritative, and biological accounts in National Wildlife, Audubon, and similar publications. Articles such as "Terns in Traffic" by M. Gochfeld in a 1978 issue of Natural History tell how beach users affect colonial nesting seabirds. Weeden (1976), in an article entitled "Nonconsumptive users: a myth", shows how nonhunting recreationists harass various wildlife species. Popular articles like "Bears and People" by Jonkel and Servheen (1977) advise recreationists how to avoid bear confrontations. Popular articles can influence the behavior of people interacting with wildlife.

Sociological Articles

Considerable sociological literature deals with benefits wildlife can provide for man (Hendee and Potter 1971, Hendee and Schoenfeld 1973), and a number of papers suggest that social scientists and biologists together design studies on the interaction of man and wildlife (Clark 1974, Hendee and Potter 1971, Hendee and Schoenfeld 1973). Schoenfeld and Hendee's Wildlife Management in Wilderness (1978) reflects a change in attitude of these authors--from what wildlife can do for man to what can be done to reduce man's effects on wildlife.

Some sociological studies relate directly to the problem of controlling forms of human behavior detrimental to wildlife. For example, methods of modifying human use of a geographical area have been described by Wagar (1975), Trahan (1977), and Brown et al. (1976). These methods vary from subtle suggestion to voluntary compliance to enforced regulation.

Controlling the activities of people involves understanding attitudes. Bart (1972), in a paper rating people's attitudes towards different animals, suggests that positive or negative attitudes toward endangered species may determine whether man will allow a species to survive.

Stephen Kellert (1976a,b; 1977a,b) was contracted by the Fish and Wildlife Service of the U.S. Department of the Interior, to study American attitudes toward animals. Objectives were to understand motivations of people involved in animal-related activities, such as hunting, pet ownership and bird watching, and to determine the social-demographic distribution of these attitudes within the population. Attitudes were analyzed by factors such as sex, race, education, and geographic location. Understanding certain negative or uninformed attitudes about wildlife and the background of the people with these attitudes provides practical information necessary for reducing human impact on wildlife. Policy implications from these data are not yet available.

Biological Papers

Behavior and life histories. Biological papers dealing directly with the effect of man on wildlife are a recent phenomena. Early publications included only peripheral information on the effect of man on wildlife. Altmann (1956, 1958), Dennis-ton (1956), and devos (1958, 1960) presented considerable information on the reactions of wild animals to human intruders, although this was not their specific area of interest. Wright et al. (1933) promoted the concept of joint occupancy of man and wildlife in wild settings in national parks. The authors felt that wildlife should be encouraged to live in close contact with man by the exercise of restraint on man's part, a principle repeated by Welles and Welles (1961), Cowan (1971), Bergerud (1971), Geist (1970, 1975b), and Bart (1972).

There are many reports on the impact of man on nesting birds: osprey, eagles, condors, and colonial nesting sea birds. Nesting failure is usually caused by birds being frightened from nests by man. The solution is to restrict human access during nesting.

Additional concern has been expressed recently about the impact of campsites and trails on song birds (Foin [ed.] 1977, Whitcomb et al. 1976), although this impact is the result of habitat modification rather than harassment from direct interaction with man. Habitat modification is also the primary impact of man on insect, amphibian, reptile, and small mammal populations.

Harassment studies. Harassment studies have usually been observational, although radio telemetry is a valuable tool for recording animal behavior in relation to man-made disturbances. In addition to the use of telemetry to determine locations and
movements of radioed animals, it is also possible to distinguish feeding, resting or rumination, and walking activity in elk from signal modulation (Ward et al. 1973). Recently Ward (1977) has used heart-rate telemetry to determine the reaction of big game to disturbance from vehicles, recreationists, livestock, and other species of wildlife. Telemetry allows scientists to measure alarm or harassment through increased heart rate of running animals and also in animals in which the flight reaction is inhibited. It can also be used to estimate energy expenditures and time required to recover from exertion, and to facilitate testing of methods to mitigate fear and stress. MacArthur addresses some of these possibilities in a paper in press on heart-rate telemetry in bighorn sheep.

Interpretation of heart-rate telemetry data from individual animals to herds, and from herd to herd in different geographic areas, must be made with extreme caution. Other factors, such as individual past experience, herd experience and cover all influence animal responses, and generalizations must be made very carefully.

Geist (1970, 1971, 1972, 1975a, b and c) emphasizes the importance of physiological and psychological stresses on wildlife and how such stresses can compound the impacts of harassment. Geist's concept of habituation (acceptance of man by wildlife) is derived from personal experience gained from living with wildlife and using behavior acceptable to the animals. He maintains that man and wildlife can co-exist if man learns to behave in an appropriately harmless fashion, allowing animals to accept man as a harmless element of their environment.

Studies of the effects of logging on elk (University of Idaho 1976), although not directly dealing with recreation, provide examples of extremes in elk behavior ranging from tolerance of roads, traffic and related disturbing events, to displacement of elk to other areas. These differences are probably the result of the amount of harassment elk have experienced in association with roads, traffic, and logging in addition to the effects of other factors such as vegetation and physiography.

Man-bear interaction. Man-bear relationships dominate the man-wildlife literature because of dramatic appeal and the danger potential. Controversies over bear management in parks have been raging for years (Gilbert 1976); however, some recommendations relating to man-bear relationships have emerged on which bear biologists basically agree (Jonkel 1977a, b, 1978; Jonkel and Servheen 1977; Cole 1974; Stuart 1977, 1978; Herrero 1976a and b; and Chester 1976):

1. Eliminate garbage.
2. Cook and hang food away from camping areas.
3. Avoid surprising bears by making noise in areas of low visibility. Be especially careful when walking into the wind and where there is noise from running water or wind.
4. Do not linger in areas obviously being used by bears.
5. Do not put grizzlies in a position where they feel threatened.

Some biologists and managers feel that outside of parks, limited hunting of grizzlies increases the respectfulness of bears for man and at the same time selectively removes bears which are less afraid of humans.

National park visitor - wildlife interaction papers. Many recent studies in national parks deal with the responses of wildlife to humans: mountain goats in Glacier National Park (Bansner 1976 and Singer 1975); elk in Rocky Mountain National Park (Shultz and Bailey 1978); wolves in Mount McKinley National Park (Chapman 1977); wildlife in Yellowstone and Mount McKinley, respectively (Chester 1976 and Tracy 1977); and caribou in Jasper National Park (Stelfox and Bindernagel 1978).

These authors report acceptance of humans by wildlife in situations where harassment is minimal. Although the degree of acceptance varies, certain species-specific behavior is apparent.

Flight distances from man vary by species but are further influenced by distance to escape cover, and the age, sex, and number of animals. Animals with young are less tolerant of disturbance than groups of mature animals. The presence of man at key locations—wolf dens, desert bighorn waterholes, snowfields used by caribou to escape heat and insects, ungulate migration routes, and salt licks—may be critical to wildlife survival. To avoid conflict, land managers may provide additional protection for
animals with young, and protection of key areas by road or trail design, campsite location, seasonal closure of areas, and information to visitors.

Impact of man on bighorn sheep. Many authors suggest that human encroachment on bighorn sheep habitat has contributed to a decline in sheep populations (Dunaway 1970, 1971a, 1971b; DeForge 1972, 1976; Dixon 1936, Nelson 1966, Tevis 1959, Wilson 1969, Welles and Welles 1961, Woodward et al. 1974). On the basis of Dunaway's proposal (1971a), zoological areas were established to protect the ranges of two sheep herds in the Inyo National Forest, California. Subsequent research (Elder 1977, Hicks 1977) suggested that human disturbance was not as significant as supposed; and management policies for recreationists are now being relaxed, although bighorn management is still a high priority (Wehausen et al. 1977). The authors emphasize that jeopardized wildlife populations necessitate prompt conservation measures—measures that can be modified later if considered unnecessary.

Theses. Various unpublished theses on a wide range of wildlife (birds through big game) contain specific reference to the effects of human disturbance and suggestions for management. For many wildlife species, theses are the only source of information on the effects of human disturbance.

APPROACHES TO PROBLEM SOLUTION

Solutions to man/wildlife conflicts include: people management, wildlife management, and/or habitat modification.

People management

The people management approach must begin with an estimate of the recreationists' understanding of wildlife biology. Stankey (1976) researched the attitudes and knowledge of wilderness users toward fire suppression in the wilderness. He found that the more people knew about the natural role of fire, the more likely their support for a natural role of fire. The policy implications of Stankey's study include the need for public education and involvement, coupled with gradual changes in fire policy.

A similar course could be charted for wildlife-harassment education—an assessment of the level of wildlife knowledge of the recreationists, followed by an education program aimed at improving the wildlife-recreationist relationship. The program could be implemented through schools, clubs, the media, and in national parks and wilderness areas that require permits. Wildlife films for educating school children and groups on the effects of recreational activities would be useful. Training trips could be given. Agency people and outfitters could be required to take courses in wildlife biology that emphasize recreational impact. It should not be considered unreasonable that future users be required to qualify for the right of back-country wilderness use. Wagar, in a 1940 article entitled "Certified Outdoorsmen", suggests this to alleviate the environmental damage caused by novice outdoormen.

Harassment can be reduced if the recreationist understands the impact of his activity and is offered an alternative, one that satisfies his needs without causing stress to wildlife, (Hendee and Burge 1974). Information dissemination at access points can be effective. It should be presented in a positive context and promote separation of people from areas intensively used by wildlife. Trahan (1977) provides examples of success in altering use patterns by the positive wording of signs. Regulations can then be changed during the year as wildlife use patterns change or critical periods pass.

In the winter and spring cross-country skiers can be directed to high country where snow is good and there are not many ungulates. Skiing on winter range during the spring may cause stress during a time when animals may be in a critical condition, and in any case the snow conditions for skiing may be marginal.

An example of a lack of conflict between recreation and wildlife is boating on the Salmon River. The major recreational season is July and August, when bighorn sheep, elk, and deer occupy the high country. Big game winter at low elevations near the river when there is virtually no recreational use. Generally, however, natural separations do not occur. Land managers with whom I have communicated attempt to keep visitors out of calving or lambing areas for the period that those areas are being used by animals. Later when wildlife have moved to higher country, the birthing areas may be used for recreation. In waterfowl refuges, canoeing, tramping, and dog
training may be restricted during the nesting season, but the area may be open for most kinds of recreation the rest of the year. Recreational use of areas near mineral licks during times of big game use could be avoided by providing alternate travel routes or prohibiting camping.

Less direct methods of restricting recreational activities in wilderness include the absence of bridges—likely to keep people out until high water (and, incidently, calving) has passed; the termination of fish stocking of certain alpine lakes—likely to eliminate recreationists whose high priority is fishing; trail-system management aimed at lessening wildlife disruption, either by the provision of alternative trails or by intentionally leaving some areas trailless. However, if these methods fail, enforced regulations are needed.

Wildlife management

Another approach to the harassment problem is the modification of wildlife behavior. Learning by wild animals must not be underestimated. Animals can learn to accept predictable types of disturbance if these events are harmless and do not inflict stress (Geist 1975b, c). Habituation is possible with certain animals in national parks, refuges, and other locations where wildlife live within sight, sound, and smell of highways. In some instances, deer and elk graze along interstate highways, becoming alarmed only when vehicles stop and people emerge. On Isle Royale, wolves have learned to accept the low-flying aircraft of researchers, but in areas where wolves are hunted from aircraft, they are conditioned to seek cover at the sound of approaching aircraft (Mech 1966).

Hunting is not permitted in national parks. With the elimination of hunting pressure, the habituation of wildlife to man's activities is noticeably increased. Still, this habituation requires the cooperation of visitors. Certain wildlife species may prove to be intolerant of certain forms of human behavior, perhaps at key locations, or times of year, and restrictions of those activities may be necessary. Other activities, such as direct approach or eye contact (as in photography), may be universally disturbing to wildlife, and this could be explained as part of the admission process in parks. The Welles' (1961) bighorn sheep study in Death Valley provided a classic example of the habituation of wild animals as a result of man's behaving in a fashion acceptable to wildlife. This study required correct etiquette in all sheep/man interactions, not just the researchers'. Welles and Welles also illustrated the importance of the behavior of individual animals—a product of past experience—in determining the responses of a band of sheep.

In areas outside national parks, alleviating wildlife harassment is considerably more difficult. Possibilities for controlling man's behavior are reduced with multiple access points and the absence of visitor regulation. In addition, animals outside parks usually are subject to hunting pressure, a significant learning experience associating man with fear and stress. Where habitat is adequate, negative habituation may be the best treatment for vulnerable or aggressive species. It is unrealistic to expect human behavioral control or the habituation of wildlife in national forests and other areas outside the national parks. In those instances, the reduction of wildlife harassment requires hard-line enforcement of regulations directing humans away from areas of intensive wildlife use, so as to provide necessary security areas.

Stock and dogs accompanying recreationists have potential impacts on wildlife. Elk tend to avoid grazing with cattle and sheep (Allen 1973, Kruse 1972, McCullough 1969, Skovlin et al. 1968), although this is not a hard-and-fast rule. Pack and saddle stock may inhibit wild ungulate use of meadows, consume feed (most important on winter ranges) and introduce exotic species of vegetation. Limiting stock use, choice of appropriate campsites, control of stock movement, and supplemental feeding of pellets can help in controlling this impact.

Dogs can be damaging to ground nesting birds, young ungulates, and ungulates on winter range (Neil et al. 1975). To prevent wildlife harassment, dogs must be under control at all times. Dogs can have positive effects in backcountry situations, too: they provide companionship, increase man's perception of the natural environment through their reactions to sounds and smells, and may be used as work animals in terrain inaccessible to horses. They may also serve as mobile "early warning system" or occupy an aggressive bear while the owner retreats or takes counteraction (Jonkel pers. comm.).
Smith and Geist (1956) provide examples of how wildlife behavior can be manipulated to enhance survival. A prime example of conditioning captive-raised species is the feeding response of hatchery-reared trout. These fish respond to surface splash disturbances by feeding, an adaptive response in a hatchery situation, but a lethal response after release into the real world of fishermen and predators. Smith and Geist (1956) describe how Bingham, Adelman, and Maatsch recognized this as a behavioral problem and formulated a training program that altered feeding methods and used electric shock to condition fish to avoid a surface splash. The results of their experiment showed that trained trout were caught in approximately the same proportions as native trout, while large numbers of untrained fish were caught the first few days after release.

Smith and Geist (1956) suggest that conditioning of game-farm birds to seek natural foods and avoid predators would improve their survival upon release, as well as provide a higher quality hunt. They emphasize that although it is difficult to image conditioning a wild population, it has, in fact, happened. They use the example of the increasing difficulty of shooting birds as hunting season progresses and birds become educated.

We can all draw examples of animal learning from our own personal experience. Bald eagles and grizzlies concentrating along McDonald Creek in Glacier National Park each year for the salmon run; use of traditional strutting and dancing grounds by grouse; discontinued use of highly desirable habitat because of disturbance; are all examples of conditioning. If biologists and managers could channel some original thinking into animal learning patterns, innovative, effective programs might be developed.

Bergerud (1971) suggests the possibility of modifying caribou behavior through genetic selection. In populations not subject to natural predation, he suggests harvesting unruly animals if animals difficult to hunt are desired, and harvesting wary animals if the desired result is a caribou population for public viewing.

Habitat modification

Finally, habitat modification can be used to manipulate the distribution of wildlife in relation to man. By providing attractive habitat adjacent to areas of human activity and allowing animals to use the area unmolested, habituation could occur. This is already the case in select mountainous locations close to human habitation where ungulates seek new grass in the spring.

Geist et al. (1974) suggest using fertilizers to increase vegetation palatability and attract elk and deer to special public viewing areas. Conversely, fertilizers or prescribed fire might be used to draw elk to areas away from potential sources of harassment. Logging can be conducted in a manner beneficial or detrimental to elk and deer resulting in attracting animals or causing them to abandon areas by reducing escape cover and providing interconnecting road systems that facilitate hunting (U. of Idaho 1976). Road closures can reduce harassment year-around and especially during hunting season, allowing elk to remain in areas they would otherwise leave.

Harassment has purposely been used to drive animals from haystacks to state game ranges where they winter unmolested, without livestock competition.

Finally, regardless of the emphasis placed on academic training, there is no substitute for on-the-ground intuitive reasoning when resolving man-wildlife conflicts. The knowledge of a perceptive land manager who has lived in an area a number of years, has a sound biological background, and familiarity with local recreational patterns, is often invaluable, especially when used in conjunction with the concepts presented above. The problems presented here provide stimuli for needed research and a challenge to land managers.

CONCLUSION

There are no simple, standard solutions to man-wildlife conflicts. In addition to working with people, wildlife, and habitat, the land manager must know the goals of the backcountry recreationist as well as his attitude toward and knowledge of wildlife. The land manager needs a fundamental knowledge of the biology of local species of wildlife. He needs to know when and where the critical periods for individual species occur. Do recreationists cause additional stress? Are wildlife denied important habi-
tat because of recreational use of these lands? Can the situation be improved for wildlife without denying the recreationist's goals? Solutions for man/wildlife conflicts must be reached through consideration of the biological requirements of wildlife, recreationists' goals, management objectives of each particular area, and an effective method of enforcement, should voluntary compliance fail.

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Stuart, T. W. 1977. Exploration of optimal backcountry travel patterns in grizzly bear habitat. 4th Inter. Conf. on Bear Research and Management.


DISCUSSION

Comment: We have a curious situation in Washington, and it might have some parallels in Montana. I wonder if you have discovered any problems relative to floating of the rivers, and conflict with wildlife. In Washington, we have a problem with bald eagles. They concentrate along the river and are frightened away by boaters.

Ream: I'm sure that Riley McClelland, who is working on bald eagles in Glacier National Park, would be opposed to recreational boating in Glacier when eagles are congregated for the salmon run. There's also a thesis on harlequin ducks (Kuchel 1977) which suggests that recreation along streams in Glacier might have an impact on nesting harlequin ducks. As for great blue herons, I have an interesting story to relate. Great blue herons aren't an endangered species, but this is an example. There is a coalition to keep the Flathead River in Montana from being dammed. A conference was held in May this year. As part of this conference 120 or 200 people floated the Flathead River. Two heron rookeries were deserted, apparently as a result of this activity. These were good guys, they were trying to save the Flathead, and heron aren't endangered, but they had started nesting, and they moved. This has also been documented in the case of a researcher climbing into heron nests and counting eggs. As a result, the whole rookery moved and established itself in Nine Pipes Refuge. Birds like Canadian geese and mergansers are really harassed on narrow rivers where there isn't a place for them to get out of the way. When one boat after another comes they are pushed. I don't know what the solution will be to this, unless little refuge side channels could be created.

Comment: Were you dealing with game species?

Ream: No, but's that where most of the literature is. I did have an interesting comment from someone in Canada, who said he had an endemic species of butterfly that occurred only in little pockets, and that they would consider this in the placement of campgrounds, because a campground in the wrong place could wipe out a population of these butterflies.

By the way, big game species tend to be more affected by direct interaction, whereas rodents, birds, amphibians, reptiles and insects are affected more by indirect impacts such as the modification of the structure of the vegetation.

Comment: I think that your ideas about harassment would apply more to large species.

Ream: Mobile species, yes.

Comment: Did you find any studies on the prevalence of bear attacks in the areas where bears are not hunted, like Glacier National Park or other national parks?

Ream: No, but in talking with land managers, I've learned definitely their opinion that in areas where bears are hunted, their respectfulness of man is greatly increased.

Geist: I'd like to make a comment about the positive aspects of hunting. Where you do have a chance to limit impact, where there's no hunting, you can afford to habituate animals. I know in wilderness the thought of taming animals purposely is rather horrifying, but it may have to be done.

The second thing is that there is some-
thing I would just like to throw out, and that is the multi-use activities concept. I think hunting is fine and dandy. I happen to be a concerned hunter, as are others present here. The important thing is that in some areas where hunting can and ought to be maintained, hiking ought not to be maintained. In short what I am suggesting is that we should look much more at the single use; I don't buy this business that multi-use is the panacea that it is often suggested to be. I would suggest that hunting and hiking are not compatible, and that hunting is a perfectly legitimate concern that ought to be maintained, if not increased. Even in the national parks.

Ream: However, I'm sure that we'll be very much outvoted, by New Yorkers and many others east of the Mississippi.
MAN-CAUSED MORTALITY OF COYOTES MARKED IN GRAND TETON NATIONAL PARK

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ABSTRACT--Coyote (Canis latrans) mortality was measured in Grand Teton National Park, an environment assumed to be minimally influenced by man. The valley floor of Grand Teton National Park is approximately 25,600 ha including 2,400 ha of non-federal inholdings. Sixty-eight coyotes, 34 males and 34 females, approximately 4 months of age or older, were collared with radiotelemetric transmitters in 1974, 1975 and 1976. The multiple-use transmitters revealed geographic location of the coyotes and served as mortality indicators. Over the 3 year period, 32 (47%) of the collared coyotes were recovered dead. Man was responsible for 29 (91%) of these deaths: 25 coyotes were gunshot, 1 was clubbed, one was trapped, and 2 were roadkilled. Seven (28%) of the man-caused mortalities were recovered within park boundaries. Five of these coyotes were killed by gunshot (3 in the park and 2 on non-federal inholdings) and two coyotes were roadkilled. Man was the principal mortality agent, both within and outside park boundaries, with the intensity of mortality differing between years.

INTRODUCTION

Historically, management of large carnivores in North America has been oriented toward removal of animals or species whose presence appeared to jeopardize human interests or safety, or toward exploitation for economic or sporting interests. Currently, these same species are in demand for aesthetic and ecologic values. Detailed biological information about these species will provide resource managers with better means for resolving management conflicts arising from various and, frequently, opposing management goals.

The purpose of this study was to evaluate and describe coyote (Canis latrans) mortality in Grand Teton National Park, an environment assumed to be minimally influenced by man.

STUDY AREA

The study area is 25,600 ha of the valley floor of Grand Teton National Park, hereafter, referred to as the park. This area includes 2,400 ha of private inholdings. The valley floor is a flat, glacial outwash plain. Glaciated ridges, terraces bordering the Snake River, potholes formed from melting glacial ice blocks, alluvial fans, and braided stream bottoms contribute to the topography (Love and Reed 1968).

The climate is characterized by long, cold winters and short, cool summers. The area receives a mean annual snowfall of 327 cm and is usually snow covered from November to April. There is an increasing gradient of accumulated snow from the southeast to the northwest. Maximum accumulated snow depths at Moose, near the center of the...
study area, range from 84 to 178 cm (Dirks 1974).

METHOD

Coyotes were captured within the park during the periods 14 May to 6 June and 6 to 19 September 1974, 4 to 24 September 1975, and 21 August to 4 September 1976. Steel traps equipped with tranquilizer tabs (Balsser 1965) were used to capture the coyotes. Each tranquilizer tab contained 500 mg of Tranvet. Young-of-the-year were referred to as pups; others were classed as adults. Ages were assigned by cementum annuli determination (Linhart and Knowlton 1967).

Each coyote was collared with a multiple-use transmitter (Kolz et al. 1973). The transmitter facilitated relocation and provided mortality detection. Individual coyote transmitters were identifiable through combinations of operating frequencies and pulse rates. Upon detection of a mortality signal, a search was made for the coyote. Field necropsies were generally adequate to determine the immediate cause of death. The time, location, and probable cause of death were recorded at the time of recovery.

RESULTS

Over the 3 year period, 68 coyotes (34 males and 34 females) 4 months of age or older, were collared with mortality style transmitter. The composite sample was 30 pups (44%) and 38 adults (56%) (Table 1). Recovered dead were 32 coyotes (47%). The proportion recovered from each marking sample varied from 0.39 to 0.55. A trend may exist between the proportion of coyotes recovered from each marking period and time (months) elapsed from marking to study termination (Table 2). From November to April, 78% of the mortalities occurred. The percentage of mortalities recovered per calendar year (1977 was represented by 5 months) varied from 9 to 44%. Thirty-one percent of the mortalities were recovered in January (Table 3). Seventy-two percent of the mortalities were recovered outside the park perimeter, compared with 28% recovered within the park perimeter (Table 4). Man was responsible for 29 mortalities (91%). The percentage that were killed from gunshot varied from 100% for male pups (N=4) to 50% for adult females (N=6) (Table 5). Seven of the man-caused mortalities (22%) were recovered within the park perimeter. Five of these were shot, two on non-federal inholdings (Table 6).

DISCUSSION

The extent, cause, and timing of mortality have been reported for several other coyote populations manipulated by man to varying degrees. Murie (1940) and Krefting (1969) reported cause of coyote mortality in Yellowstone and Isle Royale National Parks, respectively. Murie (1940) tentatively attributed all known coyote deaths (27 during the period 1936 to 1939) in Yellowstone to natural causes: starvation and disease.

<table>
<thead>
<tr>
<th>Period marked</th>
<th>Age (yr)</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>month</td>
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<td></td>
</tr>
<tr>
<td>year</td>
<td>MALES</td>
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</tr>
<tr>
<td>May 1974</td>
<td>2 3 1 2 1</td>
<td>3 1 1 1 2</td>
</tr>
<tr>
<td>Sep 1974</td>
<td>2 2 2 1 1</td>
<td>2 2 1</td>
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<td>Sep 1975</td>
<td>3 1 1</td>
<td>1 1 1</td>
</tr>
<tr>
<td>Aug 1976</td>
<td>7 1 2 1 1</td>
<td>2 1 1</td>
</tr>
<tr>
<td>Total</td>
<td>12 6 6 2 2 4 2</td>
<td>18 5 3 1 2 2 1 2</td>
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</table>

Table 1. Distribution of radio-collared coyotes by sex, age and period marked
Table 2. Radio-collared coyotes recovered and the time elapsed from marking to study termination

<table>
<thead>
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<th>Period marked</th>
<th>Time</th>
<th>Recovery period</th>
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<td>(mo)</td>
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<td>1975-76</td>
</tr>
<tr>
<td>May</td>
<td>1974</td>
<td>37</td>
<td>3</td>
</tr>
<tr>
<td>Sep</td>
<td>1974</td>
<td>33</td>
<td>7</td>
</tr>
<tr>
<td>Sep</td>
<td>1975</td>
<td>21</td>
<td>6</td>
</tr>
<tr>
<td>Aug</td>
<td>1976</td>
<td>9</td>
<td>9</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>10</td>
<td>4</td>
</tr>
</tbody>
</table>

1 June to subsequent May.
2 From marking to study termination.

Table 3. Time distribution of radio-collared coyote mortalities

<table>
<thead>
<tr>
<th>Year</th>
<th>Month</th>
<th>J</th>
<th>F</th>
<th>M</th>
<th>A</th>
<th>M</th>
<th>J</th>
<th>A</th>
<th>S</th>
<th>O</th>
<th>N</th>
<th>D</th>
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<td></td>
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<td>1975</td>
<td></td>
<td>2</td>
<td>2</td>
<td>1</td>
<td></td>
<td></td>
<td>1</td>
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<td></td>
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<td>9</td>
<td>28</td>
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<tr>
<td>1976</td>
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<td>1</td>
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<td>2</td>
<td>2</td>
<td></td>
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<td></td>
<td></td>
<td>6</td>
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<tr>
<td>Total</td>
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<td>7</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td></td>
<td>32</td>
<td>100</td>
</tr>
</tbody>
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Table 4. Coyote mortalities by location of recovery and relative age and sex

<table>
<thead>
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<th>Sex</th>
<th>Age</th>
<th>in park</th>
<th>in holding</th>
<th>out park</th>
<th>Total</th>
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</thead>
<tbody>
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<td>Pup</td>
<td>4</td>
<td>4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>Adult</td>
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<td>9</td>
</tr>
<tr>
<td>Female</td>
<td>Pup</td>
<td>1</td>
<td>12</td>
<td></td>
<td>13</td>
</tr>
<tr>
<td>Female</td>
<td>Adult</td>
<td>2</td>
<td>3</td>
<td>1</td>
<td>6</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>5</td>
<td>4</td>
<td>23</td>
<td>32</td>
</tr>
</tbody>
</table>
Krefting (1969:30) noted that the decline of the coyote population on Isle Royale coincided with the introduction of the timber wolf. He speculated: "A reduced food supply and direct killing by wolves are the factors that probably contributed most to the coyote's disappearance. A combination of these and other factors including the fact that it was an island situation probably was necessary to cause extinction." In Yellowstone and Isle Royale National Parks, man was not directly responsible for any of the coyote mortalities noted.

Clark (1972), Hawthorne (1971) and Knudsen (1976) described coyote mortality patterns of populations that were exploited by man. The basis of most coyote mortality studies has been the recovery of tagged coyotes. Hawthorne (1971) recovered 23 ear-tagged coyotes (23%) in northeastern California during the period 1966 to 1969. Light to moderate coyote exploitation practices were assumed in effect. Clark (1972) recovered 51 ear-tagged coyotes (30%) in the Curlew Valley astride the Utah-Idaho border during the period 1966 to 1970. Knudsen (1976) used radio transmitters as a marking technique in the Curlew Valley and recovered 48 radio-marked coyotes (52%) in 1972 and 19 (58%) in 1973. Moderate to intense coyote exploitation practices were in effect in the Curlew Valley. Man was directly responsible for 96, 97, and 98% of the marked coyote mortalities recovered by Hawthorne (1971), Clark (1972) and Knudsen (1976), respectively.

The percentage of man-caused mortalities recovered in our study in Grand Teton National Park, 91%, is comparable to mortality in exploited populations. However, man-caused mortalities recovered within the park, 22%, is less than man-caused mortalities recovered outside the park, 78%.

The study area is not legally classified as wilderness; however, the fauna, including coyotes, of national parks are legally protected from hunting and trapping.
Schoenfeld and Hendee (1978:77) state, "Scientists particularly tend to view the ultimate worth of Wilderness [legally classified] as residing in the scientific value of the undisturbed, and they know hunting can mar the usefulness of wild areas for certain kinds of ecological research. From their perspective it is fortunate that national park wilderness is immune to the gun."

The interaction of coyote biology, the juxtaposition of land stewardship patterns and the varied human perceptions of coyotes had effects on the park coyote population mortality pattern. Coyotes marked in the park that subsequently became nonresidents (temporary or permanent) of the park had mortality patterns similar to other coyotes exploited by man.

REFERENCES CITED


ACKNOWLEDGMENTS

The project was supported financially by the U.S. Fish and Wildlife Service through the Massachusetts Cooperative Wildlife Research Unit (Contract No. 14-16-008-1120). Wendell Dodge and James Kennelly provided administrative support and expertise in many aspects of the project. The National Park Service cooperated with and supported the study in many ways. We appreciate the efforts of Lloyd Loope, biologist, who initiated the Park Service's involvement. Also, we express our appreciation to Gary Everhardt, former Grand Teton National Park Superintendent, and Superintendent Robert Kerr for project approval and support. We wish to express our deepest appreciation to biologists William Barmore and Peter Hayden, and resource management specialist Robert Wood, who provided facilities, material, and advice. James Barmore and Kelly Rubrecht, research assistants, performed highly conscientious and creditable tasks. Wells Stephenson, project trapper, was responsible for capture of the coyotes. This brief mention does not indicate the extent of his contribution to the project.

Reference to trade names does not imply endorsement of commercial products by the federal government.

DISCUSSION

Comment: How do you age coyotes?

Tzilkowski: We extracted a lower first premolar, decalcify it, and counted the cementum annuli, tooth density "rings" in the cross-section.

Comment: How much mortality occurred as a result of your study?

Tzilkowski: One coyote may have died as a direct result of our work.
MANAGEMENT AND IMPACTS OF ROADS IN RELATION TO ELK POPULATIONS

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ABSTRACT—Wildlife managers need to understand the effects of harassment on survival, growth, behavior, and reproductive success of wild animals. Harassment may be defined as any activity which increases the physiological cost of survival or decreases reproduction.

Roads have become a subject of controversy with respect to many aspects of land management. Roads affect elk by directly removing habitat from production and indirectly by producing vehicle disturbance. A single lane road 6.7 m wide removes 1.1 ha per mile from elk production. A double lane road 10.36 m wide removes 1.7 ha per mile from elk production.

Elk were documented to move 250 m to 4 km from logging and road construction. Elk use out to 804.6 m declined 154 percent for main roads, 108 percent for secondary roads, and 33 percent for primitive roads. Using 250 m as the zone adjacent to roads avoided by elk, 80.6 ha of habitat is removed from elk production.

There is a need to create an awareness about roads in relation to environmental effects and an urgent need to consider roads in terms of long range productivity.

Within the past decade, one factor has become vividly apparent to the resource manager and administrator, namely change in response to man's shift in cultural, social, and economic needs, rather than in the sense of technological advancement. The problems faced by the land manager today are not the problems present last year and our solutions must change. This cycle of problem and solution will continue as the desires of the public continue to change. This is not a situation peculiar to one single facet of land or animal management but rather a concern common to all disciplines from engineer to biologist.

From a biologist's point-of-view, perhaps a personal view, the change has been traumatic. The continuous thread of our education and practice has been production of the maximum number of animals consistent with the habitat and utilization of the surplus through scheduled harvest. However this is not a situation unique to wildlife management. Pressures for maximum sustained yield are present in the disciplines responsible for the production and management of wood fiber, recreational opportunity, water, red meat, and wilderness.

The challenge for production has been made by the public we serve and responsibilities identified by the policy makers and administrators. To most land managers, the term production takes on corporate structure identity, but this is not the case with the administration and management of public domain. Resource production on these lands is very complex, frequently unique to the particular situation and very unforgiving when the course of action ignores the ecological constraints of the land.

Our foremost responsibility is to define the resource production capabilities of these lands and, perhaps most importantly,
the alternatives and options available to the land manager in achieving a mixture of products. The claim that new undiscovered resources will be developed on uncharted lands is no longer valid.

Wildlife managers are becoming more aware of the need to understand the effects of harassment on the survival, growth, behavior, and reproductive success of wild animals. A broad definition of harassment, for our purposes, is any of man's activities which increase the physiological cost of survival, decrease successful reproduction, or decrease the usefulness of habitats, or all three. Some of the activities which affect wildlife or their habitat are: off-road vehicle use, all-terrain vehicle travel, snowmobiling, cross country skiing, construction and habitation of summer/winter cabin sites, urbanization, mining, power line construction, hiking, oil development, water development, camping, boating, logging and road construction.

The great diversity of man's activities on public lands may result in an even greater diversity of impact on wildlife and their habitats. A single backpacker hiking through the Eagle Cap Wilderness probably has negligible impact on the sheep, goats, and deer inhabiting the area, but the cumulative effect of many such trips is much greater. Some activities place only subtle physiological stress on the animals, while others can destroy entire populations. Whether the impact is direct or indirect, the consequences must be identified and accounted for by management.

The Pacific Northwest is unique in respect to land ownership and the juxtaposition of population centers, forests, and waters. The maritime climate favorable to conifer production is also very habitable for humans. And these same lands and waters provide people with a place to recreate.

Just two decades ago, many of the wild ungulate populations within the conifer zones of Washington and Oregon were inaccessible by motorized vehicle. Forest roads were considered an investment necessary for providing access to bring timber stands under management. Biologists viewed roads as providing better hunter distribution and big game harvest. Wildlife managers were unaware of the direct impacts of roads on deer populations or the indirect effect of vehicle travel within ungulate population centers. Since that time, roads have become a subject of controversy relative to various concerns of land management.

In the past decade the relationship between ungulate populations and roads has been the subject of study by state wildlife management agencies, by the USDA Forest Service, Bureau of Land Management, and the Federal Highway Administration. The Oregon Department of Fish and Wildlife in cooperation with the U.S. Forest Service, Pacific Northwest Forest and Range Experiment Station and the Umatilla National Forest initiated the Bobsled Study in 1969 to document the effects of timber harvest and road construction on elk and their habitat. The objective of this study has been to define impacts resulting from road construction and habitat changes and develop alternatives to present forest management systems and road construction techniques.

It has been documented that roads affect elk populations directly by removing elk habitat from production and indirectly by inducing a disturbance factor, vehicle traffic and people, which displace elk from habitat adjacent to roads. This perhaps is the most important wildlife impact from access development. The cause and effect relationship between vehicle disturbance and big game populations is evident. The vehicle traffic represents forest visitors pursuing several forms of recreation, which may vary from camping to mushroom picking. These forms of visitor-days-use occur almost spontaneously with access development, and each represents to the individual a valid form of forest recreation. The resource manager is in the position of making "trade-off" decisions in regard to access development, type of recreation use, and time of use. These decisions are primary to establishing multiple use objectives.

The direct removal of forested habitat from production is a significant factor in northeast Oregon. A single-lane road 6.7 m (22 feet) wide, including cut and fill, removes 1.1 ha (2.7 acres) per mile from potential production, whether that production is projected in terms of elk habitat or timber. A double lane road 10.36 m (34 feet) wide, removes 1.7 ha (4.1 acres) per mile from production. In Newfoundland it was reported that roads remove 5-10% of the productive cutover area permanently from production at the time of first harvest and subsequent harvest could increase this loss (Sidhu and Case 1977).
During road construction we found elk use declined adjacent to the disturbed area for a distance of 1,500 m. Beyond that distance there was no significant difference between pre-disturbance and post-disturbance levels of elk use. Elk use declined 82% in a 1,000 m zone adjacent to the disturbed area, 57% in the next 250 m zone and 20% in the peripheral 250 m zone. In Idaho, elk were reported to avoid primary and secondary roads for a distance of 400 m and elk use seemed to decline in proportion to road density, intensity of use, and season of use (Hershey and Leege 1976). In Wyoming elk preferred to stay 400 m away from moving traffic on Interstate 80 and forest roads (Ward 1976). Data from Colorado demonstrate that elk pellet group density increased at 400 m from roads with higher correlation coefficients for paved and gravel roads than dirt roads (Rost and Bailey 1974). In Washington it has been reported that elk use from the road edge out to 804.6 m (1/2 mile) increased 154% for main roads, 108% for secondary roads, and 33% for primitive roads (Perry and Overly 1977).

It has been demonstrated that forest roads and associated use have an impact on deer populations. It is also fact that timber management and road construction will continue to play an important role in big game habitat modification, and that public benefits as a result of developed access to forest lands will continue to play an important role in land management decisions.

Previously, the important variables considered in road design have been the economics of construction, the economics of hauling logs, safety, and anticipated traffic volume. In some situations, road design and construction have exceeded site factors. As a result roads have been constructed at some expense to associated environmental and social values. In those forested areas where ungulate populations, elk and deer, provide valuable recreation opportunity, road-design alternatives should be used to reduce impacts to big game populations. We need to create an awareness about roads and the impacts these structures have on associated forest resources. And there is an urgent need to consider roads in terms of long-term land productivity. In the past 1.62 ha (4 acres) per mile of road may have been an equitable trade-off, but can we afford to make that trade-off in the future?

What are some of the alternatives to consider as input to present road design standards if ungulate populations are to be managed as a forest product?

1. Road density, location of roads, use intensity of a particular road, class of use, and season of use are factors which independently or in combination may constitute significant disturbance factors affecting elk.

Elk habitat requirements should be identified on a local basis and used as a basic input to every road system plan. To increase available summer range currently denied elk by persistent vehicle disturbance, existing road systems should be evaluated to determine the feasibility of initiating either closure or abandonment procedures. Results of the Chesnimnus Road Closure Study (Coggins 1975) suggest road closures can also be implemented during elk season to: (1) reduce elk harassment, (2) significantly affect hunter participation, (3) increase esthetics of elk hunting, and (4) possibly increase or decrease harvest rate over time.

2. It has been documented that during active road building, elk have moved 250 m to 4 km from the activity depending on topographic barriers, logging intensity, size of the area being logged, size and shape of the drainage, and time (season) of logging. Planned timber sales on summer range should be confined to specific areas (drainage, ridge) for one year or less with re-entry periods scheduled at minimum 5-year intervals. Security areas should be provided adjacent to active sales recognizing that ridge lines (topographic barriers) are of prime importance in maintaining the integrity of the security area. Security areas should be inviolate; this may require initiation of area closures. Security areas should be mutually agreed upon by regional biologists and timber management personnel after an on-the-ground examination.

3. During the Bobsled Study, elk movement corridors (travel lanes) were identified and correlated to cover and minimum resistance zones (MRZ). An MRZ was defined as a topographic feature which offered the least amount of resistance to elk movements, i.e., canyon bottoms, saddles, ridgelines, contour travel routes. Plans for road design location should include known elk movement corridors, and provision should be made to protect these movement lanes by: (1) maintaining security cover, (2) minimizing cuts and fills, (3) minimizing right-of-way
clearing, (4) avoiding long road tangents, and (5) preventing accumulations of roadside slash in excess of .46 m (1.5 feet) in depth (Lyon 1975, Leckenby personal communication).

4. Data from the Bobsled Study demonstrated that streamside vegetation of the riverine mixed forest (type 15) was one of the most valuable elk habitats in the Blue Mountains. Every effort should be made during the planning and on-the-ground survey period to identify streamside zones, springs, seeps, and other mesic sites. These sites should be maintained inviolate of road construction and logging which remove this habitat from production.

5. Natural meadows, important as forage areas, should be excluded from road construction. Roads built adjacent to meadows should be screened, either by distance or by vegetation sufficient to provide security cover for elk using the forage areas.

These alternatives, although based on data from several research efforts, should not be considered the final product. Together with input from associated disciplines, they should be considered a portion of the input to be evaluated in the planning of timber sales and road construction projects. Additional research is needed to identify still other alternatives, and implementation is urgently needed to generate data on the effectiveness of each alternative.

REFERENCES CITED


DISCUSSION

Comment: Could you define that corridor where you mentioned the elk stay away from the road, 250 m to 400 m? Is that a corridor 250 m wide or do you mean 250 m on either side?

Pedersen: That was 250 m on either side of the road.

Comment: Can you break that down into different classes? I didn't quite catch the whole thing about you breaking down the paved roads, dirt roads and so on. What were the distances? Did the elk stay farther away from dirt roads, or did they stay farther away from paved roads?

Pedersen: The citation I mentioned was from the recent publication of Perry and Overly in Washington. They said elk use from the road edge out to one-half mile was reduced 154% for main-haul roads, 108% for secondary roads, and 33% for primitive roads. This is an example of the correlation that has been established between the type of road and the effect of that road on elk. In this example the paved road had more impact on elk than did the primitive dirt road.

Comment: Wouldn't that be pretty much correlated with traffic volume on the road? Can you separate the amount of traffic from the type of road?
Pedersen: Certainly, there has been a strong correlation established between volume of traffic and ungulate reaction. There is another correlation, and that involves the type of road and the amount of traffic.

Comment: For a given level of traffic, though, do you think the relationship would hold in terms of general patterns?

Pedersen: I do believe there is a general relationship. For example, with the same volume of traffic over a gravel surfaced road and a primitive dirt road, the impact from the gravel road traffic will be greater. This is related to the intensity of sound produced by the vehicle. There are data which indicate that in certain situations ungulates apparently adapt to vehicle traffic and this is difficult to measure.

Comment: How do you feel about the road closures in Montana where there is a locked gate and the road is closed to the public but open for all Burlington Northern employees. Occasional traffic perhaps isn't as detrimental as continued traffic, but during hunting season, it's essentially open. I realize there is no trouble when there is no traffic on a road, but what do you feel about these closures? Are they adequate?

Pedersen: There are at least two types of road closures that I know of in Oregon. First, I would like to comment on one statement that you made that I disagree with. I stated that I was not concerned about a road without associated traffic when we are considering a disturbance factor. But, when we remove 4.1 acres of land from production for every mile of road I become concerned.

The first type of road closure program being used in Oregon involves a closure program for a specific time period and these usually involve deer and elk seasons. Such a program is being used in the Chesnimnus unit, Ochoco National Forest, and the Umatilla National Forest. When these areas are closed they are closed to all entry. The exceptions are that administrative personnel may enter the area in pursuit of violators, in case of emergency, or for animal salvage. Entry into such an area by agency personnel with keys to the gates or signed vehicles creates public relations that undermine the entire program. I would say, based on our experience in Oregon, that the situation you describe is not adequate. The second type of closure is an area closure. Within this type of closed area no entry is permitted by the public or by administrative personnel.

Comment: Are these enforced outside the hunting season?

Pedersen: In some area, yes, there are area closures and they are enforced.

Comment: But you may have administrative traffic on your closed areas?

Pedersen: In the situation where the land is closed by an area closure, administrative traffic is not allowed. Within the road the road closure areas, such as I mentioned previously, administrative traffic is allowed. But, such traffic is closely controlled and entry must be for a specific performance of duties.

DURING THE SUMMARY SESSION a number of comments were made about wildlife-road interactions. Following is a summary of those comments.

There appears to be some depression of elk use within certain distances of roads, and it depends on the type of use on the road. Elk may habituate to a particular traffic flow, as on an interstate highway, but may be disturbed by traffic that leaves or stops on the highway. The type of road (paved, gravel, or jeep) may also influence the elk effect. Timing appears to be an important factor, too. For example, a particular road system may be of little significance most of the year to elk, but if its use coincides with a calving area a very undesirable impact can result at that time. While impact depends on many factors, it can be explained by looking at how those factors interact in a given area.
user groups
GUIDEBOOKS -- FOR BETTER OR FOR WORSE?

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ABSTRACT—This paper focuses upon the effect of publishers' purposes on the contents of guidebooks, some of the problems of responsible guidebook publishing, the relationship between increased backcountry use and the proliferation of guidebooks, what guidebooks can and cannot be expected to do, how guidebooks can be used to disperse use and educate the user, and some trends—past, present and anticipated—in techniques of use.

Discussions over the past 10 or 15 years about the relationship between increased backcountry use and the proliferation of guidebooks have not really demonstrated a definite cause-and-effect pattern. However, in the absence of scientifically documented evidence, common sense indicates some judgment can and must be made about what guidebooks can and cannot be expected to do, and how guidebooks can be used to disperse use and educate the user.

Before I say anything about the effect of guidebooks, I would like to tell you a little about the effect of publishers' purposes on the contents of guidebooks, and some of the problems of responsible guidebook publishing. Books are written by writers, some more conscientious than others about the contents of their books and their possible effects. However, like the old saying that an attorney is a lawyer with a case, an author is a writer with a publisher. Publishers, and the set of convictions they work from, or lack, have considerable influence on the quality and content of books that you will find on the market. An author therefore normally seeks a publisher into whose line his work will fit, because that publisher will have developed a sales network to market his particular kind of book effectively. Harold Robbins does not send his new manuscripts to National Geographic.

To illustrate the relationship between publishers' premises and the contents of the guidebooks they publish, I'd like to give you a little background on The Mountaineers' program, because that's where my experience has been, and because we have all the same problems other publishers have, as well as some significant differences.

The Mountaineers were organized in 1906 "To explore and study the mountains, forests, and water courses of the Northwest; to gather into permanent form the history and traditions of this region; to preserve by the encouragement of protective legislation or otherwise the natural beauty of Northwest America; to make expeditions into these regions in fulfillment of the above purposes; to encourage a spirit of good fellowship among all lovers of outdoor life." Purposes like that can cover a multitude of sins.

Among their other activities, The Mountaineers developed a very successful climbing course. Eventually the need for a text for this course resulted in the first edition of Mountaineering: The Freedom of the Hills, published in 1960. It was followed in 1966 by 100 Hikes in Western Washington "to share some of the experience gained in the past 60 years with the broader community of valley-pounders, ridgerunners, and hillwalkers beyond the current membership of The Mountaineers." The membership at that time totaled around 5000; today it is approaching 10,000.

The Mountaineers • Books, as the program has come to be known, recently published its 67th title; 44 are still in print. (Not all these are guidebooks; the list includes a selection of history, natural history, and reprints of classics in mountaineering
literature.) But as the program grew, it never lost sight of the fact that The Mountaineers are primarily an outdoor-activity oriented group with a strong conservationist philosophy.

In April 1972 the Board of Trustees of The Mountaineers established an ad hoc committee to study and make recommendations on the Club's publication policy. Input was solicited from the membership and from land management agencies. The report of that committee, completed in September 1974, recognized the reality of the outdoor recreation explosion and guidebook proliferation, but concluded in summary: "Many factors have contributed to the increased participation in outdoor recreation. While in this area the recreation explosion coincided with the publication of guidebooks, it occurred also in areas for which no guidebooks were published. It is impossible to separate out the effects of the publication of guidebooks from the effects of the many other factors contributing to the recreation explosion." Pursuant to this conclusion the Board passed a resolution in October 1975 recommending no specific guidelines, but adopting general principles of the report, i.e., "Mountaineer guidebooks shall encourage dispersal of users and discourage activities which (1) lead to permanent alteration of the natural landscape, flora, and fauna, and (2) lead to diminishment of the wilderness experience." So much for the internal debates and soul-searching of one organization. The American Alpine Club and the Sierra Club carried on similar debates.

Some other publishers, the Sierra Club and the Appalachian Mountain Club, to mention two, work from these or similar premises: that guidebooks are not an end but a means to help preserve and protect wildlands. At the other end of the spectrum is the publisher who looks at the market potential only, for whom the sale and profit are the ends. And there are manuscripts available to profit from, for there's a new breed of prospector afoot in the mountains, a breed who have found if you can't get gold out of the mountains with a pick and shovel, you can still get it out with a typewriter. I don't mean to suggest that there are the good guys and the bad guys; without some profit on one book there's no money to do the next one. But the consumer, looking at an array of books in a store, may not realize the philosophy or concerns behind some of them.

Eighty years ago when the Press Expedition set off from Seattle to cross the Olympic Mountains, no white man had ever even seen what lay in the interior of the range. These hardy explorers had no maps and no guidebooks, and when they miscalculated the direction the Elwha River Valley seemed to be taking, they wound up in incredible amounts of difficulty. Their error is so obvious on
the map, but that's called 20-20 hindsight. In contrast to those good or bad old days, depending on your point of view, there is a wealth of information available today.

One recently issued catalog of outdoor publications contains 70 pages of books on backpacking and camping, first aid and survival, food foraging and cooking, orienteering, nature study and ecology, winter camping, skiing, snowshoeing, mountaineering technique and narratives, caving, canoeing, fishing, photography, and history, besides hiking guides to the entire world, from Kauai to Cape Cod and from the Turkish coast to Nepal. There are 246 titles listed in the hiking and climbing guides sections alone, and I know this isn't complete because not all The Mountaineers Books titles are listed.

So the people are out there, and the books keep rolling off the presses. What can we reasonably expect them to do? The front matter creates opportunities to educate wilderness users. We write nice educational forewords; we hope people read them; we hope people learn from them. I'm not sure we can count on it. Personally I suspect that if forewords get too preachy, people skip them, so I think it is more effective to encourage good wilderness practices by working subtle reminders directly into the text.

One of the obvious ways to control use is to select trails and/or destinations which disperse use, and to not include those which have been or might become overused. Short of personally walking each trip, one has to rely on the author's judgment and integrity and his reputation for doing his homework, but editorial suggestions are in order, say if a particular area already has a reputation for overuse. Few commercial publishers have the time, the staff, the expertise, or even the motivation to check out these things.

Lower elevation hikes can be encouraged on lands where trails and vegetation are less fragile and recover from bootstomping more quickly. This is the idea behind the new Footsore series by local author Harvey Manning.

 Sometimes circumstances create an opportunity to point out where practices could be improved. We are all familiar with the fact that the earth is usually beaten bare at the point where a trail arrives at a lake. Most people get that far and drop, and camp in the first obvious place. A guidebook can recommend campsites farther from or farther along the lake, or in less fragile or overused locations. A description of a trail may mention where switchbacks have been cut and warn against that practice. Where firewood has been depleted stoves can be recommended. Smaller parties can be encouraged to lessen impact.

There are certain difficulties inherent in publishing guidebooks. First of all, conditions can change before you get the information into print. We at The Mountaineers • Books require our authors to clear their information with the land management agency concerned. I don't know to what extent other publishers do this. Even so, by the time the manuscript gets from the supervisor's desk to the backcountry ranger who walks the trails, and back to the author again, and finally into print, the material may already be out of date.

There has never been a way to objectively evaluate the condition of an area, or to determine if that condition is improving or deteriorating. The trails inventory project is a step in this direction, and the Forest Service is doing some studies. I met a backcountry ranger in the Alpine Lakes Wilderness Area this summer. He was counting fire rings and estimating square feet of bare earth at lakes to develop a baseline for evaluation of use. This is the sort of basic information that is needed in planning guidebook coverage.

Keeping guidebooks current with user regulations is a real headache. For what areas are permits required? Where are permits obtained? How do you plan for permits next month when you don't know if it will be raining next weekend? Sometimes the managing agency cannot say for sure what the regulations will be next season, let alone in a few years. The economics of book publishing are such that to keep costs down, a practical publisher must print a two- or three-year supply, knowing the regulations may well change more than once before all the copies are sold. At one time there was a discussion of making travel on the Wonderland Trail around Mount Rainier one way so that parties would not encounter each other so often and would have more of a feeling of solitude. I don't think the Park Service had any idea what a worry that rumor was to guidebook publishers and authors.

So far we have been discussing what may be generally described as where-to-do-it
books. How-to-do-it books are subject to the same problems of cost-effective runs vs. oversupplies of out-of-date books. Techniques change rapidly. In 1934 Geoffrey Winthrop Young, in his classic work Mountain Craft, stated: "For bedding, a couple of blankets are all that is required in fine weather; spruce boughs make a perfect mattress." The first and second editions of Mountaineering: The Freedom of the Hills (1960, 1967) allowed that in remote regions, a few branches from any one tree or preferably windfalls might be used, but that boughs should be scattered or burned after use. The third edition (1974) stated that "the destruction of alpine plants and the strewing of resultant dead foliage are so repugnant that bough beds are not considered an alternative except in the direst of emergencies...Modern materials are so light, versatile, comfortable, and inexpensive as to render bough beds obsolete."

A similar trend is observed in the matter of building wood fires. Early works earnestly described the best kind of fuel, where to find dry twigs, how to keep matches dry, how to lay the kindling, and so on. Native wood fires are discouraged in many areas, now, if not entirely prohibited, and most camping technique books admit they are aesthetically pleasing, but stoves win hands down for efficiency and reducing impact on the land. Besides, they don't get your cooking pots all sooty.

There are, I think, three general types of users. There are those who would, either instinctively, or through training or common sense, do the right, the ecologically sound thing, and leave very little trace of their progress through wildlands. There are those who will always turn their kids loose with bugles and hatchets. The idiot and the irresponsible, like the poor, will always be with us. Somewhere in between these two extremes is the large group of users who know not and know they know not. They are willing to do it right, if someone will take the time to tell them how. Authors and publishers have a great responsibility to the public schools, Scouts, YMCA and church- and park-affiliated recreation programs.

As publishers, we have figured out what to tell people about bough beds and native wood fires. But what should we tell them about disposing of solid human wastes in winter? In the summer the recommended solution is to bury them in a few inches of soil and let nature take its course. That's not practical when you are traveling or camping on five or ten feet of snow. The best advice I know is to avoid what will be open water in summer and burn the used tissue. Perhaps with the dilution of melting snow, these measures are enough for the present. However, with the current upswing of interest in winter travel, we may find them inadequate in the future. More drastic measures may have to be instituted, for example, packing out solid human waste. Another possibility would be the development of a counteractive or neutralizing chemical additive.

When I started hiking back in the early 1950s tricouni nails were on the way out, and lug soles were the coming thing. Now it is becoming apparent that the deep lugs create considerable erosion without providing significantly increased traction on many sorts of terrain. I was out on the new section of the Pacific Crest Trail north of Snoqualmie Pass last Labor Day weekend. It was one of those typical Pacific Northwest days when you are in and out of rain gear half a dozen times in the course of a morning. We left the trailhead quite early, but by late afternoon, when we returned, the amount of wear and tear on the trail, in just one day, was striking. As publishers, should we recommend shallow treads or level soles?

And what do you tell a responsible, wellmeaning hiker to do when confronted with a trail-wide hog wallow? It starts in a damp spot, so the first few people who come along step beside it. The next few have to step a little wider, and after a while it can only be avoided by a network of side trails through the brush. New trail construction techniques such as raised, hard surfaced walks may be necessary, even though expensive, because the alternative is to post a guard at the trailhead to warn everyone to bring his or her own pontoons.

I think I may have raised more questions here than I've answered. But no one editor or committee of editors can be expected to know all the answers. We have to have help from you--the users and the managers and the researchers. Please let us hear from you. Thank you.

DISCUSSION

Comment: It was interesting to me that you said you try to pick areas to disperse use rather than including heavily impacted areas.
My perception of the guidebooks is that all those hikes in the guidebooks are probably really heavily used, and if I want to go where I won't see people I pick someplace that's not in the guidebooks.

Ferber: It's indeed possible to refer to guidebooks to choose a destination which is not included so as to avoid well known areas. The trick is knowing enough about a region and the available guidebooks to find one that is not described (there are some, but they are getting scarcer). However, I think the principle still holds, that if a book is published with a hundred choices, use will be dispersed more effectively than if everybody goes to the one place that was described in the last Sunday supplement.

Comment: What other kinds of guidebooks are there? For instance, the off-road-vehicle and horse people have guidebooks. You're talking primarily about hiking guidebooks, but there are other categories that add to impact. I'd like your view on that.

Ferber: In The Mountaineers • Books line there are books like Trips and Trails which list destinations reached by road, mostly backroads, and hiking and climbing guides that include trails and cross-country travel but only mention roads insofar as they get one to the start of a trail. I don't know what is available to ORV and horse people. I suppose the amount of impact these would cause would depend on where they directed the users and the sensitivity with which they were written. (Comments were made by several people in the audience expressing awareness of some material available for 4-wheel drive vehicles, snowmobiles, etc.)

Comment: Do The Mountaineers have a policy on publishing guides to undeveloped, off-trail, crosscountry routes?

Ferber: The Mountaineers' stated policy is, "Mountaineer guidebooks shall encourage dispersal of users and discourage activities which (1) lead to permanent alteration of the natural landscape, flora, and fauna, and (2) lead to diminishment of the wilderness experience." We may indeed include a cross-country route if necessary to get to the base of a climbing route, but we do not try to make them attractive as ends in themselves. In some cases where de facto trails were not constructed nor maintained by the land management agency but exist from long-established usage, they may be included as a lesser evil than sending people out to develop new way trails.
AN EDUCATIONAL ALTERNATIVE: PRACTICES FOR USERS

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ABSTRACT--This paper describes practices for users to minimize visual and biological impact from recreationists. It includes suggestions for campfire building, camping, sanitation, and other activities. The techniques were developed and tested by students and staff of The National Outdoor Leadership School, for use in the high altitude wilderness areas of the Central Rocky Mountains of North Western Wyoming, and are being adapted for use in a wide range of areas.

INTRODUCTION

This paper is a description of some techniques for minimizing the visual manifestations of impact caused by dispersed recreational users, the wilderness hikers to areas not serviced with established campgrounds. These practices were developed for summer backpack use in wilderness and primitive areas of the Central Rocky Mountains by the Staff of The National Outdoor Leadership School (NOLS) in Lander, Wyoming.

An important requirement in the design of these techniques was to create a change in user behavior while interfering as little as possible with the fulfillment of each user's intentions in participating in wilderness recreation. Thus, they are useful for hikers, climbers, photographers, groups or individuals.

HISTORY

NOLS was founded in 1965 as a training center, an educational facility to prepare individuals for careers as teachers and instructors for all types of outdoor programs. The school recognized a dual purpose in the classification and values of wilderness remain for future generations; and a recreational goal, reflecting the belief that land of wilderness character is an appropriate location for recreational opportunity.

Our task was to train students in a series of techniques and attitudes which provide a solution to the obvious conflict between these two goals. With the tremendous increase in backpacking popularity, however, we realized that our courses were insufficient to limit resource deterioration.

Our concern led to a series of experiments in 1970, experiments in techniques of minimum impact. By 1974, these practices had evolved enough to be part of a pilot program by The Shoshone National Forest, which utilized volunteers as backcountry educators.

The program resulted in the evolution of a group of guidelines, which, with a minimum of additional equipment and time have shown significant effect in minimizing impact.

PRACTICES FOR USERS

Backcountry Travel

Travel quietly in the backcountry, whether hiking by trail or cross country. You will see more of your environment, wildlife will be less intimidated, and other hikers will appreciate the solitude.

Bright colored clothes and equipment have limited advantages in the backcountry (see Winter Conservation Practices) although
they may look great in a store window. Wear "earth colors" if possible to minimize your visual impact, especially if you are traveling in a group.

Respect the needs of birds and animals for undisturbed territory. When tracking wildlife for a photograph or a closer look, stay downwind, avoid sudden motions and never chase or charge any animal.

Some birds and small animals may be quite curious, but resist the temptation to feed them. Even in low-impact areas, feeding wildlife can upset the natural balance of their food chain, and in addition your leftovers may carry bacteria harmful to them.

When following existing trails, walk on the designated path. Shortcutting a switchback or avoiding a muddy trail by walking in the vegetation causes unnecessary erosion and unsightly multiple troughs. If a trail is impassable, walk on as many hard surfaces as possible (rocks or sand) and notify the Forest Service, Park Service or Bureau of Land Management officials responsible for that area.

If you choose a route without trails, do not blaze trees, build cairns or leave messages in the dirt. Other backcountry travelers can be confused by unanticipated markers, and in addition these signs of travel make their wilderness experience less enjoyable.

Pick up any litter you can, but allow other hikers a sense of discovery by leaving rocks, plants and other objects of interest as you found them.

In areas of abundant growth, use leaves or cones as toilet papers when possible, or enjoy an occasional edible plant, but be careful not to deplete the surrounding vegetation.

If you are camping with a large group, hike in groups of four to six people at most. Four is an optimum number, especially during off-trail travel, because in the case of sickness or injury one person can stay with the victim while two people go for help. Use your judgment in breaking your group into smaller units to minimize visual impact and maximize individual enjoyment and self-reliance.

Camping

Choose a camping site well away from water sources, trails and "beauty spots." The choicest camping spots are often prime territory for animal forage or other people's enjoyment of the view, so take a little extra time to seek out a more camouflaged area.

Leave the area as you found it. Avoid trenching, cutting live branches or pulling up plants to make a pleasant campsite. If you do end up clearing the sleeping area of twigs or pinecones, be sure to scatter these items back over the campsite before you leave.

It is unnecessary to spend more than a few days at any one campsite, unless it is already an established site or "sacrifice area." Even then, be conscientious about moving your camp to avoid sacrificing the area even more.

To minimize your camping impact, pitch your tent or fly in forested or sandy areas rather than in lush meadows or other areas with fragile vegetation. If you are with a group, be particularly careful of overcamping; move your campsites before the impact becomes noticeable.

A backcountry campsite should be reasonably organized. If you have laundry to dry or equipment to air out, make sure these items are not in sight of other campers or hikers, especially near a lakeshore or open meadow.

Fires and Stoves

Fires should be used only when there is abundant dead wood available on the ground. Be very critical about the necessity for a fire; if the area is overcamped or near timberline where wood regenerates slowly, either choose an alternative campsite or use a stove.

Site Selection

Good site selection and proper care of the cooking area make effective camouflaging much easier.

Choose a resilient site for your fire or stove. Avoid lush meadows, fragile alpine tundra and other areas that can be easily
trampled. Try to disperse use throughout the campsite rather than concentrating activities in the cooking area.

Fires should be built far from tents, trees, branches and underground root systems.

Fires should never be built in litter or duff. If there is a ground cover or duff, be sure to dig through it, well into the mineral soil when constructing a fire pit. Be sure the pit is large enough to prevent the possibility of a coal smoldering in the duff. Especially when the woods are dry, do not build fires on windy days when sparks might be dangerous. To avoid permanent blackening and unnatural exfoliation, do not ring fires with rocks or build them against reflecting rocks.

Types of Fires

If you come upon an old fire ring in the backcountry and the surrounding area has not been overcamped, utilize the existing rock ring. However, in most cases we recommend building one of three types of fires to assure minimum impact.

Flat Rock Method. Spread mineral soil 5 to 7.5 cm deep on top of a flat rock over an area slightly larger than the fire will occupy, then build your fire as usual. Burn all wood completely to ashes and after the fire is out crush and scatter any residual coals. After the soil is removed and the rock rinsed, the area will be left unscarred.

This method is particularly useful in areas where thick layers of rich organic soil preclude a safe fire pit or surface fire.

Firepit Method. Remove sod or topsoil in several large chunks from the chosen area (about 24.5 cm x 49 cm or 49 cm in diameter for a cook group of two people). Excavate the pit down to the mineral soil placing the dirt nearly in a protected pile, and pat mineral soil around the firepit perimeter to avoid drying out surrounding vegetation. The pit should be deep enough to house residual wood ash as well as the original dirt and sod, but shallow enough to insure adequate air circulation for burning all wood down to white ash.

The sod, both around the firepit and removed from it, should be kept moist. For baking, mineral soil can be spread on the sod at the edge of the firepit for a bed of coals, but be sure to replace all baking coals in the firepit to be completely burned before burying the firepit.

Before replacing and compacting dirt and finally replacing the sod, be sure that residual coals are crushed to a powder or paste. Both the bottom and sides of the firepit should be cold to the touch. Make sure there are no soft spots in the filled-in firepit that will sink with age. Also make sure to contour the edges of well-defined chunks of sod to assure a flat, even texture.

Finish by landscaping the entire cooking area by scattering leaves or twigs or whatever covered the ground originally. It is worth the effort.

Surface Method. When there is abundant mineral soil available without excavation (sandy areas, old streambeds, etc.) there would be no need to disturb the topsoil by digging a fire pit. Simply spread several inches of mineral soil on the ground and build a fire as usual. As with the "flat rock method," all wood should be burned completely to ashes (residual coals crushed and scattered) and mineral soil discretely replaced. Be careful of scorching the top soil, and camouflage the cooking area before leaving.

Firewood Selection

In order to insure complete, efficient burning, select your firewood from small diameter wood lying loose upon the ground. No wood should be broken off standing trees, alive or dead. An area with discolored broken stubs and few branches within arm's reach loses much of its natural beauty. Saws and axes should not be used as they leave unnecessary scars. If adequate wood is not available by acceptable means, stoves should replace fires. When in doubt, use a stove! Firewood is a valuable and often scarce resource so it should not be wasted on excessively large fires.

Burn all wood as completely as possible. Plan ahead—do not put a "night log" on the fire that will be only half-burned in the morning. Let your fire burn down naturally to white ash before dousing it, and scatter as much of the ash as possible before burial in order to avoid an unnatural concentration of minerals in the firepit.

All fires should be attended. Be aware of overuse, and if your firepit is too full of wood ash or your cooking area unnecessarily trampled, move your campsite as
soon as possible. Stop using your fire before the impact on wood supply or vegetation becomes noticeable.

Scatter excess firewood before leaving your campsite so there are no traces of your fire.

Sanitation

Waste disposal is a difficult problem that must be handled with good judgment and common sense. We recommend that for groups or for camping in high-impact areas, latrines be used. They are easy to control and they minimize digging up something unpleasant in areas where widespread dispersal is unacceptable. But if you are in a small group or in a low impact area, we recommend individual "cat holes." Smaller, less concentrated waste disposal usually insures more rapid decomposition, although more care must be taken in finding a suitable site.

The principle factors in waste disposal vary with the environment, but sunlight (warmth), moisture and soil bacteria all play a role. Consider these factors before you decide on a method of waste disposal, because each campsite will have different variables. For example:

In areas where latrines or cat holes are dug in organic soil layers, soil bacteria constitute the major decomposing agents, therefore, topsoil should always be mixed in with feces before burial.

In more sterile soils (sand or predominantly inorganic soil layers), subsurface moisture is often the critical factor so feces should have a more shallow burial.

In cooler forest soils and tundra vegetation, feces left on the ground can often be decomposed more effectively by sunlight and/or surface moisture than if the waste material were buried.

Latrines

Latrines should be located well away from rivers, lakes, creeks, and marshy areas to allow human waste to decay and be filtered through the soil without polluting.

Latrines should be a maximum of 25 to 30 cm deep but not deeper than the organic soil and should be filled before they are 5 to 10 cm from full. Deeper burial prevents adequate decomposing bacterial action while shallower burial can foul the air and encourage animals to dig up the latrine.

After each usage, feces should be covered with topsoil and compressed with foot or shovel. Adequate decomposition can occur only when topsoil is mixed in with waste material, so a latrine containing only feces without dirt will merely compact and hide the waste rather than decompose it.

On the trail, when latrine facilities are unavailable, feces should be given a shallow burial well away from the trail with proper drainage considerations. Rolling a rock for an impromptu latrine should be discouraged, especially in heavily used areas.

Urination should also be done well away from trails and water sources, although not necessarily in a latrine. Urinate in areas with thick humus layers and drainage, but try to avoid fragile vegetation because the acidity of urine can affect plant growth.

Toilet paper, if used, should be completely burned. In low-moisture or high-fire-hazard areas, toilet paper should be bagged and packed out. When available, snow, leaves and other natural substitutes are preferable to toilet paper.

Tampons must be burned in an extremely hot fire to completely decompose; therefore, in most cases they should be bagged and packed out. Never bury tampons in a latrine.

Soap must not be used in lakes and streams. Complete soap bathing involves jumping in the water, lathering on the shore, far away from the water, and rinsing the soap off with water carried in jugs or pots. This allows the biodegradable soaps to break down and filter through the soil before reaching any body of water. Clothes can be adequately cleaned by thorough rinsing. Residual soap can cause skin irritation, so we recommend not using soap to wash clothes in the back-country.

Disposal of Food Wastes and Fish Viscera

Food can be packaged in plastic bags instead of cans, glass bottles or aluminum foil. The bags should be carried out or burned, but beware of the noxious fumes from burning plastic.
Water waste (dishwater or excess cooking water) should be poured in a corner of the firepit to prevent attracting flies. When cooking on stoves, water waste should be dispersed far from any body of water.

Avoid the problem of dealing with leftover food by carefully planning meals. When leftovers do occur they should be carried in plastic bags to use later or burned completely. Partial burning, which is likely to occur if an attempt is made to burn food shortly before dousing the fire, is inadequate. Remaining food odors can induce animals to dig up a burned firepit. Non-soluble coherent food particles (macaroni or noodles) which inevitably occur in some dishwashing should be treated like bulk leftovers, that is, either be picked up and carried out or burned.

Fish viscera should be burned completely in a campfire. When no fire is available, they can be put in a plastic bag and packed out or carried to a fire where they can be thoroughly burned.

Under some circumstances, there is an alternative to carrying viscera in a plastic bag. If there are clearly many scavenger animals and birds around, if the quantity of viscera is not so great as to take a long time to consume, and if the area is a light-use one, then viscera can be scattered in discreet places to decompose naturally. Good judgment must be used. Do not throw fish viscera back into a lake or stream because the cool temperatures in most mountain water sources prevent rapid decomposition.

CONCLUSION

We have not accumulated hard data on the effects of the practices we have described. Subjectively, we have found decreased visual impact where these practices are used and in areas where we are the only users, hydrologic studies have revealed no impact. This has led to the adoption of these practices in informational pamphlets for users of the Shoshone National Forest in Wyoming and their inclusion in management plans for lands of certain jurisdictions of the Forest Service and Bureau of Land Management. They are part of our basic curriculum, and an important part of The Outdoor Leader Certification Program.
ABSTRACT--Recreational Equipment Incorporated (REI) is an outdoor recreation retailing, manufacturing and travel cooperative doing business nationwide. As such, it comes into contact with great numbers of wildland users who are unaffiliated with any other organization. This paper details the nature of REI, its concern about wildland impacts, specific techniques it uses to make its member/customers impact-conscious and the results of these efforts.

The minimizing of wildland impacts by member/customers is an important concern of Recreational Equipment Incorporated (REI).

To understand why this is true requires an understanding of the nature of the Coop: REI, is a classic Rochdale cooperative; i.e., membership is open to anyone who is interested in joining. Members share in any Coop profits in proportion to annual purchases.

Founded 40 years ago, REI now has a membership in excess of 8,000,000. The Coop conducts business nationwide on a mail order basis as well as through retail outlets: it now has 4 stores and two more are scheduled to open in 1979. Our 1978 sales volume is likely to exceed $35,000,000 and our expectations are to pay a patronage dividend of 10% (about average for us). REI by-laws require us to remit as dividends not less than 85% of annual distributable operating profits to our own member/customers. Despite the limitations created by this self-imposed restriction on our ability to amass capital, in recent years REI has averaged an annual growth rate of 25% compounded. In addition to REI retail activities, we operate a travel business and a manufacturing facility.

In recognition of the express desires of our extensive membership, the directors of the Coop have adopted a philosophy of operation which stipulates that, "The recreational uses of the outdoors which are the reason for REI's existence depend upon the preservation of open space available to the public, and upon a healthy environment in which natural processes can function. Therefore, REI will alone or with other organizations, make efforts to protect the outdoors which its members enjoy. It will be active in helping its members use merchandise which it sells in ways that will protect and preserve the outdoors."

REI is in contact with a wide array of individual users. Presumably many of these people are unaffiliated with other environmental or recreational organizations. Because ours may be the only message they receive, it is particularly important for us to meet the obligation and the opportunity to exert a positive influence upon our user/members in protection of the wild environment. We are not alone in this position; similar retailers locally would include Eddie Bauer, Early Winters, The Swallow's Nest, North Face, etc., but no one does more to meet this responsibility for minimizing impacts.

Enough stage-setting: Let's examine what REI does about wildland impacts. Among the techniques we use--any of which is available to anyone in similar circumstances--are the following:

1. Distribution of point-of-sale reminders;

2. Publication of "Minimize Your Impacts" reminders in every catalog;
3. Presentations (in-store and out-of-store);
4. Stocking of "Impact" books;
5. Designation of an area in each store identified as an "Environmental Resource Center;"
6. Channeling money into the hands of outside groups or individuals with demonstrated ability in the field of environmental protection;
7. Advocacy on issues of environmental protection; and;
8. Sponsoring volunteer environmental work projects.

Point-of-sale reminders in protection of the environment range from signs in the various stores to labels on the merchandise. Informational handouts are available at the cash registers. Stuffer sheets are inserted in shipments or packages during the purchasing process. Environmental messages are imprinted on bags and stationery. The opportunities are endless--providing one is truly committed.

"Minimize Your Impacts" statements in our catalogs vary from publication of the REI Guiding Philosophy to Viewpoint articles and brief inserts such as "Protect Your Wilderness" or "Help preserve the beauty of our mountains and forests by using a stove instead of building a fire. In many areas campfires are not allowed. Check local regulations."

The Coop's outreach activities are quite extensive. These include formal clinics on subjects of general interest, usually about 6 per year in the Seattle store alone reaching 600 persons or more. Demonstrations of equipment are another outreach activity usually scheduled away from the stores. We conduct more than 50 of these demonstrations annually, contacting in excess of 1,000 persons.

The number of books stocked by REI with some kind of curb-your-impacts message is difficult to measure but the list is extensive, ranging all the way from instances where the message is subtle or minor (as in the 100-Hikes series) to cases where protection is the message in such books as "Sand County Almanac").

REI's "Environmental Resource Centers" are an employee/management response to the frequent requests we receive from environmental interest groups. These groups seek a place to display their messages or to leave their handouts. The centers are unstaffed usually, although interest groups are welcome to staff them in connection with some significant drive. Contents range from "Save the Whales" to "Save Our Agricultural Lands" and everything in between including the reduction of wildland impacts. Size of the centers is a function of store size but the Seattle store center is about 18 m$^2$ (200 ft$^2$). This is prime "up-front" space near the main store exit adjacent to our map, book and poster department and alongside a principal traffic aisle. As selling space it represents an annual commitment worth at least $38,000. As "image" space it has value beyond measure since it is what we say we are. It is evidence that REI cares about the environment.

REI channels money to groups or individuals with a demonstrated concern for the environment in a number of ways. We buy their products if that is appropriate (for example, REI has purchased $5,000 in maps for resale from ALPS--The Alpine Lakes Protection Society--since 1972). We make donations to certain priority causes. In 1978 such donations are expected to total $25,000 (Alaska D-2 Lands legislation, RARE II, Mountain Rescue Council and so forth).

Related support of an indirectly financial nature involves speaking out on issues of environmental protection; traveling to testify at various meetings and hearings or writing letters in support of certain viewpoints. I wish I had a dollar for every hour I have spent on the issue of river use impact curtailment this year alone.

Most of the techniques described above are essentially passive or indirect. When it comes to active efforts to minimize wildland impacts, the Co-op's principal claim lies in its sponsoring of clean-up and trail-building trips by volunteers. We have conducted these activities for more than five years now in Seattle and lesser periods at our other outlets. More than 1,000 volunteers have participated to date. In 1977, REI volunteers removed an estimated 4,950 kg (11,000 lbs) of refuse from 62 km (39 miles) of ocean beaches. In the past two years we've cleared and re-built more than 48 km (30 miles) of trails.
REI's techniques have come into existence over an extended period of time. They result from the kind of people who make up REI, the members as well as REI directors, management and staff. Together these people embody a special sensitivity for the environment. This sensitivity is deep, all-pervading and facilitated by certain formal organizational procedures and processes. The latter include, for example, our quality control staff and our all-volunteer Quality Advisory Committee. While one might construe the word "quality" very narrowly in determining the role of such people, REI has tended to interpret it broadly. Thus we look for products which will serve well in non-destructive ways without sacrifice to user safety.

Because REI makes clear what kind of organization it is, we tend to attract others with similar views. While taking public stands has its risks, we have found there are many people who care as we do or who do not hold such opposing views that we have driven them away. So, rather than be neutral or silent, we have gravitated toward speaking out. We have adopted a specific pro-environment image.

REI has four means of measuring the propriety of this pro-environmental stance: our sales volume, membership growth, what members tell us face-to-face or in their letters, and members responses to periodic questionnaires. Our sales continue to increase as does our membership (10,000 new members in one single month recently). Nine out of ten letters we receive are supportive. Responses to our questionnaires in 1975 indicated that 92% of REI's membership wanted us to be more active in protecting the environment. In a preface to another questionnaire in 1977, we very carefully described our increased activities. This time 95% of the respondents said we should "continue to be active in their behalf" and 58% said that we should be "even more active."

Even within REI there was expressed sentiment that no merchant could dare to become involved or could afford to take a position on controversial issues. Nonsense! Successful businesses do it daily so long as the issues are business-relevant. For REI, the environment is business-relevant. I submit that it would be cost-effective for more of our recreation-equipment competitors to do as we have done.

Now you know what REI is all about, what techniques it uses to maintain its image and how some of these techniques came about. As for results and some ideas about when, where and under what circumstances we feel we've been effective, I am less precise. The evidence is largely circumstantial:

- We are still in business.
- We are still being urged to extend our services.
- Environmental interest groups seem to be seeking us out in increasing numbers.
- Some wildland areas (mountains and beaches) are cleaner than they used to be because of us.
- Some of our clean-up/fix-up activities --particularly the urban ones-- have not drawn large numbers of volunteers, hence we plan to swing back to more of the wildland-trail-building kind of thing, i.e., mix the opportunities.

We plan to continue our pro-environmental stance as a matter of policy. We will continue to seek novel ways to implement this policy, including the solicitation of advice from unpaid member volunteers (like our Quality Advisory Committee, the relatively new Social/Environmental Advisory Committee and individual store advisory committees).

Such volunteers, if well selected, contribute significantly to the success of REI because of their special expertise and non-REI associations. They make us look good and their REI-involvement apparently leaves them with a good feeling because we pay attention to them. They help to keep REI impact conscious.

**DISCUSSION**

**Comment:** I think that I'd like to point out the significant change in REI in the past 20 years. REI did not always have the outlook on wilderness that it now has. It's shown a growth in its awareness of the need to minimize wildland impacts.

**Hayes:** Thank you, that's very nice. That's the policy direction that the present board supports strongly. I can't think of anyone who deserves more credit for having influenced this change in policy than Director Louise Marshall.
Comment: I wonder. I've spoken to the board of directors about impact and I'm really gratified to hear that some things are done that I wasn't aware are being done. I wish somebody would let the members of REI know that. The board of directors has a clear mandate based on surveys to show concern for the environment but what REI is doing is really peanuts compared to what they could do.

I'd like to point out, also, that there are other companies that do these things. Holubar has a policy of not selling brightly colored rainflies for their tents; they'll only sell a tan or earth-colored rainfly. I wish the Coop would do a little more in that line. I haven't seen any minimum impact brochures at the checkout counters for a couple of years, although I have looked for them. And I haven't seen any real attempt by REI to tell people the aesthetic problems of bright colors when they're choosing tents or packs. So, I think there's a lot more the Coop could do, given its resources and its personnel.

Hayes: There's no question that we could do more. This conference is not an opportunity to plug REI, it's an opportunity for us to explain what retailers of outdoor recreation merchandise can do. I would be the first to admit that REI hasn't attained my ambitions either. Still, one of the things that Coop members have to keep in mind is that we are a business in an extremely competitive field; one walks before one runs. If you'll check the trend, you'll find the trend to be favorable, and if you'll keep talking to us, I'm sure there's a great deal more that we and our competitors can do. One of the things that retailers so often overlook is their image. I can't think of a better image in our field than one of concern for the impacts of the things we sell.
SIERRA CLUB WILDERNESS IMPACT STUDY: CONCLUSIONS & SPECIFIC FINDINGS

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ABSTRACT--This paper outlines findings from a six-year investigation of Sierra Club Wilderness outing participants--their impact on vegetation, the impact of stock on vegetation, the consumption and production of firewood, the disposal of garbage and human wastes, and the interaction of small mammals and birds with organic garbage. Comments are also made regarding subjects for future studies and with respect to the planning process.

INTRODUCTION

The Sierra Club Wilderness Impact Study began in 1970. Members of the Sierra Club Outing Committee asked San Jose State University (SJSU) biology professors Dr. H.T. Harvey and Dr. R.J. Hartesveldt to investigate the impacts of the Sierra Club Wilderness Outing Program. They in turn asked me to coordinate the field studies.

During the six years of study we observed many different outings of several kinds, including knapsack, stock-supported trips, family outings, base camps, saddle trips and river trips. We visited many wilderness areas throughout the western United States. Eventually we found it necessary and more convenient to concentrate our investigations in the Sierra Nevada.

We recruited the aid of fellow faculty members at SJSU and able graduate students hoping to turn their studies into thesis projects. All in all, 15 researchers worked to produce 12 separate studies pertaining to wilderness impact problems.

These studies were reported in an interim report released by the Sierra Club in 1972. A complete collection of the final reports is being published by the Club and should be available shortly.

INVESTIGATIONS

Elian Absher studied the demographic and socioeconomic characteristics of Sierra Club Wilderness Outing participants and Jim Absher analysed discernable differences in the attitudes, aspirations and preferences of outing participants and a representative sample of Sierra Nevada wilderness visitors in an attempt to determine if Club outings have any negative effects on other wilderness users.

Rexford Palmer made observations on the impact of Club outings on meadow vegetation and conducted foot and trampling experiments at several sites in the Sierra. In addition, Rex Palmer and I attempted to determine the best ways in which to revegetate the multiple rutted trails so common to the heavily used high meadow areas. Our experiments were located on the Lyell Fork Trail in Yosemite National Park.

Steve Strand studied the impact of pack stock on meadows, especially in Sequoia National Park. He also conducted trampling experiments, this time with horses and mules at the Harvey Monroe Hall Natural Area near the Carnegie Institute Research Station in the Inyo National Forest. Steve summarized many of his general observations on stock impact in a paper on pack stock management which is included in the impact study final report.

Bill Davilla recorded the consumption of firewood on wilderness outings and determined the productivity of firewood in several sub-alpine forests by establishing permanent firewood production plots beneath trees of several different species.

Harry Reeves studied garbage disposal and human waste disposal on Club outings. He...
established research plots for determining the rate of decomposition of various types of deposits. Gerry Willy assisted him in looking into the role of insects in the decomposition of human wastes.

Dr. Henry Weston and his daughter Susan attempted to document and evaluate the role of birds and small mammals in clearing up organic garbage broadcast at campsite areas. Dr. Harvey, Dr. Hartesveldt, Clifford Schmidt and I aided the student investigators with the design of their impact experiments, the selection of study sites and the analysis of their data.

**FINDINGS**

Since time is limited, I shall try to mention one or two findings from each investigation which will be of interest to you.

In general the findings of these researchers are quite consistent with the research reports which we heard yesterday. There is always danger in trying to extrapolate data from one area to another, but we are hopeful that some of our findings will give insight into impact problems elsewhere.

Upon revisiting foot trampling plots, we found that there was complete recovery of meadow vegetation one year later regardless of the number of times trampled. These experiments involved up to 600 trappings but did not wipe out the root mass. On the other hand, woody plants were found to be much more susceptible to damage and slower to recover than the turf forming sedges and grasses. As an example, the impact of 200 trappings on red mountain heather (Phyllodoce breweri) has left a circle of bare ground which will be visible for many years.

We did not make any surprising discoveries about the trampling impact of stock, but rather confirmed what persons familiar with stock have known for a long time: the wetter the meadow, the greater the impact.

Wood production appears to vary from one subalpine forest to the next to such an extent that determinations of the availability of firewood must be made on a site-by-site basis. Bill Davilla has developed a technique for making these measurements. When recording firewood consumption we found that there is a strong correlation between the diameter of the fire ring and the amount of wood burned per hour, i.e., the smaller the diameter of the fire ring, the lower the consumption of firewood. Many Sierra Club outings build their campfire in a firepan which not only results in a lowering of firewood consumption but also eliminates the need for fire ring construction and the creation of fire scars. An analysis of firewood consumption records as they relate to group size reveals that large groups (greater than 16 people) consume significantly less wood per person than smaller groups.

I shall skip over the topic of human waste disposal. However, under garbage disposal we did find that in those areas where warm-blooded vertebrates are attracted to backcountry campsites, they, particularly some mammals, play a prominent role in removing scattered organic garbage.

Most of our attempts at trail revegetation were entirely unsuccessful; however, we did find that one approach to the problem which worked very well can be accomplished with simple equipment, utilizes materials available at the site and requires no propagation of plant materials. We achieved revegetation of multiple rutted trails by removing the sod ridges between the parallel trails, digging up the entire area at right angles to and extending slightly beyond the two outside trails, adding fine sand from a nearby watercourse in order to achieve a level equal to that of the surrounding meadow, and then planting the disturbed area with plugs derived from the sod ridges.

From our studies of Sierra Club outing participants and other wilderness users in the Sierra, we learned that the Club outings and program does provide experiences for a much wider range (age and sex) of people than otherwise go into the mountains. The two study groups varied in many ways too numerous to detail herein. Of special significance are the greater willingness of Sierra Club outing participants to camp close to another party and the importance which they place on the role of a campfire in the wilderness experience. The above, together with the tendency of Sierra Nevada visitors to become disturbed over the use of stock on large group outings, may explain conflicts between the two groups in certain instances. Both segments of user population placed major importance on seeking quietude. It is presumably not so much being alone per se that gives meaning to the wilderness experience as the contrast it offers from everyday urban existence.
CONCLUSIONS

What we have learned from our efforts? I shall try to summarize very briefly some of my general feelings about our study.

First, we studied the wrong groups. We studied Sierra Club Outings, what I call the organized group user, basically because they commissioned us to investigate the impacts of their outings.

Organized group use represents a minority of the recreational use of the wilderness. In 1975, groups comprised of more than 20 people constituted only 1.9% of the total number of groups visiting the John Muir Wilderness, while groups of ten people or fewer constituted 93.5% of all user groups.

We should have studied parties of 2, 3, 4 and 5 individuals. The average group size ranges from 2.7 to 4.3 in the studies and reports I have seen. For example, in 1973, in Yosemite National Park, 91% of the people entering the back country did so in groups of 5 or less (Lee 1975).

Why is this so important? Because the impact of a large group (12 or more individuals) is very different from that of small parties. Indeed, there are many differences between the two groups. For example, the consumption of firewood is different. When Bill Davilla weighed and recorded nightly firewood consumption for groups of varying size, including small non-Sierra Club parties, he found that consumption remained approximately constant, or, in other words, larger groups burned much less wood per person than did small groups.

One major difference between organized groups and unorganized parties is leadership and leadership training. The participants on organized group outings are generally guided by a code of conduct established by the trip leader, this being most often grounded in the generally adopted practices and procedures of the organization. Thus, as members of the group, they are willing to alter their personal behaviour to conform to leader and organization standards. The trip leader often has been involved in a training program which has included wilderness manners and minimum impact camping policies and procedures. It is the trip leader and not the individual trip member who dictates, for example, the selection of campsite location, the method and location of human waste disposal, the acceptable noise level, the location of firewood collecting, the disposal of leftover foodstuffs, the handling of refuse, the location and construction of the campfire. The end result is less per capita impact on the environment.

Second, we had the wrong focus. We focused most of our effort on studying ecological impacts.

In the Sierra, "impacts" such as trampled campsite areas, unavailability of firewood, hacked-up logs and snags, multiple rutted trails, and excessive human wastes along popular trails and at heavily used campsites are the result of the concentration of use in a very small amount of the total area. Most wilderness parties do not disperse throughout the area; they generally begin at a popular roadhead and head for a known lake or stream.

There, they set up camp on the ecotone at or near a body of water, either at the lake's edge if the forest comes down to the shoreline or if the lake or stream is in a meadow then they camp on the ecotone between the forest and a meadow. One result is that the users end up congregating close together forsaking solitude for camping in a heavily populated area at an already heavily used campsite. (Yesterday, Bob Lucas pointed out that the choice of campsites is not related to campsite impact.)

It turns out that very little of the land is being utilized. Don't misunderstand me, I am not saying that this is bad. Nor do I think we should disperse these people so they can disturb the person who has chosen to go to a less popular spot to get away from the others.

For me, the significance of all this is that in general the majority of the wildland area in the Sierra receives little visitation and is in good health. Thus, these things we refer to as ecological impacts are not significant in terms of the stability of the overall wilderness ecosystem. It turns out that physical impacts such as vegetation trampling are not as significant from an ecological point of view, as they are in terms of the effect they have on the experience. (This equates with the term damage with Bob Lucas was addressing yesterday.)

Third, we underestimated the magnitude and significance of the strong biases which average sized groups have against the minority wilderness users. In general, the average user (3.5 group size) feels in conflict with and often despises group users. Inher-
ently, he or she believes it is the large groups which are ruining the wilderness environment. He or she decries the presence of large groups in the backcountry because they deny him/her solitude, and yet is willing to camp at a popular lake with numerous other small parties. In addition, he or she feels the same way about packstock and stock-supported wilderness outings.

Organized groups and stock users are readily identifiable users and as a result are easy marks for the user or manager who wishes a scapegoat for impact problems which are really the result of the cumulative effects of many visitations by small parties.

Managers find it very difficult to control the impact of the majority of the users (average group) so they place restrictions on the activities of the minority users (large groups, stock parties) and pretend they have the situation under control.

We still aren't talking with the average-group user who is the majority user. I have attended many wilderness conferences in the past eight years, several of which were labeled as user conferences, and I have yet to see the average user there. Sure, we have representation from the Scouts and NOLS, the Sierra Club, packers and other organized groups every time, but we aren't reaching the unorganized user. We have heard at this conference that the average user is not disturbed by most of what we will call impact. We should be talking with that person.

Fourth, we overestimated the role which scientifically gathered data would play in wilderness-use decision-making. It turns out that regardless of the research findings, both the Sierra Club and wilderness managers end up reacting to peer pressure from other wilderness users and supporters when making policy decisions regarding the kinds and amounts of wilderness use.

The Sierra Club program has reduced party size in response to pressure from within the organization as well as changes in group size in agency regulations to the point that it has stretched the program financially, eliminated most of the social values of the experience and significantly reduced the variety of experiences possible. Indeed, there is a rather large faction within the Club which is against there being any Sierra Club outings. I suggest that you should not underestimate the strong bias which many wilderness supporters have against any and all wilderness use.

The Club has held the number of people on national outings in the Sierra at a constant level for several years despite increased demand for these trips. Unfortunately however, recent limitations on group size have resulted in a corresponding increase in the number of trips.

There is less use of stock within the Club because of the perceived strong public bias against stock in the Sierra and the desire of the organization to maintain a low profile (you may find that hard to believe, but it's true). Trip leaders stay away from heavily used areas especially at popular times, and they try to schedule trip departures on low visitation days.

All of these decisions to reduce impact and visibility, including setting up a computerized system to prevent trips from going to the same area at the same time, have not been based on research findings but rather on politics.

Finally, I would like to end on a positive note about what Sierra Club members are doing to reduce wilderness impact; and that is, working hard to establish more areas where people can enjoy wildland recreation. Each area which we see experiencing impact problems resulting from overuse is yet another argument for moving back wilderness boundaries, expanding the wilderness preservation system, establishing buffer zones and creating more outdoor recreation areas.

I truly believe that the efforts of a handful of people in the San Francisco Bay region to open up public access to nearby natural areas, for example in the Santa Cruz Mountains and at Point Reyes National Seashore, has done more to reduce overuse in the high Sierra than either education or management restrictions.

COPIES of the Wilderness Impact Study may be obtained from the Sierra Club Book Store, 530 Beech Street, San Francisco, CA 94108. Cost to non-residents is $13.90 a copy; California residents must add 85 cents sales tax.

DISCUSSION

Comment: I'd like to ask if you feel that your findings on the Sierra Club can be carried over to other organized groups. You
seem to be supportive of the Sierra Club. But are Scouting and church groups as well organized and are their leaders as good as what you're talking about in the Sierra Club?

Stanley: Well, you could go ask them today, apparently. But, from the conferences I've attended, you can't generalize that the Boy Scouts are ruining the wilderness either. I've listened and talked to a large number of very progressive Boy Scout groups that are highly organized and have strict policies for minimizing impact on their outings.

Comment: We've become really concerned about that impact, especially in the Sierra Nevada. So we started the Wilderness Digest in California, which is in its 6th year. The purpose of it is to reduce that impact in the wilderness. We send a copy free to every Boy Scout unit in California. And we now do this in Oregon and Washington, with a first year's edition. It's no cost to them and it's all done by volunteers, so the cost is kept down. But we are still reaching very few people, and are not reaching the unaffiliated users well.

Comment: Disregarding per capita consumption, what did you find regarding overall consumption compared to the production of firewood in the sites that you studied.

Stanley: We found some areas that cannot handle firewood consumption. The production is too low for the general rate of consumption that is going on. And these are, of course, higher-elevation areas, but they tend to vary from one place to another, so you can't generalize. You have to view these specific studies on the productivity of firewood in each basin. We found that the impact of the users was not as significant as you might expect; there is firewood. Most of the users are just too lazy to walk for it, they'll only walk a certain distance. If you run a transect perpendicular to the campsite and go several hundred of feet away from the campsite, you'll still find abundant firewood.

Comment: As a leader of the Sierra Club high trips in 1941 and 1946, in the Sierra, one of the objectives of the Sierra Club in having approximately 200 people on a trip was to try to cut the number of people per animal down to three or four. This contrasts with smaller parties, which have three or four animals per person.

Comment: Since there is usually a strong wilderness norm about large groups, as you pointed out, do you have any thoughts beyond what's just been said about why Sierra Club members who normally buy into that norm so strongly would be willing to participate in such large groups?

Stanley: Because the people who go on a group outing are going for different reasons than you would. The same people might want to go on an outing, and the same leaders often go on outings of three people, but they go for a different set of reasons.

Comment: What are the reasons?

Stanley: Well, one of the reasons that you may find really funny was told to me by a gentleman I found sitting on a mountain top where I had found him to say that dinner was ready. He said, "Oh thank you, I was just enjoying my solitude. You know, in a group of three people, you can never get away from those other two people. But here on a Sierra Club outing, someone else is fixing my dinner for me. It's not my turn tonight. I could go my own way, nobody cares, everybody knows that I'll be safe, because I know where the central camp is, and I can go find a few quiet moments away from other people."

REFERENCES CITED


APPENDIX

This policy statement adopted by the Sierra Club board of directors is included as an appendix. Because wilderness committee members from throughout the country spent two years attempting to arrive at some common guidelines which can apply to all wilderness areas, I feel that this document should receive some exposure.

Wilderness Management Policy

1. The Wilderness Act of 1964 is the basic charter for wilderness management direction. Wilderness management must recognize that wilderness is preserved for conservation, cultural, educational, historical, recreational, scenic, scientific and wildlife values.
2. Within the context of the Wilderness Act the primary wilderness management objective should be to protect "an enduring resource for wilderness" from significant degradation by man's influence and use.

3. Each wilderness possesses individual characteristics. The application of wilderness management techniques should reflect the individuality of each wilderness within the context of requirements to preserve the wilderness resource. Wilderness management plans should provide for flexibility in meeting conditions that vary with location and change with time.

4. Preexisting non-conforming structures or uses may have been included when a wilderness was designated. Maintenance and/or replacement of such structures and continuation of such uses should be determined within the context of site-specific management requirements of each wilderness.

5. Wilderness serves as a benchmark, permitting comparison of relatively unmodified environments with other environments. The protection of this benchmark function may, in some cases, require limitations on use.

6. Wilderness management should allow the maximum range of public use opportunities consistent with the preservation of the wilderness resource. Within this limit, the experiences of the individual user should not be manipulated or controlled. Limitation and/or zoning of use may be necessary to accomplish the protection of the wilderness resource. Management techniques which reduce impact on the wilderness resource in fairly non-restrictive or subtle ways should be employed before user restrictions which ration or control use. In such instances, use restrictions should be administered in a way which is as compatible as possible with the freedom that one normally seeks in wilderness.

7. In wilderness management natural ecological processes should be allowed to operate freely to the maximum extent feasible to promote, perpetuate, and, where necessary, restore the wilderness character of the land. Minimum manipulation may be allowed in order to restore man-disturbed environments or offset man-induced restrictions on natural processes.

8. The managing agencies should develop site-specific wilderness management plans for each wilderness. Development and adoption of such plans should require maximum public involvement at all stages, and the Sierra Club urges all concerned citizens to participate. In all instances the minimum tool practical for management should be used.

9. The results of continuing research and experimentation should be considered in periodic review of particular management plans.

10. Monitoring, measuring and scientific study of the wilderness environment should be allowed as long as it is as unobtrusive as possible. Restraint should be applied to and by the managing agencies over the impacts of research experimentation and environmental monitoring so as to protect the resource and experience.

Adopted November 5-6, 1977, by the Sierra Club board of directors.

Squirrel's forgotten cache
ABSTRACT--Role of horse groups in minimizing impact is discussed as well as how they are helping to construct facilities which disperse use to minimize impact. Examples of projects undertaken in the State of Oregon are cited.

What can horsemen do to disperse recreational activities to protect our wildlands from damage from over use? We all agree demand and use for recreation in our wildlands has increased much more than the facilities to protect them from over use which creates damage.

What are we doing to solve this problem? I meet with many equestrian organizations and horsemen. I find all are concerned about this fact and are studying and looking for solutions, recognizing an expanding need and setting long range goals. There does not seem to be any easy solutions. Because of the large holdings of wildlands managed by government agencies, we look to them, at least in part, to expand facilities to disperse recreation to prevent over use. Until recently, they were faced with low priorities for funding.

Let's be positive. Trails and trailheads today must serve an entirely different purpose than trails built three decades ago whose primary purpose was to go from here to there over the easiest possible route in the shortest length of time. They did not consider scenic points, historical places, outdoor study, or experiences, or most of all, permanent damage to our resources.

The past seven years we, the horsemen of Oregon, have worked under cooperative agreement with the Forest Service on planning and constructing trailheads, horse camps and trails. Neither of us have the finances to do the job. They have the resources and expertise in surveying and planning. We ask our member clubs and members to furnish some labor. I sometimes think our spirit of cooperation and enthusiasm is as valuable to the job as the actual work done. We have at this time six working agreements. All are doing well. They add recreational opportunities for horsemen and with the expertise in surveying and campground planning by the Forest Service staff, our wildlands construction causes minimum impact damage. From here we assist in the maintenance of the existing trails and flag locations of others leading from camps. Some provide short loop rides for novice or youth riders--others long distance or a challenge for experienced trail horses.

Following is an example of our activity over the past five years on the Sisters District of the Deschutes National Forest in Central Oregon. The Metolium-Windigo Trail, as planned, will traverse 125 miles of the entire length of the Deschutes National Forest. The trail will begin at the northernmost bend of the Metolius River east of Mount Jefferson and will continue to the Windigo Pass, southwest of Crescent Lake. It will provide a scenic route at low elevation which can be used for a longer period of time than most weather-bound wilderness trails. The Sisters north district section of the Metolius-Windigo Trail was completed and dedicated at a ceremony September 9, 1978 at Graham Corral. This section started at Sheep Springs Horse Camp on the north and extended some thirty-nine miles to Three Creek Meadows Horse Camp on the south. It included four horse camps and one multiple use campground. The trail was built to a standard suitable for novice horsemen and backpackers. The longest distance between watering points is
Thirty-five miles out of Bend, Oregon, on the Deschutes National Forest, lies the historical Newberry Crater. Within the crater is Paulina and East Lakes and one of the largest obsidian deposits or flows on the continent. Around the perimeter twenty-seven miles of trail was built by Fort Rock Ranger District and volunteer work by organized groups of snow-mobiles and horsemen. We think these two groups are a natural combination. The Paulina Lake Horse Camp within the crater is built to accommodate sixty-four horses in stalls with mangers. I understand the inventory value of the Newberry Crater Trails System is approximately $150,000. Without the enthusiasm and dedication of user groups these facilities could not have been completed at this time.

In conclusion, let me read from a letter dated September 13, 1978, written by Ronald L. Ketchum, District Ranger, Sisters District, Deschutes National Forest.

"When comparing the horsemen as a user group to others, it is evident that there is less vandalism and abuse of facilities than from other user types.

"Horsemen tend to be willing to volunteer labor and finance the construction of fa-
cilities such as horse camps and trails. Once they have done so, they accrue a sense of pride and ownership in these facilities. They also provide assistance in controlling people who would abuse the resource or facilities. I am aware that many individual horsemen have done maintenance work without being asked by public agencies.

"Most of the problems are such that education to encourage change to present day methods can prevent irretrievable losses."
Comment: I'd like to ask you a question about the months of use of riding. We found in hiking, people used to hike mostly in the summer months—the three summer months, but now they are hiking earlier and later in the season. Could you give us a feeling for the distribution of use through the year and whether this might be related to how in some months you prefer low elevation trails similar to hikers.

Flick: I'm very happy that you asked that question. Yes, the riding season is becoming longer and longer every year. Now, we're trying to develop lowland trails close to metropolitan areas for the people who have horses in the low lands. That's one reason I spoke of the Crescent District. The Crescent Lake area can be used into October and maybe November. Of course, some areas need more lowland trails and trails close to metropolitan areas.
RESPONSIBLE OFF-ROAD/OFF-HIGHWAY VEHICLE USER IMPACT ON WILDLANDS

Garrell E. Nicholes, President
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ABSTRACT--In planning for these vehicles, consideration must be given to recreation variables such as fellowship, aesthetics, historical empathy, and an orientation to nature. Different levels of activity are discussed, including the initial learning experience, play recreational trail, and competitive experiences. Governmental agencies must develop implementation programs which recognize all of these experiences, and coordinate the location of facilities and activities with user groups so as to minimize conflict and impacts.

Recreation activity is a highly individual way of life for participants; some hunt, others fish, ride bicycles, snowmobile, play tennis, cross-country ski...in fact the list can go on and on. Not only do people participate in different activities, they also participate in the same activity in different ways. Some cross country ski, others prefer down-hill skiing and still others may hunt big game allowing their counterparts to go after waterfowl. Some prefer quiet solitude outdoor recreation while others seek the exhilaration of motorized equipment. This paper deals with two forms of motorized recreation: off-road vehicles (ORV), those that make unrestricted use of resources such as play areas, competition facilities and cross-country travel but do not use roads or trails; and off-highway vehicles (OHV), motorized vehicles that use lineal corridors, e.g., graded and ungraded dirt roads or two-wheel trail paths.

To pursue the subject of "Responsible Motorized Vehicle User Impact on Wildlands", it would be helpful to know the activity preference profile of the group to whom I am speaking. Can I have a show of hands as to how many consider themselves motorized vehicle users? It appears there are about 15 to 20 people in the room that consider themselves motorized vehicle users. That would leave approximately 100 to 150 that do not utilize or have a personal working relationship with a motorized vehicle in a wildlands outdoor recreation experience. This show of hands is important because I have a slide presentation that will attempt to clarify how the motorized vehicle (4-wheel drive, snowmobile, dune buggy, multi-wheel ATV and motorcycle) provides a recreation experience in different ways in a wildland resource.

Whether one considers himself or herself a motorized vehicle user in the wildlands experience depends on how one defines impact and utilization of a motorized vehicle. People participate in a recreation activity because they seek social experiences and/or physical engagements and/or psychological encounters. I will emphasize that these motivators relate to all active/passive recreation activities. This means that on a continuum of 1 to 100 an individual may sit in his home, at the least extreme of recreation activity, and watch television. At the maximum extreme of activity he may seek and find the most difficult of rockclimbing experiences that will satisfy his subjective need for recreation. Within the realm of these motivators, the individual is looking for meaningful stimuli as: (1) fellowship with others; (2) aesthetic opportunities; (3) historic empathy; (4) to orient oneself to nature. As a professional recreation psychologist, I utilize these general categories of recreation participation to research, plan and implement opportunities. One area of my professional activity in the last few years has been researching, planning and implementing problem/solution models for the off-road/off-highway vehicle phenomenon.

The question is often asked in my plan-
ning efforts, what does it mean to give an experience equal to the recreator's anticipation? To answer that question, it is necessary to understand the particular recreator that one is planning for. If he or she is a solitude outdoor recreation participant, it is just as necessary for a planner and land manager to understand why this recreator participates as it is to understand why the motorized recreation vehicle participant recreates in his activity.

The motorized vehicle recreator's reasons for participating in his recreation activity can be clarified by first defining a few concepts. Motorized vehicles fall into four basic categories: the four-wheel drive, the dune buggy, the multi-wheel or track ATV (snowmobile) and the motorcycle. Please accept on faith at this time that the motivation concepts of fellowship, aesthetics, history and nature also play a major part as to the reasons for vehicle use these enthusiasts. For practicality of this discussion, I focus on the motorcyclist as he participates in his sport.

There are principally five basic areas of use and activity in which the motorcyclist participates when he is active in his sport. The first is road riding. Because we're dealing with a wildlands environment, I will exclude this activity from the discussion. When the user first purchases or becomes acquainted with the motorcycle he has to learn how to manipulate the equipment. This is a learning experience. From the learning experience the individual usually advances into a play activity where the fun and enjoyment comes from the exhilaration he attains from being able to successfully manipulate the vehicle to do what he wants it to do. The rider can also participate in unstructured competition opportunities.

When he becomes so exceptionally good at manipulating the machine that he feels superior to those with whom he associates in unstructured competition activities he will usually move to a structured competition experience. He will usually remain in that activity until either abilities are tested with seldom success, or age, accidents and/or a revised life style priority makes it mandatory for him to leave competition for a less demanding activity.

This reevaluation will place the enthusiast back into a play experience or displace him to the recreational trail experience. A play experience is defined as an activity where the motorcycle provides the fun and enjoyment through the exhilaration the participant receives from the play. A recreational trail experience is defined as utilizing the equipment as a tool of transportation to enable the recreator to participate in another form of outdoor recreation, e.g. backpacking, fishing, sightseeing, rock-hounding, photography, etc.

Unfortunately, the historical stereotyping of the motorcyclist has given him a black jacket image in the mind's eye of those who do not participate in the sport, and/or have personal negative experiences or have relied on the negative interpretations of others to formulate their own mind's eye perception of this motorized vehicle participant. In actuality and in most instances the play experience and the structured competition are the two activities that are most visual and audible to the observer, in all environments.

I think it is important now to make a distinction between off-road and off-highway vehicles. Off-road vehicles (ORV), utilize a resource in an unstructured pattern. Some of the areas that can be labeled ORV use areas are: play parks, competition facilities, cross-country travel not utilizing roads or trails; and off-highway vehicle (ORV) utilizes lineal corridors such as graded dirt roads, ungraded roads, trails, paths, etc.

I want to emphasize that it is necessary for the non-participant to understand the difference between ORV and ORH use and how
these uses relate to resource capabilities. It is increasingly necessary for the land planner and manager to be aware of the types of use that the participant is engaging in, and be fully competent to identify those land resources that can sustain that type of use. With this recreator's subjectivity of recreation choice, it is also necessary that the motorized vehicle participant be aware of his patterns of use, be able to appreciate and become responsible in pursuing his activity as that activity relates to the land resource that he is utilizing.

In summary, those areas that are designated "play" and "competition" areas should be planned and maintained to support that type of use. Those areas that are designated "recreational trailriding areas" should be planned and maintained to support recreational trailriding. Remember: a play experience utilizes the machine as the recreation activity in and of itself, for the exhilaration the participant derives from the activity. A competition experience utilizes the machine to obtain the exhilaration derived from the activities of the event and its competitive encounters.

The recreator who participates in the recreational trail experience utilizes the machine less for physical handling purposes and places increased importance on the activity variables of fellowship, aesthetics, historical interpretation and identification with nature. Some motorized vehicle participants do not conform to the above model and elect to displace play and competition to a recreation trail experience. The first tactic for eliminating displacement would be better communication, cooperation and coordination among non-users, users, and public planners and land managers. A better communication could be promoted if non-vehicle users would seek lines of communication with vehicle enthusiasts. A plan of action could: (1) devise meaningful resource inventory and demand research to set standards and definitions that put in proper perspective the needs and desires of the motorized vehicle participant; (2) seek the enactment of responsible legislation and regulations to provide money, programs and competent personnel to carry out positive solution-oriented programs dealing with motorized vehicles. May I emphasize that it is necessary to set realistic physical resource management standards and establish fair and meaningful laws, regulations, enforcement policies and penalties; (3) an educational program to teach users an awareness for the environment, other users of the resource and their own safety as they travel within the resource.

The greatest hurdle the non-participant has to overcome in the communication process is to recognize the motorized recreator as pursuing a legitimate form of outdoor recreation. At this time I see very little planning and management being done throughout the United States on public lands for the recreational motorized vehicle participant. This sport is not diminishing. Motorcycle sales for off-road and combination off-road/on-road vehicles are increasing at about 500,000 units per year. This activity is here to stay. Therefore, it is necessary to provide an implementation program to solve existing problems and develop compatible opportunities. May I suggest the following priority of problem/solutions:

1. Youth plan areas in an urban environment.
2. Urban play and unstructured competition practice areas.
3. Regional competition areas.
4. Statewide trail systems.

This priority system is suggested to alleviate some of the problems that now exist in the urban environment with high population of both people and ORV capable vehicles. This problem/solution format can then be transferred to the wildlands environment. Planners and land managers should provide a balanced program for accomplishment of the above priority suggestions to eliminate adverse impact on the urban and wildlands environment, as one affects the other.

Let me give you a few examples of successful planning and implementation. The state of Washington has developed excellent legislation which provides money and personnel to carry out a statewide Department of Natural Resource program. Today "use areas" in this state are being developed with user money to take the rider off private property and away from residential areas. They are constructing an environment for this recreator where he won't be in "conflict."

The state of Utah has developed an inventory methodology that identifies trails and areas of significant use by motorized vehicles. This information is allowing them to analyze and better plan for this recreator
as he interacts with the environment and other users of a resource. Over 12,000 miles of trails have been identified in that state where these recreators can participate in their sport.

May I again recommend and encourage a communication, cooperation, and coordination attitude on the part of public and private land managers, non-users and the enthusiast to work out viable solutions to existing problems.

DISCUSSION

Comment: Should we encourage the use of motorized recreation in natural resource areas?

Nicholes: As I've studied various types of outdoor recreation activity from the perspective of motorized vehicles vs. non-motorized recreation, I find that there is opportunity to provide motorized recreation in natural resource areas. It depends on the type of natural area we are talking about and the use that the resource can sustain, i.e., play, competition, or a recreational trail experience.

It really comes down to understanding motorized vehicles and how they are used. I would recommend that if there is a recreation activity conflict between two uses then the two groups get together and work out alternative possibilities for the utilization of a particular resource.

Comment: I don't deny for one moment that riding a trailbike would be a most exhilarating experience. I haven't done it myself, but I haven't the slightest doubt that your point is very valid. Trap shooting is exhilarating, so is the bow and arrow, so is doing anything and everything that we are skilled at. So is dancing. The problem really comes down to when two exhilarations meet and they are not terribly compatible, what then? Let me give you an example. When hiking up a trail and one's own children get splattered with mud from a motorcycle that thoughtlessly passes. This is where the antagonism develops and you have not in fact, addressed yourself to this problem and that's in fact where the problem lies.

Nicholes: I don't know if I can answer your question on particularly being splattered with mud, on a specific trail or by a specific motorcycle. In the first place, don't condemn all motorcycles or their riders because you were splattered with mud by one or two who you don't know and I don't know. There are responsible motorcyclists as there are responsible hikers. There are irresponsible motorcyclists as there are irresponsible hikers...I believe it's again the hiker and the biker getting together and communicating to work out programs of alternatives that will meet both of their needs in a specific wildlands resource. It very well may be that there is no compatibility on a trail for a walker or a hiker and a motorcycle, but each trail needs to be studied and each circumstance needs to be reviewed by both of the participants of that sport as well as the land manager who supervises the resource to accomplish solutions. Other than communication, cooperation and coordination, I don't know if I have an answer to your specific question.

Again, thank you for this opportunity that you have given me to talk to you this morning. Let me emphasize one thing before I close. Problems relating to conflict of the environment and conflict with other resource users and the safety of the recreator can be overcome and are being overcome by those who are willing to sit down and discuss in an open and rational manner alternative solutions. When that happens in relationship with the "land manager", the "environmentalist" and the "motorized vehicle participant" we will start seeing solutions to the problems that now exist.
ABSTRACT--The Human Impact Inventory System in Olympic National Park was developed to meet park managers' requirements for an extensive, repeatable survey of impact in the backcountry. The method uses 8 x 10½ inch "keysort" cards that allow data analysis with or without the use of a computer. The parameter of impact found most useful is the area of soil exposed by trampling and plant reduction at campsites.

Attempts have been made to delineate relationships between visitor use, trampling impact and ecological patterns. Data presented show a positive correlation between human impact and overstory cover percent. Red alder communities exhibit the least impact and silver fir-western hemlock communities the most. It is apparent also that patterns exist within specific camp areas which must be managed on an individual basis. Two examples are given.

Some practical findings in campsite restoration attempts are offered. A zoning approach is suggested to clarify decision-making about camp areas. Positive rather than negative sign messages are recommended for interpreting management actions on-site to the public.

INTRODUCTION

The majority of investigations concerning the effects of human impact on natural and semi-natural ecosystems describe the response of vegetation, soils, and animals to trampling. Human trampling results in varying degrees of plant-cover loss, soil compaction, erosion, changes in animal and plant community composition, and invasion by weedy plant species. Details of these and other changes are available in the literature (see Papamichos 1966, Dale 1973, Speight 1973, Schreiner 1974, Liddle 1975, and Hartley 1976).

Burden and Randerson (1972) delineate two major types of human trampling studies: first, investigations that describe ecological changes with time; second, studies that examine existing conditions, where trampling is assumed to be in equilibrium with the biotic community. A third category includes studies where trampling is simulated by controlled walking or with an artificial "foot" (Schreiner 1974). Except for the work of Bratton et al (1978), however, these lines of inquiry describe the results of tampling, but do not provide a direct basis for management.
Managers of natural and semi-natural areas initially require information that is less specific than most such studies provide. It is more useful for a manager to know the location, magnitude and patterns of human impact for example, than to know the biomass of invading species or the density of compacted soils. Thus, much of the impact information obtained to date is more suitable for "advanced" rather than initial phases of management.

An ideal management-oriented study of impact would begin with a survey that determines the scale and location of impact. Then, depending on the management policies and goals, the investigators could examine changes in impact with time, inter-relationships between site factors and visitor use, methods of predicting impact, the ecological role of weedy species, and changes in the patterns of plant succession. With respect to plants, an additional step might be to examine reproductive strategies following Harper (1978), and adaptive-competitive strategies as described by Grime (1977). These latter types of plant study would greatly assist site revegetation efforts, where species selection, modification of successional trends, and site hardening are important.

**METHODS**

The Human Impact Inventory System used in Olympic National Park was developed to meet the management requirements for an extensive survey of impact. At the same time we made initial attempts to delineate relationships between visitor use, impact, and ecological patterns. Specific study objectives were:

1. To inventory backcountry campsites and human impact over a large area (about 370,000 ha);
2. To design a system requiring a minimum of special knowledge to use it;
3. To provide a means by which impact could be remeasured in the future;
4. To provide a data base for determining patterns of visitor impact and site factors;
5. To develop a system where analysis did not necessarily require computers.

The inventory method uses 8 x 10½ inch "keysort" cards with holes along the margins for needle-sorting information. Six categories of data to be collected are printed on the cards (Figures 1 and 2). One card is filled out for each campsite. Where a group of campsites occur together at a backcountry "camp area" there will be several cards. Information about impact patterns, vegetation, and campsite features is available either through needle-sorting the cards or via computer analysis. The cards follow the Code-A-Site system (Hendee et al. 1976) in concept, but allow for more detailed impact and ecological information.

**PROcedures**

Initially, each camp area and its campsites is mapped using a hand compass and pacing survey. These maps are subsequently used to orient new backcountry personnel, to monitor trail and campsite formation over time, to record visitor use, and to relocate campsites for periodic remeasurements of impact. This map-making process familiarizes an investigator with the overall camp area and ensures a systematic reconnaissance of the area.

The main parameter of human impact we use is the quantity of bare ground (exposed soil) at each campsite. It provides a quantitative measure of the visible stages of impact described by Frissell (1978). We feel that the amount of bare ground present serves as indicator for other changes resulting from visitor use, such as soil compaction, soil erosion, vegetative cover loss, potential water pollution, and amounts of garbage at the site. The works of Frissell (1978) and Bratton et al. (1978) support this statement.

Bare ground is obtained by measuring the distance to the first live plant on line intercepts radiating along eight points of the compass from the campsite center. The average of these eight lines is then used as a radius and to compute bare ground area as a circle. We also count the number of trails entering each campsite (social trails) and the number of trampled depressions around trees from tethered horses (horse pads).

Forest canopy structure and composition are obtained by estimating percent overstory cover and average tree height for each site as well as relative cover and height by species. Ocular estimates are made for overstory cover in classes of 20% by standing in the center of the campsite and looking straight up. Understory and meadow vege-
Figure 1. Front side of the Human Impact Inventory Card
Figure 2. Back side of the Human Impact Inventory Card
tation species are ranked in order of importance. An estimate of the maximum snow depth at a campsite is obtained following the method of Long (1976), where the lowest height of uniform lichen cover down tree stems is measured. This is relatively easy to obtain in some cases, but where lichen cover is sparse it is not a good index. Estimates are limited to a shaggy green lichen, Alectoria sarmentosa, and a similar black lichen of unknown species. Percent gravel and average gravel size are also estimated for each campsite.

Several other parameters that were measured are not discussed in this paper. They are management related and include: Campsite densities, visitor attractions and potential activities, distance to water, water form, site history, and condition of toilets and any structures. Past management practices, future management recommendations, and a site map are also placed on the cards. The map of each campsite is drawn on either a 1 x 1 meter or 2 x 2 meter grid. This map serves as a baseline for the size of the bared area, the location of social trails, downed logs, and the point used as the center of the campsite.

Most of our data analysis has been accomplished with the CDC 6400 computer at the University of Washington. A listing of the computer program is available on request. We have also tested the use of the needle-sorting method and found it generally satisfactory, although it does not allow a sorting of plant information by species.

Our main statistical tool has been the Kendall Rank Correlation Coefficient using the SPSS Statistical Package developed at Vogelback Computing Center, Northwestern University. Both within-area and between-area correlations have been obtained. Between-area correlations were run on data averaged for the camp areas involved.

RESULTS AND DISCUSSION

Between-Area-Correlations

Correlations based on data averaged for each camp area appear in Table 1. Except for distance to the nearest trailhead, the coefficients are stronger with mean bare ground radius than with total bare area. This is probably because the bare radius describes an average campsite condition, while total bare

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Total bare area</th>
<th>Mean bare radius</th>
<th>Number of camp areas</th>
</tr>
</thead>
<tbody>
<tr>
<td>Elevation</td>
<td>.05</td>
<td>-.06</td>
<td>66</td>
</tr>
<tr>
<td>Distance to Nearest Trailhead</td>
<td>-.22**</td>
<td>-.19*</td>
<td>66</td>
</tr>
<tr>
<td>Lichen Height</td>
<td>.55*</td>
<td>.49*</td>
<td>11</td>
</tr>
<tr>
<td>Percent Canopy Cover</td>
<td>.29**</td>
<td>.43**</td>
<td>66</td>
</tr>
<tr>
<td>Percent Gravel</td>
<td>.05</td>
<td>-.11</td>
<td>66</td>
</tr>
<tr>
<td>Gravel Site</td>
<td>.05</td>
<td>-.11</td>
<td>66</td>
</tr>
<tr>
<td>Number of Overstory Layers (strata)</td>
<td>.08</td>
<td>.10</td>
<td>66</td>
</tr>
<tr>
<td>Tree Height</td>
<td>.07</td>
<td>.26**</td>
<td>40</td>
</tr>
</tbody>
</table>

** Significant at .01
* Significant at .05
area is the sum of bare ground present for all campsites at a given location. Mean bare radius could, for example, be identical at two areas with 20 and 10 campsites each. Total bare area, however, could be an order of magnitude or more greater since area = \( r^2 \). The fact that correlation with distance to the nearest trailhead is better for total bare area rather than mean bare radius may simply indicate more campsites per camp area closer to the trailhead.

The strongest relationship is between canopy cover percent and either total bare area or mean bare radius. This shows that where bare ground impact is greater, so is canopy cover. Since canopy cover is less in subalpine forests than continuous forests at lower elevations, this result is contrary to the popular belief that the subalpine zone is more subject to impact than lower elevations.

Elevation does not exhibit a strong relationship with either bare ground parameter. In part, this is an expression of the range of ecological conditions found in Olympic National Park. The Olympic Peninsula is subject to orographic influences that locally vary the climate and vegetation from east to west and north to south (Fonda and Bliss 1969, Kuramoto and Bliss 1970). Thus at 1240 m elevation, the west side of the park can have subalpine forests and the east side continuous montane forests.

**Within Camp Area Correlations**

Results from bare ground comparisons made within individual camp areas indicate that, while patterns do exist for some variables throughout the park, each camp location must be examined separately. Table 2 shows correlations between bare ground radius and percent canopy cover. Note that correlations are not consistent: some are strongly positive, two are negative and several are weak.

<table>
<thead>
<tr>
<th>Subalpine Areas</th>
<th>Correlation Coefficient</th>
<th>Significance (alpha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Morganroth Lake</td>
<td>.43</td>
<td>.03</td>
</tr>
<tr>
<td>Lunch Lake</td>
<td>.47</td>
<td>.005</td>
</tr>
<tr>
<td>Deer Lake</td>
<td>.31</td>
<td>.02</td>
</tr>
<tr>
<td>Hoh Lake</td>
<td>.26</td>
<td>.21</td>
</tr>
<tr>
<td>Clear Lake</td>
<td>.41</td>
<td>.24</td>
</tr>
<tr>
<td>Anderson Pass</td>
<td>.59</td>
<td>.09</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Montane Areas</th>
<th>Correlation Coefficient</th>
<th>Significance (alpha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flapjack Lakes</td>
<td>.19</td>
<td>.37</td>
</tr>
<tr>
<td>Honeymoon Meadows</td>
<td>.81</td>
<td>.001</td>
</tr>
<tr>
<td>Lake Constance</td>
<td>-.37</td>
<td>.07</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Lowland Areas</th>
<th>Correlation Coefficient</th>
<th>Significance (alpha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sandpoint</td>
<td>-.36</td>
<td>.003</td>
</tr>
<tr>
<td>Olympus Guard Station</td>
<td>.32</td>
<td>.08</td>
</tr>
<tr>
<td>Lillian River</td>
<td>.11</td>
<td>.59</td>
</tr>
<tr>
<td>Stony Point</td>
<td>.75</td>
<td>.04</td>
</tr>
<tr>
<td>Hayes River Station</td>
<td>.37</td>
<td>.14</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Park Wide - between areas</th>
<th>Correlation Coefficient</th>
<th>Significance (alpha)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>.43</td>
<td>.001</td>
</tr>
</tbody>
</table>
One key to accurate camp area management is obtaining a good understanding of these local patterns. Olympus Guard Station and Deer Lake serve as good examples.

Olympus Guard Station is a low elevation (200 M) camp area with an open grassy meadow and several different aged stands of red alder (Alnus rubra). Overall it is best described as an alder flat (sensu Fonda 1974). There is a fairly strong correlation showing greater bare ground with greater overstory cover. Visitor use tallies, however, indicate that most people camp here in sites with less canopy. Therefore, fewer people are associated with greater impact under the denser forest canopy.

Starting in 1975, at Olympus Guard Station people were allowed to camp along the meadow edges, where no camping had previously been permitted. People were not, however, allowed to build fires in the meadow. Observations to date indicate that no new bare areas have appeared in the meadow. It is hoped that in the long run this will reduce overall bare ground present by reducing visitor use in the more sensitive areas of heavier forest canopy. Visitor satisfaction may also be increased, since there is an apparent preference for the more open campsites.

There are several tentative reasons why the silver fir zone is most sensitive to visitor overnight use. First, visitor use begins in this zone by early July when plants are most sensitive to trampling. Soils tend to be saturated and plant phenology is at an early stage (just leafing out). Both factors are known to contribute to greater sensitivity of plants to trampling. Second, we have observed that sensitive, herbaceous species such as avalanche lily (Erythronium montanum) are a major understory component. Third, understory vegetation roots tend to be in the upper duff layer rather than in mineral soil (C. Grier, University of Washington. Thus one might expect these roots to be more subject to trampling damage, since they are close to the surface.

Further work about impact pattern and plant community types should examine the role of successional stage, species diversity, and overall plant form. Long (1977) and Long and Turner (1975) present successional patterns for species diversity and understory biomass, respectively. Peaks, valleys, and trends are evident in their curves. It may be that trampling impact then reflects a lower initial understory biomass, or differences in the dominant plant form associated with a particular successional stage. For example, Long and Turner (1975) show decreasing understory biomass with advancing successional stage and Grier (personal communication) has data for a 36-year-old Douglas fir (Pseudotsuga menziesii) stand where the understory component is absent. In addition, Cole (1979) points out that there seems to be a relationship between a species' shade tolerance and susceptibility to trampling, with light-loving species least sensitive. In any case, the relationship between impact and successional stage may be important.

Another example of how within-area patterns are useful is at Deer Lake, a sub-alpine area (1000 m) with mountain hemlock (Tsuga mertensiana) and red heather (Phyllodoce empetriformis) communities interspersed with sedge meadows (Carex spectabilis and C. nigricans). The greatest impact is associated with heather sites, where coarse angular rocks occur at the soil surface, and where lichen heights are low (indicating earlier snow melt). With some reasonable success, we have started to re-vegetate the sensitive heather sites and encouraging people to camp in the sedge meadows. In addition, a stoves-only regulation has stopped most fire building. The net result of these actions, and the removal of two shelters, is a shift of use toward the sedge meadows, where no new bare ground has appeared to date. Some campsites exhibit vegetative recovery.

Overstory Cover Type and Impact Pattern

In an effort to further understand trampling impact and overstory cover patterns we have aligned the camp areas by canopy cover type. The cover types are preliminary and roughly approximate vegetation zones described by Franklin and Dyrness (1973). We are, however, including the Sitka spruce (Picea sitchensis) zone with the western hemlock (Tsuga heterophylla) zone. Forest cover types, impact data, and equivalent zones are listed in Table 3. At present, understory vegetation is not being used to make the types, but will be incorporated at a later date.

Stands that have most of the overstory cover composed of red alder exhibit the smallest total bare ground area and mean bare radius of any group. These areas also have the greatest visitor overnight use in the
park, with the exception of the Pacific Coastal Area. It would appear, then, that campsites under an alder canopy are least sensitive to visitor use.

Several factors may contribute to the low sensitivity of alder stands to impact. First, the canopy is deciduous and the understory growing season starts earlier than in coniferous forests of similar elevation. Some understory species complete the greater portion of their life cycles before the canopy leaves out in May, and thus are setting seed before the heavy visitor use season begins in July. Second, alder flat communities in the Olympics tend to be dominated by grasses. According to Fonda's (1974) data along the Hoh River, many of these species could be classified as ruderal or "weedy" species. The resistance of these types of plants to trampling is well documented (Bates 1935, 1937; Burden and Randerson 1972; Dale and Weaver 1974). The early successional status (Franklin and Dyrness 1973) and high understory productivity (Turner et al 1976) of alder stands could also be contributing factors.

Camp areas that have a combination of large total bare area as well as the greatest mean bare radius occur in stands of mixed silver fir (Abies amabilis) and western hemlock in the silver fir zone. The low-to-average visitor use at these locations (Table 3) suggests they are quite sensitive to human impact from camping. Subalpine stands of the mountain hemlock zone contain campsites with the largest total bare area, but more or less average bare ground radii. We interpret this to mean that there are more campsites in the subalpine and not that this zone is more sensitive than the silver fir zone.

Campsite Restoration

From the results of our impact survey we have begun restoration efforts at some backcountry camp areas. We have used Student Conservation Program groups of 7 people to accomplish much of the work. Detailed results will not be discussed here, but some general findings are as follows:

1. Moderate-to-large clumps of plants have a better survival rate for transplanting than small seedlings.
2. Mat-forming plants, grasses, sedges, and plants with runners have the highest success.
3. Impact in heavy-use areas is minimized by concentrating use in sites dominated by grasses and sedges.
4. Multiple trailing impact can be eliminated by reducing route-finding and searching activity. One trail is made obvious and easy to travel, while secondary and tertiary routes are restored and made difficult for travel. This is especially effective around lake

Table 3. Overstory canopy characteristics, vegetation zones and bare ground at backcountry camp areas in Olympic National Park. Data represent averages for areas within each group.

<table>
<thead>
<tr>
<th>Dominant tree species</th>
<th>Vegetation zone</th>
<th>Bare ground</th>
<th>Canopy</th>
<th>Visitor nights</th>
<th>Number of areas</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Total $(m^2)$</td>
<td>Radius $(cm)$</td>
<td>Cover $(5)$</td>
<td>Height $(m)$</td>
</tr>
<tr>
<td>Red Alder</td>
<td>Tsuga heterophylla (Lowland)</td>
<td>163</td>
<td>217</td>
<td>64</td>
<td>18</td>
</tr>
<tr>
<td>Bigleaf Maple</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Douglas Fir</td>
<td>Tsuga heterophylla (Lowland)</td>
<td>378</td>
<td>340</td>
<td>69</td>
<td>27</td>
</tr>
<tr>
<td>Western Hemlock</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Grand Fir</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Silver Fir</td>
<td>Abies amabilis (Montane)</td>
<td>613</td>
<td>497</td>
<td>69</td>
<td>22</td>
</tr>
<tr>
<td>Western Hemlock</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mountain Hemlock</td>
<td>Tsuga mertensiana (Subalpine)</td>
<td>666</td>
<td>320</td>
<td>29</td>
<td>17</td>
</tr>
<tr>
<td>Silver Fir</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Subalpine Fir</td>
<td>Tsuga mertensiana (Subalpine)</td>
<td>516</td>
<td>299</td>
<td>26</td>
<td>11</td>
</tr>
</tbody>
</table>
shores.

5. Watering plants before transplanting (summer) seems to have a beneficial effect on survival.

6. Jute netting is an effective means of identifying sites where restoration is underway and helps to prevent subsequent raindrop compaction in tilled areas.

CONCLUSIONS

The data presented here show that there is a broad pattern between overstory cover percent of certain three species and human trampling impact as we have measured it. It is also apparent that patterns exist within specific camp areas and must be dealt with individually. In addition to individual site management, there are at least two other possible approaches to impact management.

First, we could do better at interpreting our actions. It is probably far more beneficial and effective to be honest with the visitor from the beginning. For example, explain why restoration efforts are underway, and where alternative camping locations exist. Most signs we see are negative, stating "NO CAMPING" or something. Why not just "tell-it-like-it-is" in a positive fashion?

A second approach is to attempt a form of zoning. We probably all agree that some methods of site management are more appropriate than others for a given set of circumstances. This approach requires that we answer the question: "How much will we manipulate the site in order to minimize impact?" Coincidentally one must determine the degree of naturalness appropriate for the area in question. For example, vehicle campgrounds might be seeded with exotic grasses without unduly sacrificing a suitable degree of naturalness. In a national park or wilderness area, however, it is obvious that exotic grass seeding is not proper. Or is it? The point is that in order to establish an efficient program a clear decision must be made about management goals, degree of naturalness, and the limits of management zoning.

ACKNOWLEDGMENTS

The National Park Service, Cooperative Park Studies Unit, University of Washington provided support to obtain the inventory cards and assistance with data analysis. John Hendee, Roger Clark, Russ Koch, Mac Hogans and Dan Wood of the U.S. Forest Service Recreation Unit introduced us to Code-A-Site (Hendee et al. 1976) and assisted in the design of the Human Impact Inventory Cards. Bob Flewelling and Kevin McCarty collected much of the data on campsite impact and the ranger staff of Olympic has assisted in collection of visitor use data.

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GUIDELINES FOR THE REHABILITATION AND PRESERVATION OF THE APPALACHIAN TRAIL SYSTEM USING THE PRINCIPLES OF LANDSCAPE ARCHITECTURE

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ABSTRACT--This paper attempts to present significant findings of a student study of the Appalachian Trail System. The findings and process included are those the author considers most relevant to similar studies that may be undertaken in other areas of the country. Three principal types of recreation use are identified and their characteristics summarized. A planning strategy is outlined for preservation of the Appalachian Trail from public- or private-sector development.

HISTORIC BACKGROUND OF THE APPALACHIAN TRAIL

The Appalachian Trail first proposed by Benton MacKaye in 1921 became a reality in 1933. This trail system links Mt. Katahdin, Maine with Cotuma Mountain, Georgia, for a combined distance of 3,294 km (2,059 miles). Today this trail borders the greatest population concentration found in the eastern United States and it follows many paths established by Indians of the region and later used by American pioneers. Thus the Appalachian Trail represents a significant segment in the history of this country, as was recognized by the federal government in declaring it a national scenic trail in 1968.

This trail system is located in the western edge of the Boston, Massachusetts to Washington, D.C. population corridor. The concentration of urban population within this regional area has created high recreational demand for all forms of outdoor recreational activity. These demands are further complicated by a general lack of public open space land areas in proportion to the population density. This is especially true of federal land holdings within the states east of the Mississippi River. In Pennsylvania for example, with the exception of the Allegheny National Forest the bulk of large land holdings available or potentially available for recreation are either state-owned parks, game lands or state forests.

OBJECTIVES OF THE APPALACHIAN TRAIL STUDY

In 1976, the State Department of Community Affairs contracted with The Pennsylvania State University's Department of Landscape Architecture to undertake a study of the Commonwealth's portion of the Appalachian Trail and to develop guidelines for the trail's preservation. Action at the state level was precipitated by a rash of secondary home developments planned or under construction in the northeastern portion of the state where there is no legal basis for public ownership and because of this, the trail's existence continues at the whim and consent of numerous private property owners.

During winter term of 1976, some twenty-six senior design students undertook a ten-week preliminary study of Pennsylvania's portion of this trail system. During spring term a smaller study group refined the preliminary findings into a final report that was subsequently published as a report titled, "The Appalachian Trail Guidelines for Preservation by the Pennsylvania Department of Community Affairs." The objectives of this study fall into the following broad categories:

1. To study and evaluate ecological and environmental constraints relative to the utilization of the Appalachian Trail System as a recreational facility. Also, insofar as possible, to determine user trail interface conflicts and incompatibilities and suggest corrective measures as necessary.

2. To study all problems created beyond or associated with the development of private lands that threaten the continued existence of the trail system. Further to recommend strategies for local government
to protect and/or enhance the trail system.

3. To identify problems and conflicts between trail use and use as public recreational areas. Further, to recommend strategies to eliminate these conflicts and enhance both recreational activities.

THE HIKING EXPERIENCE

The students' preliminary studies involved a review of available literature in order to determine the hiking experience and demands of the typical recreational user. First and foremost, it was determined that the hiker desires to get away from the trappings and pressures of civilization. Their primary objective is for a simple trail without fancy "civilized" facilities and offering the peace and tranquility of a pristine bucolic environment. Shafer and Meitz's studies in hiker values, for example, found aesthetic and emotional experiences the more important values to the hiker. Physical experience was half as important and educational and social values even less important.

To achieve these goals, the trail's location is important in that it must be able to provide a variety of user experiences. It should provide a variety of scenic experiences including variation in landscape, terrain, topography, geography, and flora and fauna to maximize user experience.

The students broke down users by broad categories of hiking needs:

The One Day Hike. The one day hiker desires a loop system with a trail of approximately 3 to 5 km (2 to 5 miles) in length. It can wind to include points of interest both natural and historic, and should return the user to the beginning. Supporting requirements include a desirable access point with adequate parking. A midday source of drinking water is desirable, but not essential.

The Weekend Hike. The weekend or three-day hike requires a longer trail system of approximately 16 to 24 km (10 to 15 miles). Usually this can be a loop system returning the user to the point of beginning; however, it can also be linear if provision is made for drop-off and pick-up at logical and identifiable access points. The trail need not be a direct route, but should include more than one geographical environment. Here, a sequence of natural or historic points of interest should be encountered. Supporting facilities include adequate overnight camping sites, water supply and road access with adequate off-street parking for both the loop and linear systems.

The Long Distance Hike. This trail must be linear and, insofar as topography permits, should also be direct. Points of natural and historic interest are still important, but not every area the trail passes through need be fully exploited, especially if this would be at the expense of increasing the distance. Exceptions may be made in unique situations, but always at the user's option. However, within the foregoing parameters variety in overall environment is still important. Location of overnight camping areas is most important, but is usually determined by reasonable proximity to a suitable water supply. Dispersal of campsite locations can prevent possible or potential environmental impacts. Secondly, provision for trash disposal where the trail crosses roadways is important. Consideration should also be given to a logical system on a regional basis for mail pickup, telephone access, resupply of provisions and possible medical assistance.

All three trail environments and hiking environments are both valuable and fragile. In areas where wilderness trails, like the Appalachian Trail, are being utilized by high demands, the volume of short-term users who create erosion, wear and litter can quickly destroy the wilderness experience for the long-distance hiker. In these areas of high recreational demands, attention should be given to other equally suitable trail systems to disperse the pressures over a much larger land area. Conversely in areas of lower recreational demand, these linear wilderness trails can be developed to provide a wider range of hiking experiences, depending upon the carrying capacity of the specific natural environment. Environments of an extremely fragile character (for example, marshy and alpine areas) require special attention in order to protect their sensitive natural uniqueness. Thus it is essential that the delicate balance be maintained between maximizing hiking opportunities and the environmental carrying capacity of the ecosystem. Overuse can destroy the natural environment, which is an essential segment of
Here in the eastern portion of the United States, recreational hikers must often share their trail with others who have a different idea of what constitutes a good trail experience. Snowmobiles, motorcycles, all terrain vehicles (A.T.V.s) and horses are frequently ridden on the hiking trail system. Motorized vehicles can and do a much greater damage to the trail environment and the hiking experience than do hikers and horses. Sound and odor pollution created by vehicles frighten wildlife, destroy the solitude of the wilderness experience, and impact the natural ecosystem. They should not be permitted in wilderness hiking trails.

People today are doing more and more hiking, and wilderness backpacking is becoming a major recreational activity. There is a need for more trail systems in order to accommodate the increased user demand but these trails must be related to the carrying capacity of the ecosystem.

**PRESERVATION STRATEGY**

In order to protect the Appalachian Trail from either private- or public-sector development, a trail protection strategy was developed by the student study group. This overall strategy included five major steps in two phases, as indicated by the following:

**Pre-Development Phase**

**Conservation and Open Space Protection.** Through the use of access and ownership studies, areas of potential future development can be delineated. Once the location of the growth areas has been determined, then local municipalities can move to protect the trails' environmental corridors. This can occur through the adoption of municipal land use controls, either zoning or land subdivision regulations, or both. The protections derived from these techniques are applicable to any endangered lands.

**Development Phase**

**Trail Environment Delineation.** Based on a sliding scale, various minimum and maximum corridor widths were established from recreational uses as least intensive to industrial usage as most intensive. If the development conforms to these recommended corridors widths, proposed plans are given municipal approval. If proposed development does not meet established criteria, then these projects should be stopped through the natural resource vulnerability screen.

**Natural Resources Vulnerability Screen.** This includes a review of those natural elements normally included in an environmental impact statement. Among factors included are evaluation of vegetation, soil erosion, surface and ground water pollution, septic tank suitability, wildlife. Future developments may be stopped for failure to conform with established local and state standards or requirements.

**Legal Solutions.** This is an expensive approach but may be used for critical areas in order to protect the trail's integrity. It can include fee simple purchase, easement acquisition, purchase of development rights and/or condemnation proceedings.

**Design and Management Solutions.** Design and management solutions may be negotiated with the developer. A cooperative approach can create a better design solution that will reduce potential impact on the trail corridor.

A final solution to the problem of developmental encroachment upon the trail may be to move its location. This should be considered only as a measure of last resort since a continuous linear trail system is paramount to any trail linkage system.

**SUMMARY**

This paper has attempted to highlight significant findings and recommendations of a rather detailed study of a portion of the Appalachian Trail System. Those wishing to review this study in greater detail, may contact the Pennsylvania Department of Community Affairs, where a limited number of copies are available. The findings selected by the author were those that were felt may have application to similar studies undertaken in other areas of the country. However, as indicated previously, the findings contained in the Appalachian Trail Study cannot be directly applied to other ecosystems.

Finally, how does one measure the success of a study such as was undertaken? In the spring of 1977, Congress passed federal legislation authorizing the National
Trail Systems Act. The original legislation has authorized a maximum trail corridor of 61 m (200 feet) wide with a maximum of 10 ha (25 acres) per lineal 1.6 km (1 mile). The 1977 Act increased the maximum corridor width to 305 m (1,000 feet), with the land's holdings increased to 50 ha (125 acres) per lineal 1.6 km (1 mile). We at Penn State have been advised that the students' Appalachian Study played a role in achieving this increase in corridor authorization.

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Oregon white oak
A SUCCESSFUL CAMPAIGN TO REDUCE TRAIL SWITCHBACK SHORTCUTTING

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ABSTRACT--This page presents a documentary of a successful, ongoing campaign to reduce switchback shortcutting on a high-use recreation trail in the Columbia Gorge. A history of attempts to stop shortcutting on the trail is presented, along with the start of the campaign and results of revegetation and education experiments.

A PERSPECTIVE

Seasoned hikers have long welcomed trail switchbacks as the most efficient way to travel over step terrain. Less energy is spent and less erosion occurs when one follows a zigzag route up or down a hillside. Less knowledgeable hikers often do not understand the longer route. If the trail above or below the switchback is visible, it becomes a challenge to take the shorter route. Now, with the growing numbers of recreationists, land managers are increasingly challenged to solve resource and safety problems caused by the shortcutters.

A campaign to reduce the detriments of shortcutting recently began on a high-use recreation trail in the Columbia Gorge in north central Oregon. Columbia Gorge trails present particularly acute safety and erosion problems. The Gorge's picturesque cliffs are composed of Columbia River basalt which is very erosive, and the trails switchback over steep unstable terrain.

The problems are compounded by the volume of visitors who hike the Gorge trails. Easy freeway access and a quick, thirty-minute drive from the Portland metropolitan area makes Multnomah Falls a center of attraction in the Columbia Gorge. At least 100,000 visitors per year hike the 2 km (1.2 miles) of trail for a spectacular view of Multnomah Creek plunging 19 dm (620 feet) to the rocks below.

Some visitors choose to hike on the trail. Some choose a shorter route, even though the shortcut presents precarious footing and sheer dropoffs. Switchback shortcutting has resulted in severe resource damage over the 60 years of the trail's existence.

The bare, eroding hillsides are highly visible to thousands of hikers each year, but managers of the area have another major concern besides resource damage: the visitors' safety is in jeopardy. Shortcutters often send rocks rolling onto hikers below; indeed, the hikers themselves occasionally tumble down the hill. Traveling off the trail has resulted in numerous minor injuries and at least two fatal accidents over the years.

There is a long history of attempts to stop shortcutting on the Multnomah Falls trail. Thousands of square feet of rock walls have been built along the trail and are still being constructed at major problem areas. They do not stop the determined shortcutter, however, and the cost to build them all the way to the top is prohibitive at this time.

Barberry bushes were planted in a few of the shortcuts in the early 1960s. Some progress is beginning to show after 17 years, but
the non-native shrubs have grown very slowly and many determined visitors still charge through despite the thorny barbs. As with the rock walls, hikers have sometimes expanded the shortcut by skirting the barriers.

Shortly after the barberries were planted, $50,000 was spent to pave the entire trail to the top. The pavement has helped hold the trail in place but seems to do little to keep hikers on the trail.

Signing was used over the years. Appeals for personal safety, such as "Please Stay on the Trail" were not effective. The standard wooden signs did not attract attention and lacked explanation.

Uniformed personnel began to patrol the trail on weekends. They talked to people about shortcutting and its detriments. Personal contacts were by far the most effective means to deter shortcutting, but salary costs to contact every hiker was prohibitive.

It became obvious a concerted effort was needed. Some safety hazards and a degree of resource damage may be acceptable in various public recreation areas. However, both resource managers and a few concerned citizens felt a trail this popular warranted an all-out, stop-the-trail-shortcutting campaign.

THE STOP-THE-TRAIL-SHORTCUTTING CAMPAIGN

A Start - Summer 1977

A stop-the-trail-shortcutting committee met in June of 1977. A group of interested citizens and resource, trail and information specialists aired their concerns and brainstormed possible solutions.

Information gathered before the meeting noted shortcutters to be of all ages. The largest percentage were 13-17 years old. Reasons to cut the trail ranged from releasing excess energy to racing a companion to the bottom. Over 90% of the visitors interviewed did not know the term "switchback", let alone the detrimental effects caused by shortcutting. Most thought they were on a trail.

From this somewhat scanty information and a wealthy background of trail experience, the committee devised a campaign. Objectives of the campaign combined revegetation with education. The committee felt revegetation would be futile without an education program to change visitor behavior. They also believed education efforts would be much more successful if visitors could see some slope rehabilitation as soon as possible.

The plan of action called for experiments to find solutions. Other plant species would probably grow better than barberry, but no attempts had been made. And other messages and types of signs would probably be read and heeded, but none had been tried. The committee felt prior attempts may have been steps in the right direction, but were not accompanied with an ongoing program. Plans were made for immediate action as well as long-range efforts.

Though we could not plant the experimental revegetation site until fall, we could try different approaches to education immediately. As the information specialist for the committee, my primary task was to implement the committee's recommendations for educational experiments.

Experiments in Signing. Visitor safety was one of the committee's major concerns. To appeal to the visitors' concern for their own safety, I felt the danger of injury or fatality would not seem imminent enough to keep hikers on the trail (past signing proved the point). I chose poison oak for an eye-catcher.

Similar efforts on some of our southern region forests reported success with a figure of a rattlesnake for an eye-catcher on signs. Poison oak abounds along the trail to the top of Multnomah Falls. One of the most effective signs reads: "Stepping off the Pavement is no Joke, You may Land in Poison Oak."

A shortcutting information bulletin board was installed near the beginning of the trail. The poison oak sign and others were posted immediately.

Target Audience Education. Observations had shown the most frequent shortcutters to be 13-17 years old, and the Portland area schools were used as a nearby source of this target audience.

Local sixth, seventh, and eighth graders were asked to participate in a trail shortcutting poster contest. Each school received a first- and second-place award and a grand prize winner was chosen from all entries. The winner and his school received a Woodsy Owl trophy and publicity in local
newspapers. The students' posters are now changeable displays on the shortcutting information bulletin board.

**Mass Media.** I contacted local TV news media to cover the campaign. Two local newspapers also ran more in-depth stories. To my knowledge, no visitors indicated they had been exposed to the coverage. Even though the media may reach large audiences, the effects appear to be short-lived and are not far-reaching enough for the changing Multnomah Falls visitors.

**Preparing for the Fall Revegetation Experiment.** A plant ecologist studied the experimental revegetation site and made recommendations for species suitable to the harsh site. The plants were ordered for delivery that fall.

Personnel prepared the area for replanting. They laid down hemp matting and seeded grass to help stabilize the bare soil. A temporary fence was strung around the .10 ha (1/4-acre) site and signs installed to explain the intended project.

**Fall and Winter 1977-1978**

A local Job Corps agribusiness class planted and fertilized $5,000's worth of vine maple, alder, Oregon grape and other—mostly native species. An estimated $6,000 was saved by utilizing crews from cooperative work programs.

**Summer 1978**

Another experiment was initiated over the 1978 summer season. Discussion with visitors showed there was a need for some of them to experience a challenge in the out-of-doors. The trail at Multnomah Falls may seem highly developed to those who spend a great deal of time in the woods, but to others, it may be an adventure in the wilderness.

Management decided to install a "legal" shortcut for those energetic individuals needing that challenge—a way to release excess energy and stress. Railroad ties were installed on a major shortcut to give them a steep, but safe trail.

There are no current plans to install more "legal" shortcuts. Visitors' reactions have been positive to date and the ties have also seemed to stabilize the slope without signing or replanting efforts; however, another heavy-use season is needed to determine their effectiveness.

The start of the 1978 summer season proved the temporary string fence would be a major maintenance problem. Visitors often used the weak material like a handrail. However, it was also observed that the fence provided a visual barrier and drew attention to the newly revegetated area. When the fence was down, a few would not notice the signs and start to use the shortcut area again.

People were anxious to cooperate when they saw the fence and the signs explaining the efforts. Trail patrol also observed a decrease in shortcutting on the trail above the unfenced area. Many hikers stopped to comment favorably regarding the project.

The effectiveness of the experiment in reducing shortcutting on unfenced, unplanted shortcuts prompted management to install a permanent fence around the revegetation area. Green sheep-wire fencing was attached to steel posts sunk in concrete to hold them on the rocky hillside.

All signboards and signs were standardized to reduce sign pollution. To retain flexibility of signing and minimize costs, I chose to keep the inexpensive plasticized paper signs. Chickenwire was attached over the face of the signs to protect them from would-be collectors. The experimental area had become a demonstration site: an educational approach in itself.

To measure success of the campaign, I noted visitors' comments indicating they had read the signs. Style of signs changed dramatically from the seasons before and their number had increased from 2 to 15. There were no comments of recognition the summer before the campaign. Visitors seemed to be influenced by the positive approach in the sign wording and often expressed enjoyment of the different poems and pleas. They were especially fond of the Burma Shave approach (Figure 1), with "Trail Saver" for its trademark.

Another way to measure progress was by periodically counting shortcutters. Shortcutting was reduced to zero at the experimental revegetation site and decreased on the unfenced shortcuts above the signed project. It seems when people understood the problem, most were willing to cooperate by staying on the trail. In some instances, visitors were observed policing each other.
Visibility and readability of signs were key factors.

The Future

Now that the project is underway, lesser expenditures of dollars and energy will probably suffice in the future. Experimental efforts that have proven successful will be continued and cooperative work forces will be utilized when possible. Plans are to continue utilizing the Job Corps agribusiness
class to transplant native species on the shortcuts outside the experimental site. A few more signs will be installed as more shortcuts are revegetated, but there are currently no plans to install more fencing.

The combination of revegetation and education was one of the keys to progress on the stop-the-trail-shortcutting campaign. The positive and/or entertaining signs encouraged visitors to cooperate once they understood the detriments of shortcutting and our commitment to correct it. They are easily able to see the difference between a planted and unplanted site.

Another factor affecting the success of the campaign was commitment by managers to make the program work. As I project an ideal picture, I see fully revegetated shortcuts all the way to the top.

Educational methods and their focal points will probably change with experience, but some commitment will always be required: commitment from the growing number of knowledgeable recreationists and commitment from land managers responsible for the fate of special places like Multnomah Falls.

DISCUSSION

Comment: At what target group should a campaign be aimed?

Matheny: Past surveys indicated the largest percentage of shortcutters to be 13-17 years old. We went to the local sixth, seventh and eighth graders as a target audience to educate through a poster contest on trail shortcutting. The nearby Portland area was a ready source of students for our contest.

Comment: Did you use poison oak in your revegetation plantings?

We've used poison oak on a number of privately-owned campground sites and it's been quite effective. It is a hardy plant; grows quite well and holds soil effectively.

Matheny: No, we didn't. We did not want to create more hazards for visitors. We did draw attention to "resident" poison oak as a deterrent to shortcutting.

Comment: How long have visitors been shortcutting switchbacks?

Matheny: Shortcut areas have existed on this trail for at least 20 years. They have continued growing in numbers and size ever since.

Comment: Now that the one site is revegetated, would you expect the shortcutting to reoccur without the intensive education program?

Matheny: Because of the audience we have, yes. Perhaps 80% of our people are visiting for the first time. The message needs to be there all the time. We utilize the signs because we can't be there to talk with 1½ million people every year.

Comment: Is there a chance that once it is revegetated, visitors will find the easiest course of action would be to stay on the trail, even though they can see from top to bottom of the shortcut?

Matheny: Yes, there is a chance. I don't think the problem on the unfenced revegetated areas above would stop without the educational and experimental site below. We decided to experiment with revegetation so something visible would start happening immediately—not just signs to explain our efforts. A plot with just a fence around it, would take a long time to heal in these harsh soils.

Comment: On how many shortcuts did you decide to build steps?

Matheny: Just one. It was a very long and narrow shortcut. The steps were one more type of experiment to deal with shortcutting.

Comment: What percentage of your visitors are from out-of-state?

Matheny: About 30% are from places other than Oregon and Washington.

Comment: Is your railroad tie trail pretty heavily-used?

Matheny: That was just installed towards the end of summer so we're still testing its feasibility. A couple of Scout groups said they really enjoyed it.
A HUMAN APPROACH TO REDUCING WILDLAND IMPACTS

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ABSTRACT--Most impacts in wild areas are not caused maliciously. Damage results from a visitor's ignorance of good land ethics or his insensitivity to the consequence of his activities. Education can correct these deficiencies and change the visitor's behavior towards the land. Land managers must become warm, humanistic teachers that reach out to the public in a personal way. In the Selway-Bitterroot Wilderness of northern Idaho, the Nezperce National Forest has reduced impacts by educating the public in town, at the trailheads, and on the trail.

FREEDOM AND WILDLANDS

Wildlands, wilderness, and backcountry: to most people these three words are synonymous with a fourth one--freedom. In the backcountry, people expect to find freedom. Here they hope to escape from the constraints of society and be spontaneous and uninhibited. Often, however, they escape from the rules and regulations of town only to find mandatory permits, campsite closures, and travel restrictions. We land managers have turned to regulations to reduce the impacts left by visitors on the physical wildland resource. But have we created a new impact by our restrictions--an impact on the wildland experience, a spiritual and mental resource?

From 1973 to mid 1978, I worked for the Moose Creek Ranger District of the Nezperce National Forest in northern Idaho. Moose Creek administers 2227 Km² (550,000 acres) of the Selway-Bitterroot Wilderness Area and is the only all wilderness ranger district in the U.S. Forest Service. With the exception of a few hundred acres, it lies entirely within the boundaries of the Selway-Bitterroot. This Wilderness contains 5263 Km² (1,300,000 acres) and is the largest classified wilderness area in the United States.

Like all western wilderness areas, the Selway-Bitterroot suffers from visitor impacts. As the garbage, erosion, areas denuded of vegetation, and violations of the Wilderness Act increased, we established regulations to solve these problems. Not only did the impacts on the land continue to increase, but the regulations themselves created new problems. We were forced to try a new, more human approach to wildland management--an approach that educates instead of regulates, persuades instead of decrees, and befriends instead of antagonizes. The resulting decrease in impacts has been dramatic.

THE FAILURE OF REGULATIONS

We discovered several reasons why regulations were ineffective, not only in the Selway-Bitterroot but in other wildland areas as well.

1. Because of the size and remoteness of western wildlands, regulations are difficult to enforce. Most violators are never apprehended. Those that are, quite often are not penalized by the sometimes unsympathetic federal court system. Compliance with regulations declines as
word gets around that nothing happens to violators. Regulations such as a permit system force us to give tickets to individuals who are not damaging the land, but simply do not have the proper papers. When the permit is self-issuing, it does little to educate visitors on no-trace camping or to disperse them from overcrowded areas. When clerks or receptionists issue permits, they seldom have the time or training to devote to visitor education.

2. Many of our wilderness regulations control personal not criminal behavior. Regulations on soaps, human waste, camping locations, and campfires are examples. Visitors who violate these regulations do so more from ignorance and lack of sensitivity than from malicious destructiveness. Changing people's personal habits is more of a job for educators than policemen.

3. Instead of befriending the public and winning support for our policies, a purely regulatory approach antagonizes visitors. Americans resent government interference in their personal lives. Regulating lives in the wide expanses of a wild area may be one of the most aggravating interferences of all. Too many such regulations in a classified wilderness area violate the spirit of the Wilderness Act of 1964 which defines wilderness as having "a primitive and unconfined type of recreation."

THE HUMAN APPROACH

Today Moose Creek turns to regulations only as a last resort. Education has become our most effective management tool to reduce impacts. Most educational programs sponsored by land management agencies are impersonal and use indirect methods such as brochures, signs, bulletin boards, and public service advertisements. The Moose Creek approach is a personal type of teaching. In all our contacts with the public, we include the human touch. We train all our employees to extend old-fashioned backcountry hospitality to people that visit their camps and stations; for example, offering free cups of coffee financed by donations from the crew. When answering inquiries from future visitors, we send original rather than form letters that include personal appeals to practice good camping ethics. But the key element of this program is a cadre of our own employees who have become Forest Service teachers. They reach out through one-to-one contact or group presentations. We discovered that one human being communicating directly with others is the most effective way to change people's behavior in the backcountry.

To gain understanding and support for our programs and the regulations we do have, we need to give visitors more than just a knowledge of what they are. They need to understand why. Once visitors know the reasoning behind regulations, compliance increases and the need for further restrictions lessens. Land managers are now allowing lightning-caused forest fires to play a more natural role in many wildland areas. The entire Moose Creek Ranger District is an example. The good results land managers hope to achieve with this and other controversial programs can be destroyed by the negative public reaction that results from lack of understanding.

This human approach to wildland management has the objectives of:

1) reducing the impacts of visitors;
2) keeping regulations to a minimum; and
3) teaching visitors the why behind the regulations we do have.

EDUCATION AS A MANAGEMENT TOOL

To accomplish these objectives, our teachers reach out to actual and potential wildland users at three areas-in town, at the wilderness portals (trailheads), and inside the wilderness itself. We teach four topics: low-impact or no-trace camping, the Wilderness Act, the natural role of fire, and fire prevention. To keep our programs from promoting use of the wilderness and thus, increasing our problems, we do not: show slides of beautiful scenery; hand out maps and brochures; discuss in glowing terms the joys of the wilderness experience; or draw attention to a specific wilderness area or a spot inside a wilderness. Our messages apply to all wilderness and backcountry areas in general.

In-Town Education

Our records indicate that most of our visitors come from a handful of population centers. For example, over 50% of the hikers and horsemen entering the Selway-Bitterroot from the west come from three college towns in close proximity to each other - Pullman,
Washington and Moscow and Lewiston, Idaho. In these and other towns, we educate future wilderness visitors before they leave their homes. Our programs include talks at universities and horse clubs, articles in newspapers and public service ads and interviews on radio and television.

But our goal is to do more than just reach today's wilderness users whose attitudes are sometimes hard to change. We make a special effort to reach youth whose minds are still open. Our youth programs include presentations at boy and girl scout camperees, elementary schools, and the National Youth Sports Program. Sixth graders are one of the most receptive groups. These students are old enough to understand the difficult concepts of the Wilderness Act, but young enough to be enthusiastic and responsive. Students in junior high and high school are not as eager to participate in discussions and group activities. In all our youth programs, we teach through discussion and physical activities rather than lecture. For example, we sometimes establish a wilderness camp on a playground complete with tent, fire ring, ashes, wood pile, garbage, soap, and gear. The students must dismantle the camp and naturalize the site, erasing all trace that it was there.

Our in-town program continues to expand. In 1976, 383 people attended our programs; in 1977, 2,763. By the end of 1978 our audience had increased to 4,500. It is impossible to measure how many thousands more our programs have reached indirectly. It is to be hoped that our visitors have spread the word to friends and relatives, and others have seen, read, or heard our messages in the mass media. The cost of the 1978 program for supplies, per diem, and wages was about $4,500.

Education at the Portals

Our next contact with the public is at the trailheads. Stationed in cabins or wall tents at the six busiest portals are wilderness information specialists or WISes (pronounced whizes). These men and women seek out visitors before they enter the wilderness and have a chance to impact the land. Striving to be outgoing and friendly, they turn their stations into places of warm backcountry hospitality where visitors are welcomed with cups of coffee. Their purpose is to:

1. Educate visitors on no-trace camping, the Wilderness Act, the natural role of fire, and fire prevention.

2. Disperse visitors from overcrowded sites through persuasion. Most users eagerly avoid crowds when a WIS offers them an alternative.

3. Keep records. Providing the information the WIS needs voluntarily, the visitor does not feel that the government is forcing him to divulge personal data. We use these records to inform our roving Wilderness rangers where people are congregating, to disperse those visitors searching for solitude from overused sites, and to learn where to direct our in-town education efforts.

Employee selection and training are essential for a WIS program to succeed. We look for applicants who have communication skills; are outgoing, persuasive, and can make a good first impression; and have a good land ethic and believe in what they are communicating.

Once selected a WIS's training includes instruction in: the Wilderness Act and Forest Service wilderness policies and programs; law enforcement; fire prevention; communication techniques; and record keeping. They also go on a field trip in which they camp using the same no-trace camping skills that they will be communicating to the public, and take periodic trips into the wilderness throughout the season. This enables them to answer visitors questions on trails and campsites.

The cost of wilderness information specialists does have to be high. We have had WISes who have worked the entire season as volunteers and have performed as well as our paid employees. Normally, we pay our WISes GS-4 wages ($4.51 per hour). In 1977 our six specialists personally contacted 2,469 visitors. Their duties also included some wilderness clean-up and station, trail, and campground maintenance.

In-the-Field Education

Our third contact with the public is inside the Wilderness boundary. Using information provided by the WISes, our three wilderness rangers contact parties in heavy-use areas and make special efforts to visit those
groups that the specialists suspect might make unnecessary impacts. Of all our programs the wilderness ranger contact is the most effective in changing an individual's behavior even though he talks to the fewest numbers. He can actually see the impacts a visitor is making and tactfully suggest ways to prevent them.

Wilderness rangers also must be carefully selected and trained. Furthermore, to be effective, they must be delegated enough real responsibility and authority to deal with the problems they encounter on the trail. Along with the wilderness clean up and public contact duties one normally associates with wilderness guards and rangers, our wilderness rangers have responsibility for: field administration of the special use permits of commercial outfitters; law enforcement; writing environmental analysis reports, news releases, letters to the public, radio public service announcements, and brochures; training and supervising wilderness information specialists, garbage clean up volunteers, and Youth Conservation Corps crews; inventorying wilderness campsites using Code-A-Site, panoramic photography, and other techniques; and developing and implementing programs for our in-town education efforts.

RESULTS

How do you measure the effectiveness of a human approach to reducing wildland impacts? We can't use measures such as board feet or visitor days to show how many attitudes we have changed or how many people have improved their camping ethics. Following are some recent developments that indicate our approach is working:

To begin with, we receive letters of appreciation from people who have attended our programs. Second, an awareness of the concepts of minimum impact has diffused through the general public in our area. By 1978, for example, the sixth graders, for the first time, already knew some facts about no trace camping, the natural role of fire, and the Wilderness Act. Evidently, previous sixth graders have passed this knowledge on to younger brothers, sisters, and friends. Also we meet hikers and horsemen on the trail who were contacted in town or at the portals and remember the concepts we taught them.

Third and most important is the condition of the land itself. Impacts are much less noticeable in the Selway-Bitterroot Wilderness today than four or five years ago. The Wilderness has become wilder. Cove Lakes, the District's most heavily used camping area, is an example. In 1973, before our education programs, we picked up and hauled out an entire packstring of garbage from this lake basin and eliminated 20 fire rings. In 1974 after one season of a wilderness ranger's periodically contacting parties at the lakes, we removed two mule-loads of garbage. In 1975, after a season of a WIS at the nearby portal, as well as periodic field contacts, the Wilderness ranger was able to carry out all the garbage on his back. In 1977, after two seasons of an in-town education program to complement the continuing efforts of the WIS and Wilderness ranger, we eliminated three or four fire rings and picked up some pull tabs, cigarette butts, and aluminum foil.

Unfortunately, a Boy Scout troop which had not attended any of our programs visited Cove Lakes in 1978 on the WIS's day off. The scouts cut down several live trees and left litter and unburied human feces.

The Selway River is the busiest single trail in the Selway-Bitterroot Wilderness. In the past, its beauty had been marred by stock damaged trees, garbage pits, litter, and large trashy fire rings. The trail receives its heaviest use on Memorial Day weekend. During the 1978 weekend, a wilderness information specialist contacted all the hikers and horsemen as they started up the Selway River. Soon every camp area for 24 km (15 miles) had a party of campers. By Monday night all visitors had returned to town. On Tuesday, the wilderness ranger hiked the length of the trail and found one small fire ring and two cigarette butts.

If all wildland managers were to become warm concerned teachers, they not only would be able to protect the land from impacts, but at the same time could protect the freedom of the Wildland experience from excessive regulation.

DISCUSSION

Comment: Have you documented different aspects of this program, particularly cost?

Bradley: The Moose Creek Ranger District has a brochure entitled "The 1977 Wilderness Education Program" that includes costs, lesson plans, and the mechanics of setting up this program. You can obtain a copy of this
information by writing to me at Joseph Ranger Station, Joseph, Oregon 97846.

Comment: Have you had any success with leaflets, maps, and handouts?

Bradley: I feel that the public is so inundated with government handouts that this approach has lost much of its effectiveness. Perhaps we need a new type of handout that is so interesting that people will actually look forward to reading it. Moose Creek is experimenting with such a brochure. Called The Wilderness Primer, it includes stories; cartoons; tree, rock, and fish identification drawings; a wildlife checklist; and a horsemen's guide. The no-trace camping message is woven in throughout the booklet. For a copy write:

   District Ranger
   Moose Creek Ranger District
   Nezperce National Forest
   Grangeville, ID 83530

Comment: Do the wilderness information specialists have duties other than contacting the public? Do they ever get "burned out" when they just work at the trailheads?

Bradley: The WISes often maintain the buildings and grounds where they are stationed, put on evening programs for the car campers in nearby campgrounds, answer letters from the public, and design trailhead bulletin boards. However, their morale does suffer if they don't have the opportunity to travel inside the wilderness. Periodically we will give them this opportunity and send them down the trail to clean up garbage, visit camps, and learn about trail conditions. This field work gives them more credibility with the visitors when they return to their trailhead duties.

Comment: What do you know about the Boy Scout troop that left the mess at Cove Lake?

Bradley: They were a troop from Cour d' Alene that had never been to any of our Scout programs. We reached most of the other Scouts in our area when we put on an all day program at the Lewis-Clark Council Rendezvous on Chief Timothy Island near Clarkston, Washington.

Three thousand Boy Scouts, Cub Scouts, and their parents and leaders attended this event. It's a shame that land managers do not spend more time teaching youth groups like the Scouts. Today there is a large Scout convention right here in Seattle in the building next door with thousands of participants. I searched for exhibits by the Forest Service, Park Service, Bureau of Land Management, or Washington State Parks and found nothing.
INFORMATION AND EDUCATION TECHNIQUES TO IMPROVE MINIMUM IMPACT USE KNOWLEDGE IN WILDERNESS AREAS

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ABSTRACT—Parts of three studies are summarized. The studies were conducted to provide information intended to help managers improve the use of communication as a management tool. Their objectives included: (1) prioritization of user groups as target audiences based on wilderness knowledge levels determined by tests, (2) the determination of sources and channels used by respondents in obtaining the test answers, and (3) the testing of several media for relative effectiveness. Wilderness-related agency literature was also obtained nationwide and subjected to content analysis.

This paper is an attempt to summarize some of the more pertinent results from three research projects I have conducted during the past five years. In two of these, I ranked user groups according to their mean scores on wilderness-related knowledge tests and, with the help of graduate assistant William Bramlette, tried to determine from what sources information of this sort is commonly received. I also examined the relative effectiveness of several channels commonly used by managing agencies to transmit—or communicate—this information.

Before looking at the results, there are two cautions that should be mentioned. First, I conducted this work because I assume there is a positive correlation between knowledge and attitude. One of my research goals is to help managers raise visitors' knowledge levels so these people will support management strategies and techniques that have been judged necessary. I have also labored under the belief that before a person can adopt a positive attitude toward low-impact camping, he or she must first be made aware of the needs and techniques involved. Unfortunately, my assumption of the knowledge—attitude relationship is challenged by some. In fact, the most recent issue of Journal of Environmental Education carried an article by West Virginia researcher Lei Lane Burrus-Bammel (1978) who said the assumption is unproven. Being more of a re-tread forester than a sociologist, I will have to leave this debate for others to settle. I did panic, however, when I read this article and immediately set my graduate student, Marc George, to the task of searching the literature for an answer. To my relief, he quickly uncovered several projects that have shown the attitude knowledge correlation to exist. So, I feel comfortable with the assumption, but thought you should be aware of this.

The other caution is that two of the three studies were conducted to assist with management problems under specific circumstances and in specific places—namely Rocky Mountain National Park and the Selway-Bitterroot Wilderness Area. When I was invited to make this presentation I hesitated because any generalizations beyond those two places are made only at some risk. Nonetheless, I believe we can use many of the results as suggestions or clues, and I am confident that further testing in other locales would bear these out.

I think we can all agree—or we would not be here—that recreational use can impact resources. This problem can be especially acute in wilderness. Of course, as has been pointed out by other speakers, impacts are perceived differently by different people. Still, I think most of us notice litter where it occurs. This is an
impact, and although the problem seems to be getting better—thanks to information and education, I believe—it is still with us, even in the center of the huge Idaho Primitive Area.

Other physical impacts I have commonly seen in wilderness areas include fire circles that blacken rocks and become trash receptacles, and the cherished campfires themselves that consume large quantities of wood, often leading to the destruction of dead limbs and scenic old snags as people fan out from popular camping spots in search of fuel. Then, of course, there are live limbs that are sometimes cut for bough beds, and poles cut for shelters that seem favored by some modern Robinson Crusoes in survival classes that are proliferating across the nation.

Another common impact results from pet dogs in the wilderness. At worst they harass native wildlife, and at best they frighten away wildlife that many recreationists hope to observe. In popular camping spots, they also create the same problem encountered in city parks or on urban sidewalks—except in wilderness it may well be where you want to put your tent or lay out your sleeping bag! So, not only do we have physical impacts, we have social ones as well.

A social impact we often encounter is that of crowding. Many times there are essentially crowds in these areas of land that according to law are supposed to offer solitude. Because of that same law, the Wilderness Act of 1964, we are also allowed to use airplanes—a mode of transportation that appears suspiciously mechanical to me. I predict that in the future, airplanes will become a source of both physical and social impact of a magnitude we cannot yet imagine. A rather bizarre and, one would hope, atypical case in point directly affected me just a few weeks ago in Montana. It was not in a wilderness, but on a wild stretch of the wild and scenic upper Missouri River where we were peaceably canoeing. Suddenly we were repeatedly buzzed and missed by a matter of yards by a small aircraft. As my slides document, the pilot was endangering our lives, his own, and those of the rescuers who would have been needed to fish him out had he crashed. This also did little for the experience we were seeking on that canoe trip!

Finally, we have the impact of colors used in wilderness. Brightly-colored tents and backpacks tend to have the psychological effect of drastically shrinking the wilderness.

WILDERNESS KNOWLEDGE

These are some of the kinds of impacts that led me to wonder how much wilderness recreationists do know about the care and proper use of the unique areas they visit. To find out, I devised a 9-question quiz about low impact camping and gave this test to users in Rocky Mountain National Park (Fazio, 1974). Later in the Selway-Bitterroot Wilderness Area, Bill Bramlette and I used a 20-question test that also went into other topics related to wilderness such as management, personal safety and equipment, and the biophysical aspects of the land (Bramlette, 1977).

In Rocky Mountain National Park, I found that overall our respondents scored 68 on a scale of 100. The user groups have been ranked by their mean scores in Table 1. Statistically, using the chi square test, there was no significant difference among the groups at the 95 percent level of confidence. Still, if I were a manager with limited funds and time, the ranked order would suggest some priority target audiences. The importance of these results should be particularly evident in Rocky Mountain because of the large numbers of day hikers that use that park. Because of its relatively small size, these users penetrate about every area of its back-

Table 1. Mean knowledge scores derived from a 9-question quiz on low-impact camping, by user groups, Rocky Mountain National Park, 1973

<table>
<thead>
<tr>
<th>User Group</th>
<th>N</th>
<th>Mean Test Score (percent)</th>
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<tbody>
<tr>
<td>Bivouackers</td>
<td>15</td>
<td>79</td>
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<tr>
<td>Cross Country Hikers</td>
<td>33</td>
<td>76</td>
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<tr>
<td>Technical Climbers</td>
<td>29</td>
<td>73</td>
</tr>
<tr>
<td>Backpackers</td>
<td>604</td>
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<tr>
<td>Group Leaders</td>
<td>9</td>
<td>66</td>
</tr>
<tr>
<td>Day Hikers</td>
<td>217</td>
<td>65</td>
</tr>
</tbody>
</table>
country. This, along with their apparent ignorance of low-impact use, can add up to heavy impact. Similarly, the low knowledge levels of group leaders, and the potential for a multiplier effect, is something managers need to carefully consider in planning information and education programs.

A similar test was conducted three years later in the Selway-Bitterroot Wilderness Area. Several more user groups were included because the area is in a national forest system rather than in a national park. The results are shown in Table 2.

Table 2. Mean knowledge scores derived from a 20-question quiz on wilderness topics, by user groups, Selway-Bitterroot Wilderness Area, 1976

<table>
<thead>
<tr>
<th>User Group</th>
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<th>Mean Test Score (percent)</th>
</tr>
</thead>
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<tr>
<td>Outfitters</td>
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<td>Backpackers</td>
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<td>Horse Campers</td>
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<td>Pilots</td>
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<td>Day Users</td>
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<td>Plane Passengers</td>
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</tbody>
</table>

Using Scheffe's multiple range test, we found that at the 95 percent level of confidence, hunters' scores were significantly lower than those of backpackers, group leaders, and outfitters (with the latter three groups not differing from each other). Plane passengers, with a very poor showing of 35% of the correct test answers, were significantly lower than members of organized groups, backpackers, group leaders, and outfitters. As in Rocky Mountain, day users again scored rather poorly, although statistically the scores were not significantly different from the others. These users are also much less important in the Selway-Bitterroot, as their numbers are relatively few and they do not penetrate much beyond the boundaries of the wilderness. But in the Selway-Bitterroot, the hunter and airplane groups are very important. With their potentially high impacts and miserably low knowledge scores, they stand out as priority targets for information and education.

It appears inconsistent that group leaders scored so poorly in Rocky Mountain and were near the top in the Selway-Bitterroot. There is a good reason for this. The Selway-Bitterroot is located near three universities' communities. A majority of the group leaders were affiliated with educational institutions in some capacity, and one might expect them to be more in touch with subjects we tested. Most of the group leaders in our Rocky Mountain sample were scout leaders and church group leaders from large metropolitan areas.

SOURCES OF INFORMATION

In the Selway-Bitterroot Wilderness Area, we asked survey participants where they received the information (i.e., their answers) on the test. We were attempting to get at the source of their wilderness information. The results for all users combined are shown in Table 3.

A few suggestions for managers emerge from these data. One is that information and education are important. Eighteen percent of the time, users more or less guessed or provided their answers based on "experience" or gut feelings. We compared these answers with whether or not they were correct answers, and found them to be correct only 60% of the time. This was lower than answers derived from any other source except television, and it runs counter to the old adage that experience is the best teacher.

The U.S. Forest Service came out highest as a provider of information, but not as high as some might have predicted. If I were a manager, the figures for "colleges/schools" and "organizations" would catch my eye. Fifteen percent of the tested information came from these sources, and here are entities that are easily identifiable within a manager's sphere of influence and are usually quite easy to work with. I would zero in on these information providers and use them to disseminate agency messages. The other sources, including mass media, were not heavily cited by our respondents.
Table 3. Sources of test answers on a 20-question quiz on wilderness topics, Selway-Bitterroot Wilderness Area, 1976

<table>
<thead>
<tr>
<th>Information Sources</th>
<th>Percent of Answers (N = 601)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Forest Service</td>
<td>24</td>
</tr>
<tr>
<td>&quot;Experience&quot;</td>
<td>18</td>
</tr>
<tr>
<td>Friend/Relative</td>
<td>13</td>
</tr>
<tr>
<td>Don't Remember</td>
<td>13</td>
</tr>
<tr>
<td>College/School</td>
<td>9</td>
</tr>
<tr>
<td>Organization</td>
<td>6</td>
</tr>
<tr>
<td>Book</td>
<td>5</td>
</tr>
<tr>
<td>Magazine</td>
<td>3</td>
</tr>
<tr>
<td>Newspaper</td>
<td>2</td>
</tr>
<tr>
<td>Outdoor Store</td>
<td>3</td>
</tr>
<tr>
<td>Outfitter</td>
<td>1</td>
</tr>
<tr>
<td>Television</td>
<td>1</td>
</tr>
<tr>
<td>Wilderness Act</td>
<td>1</td>
</tr>
<tr>
<td>Other</td>
<td>1</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>100%</strong></td>
</tr>
</tbody>
</table>

**CHANNEL EFFECTIVENESS**

Now let us ask the question, "If you are working for a wilderness management agency, what might be the best way to deliver or transmit information to user groups?" In other words, what channel or channels of communication should be used or emphasized?

We tried to find the answer to this in two different ways. In Rocky Mountain National Park, we did an experiment using backcountry users who came in to obtain use permits as required in that park. After they took our knowledge test and completed a questionnaire, some were given a brochure, some were asked to watch a set of slides, and some were used as a control group and received no messages. The brochure and slides contained the same messages—essentially the answers to the questions we asked. We also released this information via the mass media, in this case in the form of illustrated newspaper feature articles and as a special, half-hour color TV program. Five weeks after the first test, all participants were sent a second test, this one asking the same questions as the first. It was the classic pre-test, post-test procedure. By matching up survey respondents with the communication medium to which they were exposed, their changes in knowledge then suggested which of the communication techniques was most effective.

In the other study, in the Selway-Bitterroot Wilderness Area, we simply asked how the participant received his or her information from the source; that is, through what channels they received their information? There was no experimenting in this case. Here are a few of the things we found out from these two studies.

In both studies, communication through the mass media came out with a pretty poor showing. We suspected radio would be low, and did not test this experimentally in Colorado. Our judgment was pretty much vindicated in the Selway-Bitterroot research, because so few people mentioned radio as a source or channel of their information that we can consider it negligible. This doesn't mean it should be thrown out, but I certainly would not put too many of my communication eggs in that basket if I were a wilderness manager.

Television was also down at the bottom of the list of sources, mentioned by Selway-Bitterroot users as a source or channel of information only 1% of the time. In Colorado, we did test this medium. We made a half-hour videotape and knew from station advertising data that it reached approximately 75,000 viewers throughout the state. However, we found that very few of our target audience saw it. Part of the problem with TV is that agencies must depend on public service time. To be able to pick the prime time, you have to pay—and obviously it pays off. There is no doubt one can sell a lot of Cricket lighters or the advertisers wouldn't pay what they do. But agencies usually do not have money for that, so their programs are usually aired at such times as 1:00 a.m. Sunday morning. Incidentally, we also found wilderness users are not heavy TV watchers. Our Selway-Bitterroot sample claimed to watch less than two hours per day, which is...
below the national average. And the more TV they watched, the worse they did on the knowledge test!

What about newspapers? I know many managers who put a lot of emphasis on this medium. We found in the Selway-Bitterroot that only about 2% of the information was received through this medium. Here again, in Colorado we actually developed a major feature story, well illustrated, and knew from circulation figures it reached a quarter of a million people. But only a few back-country visitors recalled having seen it.

What about the good old brochure? Isn't this everyone's answer to a communication problem? Again, we produced these in Colorado and handed them to a known number of visitors. That is one of the advantages of brochures. You can control this method of communicating and even place it into the hands of visitors. But contact does not mean communication. In Colorado, our test brochure had absolutely no effect on increasing visitors' knowledge of low-impact camping. In our Selway-Bitterroot study, we found that only 6% of visitors gained information from this source. I should add, however, that those who did cite brochures as their source had very high knowledge scores. One thing is certain—the use of brochures is not the cure-all you would think it is judging from the way agencies crank these out.

Finally, in our testing in Rocky Mountain National Park, the method we found to be most effective was a set of slides with sound, and set up as an exhibit. This, more than any other method was effective in raising knowledge of low-impact camping, and I strongly urge managers to invest a little time and expense in setting up such viewing stations wherever possible. Depending on the situation, this may be at guard stations, ranger stations, visitor centers, or perhaps even at retail stores, concessionaire facilities and similar points of contact with wilderness users.

There were, of course, many methods we were not able to look into. Campfire programs were among these. In Rocky Mountain National Park, however, spot checking showed that the typical campfire program had only a very small number of backcountry users in attendance. This probably varies considerably, however, and I would like to test it in the future. Another method that is probably highly effective is the naturalists's walk and particularly Glacier National Park's Eco trek where you actually backpack for a few days with a trained interpretive naturalist who covers wilderness ethics as well as natural history. The big drawback of these methods is the extremely low number of people reached. No one in our surveys mentioned these interpretive methods as a channel of wilderness information. Another clever technique is the printing of messages directly on litter bags. The Bureau of Land Management in Montana even added a map, which makes it more useful and attractive to visitors.

Then, of course, there are the rangers themselves. In our study in the Selway-Bitterroot Wilderness, we found that visitors who had contact with "portal assistants" and wilderness rangers scored significantly higher than those not contacted. Other researchers have found wilderness visitors to be highly receptive of these contacts. Add to that the power of interpersonal communication, and the opportunity for fielding questions or otherwise dealing with feedback from visitors—and you have effective communication.

It would appear, then, that the most effective means of communicating information on low-impact use would be through personal communication by rangers. At trailheads and in the wilderness, these people can zero in on specific target audiences, modify their messages to the group and circumstances, and deliver the agency's messages accurately and convincingly. The other channel I would emphasize is a short, sound/slide program (or other audio visual method such as videotape or a film loop) at points of contact with wilderness users. Not only has this been shown to be effective, it also allows local managers to direct the messages to specific problems or needs of the area, specific groups, or even problems of a seasonal nature. Available equipment is compact, easy to program and not very expensive considering its potential.

LITERATURE CONTENT ANALYSIS

There is one other part of my work that I would like to mention. Since brochures are so commonly used to communicate wilderness information, and since there would appear to be such a golden opportunity to use this method when people are planning their trips and write to an agency for help, I was interested in knowing how well this was being utilized as a management aid. To conduct a test, I pretended to be a potential user and
wrote all over the United States to managers of wilderness and primitive areas. The information I received back was subjected to a variety of analyses, including content analysis of all literature that was specifically related to wilderness use.

It was found that most of the content in the 131 wilderness-related publications dealt with what I labeled "equipment and safety." That is, it tells visitors how to do it--how to be comfortable and how to be safe, and where to go. Second were characteristics of the terrain such as vegetation, wildlife, weather and so forth. Third, rules. Way down at the bottom of the list was information on the historical aspects of wilderness use; then just above it, fire prevention; and just above that, wilderness management--the whys of managing wilderness. At about the middle of the list of topics were the two I would call the most important--ethics, which was fifth on the list of 13 categories, and the concept of what wilderness is, or is supposed to be, which came in a low eighth as far as the amount of coverage it received. The results of the content analysis are shown in Table 4. Unfortunately, a few pieces of government literature are disseminating information actually contrary to the precepts of low-impact camping. It should also be noted that 17% of all the wilderness-related publications contained at least some material I classified as "enticing," that is, actually trying to persuade people to use wilderness areas. As use increases and we begin to allocate the final acres of land to be dedicated as wilderness, it is my opinion that the time has come to seriously look at discouraging wilderness recreation. Not one publication we received suggested alter-

Table 4. Content of 131 pieces of wilderness-related literature based on paragraphs in topic categories

<table>
<thead>
<tr>
<th>Topic Category</th>
<th>Publications Containing Topic (Percent)</th>
<th>For Publications Containing Topic, Mean Number of Paragraphs (Percent)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Personal Equipment and/or Safety</td>
<td>73</td>
<td>28</td>
</tr>
<tr>
<td>Biophysical</td>
<td>63</td>
<td>35</td>
</tr>
<tr>
<td>Unclassifiable</td>
<td>60</td>
<td>11</td>
</tr>
<tr>
<td>Wilderness Rules</td>
<td>59</td>
<td>24</td>
</tr>
<tr>
<td>Wilderness Ethics</td>
<td>59</td>
<td>17</td>
</tr>
<tr>
<td>Permit Information</td>
<td>49</td>
<td>24</td>
</tr>
<tr>
<td>Additional Sources of Information</td>
<td>45</td>
<td>8</td>
</tr>
<tr>
<td>Wilderness Concept</td>
<td>29</td>
<td>10</td>
</tr>
<tr>
<td>Sanitation (Human Wastes)</td>
<td>29</td>
<td>6</td>
</tr>
<tr>
<td>Wilderness Management</td>
<td>27</td>
<td>7</td>
</tr>
<tr>
<td>Fire Prevention</td>
<td>24</td>
<td>6</td>
</tr>
<tr>
<td>Enticing</td>
<td>17</td>
<td>6</td>
</tr>
<tr>
<td>Historical</td>
<td>16</td>
<td>15</td>
</tr>
</tbody>
</table>
native, non-wilderness areas where recreationists—particularly organized groups—might go to obtain essentially the same experience and satisfactions but without impacting areas that by law are to be preserved in a natural condition.

CONCLUSION

Time has allowed mention of only a few of the things I have found while investigating the interesting subject of communicating with wilderness users. Much of the rest will be published early in 1979 by the University of Idaho Forest, Wildlife and Range Experiment Station. It is my sincere hope that this research will be of use to managers. In my opinion, communication or—information and education, if you prefer—is the most palatable management tool we have to reduce impacts on wilderness. If we continue to study it, plan out its use carefully, and apply the results conscientiously, it can also be our most effective tool.

REFERENCES CITED


ABSTRACT--An action plan to correct and prevent impact identified visitors and managers as sources of impact. Problems are treated by regulation, education, restoration and oversight planning. Improvements in meeting objectives have resulted, although problems remain and needs for changes to improve the plan are recognized. Experience with the plan has pointed out the importance of certain planning elements, including the need for thorough documentation to assure management accountability and continuity, and the usefulness of models emphasizing objectives, inventories, actions and monitoring.

Mount Rainier National Park was established by Congress in 1899. Until 1973, use of the backcountry (unroaded areas) was virtually uncontrolled with the exception of a few general regulations. In that year a backcountry action plan was implemented. The plan consisted of policies and programs for correcting and preventing unacceptable impact. To describe the experience with this plan, five questions will be addressed: (1) Why is there a backcountry plan? (2) What is the plan? (3) How successful has it been? (4) What is being done to improve the plan? and (5) What has been learned about planning?

WHY IS THERE A BACKCOUNTRY PLAN?

The plan was initiated to control unacceptable human changes to the park's backcountry.

Mount Rainier National Park consists of approximately 980 km² (242,000 acres), most of which is easily accessible. Numerous roads lead to, into and through the Park. There are over 480 km (300 miles) of maintained trails. As in other wildland areas, use has been increasing. In 1977 over 2 million visits to the Park were recorded.

Proximity to the large population centers of western Washington, easy access, and attractive natural features have made the park's backcountry a popular use area. In 1977 approximately 200,000 people hiked trails and there were 35,000 backcountry camper-nights. A large portion of the backcountry use is concentrated in the subalpine area (approximately 1500 m (5000 feet) to 2100 m (7000 feet) elevation), even though it comprises a small proportion of the total park acreage.

In the early 1970's park managers realized the continuing years of use had caused many small but cumulative impacts in the character of the backcountry. They also realized the upsurge in visitation since the mid 1960's was responsible for an acceleration in the rate of impact. Managers perceived that these human alterations to the natural environment of the backcountry were unacceptable in terms of the legislative...
intent expressed in the laws creating the park, the National Park Service, and in terms of other National Park Service directives. In order to manage the backcountry according to legislative intent, and to guide in correcting past impacts and preventing new ones, managers wrote a backcountry action plan.

WHAT IS THE PLAN?

The plan is an "action plan." As such, it sets in operation policies and programs to meet the objectives of management.

The purpose of the backcountry plan is to correct current, and to prevent future problems of resource alteration, and the resultant loss of "naturalness-based" visitor experience opportunities. It does this by identifying two sources of these problems: visitor impact and manager impact. A third source, impact caused by forces outside the Park boundaries, was not addressed in this plan.

Visitor Impact

Visitor-caused impact problems include those resulting from indiscriminate building of campfires, proliferation of campsites, crowding in preferred camping locations, improper human waste disposal, formation of unplanned trails, and litter. From field observations, it was concluded that these problems are a function of both number of visitors and visitor behavior. In particular, it appeared that backcountry campers, compared with day hikers, created a disproportionate amount of impact. Consequently, number and behavior of backcountry campers received more attention in the backcountry plan than did activities of day hikers. The policies and implementing programs chosen to correct and prevent unacceptable visitor impact consist of a combination of regulation, education, and restoration.

Regulation

Regulations are aimed at controlling both damaging behavior, and number and distribution of visitors. Examples of regulations affecting behavior are: limiting campfires to designated sites in lower elevation forests; limiting camping in trail corridors to designated sites; requiring litter to be packed out; limiting stock to certain trails; and prohibiting cutting of vegetation.
programs and Park rangers frequently discuss minimum impact ideas with users, both in the backcountry and when issuing permits.

Restoration

The third method the action plan uses to correct and prevent visitor impact is restoration. Repairing resource impact not only corrects unacceptable conditions, but it reduces the likelihood for new impact. Where impact is not seen, it appears that people are less likely to add new damage. Considerable effort has been put into restoration work by rangers, trail crews, Volunteers-in-Parks, Youth Conservation Corps, the Student Conservation Association, Boy Scouts, Sierra Club Action teams, and the U.S. Army Reserve. Some of the major restoration tasks include identifying causes of problems, controlling erosion, replacing eroded soil, revegetating with native species, and halting new damage.

Management Impact

In addition to addressing the problems of visitor caused impact, the plan also deals with impact caused by management action or inaction. Unacceptable resource impacts can result from management activities that do not conform to legislation or management objectives and standards. They can also result from a failure to act in response to new problems. Management failures may be due to lack of proper planning, inadequate supervision of employees, or failure to monitor small, but cumulative, impacts. In the backcountry plan, managers have begun to address these issues to ensure greater management guidance and oversight in backcountry operations. Methods include writing quantifiable signing and trail maintenance standards, instituting routine monitoring programs, and providing additional backcountry staffing, training and budgets. Furthermore, past management impact, such as unnecessary facility development and failure to restore abandoned or rerouted roads and trails, is being corrected.

HOW SUCCESSFUL HAS THE PLAN BEEN?

An improvement in meeting Park objectives is evident since the implementation of the backcountry plan.

Implementation of the plan clearly has reduced some unacceptable resource impacts, in particular campfire and campsite damage. However, it is more instructive to view the plan's success in relative terms. Given current and projected increases in backcountry use, even a stabilization of impact would indicate a positive effect of the plan.

While there have been successes, some types of impact are not yet reduced to acceptable levels. Two persistent problems are improper human waste disposal, and the creation of unplanned trails in areas managed as cross-country zones.

From the standpoint of providing visitors with opportunities for varied experiences, the plan has had mixed results. A variety of areas, ranging from those with virtually no visible alteration to those which have highly developed campsites and trails, are being maintained to provide users with a variety of opportunities. Prior to the backcountry plan, this range was narrowing, with increasing high-density use areas and extensive resource alteration. The price of maintaining this variety is a reduction of the spontaneity with which visitors can use the backcountry. Because there is rationing and zoning, backcountry travel choices are sometimes limited. As visitors' actions are regulated, the backcountry experience loses some of the traditional feeling of freedom. According to the comments recorded from visitors it appears many understand the need for these trade-offs and are willing to make them. Despite the restrictive nature of management actions, the number of people using the park's backcountry continues to rise each year.

Long term success of the plan remains uncertain. Knowledge of natural processes is incomplete. Current monitoring procedures and research techniques may not be refined enough to detect all long-term impacts. Wildlife behavior or vegetation composition, for example, may be subtly changing. Even user's perceptions of their experiences may change. To the extent these incremental changes are not detected, the backcountry plan's applicability is impaired.

WHAT IS BEING DONE TO IMPROVE THE PLAN?

Management actions are routinely evaluated. The backcountry plan has been adjusted annually to enable it to fulfill its objectives.

The annual evaluation is based on the following monitoring information: (1) comparison of baseline inventory information with current resource conditions; (2) obser-
vations systematically collected of visitor and manager noncompliance with policies; (3) information from researchers working in the park; (4) studies of alternatives provided by comparison of backcountry areas where there are exceptions to the general policies; (5) systematically recorded comments from park visitors; and (6) yearly reports submitted by backcountry rangers containing observations, with recommendations based on their experience. Each autumn the park staff reviews this information and makes suggested changes in the plan. Final decisions are made after a period of public review and comment.

Current efforts to improve the plan include in addition to annual changes, reorganizing its format so the rationale is more easily understood. Site specific objectives are being proposed in addition to the existing general park-wide objectives. An effort is being made to determine precise, measurable criteria of acceptable impact. Current monitoring and research is providing some useful information. Extensive research is needed to study long term impact and test managers' assumptions which lead to decisions.

WHAT HAS BEEN LEARNED ABOUT PLANNING?

Planning is a decision process. The rationale for each step of the process should be clearly documented to provide accountability and continuity.

Accountability occurs when documentation ensures the availability of a complete explanation of a decision. If a manager is required to provide detailed explanations of decisions those decisions probably will be formed rather carefully, after consideration of all options.

Documentation also provides continuity in that subsequent managers gain an understanding of the rationale of the policies they administer. Such insight could save them from repeating mistakes or help them revise policies when new information or changing circumstances require.

Both the decision process and its documentation are easier to perform if one has a model to follow. Various decision models relating to backcountry management have been suggested, for example see Brown (1977), and McCool (1976).

Of the many factors included in models for backcountry planning, key ones are:

Objectives: What do you want to accomplish; what is acceptable?

Inventory: What do you have; does it meet the objectives?

Actions: What will you do to attain objectives?

Monitoring: What is happening; are the actions accomplishing the objectives?

Objectives

Objectives need to be specific if specific management decisions are desired. Or, to repeat a critical point, management decisions can only be as specific as the objectives under which they are formed (Koch 1974). A decision to limit camping at a lake cannot be solely guided by an objective to manage for visitor enjoyment and protection of the resource. Such general objectives need to be defined more narrowly so that managers have precise statements that enable the determination of measurable standards.

Specifying objectives can lead to disagreements and even controversy, since people can interpret general legislative objectives quite differently. Ultimately, managers are responsible for this interpretation and they should carefully document each factor that led to their decision and the relative importance they gave to each factor. In this manner, the manager can offer the rationale for his decision and demonstrate the efforts made to ensure consistency with legislative mandates. Factors a manager might consider are: (1) legislation - the most critical factor; (2) the nature of the resources' ability to sustain various levels of use; (3) the desires and concerns of the public; and (4) management principles. For example, in Mount Rainier's backcountry plan a management principle given great weight was that a margin for error on the side of resource protection should be used, rather than on the side of use. By law, preservation in National Parks and Wilderness areas has priority when preservation and use conflict.

Inventories

Inventories are needed which classify and quantify resource conditions. Inventories provide a baseline with which managers can compare changes and measure management success. An ultimate goal of inventory
have been problems throughout the planning efforts, a written plan has created a focal point around which managers can and do regularly evaluate their actions with respect to their responsibility for prevention and correction of human impact.

REFERENCES CITED


DISCUSSION

Comment: How did you deal with the word "acceptable" for impact?

Dalle-Molle: The determination of what is acceptable is basically a matter of interpreting legislation. Congress gives broad, general guidance as to what is acceptable but managers must interpret it to fit specific situations.

We do not yet have a neat framework to follow that outlines a suitable set of criteria to help this interpretation. At present, departmental and agency policies give guidance through their interpretation of legislation. But on the park level the site specific determination of what is acceptable comes down to a manager's assessment based on these policies, research results when available, public comment and staff recommendations.

A set of criteria needs to be established to insure consistency in decisions and we are working in this direction. I think it is important to realize though that any such set will
ultimately be based on a manager's judgment, on an interpretation of laws. When significant disagreement occurs over such interpretation only the courts or Congress can resolve the issue.

Comment: I would like to emphasize the importance of continuity in planning that you have mentioned. Many plans I have seen tend to deal with the present situation so much that there is little to guide future problem solving. For continuity between managers, or even continuity with the same person, a plan has to include objectives and criteria. Then you can make decisions five years from now on a problem you haven't anticipated that is compatible and within the same framework as the decisions you make now.
MISSION MOUNTAINS: PLANNING FOR A TRIBAL WILDERNESS

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ABSTRACT--Tribally owned wildlands contribute to the wilderness resource in many areas. Under contract with the Confederated Salish and Kootenai Tribes, the Wilderness Institute, School of Forestry, University of Montana developed a management plan for the Mission Mountains. The proposed management plan determines the boundary of the area, defines overall management goals, resource attributes and policy guidelines and objectives; as well as recommendations involving direct management action, user education programs and designation of smaller management units to facilitate planning. Special attention is paid to preventing and mitigating recreation impacts.

The tribal wilderness concept has great potential for producing benefits for both the Indian tribes concerned and the greater American public in general. Each tribe has the opportunity to define the classification according to its need. A comprehensive management plan will greatly facilitate long range planning to insure the perpetuation of this unique wilderness resource.

INTRODUCTION

The Mission Mountains rise abruptly and dramatically to the east of the flat, gentle Mission Valley in western Montana. The eastern half of this range has historically been managed by the U.S. Forest Service as a Primitive Area, Wild Area, and more recently as the Mission Mountain Wilderness. From the crest of the Mission Mountains down the west slope to the Mission Valley floor the land is owned and managed by the Confederated Salish and Kootenai Tribes; the divide serves as the eastern boundary of the Flathead Reservation. Four years ago, Thurman Trosper, tribal member and recent president of The Wilderness Society, suggested the Confederated Tribes establish a tribal wilderness on the west slope of the Missions.

In the spring of 1977 the Confederated Tribes contracted with the Wilderness Institute, School of Forestry, University of Montana, to develop a management plan which included boundary determinations, policy guidelines and objectives, resource attributes and both short- and long-term recommendations.

MISSION MOUNTAIN TRIBAL WILDERNESS

In 1937, when 125,000 acres on the west slope of the Missions were designated a "Roadless Area" (de facto wilderness), Bob Marshall, Director of the Forestry Division of the U.S. Office of Indian Affairs, sought to maintain a retreat where tribal members
Figure 1. Mission Mountain Location map
could "escape from constant contact with white man," and to preserve some untouched land for future generations (ORRC 1962). Since the Office of Indian Affairs served as a caretaker for tribal lands, the designation provided no statutory protection. In 1959, by tribal council resolution, the area was declassified, "to facilitate economic development" (Federal Register 1959). Since that time about one-fourth of the original Roadless Area has been logged, roaded, ranced or farmed leaving 38,000 hectares (95,000 acres) wild and untrammeled. It is this land that the tribe is now interested in protecting.

The Missions cannot be included in the National Wilderness Preservation System. The tribes, can however, create their own "Tribal Wilderness" and we have recommended such a designation. It could be done via tribal council resolution or by a tribal referendum whereby all members of the tribe vote upon it.

In preliminary work prior to developing the Tribal Wilderness management plan we were not able to find another example of a tribal wilderness in the western United States. Both the Shoshone Reservation and the Flathead Reservation have designated "sacred areas," however, where non-tribal people are prohibited. There is also a niche in the recreation management spectrum for "Tribal Wilderness." Because of the lack of mandates or regulations, the managers of such areas would have a challenge and flexibility in management rarely available in federal and state agencies. Until now, this lack of mandates coupled with a low economic potential has resulted in little management direction for the Mission Mountains. It has also led to a lack of administrative responsibility for the recreational resources. However, this lack of direction has not prevented the Missions from becoming a popular backcountry recreation area.

The activities of the tribes, the Bureau of Indian Affairs (BIA), the U.S. Fish and Wildlife Service, the U.S. Forest Service, and other agencies, groups and individuals have all influenced recreation but with none having that specific responsibility.

For example, the BIA, the Young Adult Conservation Corp, one commercial outfitter and other private groups have all had a hand in trail construction and maintenance, but each has acted independently without the benefit of any type of a unifying plan. This has resulted in some poorly planned and constructed trails, many of which now suffer from severe accelerated erosion. Further, the unmanaged recreational use has led to the establishment of impromptu trails and campsites, accompanied by overuse of some sites.

Prior to 1977, little or no information existed pertaining to the recreational resource or its use. Trails, campsites and other recreational facilities had not been inventoried and the types and levels of use occurring within the area were unknown. Upon accepting the contract to prepare a management plan for the area, the Wilderness Institute was faced with a rather unique situation. Not only was there a complete lack of information upon which to base a plan, but there was also a lack of agency policies or legislative mandate to define future management.

FIELD WORK

In order to formulate a management plan for the area we needed to inventory public trails, campsites, and recreational use of the area, and obtain basic resource data.

Trail registration boxes were placed at twelve major access points to determine the amount and distribution of use. These boxes were serviced twice each month.

The study team conducted compliance checks for seven days each, at five registration box locations to determine how many visitors actually registered.

To obtain user characteristics and measure recreational permit compliance, interviews were conducted with all individuals and groups encountered in the study area.

All trails were intensively inventoried with the Recreation Opportunity Guide (ROG) Trail Inventory method developed by the Lolo National Forest (Black et al. 1977). In addition to the ROG information, a separate trail inventory form, developed by the Wilderness Institute, was used to record mile-by-mile trail conditions.

For campsite inventories we used the Code-A-Site system developed by Hendee, Clark, Wood and Hogans (1975).

We found that during the summer of 1977 approximately 4,000 people entered the study area.
area staying for a total of 13,000 visitor days. About 64% of this use originated in the Mission Valley, 12% from Missoula and 14% from out of state. Of these visits, 60% occurred on weekends and holidays.

Non-tribal members represent over 95% of total use, and one-third of these users did not have the required tribal permits.

WILDERNESS MANAGEMENT PLAN REVIEW PROJECT

In writing the tribal wilderness management plan the study team utilized information compiled as part of a Wilderness Management Plan Review Project (WMPRP). The project, first conceived by the Recreation and Lands Division, USFS, Region 1, was conducted by the Wilderness Institute staff in cooperation with the Forest Service. WMPRP involves a review and consolidation of the assumptions and decisions featured in management plans for all Primitive Areas and Wilderness Areas west of the Mississippi River. The final product, a document displaying the similarities and differences between various agency approaches to wilderness management, is forthcoming. This information served as a guide to check the thoroughness of the assumptions and recommendations used in the Mission Management Plan.

TRIBAL WILDERNESS MANAGEMENT PLAN

The tribal Wilderness Management Proposal which the Wilderness Institute has submitted to the tribal council consists of three main parts: (1) a proposed boundary and overall management goals for the area; (2) a proposed management plan; and (3) a detailed analysis of the trails and camp sites in the area, with recommendations for their maintenance and protection.

All lands within the proposed boundary are owned by the Confederated Salish and Kootenai Tribes, with the exception of 312 hectares (780 acres) of state land and two small privately owned tracts. All lands within the boundary are essentially wild: they contain no permanent structures, and (with the exception of one clearcut at high altitude) show little evidence of human activity.

The framework of the proposed management plan is similar to the goal achievement framework described by Hendee and Koch (1978) although our terminology differs slightly. This approach involves management by objectives. Broad goals and direction are defined based on the purpose of an area’s classification. These are followed by increasingly specific guidelines for achieving these goals. What results is a hierarchy of management direction from broad to specific.

In the tribal management plan, four broad objectives were defined:

1. Preserve the scenic and wild character of the area.
2. Manage to protect the ecological integrity of the area.
3. Enhance the primitive outdoor recreation opportunities in a manner consistent with preservation of the wilderness resource.
4. Administer the area in such a manner as will leave it unimpared for future use and enjoyment as wilderness.

These objectives were in turn used as a basis for the development of more specific policy guidelines, which deal directly with uses or administrative activities within the area.

The management plan also includes a number of recommendations which suggest methods for minimizing or avoiding impacts.

Those recommendations which involve direct management action include:

1. Limitations on group size (maximum of eight) and length of stay (no more than seven days on one site).
2. Relocation of camp sites on lakeshores and wet areas where possible.
3. Establishment of corrals or hitch racks in areas heavily used by stock, such as around popular lakes.
4. Periodic maintenance of heavily used trails, with minimal trail maintenance in lightly used areas.
5. Continual monitoring of all popular recreation sites to assess current uses, impacts, and rates of charge.

In addition to these and other proposed actions, we also recommended the development of user education program. We felt this
was a key component to any attempt to minimize and prevent impacts.

Currently on the Flathead Reservation, non-tribal members are required to purchase tribal recreation permits for the privilege of recreating on tribal lands. We feel this existing program could be readily adapted to provide a vehicle for the dissemination of educational information. In the proposed management plan we recommend the development of a brochure describing appropriate wilderness etiquette, tribal policies and basic safety. The distribution of this brochure could be greatly facilitated by attaching it to all permits.

Within the education program we also recommend the hiring of a recreation guard for the Missions or even for the reservation as a whole. Working within the area, the guard could personally contact recreational users and informally instruct them in such areas as minimum impact camping. The recreation permit system plays an important role here as well. The tribes collected approximately $18,000 last year from permit sales. We found from our recreation use inventory that there was low permit compliance in the Missions. We estimate that revenue gained through increased compliance could fund the salary of the recreation guard.

Other educational options are also available to the tribe. One of these involves outfitting and guide services run by tribal members. Numerous non-tribal people would be attracted to the idea of being accompanied and guided by a tribal member intimately acquainted with an area and its history. Such a service could also be extended into an intensive educational experience which would teach nontribal people in this country the heritage of native Americans, thereby facilitating a better understanding of their culture and current problems. There are also some very positive economic benefits that could be derived from this option.

Finally, in the third section of the management plan we divided the study area into twelve different "Wildland Units" (WLUs). We found this delineation of smaller management units within the area to greatly facilitate planning. Since the study area is characterized by rugged terrain with steep canyons, restricting most use to individual drainages, we based the WLUs on these natural boundaries.

Within the plan each unit is considered separately. First we give a description of the areas in the unit receiving recreation use. This description is then followed by a recommended overall unit objective and recommendations for access, trailhead facilities, trails and campsites.

The Mission WLU, for example, (Figure 2) has several popular recreation sites (Lucifer Lake and Mission Falls), a heavily impacted trailhead and several heavily impacted campsites. We estimated that this WLU received almost 18% of all use in the Missions, a large percentage of this being day use to the spectacular Mission Falls.

We recommend that this area be maintained as a popular day use area. Specifically, we suggest the placement of an informational sign at the trailhead, the clearing of the trail as far as the most popular attraction (the Mission Falls) and consolidation of the multiple fire rings at sites around the lakes.

DISCUSSION

Tribal councils throughout the country are assuming greater control in the allocation of the resources found on their respective reservations. In many cases, these allocations have permanently altered ancestral homelands—causing conflicts between spiritual values and the need for economic development.

Historically, the values of wilderness have been largely overlooked in nearly all levels of land-use planning, be it federal, state, private or Indian (currently there is only 1 "roadless area" designated by the Bureau of Indian Affairs; there were 15 in 1937). However, like any other limited resource, the values of wilderness increase as supply diminishes. The current Forest Service RARE II process and the overall theme of this conference illustrate this increased public awareness of the values inherent in wilderness and other dispersed recreation areas. This increase in value when coupled with the potential economic benefits derived from such a classification, makes tribal wilderness designation an important managerial option.

Tribal governments considering a designation similar to wilderness must deal with problems resulting from the quasi-private nature of the land ownership. The two major problems mentioned earlier involve the
definition of mandates for the area and the
delegation of administrative responsibil-
ities.

In defining management of a proposed
wilderness area each tribe must define the
purpose of the area's classification. For
federal wilderness areas this comes from the
Wilderness Act, but as mentioned earlier,
the act does not apply to Indian lands.
Therefore, the tribe must define this pur-
pose clearly before making management recom-
mendations for an area. These mandates can
be as unique as the area and the needs of
the local tribes. The spiritual area
restriction, mentioned earlier, on the
Flathead and Shoshone reservations, is an
excellent example of a mandate which direct-
ly addresses the needs of the tribe in
relation to the area.

Once the basic objectives are defined,
a clear definition of administrative respon-
sibilities is necessary. As illustrated by
our review of the Missions, important admin-
istrative responsibilities tend to be
scattered and lack unified direction. The
extent of managerial involvement for each
group or agency must be clearly defined. A
well-organized management plan will greatly
facilitate the overall organization and
direction each area's management will take.

In summary, the tribal wilderness con-
cept has great potential for producing bene-
fits for both the Indian tribes concerned
and the greater American public in general.
Each tribe has the opportunity to define the
classification according to its individual
needs. In so doing, tribes must be aware of
their responsibilities to clearly define the
area's mandates and delegate administrative
responsibilities. A comprehensive manage-
ment plan will greatly facilitate this
long-range planning, and help insure the
perpetuation of this truly unique wilderness
resource.

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Missoula, Montana, 144 p.
ABSTRACT--The development of the no-trace-ethic slide/tape program, including background of why ethics are necessary, is described. Details are provided on how the program may be acquired and used.

BACKGROUND

Many of our back-country users accept degradation over a period of time as inevitable. How many of you have camped in an area over a period of years? Do you remember ten years ago when only a few footpaths existed? Now a myriad of paths may cross your favorite meadow.

About three years ago, some of our wilderness rangers in the Eagle Cap Wilderness of eastern Oregon began to talk to the hikers they met about no-trace camping. Their idea was that if everyone did their part toward leaving no trace whatever of their stay, the wilderness would be better off. And, in fact, we may be able to do away with some of the rules and regulations that we have had to impose. Mr. Deans of the Appalachian Mountain Club emphasized that the user is an important factor in area management. We may study an area; we may regulate it; but unless the user cooperates, these efforts will fail.

Last winter, the U.S. Forest Service, Pacific Northwest Region, began a three-fold thrust for an educational campaign that we call simply "no-trace." Our idea was to produce a slide/tape program for use both in-service and outside by various groups. In conjunction with this, we also prepared a discussion guide for each person using the program to lead the audience into a thorough discussion of what they can do on their next wilderness trip to reduce their impact. Finally, we produced a brochure that is currently available at every place where people apply for wilderness permits. This winter we will be testing and evaluating more ideas for getting the no-trace message to as many people as possible.

SLIDE/TAPE PROGRAM SYNOPSIS

Without A Trace--The Wilderness Challenge was written by Steve Morton, now on the Lolo National Forest in Montana, and first discusses historic American feelings about wilderness. Early explorers left little trace because their numbers were few. Life processes in the higher elevations evolved over a long period of time. They are geared to the natural elements but not the hoards of people now literally "loving them to death." Slides show what happens to meadows, flowers, trees, trails and the landscape when visitors are not aware of the cumulative effects of their actions.

The second portion of the program explains the differences between past practices and why many of these practices must now be obsolete. It then suggests that a modern code of behavior should be followed by everyone to leave little or no trace of their stay. Examples might include repackaging food in lightweight plastic bags, keeping groups small, obliterating traces of a cooking fire, burying human waste, proce-
dures for tying horses, using inconspicuous tent colors, and allowing others to enjoy the same solitude that you want.

We used to say that wilderness survival was the ability of man to survive in the wilderness. Now we refer to wilderness survival as the ability of the wilderness to survive man. "Without a trace" is the real wilderness challenge.

We decided to keep the slide/tape program as simple as possible. Many people told us that we could make a bigger impression with a multi-projector program. However, since we are going to be loaning this program out to people who probably would not be familiar with sophisticated equipment, we decided to keep it to one carousel drum and one projector.

HOW TO GET A COPY

It is our intent that as many people as possible see the program. Many of our Forests and district offices have made a real effort to show the program and loan it as often as possible. We encourage any organized group who wants to use the program to let us know. Copies can be borrowed from most U.S. Forest Service offices in Oregon and Washington or from the:

U.S. Forest Service
Pacific Northwest Region
Unit of Recreation, 6th Floor
P.O. Box 3623
Portland, OR 97208

Copies of the program can also be purchased through:

Westway Recordings
1226 SW 16th Avenue
Portland, OR 97205
(phone: (503)226-1940)

Single copies are priced at $56.50 with five or more copies being available at a reduced price.
SUCCESSFUL METHODS OF DESIGN AND CONSTRUCTION FOR MANAGING IMPACT ON TRAILBIKE TRAILS

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ABSTRACT—Impact control for trailbike trails begins with the planning process. Location and design of such trails must be carefully done by planners familiar with trailbikes and their impact. Although sensitive areas cannot always be avoided, special protection features to avoid drainage problems and prevent trail saturation can avoid most physical impact problems.

INTRODUCTION

In 1971, the state of Washington enacted legislation to "increase the availability of trails and areas for off-road vehicles." Shortly thereafter the Department of Natural Resources began building trails designed to meet the needs of motorbike recreationists. It was soon discovered that impacts (inherent in all types of trail use) were intensified by: (1) growing numbers of trailbike enthusiasts, and (2) a diminishing number of trail miles available for this particular recreation.

MANAGING IMPACT ON TRAILBIKE TRAILS

This presentation discusses several methods which have been successfully used to manage impact on trailbike trails.

Ideally, impact control begins with the planning process. By utilizing appropriate techniques of planning and construction, informed land managers can be in control of potential impacts before wheels are put on the ground. Planning is the key, and it should pave the way for accomplishment of three objectives: (1) protection of the resource; (2) satisfaction of user needs; and (3) cost-effective construction and maintenance.

Location and design are critical steps in the planning process. The planner must select a suitable location and design the trail to fit each site along the route. Trails located specifically for trailbike use should avoid sensitive sites (any site on a particular trail location which may require extra protection or preventive maintenance) where undesirable impact may occur. Large ultra-sensitive areas should be rejected entirely. Since trail locations cannot always avoid sensitive sites, special protection features must be designed into the plan. These features normally require extra construction costs.

Location and design of trailbike trail require detailed knowledge of user needs, machine operation, development costs, construction procedures, and resource impacts. Planners, unfortunately, have considerable difficulty obtaining adequate knowledge of user needs and machine operation. In the writer's experience, it is very difficult for one who does not have in-depth first-hand experience with the sport to consistently design suitable trailbike trails.

The detailed knowledge needed is best obtained by careful observation, conversation with users, and many hours of motorbike operation, to obtain adequate knowledge about trailbike recreation.

SPECIAL PROTECTION FEATURES

Once a suitable location has been selected by a qualified planner, special protection measures are designed to safeguard sensitive sites along the route. Before the final location is chosen, many alternatives will be examined and rejected. The number of sites requiring special protection should be minimized. Special protection measures are physical features built into the facility to prevent adverse impact or excessive maintenance costs. Protective
features should be planned for and built into the trail during initial construction; however, in most cases, they can be built into existing trails. The following descriptions identify some of the special protection features used by the Department of Natural Resources (DNR):

**Drainage Dips.** Drainage dips are developed during initial construction by reversing the prevailing grade for a distance of 4.7 m (15') or more. They are used to divert run-off from the trail tread. Drain dips are effective, inexpensive, and do not detract from the natural setting.

**Water Bars.** Water bars are small—12.7 cm (5") in diameter or less—log barriers placed perpendicular to the direction of travel and staked into position. They serve the same purpose as drainage dips. Water bars are inexpensive, and unlike drain dips can be placed on an existing trail. They are "less" natural and may constitute a hazard to novice riders if not properly constructed.

**Culverts.** Culverts are used to keep traffic out of the water source. They are difficult to transport and should not be less than 30 cm (12") in diameter. Bare metal ends may be unsightly, and adequate diameter is essential to prevent plugging up. Routine maintenance is necessary.

**Bridges.** Bridges are used on larger streams and serve the same purpose as culverts. Rustic construction utilizing native materials is the key to eye pleasing facilities.

**Ditches.** Ditches are used to intercept water and prevent saturation of the trail. They can be hazardous to the rider and should be placed as far from the trail as practical.

**Tread Armor.** Tread armor is a protective covering of borrow material (crushed rock, for example) placed on top of the native soil. It is expensive and difficult to transport extended distances. Armor is an effective tread protection, but it is unsightly when first applied.

**Concrete Blocks.** Concrete blocks imbedded in the trail provide a solid, unyielding surface. They are quite effective, but expensive and difficult to transport, and can be hazardous if improperly used. There are still technical problems to be worked out, and this treatment should be used sparingly and only for short distances.

**Puncheon.** Puncheon is essentially a "land bridge" constructed with hand split planks and round logs. Puncheon is used to cross water saturated soil. As in all features of this type, rustic construction and native materials should prevail. Costs are highly variable and the effective life span of this treatment is uncertain.

**Turnpike.** Turnpike is a method used to elevate the trail tread above wet soil. It is constructed by placing parallel log "sideboards" 91.4 to 152.4 cm (3 to 5') apart and backfilling with soil containing a high proportion of fractured rock. Turnpike must be "crowned" to provide drainage. Properly applied, turnpike is an effective treatment.

**Wire Mesh.** Wire mesh covering the trail tread and fastened to parallel log stringers is presently under evaluation. It appears to greatly reduce "rutting" in soft clay soils.

It should be obvious that none of the "special protection features" are intended for continuous, uninterrupted use over the entire trail system. Their use should be confined to specific problem areas along the route. Location and design must minimize the sites where protection features need to be used.

**OTHER IMPORTANT FEATURES**

Selection of trail location, length, and rider appeal may ultimately be as important as special protection features for controlling trailbike impact. A major cause of trailbike impact may be the relatively small amount of trail available to a large user population. Length of available trail can clearly be significant in terms of reducing
overuse. Observations indicate that the tendency for off-trail travel is considerably reduced when rider needs are adequately met with well designed facilities. Managers know that impact occurring on designated routes are relatively simple to discover, budget for, repair, or eliminate. Off-trail impacts are not so easily handled.

ORV user education has been suggested as a viable option for managing vehicle impact. In 1977, the Northwest Motorcycle Association Trail Division sponsored an amendment of the Off-Road Vehicle (ORV) Act which requires the DNR to, "conduct a statewide program of ORV user education and information." The Sierra Club's ORV Monitor (November 1977) has also suggested the need for such programs. This activity may prove to be an effective tool for reducing vehicle impacts.

Yet another method used to manage trailbike impacts is to provide "play areas" where riders can climb hills, ride over rocks, and find other challenges the manager may want to control. In some cases, we have designated gravel pits as play areas, posted them open and routed trails through the area. The idea is for the land manager, not the rider, to select the locations for such activities. Future gravel removal will render wear and tear by trailbikes totally insignificant.

The DNR aided by the active participation of trailbike enthusiasts developed a number of innovative techniques for managing trail resources. I want to encourage the academic community and other agencies to help us go beyond mere problem identification and begin to focus their attention on problem solution. It won't be easy, but it can be done.
VISITOR ACCESS OVER COASTAL WATERWAYS

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ABSTRACT--At Glacier Bay, access to hiking and kayaking areas is primarily obtained through the air or over water rather than by road. However, as with more traditional means of wildland access, impacts do occur. Zones of access and use are limited by topography and vegetation. Visitors in these zones conflict with wildlife habitat and produce aircraft and boat noise impacts. Because of the magnitude of the waterways, there are few control points and patrol or enforcement of access is difficult. Water access is still probably the best system for Glacier Bay but some conflicts are unavoidable.

Though access by water is not relevant in most situations, I believe some of the concepts I will present have application to each one of you. Glacier Bay National Monument is appropriately named for its major feature, a large body of salt water which contains or is associated with 16 tidewater glaciers. These glaciers originate within the rugged mountains of southeast Alaska where the topography ranges from sea level to an elevation of over 4.7 km (15,300 feet elevation). Hiking is difficult in such terrain. Visitor access to the wild country along Glacier Bay is entirely by boat or float aircraft. Continued use by these methods is a management objective of the National Park Service and is expected to remain so in the future.

The coastal waterways, as they are called, or the Bay itself were selected and developed for visitor access on the basis of several criteria. Since the deep-water marine route bisects the biologic and geologic systems, it was logical to encourage boats and float planes instead of constructing roads or other traditional methods of overland travel. It was also very easy to apply the historic perspective of travel: for thousands of years the Tlingit Indians have very successfully used boats to get around in the country. Finally, a comparison of the relative impact upon the land and the wildlife demonstrated that travel by water was simply the best method.

Glacier Bay National Monument includes 1134 km² (2.8 million acres) of land, glaciers, and salt water. But that size is deceiving: not all land can be used by the hiker or kayaker. Only about 20% of the land area can be effectively used by hikers. More important, the hikers themselves perceive that about 5% of the land is really usable. Large areas are either unknown or simply appear to be impassable and beyond use. About 30% of the saltwater area is available for safe kayaking or canoeing, although less than 10% is actually used because the kayakers tend to stay close to shore.

Scheduled visitor access began in 1966 with airplane service offered in conjunction with the completion of a major lodge. Scheduled tour-boat service also began in 1966. Prior to that time, charter boats, a limited number of charter aircraft, and an occasional fishing boat were the only means available for getting into the wild country. Level of use at that time was assumed to have little effect on the resource and for years very few people expressed concern.

Over the last 12 years significant increases in the number of aircraft, charter boats and kayakers have occurred. Since 1974 private boat and charter boat use has increased 400%. The total number of visitors traveling on the concessioner's tour boat has increased about 300%. The number
of back country users has increased 600%--
all of this in four years. When considering
level of use, the absolute numbers at
Glacier Bay are not very significant but the
rate of increase has had a major effect.

These waterways offer a potentially
flexible system which has provided the kay-
akers and hikers a way to reach primary use
areas without a measured impact upon land
features. The system also allows designa-
tion and relocation of travel routes without
any visible and lasting impact upon the land
resource and with no real visible effect
upon the water. Compare, for example, the
relocation of an access route at a place
like Glacier Bay, where you simply divert
the boats, with the relocation of a road
into an alpine area.

Scheduled and charter boats are the
prime method of access. However, the great-
est potential for increased use is through
charter aircraft. Their relative cost of
operation, ability to get to remote areas,
and flexibility make aircraft economically
attractive. Design of boat hulls and power
systems which have been used in Glacier Bay
has not been considered on the basis of im-
 pact on the environment, and in many cases
has not been selected for maximum economy
and efficiency. Time in travel and passen-
ger capacity are the major concerns.

Geographic and psychological barriers
affecting hikers are the presence of ice
fields, glaciers and rugged terrain, along
with some adverse weather conditions which
limit and control the distance that hikers
travel on any hiking expedition. Transpor-
tation along the waterways has several
inherent problems which must be considered
before these methods are adopted in other
areas.

Consider some of these problems. Com-
mmercial transportation systems operate along
a rigid route and on a fixed schedule, so
the number of specified access points is
limited. There are only a few places that a
commercial public transportation system can
stop to allow access and still maintain a
schedule. This reduces the opportunity to
disperse use and provide a variety of areas
attractive to the visitor. This condition
is further compounded by the rugged terrain
which restricts the access and the movement
of the hiker. In addition, boats which are
used to provide access usually serve a mul-
tiple function. At Glacier Bay vessels
which haul large groups of tour-oriented
visitors are also expected to haul hikers
and kayakers. These expectations result in
conflicts over the function of the vessel.
Most passengers enjoy seeing an occasional
hiker or kayaker enter the wild country, and
for many people it's the only time of meet-
ing a wilderness visitor. However after the
experience has been repeated several times,
these same passengers object because it re-
duces the time that the boat will spend at
their primary attraction, which is usually a
tidewater glacier.

Another problem which must be consid-
ered with boat and aircraft transportation is
cost. Operation is expensive, and re-
stricts visitor use to those people who can
afford to pay the price, or to those people
who have a very strong interest in the area
and choose to pay in spite of the cost.
Most potential visitors with low income have
no options; they simply cannot consider the
trip.

Boat and aircraft access also places
people in areas of prime wildlife habitat,
at least in the southeast Alaska with condi-
tions such as Glacier Bay. The narrow beach
zones cannot tolerate concentrated human
use. These are the same areas that wildlife
are dependent upon for their migration and
much of their habitat. This problem can be
resolved by allowing visitor use only in
locations or at times when wildlife are not
present.

Another problem is patrol and enfor-
acement of access routes used by private ves-
sels. This is compounded when you consider
the marine way of Glacier Bay is 96 km (60
miles) long and 8-16 km (5-10 miles) wide.
The entrance into this area is 8 km (5
miles) wide. Contrast that with a road, a
two-lane road where managers have an oppor-
tunity to make contacts and provide some
control. Individuals who fail to intention-
ally contact a park ranger may only be con-
tacted during a routine patrol providing
resource information, safety guidelines, or
regulations controlling the use of a spe-
cific area.

Management objective to reduce impact
upon the biologic systems and improve
aesthetic qualities can nevertheless be
achieved.

Interagency cooperation is critical to
improving public information and dispensing
information on wild areas. Potential visi-
tors should have an opportunity to make
decisions based on objective information stripped of all propaganda before coming to Glacier Bay or any other place. Major steps are greatly needed to improve interagency information systems. It is important that wildlands not be represented by any agency or organization as offering all things to all people. Perhaps because of its remoteness, the grandeur of Alaska is often misrepresented. Alaska should be portrayed for the conditions that exist, with its adverse weather, topographic barriers, cost of access, restrictions on use, and the presence or absence of facilities. A reliable, advance information system is especially important if visitor access is dependent upon commercial systems. Once people arrive they have no options except to get back on the boat or airplane and leave at a tremendous cost and with a very terrible experience.

Another approach to improving levels of information is through research and monitoring of visitor expectation, experiences, and environmental impact. During 1978, the National Park Service conducted socio-economic studies in Glacier Bay to help determine the characteristics and behavior of wildland visitors. This research will measure and evaluate how trips are planned and provide essential data on expectations, experiences, and an evaluation of the resource by the visitor. The results will be very important in helping develop future policies and procedures for improving information and transportation systems. An important study is scheduled next year and will analyze the relationship between visitors and wildlife which use the narrow beach zones of the Bay. The results of this study can be helpful in determining maximum level of human use which can be tolerated in these sensitive wildlife areas before there is an adverse effect on wildlife behavior.

The most important message is that we should never look at any management system as perfect. Reflect back to the origin of the water access system at Glacier Bay. At the outset it was considered to be a system which would result in no problems. The use of major coastal waterways to provide access to wildlands affords exceptional positive opportunities for visitor use with a limited affect upon the primary resources. I'm confident that if park managers were to begin over, the same system would be selected. Access by water is the method of least impact, but without constant evaluation and controls the system will result in internal or secondary systems which do create major conflicts.

DISCUSSION

Comment: What is the dependence in Alaska on air travel?

Ritter: I'm glad you gave this opportunity to discuss this important method of travel because use of airplanes in Alaska is a way of life. We get in an airplane to conduct business just like people in Seattle use a taxi cab--without a thought. But we should be thinking something about it, and we should be preparing right now to include air access in all of our planning. We can control the airways only if we can verify that planes are disturbing wildlife or the resource on the ground or that they are flying too low over a populated area. Usually resource managers do not have control of the airways and that is a big handicap.

Comment: Do you have control over the float planes in the area?

Ritter: We have control over the float planes in any area where they land. If an adverse affect occurs, any area can be closed for landings. First indications from the studies that were conducted this summer on the back country user's experiences show the most adverse effect upon their experience was from airplanes. This was greater than impacts from very noisy boats, even those that could be heard 8 km (5 miles) away. Some ships hauling 1,000 passengers go along these same waterways. With respect to aircraft access, something that we should be considering very soon is the use of private helicopters. Now people will say that no one can fly a helicopter unless they have thousands of dollars. But if we consider what has happened with other technology, it's very conceivable that small recreational helicopters will soon be available and we should be preparing now to work with this use before problems develop.

Comment: Are the planes that have been bothering hikers float planes or wheeled aircraft?

Ritter: Both types. Most of them are coming on a commercial function. But they may be wheeled planes that are on a sightseeing tour. Most aircraft in the Glacier Bay area are related to a commercial function and are
Comment: How do the back country users, not the sea coast users, but people who go into the back country lakes by plane and are accustomed to that as a form of transportation -- how do those users feel about planes coming in and landing?

Ritter: The frequency of aircraft use is a critical matter. If you were at a lake you had reached by float plane, I doubt very much that you would object if a float plane used the area two or three times during the week. But what if there were five planes a day or ten each day? That may exceed your tolerance level, and I believe that this is the general reaction of most people.

Comment: In southeast Alaska, we appear to be heading towards some establishment of wilderness. Do you think existing transportation systems may be in conflict with our traditional view of wilderness?

Ritter: It is true conflicts will occur. Coordinated management must be achieved with cooperative programs. But to develop a blanket policy one way or the other and say "wide open access, or none at all" simply is not the answer. Some type of transportation is needed for access and enjoyment of most areas.

Comment: People flying airplanes bring no physical impact to the land. This is kind of interesting. The impact is on someone on the ground, and is a social impact. It seems to me if we're going to remember this whole concept of opportunities and experiences we just have to realize that there may be some impact to obtain access, and maybe we're better off flying above as opposed to impact on the ground.

Ritter: There are cases to support your argument and I'll give you a very good example. Almost every day commercial airlines fly large jet aircraft to the park. Seventy-five percent of the time the weather allows them to fly over the park. I don't think there are very many places that a jet flies on a reconnaissance flight, but it happens over Glacier Bay. It's a good experience and it has little effect upon the people on the ground. I doubt that a representative from the Federal Aviation Administration is at this conference and yet they are the regulating agency controlling air space and air travel. We all must start working together, because their policies have a great deal of effect upon wildland users.

Comment: I'm here to represent the Seaplane Pilots Association. I was of course dismayed by a colleague's attack against the airplanes. I also fly commercial jet airplanes for a major airline. When the opportunity arises I take my passengers for a tour in the air as I depart or come in from Seattle (Mt. Rainier) and I get tremendous response from passengers. People just love it. Occasionally we'll get a letter from someone who was disturbed. We're talking about a trade-off. We're talking about an airplane with 150 passengers who obtain a tremendous experience. I've seen grown men walk in the cockpit with tears in their eyes and say how much they enjoyed that view and it's a view that they would never see otherwise. I think that the word selfish was used yesterday in respect to environmentalists who selfishly want their own wilderness for their own private enjoyment. Well, that's wonderful. We'd all like to have that. However, I think that it's a selfish thing to do. A hiker doesn't want anyone to fly over this wilderness enjoyment spot.

Ritter: Your opinion fits reasonably well with the management policy of the National Park Service: to provide for visitor use and enjoyment and to protect the resource. It's very easy to be influenced by the use of slogans and words. Careful examination does show that two uses cannot occur in the same place. Whatever term you wish to apply in describing management systems and policies it is clearly recognized that most functions can only be conducted if we zone and separate types of users. An airplane flying at an assigned altitude such as you mentioned over Mt. Rainier, is generally a satisfactory experience. As long as there is enough space to separate uses and the zoning criteria is understood, then both visitor use and resource protection can be realized.
ABSTRACT--A paved all-weather highway was opened in 1971 between Anchorage and Fairbanks, increasing visitation at Mount McKinley National Park. Some private vehicle traffic was restricted, and public bus transportation was provided by users. The system has worked well; advantages and disadvantages of the system are described.

Mount McKinley National Park was created in 1916 by an act of Congress, to protect outstanding scenery of extensive geological, glacial and biological significance, while providing visitor use. The park is considered a well-balanced ecosystem, of large predators and their prey, that is little influenced by man. A distinctive feature of the park is its integrity as a wilderness area.

A single road passes from the east boundary some 136 km (85 miles) to a point on the north boundary near Wonder Lake. The eastern 19.2 km (12 miles) are paved with the remainder dirt and gravel. There are seven campgrounds with a total of 223 sites. A concessioner-operated hotel/food facility exists at the eastern end of the road, and there are National Park Service visitor centers at km 105 (mile 66) (Eielson Visitor Center) and 1.6 km (mile one) (Riley Creek Visitor Center) along the park road.

Wildlife is abundant and easily observed, with primary species including wolves, grizzly bear, caribou, Dall sheep and moose. Alpine tundra, shrub tundra and boreal forest are the principle vegetative resources. Geological resources include minerals and ice and snow.

Approximately 80 km (50 miles) of constructed trails exist in a few limited areas of the park. Backcountry travel is predominantly cross-country with stream gravel bars as more popular routes.

Access to the park prior to 1957 consisted of the Alaska Railroad (a few pilots utilized the McKinley Park airstrip). Driving a vehicle into the park was possible only if visitors had them shipped by rail to the entrance at $35 per vehicle. The Denali Highway from Paxson opened in 1957, providing automobile access to the park. However, vehicles did not overflow McKinley, though visitation increased, for the highway is an arduous 256 km (160 miles) of unpaved road. Anchorage and Fairbanks remained at a distance of 587 km (367 miles) and 542 km (339 miles) respectively. In 1959 visitation increased to a level where more than 5,000 private vehicles used the park road.

In late 1971, a new, paved, all-weather highway opened between Anchorage and Fairbanks, the two major population centers in the state. This highway traverses the eastern edge of the park and provides much easier access to the park. This highway is one of Alaska’s most rapidly developing travel corridors, and greatly enhances the park’s popularity with both Alaskan and out-of-state visitors.

The National Park Service implemented a policy designated to minimize the impact of visitor and vehicle increase expected from the new highway. Three main areas of concern of the park management were:

1. That the campgrounds would be crowded beyond their designed capacities;

2. That motor vehicle use on the park road into the interior of the park would exceed its capacity for safe motor vehicle travel due to the road design and driving hazards along the often narrow,
3. That wildlife would be driven away from the central road corridor area or otherwise adversely affected by increased travel along the road corridor and the natural beauty of the park would be impaired.

The problem was to provide access into the park for more visitors, without increasing the use of motor vehicles beyond a level that would be safe and at the same time maintain the wilderness character of Mount McKinley National Park.

A new policy was promulgated by the National Park Service to limit impact of vehicles in the park.

On June 1, 1972 the transportation policy went into effect with three central features:

1. A general prohibition against driving vehicles beyond the Savage River, a point approximately 19 km (12 miles) from the park entrance;
2. A requirement that people using the campsites beyond Savage River must secure a reservation in advance and be permitted to drive their vehicles to the reserved campsites, but no further.
3. The provision of public bus transportation at no cost to the user.

Only access by private vehicle, not use of the park, is restricted under this management plan. Visitors are still encouraged to experience the park by hiking and backpacking.

An alternate transportation system (ATS) was established. Buses—referred to as shuttle buses—are operated through a contract with Outdoor World Limited (the park concessioner) on a reimbursable, 10% profit basis. The contractor leases regular city/rural school buses from a school transportation company during the summer season when the buses would normally sit idle.

The ATS operates as a free shuttle system and is not designed as a tour. It may be compared to a municipal bus system (without fees). Visitors may board or leave a bus anywhere along the route as the buses travel on a prescribed schedule. This allows the visitor to day-hike, overnight travel or just spend an hour among the arctic flowers, and be able to board a bus anywhere to return to a camp, hotel room or vehicle.

Buses operate from the Saturday prior to Memorial Day until the second Sunday following Labor Day. Thirty-five 44-passenger buses depart the eastern terminus, Riley Creek Visitor Center, daily, on an hourly schedule, between 6 A.M. to 6 P.M., for a 211 km (132 mile) round trip to the Eielson Visitor Center, while one bus daily, each makes three 58 km (36 mile) round trips between the Eielson Visitor Center and Wonder Lake. Fewer buses operate during the early and late periods of the season. Bus drivers do not provide ongoing interpretation but answer questions and make short stops to view wildlife.

Several of the buses deadhead, without passengers, into the interior of the park where they pick up visitors at the interior campgrounds or along the road.

An "entrance" station was established at Savage River, where all private vehicles traveling into the park interior must provide the appropriate campground or special travel permit that are obtained at the visitor center.

Bus passenger counts are recorded at the Savage Station. Bus drivers also record all passengers boarding their buses during the entire round trip.

Following the inception of the ATS, park visitation continued to increase as did, of course, the use of the shuttle buses (Table 1-2). Recreation visits is defined as those visitors actual using the park facilities or the park road, while total visits includes recreation visits and those visitors passing through the park on the Fairbanks-Anchorage highway.

During 1971-72 total travel increased five times, while recreation visits doubled. Most additional visitors were motorists as private vehicles increased by multiples of five or six rather than doubling. Recreation visits increased 400% during the 1971-1976 period.

This multitude of private vehicles has not utilized the park road. Their occupants travel by shuttle bus. Considering three persons in each private vehicle and the number of visitors traveling into the park by
shuttle bus, the shuttle displaces a daily average of 200 private vehicles which would otherwise travel the park road.

Besides the advantage of reducing the number of private vehicles, numerous other benefits have been realized by the visitors as well as the park resources and management. Wildlife remains visible along and directly adjacent to the road. Wildlife is more readily located as there are 45 pairs of eyes in each bus looking for animals, instead of three pair in each private vehicle. Passengers are seated higher than in a private vehicle and therefore have improved visibility.

Travel through the park is easier and more pleasant for most visitors when they are not driving—"Take the bus and leave the driving to us." Traffic safety on the park road is, of course, essential and the reduction and prevention of heavy traffic congestion has directly accomplished this management goal. Campground use is limited to designated capacities by use of travel permits to regulate private vehicles to the specified campgrounds. Fewer roadside turnouts, interpretive and information signs, and trash cans are necessary along the road. Vegetational impact adjacent to turnouts is minimal.

Park regulation and policy information is more readily provided visitors. Bus drivers advise backpackers of the necessary backcountry use permit, as well as educating the visitor about closely approaching a grizzly bear.

Approximately 90% of the visitors tend to remain on the buses and cause minimal if any direct physical impact upon the resources (This will also be addressed later as a problem). The typical park visit to Mount McKinley National Park is made by a couple in their mid-twenties, with no children, who are on their first trip to the park, will stay two days, and are not interested in hiking.

Certain problems and disadvantages also exist with the ATS. Overcrowding of the system is a major problem. Since 1977, buses consistently depart the eastern terminus full, with numerous visitors unable to travel into the park.

Many passengers leave the buses at the Eielson Visitor Center (western end of the basic transportation system), to hike, view Mount McKinley, and attend interpretive programs. The early buses therefore return to their point of origin half full, resulting in a late afternoon shortage of shuttle bus seats. Park rangers provide transportation and "extra" buses are dispatched to accommodate the persons left stranded by over­loaded buses.

Overcrowding results in a more serious problem; visitors will not leave the buses to hike or otherwise enjoy the park "on the ground" because they are afraid to give up

<table>
<thead>
<tr>
<th>Year</th>
<th>Total Visits</th>
</tr>
</thead>
<tbody>
<tr>
<td>1936</td>
<td>1,073</td>
</tr>
<tr>
<td>1939</td>
<td>2,124</td>
</tr>
<tr>
<td>1942</td>
<td>63</td>
</tr>
<tr>
<td>1945</td>
<td>2,012</td>
</tr>
<tr>
<td>1950</td>
<td>5,961</td>
</tr>
<tr>
<td>1953</td>
<td>6,839</td>
</tr>
<tr>
<td>1955</td>
<td>3,393</td>
</tr>
<tr>
<td>1956</td>
<td>5,122</td>
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<tr>
<td>1957</td>
<td>2,372</td>
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<tr>
<td>1958</td>
<td>6,323</td>
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<td>1959</td>
<td>25,819</td>
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<tr>
<td>1965</td>
<td>21,406</td>
</tr>
<tr>
<td>1966</td>
<td>31,316</td>
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<tr>
<td>1970</td>
<td>42,344</td>
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<tr>
<td>1971</td>
<td>58,342</td>
</tr>
<tr>
<td>1972</td>
<td>306,027</td>
</tr>
<tr>
<td>1973</td>
<td>360,132</td>
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</tbody>
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Table 2. Recreation Visits and Shuttle Bus Use at Mount McKinley National Park

<table>
<thead>
<tr>
<th>Year</th>
<th>Recreation Visits</th>
<th>Bus Passengers (Savage River)</th>
<th>Bus Passengers (Boarded)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1971</td>
<td>44,528</td>
<td>24,279</td>
<td></td>
</tr>
<tr>
<td>1972</td>
<td>88,615</td>
<td>32,898</td>
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<td>1973</td>
<td>137,283</td>
<td>33,356</td>
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<td>1974</td>
<td>161,426</td>
<td>42,190</td>
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</tr>
<tr>
<td>1975</td>
<td>160,600</td>
<td>48,356</td>
<td>142,615</td>
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<tr>
<td>1976</td>
<td>157,609</td>
<td>60,459</td>
<td>145,266</td>
</tr>
<tr>
<td>1977</td>
<td>170,031</td>
<td>59,331</td>
<td>170,100</td>
</tr>
<tr>
<td>1978</td>
<td>220,907*</td>
<td>222,247**</td>
<td></td>
</tr>
</tbody>
</table>

* As of September 30, 1978
** Projected

their seat and risk a delay in being able to return to their camp or room. Thus the shuttle bus becomes a "tour" bus in conflict with the concessioner's wildlife tour.

The park concessioner operates a wildlife tour, at $18 per person, that travels the same route as the ATS. This tour departs at 6 A.M. and 3 P.M. daily from the hotel at the eastern end of the park, and makes a 211 km (132 mile) round trip. The driver interprets the park during the tour. This tour operation provides an even more restrictive control of the visitors as they do not leave the buses, remaining as part of an organized bus group.

Additional problems existing are:

1. Mechanical failures of ATS buses;

2. Breakdowns of the wildlife tour buses necessitating that passengers be transferred to shuttle buses for the return trip to the hotel area;

3. Shortcomings of the buses. School buses are designed for carrying "school" children primarily on paved roads; they are uncomfortable for many adults, and susceptible to breakdowns on the rough gravel road. Ideally, tour-type coaches, with large windows, and toilet facilities would provide the necessary visitor comforts and services. However, the costs and short "annual use period" makes such coaches unfeasible;

4. Funding, in a time of considerable inflation continually limiting the numbers of buses operated - the 1978 budget for the ATS was $862,000;

5. Insufficient private vehicle parking area at the Riley Creek Visitor Center;

6. Difficulty in scheduling the proper number of buses at the correct time to meet the use demand of the visitors;

7. The lack of direct and specific supervision of the bus drivers by park management;

8. A loss of freedom by the park visitor in not being able to control travel time and locations of stops, and not at the same time being in "one's own" vehicle;

9. The disturbance to wildlife to a definite but unknown degree;


11. A vehicle-bus-accident has the potential of 44 injured.

Specific private vehicle travel on the park road is necessary, but limited. Special travel permits are issued to the handicapped, Kantishna mining district residents whose only road access to their property north of Wonder Lake is through the park, professional photographers, campground use,
and for other administrative use.

The ATS was heavily challenged in 1972 by numerous Alaskans who believed their rights to use the National Park were being violated. However, a study, by Gordon S. Harrison, University of Alaska, indicated that 84% of Alaskans and of non-Alaskans favored the shuttle bus system and access limitation policy.

In summary, the alternate transportation system in Mount McKinley National Park is providing a direct resources protection along the park road corridor by limiting private vehicle use while transporting park visitors into the park. Indirectly, back-country impact is limited by "control" of hikers with bus drivers, and with park rangers at the bus termini providing park policy and regulation information.

The transportation system provides a service for visitors not requiring the use of a private vehicle but rather a "quick, convenient" trip through the park. There are recognized problems and disadvantages with the system. Currently the buses are unable to accommodate all visitors requiring transportation. However, natural resource protection is paramount and at this time park management is determining the maximum number of buses that will operate on the park road, considering the buses as an impact. Simultaneously, funding may also be a limiting factor.

It very well may be that if Mount McKinley National Park is to maintain its integrity as a wilderness area, it will not be able to accommodate all persons desiring to visit.

DISCUSSION

Comment: If someone wants to see all they can by road using the bus system, how long will it take them to get to the west side?

Brown: They transfer at the Eielson Visitor Center to the other buses. We have three buses that do nothing but shuttle between Wonder Lake and Eielson. They can transfer and go to the Wonder Lake area. We do not provide service outside the park. It's about an 8-hour round trip to the Eielson Visitor Center. There are some private lodge facilities and some overnight accommodations outside the park at the west end of the road. They would have a few miles to walk to get to these lodges.

Comment: Do you find that the shuttle bus concept was handled successfully to disperse overnighters and back-packers?

Brown: Yes, but not just in itself. I would have to go down into the backcountry use program. The park is divided into back-country use units, and there are specific capacities or limits. Anybody on the bus going into the backcountry already has his permit (or should have) and is going to a specific destination, normally a drainage basin. Our units are pretty much set up where major hiking routes are located. We do not have trails but hiking is on the gravel bars or the streams. So, dispersal -- yes, by the transportation system. But, more importantly for the backcountry, by the backcountry management system itself.

Comment: Is Wonder Lake camping completely eliminated now?

Brown: No, it isn't. I wish it was. It is tents only. Twenty-three sites. It sits on a small knob right above the lake, and is a visual obstruction. It's a crowded camp, but has a beautiful view.

Comment: But by reservation then there is a possibility that you can get a reservation for camping there?

Brown: Yes. We began taking reservations for the four interior campgrounds April 15 each year.

Comment: Can you drive through to the Kantishna?

Brown: We issue special travel permit to those people who need access, their only access being by the park road to reach the Kantishna mining district: i.e. miners, residents, the people at the lodges, guests of those people at the lodges. We're fairly restrictive on other people who are just going out for example to sightsee or fish.

Comment: Is Denali a park concession operation?

Brown: No, Camp Denali is a lodge outside the park. It operates on a special use permit for providing their guests with tours through the park.

Comment: I'd like to make a comment as a
user of the Park. I traveled through there this summer for the first time in about ten years. And I understand the gravity of the situation, but though I used the bus system and like the opportunity it provides, I don't consider the road corridor as wilderness because it is so visible. The other comment I would like to make is that because of the requirement for permits for the backcountry, the Park no longer offers me the same kind of wilderness experience as I might have, say, in the Brooks Range or the Wrangell Mountains. I'll admit freely that if I went to the Park again and decided to go backpacking, I would not use a permit, mainly because the permit system and the backcountry zoning system denies me the freedom of choice and spontaneity that is a critical part of the whole wilderness experience for me. It has become a Police State wilderness. That's a little strong but it dramatizes the problem of increasing regimentation for backpackers. I enjoy visiting the Park and I think it's tremendously valuable for wildlife viewing experiences, but as far as wilderness goes, there are other places in Alaska where I can still have an unrestricted, and more enjoyable, wilderness experience.

Brown: Well, I'm not trying to defend the wilderness. I think there are some degrees in wilderness here too. And the corridor to begin with has a road, and you're right, we have a visibility problem. A visibility problem works in reverse too. When the people come along on that bus, on that shuttle bus, and they look off and a half a mile or a mile away, there's a brilliant orange tent in the background of a herd of caribou. That's somewhat distasteful for them. But I'm not trying to say that as you're using that shuttle bus you're having a wilderness experience.

A wilderness experience should be that you get away from the road. Now, as far as backcountry zones are concerned, we've had a sociological study going in the park this year to try to give us some answers to some of the things you've broached, including noncompliance. Anna Plager, who worked on the study is here. So, I suggest you supply her with any information that you think would help in our study.

Comment: Who does the training of the drivers?

Brown: Originally, it was the Park Service responsibility. Now, under a concession contract the concessionaire hires professional bus driver trainers.

Comment: I don't understand how come there is not a backpacker route that uses the buses to go from headquarters to Wonder Lake without getting stranded overnight.

Brown: You can go to Wonder Lake in one day with no difficulty, provided you leave in the morning hours from the eastern terminus. Printed schedules are available and it takes a little thought and planning.

Comment: I had the opposite reaction with the buses. I thought it was great, because for the first time I could go to a place with no trail and know there would be very few people in the whole area I would be visiting. Another question I have in relation to this idea is with more and more people who want to use the area. Have you thought of any strategies to deal with this?

Brown: First, let me say that there's a level of impact, that we're going to accept. There is impact from the very first vehicle on the road. How about a reservation system? A reservation system is being considered as a way to disperse the growing number of people. But a nation-wide public information system is essential to make it work.
MCKINLEY'S SHUTTLE BUS SYSTEM AND THE MANAGEMENT OF TRAFFIC IMPACT ON WILDLIFE

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ABSTRACT--Quantitative studies conducted during 1973-1974 and other observations indicate that traffic in Mount McKinley National Park has demonstrable effects on large mammals. Reaction types are illustrated by caribou (Rangifer tarandus) and sheep (Ovis dalli) behavior, especially within 200 m of the road. Dust, motion, and noise associated with vehicles and passengers are problems. Buses increase the passenger/disturbance ratio but need improved maintenance, more skillful handling, perhaps clumped scheduling, and an extended season. Education and control of passengers can be improved. "Car fences" which frequently separate members of animal groups, especially bear families, or block movements of sheep bands should be avoided. Possible changes in system operation that might lower impact are offered.

INTRODUCTION

Does traffic have an effect on wildlife? Yes, but therewith ends the simple part of the answer. What kinds of effects? And can and should these impacts be managed? We will attempt to provide some answers to these questions based on studies and observations at Mount McKinley National Park and relate them in particular to the role of the shuttle bus transportation system that is currently in use there.

The impacts of traffic on animals are generally on individuals but at times are translated to the population level through a summation of individual reactions and through group behavior patterns. Some effects such as changes in mortality rates are evident only at the population level. Effects on individuals are of several types: physiological, behavioral, and distributional, for example. When animals are presented with new stresses, they may respond either "passively" or "actively." A frequent "passive" response is avoidance of areas where the particular stimulus is stronger than the individual's threshold of tolerance. "Active" adjustment in the sense that we are using the word implies adjustment toward the stimulus. This may involve learning that real harm is not likely and thereafter increasing the level of tolerance for that particular stimulus. It may also be accomplished by sensory filtering; we do this with city noise and crowds. Often these adjustments are used in combination.

Gary Brown, in the preceding paper, has provided an introduction to conditions in Mount McKinley National Park, the history of visitation and access, and the shuttle bus system which was started in 1972. Late that year the National Park Service asked the Alaska Cooperative Park Studies Unit to investigate the effects of traffic on wildlife and, in particular, the effect of closing the road to unlimited private vehicle access.

It was a bit like trying to weigh a long-gone horse using the depth of hoof prints in the stable floor. Field work lasted two years and is presented in depth by Tracy (1977).

We designed the study with the objective that it would:

1. Provide a quantitative description of
the types and levels of vehicle and visitor activity along the road;

2. Provide a quantitative description of the behavioral response of the large mammals;

3. Determine the effects of human activity on the distribution of large mammals near the road;

4. Provide quantitative baseline data on the distribution, relative abundance, and population composition of these animals; and

5. Suggest ways to minimize the impact on the animals as individuals and populations.

Tracy concentrated on caribou (Rangifer tarandus), moose (Alces alces), Dall sheep (Ovis dalli), brown bear (Ursus arctos), and red fox (Vulpes fulva) though information was gathered on other species as well.

METHODS

The work was planned to take advantage of several methods of assessing the way animals, mostly large mammals, were using the area in the vicinity of the park road; their behavior while in that zone; and their reaction to traffic. During 1973 and 1974 a total of 70 eight-hour trips was made on the buses (both shuttle and hotel tour buses). Thirty trips in a pickup were made in series timed to span the closing and opening of the road to traffic in May and September. Over 300 hours were spent intensively observing individual animals and small groups. A series of counts was made on large plots paired in road/non-road fashion.

Over 4,400 observations on individual animals were accumulated in over 1,100 groups (excluding large groups of migrating caribou). These observations occurred during the course of the bus rides between the Headquarters end of the road and the Eielson Visitors' Center at Km 107. The trips were set to sample the 0400, 0700, and 1500 hour buses in 1973 and the 0400 and 1500 hour buses in 1974. The day of the week on which a particular trip was made was randomized. An extensive set of data was recorded for each animal sighting made from the bus. Reactions were classified as unknown, no visible reaction, mild (limited to watching the vehicle and/or walking for a distance less than 10 m), and strong (movement at a rate faster than a walk and/or for a distance greater than 10 m).

In addition to the intensive study with Tracy on effects of shuttle buses, Dean has worked in Mount McKinley National Park for several seasons beginning in 1957 and spanning the transitions from access by railroad only, to the opening of the Denali Highway, to the opening of the Anchorage-Fairbanks Highway. While most of his work has been concerned with the ecology of bears, he has had many opportunities to note the reaction of various animals to traffic and to observe the behavior of people and the way they handle vehicles in relation to animals.

None of the work which we have done provides any quantitative measure of physiological stress caused by traffic-associated stimuli. We have concentrated on the behavioral and distributional manifestations.

DISCUSSION

There are difficulties in interpreting the results of Tracy's study. We may have been studying a subset of the park animal populations that contains an abnormally high proportion of individuals already adapted to traffic stimuli. Additionally, there was no way to recognize most animals as individuals. A high proportion of "short timers" in the zone along the road could result from a continual flux of animals through that zone. Caribou reactions are confounded by the coinciding of the park road and the major migration route and by the steady decline of the caribou population since the 1940s.

What are the most likely sorts of stimuli and impacts associated with traffic in McKinley Park? Because of the extensive areas of low shrub and tundra, there is an obvious visual sensing of a large, moving object foreign to the animal's normal environment. Noises are produced by the vehicles. There are sudden changes in both the visual and audio stimuli as vehicles start, change gear loading, or stop. Many of these stops are associated with animals sighted close to the road. Another set of stimuli comes from the passengers in the vehicles who frequently will make loud noises to produce a reaction from the animal; anything for increased photogenicity. People frequently disembark from vehicles and may leave the road, moving toward the animal. Even those that do not leave the road change the stimuli from the perspective of the
animal. Rather than a single large object of a sort that is quite effective as a blind, there are suddenly several animated objects frequently associated with the need for flight.

Another class of impacts results from more direct or mechanical effects: dust production and injury or death from collision. All of these stimuli and mechanical effects can be manifested in a variety of ways. On the physiological level there may be abnormally high levels of hormones such as adrenaline; digestion may be interrupted; energy may be diverted from normal maintenance into extra nervous and locomotor activity. This requires a greater energy intake to compensate for the loss and possibly periods of time with particularly low levels of disturbance to offset the effects of the energy switch. Fetal development and survival may be affected if pregnant females are subjected to stress. We made no attempt to measure these physiological responses, but neglect does not remove them.

Behavioral and distributional changes are easier to work with and seem to be demonstrable by Tracy's analysis. Some of these relate to the spatial distribution of animals within the environment and others to the manner in which they used their time. We will deal first with the least complex effects.

Two impacts of dust come to mind directly. Although they have not been examined in McKinley Park, we have no doubt that they are significant for some subpopulations of mammals with restricted home ranges. Herbivores feeding on forbs or browse covered with a significant layer of dust will have increased rates of tooth wear. Dean has observed very significantly increased tooth wear in a muskrat population restricted to a diet with a high silica content and believes that the mean life span in that population was reduced as a result. The same applies to road dust, especially for animals whose home ranges may be largely or entirely within the wind-blown dust deposit zone. This zone extends at least 100 m from the road in many areas and receives a substantial dust fall. That could encompass the home ranges of some microtines and ground squirrels and significant portions of the home range for many porcupines, snowshoe hares, and even moose in some of the narrow stream bottoms. These same animals might show lung problems resulting from dust just as one would expect in humans who spent much of their time in a dusty environment. The dust zone affects very small proportions of the park population for each of these species.

There is a steady but unmeasured drain on the ground squirrel population as a result of collisions with vehicles. There are fewer casualties among other species. Large mammal losses are probably less than one per five years. An indirect effect of these road kills is a substantial amount of carrion not otherwise available. Scavengers, including ground squirrels, use this source of food freely. In doing so, they are subjected to an increased risk in traffic death.

Both the amount of dust displaced from the road and the number of animals involved in collisions are closely related to the number of vehicles on the road, vehicle design, vehicle speed, and the manner of operation. More will be said on this later.

What about some of the kinds of behavioral and distributional impacts we have noted? In view of time and space limitations, we will only present a suggestion of our observations. Tracy's analysis indicated the following with respect to caribou. Both the percentage of caribou that showed visible reactions to buses and visitors and the ratio of strong to mild reactions decreased with distance from the road. Just over 60% of the caribou seen less than 100 m from the road showed some visible reaction to bus-related human activity. Forty-one percent exhibited strong reactions within this distance. At greater than 400 m less than 10% of the animals showed visible reactions. A high percentage of the caribou within 200 m of the road reacted, and combining this with traffic frequency, the result of on the order of 4 1/2 mild and 2 1/2 strong reactions per hour for the "average animal" between 0800 and 1700. In comparison, literature reports indicate one disturbance per 11 hours in the case of caribou in the Tanana Hills of interior Alaska interacting with bird and mammalian predators (Curatolo 1975) and one non-insect, natural disturbance per 8 hours or longer for Norwegian reindeer (Thomson 1973). Tracy demonstrated that caribou within the 200 meter zone spent more time traveling, and combining this with traffic frequency, the result of on the order of 4 1/2 mild and 2 1/2 strong reactions per hour for the "average animal" between 0800 and 1700. In comparison, literature reports indicate one disturbance per 11 hours in the case of caribou in the Tanana Hills of interior Alaska interacting with bird and mammalian predators (Curatolo 1975) and one non-insect, natural disturbance per 8 hours or longer for Norwegian reindeer (Thomson 1973). Tracy demonstrated that caribou within the 200 meter zone spent more time traveling, and combining this with traffic frequency, the result of on the order of 4 1/2 mild and 2 1/2 strong reactions per hour for the "average animal" between 0800 and 1700. In comparison, literature reports indicate one disturbance per 11 hours in the case of caribou in the Tanana Hills of interior Alaska interacting with bird and mammalian predators (Curatolo 1975) and one non-insect, natural disturbance per 8 hours or longer for Norwegian reindeer (Thomson 1973). Tracy demonstrated that caribou within the 200 meter zone spent more time traveling, and combining this with traffic frequency, the result of on the order of 4 1/2 mild and 2 1/2 strong reactions per hour for the "average animal" between 0800 and 1700. In comparison, literature reports indicate one disturbance per 11 hours in the case of caribou in the Tanana Hills of interior Alaska interacting with bird and mammalian predators (Curatolo 1975) and one non-insect, natural disturbance per 8 hours or longer for Norwegian reindeer (Thomson 1973).
traffic are already under some degree of stress from insect harassment (which can be severe), antler production, or lactation.

Tracy's work failed to demonstrate a significant difference between the strength of reactions by caribou to buses that passed without stopping as opposed to those which stopped and did not discharge passengers. When people disembarked the percentage of strong reactions by caribou nearly doubled.

The effect of traffic on Dall sheep represents a somewhat different sort of impact although some features parallel those associated with caribou. Most sheep are seen more than 200 m from the road because of habitat distribution. However, sheep encountered close to the road, with the exception of a few habituated individuals, seem to be more sensitive than caribou to noise from either vehicles or people.

The principal problem relating to sheep involves their crossing the road successfully during shifts from one section of range to another. In most cases these are movements from winter range to summer range in May or early June and back again in late August, September, and October. There is ample evidence in the form of observations made by both of us that groups of sheep are very skittish in approaching the road and hesitate to cross if there is traffic in the vicinity. They have been seen to deflect more than 1000 m in order to avoid close encounters with vehicles. This is frequently impossible as the vehicles will move, and the sheep are often stalled in their crossing attempt. The delay in crossing may force migrations across lowlands to become considerably extended in time with consequent increased exposure to predation by wolves and bears. The stress that the animals are under is clearly evident. Increased frequency of strong flight reactions by females in late pregnancy may possibly affect lamb survival. Individual adult animals are likely to suffer an increased accident rate as a result of attempting escape from vehicles at steep road cuts.

Although portions of the sheep population are apparently becoming habituated to people, this is taking place most commonly in areas far enough from the road so that the accommodation is not to vehicles and the associated passengers, but rather to people as individuals or in small groups who are approaching quietly for photographic or observational purposes. It is also related to locations where the sheep feel secure.

In addition to the direct and indirect stress and mortality suggested above there is a broad question of the limitation of sheep to units of range which they would normally leave fallow during the summer. Such range restriction is likely to have consequent physiological affects if portions of the range become over-utilized and incapable of providing the necessary nutrients for the all-important regenerative recovery from the stress of winter and of pregnancy. The effect may eventually extend from the individual level to a substantial population effect.

There are already several areas that seem to be used by sheep much less during the summer than was the case in the late 1950s and early 1960s. The potential of a high level of traffic becoming an effective though "invisible" fence between winter and summer range is a very real one. The crossing points used by migrating sheep are usually ridge tops and represent a small part of the total road length. No valid alternatives exist. The sheep traditionally have made movements that must be high risk with respect to predation; they may not have buffer enough to absorb substantially increased stress.

The "car fence" is a very real problem in other ways as well. By "car fence" we mean the accumulation of from a few to the dozen or more vehicles on a nearly bumper to bumper basis in association with a roadside animal. Small aggregations of vehicles are common throughout the summer season, frequently consisting of two or three passenger cars and up to four buses. Thus a large number of people may be involved and may also have an opportunity for viewing an animal. A commonly associated problem is separation of the members of groups of animals; in the case of bears these are especially likely to be family groups. Frequently one can see such strings of vehicles shift back and forth with the movements of the animals in order to achieve the best possible opportunity for viewing and photographing.

The fences are apt to develop and shift with the animal to a greater extent in the case of bears than is true for other species. Bears have great attraction, and because the potential hazard is at least partially recognized, most people are reluctant to get too far from their vehicles. In many cases the bears are within a few meters
of the road; frequently a female will have part of her family on one side of the road and the rest on the opposite side. There have been occasional attempts by bears to attack people in such situations, but fortunately the potential for real injury to park visitors has not been realized yet. However, these are unquestionably stressful situations for both adults and young. Frequently people intent on animals on one side of the road ignore the rest of the group, often including the female.

This type of situation has at least three ramifications: (a) direct stress on the animals concerned; (b) substantial potential for immediate injury to the people; and (c) a strong contribution to the deduction of young bears that while people may be the source of irritation, they cause no real injury, thus furthering the development of the unafraid, aggressive bear populations that seem increasingly common in parks.

The preceding discussion was intended to illustrate some types of traffic impact on wildlife and to suggest the current level of impact. Where are we with respect to impact thresholds? Our answer is derived from a moderately long sequence of personal observation in McKinley Park, Tracy's quantitative study, and the reported experience of others.

First though, the policy question of attempting to control traffic impact on wildlife in McKinley Park must be addressed. Geist (1971) has documented the development of habituated animals after extended association with park visitors. Canadian Rocky Mountain parks certainly display morpho-images of bighorn sheep on road embankments, but they are approaching the status of animated statues. Animals such as these are certainly dangerously close to the brink of using food, shelter, and/or protection derived directly or indirectly from man. As the roadside bighorn begins grazing on lawn grass or as a fox turns beggar, substantial wilderness is lost. Many people consider animals that have become habituated to man's close presence as having lost much of their natural character. Others draw the line at the point at which the animal makes use of or becomes dependent on man's "services." However one defines "wild," habituated animals are either at or very near the boundary between wild and non-wild.

Most visitors to wildland parks are attracted and rewarded by qualities of wilderness (even when not in wilderness). Granted that visitors are unlikely to come without reasonable expectation of seeing at least several of the characteristics species in an area; we still feel that much of the attraction of wild parks for most visitors would be lost if there were not more uncertainty than one finds at a zoo. The 1978 McKinley Park experience with wolves suggests that the aura may fade as habituation results in: "Oh sure, we saw two yesterday."

The maintenance of the qualities of wilderness will be extremely difficult in wild areas that are not wilderness. Mount McKinley National Park presents a real challenge. The eastern half of the present park is nearly all accessible to one-day hikers and has a road traversing much of its best wildlife habitat; the country is basically subalpine and tundra; visitation is skyrocketing.

We believe we are at some consequential wildlife impact thresholds and probably past others. We also feel that McKinley Park offers, and most visitors want, a sense of wilderness that should be maintained even if it means restricting access. The precedent of restriction has been established with respect to true wildland parks in Africa where visitors do not disembark from vehicles and also in numerous American parks that have not been wild for several decades at best.

The transport system in McKinley Park can be managed to keep impact on animals from increasing and perhaps even to reduce it from present levels. There are some obvious benefits from packaging park visitors in transportation units of higher capacity than personal cars. The number of visitors per disturbance is raised sharply, and Tracy has shown that many animals appear not to react more strongly to a bus than to a private car given the same "behavior" on the part of the vehicle. This "behavior" includes the manner and rate of operation, changes in speed and gear loading, and the noise produced by the vehicle and the passengers. As was noted in the discussion of caribou, the disturbance frequency resulting from traffic at 1973 and 1974 levels was already many times what has been found in at least two natural or near-natural situations. Thus, given the desire to accommodate as many visitors as possible and yet minimize disturbance of animals consistent with the desired visitation level, the use of buses is a very realistic part of the
solution.

What can be done to make it even better? Increasing the level of maintenance on the buses, both shuttle and hotel tour vehicles, in order to reduce the noise associated with engines and transmissions would help considerably. Insistence on more skillful operation with respect to disturbance criteria and developing a real sense of pride among bus drivers in their ability not only to show visitors animals but to leave the animal as undisturbed as possible for the next set of visitors. This will take more intensive pre-season training of drivers. Greater education and control of visitors with respect to noisemaking and appropriate behavior when viewing animals would help considerably. Currently this depends on individual bus drivers' personal concern; they are not National Park Service employees.

Other possible changes in the nature of the shuttle bus system need careful consideration. One smaller bus, a Mercedes-Benz diesel 19-passenger unit, is currently in use by a lodge owner who transports visitors through the park to a resort outside the west-end boundary. Designed for scenic tours it is a good vehicle from which to view. It seems to be quieter in operation and more comfortable than the school buses used as shuttles. If this vehicle type were adopted, it could result in a quieter operation, a more pleasant ride, and probably less dust production. Adversely it would necessitate a larger number of vehicle units for the same number of riders. At this point it is difficult to say whether or not the quieter operation would offset the increased number.

Further reduction of the number and frequency of vehicles could be achieved by transporting people to reserved camp sites by shuttle rather than by continuing to allow private cars past the Savage River check station. For the same number of vehicle units the number of visitors would be increased substantially.

No attempt has been made to really determine whether a change in scheduling would be beneficial, but some ideas need thought. Currently both the hotel tour and the shuttle begin fairly early in the morning and run until late in the evening. What would happen if true shuttle schedules were compressed into the mid-part of the day when animals tend to be less active, may be resting, and thus are perhaps farther from the road and in a less reactive condition? Perhaps the early and late trips could be restrictively prohibited from disembarking passengers except at a few designated stops. What would happen if instead of scheduling single buses at fairly short intervals, clusters of buses were initiated at less-frequent starting times with the expectation that the vehicles in the cluster would maintain their association during the entire trip? This could have the effect of clumping disturbance (i.e. reducing frequency) without direct multiplication by the number of vehicles, assuming that vehicle and passenger behavior was appropriate. This would require strong efforts at dust control if passengers in following buses were to have a decent experience.

The management of traffic so that the car fences can be avoided presents a somewhat different set of problems. In part it is the problem of scheduling shuttles and maintaining whatever schedule is set. In part it will require some thinking about whether it is better to maintain substantial intervals between parked vehicles from which people are observing an animal or to create the minimum total fence length by accumulation of the vehicles in the shortest possible distance. In the case of the bear family situation, when family members are on opposite sides of the road, it may be better to leave some space between the vehicles through which the animals can pass. Spacing of 30 to 50 m is recommended as a trial. Appropriate slow movement of a cluster of vehicles trading parking spots would provide nearly equal viewing opportunity in most such situations.

Currently the shuttle system carries with it some characteristics of people-handling that tend to minimize disturbance to animals. People are much more likely to leave private vehicles than they are buses. They are much more likely to leave the road from private vehicles than they are from buses. This may result from active or passive inhibition by other visitors on the buses and, in some cases, control by the driver. Concern about loss of a seat is a strong factor as well. It frequently is difficult to encounter a bus with an empty seat later on. Thus the shuttle bus tends to keep people more confined to the vehicle and to the road than do private cars. "Fences" are less likely to last as long when composed of buses due to the reasonably fixed schedule.
Perhaps the greatest contributors to car fences during the season the shuttles are running are the professional photographers. When they abuse their special privilege, quicker disqualification might be appropriate. After the shuttle system has been shut down in the fall, car fences are frequent occurrences. On one recent September weekend day Dean observed two dozen cars stopped near bears at one point, a string of ten or so at another, another string of about a dozen at a third point, and a fourth group that involved seven or eight vehicles. The total distance along the road spanned just over 24 km; all were associated with bears.

Reports from long-term users of the park road suggest a definite although unquantified reduction in the number of animals seen from the road as the road is opened to traffic in the spring. On the few occasions when Dean has had the opportunity to drive the road beyond the point at which it was closed to all traffic in the fall, he has observed tracks in the snow which indicate a high level of use of the road surface by bears, wolves, and other animals. In some cases the road was being used as a definite trail for distances exceeding 32 km. This would be exceedingly uncommon while traffic was operating.

All in all, it seems that if the wilderness of Mount McKinley National Park is to be maintained, we need to recognize some constraints and accept some serious control of access and use. We feel that a modified shuttle system offers the greatest potential for balancing the number of visitors and impact. However, we recommend operation of the shuttle system during the entire period that the road is open beyond the Savage River guard station.

The shuttle system solves only a part of the problem; if wilderness is to be maintained, the entire question of the primary purpose of and benefits from Mount McKinley National Park need addressing. The reduction of impact from traffic and people associated with vehicles will be hollow indeed if the only off-road animals the bus-bound see are super-abundant, gaudily adorned Homo sapiens.

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DISCUSSION
Comment: Maybe it would create more problems than it would solve, but what about dust palliatives on the road?
Dean: The dust problem is something that has been thought about. This is not something I've been directly involved in. The Park Service has been studying road construction in the area, and has looked at different surface treatments, all the way from "no treatment" up to "paving," and dust palliatives have been considered. We've tried to get some information on various ones. There are some that companies claim are biodegradable, totally organic natural products; that can be used on agricultural soils. Whether they really work I don't know.
Comment: I would recommend you contact Region 6 of the Forest Service. They've done a lot of studying on this, and most of those you can put on a sandwich don't really make it for dust.
G. Brown: In the study that's just being finished the Forest Service was contacted.
Comment: I just wondered if there have been any studies in Africa where animals are seen in parks by people staying in vehicles. I was working there one summer. People are not permitted out of the vehicles. The
driver can go chasing across country after
animals. I was just wondering if there
might be studies on impact in Africa that
might be correlated with your studies of
impact.

Dean: I don't know. Cathy, have you run
into any references on such impact in
Africa?

Ream: Yes; there is one rather unsophisti-
cated study that was published in an African
journal. But I don't think it said anything
that you couldn't have anticipated.

Dean: I think that the original reason for
staying in the vehicle there was visitor
safety rather than animal safety.
rehabilitation
REVEGETATING THE FOREST ZONE OF NORTH CASCADES NATIONAL PARK

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ABSTRACT—North Cascades National Park was established in 1968 and inherited areas of overuse. A rehabilitation program was begun at Cascade Pass in 1970 and the subalpine areas were given first priority. In 1974 the Backcountry Management Plan for the park called for the rehabilitation of old campsites in the forest zone. After three years of experimentation we had our greatest success when we transplanted in cool, damp weather using small vegetative reproducers or transplanted whole micro communities. Visitor education was essential for a successful revegetation program.

INTRODUCTION

North Cascades National Park was established October, 1968 by an act of Congress. The act designated a two-unit park plus two recreation areas for the purpose of preserving the pristine beauty of the peaks and valleys.

The Park inherited from the Forest Service a region already showing signs of stress and overuse. In the forest zones large denuded scars indicated overuse by campers and horse using parties at camp areas and old shelter sites. In 1972 the use increased with the opening of the North Cascades Highway, bringing high-speed civilization in a rapidly diminishing wildland.

Thornburgh (1970) started the revegetation effort in the Park by doing a survey in the Cascade Pass area and then making management recommendations for rejuvenating the area. Field studies and experimenting begun by the Millers in the same area in 1970 proved to be very successful. In 1974 the Park initiated a backcountry management plan. The intention was to keep foot traffic to a minimum in the fragile subalpine and alpine areas and limit camping to designated campsites. This was accomplished by providing more camping within a day's hike of most trailheads in the more tolerant forest zone, and at the same time removing camps, fires and horses from the less tolerant subalpine areas.

TYPES OF IMPACT

Impact was classified into three categories: day, overnight and horse use. Each caused considerable impact in a different way.

Day use was concentrated close to trailheads, generally within two or three miles of the road. Trails become overused through concentration of large numbers of

WASHINGTON
people in a small area. New trails were created to get around sections with mud or water on them. Fishing, sightseeing, and water-gathering trails are all very common. Picnics, often with fires, are held in closed campsites that have been revegetated.

Overnight campers have caused and continue to create most of the problems. In the past they could camp almost anywhere they wished. Large areas in the backcountry became denuded. Today camping is restricted to designated sites. Hikers often overestimate their abilities and are unable to hike to their assigned site. They camp in the old worn-out sites, aggravating the problem. In designated sites, impact is caused by social trails that lead to the toilet, to water, and from one site to another.

Horse use in the backcountry has not been a major problem for the Park because trails were not designed to accommodate heavy horse use. Horse use is limited to a few regions in the park where the trails have been adequately designed and the terrain is not too steep. There are areas, most prominently subalpine passes such as Cascade Pass, that have received a lot of horse pressure in the past and still carry the scars.

Common to all impacted areas is the fact that soils have been bared, compacted and stripped of their upper horizons, making them very acidic and unable to sustain plant life. Adding to this problem are the effects of campfires on the soils. Campfires create two kinds of problems, one caused by the collecting of firewood and the other by the effect of fire and heat on the soil. Collecting firewood has a damaging impact: it removes important decaying materials from logs and branches that are major colonization areas for tree seedlings. This also removes ground cover that retains moisture and nurses vegetation. Fire damage, from its relatively high temperatures over long periods of time right at the soil surface, causes loss of nitrogen and organic matter (Schreiner 1978).

METHODS

In 1976, Schubert, Student Conservation Association Park Assistant (SCA), began a study to attempt to determine whether revegetation was possible in the forest zone during the summer months and which species were the most suitable. A method was devised whereby photos of impacted and untreated sites were taken and a general description of the camp written, listing the plant communities. At each camp control plots were established. The soil was turned in some and in others it was left compacted as found. One m^2 plots were dug to a depth of 20 cm and reasonable efforts made to remove most dead roots. The transplants were dug differently for each species, but efforts were made not to damage the root system. The plots were filled with moss, herbaceous plants, shrubs or trees or some mix of these.

Where possible Schubert tried moving in partially decayed trees for use as nurse logs. The log was half buried to retain moisture in it, thus permitting the establishment of young conifers as well as ground covers.

All the plants used were obtained from the vicinity of the plots but well out of sight of trails. The plots were marked with survey stakes and surrounded by string. After planting, another set of photos was taken and records made of the plant materials used. Some of the closed camps were watered during the summer.

By moving rocks, logs and brush into the sites, efforts were made to prevent further use by campers. The area was mulched with available organic material such as decomposing logs and a sign "NO CAMPING—PLANT RESTORATION" was placed in the area. A map of the area was made showing the locations of all plots and nurse logs as well as reference marks such as trails and natural vegetation. An announcement explaining the work was placed on the trailhead bulletin board.

RESULTS

Seven sites were revegetated during the summer of 1976. They were checked two months later, and most of the plants survived at least during that period. In 1977, Ellman, another SCA, had the task of checking the work done by Schubert the year before. She used a different method of evaluating the plots than that used originally, but her conclusions nevertheless have some validity.

In general she felt that there were problems in transplanting. Root systems were damaged, soil was too compacted, little water was available during the hot, dry summer months and plants were not matched for sun or shade types. Plants that did well at most of the sites were Cornus canadensis, Clintonia uniflora and Linnaea borealis. There were mixed results with Vaccinium sp. and conifer seedlings. All of the nurse logs
were successful.

To improve further planting success she recommended transplanting with plugs of vegetation about 25 cm on a side in much the same way as the Millers had done in the subalpine areas. She also recommended continued use of nurse logs, especially in areas with soil problems such as in old fire rings. Since continued camping in the revegetated areas proved to be a problem, she suggested scattering brush and rocks in the sites and placing "No Camping" signs in all sites to discourage would-be campers.

SUGGESTED TECHNIQUES

Two full time SCA's, Calder and Sarrantonio, were involved in our 1978 revegetation efforts. Their job was to evaluate the work of Schubert and Ellman and to continue with revegation on their own. From this evaluation, they developed a methodology for revegetation in the Forest Zone.

EXAMINING THE AREA

The area should be examined to determine zone type, understory and overstory (shrubs, trees, herbaceous plants); natural succession patterns (Franklin and Dyrness 1973); and an inventory of plants, where they grow and their interrelationships.

Information on the denuded area should include soil conditions, that is, moisture (rainfall retention), compaction, horizons, (litter, organic layers, mineral layers), pH level, and erosion and drainage factors; soil components, that is, silt, clay, rock content; sunlight and shade conditions; data as to which plants have survived or pioneered; native seedling cover; nearby water sources; and abundant sources of transplants. In addition, it should be determined whether the area is still being used and how heavy the impact is; and which plants would transplant well, remembering that a section of soil can differ greatly from its neighbors, i.e., one area might be dry and devoid of nutrients while another might be less impacted and therefore much better for revegetation purposes.

DEVELOPING A REVEGETATION PLAN

Based on this information a revegetation plan can be developed. At this point it is crucial to determine whether to begin transplanting or to treat the soil first. Plants may be transplanted correctly and carefully but may perish if the soil is particularly poor. Once the soil is ready, transplantation can begin. The procedure is outlined in detail.

Day before transplantation:

1. Water area thoroughly.
2. Ideally, water plants to be transplanted.
3. If surviving plants and tree seedlings will not be disturbed, cultivate in order to aerate soil and incorporate richer organic layer into nutrient-lacking mineral layer.

Day of transplantation:

1. Notice weather conditions. Cool, cloudy or rainy weather is best for transplanting. If air temperature is intense, transplant in late afternoon or early evening and preferably when the area is shaded. If it is hot and dry, plants may go into shock.
2. If the area is to be used for experimental purposes also, take a photograph before and after revegetation so that progress can be monitored.
3. For each transplant, dig a hole that is capable of supporting a root biomass; leave the removed soil in recognizable horizontal layers of litter, organic, and mineral material, so that they can be replaced in the proper order.
4. Space these holes no less than .5 m apart. Compacted soil makes spreading next to impossible; help the plants out a bit. Also, the placement of transplants determines whether or not human impact will continue.
5. Remove human rubbish from soil and pack it out. Do not bury it, as it will continue to pose a problem for soil restoration.
6. Water the holes and allow enough time to pass for adequate soaking of the soil.
7. Cultivate the area around each hole to loosen the soil so that root systems can spread and moisture can seep into adjacent soils as well.
8. In gathering transplants from the surrounding area, draw from a large area so as not to denude one area. Gather only small plants. If they are large, root systems are too extensive to be dug up without being amputated. Try getting as many vegetative reproducers, such as...
Linnea borealis and Rubus pedatus, as possible.

Do not transplant large saplings or woody shrubs. Their success record has been low at best. Anything under 5 inches or 12 cm has a relatively good chance for survival, providing that it is transplanted with its own soil and mycorrhizal components. Do not remove moss from trees, logs or rocks for transplanting because it cannot survive without its own habitat conditions. When transplanting nurse logs submerge sections of the logs halfway into shallow troughs, with soil cultivated at least 30 cm in all directions in order to allow aeration and water percolation to occur. When transplanting sections of moss from the forest floors, make sure that the transplant hole is well filled with mosses' native soil. Usually, moss when transplanted in this manner, is used as a carpeting to support herbaceous plants and tree seedlings while they take hold in their new habitat.

Transplant relatively large sections of turf (.5 by .33 meters is ideal). This will insure adequate room for the roots and fibrous hairs that are the plant's water absorbers. Turf can be rolled up like carpeting and carried in plastic bags.

Do not transplant moisture-loving plants into dry soils of impacted areas. Stick with tough and strong species from drier habitats, ones that are known to survive in similar conditions. Dig up plants carefully by pointing the shovel straight down rather than inward through the plant's root system. Remove the plug by lifting up with the shovel; do not pull the plants as they will become bruised or broken in the process. Make sure to get plenty of the nutrient-rich soil underneath; this is what is lacking on the impacted sites. Frequently, plants to be transplanted will have large root systems of other species directly beneath them. A sharp rap with the shovel may cause these to crack. Nurse logs, too, may be broken with the blade of a shovel, and moss may be removed from logs in the same manner. 

Do not transplant scraggly or fragile-looking plants. Transplant plants in sturdy garbage bags or tarp slings. Do not pile them on top of each other because plants can be damaged easily and must be strong when transplanted to survive the shock of a new environment.

9. Cover resulting scars in the forest with debris and mulching in order to help these areas recover also.

10. Do not dig up more plants than can possibly be transplanted immediately. Do not leave dug-up plants sitting in the sun for any length of time. If they must sit for a while, cover them or at least cover their roots with plastic or dirt.

In transplanting, water transplant holes again with a weak solution of root stimulator (strong solutions will tend to burn plant roots). Transplant the plant and its accompanying soil, but try not to double the roots over upon themselves.

CONCLUSIONS

In the past three summers, revegetation in the forest zone of North Cascades has proven to be feasible and successful in the majority of cases. Though still hampered by numerous problems, our 1978 evaluations demonstrate that, with some effort, difficulties can be overcome.

During the hot dry summer months of 1979, two or three people will do a survey of the revegetation needs of the park. A comprehensive plan will then be written. It's suggested that anyone thinking about revegetation do this first. A program for each site is essential for a smooth operation of a revegetation program.

The plan will include the amount of work each area needs, a general description of the site, a plant inventory, what time of year the area can be reached and the best time for revegetation.

With such a plan, four or five months of work could be planned well in advance, saving time and making more headway.

The one big problem is visitor education. How can we get our message across? Next summer at our permit station we will have a display of our revegetation efforts and a mock Minimum Impact Camp. It will demonstrate how to camp with little or no impact on the environment. Our Backcountry Techs will have more training in revegetation techniques and how to teach Minimum Impact Camping to the visitors. We will be publishing a self-guiding nature trail booklet explaining our revegetation efforts and developing a better sign for the revegetated site.

With these efforts I think we will see
much more understanding from the public and more headway in our efforts to heal some very old scars.

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SIX YEARS OF SITE RESTORATION AT LYMAN LAKE

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ABSTRACT--Campsites and trails established in the Lyman Lake area for early mining continued to be used by recreationists. In 1973 Forest Service Managers started rehabilitating the area by influencing public behavior, removing campsite facilities and beginning revegetation efforts. These actions were successful in increasing plant cover on impacted sites, and in 1978 the plant response to the various revegetation treatments was documented. Seedbed preparation techniques had proven most successful in providing new plant cover. Luetkea pectinata and Polygonum bistortoides were the most important contributing species.

INTRODUCTION

Although the 1964 Wilderness Act defined how classified wilderness areas were to be managed, it left the interpretation of "untrammeled by man" to field managers. This paper is a case history of restoration efforts at Lyman Lake and is a first-hand account of how Forest Service employees wrestled with the questions of "What is impact?", "How much can be tolerated?" and "What can be done to reverse it?".

SITE DESCRIPTION

The Lyman Lake/Cloudy Pass area is located in the North Cascade mountains of Washington within Glacier Peak Wilderness Area and is 11 miles northeast of Glacier Peak, 8 miles west of Holden Village, and 7 miles east of Image Lake. The elevation ranges from 1,676 m at Lyman Lake to 1,931 m at Cloudy Pass.

The sandy loam soil surrounding the area (McColley 1976) is porous, light in weight, low in fertility, is highly susceptible to both wind and water erosion, and has a generally low water holding capacity, but due to the porosity of ash in the soil, the water holding capacity may be somewhat higher in places. It also ranges from frigid to cryic (colder than frigid) and varies in depth from 180 cm to only a few centimeters.

The area averages 275 cm of precipitation per year, mostly in the form of snow accumulating between November and April. In a normal season snow pack recedes to the point of making the area usable by July 15th and is the greatest deterrent to early recreational use.

The vegetation at Lyman Lake is transitional from a mountain hemlock subalpine forest to a sedge subalpine meadow. Cloudy Pass is strictly subalpine meadow of low herbaceous and heather plant communities (Franklin and Dyrness 1973).
HISTORY

The Railroad Creek Trail to Lyman Lake was built in the early 1900s and used by miners. From 1937 to 1957, 600 people resided at Holden Village, the largest of the mining operations. During the Holden mining days, groups as large as 50 people and 70 horses traveled up the trail some 13 km (8 miles) from Holden Village around Lyman Lake.

After 1960, horse use declined, but hiker travel increased dramatically. Although the impacts in terms of type of user lessened, the hikers gravitated to the already denuded areas around Lyman Lake. Users have included not only Holden visitors, but also outfitter-guides, Boy Scouts, and commercial groups, such as National Outdoor Leadership School and Northwest Outward Bound.

THE MANAGEMENT PROBLEM

When the Wilderness Act was passed in 1964, tent trenching, horse tethering, and continuous use of fragile sites at Lyman Lake were still considered as acceptable practices, and tables, fireplaces and willow toilets remained as convenient attractions to users.

The first step taken to reduce soil and vegetation loss was the relocation of the Cloudy Pass trail which had grades up to 30%. Unfortunately the only provision made to restore the abandoned trail was to block off the entrances with logs. Users continued using the old trail during the early season when snow still covered the new trail.

In the early 1970s, wilderness rangers at Lyman Lake began to be concerned about increasing devegetation and erosion. Supervisors, however, still felt uneasy about introducing restrictions on use in an area to be managed as Wilderness. Lyman Lake continued receiving heavy use until a wilderness ranger’s documentation in the early 1970s clearly demonstrated the continuing loss of plant cover and soil. In 1973 an action plan was developed and implemented. It called for a program of public information, education and enforcement. Campsites were removed or relocated and revegetation work was started.

Since erosion and plant loss was greatest within 60 meters of the lakeshore, camping was prohibited and all tables and rock rings were removed. Areas completely devoid of vegetation were spaded, transplanted, and fenced with stakes and twine. The wilderness ranger, portal guards, and receptionists were trained to make contact with the public and explain the what, where, and why of the program. In addition, we placed signs at alternate campsites in the more impactresistant forest to attract people before they got to the more fragile sites around the lake.

REVEGETATION TECHNIQUES AND RESULTS

Lyman Lake

Impacted sites around the lakeshore are under the influence of a coniferous canopy, either on the edges of clearings and meadows or in tree islands. Therefore, the results are best described as a plant response in the margin between forest and meadow. The lake receives its heaviest use during periods of bad weather when campers are seeking sheltered campsites, scenery and exposure to the sun.

Three years after spading abandoned camps and trails to a depth of 20 cm and leaving the seeding to mother nature, native species had established themselves in the spaded areas in between transplanted plugs. Frequency counts identified partridge foot (Luetkea pectinata Kuntze), small winged sedge (Carex microptera Mackenzie) and American bistort (Polygonum bistortoides Pursh) as the most prominent invaders. However, on sites with heavy shade the response was poor, and a Vaccinium species was the only significant contributor. This summer of 1978 we observed the soil compaction in one campsite to be 17.5 cm deep, suggesting that the 20 cm spading treatment was adequate.

The transplants at Lyman Lake were done in conjunction with spading the entire site. Most of the plugs planted since 1973 have survived and show vigorous plant growth above the plug but are not yet spreading beyond. In many cases the species invading the spaded area are different from those on the plugs, indicating that the transplants are not serving as a seed source or spreading vegetatively. To some extent the failure of the plugs to contribute to further revegetation may be due to their transplantation from a sunny meadow into a partially shaded forest margin.

In 1978 we mulched with rotten log material on a limited basis. Shortly after-
wards, Phil McColley, Soil Scientist for Wenatchee National Forest, came up to Lyman Lake and found very cool soil temperatures in the subalpine forest margin. The August morning soil surface temperatures were 9°C, at a depth of 50 cm below the surface the temperatures were 6°C. McColley questioned the use of organic mulches, which in his opinion acted as an insulator, keeping soils cool and slowing plant growth. He also pointed out that putting woody organic matter on sites would raise the carbon-nitrogen ratio and might immobilize available nitrogen.

Cloudy Pass

Two different treatments were applied to the lower trail and steeper upper trail at Cloudy Pass. Early revegetation efforts on the lower trail involved a ground preparation of spading to a depth of 20 cm and the occasional addition of brush to impede travel, alleviate visual impacts of ruts, act as sediment traps and provide root runs for invading plants. Three years after treatment the plant response was fair where the brush was located. An estimated 30% to 50% of the ground was covered by vegetation. Relative abundance ratings showed that American bistort and woodrush (Luzula spp.) were the most important contributors coming up through the branches. Partridge foot was also a significant contributor, but only on the side walls of the deepest ruts where nothing else was growing.

In 1975 we tried seeding with western anemone (Anemone occidentalis, Wats) in a spaded soil, but it failed completely. Nor did we find it invading other spaded areas, even though there is a plentiful natural seed source. This suggests that it does not favor disrupted sites.

In the summer of 1977 the upper section of the abandoned Cloudy Pass trail was re-spaded to a depth of 20 cm and jute netting was installed. The netting is lawn green in color, but quickly fades to light green and will decay within 10 to 15 years, during which time it helps to prevent soil erosion. One year after treatment the results are encouraging. Partridge foot, American bistort, and alpine speedwell (Veronica wormskjoldii, Roem and Schult) are the most numerous species coming up through the jute netting.

The transplants in both upper and lower Cloudy Pass trail have survived well -- perhaps 80% to 90% survival -- though a few near the top of the pass were killed by frost heaving. As was the case at Lyman Lake, there was vigorous growth on the plug, but no growth spread beyond the plug, and there is no contribution to seeding. The plugs were taken from a sheltered residual microhabitat and moved into a more exposed rawmark habitat (Franklin and Dyrness 1973). Soil Scientist Phil McColley observed the soil compaction on the trail by digging a pit and looking for the platy soil structure indicative of soil compaction. He found it to be 35 cm deep. The treatment of spading the top 20 cm in the area around transplants may not have been adequate to allow root penetration by the transplants.

In the summer of 1978 we started work on the trail from Cloudy Pass and going down the west side to Agnes Creek. The work involved rehabilitating 36 m² of old trail. At one end of the trail 18 m² were transplanted, mulched, and brush was placed in the trail.

The total cost for rehabilitating 36 m² of old trail was $315 in 1978.

Estimated Cost for Revegetating 36 m² of Abandoned Trail:

<table>
<thead>
<tr>
<th>Item</th>
<th>Cost</th>
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</thead>
<tbody>
<tr>
<td>Roll of jute netting</td>
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<tr>
<td>Labor to cut netting usable width for trails</td>
<td>$20.00</td>
</tr>
<tr>
<td>Horse packing costs:</td>
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<tr>
<td>Packer wages (7 hours)</td>
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<tr>
<td>Animal maintenance (project share of annual</td>
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<td>cost to maintain stock)</td>
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<tr>
<td>Labor (28 hours)</td>
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</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>$315.00</strong></td>
</tr>
</tbody>
</table>

Conclusion

The deterioration of Lyman Lake was first recognized by a wilderness ranger who was stationed at the Lake during three summers. His perseverance and year-to-year photo documentation of site degradation convinced those with authority to institute regulations and a restoration program.
ACKNOWLEDGMENTS

The authors express their very special appreciation to Jud Wiebe, who was the Lyman Lake Ranger in 1975 and has been the Wilderness and Backcountry Supervisor of the Chelan District since 1975. His efforts to photograph, label, date, and store slides of Lyman Lake revegetation made it possible to recreate what revegetation techniques were applied and when.

REFERENCES CITED


Wind-shaped Engelmann spruce at timberline
ABSTRACT--Significant modifications of plant-community composition and loss of vegetation due to long-term grazing and recreation use in the Image Lake basin have been recorded. Management efforts beginning in the late sixties and continuing to the present have been aimed at reducing use and at reestablishing a natural appearance in the lake basin. Transplanting native materials and spading compacted soils have worked well to initiate the long recuperative process.

INTRODUCTION

Image Lake is located in a small basin on Miner's Ridge sixteen miles by trail into the west side of the Glacier Peak Wilderness in Washington. The area has been of interest for many years. A significant east-west Indian trail was located nearby; it later provided access for sheepherders and miners who moved into the area in the early 1900s. Recreationists came somewhat later, but when they did, it was in great numbers.

A shelter was constructed at the outlet of Image Lake by a volunteer group in 1951. As word of the beauty of the area spread, more people visited the lake, including many large backpacking and horse groups. Other facilities including hitchrails, signs, and toilets were installed to localize impacts from increasing use. Recreation use here reached a peak of about 2,000 camper-nights annually in the early 1970s. By this time an extensive trail system and a great many denuded campsites had developed around the lake.

THORNBURGH'S RESEARCH

The impact of recreation on vegetation and soils was initially surveyed by Dr. Dale Thornburgh and incorporated into a Master's thesis in 1962. Twenty-five permanent transect plots were located in the lake basin for later evaluation. These transects were restudied in 1966, and in 1971 they were again measured and a more complete vegetation survey of the lake basin was completed.

Thornburgh described the Image Lake basin 1,828 m (6,000 ft.) as part of the Mt. Baker-Subalpine Zone and listed 7 plant associations.

1. Subalpine fir type. This plant type occurs in clumps of Abies lasiocarpa on the outer edges of benches, on convex slopes and on mounds or small spur ridges throughout the basin. Soils are well drained and free of snow early.

2. Phylloclodeo-Vaccinium type. This plant type is characterized by dominants Phylloclodeo empetrifomes and Vaccinium deliciosum and occurs in the same microsites as the subalpine fir-type. It is a successional stage which will be slowly taken over by subalpine fir.
3. Phyllodoce-Cassiope type. This type is dominated by *Phyllodoce empetriformis* and *Cassiope mertensiana* and is found on well-drained soils on convex slopes and small hills or mounds. The dominance of these two species tends to retard the growth of other plants by creation of acidic and nutrient-deficient soil conditions. This type is very sensitive to recreational impacts.

4. Vaccinium deliciosum type. This type is dominated by *Vaccinium deliciosum* but also contains a rich mixture of showy flowering herbs; it occupies steep, well-drained slopes around the lake basin.

5. Herb-dominated meadow communities. Lumped in this type are a number of herb or grass dominated communities. The herb-rich communities occur on moderately drained slopes, while the grass and sedge communities occupy poorly drained sites and/or those which experience late snow melt.

6. Antennaria lanata-type. This herb rich community dominated by *Antennaria lanata* is classed separately because the species here indicates a recovery from severe recreation or grazing impacts.

7. Wet-sedge type. This sedge meadow type occurs in perennially wet depressions.

Thornburgh's work concludes that the most obvious effects of man's use of the basin for recreation and grazing are the loss of vegetation where use concentration occurs and a change in the character and composition of plant communities. Management efforts prior to 1971 had allowed some areas to begin a recovery; however, increasing recreation use was causing damage in others.

Thornburgh recommended *Polygonum bistortoides* for rehabilitation work. His research also indicated that certain species were resistant while others were susceptible to impacts, as follows.

Resistant species included *Antennaria lanata* (Pussytoes), *Aster foliaceus* (Aster), *Potentilla flabellifolia* (Fanleaf cinquefoil), *Argrostis idahoensis* (Idaho redtop), *Deschampsia atropurpurea* (Mountain hairgrass), and *Luetkea pectinata* (Alaska spirea).

Susceptible species included *Phyllodoce empetriformis* (Red mountainheath), *Vaccinium deliciosum* (Delicious blueberry), *Valeriana sitchensis* (Sitka valerian), *Phlox diffusa* (Spreading phlox), and *Lupinus arcticus* (Alpine lupine).

**MANAGEMENT ACTION**

Sparse documentation of early management actions provides only a general picture of the actions taken and weak evaluation of their effectiveness.

Sheep grazing on Miner's Ridge was terminated in 1940. Also, in 1963 a trail was constructed around the lake in the upper basin to help draw use back away from the lake. Previously the main trail had been through the basin, across the lake's lower end -- an area of limited flat space and the area receiving the most concentrated recreation use.

Recreation management through the 60s could be described as anthropocentric. The approach was oriented at concentrating use by addition of facilities for user convenience. These facilities included hitching rails, trails, toilets, and a shelter.

Several factors helped stimulate a change in management to a more biocentric approach. These factors were (1) passage of the 1964 Wilderness Act with subsequent policy development, (2) Forest Service interaction with users, and (3) Thornburg's work. Management objectives in recent years have focused on reestablishing a natural appearance in the lake basin by lessening obvious signs of human influence. To accomplish this objective the Forest Service's efforts have been directed toward (1) changing recreation use patterns and (2) utilizing various techniques to reestablish native vegetation.

The more important management techniques employed at Image Lake are summarized below. Evaluation of a specific technique is difficult since many techniques were employed simultaneously.

**Reseeding**

Prior to 1971 the seeds of *Anemone occidentalis* were collected and sown in denuded areas. Commercial mixtures of grass seed were also tried. The soil in treated areas was spaded. Corms of *Erythronium grandiflorum* were also transplanted into denuded areas. Several hundred pounds of bark were spread to a depth of 1 to 2 inches around the shelter and used as a mulch over seeded ground.
Evaluation. None of these efforts met with noticeable success. Seeds or corms did not take. The bark dried and was carried away by wind and foot traffic (despite string fences) and by next season little remained.

Visitor Contact

Prior to 1972 a wilderness ranger stationed at Image Lake was the only Forest Service contact with visitors. The objective of visitor contact was to protect the shoreline areas and to move campers away from the lake shore. There was also an effort to channel use on the lake's lower end onto paths and limit camping to one party in the shelter at a time.

Evaluation. Users moved back into the subalpine fir clumps and away from the lake-shore. They frequently moved into areas containing the Phyllodoce Vaccinium plant community which was more sensitive to recreation impacts than the lakeshore plant communities. The shelter area continued to be unmanageable.

Plug Transplantation

After 1971 the primary revegetation technique used was transplanting plugs of herbaceous vegetation from an out-of-the-way spot into a denuded area. Plugs were generally about 20 cm square and were set into the ground slightly below the surface. Transplanting began as soon as the snow melted and ended about mid-summer. An attempt was made to water the plugs for a period after transplanting.

In areas of completely denuded soil the whole site was spaded before transplanting. Compacted soil was usually not turned over but just loosened so as to reduce compaction and a rough surface to catch seeds.

The technique used involved the use of two washbasins. The transplant was dug and placed in one. Soil from a hole to receive the transplant was removed and placed in the second basin and was then used to fill the transplant's original site. Most recently transplant material has been collected entirely from spots where it has sloughed off onto trails and would be removed with normal trail maintenance.

Evaluation. Transplanting plugs of native material was quite successful with little mortality of transplanted material. Simple spading of the soil yielded good quantities of strong plants in 2 to 3 years. Costs for this treatment are obviously lower than for transplanting. Exclusion of users from the treated sites contributed to the plant survival success. Campsites and user-built trails in sedge-grass and Vaccinium which were only lightly impacted recovered fairly well in about 5 years.

The amount of time required for vegetation to reestablish itself on more heavily impacted sites appears to be in the neighborhood of 20 years. Work with campsites and fire rings has been satisfactory; well-entrenched trails are more difficult to rehabilitate.

Areas from which large numbers of plugs were removed looked raw for two or three years.

Efforts to Change Recreation Use

A number of techniques were employed to change recreation use patterns in the lake basin.

Wilderness permits were required in 1972 of all overnight visitors in the Glacier Peak Wilderness. This permitted contact with users before they got to the lake to encourage use of alternative areas and minimum impact techniques. Visitors have been very cooperative when informed of the rehabilitation project and restrictions they would encounter. By 1974 backpackers were asked to camp only at sites below the lake. Livestock users were asked to camp at Lady Camp about 1 mile east of Image Lake and to keep horses on the upper basin trail. Users were also asked not to build fires anywhere in the lake basin. In 1975 regulations replaced voluntary requests for camping and fire restrictions used in 1974. Maps showing alternative camp areas were given to users when they received a permit. The wilderness ranger's camp at the lake was abandoned and the ranger camped at the Miner's Ridge Lookout 1 mile west.

Signs and string fences were used to encourage users to stay out of the areas being rehabilitated. Handwritten notes from the wilderness ranger were posted on trailhead bulletin boards and sign boards at entrances to the basin. These notices informed the public of the problem and explained rehabilitation. The notes also encouraged user cooperation.

In 1975 wilderness rangers began keeping
maps and notes of rehabilitation so sites could be evaluated later.

**Evaluation.** Management restrictions progressed from voluntary to mandatory measures. Use in the basin dropped from an estimated 2,000 camper nights (backpackers and livestock users) per year in the early 1970's to approximately 1,000 backpacker nights per year in 1975-77. Almost all overnight horse use now occurs at Lady Camp, one mile east of the lake. It has been possible to reduce overnight use in the lake basin by dispersing use and to make a good start on reestablishing native vegetation in the most visible areas. A trade-off that has been considered acceptable is the increased loss of vegetation at the Lady Camp horse camp and the backpackers' camp below the lake basin. By 1977 vegetation at these two camps had stabilized. Efforts have been made to involve users in decision making and public acceptance of these management actions has been outstanding. Volunteers, especially children camping at the lake with parents, have been very helpful with watering and transplanting work, but wilderness ranger supervision was necessary.

**CONCLUSIONS**

Transplanting and spading techniques worked well when combined with efforts to exclude hikers from treated areas. Costs for rehabilitation would be very high if it were not for the large amount of volunteer labor contributed both by wilderness rangers and area visitors. Following basic scientific methods for rehabilitation would have allowed for detailed evaluation of work and greater efficiency. Employment of wilderness rangers skilled in horticultural practices and/or botany was very helpful. Public cooperation with such projects is essential.

**DISCUSSION**

Comment: Bernie, you have had much success at Image Lake. What has happened to the areas where you have diverted campers? Have they caused a consequential degradation in the vegetation?

Smith: The Image Lake basin receives half the use now that it did in the early 1970s. Wilderness permit data for the last 3 years shows a relatively stable use level of about 1,000 camper nights a year. We were able to disperse use and rehabilitate the areas of major concern. We've also made some trade-offs. The horse camp at Lady Camp is probably more heavily impacted than it was previously, and also the backpacker camp shows heavier use than it did previously. We've shifted the use to areas where impacts are insignificant or at least more acceptable than in the lake basin.

**REFERENCES CITED**


ORV SITE RESTORATIONS

Thomas J. Spolar
Resource Assistant
Wenatchee National Forest
USDA Forest Service
Ellensburg, Washington

ABSTRACT--Resource damage from ORV use can be minimized through good facility design and proper location with full involvement of the user. Rehabilitation efforts must involve management objectives, alternate routes, signing and user contacts.

Off-road-vehicle (ORV) use, like other recreational uses, often leads to the need for site rehabilitation. Successful rehabilitation rests on the manager's knowledge of good facility design and the experience offered to and/or anticipated by the recreationist.

Many ORV routes are converted trails and stock driveways designed and built for low-volume use by foot and horse travelers. Their location did not include consideration of maximum snow-free periods or maintenance costs. Meadows and grasslands are frequent destinations, and usually the trail traverses rather than skirts them.

Most trails are not designed with proper grades, tread width, drainage and switchbacks. All of these affect user experience. Excessive grades magnify drainage problems. Poorly designed and constructed switchbacks can lead to cutting and in some cases, hill-climbing. Narrow tread width can pose safety problems, particularly on steep side slopes. Good redesign, particularly of switchbacks, can ward off many of the problems associated with our inherited trail systems.

Opportunities for all age and skill levels are needed. A major problem encountered adjacent to campsites is hillclimbing by unsupervised youngsters. What does a youngster do with a bike when he lacks the capability of handling a trail or is not asked to participate with adults? He finds an alternate source of enjoyment, usually in hillclimbing in the vicinity of the campsite. Rehabilitation of these impacted areas starts with informing the user of the problems and providing acceptable alternatives for bike riding. Not until education is successful can the actual restoration begin.

My experience shows that grade and tread rehabilitation is best accomplished by filling the old tread with plenty of brush. This slows down runoff and provides microsites suitable for the establishment of native vegetation or seeding.

Four-wheel-drive routes can be water-barred and seeded. On some sites, if accessible, a road grader may be used to scarify the tracks. They may then be water-barred by hand and left for adjoining native vegetation to invade. I plan for three to five years for satisfactory site recovery.

Land-management objectives must be reviewed and analyzed to determine the type of rehabilitation to be undertaken. We have had success revegetating sites with proven domestic grasses and native shrubs, according to soil types and aspect. Backcountry and high-elevation sites or any management zone with a high visual constraint are treated to retain the native vegetation if possible.

Vegetation change from four-wheel-drive vehicles is most severe on wet meadows, and site protection is the most efficient healer. Dry meadows and grasslands require scarification, soil replacement and protection from use for long periods of time. These sites can be protected with brush, fallen trees and logs. Stream crossings used by four-wheel-drive vehicles can be protected by hardening such as corduroy built from logs or with available river rock.

The ability of the outdoor-recreation-vehicle user to get around is, in general, limited by vegetation and topography. Timely maintenance is a must. The user's ingenuity gets him through many tight spots, but if the track or trail is poor, he may deviate from
the constructed route, causing additional damage to vegetation and soil.

Involving the user in site rehabilitation is of major importance. I use signing and personal contacts to identify and describe projects and to inform the user of alternatives. I am most successful getting user support and understanding by assuming that the vehicle user has a basic purpose—to enjoy his outing—not to destroy the forest.

DISCUSSION

Comment: What's the annual precipitation in the areas where you did that rehabilitation?

Spolar: We're at an advantage over what you're trying to do in the high country. Generally, we're working in better soil types and higher precipitation zones. The precipitation is about 100 cm (40 inches).

Question: Is most of that precipitation winter snowfall, or do you get summer rains?

Spolar: It's mostly winter snowfall.

Question: Are you systematically eliminating all of your jump sites or your hill-climb sites?

Spolar: No, the primary reason for closing hill-climb sites is visual considerations such as visibility from campsites. Hill-climb sites are acceptable on established hardened sites where there is no soil runoff into streams. Our trail program is intended to provide something for the total family with a mix of skill levels.

Question: Do you think that building steep sections such as sections with a 40% or 50% grade would provide enough challenge to allow you to eliminate hill-climbing areas?

Spolar: No, I think it's the tree roots, rocks, and deep tread where your motorbike pegs are dragging that provide challenge. Without those, little skill is needed because most of the high horsepower bikes that are out would have little difficulty on a 40 to 50% grade. We're trying to leave a few of these challenging situations on some of our ridge-top trails, particularly where erosion is not a factor, that is, where it is rocky, or very stable soil. If we find this kind of situation, we provide an alternate route for those who do not want the challenge.
ABSTRACT--A review of principles and techniques found successful and unsuccessful in resource restoration work in a subalpine environment at Mount Rainier National Park, Washington is presented. Specific references are made for controlling major erosion problems, filling erosion scars, establishing vegetation, post-restoration site protection, and monitoring results. A basic problem-solving format is included.

INTRODUCTION

The Sunrise Developed Area is located in the northeast corner of Mount Rainier National Park, Washington. The ranger station, visitor center, and day lodge are located at an elevation of 1,950 m (6400 ft.) in the middle of one of the larger subalpine meadows in the park. Trail systems radiate out from these facilities into the surrounding meadow areas. Sunrise receives 8,000 to 10,000 visitors on busy summer weekends. Past National Park Service development practices and visitor use patterns have created major visual scars and erosion problems in this scenic area. There has been an active program since 1970 directed toward controlling new impact and removing the signs of past abuse. Work projects have included the removal and revegetation of roads, trails, and old building sites in subalpine and alpine frontcountry and backcountry areas. Many work sites in the frontcountry are accessible by wide trails or old roads. This has facilitated the use of ground vehicles in restoration work. The available local water system and creeks have been used to irrigate many restoration sites.

Festuca viridula, Lupinus latifolius, Anemone occidentalis, Castilleja parviflora var. oreopola, Potentilla flabellifolia, Veronica cusickii, Polygonum newberryi, Agoseris glauca var. dasycephala and Aster tedophyllous are common meadow plants. These plants tend to grow in clumps, often centered around the bunchgrass Festuca viridula. Located in the rain shadow of Mount Rainier, the Sunrise meadows show many similarities to areas east of the Cascade Mountains.

The vast preponderance of moisture comes from winter snowfall. Clear, dry periods of two to three weeks are not unusual during the summer growing season. These dry periods are interspersed with summer rainstorms and occasional snow. The dryness, coupled with 40°C soil surface temperatures and the porous pumice soil often places meadow plants under extreme moisture stress. Only deep rooted, well established individuals survive. Fall frost action is extreme. Needle ice formations 3 cm in height are common. Summer drying, fall frost action, erosion, and trampling by visitors represent the major constraints to revegetation work on disturbed sites at Sunrise.

Virtually all the impact for which restoration is scheduled can be attributed to past National Park Service development practices. Current visitor-use impacts are negligible in comparison to these past disturbances. Past concentrations of visitors in campgrounds and overnight cabins caused radiating mazes of informal trails. The cabins were removed in 1941 and the campgrounds closed in 1971, but scars remain from trails, roads, buildings, and water lines.

PRINCIPLES AND TECHNIQUES

The following format is the same used at Sunrise when analyzing and solving actual resource restoration problems. The project analysis consists of three steps. The first step is identifying the management objectives for the area, in order to establish the
purpose of the area and the levels of acceptable change. The second step is the identification of resource problems, or situations in conflict with the management objectives. The third step is the selection of a solution to the problem, based on observation, communication with persons who have dealt with similar problems, and a search of available literature. Once these steps are completed, restoration efforts can begin.

Work Techniques

Failure to apply work techniques in a logical order may result in repeated disturbance of areas that are beginning to regrow or in less-than-optimal restoration results. The following order has proved to be the most successful at Sunrise:

1. Major Erosion Control.

We have found that correction of major erosion problems must be the initial step in any restoration scheme. There will be a continual loss of the soil resource, and vegetation establishment will be minimal in actively eroding areas. The majority of our erosion problems stem from spring-melt water channeling into old trails. Standard trail maintenance practices, such as water bars and silt bars, have proved to be the most effective in these areas. Jute netting and other similar products are not successful in controlling this heavy flow of melt water. The velocity and volume of normal spring runoff is sufficient to erode the soil from underneath netting materials, leaving them suspended in mid-air. Further action is taken only when major erosion is controlled.

2. Fill Dirt Placement and Surface Modification.

Physical modification, as well as revegetation, is often necessary to restore an area to its level of functioning prior to disturbance. The filling of deeply eroded trails is the most expensive and time-consuming part of restoration work at Sunrise. Scars left unfilled attract visitor use after revegetation and remain as permanent erosion problems that require maintenance. Hundreds of yards of fill have been placed by backpacking, wheelbarrows, motorized wheelbarrows, three-wheeled Cushman scooters, small "Bobcat" type loaders, dumptrucks, and helicopters.

Ground vehicles have proved to be the most cost-effective equipment in low angle areas near roads or established trails. Many areas have been filled by moving equipment over meadows on runways of plywood or heavy cardboard. Damage is very light if this work is done in the late fall when the aerial portions of the plants are dead or dormant. Very few alternatives exist for placing fill in steep, remote sites. Backpacking has been used but is very slow and worker-associated impact is high. Helicopters can be used very effectively with special cargo nets and quick loading techniques. The average cost is $10.00 to $15.00 per yard of fill placed by helicopter on sites within the immediate Sunrise area.

Road and trail scars have been effectively removed by replacing fill material originally excavated from the hillside and used to form the roadbed. This material, when placed in the cutbank, returns the slope to its natural grade. Plants on the bank areas are removed and transplanted back onto the new, graded slope.

Contouring open areas and access points with dirt mounds has been effective in redirecting undesirable use patterns. Subtle changes have produced suprising results.

3. Establishing Vegetation.

Attempts at establishing vegetation are undertaken only after erosion is controlled and any necessary physical modifications are made. We have found it is better to wait a few years until trails can be filled, rather than hastily committing seed and transplants to areas that may remain as permanent problems.

Natural revegetation is very slow at
Sunrise, varying from 10 years on very moist sites to more than 50 on dry south slope sites. Areas that have an abundant seed source, are damp, and are receiving little present-day impact have been allowed to revegetate naturally. Also, certain sites in all plant associations are being left as controls. These areas are providing interesting information on successional patterns and time requirements for revegetation.

Transplanting. Transplanting has been extensively used since 1971. Plants were placed in wide, barren trails with the idea of stabilizing soil movement and providing additional seed sources. Also, the visual appearance of some plants in a trail seems to help discourage visitor use. While survival of the transplanted grass clumps and associated forbs has been excellent, vegetative spread and seedling establishment has been slow. The mature clumps transplanted seem to have attained their size potential just as in the adjacent natural meadow. The current practice is to divide a large clump into several eight-to-ten centimeters divisions in the fall. The survival rate of even the unwatered divisions has been excellent. These divisions are expected eventually to expand into large, mature clumps. By using this technique, a greater area can be covered with fewer plants taken from the surrounding meadow. Pruning, rooting hormones, shading, and watering have all been tried while transplanting. The majority of the plant species show excellent survival if they are watered when first planted. Plants moved during dormant periods in the late fall need no watering. It is hoped that seedling survival in the bare areas between transplants can be improved by mulch treatments.

Shrub and tree transplants of less than one meter have shown good survival. Abies lasiocarpa and Sorbus sitchensis are the species used to date. They have been placed primarily at trailheads as barricades and in picnic and camping areas for screening. Studies with early-season root pruning and fall transplanting are being done to see if larger plants can be moved successfully. Experiments with stem and root cuttings are being conducted with Sorbus. The extremely poor seed germination has led to a search for other means of propagation.

Native seeding. Native seed has been used in revegetation work at Sunrise since 1970. Seedling survival was poor, but seeded areas show more revegetation than unseeded areas. Currently, emphasis is being placed on using seed from species that appear to invade disturbed sites naturally. Plants with large tap roots seem to be the best invaders. The native grass, Festuca viridula, seems to invade only the stable island created by the deep-rooted pioneers.

Most seed used to date has been picked by hand. Thirty mandays were required to pick and plant seed for 2,600 square meters of trail. Vacuum cleaners have been successfully used to pick seed of members of the Compositae. A lawn mower with exhaust bag will be tried next year.

It is very important early in the season to identify high-concentration areas for each species to be picked. Also, flowering times within a species vary from area to area. A longer period of picking for a particular species is possible with a knowledge of the patterns of this differential ripening. We have only picked seed that is dispersing naturally from the plants. Some test samples have been taken of immature seed, but viability information is not available yet. Most seed has been sown directly into the field areas in late fall. Some seed has been used in nursery beds and a greenhouse with the idea of transplanting two-year old plants into the field. Several native species have been successfully grown from seed (Table 1).

Small-scale experimentation has been done with Chewings Red Fescue (Festuca rubra var. commutata) as a cover crop to reduce erosion, soil temperatures, and frost action, and to increase the organic matter of disturbed areas. However, no invasion by native species has been observed in areas that were seeded as much as four years ago, while artificial mulches have yielded more favorable results. Many bare areas of similar moisture levels show better revegetation by native species when Festuca is not planted, and accordingly its use has been discontinued at Sunrise.

Mulches. A variety of mulches and common erosion-control products have been tried in an attempt to moderate the extreme dryness, frost action, and other environmental factors responsible for seedling mortality. Jute netting has been used for eight years. It does a fair job of controlling surface erosion, but it provides little as a mulch. The shifting of the coarse netting tends to uproot small seedlings. Hydromulch material has been applied in dry form. However, it mats and clumps to such a degree when applied in this form that only grasses are able to
push through it. Straw mulch shows excellent results, but finding a straw source free from exotic seed is a major problem.

The best alternative tried to date is excelsior matting. Native seedling survival is high during periods of dryness and intense frost action. Some initial problem with wind disturbance was encountered, but more extensive staking seems to have solved this problem. In 1978, 2,600 square meters of excelsior was used to cover seeded areas on a variety of slopes and plant associations.

Post-Restoration Site Protection

Some form of protection is necessary for those areas that may receive use during the period of vegetation recovery. A great deal of new impact can be prevented by redirecting use. The most effective techniques for a particular situation can be discovered by repeated observation of visitor behavior and by asking questions. Areas can be blocked with logs, rocks, limbs, and dirt mounds, islands, or a few trees or shrubs can be transplanted to disguise a trailhead or view-

<table>
<thead>
<tr>
<th>Table 1. Germination Success¹</th>
<th>Greenhouse²</th>
<th>Field Seeding³</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Agoseris glauca var. dasycephala</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>2. Anemone occidentalis</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>3. Antennaria lanata</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>4. Arenaria formosa</td>
<td>0</td>
<td>NT</td>
</tr>
<tr>
<td>5. Aster alpigenus</td>
<td>NT</td>
<td>X</td>
</tr>
<tr>
<td>6. Carex sp.</td>
<td>X</td>
<td>NT</td>
</tr>
<tr>
<td>7. Erigeron peregrinus</td>
<td>NT</td>
<td>X</td>
</tr>
<tr>
<td>8. Eriogonum pyrolifolium</td>
<td>X</td>
<td>NT</td>
</tr>
<tr>
<td>9. Festuca viridula</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>10. Juncus drummondii</td>
<td>X</td>
<td>NT</td>
</tr>
<tr>
<td>11. Ligusticum grayii</td>
<td>0</td>
<td>NT</td>
</tr>
<tr>
<td>12. Lupinus latifolius</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>13. Polygonum newberryi</td>
<td>0</td>
<td>X</td>
</tr>
<tr>
<td>14. Potentilla flabellifolia</td>
<td>X</td>
<td>NT</td>
</tr>
<tr>
<td>15. Sitanion hystrix</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>16. Sorbus scopulina⁴</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>17. Veronica cusickii</td>
<td>X</td>
<td>NT</td>
</tr>
</tbody>
</table>

¹Key to success ratings: X = some germination, 0 = no germination, NT = not tried.
²Seed was chilled for 60 days at -1°C (30°F) prior to planting.
³Seed was planted directly in soil at sunrise in the late fall.
⁴Tests were done with non-frozen whole berries, whole berries frozen at -1°C (30°F) for 15 days, non-frozen excised seed, and excised seed frozen at -1°C (30°F) for 60 days.
point. Impact caused by visitors walking around snowbanks can be corrected by dusting a trail with dirt or even shoveling a small path through the snow. Simply correcting drainage problems will often return the use pattern from side trails back to the maintained trail.

Signs are used when these less obtrusive techniques fail. Often small signs are adequate. Directional signs may keep people from repeatedly leaving a trail for a view when maintained viewpoints are nearby. Signs first used to close trails stated only "trail closed", but better compliance was gained by briefly explaining why the trail was closed. When we realized many people didn't understand the word "restoration" this wording was changed to "recovery." It is important to provide visitors with alternatives. Signs at the head of major closed trails should give directions to the maintained trail system.

Signs serve an interpretive function, but pamphlets, nature walks, and visitor-center exhibits can convey more information, often before the visitor is confronted with a closure situation. We have found the vast majority of people are responsive to education.

Monitoring

Systematic records of techniques and dates have been kept so success can be monitored. We have used before-and-after photos, permanent photo plots, maps labeled with techniques used, and narrative reports by workers. This information has been helpful in estimating successes and failures of methods over a period of years and pointing out research needs.

SUMMARY

The major successes of the resource restoration program at Sunrise have been the correction of major erosion problems and the control of new impact. Successful methods for placing fill dirt have been developed. The main area of interest at the present time is in finding better techniques for establishing vegetation.

REFERENCES CITED


DISCUSSION

Comment: Several people seem interested in Luetkea pectinata. Why is it an especially interesting plant?

Van Horn: The rhizomatous root system easily divides into small pieces for propagation purposes. This root system accounts for its ability to spread into barren areas from the margins. It grows on a variety of sites and is fairly resistant to trampling.

Comment: Luetkea is one of our principal species. George Douglas, who has probably done more ecological work in the Cascades than anyone else, says Luetkea has wider ecological diversity than most plants found up there. It also pioneers on bare rawmark soils, and pioneer species are always good because they adapt readily to disturbed areas. Luetkea is very easy to propagate, and it spreads rapidly from planted clumps.

Comment: Do Carex species you've worked with have rhizomatous root systems?

Van Horn: Yes.

Comment: How much success have you had transplanting Lupinus sp. and Polygonum newberryi which have large tap roots?

Van Horn: Very good success when the transplants are heavily watered, pruned and treated with hormones to reduce the shock of transplanting. I suspect there is a great deal of carbohydrate storage in the large roots. These plants will survive if given some care. Also, root pruning trees and shrubs three months prior to transplanting seems to ease the shock of transplanting.

Comment: What are your thoughts on the potential of using shrubs in restoration work?

Van Horn: I think shrubs are very important. They work well for blocking or disguising the start of social trails and are useful for screening purposes in picnic areas and campgrounds. Mountain ash (Sorbus sp.) is particularly good for this purpose. The plants must be fairly large to be effective. Mature plants can be transplanted but prior root pruning is essential. Propagation from seed and cuttings is an alternative, but would be expensive for large projects. The SEAM program of the Forest Service Intermountain Region, dealing with mining rehabilitation, has been successfully propagating many shrub species.
ABSTRACT—A method to predict the resistance of vegetation to trampling is presented. The procedure is summarized as follows:

1. Classify the vegetation and assess the abundance of at least the common species.

2. Determine the resistance characteristics of each species based on selected morphological and ecological properties. In this study, I used moisture preferences, leaf-form, perennation, season of activity, and growth form.

3. Calculate the species resistance index \( (S_r) \), which is the mean of the resistance characteristics (expressed on a numerical scale) determined in Step 2.

4. Calculate the plot resistance index \( (P_r) \), which is the product of each species' cover and its resistance index, divided by the total cover. \( P_r \) thus ranges over the same numerical range as the species resistance index.

5. The community resistance index \( (C_r) \) is the mean plot resistance index of samples assigned to that community. The rank order of \( C_r \) values in an area is an estimate of community resistance to trampling.

The community resistance index was compared to estimates of resistance based on transects across trails and proved to provide reliable estimates of trampling resistance. A similar index, based on habitat characteristics, was less successful in predicting resistance. This method produces both species-specific and vegetation-specific predictions that require no destructive sampling and which can be accomplished with relatively little field effort. I conclude that the method offers an economical way to predict the impact of human treading on vegetation.

INTRODUCTION

A major realm of ecology deals with predicting the consequences of alternative perturbations or management schemes for ecosystems. The ability to predict consequences is of vital importance both to those concerned with minimizing environmental impact and to those who wish to minimize management costs. This paper deals with a method of predicting habitat resistance to stress; this method offers several advantages to land managers without sacrificing much accuracy.

There are several methods of assessing how well a community can resist impact without substantial degradation. Briefly, these methods include the analysis of soil properties (Chappel et al. 1971, Oliver et al. 1978), other aspects of the habitat (Willard and Marr 1970; Cielinski and Wagar 1970, Liddle 1975), direct experimentation (Schreiner 1975) and trail survey methods (Dale and Weaver 1974). Each of these methods has advantages and disadvantages. Analysis of soil takes much time but can give excellent results where soil characteristics
determine habitat resistance. The use of combinations of soil and other habitat properties may suffer from several drawbacks as predictor variables. Data acquisition is time-consuming and expensive. The various parameters relate to each other in complex, nonlinear ways that are not easily integrated into a single predictive model. Once a model is constructed and validated for one ecosystem, there is little to guarantee that it will be applicable in another. Direct experimentation is both costly and time-consuming. Further, even the best-controlled experiments do not accurately mimic natural use (Schreiner 1975). Trail survey methods are reliable, but must be related to the vegetation. In the absence of trails, this method is obviously of no use.

The method to be discussed was developed to satisfy the need for a generally applicable method that is easily applied, rapid and inexpensive, and has high predictive value. As applied here, the method concerns the prediction of resistance, which is the ability of vegetation to remain unchanged under a given stress or disturbance. Resilience, the ability of vegetation to recover from disturbance, is not my concern here. Vegetation may have very different resistance and resilience features. Those pursuing reclamation studies may also benefit from a consideration of this approach, if not from the details.

THE STUDY AREA

The study area is a small cirque (7.5 km²) located near Mt. Stuart in the Wenatchee Mountains, a spur of the Washington Cascades. The terrain is varied in slope, aspect, and degree of natural disturbance from rock fall and avalanche, and contains many small lakes and ponds. Elevations range between 2060 m and 2600 m.

The climate is modified maritime, but accurate records are meager. Most precipitation falls as snow between October and June. Summer rains are unpredictable but usually account for less than 10% of the annual precipitation. In years of heavy snow pack, as between 1972 and 1976, several higher elevations, north-facing ice fields remained throughout the summer.

All substrates are derived from the Mt. Stuart granodiorite, a massive igneous batholith dating from the early Tertiary period (Pratt 1958). Soils are usually coarse, porous, and not readily compacted, except in alluvial or boggy situations. Clay fractions are under 10%. Where wind erosion occurs, the surface is of coarse sand or gravel, with finer sands below the surface. Little soil is to be found on the steeper slopes. Alpine soils are primarily entisols, lacking true profiles, while forested soils are primarily cryothols (podsols).

METHODS

The Resistance Index

The development of a resistance index based on species composition is most applicable to areas that have been disturbed infrequently or in which further development is contemplated. To the extent that trails or other human disturbances exist, validation studies under local conditions can be employed. However, it is the basic assumption of this method that the species themselves contain information sufficient to judge the resistance of any given plant community.

Step 1. The vegetation under study is first clustered. The details of this step depend upon the type of vegetation, its complexity, and the time and manpower available. In my study, several other objectives were to be realized, so a detailed analysis was undertaken. In subalpine vegetation, 10 m by 20 m quadrats were arrayed over the available landscape to fully encompass the subjectively determined range of vegetation variation. Each tree was counted and its diameter at breast height determined. Total plot canopy cover was determined by vertical projection. The understory of each plot was subsampled with 10 1 m² quadrats. This study, relative cover of herbs and relative canopy cover of trees were used. Alpine plots, which lacked trees, were 10 by 10 m in size. Otherwise, the vegetation was treated as in subalpine plots. The vegetation was analyzed by a numerical clustering procedure called MINF0 (Goldstein and Grigal 1972) that produced 11 subalpine vegetation types and 10 alpine vegetation types (del Moral 1979).

Field workers could modify Step 1 in several ways. Rare species little affect the results. These species may be ignored, unless it is known that particular species have high indicator value or are among the officially recognized rare, endangered, or threatened species. Precise estimates of cover or abundance are not essential. Any standard dominance scale can be employed (Mueller-Dombois and Ellenberg 1975), though care should be exercised in using such data
in numerical methods. If the vegetation of the area is reasonably well-known, then rather than sampling vegetation, plots may be "keyed out" to the appropriate, previously determined vegetation type, in a manner analogous to that used in plant identification (see del Moral and Deardorff 1976). The time and effort for Step 1, which is the most time-consuming step, are reduced dramatically when a diagnostic vegetation key is available.

**Step 2.** The goal of this step is to assess the degree of resistance to trampling inherent in each species. I employ a five-point scale for each parameter. This procedure is adopted because 1) it is not realistic to make fine discriminations between species whose characteristics may be poorly known; 2) subsequent use of approximate cover values renders precision at this stage counter-productive; and 3) precision is not required because ultimate comparisons are relative, not absolute, and based on comparative ranks, not any absolute numerical value. The characteristics employed may be varied by the investigator, depending upon his experience, other external information, and the types of plant community characteristics for which predictions are desired. In this study, I employed the characteristics listed in Table 1. These characteristics were selected after consulting the literature (Bates 1935, Markle 1963, Wager 1964, LaPage 1967, Thornburgh 1970, Bell and Bliss 1973, Schreiner 1975, Grime 1977, Cole 1978) and reflect my personal judgment and field experience. The stem characteristics affect the entire plant's ability to resist physical abrasion. Woody plants are believed more resistant, though less resilient, than herbaceous plants. However, woody plants that break easily are less resistant than flexible, usually evergreen plants.

The moisture requirement of a plant provides an indication of habitat sensitivity and is therefore given double weight. In this study, moisture scores were assigned after a detailed species ordination study (del Moral 1979). In other cases, the habitat characterizations in Table 1 can serve as examples. Note that this scale would be quite different if habitat resilience were of direct concern. The score assigned a species may vary somewhat depending on region.

Perennation describes the location of the growing tip. The more exposed to trampling is the meristem, the less the expected resistance. This category reflects the resilience of different growth forms.

<table>
<thead>
<tr>
<th>Index Value</th>
<th>Moisture (2X)</th>
<th>Leaf-Form (2X)</th>
<th>Perennation</th>
<th>Activity</th>
<th>Growth-Form</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Wet meadow</td>
<td>Ephemeral, delicate</td>
<td>Exposed meristem</td>
<td>All year</td>
<td>Herbaceous, delicate</td>
</tr>
<tr>
<td>2</td>
<td>Moist meadow</td>
<td>Perennial mesophyll</td>
<td>Tips elevated</td>
<td>Flowers late</td>
<td>Herbaceous, sclerophyllous</td>
</tr>
<tr>
<td>3</td>
<td>Moist forest, dry meadow</td>
<td>Deciduous mesophyll</td>
<td>Basal meristem</td>
<td>Flowers early, persistent</td>
<td>Base woody, stem herbaceous, brittle</td>
</tr>
<tr>
<td>4</td>
<td>Dry forest, xeric meadow</td>
<td>Silicaceous, perennial</td>
<td>Buried</td>
<td>Late developing</td>
<td>Stem woody, flexible, leaves deciduous</td>
</tr>
<tr>
<td>5</td>
<td>Rock sites</td>
<td>Sclerophyllous</td>
<td>Above 2 m</td>
<td>Spring ephemeral</td>
<td>Stem woody, flexible, leaves evergreen</td>
</tr>
</tbody>
</table>

Table 1. Plant characteristics used to construct the species resistance index ($S_r$)
The season of main activity was used though it is probably the least-valuable parameter employed. T. Weaver (personal communication) and others concur that plants active all year run larger risks from trampling than do spring ephemerals which avoid the trampling season.

Physical resistance of leaves to abrasion and breakage is given a double weight since it appears to be the single most important morphological property. Only photosynthetic tissue was considered because other aspects of life form are included under perennation and herbaceousness.

Step 3. The scores for each parameter are combined for each species by the following formula to produce the species resistance index:

\[ S_r = \frac{n}{\sum_{i=1}^{n} r_i w_i / 7} \]

where \( S_r \) is the species resistance index, \( r_i \) is the index value for the \( i \)th parameter, \( w_i \) is the weight of the \( i \)th parameter, if any, and 7 is the constant appropriate to this case that constrains the index between 1 and 5. This index should be valid for a species within a region. However, caution should be exercised with the use of the moisture index since it is susceptible to change over geographic location. The morphological parameters should not change through the range of the species.

Step 4. The resistance indices of each species are combined with a measure of their abundance in a plot to create the plot resistance index:

\[ P_r = \frac{s}{\sum_{i=1}^{s} D_i} \frac{s}{\sum_{i=1}^{s} D_i} \]

where \( P_r \) is the plot resistance index, \( D_i \) is the dominance of the \( i \)th species, \( s_{ri} \) is the resistance of the \( i \)th species and \( s \) is the number of species. The index is bound between 1 and 5. The mean \( P_r \) of plots in a community is determined to form \( C_r \), the community resistance index. Because nonparametric statistics are applied, it is sufficient that this step results only in a rank order of communities. Small numeric differences are not meaningful. It is this ranking feature of the method that produces its robust behaviour with respect to the exclusion of rare species and with respect to the precision of dominance estimates. If vegetation samples have been keyed out, rather than described, the relative dominance or dominance index of those species comprising 90 to 95% of the dominance should be recorded.

Validation

As a check on the resistance index, community resistance was determined directly by a detailed examination of the effects of trails on vegetation. In addition, a second resistance index, using habitat data, was constructed. The two resistance indices were compared to each other and to the results of trail transects.

The parameters used in constructing the habitat resistance index are shown in Table 2. The stand resistance index is calculated as follows:

\[ E_r = \frac{m}{\sum_{i=1}^{m} w_i H_i / 12} \]

where \( E_r \) is the resistance of a sample based on \( m \) environmental properties, \( H_i \) is the index value assigned to the \( i \)th parameter, and \( w_i \) is the weight. The constant, 12, constrains the index between 1 and 5. Once \( E_r \) is calculated for each stand, the mean \( E_r \) is calculated for each community to yield \( H_r \), the resistance index based on habitat properties.

Moisture is weighted threefold because it appears to be the single most important environmental variable relating resistance to trampling.

Loss on ignition (L.O.I.) affects compressibility and is correlated with moisture. Sites with high L.O.I. have soils easily compressed, thus reducing aeration and leading to necrosis and species compositional changes.

Elevation is a crude index of the length of the growing season, in this instance an index of the period "at risk". A short growing season may enhance resistance but resilience will be curtailed.

Aspect affects both moisture and growing season. Very long protected sites are quite wet, but very dry sites will be at risk for long periods. Intermediate sites should provide a combination of sufficient moisture and relatively short growing season to maximize species resistance.

Slope is a measure of the erodability of a site. A gently sloping resistant habitat
Table 2. Characteristics used to construct the habitat resistance index ($E_r$)

<table>
<thead>
<tr>
<th>Index Value</th>
<th>Moisture (%)(3X)</th>
<th>Loss on Ignition (%)</th>
<th>Elevation (m)</th>
<th>Aspect</th>
<th>Slope (°, 2X)</th>
<th>Texture (% Clay)</th>
<th>Cover (ground layer)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Marsh</td>
<td>&gt;21</td>
<td>&lt;2165</td>
<td>NE, SW</td>
<td>&gt;25</td>
<td>&gt;20</td>
<td>&gt;50</td>
</tr>
<tr>
<td>2</td>
<td>Wet meadow</td>
<td>10.1-20</td>
<td>2165-2254</td>
<td>NNE, ENE</td>
<td>21-25</td>
<td>13.5-20</td>
<td>30-50</td>
</tr>
<tr>
<td>3</td>
<td>Dry Meadow</td>
<td>5.1-10.</td>
<td>2255-2349</td>
<td>N, E SSE, W</td>
<td>16-20</td>
<td>10.8-13.4</td>
<td>20-30</td>
</tr>
<tr>
<td>4</td>
<td>Dense forest, fell field</td>
<td>1.5-5.0</td>
<td>2350-2439</td>
<td>SE, WNW, NNW</td>
<td>11-15</td>
<td>7.8-10.7</td>
<td>10-20</td>
</tr>
<tr>
<td>5</td>
<td>Krummholz</td>
<td>&lt;1.5</td>
<td>&gt;2440</td>
<td>ESE, NW</td>
<td>&lt;10</td>
<td>&lt;7.8</td>
<td>&lt;10</td>
</tr>
</tbody>
</table>

will not erode upon disruption of soil or plant cover. Weaver (1979) experimentally demonstrated that steeper slopes are less resistant than gentle slopes.

Texture, like organic matter, is correlated with the compactability of soil. Soils with high clay fractions are more compactable and thus more susceptible to poor aeration or water logging.

Percent ground layer cover, a structural measure, was used in this study, though its inclusion only slightly affects community rank orders. Communities with high cover present a greater surface area for damage, while communities with low cover afford greater opportunity for the avoidance of vegetation.

Trail parameters used are listed in Table 3. The depth and width of a trail, given even use, reflect the amount of soil compression and soil erosion. Resistant vegetation will offer a greater protection to the soil, so these parameters relate directly to the vegetation. The rate at which cover and species richness return to normal as a transect moves away from the trail measures the level of impact upon vegetation that is not on the immediate footpath. Cole (1978) compared the proportions of cover reduction and of different species present from trail edge to a site 10 m distant, parameters comparable to mine. Plant height comparisons could also be employed if care were taken to compare individuals of the same species in comparable conditions and to estimate variability. Trail assessments were made on from three to five transects in each community type.

The rank order of communities produced by each method were compared using Spearman’s rank correlation tests (Nie et al. 1975).

RESULTS AND DISCUSSION

Community Resistance

Details of community composition will be described elsewhere. Community dominants and a number of resistance indices are shown in Table 4. The Spearman rank correlation of habitat scores ($H_r$) of subalpine communities to ranks produced from trail transects is significant ($r = 0.67$, $P < .024$). The ranking based on species composition ($C_r$) is highly significant ($r = 0.61$, $P < .043$). Thus, in the forest vegetation, species-resistance scores provide excellent predictions of community resistance to treading. Rankings based on environmental parameters are fair, but better habitat data could improve the predictive value of this type of data.

In the alpine region, there is little correlation between $H_r$ and $C_r$ and the $H$
Table 3. Parameters used to construct the ranks based on trail transect data

<table>
<thead>
<tr>
<th>Index Value</th>
<th>Depth (cm)</th>
<th>Width (cm)</th>
<th>Cover Increase 1/ (%) gain</th>
<th>Species Increase 1/ (%) richness gain</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>&gt; 8</td>
<td>&gt; 100</td>
<td>79-90</td>
<td>&gt; 90</td>
</tr>
<tr>
<td>2</td>
<td>6-8</td>
<td>80-100</td>
<td>61-75</td>
<td>70-90</td>
</tr>
<tr>
<td>3</td>
<td>4-6</td>
<td>60-80</td>
<td>46-60</td>
<td>50-70</td>
</tr>
<tr>
<td>4</td>
<td>2-4</td>
<td>40-60</td>
<td>31-45</td>
<td>30-50</td>
</tr>
<tr>
<td>5</td>
<td>0-2</td>
<td>0-40</td>
<td>&lt; 30</td>
<td>&lt; 30</td>
</tr>
</tbody>
</table>

1/ expressed as gain per meter, starting with the first vegetation.

ranking is not correlated to the trail transect ranking. In contrast, \( C_r \) is highly correlated with the trail transect ranks (\( r = 0.92, P < .001 \)).

Analysis of a few specific communities will provide some insight into general properties that render communities more or less resistant to trampling. The most sensitive forest community is the Larix lyallii/Phyllodoce glanduliflora community type. This community occurs on steep north-facing rocky slopes. Wet soils, steep slopes, and limited vegetation cover result in a site sensitive to erosion effects. Phyllodoce glanduliflora is relatively sensitive due to the brittle stems and inability rapidly to replace injured tissue. The L. lyallii/Cassiope mertensiana-Phyllodoce empetriformis community type is quite sensitive and also occurs on north-facing slopes with many small streams and snow melt channels. Thus, characteristics of sites vulnerable to trampling include: high ground cover and wet soils combined with frequently steep slopes; understory dominated by woody species with brittle stems and lush forbs; and scarcity of herbs capable of soil stabilization.

Exposed ridges with little vegetation. Soils are gravels or sands with little organic matter or clay. Much of the substrate is bare rock and there is little ground cover. These conditions combine to produce a habitat quite resistant to trampling. The dominant understory species are sclerophyllous and resistant to damage.

The most resistant forest community type is dominated by Pinus albicaulis and Juniperus communis. This type dominates dry, exposed ridges with little vegetation. Soils are gravels or sands with little organic matter or clay. Much of the substrate is bare rock and there is little ground cover. These conditions combine to produce a habitat quite resistant to trampling. The dominant understory species are sclerophyllous and resistant to damage.

The most sensitive of the herb communities are those dominated by Carex nigricans and Lupinus polyphyllus and by Cassiope mertensiana and Phyllodoce glanduliflora. The former contains many forbs not resistant to trampling, such as Kalmia microphylla, Pedicularis ornithorhyncha and Potentilla flabellifolia. The latter is dominated by low, brittle shrubs and lush forbs. These habitats are often quite wet and have high vegetation cover. Due to the greater protection afforded the perennating organs, the sedge community probably is able to recover from damage more quickly than the heather community.

The least sensitive communities are dominated by Carex spectabilis and Luzula hitchcockii and by Phlox pulvinata and Arenaria obtusiloba. The former is dominated by graminoid species with high resistance indices and occurs in open, late-snow-melt sites. The latter occurs in dry sites where...
Table 4. Ranks of communities scored by habitat resistance, species resistance, and trail transect scores.

<table>
<thead>
<tr>
<th>Subalpine Vegetation</th>
<th>$H_T$</th>
<th>$C_T$</th>
<th>A</th>
<th>B</th>
<th>B'</th>
<th>C</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>3.45</td>
<td>3.89</td>
<td>4.35</td>
<td>3.30</td>
<td>6</td>
<td>3</td>
</tr>
<tr>
<td>B</td>
<td>2.78</td>
<td>3.69</td>
<td>4.32</td>
<td>2.97</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>C</td>
<td>2.91</td>
<td>3.62</td>
<td>4.32</td>
<td>2.70</td>
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<tr>
<td>D</td>
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<td>4.73</td>
<td>3.23</td>
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<tr>
<td>E</td>
<td>3.19</td>
<td>3.72</td>
<td>4.34</td>
<td>3.10</td>
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<td>F</td>
<td>3.52</td>
<td>3.74</td>
<td>4.37</td>
<td>3.12</td>
<td>4</td>
<td>6</td>
</tr>
<tr>
<td>G</td>
<td>3.93</td>
<td>3.88</td>
<td>4.43</td>
<td>3.36</td>
<td>8</td>
<td>7</td>
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<tr>
<td>H</td>
<td>2.92</td>
<td>4.02</td>
<td>4.61</td>
<td>3.42</td>
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<tr>
<td>I</td>
<td>4.16</td>
<td>4.22</td>
<td>4.56</td>
<td>3.88</td>
<td>11</td>
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<td>4.12</td>
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<td>4.50</td>
<td>3.47</td>
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<td>10</td>
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<td>K</td>
<td>3.28</td>
<td>3.91</td>
<td>4.51</td>
<td>3.31</td>
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<table>
<thead>
<tr>
<th>Alpine Vegetation</th>
<th>$H_T$</th>
<th>$C_T$</th>
<th>A</th>
<th>B</th>
<th>B'</th>
<th>C</th>
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<tbody>
<tr>
<td>Phlox pulvinata-Arenaria obtusiloba</td>
<td>3.56</td>
<td>3.24</td>
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<td></td>
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<td>9</td>
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<tr>
<td>Lupinus lepidus-Penstemon davidsonii</td>
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<td>2.95</td>
<td>4</td>
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<td>Phlox diffusus-Eriogonum pyrolifolium</td>
<td>2.80</td>
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<td>9</td>
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<tr>
<td>Carex spectabilis-Lupinus ledipus</td>
<td>3.02</td>
<td>3.22</td>
<td>7</td>
<td>7</td>
<td></td>
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<tr>
<td>Carex spectabilis-Erigeron aureus</td>
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<td>3.20</td>
<td>6</td>
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<tr>
<td>Salix cascadensis-L. lepidus</td>
<td>3.05</td>
<td>2.75</td>
<td>3</td>
<td>4</td>
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<tr>
<td>Carex nigricans-Phyllococe glanduliflora</td>
<td>3.30</td>
<td>2.70</td>
<td>2</td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Salix cascadensis-Phyllococe glanduliflora</td>
<td>3.79</td>
<td>3.45</td>
<td>10</td>
<td>10</td>
<td></td>
<td></td>
</tr>
<tr>
<td>P. empetriformis-Junecus parryi</td>
<td>2.78</td>
<td>3.02</td>
<td>5</td>
<td>3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Carex nigricans-Lupinus polyphyllus</td>
<td>2.89</td>
<td>2.65</td>
<td>1</td>
<td>1</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

$H_T$ = habitat resistance index  
$C_T$ = species resistance index  
A = $C_T$ based on trees  
B = $C_T$ based only on herbs  
B' = rank of $C_T$ for herb layer  
C = rank determined from trail transect
most species show drought adaptations that result in resistant morphological features.

A comparison of the species resistance indices ($C_r$) suggests that the subalpine vegetation is more resistant to trampling than the alpine. The mean subalpine stand has $C_r = 3.85 \pm 0.19$, compared to the mean for alpine stands of $3.04 \pm 0.24$ (P < .001). However, subalpine stands are strongly weighted upwards by tree species, which are generally not subject to any trampling. The understory of subalpine stands has a mean $C_r = 3.25 \pm 0.29$. This difference is statistically significant but not biologically significant, in view of the broad overlap of values.

Cole (1978) suggested that meadow communities were more resistant than some forest communities and Schreiner (personal communication) reported that Abies amabilis forests are the least resistant of any community he has studied in the Olympic Mountains. Weaver (1979) reports that meadow communities are highly resilient in comparison to the forest understory. These observations suggest that (a) one should carefully distinguish between resilience and resistance and (b) no broad generalization can be made.

The communities in Table 4 may be grouped into classes of postulated approximately equal resistance. Communities B, C, E, F, 7 and 10 are the least resistant. All but 10 are dominated by Vaccinium and heather species that are brittle and which also regenerate slowly. The latter is a wet sedge-lush forb type in a fragile habitat type.

The most resistant subalpine communities are dominated by Pinus albicaulis and xerophytic herbs (H, I, J). The understories of the subalpine are structurally similar to some of the most resistant alpine communities, such as Phlox pulvinata-Arenaria obtusiflora (1) and Phlox diffusa-Eriogonum pyrolifolium (3). The remaining alpine communities probably fall between Larix -- heather dominated communities and Pinus dominated communities.

Species Resistance

A brief discussion of species typical of different resistances to trampling is appropriate to illustrate the types of species characteristic of different resistance levels. A more complete list, arranged in order of increasing resistance, is shown in Table 5.

Species such as Dodecatheon jeffreyi, Anemone drummondii, Pedicularis groenlandica, and Lloydia serotina are highly sensitive plants. Dodecatheon, for example, is completely herbaceous, is found in the wettest habitats, has exposed perennation, is active for much of the year, and is only slightly resistant to breakage. Slightly less sensitive species include Caltha biflora, Aquilegia formosa, Epilobium latifolium, and Lupinus polyphyllus. Lupinus has intermediate and wide moisture tolerances, but is herbaceous, has exposed perennation, is active most of the season, and has leaves with little resistance to abrasion. At the opposite extreme are species such as Arenaria capillaris, Geum rossii, Lewisia columbiana, Penstemon davidsonii, Juniperus communis, and the conifers. Arenaria has a woody base, is found in dry habitats and displays drought-resistant traits that enhance resistance, has multiple, moderately protected perennating organs, and has quite resistant leaves. Lewisia is succulent, with a perennating tuber below ground, is found in dry sites and usually grows out of protected cracks, is active fairly early in the season, and is quite resistant to abrasion. A highly resistant species would appear to combine traits such as these: woody, prostrate with both an underground perennating organ and the ability to regenerate by layering, sclerophyllous leaves, and the ability to grow in stressful environments where ground cover and competition is reduced. A highly sensitive species appears to combine these traits: Delicate leaves, a single, exposed perennating organ, active throughout the season, and adapted to wet-to-moist habitats, where soils are easily compacted and competition from other species is severe.

CONCLUSIONS

Effective wilderness management requires site-specific data about the sensitivity of communities of various types of disturbance (Cole 1978). The method I have outlined suggests that studies of individual species characteristics with respect to particular forms of disturbance can lead to accurate predictions of potential effects. Balanced against the reduced precision of this approach is its ease of application, simplicity, and cost-effectiveness.

Other approaches cannot be discounted or discontinued, but each has drawbacks. Experimental trampling experiments are not
Table 5. A spectrum of resistance indices ($S_r$) for species of the Enchantment Lakes, Alpine Lakes Wilderness, listed from least to most resistant

<table>
<thead>
<tr>
<th>Species</th>
<th>Index</th>
<th>Species</th>
<th>Index</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dodecatheon jeffreyi</td>
<td>1.42</td>
<td>Spiraea densiflora</td>
<td>3.14</td>
</tr>
<tr>
<td>Saxifraga ferruginea</td>
<td>1.56</td>
<td>Phyllodoce empetriforis</td>
<td>3.14</td>
</tr>
<tr>
<td>Lloydia serotina</td>
<td>1.71</td>
<td>Polyedichium lonchitis</td>
<td>3.14</td>
</tr>
<tr>
<td>Pedicularis ornithorhyncha</td>
<td>1.71</td>
<td>Carex breviori</td>
<td>3.28</td>
</tr>
<tr>
<td>Valeriana sitchensis</td>
<td>1.71</td>
<td>Carex nardina</td>
<td>3.28</td>
</tr>
<tr>
<td>Anemone drummondii</td>
<td>1.85</td>
<td>Deschampsea caespitosa</td>
<td>3.28</td>
</tr>
<tr>
<td>Oxyria digyna</td>
<td>1.85</td>
<td>Luzula hitchockii</td>
<td>3.28</td>
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<tr>
<td>Pedicularis groenlandica</td>
<td>1.85</td>
<td>Juncus parryi</td>
<td>3.28</td>
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<tr>
<td>Aster alpigenus</td>
<td>2.14</td>
<td>Luetkea peritina</td>
<td>3.28</td>
</tr>
<tr>
<td>Caltha biflora</td>
<td>2.14</td>
<td>Arenaria alpina</td>
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<tr>
<td>Epilobium latifolium</td>
<td>2.14</td>
<td>Arenaria obtusiloba</td>
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<td>Lupinus polyphyllus</td>
<td>2.14</td>
<td>Cassiope mertensiana</td>
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<td>Polemonium elegans</td>
<td>2.28</td>
<td>Draba paysonii</td>
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<td>Saxifraga tolmiei</td>
<td>2.28</td>
<td>Phlox diffusa</td>
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<tr>
<td>Spraguea umbellata</td>
<td>2.28</td>
<td>Phyllodoce glanduliflora</td>
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<tr>
<td>Aquilegia formosa</td>
<td>2.42</td>
<td>Poa alpina</td>
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<tr>
<td>Artemisia trifurcata</td>
<td>2.42</td>
<td>Potentilla fruticosa</td>
<td>3.42</td>
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<tr>
<td>Carex nigricans</td>
<td>2.42</td>
<td>Saxifraga caespitosa</td>
<td>3.42</td>
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<tr>
<td>Campanula scabrella</td>
<td>2.42</td>
<td>Arabis lyallii</td>
<td>3.56</td>
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<tr>
<td>Ledum groendlandicum</td>
<td>2.42</td>
<td>Carex proposita</td>
<td>3.56</td>
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<tr>
<td>Vaccinium deliciosum</td>
<td>2.42</td>
<td>Penstemon procerus</td>
<td>3.56</td>
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<tr>
<td>Stibbaldia proembens</td>
<td>2.57</td>
<td>Poa cusickii</td>
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<tr>
<td>Carex spectabilis</td>
<td>2.57</td>
<td>Trisetum spicatum</td>
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<td>Kalmia microphylla</td>
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<td>Antennaria dimorpha</td>
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<td>Veronica americana</td>
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<td>Eriogonum pyrolifolium</td>
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<td>Dryas octopetala</td>
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<td>Senecio paeperculus</td>
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<td>Lupinus lepidus</td>
<td>2.85</td>
<td>Arenaria capillaris</td>
<td>4.00</td>
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<tr>
<td>Senecio divergens</td>
<td>2.85</td>
<td>Geum rossii</td>
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<tr>
<td>Smelowskia calycula</td>
<td>2.85</td>
<td>Lewisia colombiana</td>
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<tr>
<td>Erigeron aureus</td>
<td>3.00</td>
<td>Juniperus communis</td>
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<tr>
<td>Salix cascadensis</td>
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<td>4.14</td>
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<tr>
<td>Vaccinium myrtillus</td>
<td>3.00</td>
<td>Abies lasiocarpa</td>
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<td></td>
<td></td>
<td>Larix lyallii</td>
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</tr>
<tr>
<td></td>
<td></td>
<td>Pinus albicaulis</td>
<td>4.66</td>
</tr>
</tbody>
</table>
comparable to normal trampling. Such experiments often fail to take into account the effects of moderate, chronic disturbances. Correlations to habitat factors are fraught with ecological and statistical difficulties (Edmond 1962, Schreiner 1975). Habitat variables may affect resistance directly or indirectly through their effects on species composition and competition. The relationships may be nonlinear and interactive. Factors may operate differently in different localities.

The approach outlined here is not immune from error. Liddle (1975) has demonstrated that the ability of vegetation to recover from damage is a function of community productivity, but in this study it has been shown that less productive communities are more resistant. The paradox is resolved when it is realized that many morphological features that permit resistance (thick leaves, sclerophyll) generally reduce the maximum growth rate (Grime 1977). This serves to underscore the necessity of keep resistance and resilience separate in our thinking and planning.

None of the methods I used to assess potential trampling effects is unbiased. The analysis of trail transects assumes that the intensity of trail use is similar for each segment. Sufficient observations were made over three seasons, on about 40 days, to confirm that the assumption is not grossly violated.

Weights assigned to habitat scores are based on a combination of intuition and the frequency with which the various characteristics were cited in the literature. Several combinations of reasonable weights were employed and the results are those providing the highest correlations to transect ranks. A major constraint on the use of habitat variables was that moisture and compaction could not be accurately measured in situ.

Weights assigned to species characteristics were based upon intuited importance of each characteristic as a factor affecting species resistance. The weights are partially confirmed in the literature. Except for a few species, seasonality is a weak parameter. The moisture index for each species is the most difficult determination. Future workers might rely on regional studies (e.g., Douglas and Bliss 1977). Alternatively, the techniques of gradient analysis (Whittaker 1978) might be applied. However the appropriate use of gradient analysis requires substantial experience, considerable field sampling, and access to a large computer. This may be a major limitation to that approach.

A major use of the method is as follows. Given that a primary survey of the vegetation in a region to be developed has been accomplished (e.g., as part of an environmental impact study), the resultant vegetation map can be converted into a site-resistant map by use of abundance values and the species-resistance indices. This map may then form a basis for decisions about trail siting, camp locations and so forth.

The method described may be modified to meet specific management needs. Rather than undertake a complete primary survey, only those areas identified as potentially impacted are sampled. If necessary, rare species can be eliminated from consideration since they do not materially influence the plot indices. Species resistance scores should be used to produce a weighted plot resistance index which should then be compared directly to each other.

An alternative approach that I have not explored, but which seems worth mentioning, is to substitute aerial or satellite resource photography for the primary survey. Rapid advances in this field may make it possible to map vegetation on a sufficiently detailed scale to optimize field sampling. I estimate that such an approach would reduce field time to no more than 20 percent of that required for a full primary survey.

Where trails exist, the method may be reversed, to estimate differences in trail use. For example, if a trail through a sensitive community displays fewer impact symptoms than one through a more resistant community, a safe inference is that the former trail suffers less use.

Species-based resistance determinations appear to provide evidence about community resistance to trampling that is at least as good as data acquired in more expensive or time-consuming methods. Where an experimental data base exists, the method may be refined further.

ACKNOWLEDGEMENTS

Funds for this study were provided by the Graduate School, University of Washington. E.G. Schreiner, Ola Edwards, and Melinda F. Denton, made several suggestions on an earlier draft of the paper. Field work was
assisted through the efforts of J.E. Canfield, M.J. Cushman, R. Hagen, and A.F. Watson.

REFERENCES CITED


DISCUSSION

Comment: Can you incorporate the effects of differential survival at different densities into your scheme?

del Moral: No. Such information is likely to be extremely site-specific and cannot be determined by the survey method employed.

Comment: Does the time of the impact seem to be an important consideration?

del Moral: Yes. It was used in the habitat index, in a crude way, using elevation. The higher the elevation, the shorter the growing season, and the more resistant the site. It is also incorporated into the floristic index, using what we know of species pheno­logy. The longer the species is exposed to trampling, the less resistant it is considered to be.

Comment: Might not another characteristic of resistance be the tendency to refuge in cracks?

del Moral: That is incorporated by using the absolute cover index in the habitat resistance index. With the species index, it is not directly used, but such a tendency is correlated with xerophytic morphologies. It is accounted for, indirectly, in at least two of the parameters used in the floristic resistance index.

Comment: Rather than the summation of characteristics, might a plant succumb to its weakest link?

del Moral: Yes, that is possible and might explain a few anomalies. However, this index appears to work for most species and in the aggregate. The advantage of a "critical factor" method is more precision. The main disadvantage is that for most species the critical factor is not known. And I expect that the critical factor might vary from place to place for the same species.

Comment: To what extent do you think that phenotypic or site-specific characteristics that are bound to characterize the whole foundation of your research can limit the applicability of results to other places?

del Moral: The data used, except for the moisture index, are general to the species and are not likely to change significantly over the range of the species. Therefore, within a region, a species' resistance index should remain fairly constant.

Comment: Would it be possible to test each parameter for significance by experimental means and incorporate only the significant ones into a summation index?

del Moral: Yes. In this study there was no opportunity to do so, but that's the obvious next step.

Comment: Given practical considerations, do you feel that this method can be used in the field as part of the regular work schedule of an area ranger?

del Moral: Yes, the method is robust. One approach is to prepare keys to vegetation types with different sensitivities or resistance. The ranger need only know the more common species to typify any particular site.

Comment: If a single species has different sensitivities in different areas, do you think that it would show up in the species resistance index?

del Moral: Probably not, since the phenotypic characteristics are based on the regional flora. That is a weakness of the method. It might show up if its relative moisture relations differed. Also, local information should be used if it differs from the general information. Two points need to be emphasized. First, the method as described refers to the prediction of resistance to trampling, not to the rate of recovery, or resilience. The method could easily be modified for use as a resilience index. Second, as a practical tool, the method offers two main advantages. It is sufficiently general that many experimental programs involving trampling can be scaled down. Based on information gathered by this approach, simple field keys to resistance types can be constructed to make the job of field personnel simpler.
ABSTRACT—Restoration efforts at the severely impacted Cascade Pass in North Cascades National Park, Washington, began in 1970. Because of the scarcity of undamaged meadow vegetation for transplanting, revegetation has largely proceeded by the propagation of native plants at a lower elevation and their subsequent transport and planting at the Pass. The National Park Service constructed plastic-covered cold frame and greenhouse facilities at Marblemount, Washington in which plants are propagated from cuttings, divisions and seeds. Most successful species to date have been Carex nigricans, Luetkea pectinata, Phleum alpinum and Sibbaldia procumbens.

INTRODUCTION

When it was established by Congress in October, 1968, the highly scenic new North Cascades National Park in Washington presented its administrators with a number of management problems. Among the most critical was serious recreational overuse of several of the heavily traveled subalpine passes.

Cascade Pass was the most accessible, most popular and most heavily impacted of the high elevation scenic areas in the new park. Three years prior to the Park's establishment, the Forest Service had extended the Cascade River road 1 km closer to the Pass, built a large new parking lot at its terminus and constructed an entirely new trail with low gradients and numerous switchbacks. The new trail brought about a heavy increase in visitation and recreational impact.

In its first season of operation, the North Cascades administration engaged Thornburgh to survey the recreational impact at Cascade Pass and make management recommendations for restoring the area. As a result of his study (1970) the Pass area was closed to fires and camping at the start of the 1970 season, and late that summer the Park superintendent instructed us to attempt to carry out some of Thornburgh's suggestions for re-vegetating the area.

For nine seasons we have tried to restore as many of the impacted areas at Cascade Pass as possible by a variety of revegetation techniques, being careful to use only plants naturally occurring in the area. Direct seeding has been minimally successful, and the transplanting (plugging) of plant material from adjacent undamaged areas, has been ruled out by the limited size of the meadows (Miller and Miller, 1976). This paper discusses only the propagation of plant material at a lower elevation and its subsequent replanting in the subalpine zone at Cascade Pass.

ENVIRONMENTAL CHARACTERISTICS OF THE STUDY AREA

Cascade Pass is located in what Franklin and Dyrness (1973) describe as the upper Parkland Subzone of the Tsuga mertensiana Zone. The elevation at the Pass is 1,644 meters (5400 ft).

The climate is mild, moist and maritime. Annual precipitation is approximately 2400-2600 mm, with the greater part falling in the form of snow. Growing seasons are short, particularly in the meadows where snow remains late in the summer.

The soils at Cascade Pass are complex in nature, ranging from well developed Podzols under the subalpine tree clumps to poorly developed Regosols in areas of bare soil in
the rawmark phase. All soils are moderately
to highly acid except in old fire rings.

**PLANT COMMUNITIES**

The subalpine parkland is considered by
most plant ecologists to be a successional
stage on the way to a climax state of closed
canopy forest. A number of hypotheses have
been advanced, including the role of fire, to
explain the creation and maintenance of the
meadow components of the mosaic (Franklin and

The most thorough ecological studies of
the subalpine meadow-forest mosaic in the
Northern Cascades Province and of the Cascade
Pass area in particular have been conducted
by Douglas (1972, 1977). He hypothesizes a
successional status as follows: Carex
nigricans as the pioneer species, followed by
serial stages of Luetkea pectinata to Vaccini-
um deliciosum to Phyllodoce empetriformis-
Cassiope mertensiana to the Tsuga mertensi-
ana-Abies amabilis climax. L. pectinata also
pioneers on xeric rawmark soils.

On steep, well watered slopes a lush
herbaceous community dominated by Valeriana
sitchensis-Veratrum viride occurs, and this
grades into a somewhat more attenuated tall
sedge community dominated by Carex specta-
bilis and Polygonum bistortoides. The meadow
at the top of Cascade Pass is an example of
such a community.

Most of the denuded areas at Cascade
Pass were hacked out of heath-dominated
vegetation, although a number of the old
campsites were located within the Tsuga
mertensiana tree clumps where it was probably
too shaded for the development of the heaths.
A few of the bare sites were also located in
the sedge communities.

**PROCEDURES**

In 1970, our first year of revegetation
trials at Cascade Pass, we carried down
vegetative bulblets of Saxifraga ferruginea
to attempt their propagation in an unheated
greenhouse in Bellevue, Washington (1,560 m
lower elevation). We found that the S.
ferruginea bulblets, when sown on a peaty
soil mix, developed rapidly over the winter.
A year later, they were mature plants ready
for transplanting at the Pass.

In 1971 we collected stem cuttings and
divisions of Luetkea pectinata and Sibbaldia
procumbens and rooted them in our greenhouse.
Finding these species to be easily
propagated, in subsequent years, we tried a
number of other species native to Cascade
Pass.

In 1973 we used the propagating
facilities of the Patricia Calvert Greenhouse
in the University of Washington Arboretum.
Cuttings of Cassiope mertensiana, Luetkea
pectinata, Phyllodoce empetriformis and
Sibbaldia procumbens were treated with
Hormodin 3 (.8% indolebutyric acid) and
inserted in a mixture of equal parts sand,
peat and perlite. The flats were placed
under intermittent mist with bottom heat
(soil temperature of 21°C). Following
rooting they were transplanted into standard
nurseryman's plastic bedding plant trays in a
potting mixture of 3 parts loam, 2 parts
sand, and 1 part peat and placed in a lath
house. Some of the more vigorous plants of
S. procumbens were ready for planting at
Cascade Pass only six weeks after the
cuttings were taken. We overwintered the
remaining plants in a lath house at the
Arboretum and in the unheated greenhouse.

In September, 1974, 159 plastic trays of
rooted plants were transported to Cascade
Pass in wooden fruit boxes lashed to pack
frames. Four volunteers helped the authors
carry and transplant 17 boxes of plants
weighing 154 kg from the parking area to the
Pass some 6 km distance.

The fall rains needed to enable the
plants to enter the winter in good
condition, failed to materialize until late
October. Despite this drought, survival
rates, when evaluated in the summer of 1975,
were sufficiently high that we recommended to
the North Cascades Park administration the
construction of a modest propagating facility
at the Skagit District Office at Marblemount
for growing selected species of plants for
subalpine revegetation. Based on plans which we submitted, the Skagit District constructed a simple cold frame measuring 1.22 x 3.66 m with two hinged lids covered with 6mil clear polyethylene. The district also built 20 flats measuring 30 x 46 cm to contain the rooting mixture.

We used a rooting medium based on the Cornell "Peat-Lite" Mix B formula (Hartmann and Kester, 1975) as follows: 1 part peat moss, 1 part horticultural perlite, 64 g/.028 m³ (1 cu ft) ground dolomitic limestone (50% Ca CO₃, 40% Mg CO₃), 32 g/.028 m³ superphosphate (0-18-0) and 32 g/.028 m³ complete fertilizer (5-14-10). The fertilizer also contained fritted trace elements in the following amounts: Iron (Fe) .7%, Boron (Bo) .0375%, Manganese (Mn) .09%, Zinc (Zn) .087% and Molybdemum (Mo) .0025%.

Although it is not usual to incorporate fertilizers in rooting media, we felt that the small amounts used would provide some stimulus to rooted divisions while at the same time not inhibiting the formation of roots on stem cuttings. Another reason for using an artificial soil mix rather than a standard rooting medium was that it would not be possible to transplant the rooted cuttings into potting soil before they were to be planted at the Pass.

In September, 1975, we collected plant material at Cascade Pass and stocked the flats with stem cuttings of Luetkea pectinata, Potentilla flabellifolia and Sorbus sitchensis and divisions of Carex nigricans, Saxifraga tolmiei and Sibbaldia procumbens. All the cuttings and divisions were dipped into a rooting hormone (Rootone No. 10, .4% Alpha Naphthyl Acetamide) before being inserted in the rooting medium.

The flats were watered periodically by Park Service personnel during the winter, and, beginning in March, 1976, were fertilized monthly with a weak solution of liquid fish-base fertilizer (10-5-5). The Potentilla, Saxifraga and Sorbus did not survive. The Carex was the most successful from the standpoint of survival and coverage, and most of the flats of Luetkea and Sibbaldia made reasonably good growth.

In August, 1976, the most vigorous flats of plant material were dumped out into plastic bags for transplanting at Cascade Pass. The flats were solid mats of vegetation by this time and survived several days' storage at the Pass while severe storm conditions subsided.

Encouraged by the success of the cold frame, the Skagit District built a plastic-covered unheated A-frame greenhouse at Marblemount in late 1976. Propagation results from this facility in the 1976-1977 season were somewhat less than optimal, probably because of a failure to communicate to Park Service personnel proper directions for handling the plant material.

In April, 1978, the operation of the Marblemount greenhouse was taken over by Kathryn Lester (Volunteer In Park). She found that the rooted cuttings taken the previous year were making unsatisfactory growth in their mixture of peat and perlite. She transplanted all surviving plants into individual plastic and pressed paper pots containing a commercial potting soil, Daisy-Prep Redi-Mix. This mixture is heat sterilized and contains in unspecified proportions: charcoal, vermiculite, cow manure, peat moss, leaf mold, sandy loam and "humus mulch."

The plants were removed from the greenhouse for the summer and placed on raised benches under partial shade. Their growth during the 1978 season was rapid, and on September 7, 1978, 584 pots of plants were carried to the park in plastic nurseryman's flats strapped to packboards. The porters, 3 Park Service personnel and 5 volunteers, also planted all material transported. Species were Carex nigricans, Luetkea pectinata, Phleum alpinum and a small number of Lupinus Tatifolius and Sibbaldia procumbens.

In addition to the above propagation from cuttings and divisions, we have also conducted trials with seed of Phleum alpinum (alpine timothy). This grass, which occurs sporadically at Cascade Pass, has excited our interest since we read of its successful use in high-elevation areas of Glacier National Park, but we had never been at the Pass late enough in the season to find ripe seed.

On September 17, 1975, we dug a clump of this grass with immature seed heads and carried it to our home in Bellevue, Washington, elevation 84 m (275 ft.). The clump was planted in a 1-gallon nursery can and allowed to ripen. A month later, we picked the seed heads and sowed the seeds in a flat containing an artificial soil mixture of: 60% sphagnum peat moss, 30% horticultural perlite, 10% vermiculite, 64 cc/.028m³ complete fertilizer (5-14-10).
The flat was kept in an unheated greenhouse during the winter months and, beginning in March, 1976, the young seedlings were watered about every two weeks with dilute fish-base fertilizer (10-5-5) at the rate of 3.9 cc/liter water. In late spring the flat, by now a solid mass of culms, was placed outside in a spot receiving full sun. The maximum height reached was 7 dm. Beginning July 1, 1976, 71 panicles of ripe seed were harvested. Viability tests were conducted by placing moistened seeds in a seed doll which was kept at 28°C for 16 hours and 20°C for 8 hours daily. Germination occurred in 7 to 12 days with a germination percentage of 48.

The flat of alpine timothy was carried back to Cascade Pass in August, 1976, chopped into clumps and planted on one of the most severely impacted old campsites. We collected ripe seeds from these clumps in October, 1977, and grew them in two flats of artificial soil in the unheated greenhouse. These were turned over to Lester at the Marblemount greenhouse in May, 1978. She separated the individual plants and transplanted them into plastic pots filled with Daisy-Prep potting soil. Included in the mass planting of September 7, 1978, were 108 pots of Phleum alpinum.

RESULTS

Mature plants of Saxifraga ferruginea, grown over the winter in an unheated greenhouse from vegetative bulblets, were set out at Cascade Pass in 1971, 40 in each of three 1 m² plots. On the most severe, dry site, the plants persisted for three years but eventually died. On another relatively unprotected plot with southern exposure, S. ferruginea constituted 30% cover in 1977. The third plot, shaded and protected from wind, showed 75% cover. This plant is very easily propagated, but it is so succulent and susceptible to impact that it does not constitute a suitable ground cover.

The other species propagated in the University of Washington Arboretum Greenhouse and our own greenhouse and planted in the years 1973, 1974 and 1975 show survival rates as indicated in Table 1.

Material grown in the Skagit District propagating facilities was planted by Park Service backcountry technicians in 1976 and 1977, and we no longer have detailed records of locations, numbers and species planted. However, a cursory examination of those 1976 plantings we could locate in October, 1977, showed substantial survival (75-90%) despite the record-breaking 1976-77 drought.

| Table 1. Survival rates of Cascade Pass transplants of 1973-75 by species |
|-----------------------------------------------|-----------------|-----------------|-------------------|
| Species                                      | No. Units Planted* | No. Surviving 1977 | Percent Survival  |
| Cassiope mertensiana                         | 16              | 13              | 81.3              |
| Luetkea pectinata                            | 54              | 45              | 83.3              |
| Phylloco empetriformis                       | 36              | 29              | 80.6              |
| Polygonum bistortoides                       | 2               | 2               | 100               |
| Rubus pedatus                                | 5               | 0               | 0                 |
| Sibbaldia procumbens                         | 59              | 47              | 79.7              |
| Total                                        | 172             | 136             | 79.1              |

*A unit is a flat or tray containing several plants or a pot containing one.
Growth rates of the propagated material were difficult to measure because of the varying sizes of the young plants when set out. Generally, we observed that growth of rooted cuttings of the heathers was almost imperceptible and that propagated Luetkea seemed to grow more rapidly than transplanted plugs probably because of the undamaged root system. Propagated Sibbaldia planted in cultivated soil mixed with peat and perlite on an unfavorable site had a higher survival rate and double the growth rate of that planted in unprepared soil.

The clumps of Phleum alpinum planted in 1976 had reached a height of 2 dm during the 1977 growing season and produced an abundant crop of seed. Seed of the same species planted at the same time produced a few seedlings that were only 2-5 cm tall a year later.

CONCLUSIONS

We have found revegetation of impacted areas at Cascade Pass through propagation of plant material at a lower elevation preferable to direct seeding for a number of reasons. Nearly all the plants in the upper subalpine zone are perennial and not dependent upon the production of annual seed crops in order to exploit their environment. Seedling establishment is rare and very slow; it is often several years before a seedling is firmly established (Billings 1978).

Once the vegetative cover is removed, as in the old campsites at Cascade Pass, the microenvironment becomes even more unfavorable. Ballard (1972) found summer soil temperatures on such sites in a similar area to reach extremes lethal to young seedlings, often as high as 49°C. Another limiting factor to seedling establishment is the severe moisture stress on many sites during the summer months (Brink 1966). On only 3 of the 12 sites at Cascade Pass where direct seeding was attempted was satisfactory coverage achieved (Miller and Miller 1976).

Of the material grown from cuttings or divisions, Carex nigricans, Luetkea pectinata and Sibbaldia procumbens appear to be most useful for rapid restoration. Besides pioneering on disturbed sites, these species are all quite resistent to human impact. Luetkea, particularly, appears to have greater adaptability to ecological diversity than most other species in the high subalpine, making it a good choice for propagation. The heaths are more difficult to propagate, requiring bottom heat for satisfactory rooting, and young plants are easily destroyed by trampling.

Phleum alpinum is the only species we have propagated from seed in quantity, although we have grown some plants of Sibbaldia procumbens from seed, and Lester has grown some plants of Aquilegia formosa, Luetkea pectinata and Lupinus latifolius from seed in the Marblemount greenhouse. There are probably a number of other subalpine species which would perform well, but there is a problem of overcoming seed dormancy (Miller and Miller 1978).

Only a minority of high-elevation plants possess seed dormancy, but it is most common among the dominant and abundant species and may be a factor contributing to their success (Amen 1966). In wet meadows the principal species -- Carex, Luzula, Deschampsia, Erythronium Polygonum bistortoides -- have dormancy mechanisms (Billings and Mooney 1968).

We have found that seed of alpine timothy is not dormant, and presumably there are other subalpine species that do not possess dormancy. A species that germinates readily when given favorable conditions of moisture, temperature and light is obviously much easier to work with than one that must be subjected to stratification or other dormancy-breaking techniques. We recommend experimental work with those species that naturally occur on well-drained sites subject to some summer moisture stress, as their seeds probably are not dormant.

We have not applied fertilizer to planted stock at Cascade Pass but believe we could have improved growth rates by doing so. The literature contains numerous reports of studies indicating enhanced survival and productivity of high-elevation plantings, particularly of sedges and grasses, as a result of fertilizer application. Because there is no permanent water supply at Cascade Pass, we have not used transplanting hormones, but we believe this practice would also improve survival and growth rates of new transplants.

There are obvious logistic problems in revegetating many of the more remote disturbed subalpine areas in North Cascades National Park with material propagated at lower elevations. In an area as accessible as Cascade Pass, however, this has not been a major consideration. Sufficient numbers of volunteer porters can usually be found if
there are available supplies of plants to be transported. This method would also seem to be practical in other parks and wildlands with more extensive road nets.

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SUMMARY COMMENTS -- REHABILITATION SESSION

M. Miller: With due respect to the case histories presented today, I think we have learned that the state of the art in revegetation is not very advanced. Some of you have experienced problems preparing your papers because of inadequate records of the early work done on your study sites. Perhaps one reason revegetation work is no further advanced is that those of us practicing it haven't kept very good records. In order to get better results and share our findings with each other, all of us should improve our record keeping.

We haven't addressed a couple of important questions. One is the effect of frost action and methods to counter it. Another is the question of exotic as opposed to native species. Those of us working in the national parks feel that we should stick with natives, but there are places, I'm sure (Colorado, for example), where exotics have been tried and have succeeded.

We have a big question to address: What would you do if you were starting all over again? What would you do differently to improve your revegetation results?

Dalle-Molle: I think it would be most useful to have a baseline inventory of the existing situation. Maybe you should take a lot of pictures right at the beginning to have a record of the way things are before you start rehabilitation. Assess your problem and then try to identify your objectives -- what you want to do, what your end product is going to be, what you want to accomplish for that area. Then pick out your priority areas and start working on them.

The other thing is to try to complete your project. Frequently in the park it is hard to get the equipment when you need it so you're working on about five things at once. When you can't get something over here, you run over and do a little bit on this project and a little bit on that one. In the process your energies are dissipated, you're redisturbing sites, and the project lingers on. It is difficult, but if we could get at
things in a systematic manner, I think we would minimize many problems. Another helpful habit is to document everything.

Dull: Regarding documentation: It would be most useful to us to have permanent photo locations from the beginning so that we could go back and rephotograph the end product.

Ells: One of my responsibilities at Mt. Rainier is trying to keep photo files organized. Photographs are of little use unless they are labeled and dated. I have found valuable photographs taken four or five years ago by a ranger who left them in his desk drawer without identification when he was transferred. They really aren't too useful that way.

Van Horn: We are taking slides and color prints of our projects. Maybe for the long term we ought to be taking some black and white pictures, too. I understand that color photographic material fades eventually, and we really should be making permanent records.

Mann: A tool we utilize in the Forest Service is called "backlog", that is, the existing backlog of soil-degraded and water-degraded areas. We should make an inventory of the backlog of degraded sites, compare those sites and determine just what we are calling acceptable and unacceptable impact, and then focus our activities on the worst-damaged areas. That might be the most cost-effective way to proceed.

Furthermore, we could use this kind of information as a guideline to predict potential degradation in the future. We have sites, like the new section of the Pacific Crest National Scenic Trail where there is potential for impact in some very fragile basins. We should identify those areas so we can prevent degradation from occurring. This would be more cost-effective than repairing a problem after it occurs.
"Consider whence each thing comes, of what it consists, and into what it changes, what it will be like when changed, and that it will sustain no harm."

Marcus Aurelius
170 A.D.


Native American (Name unknown)
Prize-winning verse in contest sponsored by The Oklahoma Farmer Stockman.

INTRODUCTION

This special session was an "environmental impact show-and-tell event." There were several formal presentation scheduled in advance, along with a number of informal presentations. While there was variety and diversity to the subject matter, all presentations were geared to effective techniques for minimizing recreational impact on wildlands.

The evening commenced with a showing of the film "The Eternal Land," produced under contract for the National Park Service by Robert Pendleton and George Lukens Jr. The film illustrates the balance of a great wilderness environment - Mount McKinley National Park in Alaska. It depicts a land that is eternal, only as far as man continues to permit it to be. The production has already won four national and international awards.
REACHING YOUR PUBLICS THROUGH TELEVISION

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Reaching your publics with significant messages, such as those on minimum recreational impact of wildlands, can be effectively done through television. In 1978 the Pacific Northwest Regional Office, National Park Service, conducted an experimental program in the production and distribution of public service announcements for commercially operated television stations in Washington, Oregon, Idaho and Alaska. Under FCC regulations, a certain percentage of time is furnished cost free by commercial television and radio stations for messages of public concern. Competition for this free air time is keen.

The experimental program consisted of four messages on visitor hiking safety and crime prevention in parks and recreation areas. Two of these border on wilderness-impact education. The messages were produced on contract with KCTS-TV, public television, University of Washington. Production plans for 1979-80 call for at least one of three new messages devoted to the wildlands impact theme, through KCPQ-TV, public television, Clover Park School District, Tacoma, Washington.

Use of the public service announcement material by the 40 commercial television stations in the Pacific Northwest was unusually high. The messages were frequently shown during prime time, often in association with children’s television programming.

Several conclusions are drawn as to the reasons for the success of the project. Programs were regionally oriented, and this was emphasized in preliminary contacts with station personnel. The program was conducted on a highly personal level. Telephone calls were made to every television station in advance, and the name and title of the staff member directly involved with programming public service announcement material obtained. Following this, a telephone conversation was held with that staff member to describe the material and the general philosophy behind this particular educational endeavor.

The material was professionally produced on two-inch videotape, the size universally used by television stations today, and the videotape reel was mailed in a standard industry-type mailing carton for this product. Special labels, featuring the cartoon work of the artist contracted for the project, were used on the outside of the cartoons. These labels contained the name and address of the sponsoring agency, the titles of the programs, and the exact length of time for each. The reel of tape was accompanied by a copy of a personal letter addressed to the individual who had been contacted by telephone. This letter reviewed the objectives of the program. Follow-up letters of appreciation were also a part of the project.

The videotape material itself consists of three 30-second programs and one 60-second program. The three 30-second programs feature original still cartoon material by Seattle artist Bob Cram. Both panning and zoom photographic techniques were used with the cartoons. The 60-second program consists of excerpts from a recently produced film on children’s hiking manners, Trail and Error (also developed for the National Park Service on contract by KCTS-TV, University of Washington). The hiking safety and crime prevention messages were produced with flair and have a sense of humor. All four of the public service announcements contain agency identification at the end. Narrative material emphasizes the Pacific Northwest, as did the letters to the television stations.

Positive impact on the Pacific Northwest community was great. One large Seattle television station estimated that a single showing reached 800,000 homes. Audience numbers, of course, vary with the size of the community.
To extend the use of these messages into the parks themselves, videotaped material was transferred onto 16mm optical film. In addition, slide sets were made of the three cartoon programs and accompanied by a script.

This type of public service material was one of the most cost effective communications tools ever used by the National Park Service in the Pacific Northwest.

A number of other methods can be used to produce public service announcement material for television. One simple and inexpensive method is to use 35mm slides and a script. Stations will also accept slides with taped messages. Furnish a script with taped messages to clearly show slide changes. In the case of one-slide messages furnish a script too. Stations may prefer to use their own voices. Check with the stations on the type of tape used as well as on the preferred message length. Most slide messages are brief and, like videotape messages, are in 30-second lengths or multiples thereof. Advantages of slides are low cost and production capability by the initiating agency or organization.

The use of motion picture films on television can also be an effective communication tool. Films produced by your agency or organization need no legal clearance. Commercially produced films not owned by your agency or organization do require clearance for television use from at least the producer. Both commercial and public television stations may be interested in your films. Public television stations are often interested because of their commitment to educational programming and some flexibility in scheduling. A telephone call to determine interest, followed by a preview copy of your film is a good procedure.

Your film program is more effective if accompanied by a brief typed introduction for possible direct reading or extraction by station personnel. In the case of stations near your location, you may even consider an in-person introduction.

Public television stations might include the title and description of your film in printed bulletins or schedules sent to schools. This normally requires substantial lead time. One very effective method used through the University of Washington station was the production of a simple printed flyer/poster announcing a special film showing or series. This was mailed by the station to all schools within its viewing range. KCTS-TV, public television at the University of Washington, estimates an audience size of 50,000 during the day and 300,000 at night.
MANAGEMENT PROBLEMS IN OFF-ROAD-VEHICLE RECREATION

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ABSTRACT—Management of off-road-vehicle (ORV) recreation has been handicapped by a lack of planning by public agencies. As a result ORV management has been largely reactive, that is limited to repairing damage, rather than aimed at minimizing the incidence of damage through land-use planning and education of ORV users. Impacts of ORV recreation are shown to be of very large scale, necessitating active management which can only follow from managers' commitment to conscious positions on questions of public policy concerning the value of ORV recreation.

The phenomenon of off-road vehicle (ORV) use as a mass recreation is relatively new. It came on the scene about 20 years ago and quickly grew at an almost astronomical rate (Sheridan, 1978). Because it came so suddenly and grew so quickly it took most land managers by surprise, and for the most part the managers have never caught up. Two decades after ORV use in natural settings began to show serious negative impacts on land and recreation resources, most management of ORV recreation is still merely reactive. ORV users do much of the decision-making, and managers come along after and try to clean up.

Several cases clearly illustrate what can be expected when ORV use is managed by reaction rather than planning.

The Hollister Hills Vehicular Recreation Area is a ORV park in central California owned and operated by the state and purchased specially for this use. The State Parks Department did not seek a site where maximum ORV use could be managed with minimum impacts (and, therefore, minimum maintenance); it selected Hollister Hills primarily because of its long-established use as an ORV park by motorcyclists. Thus, in essence, it was the ORV users who selected this site. They did not consider manageability: their use of the area was dictated solely by their recreational preferences and the accessibility of the site.

Only after acquisition of the site did the state of California commission a soils study, which concluded that the soils and topography of the area were largely unsuitable for ORV use because of high erosion potential (Webb, 1977). That study confirmed what was apparent to users and others who saw trails disrupted by 8-foot-deep gullies, natural drainages choked with silt and debris carried by greatly increased runoff, and the failure of one dam built to contain siltation on-site.

The U.S. Forest Service manages 188 million acres of public lands for which ORV management planning was directed by Executive Order 11644 (Nixon, 1972.) A memo from Forest Service headquarters to all Regional Foresters (Smith, 1976) advised the following policy toward ORV planning:

Restrictions and closures are to be used only as a last resort...Restrictions will be based on...adverse effects to resources/environment (damage must be occurring or be in immediate danger of occurring). The inclusion of large acreage in closures or restrictions to a localized problem is not accepted.

These instructions clearly weigh against even the most rudimentary types of prophylactic management. Managers are instructed to forego the precaution of planning for areas where ORV use is not already established and apparent. Management is restricted to following existing ORV routes looking for problems.

The intent of these directions is to minimize the management presence, in keeping
with generally accepted wildland recreation objectives, but in actual practice, they represent a short-sighted strategy toward that end. When managers follow ORV trails looking for problems, they end up closing areas with established use. No matter how small a percentage of the total management area these closures represent, they are very evident to ORV users.

There is, in fact, a general belief among many ORV users, widely expressed in ORV-oriented media (Kramer, 1978; Leadabrand, 1978; American Motorcyclist Assoc., 1978), that federal agencies operating under this management approach are closing down all or most ORV use on their lands, despite the fact that the vast majority of federal lands are officially open to ORV use. An analysis of ORV planning in 27 National Forests showed that only 13.4% of their 29 million acre land base was designated closed to ORVs (Wilshire, 1976). It is interesting to note that over 10% of all National Forest lands were closed to ORV use before Forest Service ORV planning, largely by Congressional designation of wilderness areas (U.S. Forest Service, 1973).

A logical way to minimize the need for response-management is through positive planning efforts based on resource information—particularly on soils, slope and vegetation data—by zoning ORV use to reduce potential problems (Geological Society of America, 1977). A more positive management approach might also make solutions other than closure more acceptable where problems occur in areas zoned for ORV use. A number of techniques for trail-hardening, for example, have been demonstrated on a limited basis (Rasor, 1977), but their use requires a commitment to active rather than passive ORV management.

Further, spot closures are far more difficult to enforce than area closures, especially where these closures are on previously existing ORV routes. In short, the primary planning task in ORV management is the decision of where ORV use is appropriate; managers' abdication of this responsibility to ORV users is both bad land management and bad recreation management.

Planner reluctance to use resource data in zoning ORV use is due in part to a lack of data on the "carrying capacity" of various landtypes for ORV recreation. While quantification is needed, data are available on the relative suitability of different sites.

The Forest Service manages ORV use as a "dispersed recreation," characterized by "relatively low-density use and occurring over rather broad expanses of land" (U.S. Forest Service, 1976). The basic management strategy for dispersed recreation is to keep density, and thus impacts, down. The effectiveness of this strategy for ORV recreation requires that (1) ORV users do disperse, and (2) that this dispersal is adequate to keep ORV use intensity below "carrying capacity."

However, ORV users do not always meet these two requirements. They are often gregarious and congregate in specific areas or on specific trails—and in doing so sometimes clearly exceed "carrying capacity" for those specific sites.

Federal land managers are required by Executive Order 11644 to "monitor the effects of the use of off-road vehicles," but there has been no programmatic effort by any land managing agency to gather usable data on the levels of impacts or the levels of use: the order has been interpreted to mean that managers should keep on the lookout for trouble spots, and no more. Obviously, the compilation of data on both impact and use is the necessary first step in determining "carrying capacities."

The sufficiency of dispersal as an ORV management strategy is intuitively supported by our consciousness of the huge area of the public lands—341 million acres of National Forest and Bureau of Land Management (BLM) lands in the lower 48 states (BLM, 1976). But this has to be tempered by an equal consciousness of the enormous number of ORV users and the size of their potential impact. There may be as many as 12 million users of off-road motorcycles alone (David, 1978). Considering that the motorcycle industry estimates that motorcyclists traveled 4.5 billion miles off road in 1977 (Motorcycle Industry Council, 1978) and that typical off-road motorcycle tire track covers one acre in twenty miles of travel (Wilshire, 1977) estimated motorcycle impact (in 1977 was) equivalent to a single motorcycle pass over 225 million acres. This is an annual impact. This figure is not proposed to be exact—it doesn't count use on non-federal lands or impacts extending beyond the motorcycle track. It is, however, a clear indication that the impact of millions of recreationists multiplied in speed, range and power by gasoline engines, is more than large enough to call for active, effective management.
Eventually, any management of ORV recreation as part of "multiple-use" lands under a mandate for sustained productivity and yield will have to be justified and guided by carrying capacity or some related concept. One alternative approach to providing a rational data base for policy and planning decisions in ORV management is accounting the costs of ORV impacts. Once quantified, these costs could be balanced with the value of providing ORV recreation opportunities (fixed by public policy decisions). Quantification of the costs of ORV use over large areas with scattered ORV use has not, to my knowledge, ever been seriously attempted. There have been some opportunities to quantify costs in some smaller, more intensively used ORV recreation areas.

In Richmond, California, a regional parks authority acquired a site of trespass ORV hillclimbing as part of a larger project. The parks district has been trying to reclaim this area to reestablish ground cover and soil stability. The cost of this reclamation effort has been approximately $2,000 per acre. The area is being reclaimed, not restored: most of the original soil is gone and it will never look like it did before ORVs began using it. ORVs will not be able to use this particular area again.

The county of San Diego has spent several years planning on ORV park with goals of compliance with county environmental standards and non-degradation of the area from the users' point of view (i.e., the area would be maintained so as to have a long useful life as an ORV park) (San Diego Co. Board of Supervisors, 1978). The planners computed that to meet these goals at the chosen site would require $9.5 million for acquisition and set-up and almost $1.4 million annually for maintenance and operation (San Diego Co. Integrated Planning Office, 1978a). This would provide 136,500 user-days of ORV recreation per year on the 1,500 acre site (San Diego Co. Integrated Planning Office, 1978b).

Part of the cost would go to keeping enough ORV competition and other use going on in the area to provide for some return to the county to offset the area’s costs; however, the end cost is still over $10 per user-day for ORV recreation, not counting the acquisition and set-up costs.

As originally proposed, the County's idea for an ORV park could have been a legitimate service for the owners of the 175,000 ORVs in San Diego County (San Diego Board of Supervisors, 1978). But when costs were calculated, county officials were not interested in paying for providing ORV recreation. They insisted on adding ORV competition and other features to the facility to make it cover its own costs through such revenue sources as admission fees and concessions. It became a monster, and as a result the County has retreated to the non-managed-use option: no park.

At least the cost of ORV use was computed in that case. People were made aware that there is a cost to ORV use and that at least some of that cost can be put into dollars and cents. In the case discussed above, the County decided it didn't want to pay the cost. Nevertheless, the price is still being extracted: there are still 175,000 ORVs in the county and they are still being used.

That ORV use costs the public money is not a reason for refusing to allow it; it is, however, a necessary piece of information for deciding when, where and under what circumstances to allow it. It involves confronting the questions of how much we are willing to pay for ORV recreation and how we can get the most ORV use for our money or resource commitments. ORV management will have to come to grips with such basic policy questions if it is to take the strong management actions needed to manage a phenomenon as large as ORV recreation.

One of the key variables in "carrying capacity" for ORV use, and one of the greatest potential sources of increasing "carrying capacity," is the attitude, knowledge and responsibility of the ORV user. But the reluctance of managers and their superiors to commit themselves on basic policy questions has left a great void in the guidance and education available to ORV users. There have been signs of slow progress in this area, and they are encouraging. But the potential for increasing carrying capacity will remain greatly under-exploited. Managers continue to let users make planning decisions without guidance and merely follow close behind to correct.
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Black cottonwood chewed by beaver
ESTABLISHING A VOLUNTEER WILDERNESS HOST PROGRAM

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Attracting adequately skilled volunteers to work on important wilderness management projects and obtaining funding to adequately manage and conduct a volunteer program are problems with which agencies have had to struggle with for years. In 1977 a volunteer "Wilderness Host" program was successfully field tested in the Glacier Peak and Alpine Lakes Wildernesses. The concept was developed on a backpack management field trip led by Cal Dunnell, Recreation Staff Officer, Wenatchee National Forest. This was a cooperative effort involving personnel of the Mt. Baker-Snoqualmie and Wenatchee National Forests, Ruth Ittner of The Mountaineers (Seattle) who performed as project catalyst, and many other supporters.

Early in 1977, after preliminary discussions of volunteer programs with members of The Mountaineers, the Forest Service polled personnel of the ranger districts which manage the two wildernesses. Object of the poll was to determine the need for volunteers, support available (housing, equipment, supplies, transportation, and funds available for per diem and other incidentals), and willingness to participate in the Wilderness Host program. They found that volunteers were most needed to assist wilderness rangers with trail maintenance, minimum-impact educational efforts, resource inventories, collection of user data, and rehabilitation projects.

Editors of local club publications and Pacific Search were provided with a news release which described the Host program and encouraged qualified individuals to apply. To qualify, a volunteer had to:

1. Have taken the Mountaineers basic climbing course or have equivalent mountaineering skills and knowledge, and be an experienced backpacker, hiker and camper under wilderness conditions;

2. Possess a current Mountaineering Oriented First Aid Certificate;

3. Have previous experience contacting the public and a sincere desire to serve as a considerate, understanding host to wilderness visitors;

4. Be dedicated to wilderness principles and concerned about wilderness management issues;

5. Be a mature individual capable of working unsupervised; and

6. Be available for a period of time—from at least several three-day weekends to all summer—and be available to attend a one week wilderness ranger training session the third week in June.

Districts varied in their volunteer needs and support capabilities. About fifteen applications were received, about half of the number of positions available. However, the caliber of the applicants was excellent. About eight applicants went to work on the Wenatchee National Forest and five on the Mt. Baker - Snoqualmie.

In most cases applications were sent to the Mountaineers' Clubroom and were then handled by a screening committee. The committee's task involved reviewing the applications and directing them to a contact at the preferred work area or in some cases trying to match applicant skills to management needs. The screening committee was important as a coordinator to keep track of applications and to followup with managers to insure prompt and suitable placement of the volunteer. Some applicants obtained paying jobs at the last minute.
Efforts were made to provide for volunteers' backpacking equipment, transportation between the Ranger Station and trailhead, and when possible, housing or a small payment for subsistence. The Mountaineers also made a significant effort to obtain outside support for the program. REI Co-op, Swallow's Nest and Eddie Bauer responded with support in the form of special offers for trail foods. However, because the offers came in such different forms and the volunteers were so widely separated and had varying tastes, it became logistically impossible to accept these offers.

In general the volunteers performed the same types of work normally assigned to wilderness rangers. The tasks were varied and ranged from contacts with wilderness users to promote a good wilderness ethic and minimum impact techniques to light trail maintenance work.

The latter involved removing small windfalls and debris from larger ones to facilitate removal by trail crews, removal of small slides and rocks, maintaining trail drainage, removing old paint blazes from rocks, and maintaining trail signs.

Volunteers also made significant contributions to several projects such as, rehabilitating severely used areas and inventorying campsites, signs, and species of wildlife.

It was quite important that the supervising manager and the volunteer develop at the outset an understanding of what the job was to involve. A semi-formal, written job description and work schedule were helpful.

Several volunteers participating in the Wilderness Host program were hired as full-time seasonals a short time after they began their volunteer work. In any case work experience and recommendations aided volunteers in obtaining better paying jobs the next season.

It may be worthwhile to consider expanding this program to seek quality volunteers for additional purposes such as for trailhead contacts or to watch cars at heavily used trailheads where vandalism is a problem.
The development and distribution of a one-page flyer entitled The Responsible Trail User is a good example of cooperation between J.S. Forest Service, users and private industry. The idea developed when about a dozen people from various organizations met to informally discuss the problems related to trails. Early in 1976 a number of drafts of a flyer relating to what the trail user should know and do were reviewed and revised. Although printed on the following pages in consecutive order, the original layout was designed for a three-way letter fold.

Mt. Baker-Snoqualmie National Forest participated in the process. Ramona Hammerly, an artist contributed the sketches, and a draftsman helped with layout. The Mountaineers printed 3000 copies for distribution to climbing, alpine-scrambling and backpacking course participants. Copies were also sent to ranger stations for the public. In June REI Coop reproduced copies and made them available to customers. Early the next year the U.S. Forest Service, Region 6 reprinted the flyer and these were distributed by The Mountaineers through 19 outlets in the Seattle Metropolitan area.

KNOWS

WHAT A WATER BAR IS?
Those half-buried logs diagonally across the trail held in place by stakes are called “water bars.” To function the uphill side must be able to catch the water and keep the lower end free of debris to permit drainage.

THE REASONS FOR SWITCHBACKS?
To reduce the grade so it is hikeable and to prevent erosion are the reasons for switchbacks. Cutting switchbacks create a severe erosion problem, damaging the land. First the vegetation vanishes, then, the topsoil washes off narrowing the trail tread. The process continues until the trail is washed out and bare rock is exposed.

THE MEANING OF DEBRIS ACROSS ONE OF TWO TRAIL CHOICES?
The trail has been relocated — the trail with the debris across is the wrong choice. Debris is also used to discourage the cutting of switchbacks.

REGISTERING AT TRAILHEADS IS SIGNIFICANT?
Trail user statistics are used to obtain funds for trail maintenance. Reasonable and economical suggestions are taken seriously.

WHAT TO DO ABOUT

TRAILS WHICH HAVE BECOME STREAMBEDS?
Go to the source and remove debris from natural water course.

MUD PUDDLES IN THE TRAIL?
Using the heel of your boot or ice axe or stick make a drain channel.

DEBRIS ON THE TRAIL?
Move off the trail and scatter on lower side. Small trees can often be moved by several people.

ROCKS?
Move those over six inches in diameter if possible without endangering anyone below.

BRUSH?
Encroachment upon trail can be minimized by breaking off the growing edge and scattering it on the downhill side of the trail.

CAIRNS?
Keep the piles of stones used for landmarks intact.

LITTER?
Pick up and carry out.
The Responsible Trail User answers such questions: What is a water bar? What are the reasons for switchbacks? What is the meaning of debris across one of two trail choices? Why is it important to register at trailheads? What should the trail user do about trails which have become streambeds, mud puddles in brush, cairns, and litter? What and how should the trail user report washouts, blowdowns, the lack of trail signs, dangerous stream crossings, and mud wallows? In addition, the brochure has some suggestions for stretching trail maintenance dollars.

**WHAT TO REPORT**

**WASHOUTS**
Trail tread undercut
By the stream below or
Obliterated
By avalanche or landslide
From above.

**BLOWDOWNS**
Trees across the trail
Single ones
Difficult to negotiate
Because of size, angle, or
Location

**TRAIL SIGNS**
No longer readable
Missing
On the ground.

**DANGEROUS STREAM CROSSINGS**
Damaged or destroyed bridges and
foot logs

**MUD WALLOWS**
Boggy area
Which has become
Nearly impossible
Due to use.

**HOW TO REPORT**

**WHERE**
To District Rangers Office:
Forest Service Maps
Contains addresses
And telephone numbers
Why not leave a note about
Trail conditions at the Ranger
Station on your way home or
Leave in trail registration
Boxes

**INFORMATION NECESSARY**
Trail name
and number
the problem and
its approximate location

**RECORD INFORMATION**
On the spot
to obtain details and help you
remember to report. Another
way would be to take photos.

**HOW TRAIL MAINTENANCE DOLLARS**

CAB BE STRETCHED BY
Undertaking volunteer trail mainte-
nance. Your group - organization,
family, or friends - can increase
the trail mileage available for
you - to hike.
It is fun to work together!
It is also worthwhile!
Become a trail supporter!

Locating old abandoned trails
suitable for recreational use.
If the land manager agrees, brush
them out. Mark them. Report
them. Give your reasons why
this trail should be part of
our trail system!

Photographing problems from several
angles and sending them to the land
management agency is the most
effective method of reporting.
From photos the problem can be
analyzed, solutions determined,
equipment and material selected
without an extra trip to the site.
ABSTRACT--Interpretive Structural Modeling (ISM) is a computer assisted technique for structuring complex problems. This paper presents a short description of the process of ISM and the results of an exercise that applied this methodology to the problem of recreational impacts on wildlands. Although the results are only illustrative, they demonstrate that a careful modeling study, performed in such a context, could help to uncover and specify the different interconnected elements that make such problems difficult to solve in a piecemeal manner.

Interpretive Structural Modeling is a computer assisted process for structuring complex system problems. A complex system problem is one that involves many interconnected variables of concern at different levels of abstraction. An example would be the "import management problem" that includes physical, biological, and socioeconomic effects. ISM, rather than being concerned with the evaluative aspects of systems problems, focuses on the structural aspects that provide a framework within which evaluation can occur.

With ISM, the development of a 'framework' takes place through the use of graph theory, which produces a network representation of the complex problem or issue as in Figure 1.

In such a representation, the elements of interest are the 'points' or 'nodes' that are interconnected by the 'arrows' or 'paths' of the network. The 'arrows' indicate that a certain relation holds between any pair of elements. This relation can indicate relative importance, influence, or any sort of directional property than can serve as a basis for the network.

The computer-assisted ISM process allows people to structure a complex problem in a systematic fashion that is both efficient and complete, once the elements have been initially defined. The essential advantage of the procedure is that the computer allows people to consider single relationships at a time, while it automatically performs all the bookkeeping chores and draws all logically permissible inferences from the human judgments it requests. As a result, although participants need only focus the relationship between two elements at a time, the computer's application of logic and bookkeeping builds a complete structural model of the interrelations among all elements.

At this conference on Recreational Impact on Wildlands, an ISM workshop session was held to introduce conference participants to the technique and to help structure...
some collected user expectations and motivations in wildland recreation that could serve as a springboard for the final session. The remainder of this paper will provide a 'walkthrough' of the ISM session.

There are two main phases in the use of ISM. In the first phase, a text file is created for entry into computer storage. This requires identifying and defining:

1) the elements of interest to the problem; and
2) the relationship of interest among elements that will build the model.

These steps do not involve computer assistance or guidance, but are critical to the subsequent success of the modeling effort. It is at this phase that the old expression of the programmer "gigo" (garbage in-garbage out) becomes most relevant. The computer can only work with the information given it. It cannot improve on the intelligibility or insightfulness of the elements chosen to construct the text file. Sufficient care and consideration here will prove invaluable to the success of the remainder of the ISM process.

In this workshop, the context was "wildlands recreation" and elements of concern were selected from a list of user expectations and motivations that had been constructed earlier. The element set used in the workshop is as follows:

1. Having a primitive outdoor experience
2. Drinking water from a free-running source
3. Observing wildlife
4. Getting exercise in natural setting
5. Experiencing a contrast to everyday life
6. Gathering natural foodstuffs
7. Experiencing companionship out of doors
8. Learning outdoor survival skills
9. Family sharing experiences
10. Exploring new places
11. Being alone
12. Studying flora and/or geological features
13. Trapping or hunting for game
14. Mountain climbing
15. Using four-wheel drive or trailbike vehicles
16. Photography outdoors
17. Horseback riding with or without pack horses
18. Building a campfire

This set is far from comprehensive. The elements were selected to provide a variety of concerns and levels of abstraction within a list length that fit the time requirements for the session.

The relation selected was the subset or component relation. In the session, it was worded as "________ is a component or aspect of ________ in the context of wildlands recreation." The component relation was chosen because it had worked well in earlier practice sessions, and because it is utilized in most hierarchical evaluation models, which proceed by breaking down complex value issues into their component parts.

Once a computer file is established that holds the elements, the relationship, and the context, the second phase may be executed at any convenient later time. The second phase is interactive with the computer. The session may involve any number of people appropriate to small-group decision-making. During this session, the computer presents statements composed of pairs of the elements juxtaposed by the relation and qualified by the contextual phrase. For each pair of elements, the computer asks the session participants whether or not the relation of interest holds between that particular pair. Participants may answer that the relation holds in one direction or the other, or both, or not at all.

As an example, the first question given the session participants was: "Having a primitive outdoor experience is a component or aspect of drinking water from a free-running source in the context of wildlands recreation." Their response was that the relation held "upward" (the second element to the first) but not "downward." In other words, drinking water from a free-running source was judged to be a component of having a primitive outdoor experience, but not vice versa.

The available ISM program does not permit multiple or uncertain judgments on whether a relation holds or not, so a majority vote among the participants served to provide the necessary judgment.

As the session proceeds, the computer keeps track of the judgments and begins internally to build a model of the inter-relation network among the elements. This procedure does not require that participants make judgments on all pairs of elements.
Instead, the computer is equipped to make the necessary transitive inferences to complete a binary matrix (0,1) representing all possible pair-wise connections among elements.

The mathematical process of ISM is based upon the one-to-one correspondence possible between a binary matrix and a graphical representation of a directed network. The elements form the contents of the index set for the rows and columns of binary matrix created by the computer. In our session since we had 18 (eighteen) elements, this would be an 18 x 18 matrix. If participants decide that a relationship holds between any pair of elements i, j; a 1 is entered in the corresponding intersection of row i and column j. If the relationship does not hold, a 0 is entered. Once the matrix is completed (with the savings acquired by the computers' transitive inferences), the computer is prepared to derive higher order connections among the elements and then to partition the elements into 'levels' that represent both immediate and second-order (or higher) connections.

The derivation of higher-order connections among elements is mathematically a simple task that requires transforming the basic binary matrix by raising it to successive 'powers' until no new '1's appear in the cells. All of this is, of course, done automatically through the ISM program.

The final result of this process is a printout from the computer that shows:

1. Which elements are functionally equivalent to others in terms of their connections within the structure. This is described as elements forming a 'loop' on one element, and means that for the relational purposes of this network, they may be regarded as functionally identical. In our session, the elements 7 and 18, and 1, 9, 10, and 11 exist in such logos.

2. Which elements exist on different "levels" within the network structure. For example, an element that has many other elements as "components or aspects of" itself while not being "a component or aspect of" others will be placed on a higher numbered level.

The output of the conference workshop session is shown in Table 1, and a graphic summary of the session results is shown by Figure 2. Although it is possible to infer some interesting and non-obvious conclusions from this representation, (e.g. 'Desire for Exercise' as a basic motivation is independent of a motivation for a primitive experience.) This is not its purpose. Rather, the representation should be looked at as a possible source of hypotheses or as a stimulus for creative thinking.

It should be emphasized that an output of ISM should not be regarded as a 'given' and treated as a 'true' or 'optimal' configuration. The representation is no better than the judgments that went into it, and it involves only one relation. Its value lies in its usefulness as a stimulus for discussion and a source for comparisons with other representations using different relationships. ISM does not replace human insight and subjectivity; instead, it assists these uniquely human characteristics to help them become more systematic, rational, and efficient. Final resolution of systems problems, be they management or impact issues, will incorporate evaluative as well as structural thinking. Here, too, there decision aids such as multi-attribute

Table 1. The print-out from the ISM evening session at the Wilderness Conference. "Loop"s identify relational equivalences and arrows indicate first-order connections among the elements.

| Loop on 1 | 9 | 10 | 11 |
| Loop on 7 | 18 |
| Level 1 | 1 | 4 | 15 |
| Level 2 | 5 |
| Level 3 | 8 | 14 |
| Level 4 | 2 | 6 | 16 |
| Level 5 | 13 |
| Level 6 | 17 |
| Level 7 | 3 | 7 | 12 |

(5) • 1 4
(8) • 5
(14) • 5
(2) • 8
(6) • 8
(16) • 14
(13) • 6
(17) • 13
(3) • 16 17
(7) • 15 14 17
utility theory that may be useful for analysis. But all of these share the requirement that some structuring of the decision context be made prior to employment of the evaluation technique. The ISM process can play the sort of role in this structuring that more traditional decision models play in subsequent evaluation. Taken together, the combination of Interpretive Structural Modeling and decision analysis would seem to provide a formidable holistic methodology for an assault on the kinds of problems encountered in the management of wildlands recreation while there still remain some real choices.

Figure 2: The graphic representation of the ISM output in Table 2. Elements higher on the page are more inclusive elements of wilderness users expectations or motivations. A line indicates a first order component relation. The diagram can be read as: 8 and 14 are components of 5; 7 and 18 are components of 14 and 15; and 14, in turn is a component of 5. This representation is for demonstration only, and should not be construed as an empirically valid finding.
Robinson: The Flathead Backcountry Horsemen is a relatively small organization from the northwest corner of Montana. We started operation in 1973 and since that time, we have seen a proliferation of horse use in our area and in other areas. The prime reason for establishing the organization was genuine concern about horse use in the backcountry; our traditional use is being challenged. Today we have five sister clubs throughout western Montana and Idaho, and in the spring of 1979 we are holding our first convention to try to get some coordination between these groups.

Our primary use area is the Bob Marshall Wilderness Area, which, with the recent addition of the Scapegoat Wilderness Area and the Great Bear Wilderness Area, gives us a wilderness extending from the southern boundary of Glacier National Park, along the Continental Divide, about, probably 120 miles and this area of steep rugged mountain ranges dividing rather broad open valleys has traditionally been horse-use country. Many outfitters and guides operate here in the summer and fall months during hunting, and there has always been extremely heavy horse use.

I would like to read just a little bit from our publication "Backcountry Horsemen's Guidebook" which explains our purposes.

"We believe that continued horse use in harmony with the capacity of our public lands is in the best interest of the majority of Americans. The following from our constitution is the purpose of our organization:

'The purpose of this organization shall be (1) to perpetuate the common sense use and enjoyment of horses in Montana's roadless backcountry, (2) to assist the various government agencies in their maintenance and management of said resources, and 3) to educate, encourage and solicit active participation by various members of the general public in the wise and sustaining use of horses and by people commensurate with our heritage and our back-country's resources.'

"The Backcountry Horsemen hope to achieve their goals of continued responsible horse use, not as a pressure group, but as a service group to our backcountry resource. We've offered our time and equipment to various government agencies for such tasks as rolling up and packing out outmoded telephone wire, clearing trails, building end-of-road facilities, and other projects which will benefit both horsemen and non-horsemen. To further our goal of reducing or eliminating impact we have assembled a guidebook from suggestions and information from a vast storehouse of knowledge: commercial packers and outfitters, backpackers, horsemen, professional foresters and resource managers."

Our part in alleviating impact is mentioned here. We do cooperate with the Forest Service in constructing facilities not only at the trailhead but also in the backcountry. Some of you saw slides today of trees to which horses had been tied over lengthy periods. When horses are tied for quite some time, they often start to paw with their front feet, and after this has occurred for a few years, the trees die. In order to eliminate this, we construct hitch racks in heavily used areas. In a trail area where the ground is somewhat swampy and subject to erosion, we also construct a corduroy, that is, we use native materials to rebuild the
trail in such a manner as to help eliminate erosion. In the Bob Marshall Wilderness area I have seen some trail erosion, though not quite as severe as that we saw in the slides, caused by the off-road vehicles. But given enough rainfall and the right kind of soil conditions, I'm sure that would happen from horse use also. Through better planning, and reconstruction, perhaps, the erosion caused by horse use can probably be eliminated.

The use of off-road vehicles discussed by another speaker is interesting to us. As has been stated, different uses can quite often be compatible; for example, horsemen and drivers of off-road vehicles don't really antagonize each other. In Montana, the managing agencies have closed access trails such as those in the Bob Marshall and Mission Mountain Wilderness areas, to motorized off-road vehicles. Those closures were probably based to a great extent on safety than on impact. I shudder to think of what would happen if I were riding a green horse and happened to meet an off-road vehicle on a narrow trail.

The same is true of encounters with backpackers. Our areas are all open to backpackers, and we, as horsemen, don't object at all. Again, we sometimes have a slight problem with a green horse or a string of green mules encountering a backpacker in cut-off pants and a large orange pack with the sleeping bag rolled up on top. Horses just don't seem to be able to recognize those kind of things as human beings. More than once I've found myself heading down the trail rather rapidly because a backpacker suddenly appeared around a corner. We feel that the goals of backpackers and horsemen are pretty much the same, that is, the realistic enjoyment of the wilderness areas. And we do really try to cooperate.

Caldwell: This is the commercial. The Backcountry Horsemen of Washington, as Ken stated, was formed in April, 1977 as a separate organization from the Washington State Horsemen so as to better serve the trail-riding horsemen. We now have 375 members, after only a year's existence. And we are very much in accord with many of the basic tenets and ethics we have a brochure on basic ethics for horsemen to follow in the backcountry which we hand out to people who are going in at the trailhead. Our basic purposes are to work toward better education of horsemen, to make them more aware of the impacts of horse use in the backcountry, particularly the fragile areas, and to use all areas in such a manner as to minimize these impact; to work with public agencies, local, state and federal, in cooperative work programs to maintain existing, and to build new trails, trailheads and other facilities, for our and general public use; and finally, to become involved with public agencies in their meetings, hearings and planning, to show that horsemen are responsible citizens, concerned with the protection of our environment and the economy of our country and communities. We are trying also to encourage the development and construction of lowland trail systems in order to diversify horse use, to give the backyard horseman a place to ride which we believe will also relieve the backcountry of a lot of traffic.

Wilcox: Several years back, we recognized that horsemen are held in pretty low esteem by a good percentage, of backcountry users and managers—and for very good reason. You didn't have to look very far in the back country, to see evidence that too often horse use is very destructive of our wilderness environment. We saw that managers were responding to this environmental problem with an ever-increasing list of regulations and restrictions of horse use. We could see that eventually this might lead to total closure. There had to be another solution. I think we have found it and it is education of the horseman, by the horseman.

Last year we organized the Horseman Patrol, consisting of about 80 members who while on recreational trips in the back-country, met and preached minimum impact to the other horsemen they met. This Horseman Patrol is authorized by the Forest Service, under a cooperative work agreement and I believe it has done a pretty fair job for the short time it's been in effect, as quite a few of the wilderness managers will tell you. We hope we can expand this and eventually, the average user, the non-horseman, will realize the fact that horses properly used have no more adverse impact on the backcountry than people.

DISCUSSION

Bradley: I feel that wilderness areas can serve both backpackers and horsemen. One difficulty we're running into is the constant barrage of letters and comments from hikers that are anti-horse. We run into this every day, in the Eagle Cap Wilderness. Have you had any success in reaching out to backpackers, environmental groups and others
with negative feelings about horses, in trying to convince them that horsemen really are trying to protect the land out there?

Wilcox: I believe that this is going to require kind of a show-and-tell operation. First it is going to be an educational program to show them that this can be done. When we can point to the fact that damage from horse use is diminishing, then I believe we can say, "Hey, we're good guys too." Like the ORV and every user group, our whole user group is suffering because of a number of bad apples, who completely disregard the protection of the back country.

Bradley: Just having meeting like this I think is a big help.

Wilcox: Well, we have, in the last two years, probably conducted 40 meetings around the state in different areas, involving Forest Service managers, Park Service managers, state people, and the local horsemen; through these meetings, through preaching minimum impact, I believe we are helping. Last year, on the early buck hunt, we were being monitored closely because of previous damage on other hunts, and we didn't get a bad report. We had our backcountry Horseman Patrol out there, we'd done a little newspaper work, and we preached at meetings around the country.

When was the last time you closed the trail to a biker because there was conflict with a horseman as you close them to the horseman because the bikers complain? When green horses are taken into the backcountry at some peril to the horseman it is easy to blame other users when they react badly. Most of the horsemen I've run into in this state take that burden themselves. They talk about their horse misbehaving but say it was looking for a reason to misbehave anyway and the bike just gave it to him.

Comment: What's your experience been with off-road vehicles in these areas?

Wilcox: In Washington State we have had to learn to coexist with all users, including the bikers. And it has been quite a few years since I've had any problem with bikers. We hear them coming. By the rules of the trail they pull off for horses, but in most cases the horsemen hear the bikers coming along before the bikers know the horses are even in the country, and if there's an opportunity to pull off the trail, we do it. Sometimes there's a pack string behind us, and it gets a little hairy, but in that case, the biker spots us, he pulls up, he stops, he shuts his bike off, and wheels it off the trail and will pull aside generally, and stands there until we stream on by. We have no problem with them.

It's not quite the same with jeepers because we're not running the same trails, but we have found them in a number of places such as the Wenatchee Mountains. When jeepers come wheeling around a bend and spot horses, they pull right over and shut the motor off. But we don't have any problem with jeepers either.

Comment: Are you trying to reach out to people who are only occasional horse users such as people who use horses once or twice a year to get farther in for the high hunt and have no concept of wilderness?

Wilcox: Yes, we are. This is one of the purposes for the Horseman Patrol. We meet these people on the trail up in the backcountry. With the wet weather in 1978 most of the horsemen stayed home but we had pretty good contacts up there in 1977 and I talked with Bernie Smith, the recreation manager in the Darrington Ranger District; he gave us good reports last year.

In addition, several outfitters who are members of our organization have pockets of brochures and materials that they are handing out to many of the people packing in. Some of them are very adamant, but we are, I think, getting through to them. We've made a few of them change their approach.
Discussion during the Idea Exchange pointed out some of the issues in the area of water quality. Since this subject is so very important the editors have taken the liberty of including information from additional studies in the Pacific Northwest in order to indicate in general terms the status of current knowledge and need for further research.

In 1975 Rocky Mountain National Park started monitoring water quality in heavily used back-country areas to establish a base line. They found increases in the total coliform as a stream descended down Long's Peak in the park.

Because of this finding and recent giardia outbreaks, the public was informed of the possible hazard both on the trailhead bulletin boards and in back-country handouts. Management recommended that all water used for human consumption be either boiled or treated with chlorine or iodine. The Long's Peak stream contamination may be caused by animals as well as humans.

The Long's Peak example is illustrative of a general need for efforts to prevent water contamination. We really need some kind of technique to monitor back country lakes and streams and get the resulting information to the user.

There are a number of additional studies concerned with water quality which have implications for back-country recreation. As early as 1965, Dr. Fred T. Darvill, Anacortes, physician and guidebook author, conducted a study of high mountain water in the North Cascades and found that water sources commonly used by mountaineers are contaminated with bacteria originating in the stools of native animals, stock animals and human beings.

During the summer of 1978 Ted McDowell, Graduate Student, Geography, Oregon State University conducted a study of Ice and Aneroid Lakes, Eagle Cap Wilderness, Oregon. All samples were collected during dry weather. No fecal coliforms were present in water samples at Ice Lake. While horses had been excluded for seven years prior to the sampling, a limited number were in the watershed during the latter part of the summer season. Fecal coliform counts were found only on one occasion in one of the streams entering Aneroid Lake.

Deborah Berman and Susie Judd, graduate students, Public Health, University of Michigan, conducted a study in the Horseshoe Lake area, Eagle Cap Wilderness, and found weather conditions to be a major factor in moving pollutants into streams. There were no significant counts at the beginning of the 1978 season but fecal coliforms were found during a rainstorm in the middle of summer, indicating the potential for pathogens in the water.

The Darrington District in Mt. Baker-Snoqualmie National Forest started monitoring the Kennedy Hot Springs area in Glacier Peak Wilderness in the summer of 1978. Results were negative at the beginning of the season but at the end of the summer, especially during the rainy period, when it might have been expected to be a little cleaner, it was extremely polluted.

Drs. Robert Lapen and Robert Pacha, microbiologists, Department of Biological Sciences, Central Washington University, in cooperation with the Pacific Northwest Forest and Range Experiment Station have studied the effects of cattle on the microbiological quality of water in Wenatchee National Forest. The presence of cattle apparently increases the number of fecal bacteria in surface waters. Rain accelerates the movement of fecal bacteria from soil to surface water. These bacteria can survive 4 to 5 weeks in streams and for more than one year in bovine stool.

Gordon A. McFeters et al, Department of Microbiology, Montana State University studied selected waters from the high alpine zone within Grand Teton National Park and analyzed bacteria indicators during the sum-
mers of 1972-1974 to determine the influence of various factors on the quality of these waters. The study indicated that the presence of humans in the high alpine zone had minimal effect on the aquatic microflora. The nature of the flora and fauna of the biological communities through which the streams flow affects the numbers of bacterial indicators. Several bacteria known to cause disease in man have been isolated from wild animals. However even by monitoring the safety of drinking untreated water cannot be assured since the action of a single careless individual could create a health hazard.

The authors also pointed out the difficulties in establishing meaningful water quality criteria for pristine waters. At present it is relatively easy to show when water is unsafe but extremely difficult to indicate by use of bacteria indicators exactly when water is safe for human consumption.

Donald L. Johnstone and A. Mark Kubinski, State of Washington Water Research Center, Pullman, examined pathogens in oligotrophic waters and the factors in the natural self-purification process in the North Cascades in 1973. Their study showed bacteria indicators tend to survive longer in cold water. It also emphasized the delicate nature of high-quality waters and the need for strict sanitary guidelines to ensure their future safety and quality.

Another water microbiology study in Grand Teton National Park by McFeters (1976) indicated that horse camps and corrals should be planned for areas where drainage is not likely to go directly into a watercourse. In addition, soil porosity and ground water levels should be critically evaluated to prevent or minimize contamination of streams.

Researchers noted the difficulty of collecting and analyzing water samples. Standard methods for the examination of water and wastewater required that no more than six hours pass from the time samples are taken until analyses are initiated at the lab and that the samples be kept iced while being packed out. A holding medium which allows a longer delay in placing the sample in an incubation medium would be valuable in sampling high mountain waters.

A delayed incubation technique has been tentatively accepted according to the American Public Health Association's 14th Edition of the Standard Methods for the Examination of Water and Waste Water (1975). This technique requires filtering the water sample for analysis of fecal coliforms as soon as possible and placing it on a holding medium. Not more than 72 hours should elapse before the sample is placed on the incubation medium and incubated at the standard temperatures.

Despite tentative acceptance by the American Public Health Association, work in 1976 at Central Washington University by Varness indicates that delayed incubation may not be an acceptable analytical tool. He compared fecal streptococcus and total and fecal coliform counts after holding periods of 24, 58, and 72 hours at 4°C with counts from immediate incubation. Delayed incubation did not significantly reduce fecal streptococcus counts, but fecal coliform counts were significantly and unacceptably reduced for all holding periods relative to immediate incubation. With the exception of one holding medium for 24 hours, total coliforms were also significantly reduced by delayed incubation. The 72-hour holding period reduced counts by nearly 50%.

Other suggestions affecting managers and users emerged from the discussion. Briefing managers on the newest technique and methodology of water samples and establishing a reporting procedure would make it possible for their research efforts to be added to total data available. Users from organization groups, provided they were properly briefed might be able and willing to bring samples back regularly from selected sites such as those on scheduled climbing routes.

Giardiasis is another object of increasing interest among outdoor recreationalists. Giardia is the most common fecal parasite in the United States. In November 1978 a Giardia Conference was held by EPA Lab in Cincinnati. The parasite can be transmitted by water or by fecal/oral mechanisms with potential risk factors perhaps more likely during the summer months. Nevertheless, a clear seasonality to giardia infection in Washington State has not been demonstrated.

Giardia infection can lead to asymptomatic carriage of cysts or acute or chronic illness. Experimental studies have shown that the number of organisms ingested bears no clear relation to severity of
symptoms, suggesting that host factors are important. The exact pathogenic mechanism of giardia infection is unknown. Laboratory diagnosis of giardiasis is best accomplished by microscopic examination of passed stool by an experienced parasitology technician. The number of parasitology specimens submitted to the Washington State Public Health Laboratories has roughly tripled over the last five years.

The Health Service Division, Washington State Department of Social and Health Services, with funding from the Environmental Protection Agency has been studying giardia infection in Washington for the last 18 months. By April 1979, the study has found:

Some 500 cases of giardiasis have been reported in a recent 8 month period. The incidence is undoubtedly higher since not all those who contract giardia see a physician and not all physicians report cases.

Roughly 25% of investigated giardiasis cases among persons over age 10 have no obvious source of infection identified; about half of the cases were related to drinking untreated water.

There is some evidence that beavers and muskrats may be carriers, transmitting the parasite to humans, but other mammals may also be carriers. In the Rocky Mountains, elk are suspect. Since 1976, animal samples provided by commercial trappers from 30 counties have been tested and positive samples found in 20 counties in both the Cascades and Olympics. Recent animal trapping in many areas of the state has turned up about 16% giardia positivity in beaver and 32% in muskrat. Where animals get the infection is unknown.

Last fall 17 of 23 members of a brush disposal crew working in the Olympic National Forest contracted giardiasis. Their water was obtained from a tanker truck filled at the most convenient spot in the field, a beaver pond.

Fecal coliform which is used as an indicator organism for measuring the potential of bacterial pathogens in the water does not measure the presence or absence of giardia. However, the chances of giardia are greater when there is a high fecal coliform count. It is possible, though extremely difficult, to detect giardia cysts by microscopic examination of specially filtered water samples.

The best means of preventing giardia infection is avoidance of potentially contaminated water. Backcountry travelers, especially in areas frequented by aquatic mammals, should not drink directly from stream. The most effective disinfection procedures is to bring water to a rolling boil before consumption. Another approach is the addition of iodine crystals.

Backpackers who enjoy drinking from a cold clear mountain stream wish there were a method for getting an instant indication as to whether the water is safe to drink but there does not appear to be such an indicator coming on the market or being developed in the next few years. The recognized method of obtaining an indication of pathogens in the water involves culturing the organisms for an incubation period.

The USDA Forest Service, Recreation Research, Seattle is preparing a state-of-the-art on water quality and human use. Anyone having information about reports and studies on this subject should get in touch with them. Only by pooling the information we now know can we begin to come to grips with the problem. The problem of water quality and backcountry recreation requires not only more attention but greater cooperation between researchers, managers and users.

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Abstract--Summary of a study conducted to determine what information is being sent to users by the national parks and monuments and national forests with responsibility for wilderness. Educational approaches tried on various wildland areas and the attitudes of managers toward the role that education will play in reducing impact are summarized. Ways in which individual users and land managers can educate the wildland user in the intent and techniques of minimum-impact travel and camping are suggested.

Introduction

In 1971, after completing four years in the Air Force as a survival instructor, I founded the Institute for Survival Education in Seattle, Washington. My intent was to offer survival education to the general public. During the past five years, however, my human-survival emphasis has shifted to give equal time to the techniques and need for survival of wildland environments.

Any wildland environment that is open to recreational use needs protection from undesirable change on the land by the ignorant or thoughtless. This is accomplished either through regulation or education of the user. This paper will look at various alternatives to strict regulation of the wildland user and encourage managers to place more emphasis on viable educational programs to reduce impact. Also, recommendations will be offered that should allow the experienced wildland traveler to more readily share his or her knowledge with individuals and groups.

University of Minnesota Study

In 1977 I did a study of written materials land managers of wilderness areas and national park backcountry were sending to users. Of most interest were those materials suggesting techniques for minimizing environmental impact. My results indicated that very little was written dealing with the concept of minimum-impact travel and camping. In fact, some managers were sending information (USDA 1972, 1976) that contained pictures of antiquated and destructive camping techniques. Included were pictures of using natural poles for shelter material, cooking over a fire (not necessarily bad, but not always desirable in wilderness and backcountry), and how to safely clear a fire-circle on previously unused ground, with no regard for returning the area to its natural state.

Though little material is widely distributed, staff at many national parks and forests are really creative in their handout material and general approaches to educating the user regarding impact. These vary from talks by rangers and handouts devoted to minimum impact and backcountry manners, to a pervasive emphasis throughout the Backcountry Management Plan (Olympic National Park: 1976) to insure that impact is considered in all phases of management.

Summary of Results

All national parks and monuments with over 20,000 acres and all national forests with management responsibilities for wilderness areas were surveyed with a letter. The letter asked respondents to:

Send copies of any materials normally mailed to persons requesting information in anticipation of a trip on their lands as well as any specific material on...
Tell whether or not their forest or park had attempted to demonstrate minimum-impact skills to visitors;

Comment on the potential role of education in solving the problems of wildland abuse;

Make any additional comments, recommendations, resources or additional information that will help determine the "state of the art" of minimum-impact education.

A total of 84 national forests, 49 national parks and monuments, and 34 miscellaneous organizations within the U.S. Forest Service (informational only) were mailed the survey letter.

A total of 106 responses were received, a 78.1% overall response rate: the forest service return rate was 70.7%; the National Park Service return, 91.3%. This was really encouraging, considering that no follow-up letter was used. Managers are obviously concerned with all methods capable of reducing user impact on their lands.

Responses to the Questions

Of the responses received, 88.7% included some form of written response to the survey questions. This is a true indication of the importance of the subject to management.

A total of 864 maps, pamphlets, handouts, rule-and-regulation sheets, backcountry plans and miscellaneous materials were received. The national parks and monuments contributed 205 pieces while the national forests sent 659. It would appear there is plenty of material available even though there is substantial duplication; also, changes in emphasis are needed.

To the question, "Has your forest or park made any attempts to demonstrate these skills (minimum impact) to visitors? If so, how?" responses were as follows:

35 indicated no attempts have been made;
31 provide handouts or brochures but 6 stated they were sent only on request;
28 encourage contacts by rangers where possible, with the greatest number occurring in the field;
17 give slides, films, and lectures upon request or as part of an existing program;
14 emphasize minimum impact in these programs
9 contact various media such as TV, radio, and newspapers;
8 conducted naturalist programs;
6 hold demonstrations in the field for educational purposes; and
2 have developed a display.

In the majority of management units relatively little is being done to educate the user, so there is a lot of room for the ingenious ranger to be creative in his or her approach.

To the question, "If practical, comment on the potential role of education in solving the problems of wildland abuse."

13 said education is the answer;
26 said education plays a major part;
15 said education plays a part;
3 said education will have little value, if any;
23 did not directly mention education at all.

This indicates that education takes a high priority in many managers' minds. Twenty-six respondents said they thought the project was worthwhile and 16 stated they want a copy of whatever is developed.

Comment on the Results and Current State-of-the-Art

Even though the survey was conducted two years ago, much still needs to be accomplished. Many agencies and areas are receiving serious fiscal cutbacks, reduced personpower, and increased visitation on a yearly basis. Since many managers are in a "survival mode" of doing what is essential and not "all that could be done if only . . ." creative approaches to minimizing user impact are more important than ever.

What Can Be Done
Whatever approach individuals and managers take toward minimizing impact, combining forces is a must. Seek out the resources and approaches available to you in an area. Invite user groups and management groups to address the problems together. Shared ownership of the solution to a problem, even if it requires strict regulation, will be much more easily accepted and followed.

The ideas I'm sharing in this paper have evolved from many sources and people. Many of you have undoubtedly found some of these unrealistic for your areas or thought of creative methods. Whatever the case, more can and must be done.

People often comment that regulation is the only solution because some people won't change. In many situations, education won't change people who feel they have a right to act differently in an area or aren't concerned with depreciative behavior. In these cases, non-education approaches such as regulations and enforcement are necessary and the only reasonable option.

However, much damage is done by the poorly informed or uneducated user. Scientists and educators have often cited the need for a more informed wildland user (Hendee, et al., 1968; Lucas, 1974; Lime, 1975). Much of the damage sustained by the environment can be lessened through education of the user (Petzoldt, 1974).

What Individuals Might Do

You might feel that individually there is little you can do to impact or educate people in the skill of minimum impact. Considering your background and experience, there are many organizations that will gladly put your expertise to use.

Inventory your skills and knowledge. How many years have you been traveling the backcountry? Do you have a lot of equipment? Can you camp comfortably? Can you identify and treat the common cold, heat injuries and first aid problems people may face when in the wilds? When you understand what you know and need to learn, gain these skills and offer to teach others. Fear (1975), Mitchell (1975), Manning (1975), and Petzoldt (1974) have all written excellent books on various aspects of wildland travel. Many fine works exist other than these cited here. Check your library.

Offer your services as a guest lecturer/teacher for scouting groups, church groups, schools and others. Many organizations are looking for people with basic equipment and knowledge to put on demonstrations for their respective audiences.

Gather other "experts" and run a course for the general public on wildland travel. Such topics as hypothermia, clothing, equipment, packing, sleeping, warm, cooking, first aid, hiking, map and compass, emergency survival techniques (not wild foods or traps and snares--few people die of starvation), and wilderness philosophy are some possible topics. Minimum impact should not just be a topic in a program, it should be the underlying theme of everything that is said. Teach positively. Don't threaten "death" if one doesn't do what is required.

Offer to help your local land managers (Department of Natural Resources, national forests, national parks, Bureau of Land Management) in any way practical to help educate the user. Running seminars, setting up displays, talking with users, and clean-up in the backcountry may be options. Sell yourself and your ideas and demonstrate how you can be of real service and not just another management problem.

What Managers Might Consider

At first glance some of these might seem impractical or impossible. Whatever you do, give it a fair consideration. Any good program has to have a good deal of preparation and planning.

Feed teachers, educators, and the media with really creative educational materials. They are often looking for interesting methods of teaching and informing their respective audiences. Four agencies that have a history of doing exceptional jobs in this area include: 1) Pacific NW Region, National Park Service, Seattle; 2) USDA Forest Service, Region 6, Portland; 3) USDA Forest Service, Wallowa-Whitman National Forest, Baker, Oregon; and 4) Minnesota Department of Natural Resources, St. Paul.

Send your staff into the community to guest lecture. Schools and groups find the idea of a "Ranger" putting on a program really appealing. Many Forest Service and Park Service people are eager to share their knowledge if encouraged to do so. You may even be able to recruit people from colleges and universities to "represent" you as a

334
voluntary, educational "arm" of your forest or park.

Set up both static and dynamic displays to educate. Static displays are often used to depict natural history and relevant information about an area. Consider adding displays depicting a properly dressed and equipped day hiker; or what to do if one gets lost; or why a wood fire is often unnecessary and the advantages of using stoves.

Dynamic displays are those in which you actually become involved. Try setting up a trailhead display showing a properly pitched tent, a ground pad and sleeping bag, a vestibule in front of the tent for a dry area in which to cook and socialize, cooking over a stove, a demonstration of equipment colors that blend versus ones that stand out in the natural setting, use of a signal mirror in case of an emergency, and others. You can either commit your staff (often too busy) or solicit volunteers to answer questions, run talks, give demonstrations, and watch the equipment. What better place to educate users than when they are getting ready to depart into the backcountry?

Some people may argue that it consumes too much time away from users' trips and they won't take the time. If the displays are set up well, strategically located, and interesting, people will stop and learn.

Update antiquated and misleading materials to reflect minimum-impact travel and camping and modern approaches to non-consumptive recreational activities where appropriate.

Minimum impact leaders' course. This may prove to be your biggest ally by insuring educated outdoor leaders and supplying a source of volunteer educators for your other programs.

Every geographic area has group leaders who run programs on your wildland environments. These leaders (scouts, churches, clubs, conservation groups, colleges, commercial ventures, and others) all have the capability to influence the conduct of many (often young) people while in the wilderness.

Once you have them identified, invite them to attend a week long "Wilderness Leadership Seminar" sponsored by your agency on the lands they often use. Give them two or three days of academic instruction and then break them into small field groups under the leadership of one of your staff familiar with minimum impact and human survival techniques. These leaders will become strong advocates of the knowledge gained if it is presented well. They will be eager to incorporate as much of the material into their programs as possible.

This endeavor will require a great deal of planning and cooperation among many people. If the participants feel they were selected because of their leadership ability and background, how can they refuse you an invitation?

Use non-career people in backcountry. Legal restrictions aside, there are many very qualified people who would love to spend time as a volunteer ranger policing up areas, checking camps, meeting campers and educating users. Check with rescue agencies, sheriff's offices, backpacking stores, clubs and organizations for qualified volunteers. After they have been selected, require their attendance at training sessions to learn protocol, procedures, techniques, philosophies and methods of land management, human survival and the minimum impact techniques you want stressed.

Insure your field people are adequately trained. An untrained and unskilled ranger is of questionable value to those in need of help or education.

Recognize the importance of the example set by your staff. If they are clad in inadequate clothing such as cotton jeans instead of wool pants in snow country, they are setting a bad example. After all, "if jeans are good enough for the ranger, they are good enough for me." Traveling alone as a ranger while encouraging users to go with someone else appears to be inconsistent behavior.

Increase the educated users' freedom. This may be the toughest area to define and administer, but it may prove to be a very equitable management tool. If one can prove his or her human survival and minimum-impact ability via test, conversation, proven ability, experience and background, or whatever criteria set, let them go into areas that may otherwise be closed because its "carrying capacity" has been reached. This doesn't discriminate against non-educated users since they can use the area until its carrying capacity has been reached.

The rationale for letting the educated
users in is that they have the ability, knowledge and equipment necessary to travel unobtrusively along the trail or cross-country, select a camp away from the heavily used areas, and leave no trace of its existence when they move on the next morning. These experienced people won't bother those already in the area nor will they impact the wildland environment.

The difficulty comes in establishing the criteria that will equitably prove the competence of the user. I argue that an experienced land manager can "get a feel" for the competence of users in conversation and by observing their equipment. If they plan on using fires, have bright equipment, are underequipped or inappropriately clothed, and can't correctly describe the correct techniques of food and waste disposal and cleaning their utensils and bodies, don't let them go. You might also ask them why they should be allowed to go— their answer may prove enlightening.

Wildland managers have attempted this competency judgment and find it difficult to insure equity (mostly because of wide experience differences in the rangers making the decisions). When users and managers describe the criteria together, it helps resolve disparities.

A few brainstorming sessions with your staff and local resources will probably yield some viable options. Try them and modify them until they work. Then share this approach with other rangers on other lands.

What Will Be Done

If you feel none of this will work in your area, it won't. On the other hand, if you want to do more and are willing to spend the energy (whether you are a user or manager) some of these ideas may prove to be options available to help you reach your goal, thus minimizing impact upon wildlands by all users and user groups.

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In the last session of this conference, 300 people shared for three hours what they felt they had learned to guide their own role, and the roles of others who comprise the uneasy triumvirate of manager, researcher, and user of wildlands. It was both a difficult and rewarding session: difficult because of our inevitable differences and the elusive nature of our central problem; rewarding in that experiences and imaginations created a flow of ideas and insights distinguishing where we were from where we were going.

How to conceive, represent, and manage recreational impact is a 'systems problem', and yet, we are individuals who by necessity must experience and conceive the problem in highly individualistic ways.

"We need a framework to stuff it all into"..."a framework that allows you to look at alternative value systems in terms of user-defined perceptions of impact..."But then, is it really the perceived impact that is critical?

"Acceptable impact level should be based on some sort of ecological changes... In an area that's very fragile, the ecological carrying capacity might set a limit long before the social capacity has been reached."

"Acceptable impacts. This keeps coming up. What is an acceptable impact?"

"And how do we define what is acceptable and unacceptable? I think that's the biggest question here, and we really haven't talked about it much."

"(What) I found a little bit disappointing was the continued reluctance of all three of the groups to confront the idea of acceptable impact, and who decides."

"Should it be a majority rule among the users?"

"Should it be an educated guess on the part of the managers?" (And how much input should the researchers have into that?)

"Acceptable impact level should be based on some sort of ecological changes, whether or not these are apparent to most people."

"But other people say that they ought to be based on more evident visual kinds of evidence that at least maybe more perceptive visitors can see."

"(It) kind of seems to me that maybe the answer is that it's a little bit like the model that's been used before of social and ecological carrying capacity that might set a limit to permissible use."

"This concept of acceptable impact is really a very complex idea." So it would seem. And as this session illustrated, the conferees had not been able to come to a satisfactory definition of what 'carrying capacity' might mean in terms of recreational usage, even though the concept appeared to be an attractive one.

Technically, 'carrying capacity' refers to the ability of a resource to absorb a particular kind of use while constant measures are maintained on a set of variables that monitor the 'quality' of the resource.

An effective delineation of 'carrying capacity' in any useful sense means that the resource quality variables must be defined and measured. The particular types of use variables must be characterized, and then use quantity change must be related to resource quality change through an appropriate system of transformations. This kind of 'modeling'..."
treatment would bring the conferees line of thought to an operational condition. Very likely the development of such 'carrying capacity' models will become a central research area in the near future.

Of course, such models, as they encompass the language of the systems theorist or the mathematics of the researcher could well be difficult to translate into the unavoidable realities of the impact manager or the primary sense experiences of the wildlands user. No researcher's model, however elegant, is fully realizable unless it can be successfully communicated to managers and users. And communication was another primary source of concern to the conferees:

"This whole conference points out that these groups don't have to work independently or in isolation from each other."

"I saw that there was a lot of research that had been going on, for example, in trampling impacts, that in my experience was simply being underused"... It's partly a communication problem, partly a problem that it's nobody's job to do that... There's no one trying to pull what is usable out of the research, and say where it's usable, under what circumstances."

"Well, I'm a planner, and we (planners) fall in between the research and management side of this, but I haven't heard a lot said about planning..."

The conferee was correct in his perception. Not much has been said about planning, and yet, it is in precisely the planner's role that part of the communications gap--that between researcher and manager--might be bridged.

But bridging gaps requires more than finding a communicator. It also often requires a change of perspective or thinking on one or both sides.

"An illustration of the difference in the perspective of the researcher and the manager is that a lot of research work (relating to impact) was done with extremely scientific methods, but when you look at the methods used by the managers to carry out researched conclusions, you find that they are frequently not nearly as refined"... "I think that learning how to fudge with precision is a sort of key to communication between the researcher and the manager. For example, although there are all sorts of indices for impact on vegetation, the real index, in the field, is how much bare ground there is. Learning how to economically collect sufficient information for decisions is the problem here."

To the researcher, the pursuit of scientifically derived fact is independent of the decision-making process; fads are elements of many types of decisions. But the manager requires facts that are most relevant for each decision alternative. And these change drastically, not only with states of nature, but also with the options open to the managers. In this respect, it is not what is 'true' or what is 'significant' at the .01 level that the manager needs to know. It is, rather, what is significant for the immediate problem.

"If the manager says, there's a problem up on the hill, go and do some research on it, he's going to probably get something fascinating and esoteric, but maybe not very useful. He has to be very specific of what the requirements are, and only then can the researcher home in on a particular problem and the results will be much more applicable, more easily interpreted." That is, if the problem (or the manager) is still around when the research is finished.

"...where we get into continual frustration between managers and researchers is in the whole time dimension. The manager has a problem we need to solve now, and by and large, the researcher is working in tomorrow's lap. It's important that we as researchers make our best shot, now, today. It has not been too long since we as researchers were really punished by stepping out and saying "Here's what I believe now, and maybe a lot of it's my opinion because I don't have all the facts.' Research evaluation panels can really ding you for stepping over the line from objectivity to subjective judgment. But it's important that we do that, as you've heard happen at this conference."

And in this speaker's urging, there is also a glimmer of the future. The mere occurrence of a conference of this sort has provided a forum for managers and researchers to express something of their personal conflicts and values to each other. Communication is possible if the appropriate opportunities are provided, and it seems safe to predict that many more future conferences will be organized to promote such cross-role exchanges.
But what of the 'users' role in this regard? Both the manager and the researcher have vested professional/career interests in achieving a mutual understanding. Is the user inevitably left to play a much more subsidiary role?

"User, how do you really have some input that means anything? How do you really influence decisions? It's frustrating that all the methods of input--letter writing, testifying, and all the rest--lose their meaning on the bottom line. Every day, at least twenty new public hearings, EIS's, area plans, backcountry plans, master plans, and all these things, are asking you for your comments. But there's just too much of it, too fast. I think that as a manager, I'm more aware than I was before at user frustration with trying to have meaningful input."

"But I wonder if we really don't also have as a problem the vast majority of users who don't participate in anything. One thing that's emerged from this conference is the growing awareness on the part of the managers that we really have a big job to do in reaching the bulk of our users that we ordinarily don't communicate with. A good example is our interpretive programs. We take such pride in them, but we only reach a very small percentage of park visitors for a great deal of effort. At best, we probably only reach 5% of the people who are passing through our area. I propose we need to focus much more attention on contacting the general public."

Of course, the form that such an intensive program of public contact might take is another item for our agenda of the future. It is perhaps here that the most innovative ideas are still awaiting expression.

"The East seems to have had a tremendous amount of success with involving users and giving them responsibility. Maybe that's the answer to some of our problems here."

But there is another side to the same coin. What about users that deliberately seek out an active involvement in the impact management process?

"I wonder if the managers are not neglecting a potential source of research expertise by not tapping volunteers? I think managers tend to be somewhat suspicious of volunteers generally, . . .but maybe managers should explore the idea of utilizing volun-

teers, not just for grunt work, but for research."

"I believe that members of user organizations would be receptive to coming to, say a series of seminars with managers or researchers, to learn what the specifics are and how they can handle it. We've done this basically in bringing together about fifty people to learn how the Forest Service operated. We could do the same thing with this impact business."

"What indeed would be the contents of a good program on minimum impact? Could there be some basic, small programs--evening programs and seminars--to groups, any organized group that is looking for a speaker?" But from the manager's perspective:

"We want to use volunteers, and we do use them, but there's a limit. Volunteers want to work in your area, and they need a place to stay, and we don't always have housing or facilities to put them up. One of the other problems with volunteers is that they want to come in to do the projects they like to do. They really don't always want to do what we (managers) feel we really need done.

Why don't you volunteers, with information that you have available to you on minimum impact get out there and become a scout master, a den mother, or whatever. School systems have all sorts of volunteer programs, too. Go to these school systems and help them."

"As users, we need to pull together ingenious ideas about uses for volunteers and communicate those ideas to you in management agencies. I believe there is an opportunity if an agency can change its configuration. The present configuration doesn't leave enough people available to provide the necessary volunteer leadership. An unsupervised volunteer is a disaster waiting to happen.

But give some thought to altering your agency configuration gradually to take advantage of some of the ingenious skills that exist in an audience like this."

At this point, it might be useful to recall an old proverb that goes something like: "Any agency is harder to reorganize than a cemetery." But the preceding exchange does point out some of the basic problems that inevitably confound the most well
meaning intentions shared by manager and user. By and large, individuals may not be equipped to perform much more than the most routine aspects of specialized managerial tasks. And the organizations that are responsible for such tasks have not been designed to allow casual participation by outsiders.

But there are good examples, such as community crime-prevention programs, or block-watch organizations, that demonstrate that agencies which acquire the ability to reach out are often able to develop significantly beyond what pure internal efforts alone would achieve. These sorts of program innovations have yet to be established in the agencies responsible for natural resource maintenance, but it seems reasonable that the future of impact management will be influenced by incorporating individuals who might come to be seen as 'paraprofessional volunteers'.

But regardless of how roles may be established or agencies restructured, it should be apparent at this point that what is required for these interacting parts is a sustaining image, a conceptual net into which the impact problem might be cast so as to view it, however transiently, as an understandable whole. Professor Valerius Geist of the University of Calgary proposed such an image when he spoke of the problem of impact management as a "Commons Problem".

"A Commons Problem is one of a large number of users for a limited resource, each of which has equal access.

"According to Garret Hardin a Commons Problem has no enduring technical solutions, but only political solutions, so that an inevitable crunch comes down somewhere. Now, the inevitable crunch on the problem of the commons is either:

- An increase in the size of the commons, which means that some land user is going to have to give us his/her exclusive use.

- A reduction in the uses of the commons, while leaving the number of users as they are. Ultimately this would mean developing a technological cocoon around each individual wilderness user in such a fashion that impact is minimized.

- Reducing the number of users, so that the freedom of actions may be maintained, and this means that you have either direct or indirect restrictions. Direct restrictions are lotteries or whatever, while indirect restrictions lie in an area of policy that somehow regulates use. A policy of not upgrading certain roads, for example, indirectly removes an area from those who would only reach it via the family car.

"The activities that scientists, managers, and users have been most concerned with up to now save time at the very best, but they do not circumvent the ultimate political crunch that any use of the commons entails. Should we not spend a little of our time thinking about what forms that political and social solutions to this problem might take?"

While Professor Geist is correct in his assertion that technical solutions only delay the inevitable here, it is nonetheless unavoidable that this is the type of solution that participants in this kind of conference are most able to conceive. Wildlands users, managers and researchers possess neither the politician's ability nor the social technocrat's motivation to pursue a 'Commons' problem in these other contexts. The regretful conclusion is that the future will probably see more social/political 'solutions' imposed on wilderness recreation from outside sources that result in diminishing the room for 'technical' solutions. For those users, managers, and researchers who find this distasteful, it would seem that the only alternatives are to become politically adept or to quickly adopt successful small-scale technical solutions that in turn constrain the application of future social/political decisions.

In this regard, there were certain short-term strategies raised by participants that deserve mentioning here, in order to illustrate both desirable and avoidable consequences.

A tempting short-term strategy is "to relax the present standards we've adopted to only serve the benefit of the average user" and not try to maintain conditions beyond what the average user might expect. But as the same speaker pointed out, extrapolating this to the future (with its apparently increased demand) would mean that the average conditions we adopt today would be likely
viewed as the best conditions later on. This
leads to a successive slippage, as it were,
that incrementally results in eventual
deterioration of the resource.

Of course, there could be productive use
made of relaxed standards in terms of what
has been called a 'sacrifice area'. This
means that certain areas are allowed to
degradate, deliberately sacrificed to the
satisfaction of high demand so that other
areas may be sustained in a more pristine
state. The idea is a more prosaic version of
what may be inferred from Dr. Clark's Recre­
atinal Opportunity Spectrum concept.
Depending on the recreational purposes
people have, it is not necessary to maintain
pristine conditions for users whose inter­
action with the outdoors depend upon such
conditions. Certain areas can be developed
to more relaxed standards that will fulfill
the recreational demands of a proportion of
users, and thus will allow other areas to be
maintained to more exact criteria. In
essence, this is a problem of establishing a
satisfactory trade-off between degrees of
impact on different (resource) areas, where
the two conflicting values are resource con­
dition and user satisfaction. Fortunately,
there are decision analysis techniques
available to assist this process (see, for
example, Keeney and Raiffa, 1977) although
such quantitative methods may be regarded
with a great deal of suspicion by concerned
conservationists and others.

In summary then, the final session, like
the conference, reminded participants of
their differences in perspective as well as
their unity in concern for the recreational
natural environment. The conferees came to
no final conclusion on "what is acceptable
impact, and what is not". But there was
certainly extensive exploration of the
ecological and social implications of this
kind of judgment. By themselves, these dis­
cussions contribute significantly to how the
acceptable impact question can be resolved in
more specific contexts. As this session
summary has attempted to illustrate, the
identify of those who ask the question, the
conceptual framework within which it is con­
strued, and the available decision
technology all combine to produce the end re­
sult. Perhaps emphasizing this is "making
the problems difficult" as one conferee
lamented, and may even leave a hollow feeling
of what one is expected to do next.

"Go home and get one concept--just one
concept--across to some young group", is the
advice of another participant.

"If we each go home and get one concept
across to a group of young people, it will
get the step going." With the magnitude of
the task, and the time remaining, this author
can only observe that any steps, however
small, will certainly be courageous ones.

REFERENCES CITED

Keeney, Ralph L. and Howard Raiffa. 1976,
Decision analysis with multiple con­
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The INSTITUTE OF GOVERNMENTAL RESEARCH, University of Washington, is concerned with public policy research particularly problems concerning the state of Washington and the Pacific Northwest. One of its objectives is to participate in identifying and solving major public policy problems through the application of a variety of disciplines. Also the Institute disseminates information on the analysis of public problems and applicable research findings to technical and lay audiences through conferences, television programs and publications.

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