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The Carrying Capacity Of Wild Lands For Recreation

BY
J. ALAN WAGAR

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Preface

The study reported here was initiated with the view that the carrying capacity of recreation lands could be determined primarily in terms of ecology and the deterioration of areas. However, it soon became obvious that the resource-oriented point of view must be augmented by consideration of human values.

In this monograph the author has described an ecological experiment and has included ecological discussions. But in weighing the merits of limiting the numbers of recreationists, he has also considered the objectives and values of using land for recreation. Since these considerations go beyond available data and beyond the possibilities of reasonably small experiments, much of this study is at an abstract level. Accordingly, many of the conclusions are based on a reasoned analysis rather than measured data.

Acknowledgements

The author wishes to express his gratitude to those who have contributed to this undertaking. For comments, advice, and encouragement that have strengthened this study from the first outline to its final form, particular thanks are expressed to the doctoral committee: Professors Grant W. Sharpe, Stanley A. Cain, Kenneth P. Davis, G. Robinson Gregory, and Harlow O. Whittemore. At the Northeastern Forest Experiment Station of the U.S. Forest Service, Hubert D. Burke and Warren T. Doolittle reviewed the entire study; C. Allen Bickford and Kenneth D. Ware reviewed the handling of statistical data. The Division of Parks in Michigan's Department of Conservation gave permission for the field study on its Brighton Recreation Area; Leonard W. Bierlein, then manager of the area, was very helpful. Glen P. Bruneau, of the Department of Wood Technology, University of Michigan, helped build the tamp used in the field study. Lastly, and most of all, the author is indebted to his father, J. V. K. Wagar, for years of stimulating thought concerning the management of wild lands.

The author has selected, interpreted, and omitted ideas from the wealth of materials suggested by these people and is solely responsible for any errors that remain.

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J. ALAN WAGAR

Abstract. As increasing numbers of recreationists visit wild lands, some values are so diminished that many people have wondered if these lands have maximum carrying capacities at which recreational use should be limited. This study analyzes the carrying-capacity problem in terms of (1) the impact of the recreational environment on people, (2) the impact of people on the recreational environment, and (3) management procedures to modify these reciprocal impacts. The study includes an analysis of the human as well as the ecological and management considerations that must go into administrative decisions to limit recreational use. It also evaluates the probable effects of crowding on satisfaction of the needs and desires that motivate wildland activities. Ecological considerations include an experiment in which recreational foot traffic was simulated on a series of vegetated plots. Management considerations include zoning, engineering, interpretation, and persuasion. Ten conclusions are given. Among these are: (1) Recreational carrying capacity is not an absolute value inherent solely in the ecology and characteristics of each land area; (2) accepting limitation of use is only one of the costs that can be paid for quality recreation; (3) for some kinds of recreation, management procedures may permit high rates of use without a reduction in quality; and (4) relationships between vegetation, visitor use, and site factors can be described and used as tools for predicting the impact of visitors on recreation areas.

Introduction

MANY CITIZENS of our relatively young nation still crave the vigorous outdoor adventure, vast space, and freedom that are so prominent in American traditions of self-reliance, fortitude, and pioneering. In recent years better highways and automobiles, increased leisure time, a rising standard of living, and an expanding population have contributed to an explosive increase in wildland recreation (Fig. 1).

Although most people in the United States no longer accept the cut-out-and-get-out exploitation of timber, our attitude toward wildland recreation is often one of exploitation. We still tend to think of recreation primarily in terms of access rather than as something to manage on a sustained basis. National traditions hold that wildland recreation is free, is a right and heritage, and is available in undiminished quality for all who seek it. But quality in such recreation is no longer assured merely by provision of access.

The author is Leader of the cooperative recreation research unit of the Intermountain Forest & Range Experiment Station, Forest Service, U.S. Department of Agriculture, located at Utah State University, Logan, Utah. From 1959 until July 1962 he served as Research Forester in recreation studies at Warren, Pennsylvania, with the Forest Service's Northeastern Forest Experiment Station. This paper is based on a doctoral dissertation accepted by the University of Michigan in 1961. Manuscript received Oct. 11, 1963.

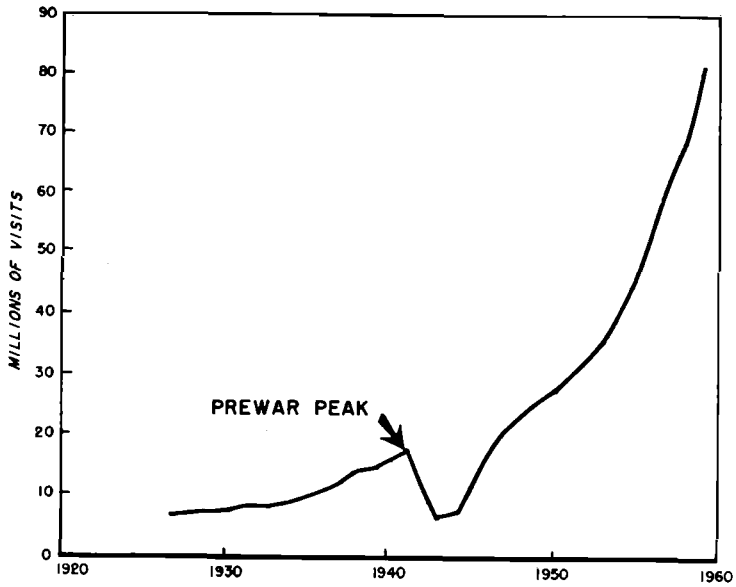

FIGURE 1. *Recreational use of the national forests. (Adapted from "Operation Outdoors," U. S. Forest Service 1957.)*

When too many people use the same area, some traditional wildland values are lost. Adams (1930), Meinecke (1932), and Leopold (1934) wrote of this even before the big increase in outdoor recreation after World War II. And articles such as "Let's Close the National Parks" (DeVoto 1953), "It's getting Crowded in the Great Outdoors" (Anonymous 1957), and "Crisis in Outdoor Recreation" (Clawson 1959) appear with increasing frequency.

Swamped with visitors, the National Park Service launched Mission 66 in 1956 to meet both immediate demands, and those predicted for 1966, the service's fiftieth anniversary. Subjected to the same recreational pressures, the U. S. Forest Service initiated Operation Outdoors in 1957 to provide for the visitors expected by 1962. Actual use has exceeded the conservative predictions of both programs, and visits to the national forests in 1959 were already more than 15 million above the 66 million that had been predicted for 1962. Since 1956, a bill to provide a wilderness system has been introduced in each Congress; and in 1958 Congress authorized the Outdoor Recreation Resources Review Commission The same questions recur: How much land is enough? What is the carrying capacity of these wild lands? Must wildland recreation now be managed on a sustained-yield basis?

Resource managers are already accustomed to thinking of sustained-yield management in such terms as allowable timber harvests and allowable numbers of livestock on rangelands. Studies of these allowable limits have proved useful, and the same patterns of thought have been applied to recreation (Wagar 1946). Thus in recent years the carrying capacity of wild lands for recreation has been identified as an area in need of study. For example, in his problem analysis of forest recreation research Dana (1957) listed determination of carrying capacity as a major problem area; and the Outdoor Recreation Resources Review Commission (1960) recognized the importance of inventorying the carrying capacities of present and potential outdoor recreation areas.

Although carrying capacity is frequently mentioned in discussions of wildland recreation, the term has been applied loosely. There is no accepted statement of what it means or how it should be computed. To clarify the meaning and use of the concept, the purposes of this monograph are: (1) to identify and analyze the main factors that determine the recreational carrying capacity of wild lands; (2) to discover the place of carrying capacity in the management of recreation lands; and (3) to test the possibility of using regression equations for describing the relationships between vegetation, visitor use, and site factors on recreation areas.

Terminology

Several of the following terms are subject to more than one interpretation, but in this mongraph they are used as defined below.

Wild lands are non-urban areas that are not intensively managed and manipulated. They include most managed forests but not city parks with their exotic plants, "manicured" lawns, and sprinkler systems. The term is not exact because it includes lands that are under management and are not truly wild. Through long usage it has come to apply to lands that are sparsely settled and present a fairly natural appearance. Forests, deserts, mountains, grasslands, and other extensive lands are normally included.

Recreation refers primarily to creative leisure-time activities (U. S. National Park Service 1941) rather than the benefits or effects of activities. As Slavson (1946) pointed out, "since the chief value of recreation is in that it balances the human organism physically and psychologically, . . . (it) must be based on self-choice, initiative, and spontaneity."

Wildland recreation is recreation that is characteristic of wild lands and includes activities ranging from typical state park recreation to wilderness travel. This includes such activities as picnicking, hiking, and viewing natural surroundings.

Recreational quality is the degree to which a recreational experience or area normally contributes to the physical and psychic well-being of recreationists. Thus a thoroughly worn area usually offers lower recreational quality than areas presenting a fresh and natural scene. Individual tastes differ, and an experience is of high quality only to people for whom it provides a large measure of enjoyment or well-being.

Recreational carrying capacity is the level of recreational use an area can withstand while providing a sustained quality of recreation. Defining this capacity has some similarity to defining how many people one pie will serve. The number served depends on the size of servings. In many recreational situations, however, the dynamics of living communities must be considered. If quality is to be sustained, it is important that values not be used up faster than they are produced, a process equivalent to spending both interest and capital from a savings account.

Needs and desires are considered together in this analysis and include all the requirements, drives, and wishes that motivate human behavior.

Carrying Capacity and Its Place in Wildland Recreation

The Concept of Carrying Capacity

Man has faced the limited carrying capacity of land since prehistoric times. The Old Testament and other ancient writings contain many references to the land's limitation. Usually the problem has been one of insufficient food. Thus Haddon (1927) wrote of human migrations as "nearly always resulting from a dearth of food or from over-population." The many food shortages and migrations are indicated by Spoehr's (1956) estimate that man had spread into every major land area by 10,000 or perhaps 20,000 B. C.

Needs for sustained production of timber were recognized as early as the ninth century when, in Japan, "fear of timber famine led even to planting in the provinces of Noto" (Fernow 1911). According to Heske (1938),"The fear of wood famine forced the regulation of timber cutting and thereby introduced sustained-yield management . . . in the more densely populated parts of Germany between the thirteenth and sixteenth centuries." In France it was recognized that unlimited grazing might destroy whole forests, and beginningin1318 royal edicts restricted the area of public forests on which grazing was permitted (Buttrick 1926).

Although overgrazing had caused severe damage in the Old World, the United States did not profit from the example. Destruction of range lands began as early as the 1860's (Stewart 1936). By the 1880's the problem was generally recognized. Many areas, however, are still overstocked today. Nor is land abuse limited to the United States. Vogt (1955) estimated that, of the earth's population, "well under twenty percent—perhaps even fewer than twelve percent—are using their soil, water, forests, and grasslands on a sustained yield basis."

Carrying Capacity in the Management of Recreation Lands

The effects of human numbers on recreation were also recognized very early, and some of the first regulations in European forests were those reserving hunting as an exclusive right of the nobility. During the reign of Charlemagne (768–814) severe fines were imposed on poachers (Fernow 1911, Heske 1938). This guarded the prerogatives of high-born persons but may also have shown concern that too many hunters would reduce the quality of the sport. From England an anonymous poem of 1598 (as quoted from *Outdoor America* 1955) complained:

> But now the sport is marred;
> And wot ye why?
> Fishes decrease—
> For fishers multiply.

Since the automobile was developed, and especially since the end of World War II, outdoor recreation in the United States has increased tremendously. And managers of overcrowded areas face problems of defining, understanding, and augmenting the carrying capacity of recreation lands.

On the basis of experience, several guides have been developed for the space requirements of recreationists. The U. S. Forest Service (1957) has used 100 feet as the standard minimum distance between family camping units. Allowing for roads and toilets, such spacing permits about three campsites per acre. The National Park Service (1960) has generally placed between four and seven campsites per acre. One state park in New York allows 25 to 35 feet of linear distance along a roadway for each site. Experience there has shown that two parties often try to use one site if 40-foot site spacing is used.[1]

To estimate space requirements for summer camps, the Boy Scouts of America (1950) have used 1 acre per boy for the maximum weekly attendance expected. For every thousand people the National Park Service (1959) has suggested the following standards of area for parks, wilderness, nature preserves, and scientific monuments: 15 acres in areas of local significance, 30 acres in areas of statewide significance, and 200 acres in areas of national significance. For wilderness a standard of 1 man-day of use per season on each 3 acres has been suggested. This intensity of use is less than that now found on the most heavily used Forest Service wilderness areas.

In every statement of carrying capacity there must be, at least implicitly, a statement of some management objective. For example, a rancher may want to stay in business and to pass a productive ranch property to his descendants. His management objective would be the production of animals at a level that could

[1] Wintermute, Clyde. Personal communication 1960.

be sustained indefinitely and would yield the greatest continuous profit. To reach his objective he would set a carrying capacity that would not reduce range quality below the level required by his objective. Levels of stocking might be increased without damage to range quality by investment in such range improvement measures as brush removal and reseeding.

In the same manner, recreational carrying capacity must be considered as a means to an end, not an absolute limit that is inherent in each area. Recreational carrying capacity is the level of use at which quality remains constant. But quality can be constant at high or low levels. For example, a small picnic area may withstand 100 people per day for many years while maintaining a constant level of greenery, quietness, and general pleasantness. This is a fixed level of quality, and one level of carrying capacity is thus 100 persons per day. But if exactly 200 people were to use this area each day, some of the vegetation would die, noise levels would increase, and there would be a decline in quality. At this new level of use, however, a new equilibrium would be reached at which quality no longer declined. By definition, carrying capacity would now be 200 people per day. As an extreme case, it would be possible to put so many people into the area that all the vegetation and soil would be lost and the place would become noisy and unpleasant. Even here the quality, while very low, would reach an equilibrium and remain constant for a constant number of visitors. Carrying capacity might now be 20,000 people per day. Obviously, there must be some management objective on which to base a satisfactory level of quality.

People seek wildland recreation for the enjoyment and benefit it gives. Yet it is only one of the products and services they want from a limited supply of land. Just as material products tend to reach a market price according to supply and demand, for any set of circumstances there will be a limit to what other values people will sacrifice for quality recreation. Thus, for purposes of determining recreational carrying capacity, the objective of managing wild lands may be stated as *sustained production of the highest quality recreation that is possible at acceptable costs*. On public lands, which provide most wildland recreation, decisions as to what costs are acceptable will have to be made by public servants striving to achieve the public good.

Accepting limitation of use will mean fewer visits per person and is only one of the costs that can be paid for high-quality recreation. Recreationists can also pay for quality by:

1. Giving up quantities of products and services that could be produced if recreation were restricted to less land. For example, New Yorkers have been willing to forgo the timber that could have been produced in the Adirondack Forest Preserve.
2. Paying higher costs for products and services that are less abundant because recreation has been included among land uses. Thus lumber may be more expensive because timber harvests are reduced in roadside strips left for the benefit of recreationists.
3. Accepting regulation of conduct and movements. If people are willing to remain on trails, they will not damage off-trail areas.
4. Accepting a different kind of recreational experience. For example, concrete walks and irrigated lawns are unnatural but withstand more use than semi-arid forest lands.
5. Spending time, money, and effort to reach quality recreation areas. Examples would include fishing in Canada, hunting in Africa, and hiking beyond crowded roadsides.
6. Paying for acquisition, development, and management of recreation lands through taxes, entrance fees, or other means. To some extent, these costs can be substituted for limitation of use and for each other.

Wildland recreation has traditionally

been inexpensive in this country, and many of our attitudes toward it were developed when the country was sparsely settled and land was abundant. Quality recreation then cost only the effort of getting to it. But as the United States becomes more fully settled, and as desires for land greatly exceed the supply, quality in wildland recreation will become more costly.

Traditions of freedom make restriction of use an especially distasteful cost. But for some kinds of recreation, unrestricted use may prove even more objectionable by reducing quality and enjoyment. The degree to which use should be limited will depend on (1) the natural durability of wildland areas, (2) the effectiveness of various methods for keeping areas in good condition, and (3) the degree of naturalness and solitude that people demand after considering the costs and sacrifices necessary to maintain such conditions. Thus, carrying capacity ultimately depends on the value judgments of people.

Crowding and Recreational Quality

Quality and the Satisfaction of Needs

Because the objective of recreation is to provide benefit and enjoyment for people, managers of recreation areas must consider how management procedures will affect satisfaction of the needs that motivate recreation. To decide whether it is appropriate to define a carrying capacity and to limit use, they must know how this satisfaction, which determines the quality of recreation, will change with different amounts of crowding.

Unfortunately, no precise method is available for measuring satisfaction. Even if we could measure how satisfied one person is by a specific recreational experience, we have little reason to believe that the same experience would provide the same satisfaction for another person or for the same person at another time.

Although satisfaction is not precisely measurable, its relation to numbers of people can be reasoned and described from considerations of human needs. Psychologists disagree on what needs are inherent and universal but do agree that much of human behavior is motivated by a combination of various physiological needs and acquired drives. Even though survival requires that certain physiological needs be met, the behavior they cause is usually greatly modified by training and culture. Thus needs acquired by learning are of primary importance in explaining human motivation and behavior.

Many lists of needs have been or could be compiled. As units for analyzing recreational quality, within our culture, the following categories of needs and desires have proved useful and are examined here.

Exercise
Healthful environment
Self-esteem and social prestige
Esthetic enjoyment
Understanding
Freedom of choice
Perpetuation of early traditions and conditions
Self-reliance
Change and escape
Companionship
Cooperative endeavor

The author believes that, in various combinations, the few categories of needs and desires listed above explain the motivation of most wildland recreations. Thus the effects of crowding on satisfaction are examined for each of these relatively few needs and desires rather than for the nearly limitless variety of recreational activities. This requires that each need be abstracted from specific activities and be examined as a fundamental force that helps to motivate a great number of activities. The effects of crowding on the satisfaction derived from a specific activity can then be evaluated by considering the needs that commonly motivate it.

The graphs in Figure 2 illustrate the effects of crowding on the satisfaction of these needs. These graphs are not based

on measured data but are freehand curves that show probable relationships.

Exercise. Modern occupations tend increasingly to involve mental activity and precise work with the small muscles of the hands. Yet man evolved as a running, jumping, throwing creature who used all his muscles. In modern American society, jobs that use the muscles tend to be esteemed less than occupations requiring mental effort.

Increasingly limited in our working lives, exercise becomes correspondingly

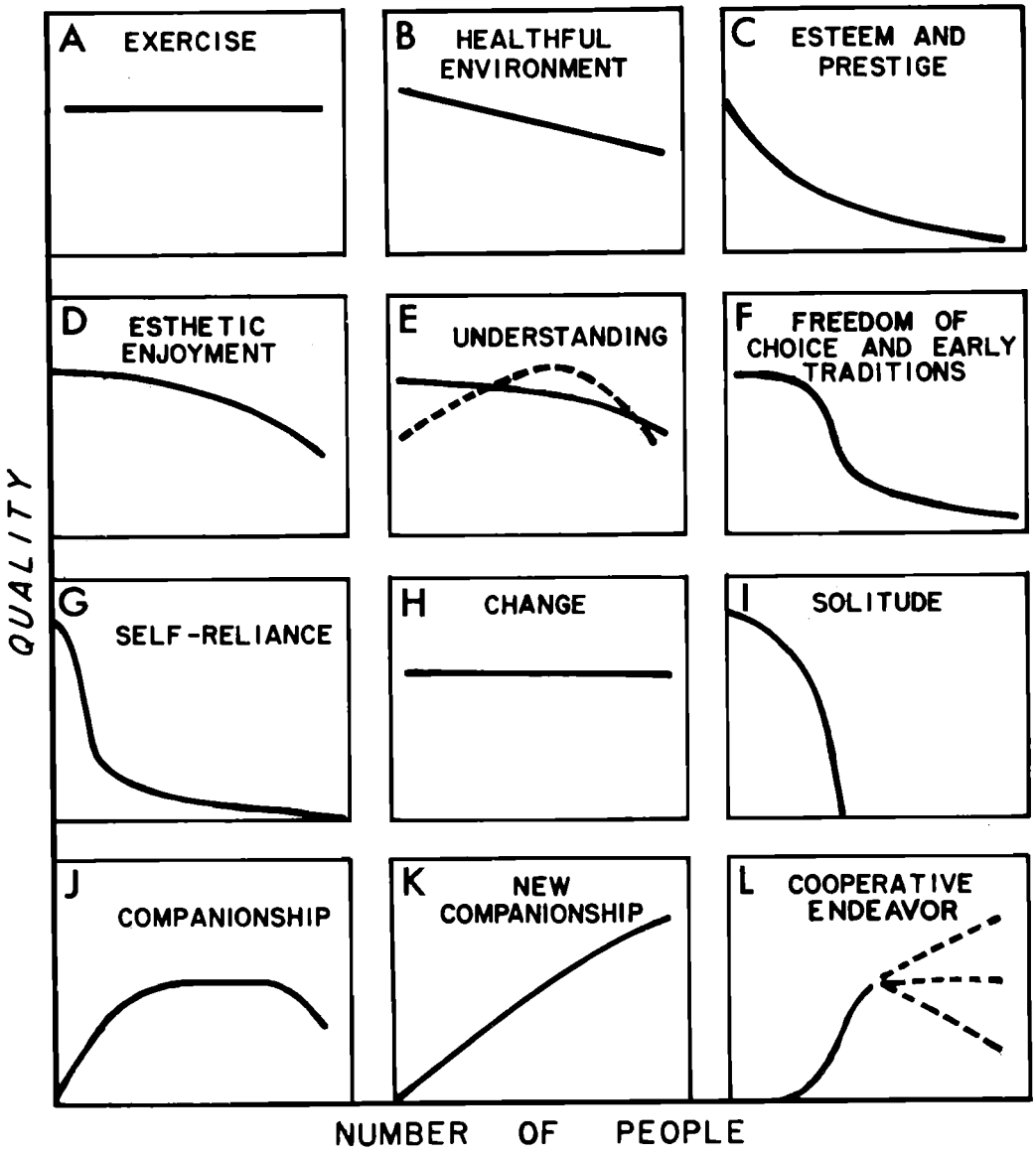

FIGURE 2. *Effects of crowding on the quality which results from satisfaction of the needs that commonly motivate outdoor recreation. On the horizontal axes, number of people increases to the right. On the vertical axes, quality increases with height.*

more important in our play, and the same society that scorns heavy work admires and emulates people who perform skillful muscular feats in the name of sport and recreation. Participants gain satisfaction from improved physical well-being, and exercise contributes to recreational quality. How then will increased numbers of people affect the satisfaction and quality gained through exercise?

Satisfaction from exercise need not decrease with crowding because vigorous use of the muscles requires little space. Running, swimming, and many other activities can be actively pursued in small areas amid great crowding.

Again it is emphasized that needs are being considered individually and apart from whole activities, which are usually motivated by several needs. Thus the place and incentive for activities such as hiking might be eliminated where great crowds occur, but this could be explained by reduced possibilities for satisfaction of associated needs for such factors as solitude, self-reliance, and esteem. The opportunity for exercise remains little affected by numbers, and satisfaction of this need would be unchanged by crowding (Fig. 2A).

Healthful environment. Clean, unpolluted surroundings are one of the attractions of wildland recreation, especially now that we are primarily a nation of city dwellers. Many centers of population are smoky places with drab skies, sewage-laden waters, evil smells, and sweltering summers. In contrast, wild lands are sought for their blue skies and sunshine, low humidity, moderate summers, and clean air and waters.

Changes occur in wild lands as they become crowded. And the satisfaction available from healthful surroundings would decrease gradually with increased crowding (Fig. 2B). The purity of waters is usually lost first, and only on relatively unused lands is it safe to drink from streams and other surface waters. With higher levels of use, the land itself may become polluted as garbage, dishwater, and other wastes are scattered over it.

With management, healthful conditions can be maintained at high levels. Water supplies can be developed and purified. Facilities for waste disposal can be installed and custodians can be hired to clean up after careless and irresponsible people. Intensity of management can be matched to levels of use, and healthful conditions need not deteriorate very far. However, no cleanup measures will remove all pollution instantly, and minor deterioration will inevitably occur with crowding.

Self-esteem and social prestige. Many recreational tastes are explained at least partly by needs for self-esteem and social prestige. The two needs can be distinct, but fulfillment of either bolsters a person's ego and gives satisfaction. For this analysis they are similar enough to be described together.

To merit high esteem an accomplishment must be outstanding or unique in some way. For example, in advertising a trip to the Northern Saint Elias Range, the *Sierra Club Bulletin* (Anonymous 1956) said, "For those who wish to climb, first ascents can almost be guaranteed provided there is good weather." To be first is unique and desired. As another example, Earl Shaffer endured great exertion and many discomforts to be the first person to walk the full length of the Appalachian Trail in one season. During the trip he met a pair of hikers who were attempting to walk the trail's full length in the opposite direction. He said that they probably could have completed the distance but gave up after hearing that he had finished first.

Because an experience is no longer unique once it is known by many people, satisfaction of needs for esteem and prestige falls rapidly when increasing numbers of people achieve the same goal (Fig. 2C). However, even commonplace achievements contribute to some self-respect, and a person can excel even when his activities are not unique.

In addition to bringing many people to the same activity, crowding can reduce chances for prestige and esteem by modifying a recreational resource. If, for example, a deer herd is so heavily hunted that most bucks are taken as yearlings, each hunter's chances of shooting a deer with large antlers will be greatly reduced.

Esthetic enjoyment. Many wildland areas are treasured for their beauty, and a desire for esthetic things attracts many visitors. The abundance of dropped film wrappers at scenic attractions gives evidence of the visitor's desire to enjoy and capture beauty. In fact it has been suggested, facetiously, that the outlawing of color photography would solve the problem of crowding in our parks.

Possibilities for esthetic appreciation can be maintained in spite of increasing numbers of people if these numbers do not damage the objects appreciated or the atmosphere necessary for their enjoyment. Thus the esthetic value gained from viewing the Grand Canyon or examining paintings in an art gallery would not be greatly changed by the presence of a few people. When lands become moderately crowded, however, observers and especially photographers have difficulty avoiding unwanted subjects in scenes. And if use became so great that each visitor had to be told, "You have 30 seconds and must then move on to give others a chance," esthetic enjoyment would obviously decrease.[2]

Concentrations of people can destroy objects of beauty—particularly where they trample vegetation or delicate geologic formations. The construction of facilities needed to handle crowds can also destroy or diminish the attractiveness of an environment, and debris left by thoughtless visitors will detract from the general scene. But constant cleanup and thoughtful engineering can reduce these impairments to the landscape. Because there are many types of beautiful things, and because damage can be fairly well controlled, satisfaction of an individual's need for esthetic enjoyment need not decline greatly until extremely heavy use is reached (Fig. 2D).

Understanding. People are normally curious and many enjoy studying and understanding what they see. The prevalence of this desire is demonstrated by the crowds that visit museums, flock to lectures, and ask questions of rangers and guides. Among the recreational agencies, the National Park Service has specialized in meeting this need.

Satisfaction of the need for understanding could either decrease gradually or increase and then decrease under conditions of increasing crowdedness (Fig. 2E). Observation of natural objects usually becomes increasingly difficult with crowding. However, in a well-informed group, members would probably exchange information, and understanding would probably increase with group size until crowding interfered strongly with observation and discussion.

Satisfaction of needs for understanding is probably less diminished by crowding than satisfaction derived from esthetic conditions, because phenomena can be understood even if not beautiful. Thus the processes of ecology continue to be fascinating whether observed in the purest wilderness, in a well-managed timber stand, or at a city dump where weeds are establishing themselves on new fill. However, as in the case of esthetic enjoyment, extreme use might destroy the range of things to be understood and the conditions conducive to observation.

Freedom of choice. One of the most distinctive and yet perishable attractions of wild lands is the freedom of choice they allow. At one time wild lands were free from the restrictive paraphernalia and prohibitions of a civilized society. But as these lands become more heavily used, civil laws, stop signs, etc., had to regulate use. Early campers made bough beds,

[2] The sergeant in charge actually enforced such a schedule while a military group was visiting a national park.

built fires where they wanted to, and shot much of their food. But their total impact on the land was usually small. By contrast, if present crowds of recreationists were allowed the same privileges, many recreation areas would soon lose much of their attractiveness. As James Truslow Adams (1930) pointed out in writing of Point Montauk, the many cannot enjoy all that the few enjoyed. This may be undemocratic but is an unavoidable fact.

Satisfaction of the desire for freedom of choice will decrease as wild lands become more crowded (Fig. 2F). Up to some critical level, use could probably continue with very little loss of freedom. Beyond this level, however, legal restrictions would become necessary, and the presence of crowds would also restrict free choice. But after much freedom had been lost, the activities still possible could continue with few additional losses.

Perpetuation of early traditions and conditions. As a relatively young nation, the United States is still conscious of its pioneering days. School books present vivid accounts of such early adventurers as Daniel Boone and Lewis and Clark. Television and motion pictures find a ready market for sagas of the western frontier, man against the wilderness, and similar subjects. The Boy Scouts of America offer a merit badge in pioneering and require its completion before bestowing the rank of Eagle. All of these things are based on American traditions, and all are closely linked to wild lands.

Because many early-day experiences depended on the way vast spaces challenged and molded a mere handful of men, increasing numbers of visitors on our dwindling wild lands must decrease the possibility of experiencing much that was known by earlier generations. However, a residual assortment of traditional activities and conditions would persist, even with great crowding. Thus crowding can be expected to reduce satisfaction of needs for early traditions and conditions in approximately the same way it would reduce satisfaction of needs for freedom of choice (Fig. 2F).

Although modern wilderness experiences are satisfying, they are only partly representative of earlier eras, and much of the enjoyment must come from satisfaction of needs other than those for early traditions and conditions.

Self-reliance. Although its fulfillment is not wholly a matter of enjoyment, self-reliance is still a genuine need that helps to motivate some recreational activities on wild lands. As crowding increases on wildland areas, facilities will usually be added, and help will be increasingly available in case of emergency. Thus satisfaction of the need for self-reliance will decrease sharply with crowding (Fig. 2G).

In contrast with cities, where people are increasingly protected from many of their own ineptitudes, wild lands may demand high levels of keenness, vigor, and self-discipline and may impose immediate penalties on visitors who lack these qualities. Thus wildland ventures have enjoyed a reputation for building worthy and self-reliant men at least as far back as about 400 B.C. when Xenophon (as quoted by Grinnell and Sheldon 1925) pointed out that "men who love sport" make tough and steadfast soldiers and "will gain bodily health, better sight, better hearing and a later old age."

Change and escape. In one sense or another, change is a vital need for humans, and prolonged periods in one position or at a single activity usually become unbearable. The relief brought by change makes it one of the primary foundations of recreation. Farmers enjoy trips to town; city dwellers enjoy the countryside.

With one exception the possibilities for change and escape need not decline with an increase in human numbers. New activities provide opportunities for change, and people probably add to the range of interesting activities more than they detract from it. Thus an individual's

satisfaction of the need for change or escape would be little diminished by increased crowding (Fig. 2H).

The exception to the reasoning above is a desire for solitude or escape from people. Obviously this need will be less satisfactorily fulfilled as numbers of people increase (Fig. 2I).

Companionship. Many wildland activities are partly social in nature. Hunters enjoy the company of friends and often gather in hunting camps. Camping trips, picnics, and even wilderness experiences usually involve several people—often one or more families. The manager of an eastern state park noticed that in the evenings campers gather around a fire at every fourth or fifth campsite and seem to find this sociable environment a substitute for a neighborhood sociability that is becoming less common in towns and cities.[3]

Satisfaction of needs for companionship probably increases for the individual up to an optimum group size. Larger groups have difficulty maintaining unity and usually break into smaller units. Thus individual satisfaction tends to rise to a maximum and then to remain fairly constant until groups become so crowded that they interfere with each other. With such crowding, satisfaction declines (Fig. 2J).

If people are seeking new companionship, each person's satisfaction can increase with crowding because there are more opportunities to meet new and enjoyable people (Fig. 2K). Such thinking is common at resorts, but frequently visitors to more natural areas also mention enjoying the people they encounter.

Cooperative endeavor. There may be no need for cooperative endeavor as such, but whether or not some activities yield satisfaction depends on what cooperation is possible. Some wildland recreations such as mountain climbing and game drives usually are not pursued alone.

For example, two hunters wanting to drive deer on a tract of several square miles might consider the task hopeless. Four men might do a passable job, and eight might conduct a productive drive (Perry 1954).

In some cooperative ventures excessive group size interferes with accomplishment of objectives and decreases satisfaction. Climbers, for example, find that a large party is slow and dangerous.

For most cooperative or team endeavors, individual satisfaction remains low until enough people gather to attempt the objective. Satisfaction then rises rapidly till an efficient number is reached. Beyond this it continues to rise, becomes approximately unchanged, or declines—depending on the activity at hand (Fig. 2L).

The Diversity of Tastes in Wildland Recreation

Although only a few categories of needs and desires have been discussed, they motivate an amazing variety of recreations. For example, "river rats" floating down the gorges of the Colorado and its tributaries, skin divers off the California coast, and deer hunters in Maine may all be seeking the self-esteem that accompanies adventure and achievement. People can find esthetic enjoyment in landscapes and scenery ranging from sea coasts to lakes, forests, deserts, plains, and mountains. With little effort long lists could be compiled to show a variety of recreations motivated in part by each of the other needs and desires discussed in this paper. Such lists would include everything from desires for crowded beaches, group picnics, and fully developed trailer sites at one extreme to

[3] Wintermute, Clyde. Personal communication 1960.

back-packing, wilderness camping, and exploring at the other.

Even within one type of activity there may be a diversity of tastes, and camping provides an example. During the summer of 1958 the author conducted a study at Mount McKinley National Park. Of the campers who were sampled, 27 percent said they preferred to camp away from others, 68 percent indicated a desire to camp near a few others, and only 5 percent answered that they preferred to camp in a large campground near many others. Yet a few miles from Ithaca, New York, people enjoyed camping in rows of lots only 25 to 35 feet wide. Visitors to the wilderness of McKinley sought and expected something different from what was offered near Ithaca. And as long as present attitudes persist, the carrying capacities consistent with high-quality recreation will be vastly different for campgrounds on the two areas.

Visitors to the same general type of area may also have vastly different tastes. Thus while canoeing in the Quetico-Superior wilderness, the author and his father enjoyed periods of several consecutive days without seeing other people. During the 12-day trip, desires for solitude, primitive environment and travel, freedom of choice, and self-reliance and esteem were largely satisfied because of the meager evidence of other visitors.

By contrast, lodge guests seemed well satisfied with their more populous and developed environment at Basswood Lake where the canoe trip ended. Even though rather heavily used, this lake provides high-quality recreation for people motivated by desires for companionship, change, and an attractive and healthful environment.

Whether land is used for recreation or for other purposes, the ultimate measure of proper use must be its provision for the fulfillment of human needs and desires. Thus even severe abuse of land and other resources is not wrong from the standpoint of the resources themselves, but because of the impact that deteriorating resources have on the fulfillment of human needs and on the sustained welfare of society. For evaluating recreational carrying capacity, comparing alternative uses of land, or for making other land-use decisions, human needs and desires provide the primary criteria for judgment.

Providing Quality Recreation for More People

Carrying capacity implies that use will be limited, but mounting visitor pressures make this a distasteful course of action on much of our recreation land. Increasing numbers of people demand some place for recreation. To provide a better basis for deciding whether or not use should be limited, we must examine other methods for reducing and offsetting the decline in quality caused by concentrated use.

As discussed earlier, the quality of a specific recreation depends on how well it satisfies the needs that motivate it. Quality may be limited by the presence of people, the condition of an area, or both.

Management procedures may allow both high-quality recreation and high rates of use if they: (1) reduce conflicts between competing uses, (2) reduce the destructiveness of people, (3) increase the durability of areas, or (4) provide increased opportunities for enjoyment. Such management would raise the carrying capacity that is consistent with a chosen level of recreational quality. The techniques required are zoning, engineering, persuasion, interpretation, and the management of biotic communities.

Zoning

As recreationists increase in numbers, they tend to interfere with each other's activities. With zoning, opportunities for competing activities can continue to exist. Without zoning, uses and users with the greatest crowd tolerance and aggressiveness may drastically reduce the quality and possibility of other types of recreation. For example, water skiers are

less bothered by fishermen than fishermen are by water skiers.

While zoning can perpetuate a range of recreational opportunities, it can also contribute to efficient land use. Competition for wilderness areas provides an example. Robert Marshall in 1933 wrote that "the primeval area exibits primitive conditions of growth whereas the wilderness area exhibits primitive conditions of transportation." So defined, wilderness and primeval meet sets of needs that are at least partly distinct, and separate classification of the two types of areas might be desirable.

If primeval areas were surrounded by large wilderness areas, in Marshall's terminology, both sets of values might be preserved and might yield higher levels of satisfaction. Temporary roads, timber management and other commercial uses could be allowed in the wilderness zone without destroying conditions of primitive transport. The distance across this zone would protect the enclosed primeval area. Under such a system, primeval areas might receive better protection than they are now given; greater areas could be reserved for primitive transportation; and a smaller area would be barred to commercial uses. The Superior National Forest is zoned in a pattern approaching this system (Pike 1953).

Engineering

Thoughtful engineering can increase the carrying capacity of some wildland recreation areas: (1) by channeling the movements of people and therefore limiting the amount of area they damage, (2) by providing surfaces that withstand tremendous use, and (3) by providing access to areas that are otherwise unused.

Because people usually walk or drive along the easiest route, their movements can be guided by the design and arrangement of facilities and barriers. For example, most people will stay on a path that leads where they want to go. Rocks and logs can also channel people's movements and can be placed so that few visitors recognize them as unnatural (Taylor and Hansen 1934). Where necessary, elaborate guard rails and fences can be erected.

Certain kinds of recreation require no physical contact with the resources on which they are based, and many people are content to view a scene without touching it. The Anhinga Nature Trail in Everglades National Park provides an excellent example. As part of the trail, an elevated walk built over a slough allows visitors to see alligators, gar, gallinules, and other swamp fauna and flora. The alternative to an elevated walk would be wading or boating, which would cause continual commotion and damage to the natural conditions being displayed.

Some recreation sites are important as surfaces that withstand wear or permit occupancy rather than as points of attraction. Thus spectacular views may be possible from a barren or paved picnic area. Or, a non-scenic campground may serve as a headquarters from which more interesting areas may be reached.

While concentrating traffic on durable surfaces, the construction of facilities can also provide improved access. Roads are the most common means of access to scenic resources, and motorists can see some of our most spectacular scenery without leaving their vehicles. But a more striking example of access is provided by Carlsbad Caverns.

Few of us have the temperament, time, courage, or interest needed to explore undeveloped caverns. Yet thousands of visitors enjoy Carlsbad each year. Installation of lights, trails, lunch counters, restrooms, and elevators has destroyed some of the original cave formations. But very few people would enjoy the caverns without these unnatural intrusions.

It is important to recognize that engineering and the development of easy access may alter the type of recreation an area offers. Compare, for example, the conducted tours in the well-lighted Carl-

sbad Caverns with the gloomy wanderings of exploring speleologists. Or, contrast touring on a modern highway with traveling by pack train in the wilderness. Fortunately, we still have areas for people who want to experience the wilderness or primeval conditions. These areas serve as museum specimens of the past and provide a continuing symbol and source of the self-reliance and self-discipline that are part of our national tradition. If a broad variety of outdoor recreation is to persist, it will be desirable to actively develop many areas while vigorously opposing the "vandalism of improvement" on others.

Persuasion

Such needless damage as bullet-riddled signs and initial-scarred trees shows that recreation areas will stay in better condition if people can be persuaded to improve their behavior. Within limits, this is possible through education, regulations, and law enforcement. The Smokey Bear program is an example of effective persuasion by publicity and is credited with a great reduction in forest fires.

In New York the General Manager of the Allegany State Park Commission estimated that his costs for roadside litter removal dropped from $2,500 to $700 per year as the result of anti-litter efforts.[4] Much of this improvement he attributed to increased public awareness caused by widespread anti-litter campaigns, but park signs reinforce this awareness by warning visitors of fines up to $250 for littering.

Restrictions and reminders are needed when people do not understand or care about the consequences of their actions. Thus game laws are meant to maintain the quality of hunting by restricting the actions of hunters. Keep-off-the-grass signs are widespread, and in many areas the cutting or removal of live vegetation is forbidden. Hall (1929) wrote that Switzerland's national park in the Lower Engadine is open to all visitors as long as they stay on the trails, but "only those holding cards issued by the Commission are permitted to wander at will over the park."

At Mount McKinley National Park, signs and regulations now prohibit people from leaving the road along a 5-mile zone where motorists can expect to see Dall sheep, moose, caribou, foxes, and grizzly bear. By preventing photographers from frightening the animals away, this restriction maintains recreational quality for highway-bound visitors. Photographers and hikers are free to leave the road throughout the remainder of the park.

Certification of outdoorsmen has been suggested as a method of training recreationists to take care of outdoor areas (Wagar 1940), and German hunting provides an example. As reported by Webb (1960):

> The first step toward becoming a hunter is to secure a license, which can be issued only when a person has successfully passed a detailed examination. The examination covers life history of game, game management, use of firearms, including some aspects of ballistics, and a great deal of material on the traditions and ethics of hunting. This is not an easy examination. Many intelligent persons who take the test are failed one or more times.

In the United States a few states require new hunters to pass a course in firearm safety (Anonymous 1960); and as recreation lands become more crowded, license examinations may become increasingly desirable to maintain the quality of such recreations as hunting and wilderness travel.

Law enforcement also has a place in the management of recreation lands. Unfortunately, a few visitors cause damage out of all proportion to their numbers. Increased educational efforts could reduce such destructiveness by improving the attitudes of some people or by creating social pressure which inhibits destructive acts. But when all else fails, law enforcement and prosecution are necessary. One park official said that a record and reputation of getting 98 percent con-

[4] Batterson, L. J. Personal communication 1960.

victions on arrests have kept the need for such arrests to a minimum.[5] Such cooperation from law-enforcement officials serves as a strong deterrent to improper conduct, and, in combination with other means of persuasion, helps to maintain the quality of recreation areas.

Interpretive Services

For many visitors to wild lands, knowledge of their surroundings opens new possibilities for recreation and enjoyment. And as wildland areas become increasingly crowded, interpretive services offer an outstanding means of maintaining quality recreation by replacing some of the values lost with crowding.

In most National Parks and in some state parks there are illustrated talks, tours, nature walks, and campfire programs. Recently the Forest Service initiated its Visitor Information Service to provide similar benefits for recreationists. Depending on the attractions at hand, fossil remains, prehistoric people, the life histories and ecology of plants and animals, cave formation, erosion, vulcanism, or other phenomena can be interpreted. In addition to organized programs, visitors are often provided with self-guiding trails, museums, road and trailside exhibits, signs to mark and explain interesting features, and brochures with pertinent information.

Management of Biotic Communities

The enjoyment of nearly all wildland recreations depends at least partly on the presence and condition of living things. And where not in conflict with the type of recreation being offered, management techniques can increase the abundance and durability of both animals and plants. An extreme case is the stocking of legal-sized fish.

Wildlife managers use a variety of techniques to increase the abundance of game. In the Southwest a water-catching and storing device called the "gallinaceous guzzler" provides game birds with water where a shortage previously limited their populations. Winter cutting of cedar helps white-tailed deer survive winters in the swamps of the Lake States. Other techniques for encouraging wildlife include controlling water levels in waterfowl nesting areas, and planting vegetation for food and cover.

Management techniques can also increase the abundance and durability of vegetation. Fertilization and irrigation now used for lawns in some of the more highly-developed outdoor recreation areas might increase the durability of trees and other vegetation subjected to recreational use. As in the case of lawn grasses, species of trees and shrubs can be selected for durability. Thinning of the overstory can increase resistance to abuse for trees as well as understory vegetation.

Where wild lands are valued primarily for their naturalness, the management possibilities considered above may be less acceptable as "costs" for quality recreation than limitation of use. Zoning can be used to provide for a variety of tastes. But as recreation pressures increase, some degree of unnaturalness will have to be accepted on the bulk of our recreation lands. Where this unnaturalness is acceptable, engineering of areas, persuasion of people, interpretation of phenomena, and the manipulation of living things can be used to provide quality recreation for more people.

Predicting the Durability of Biotic Communities

The Capacity for Self-Repair

The composition of living communities results from the interplay of many forces: light, moisture, soils, the effects of species on each other, and many other factors. In combination, such factors may maintain relatively stable communities or may cause fluctuations and changes. But because the forces controlling community

[5] Batterson, L. J. Personal communication 1960.

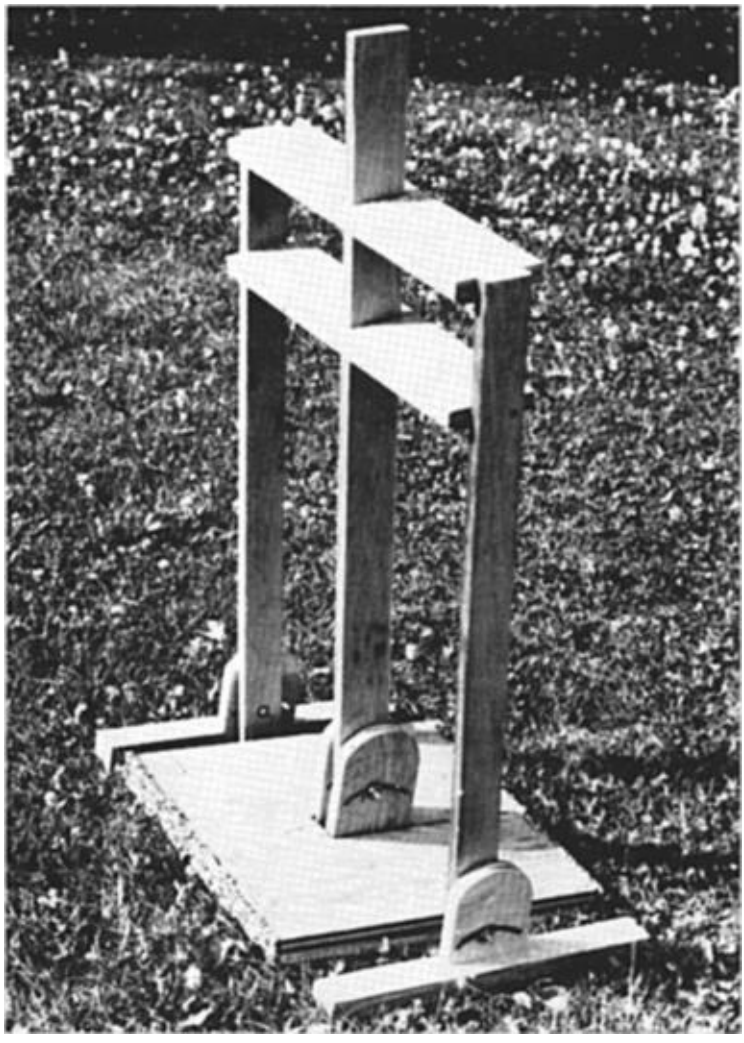

FIGURE 3. *The tamp used to simulate recreational traffic on the experimental plots. Each time it is dropped from full height it applies approximately 8 foot-pounds of energy per square foot of surface area. The handle, attached to the square tamping foot, slides vertically through the two cross pieces of the frame. Both handle and uprights are adjustable to allow the tamp to drop vertically regardless of slope.*

composition are seldom constant and are often adverse, most of the species that have survived are able to withstand moderate disturbances. Thus rabbits reproduce in such numbers that they can feed predators and still maintain their populations. For individual plants, food storage and photosynthesis are usually so ample that moderate loss of leaf material to animals or other plants does not endanger chances for survial. As Meinecke (1929) pointed out, "It is characteristic of all living beings that they are prepared to take care of minor injuries."

Safety margins within species provide communities with a capacity for self-repair, and minor damage only dips into the excess of vitality and tissue. When

the damaging force is reduced sufficiently, the species tend to regain any loss in community position. Graham (1956) cited "the power of plant communities to reconstitute themselves when the cause of disturbance disappears."

As a visitor to wild lands, man can change biotic communities by altering the forces that determine community composition. Yet on many areas valued for their wildland character, it is desirable to keep man-caused changes within narrow limits. To decide what restrictions to impose on visitors or what facilities are needed to protect living parts of these areas, managers need to know what will happen to biotic communities subjected to varying intensities of direct contact with recreationists. To test one method for predicting such changes, the durability of trampled vegetation was studied during the summer of 1959.

The Durability of Trampled Vegetation

If adequately described, relationships between visitor use, site factors, and amounts of vegetation may be useful for predicting the impact of visitors on recreation areas. To study these relationships, simulated recreational use was applied to a series of vegetated plots in the unused portion of the Brighton Recreation Area in southeastern Michigan. This is an area of potholes and glacial sands forested principally with red and white oaks. By multiple regression methods, amounts of understory vegetation were related to: (1) intensity of simulated use, (2) composition of plot vegetation, (3) amounts of sunlight or shade, and (4) amounts of vegetation growing in the absence of simulated use.

Rather than to provide land managers with tools for immediate use, the intent of this investigation was to test the possibility of developing such tools. Procedures used in this study can probably be refined and extended to provide tools that will allow managers to predict the durability of potential recreation sites representing a variety of locations and conditions.

Procedures. In the spring of 1959, groups of plots, 16 x 64 inches in size, were established in the Brighton Recreation Area, each group being located in a different stand of ground-cover vegetation. Each group contained an untreated control plot matched with one, two, or occasionally three adjacent treatment plots. At each plot group, measurements were made of: plant composition, season-long sunlight or shade, slope steepness, aspect, position on slope, soil texture, depth of soil with organic stain, and the basal area of adjacent trees.

At approximately weekly intervals between June 29 and August 10, various levels of trampling were simulated on the treatment plots by dropping a square tamp (Fig. 3). On August 18, the vegetation on all treated and control plots was clipped, dried, and weighed. Survival of the treated vegetation was determined by comparing the clipping weights of treatment plots with weights from matched control plots.

At the time of clipping, some plot groups had visible gradients of plant volume and vigor extending across the plots and adjoining vegetation. These gradients had not been visible during the spring when plots were selected. Because uniformity within plot groups was necessary for an accurate expression of treatment effects, the non-uniform plot groups were excluded from the analysis.

Equations. Of the original 87 treated plots, 41 were retained and analyzed by multiple regression methods to give two prediction equations:

$$Y_1 = 12.901 + .670\ X_1 + .389\ X_2 + .255\ X_3$$

$$Y_2 = 1.559 - .217\ X_4 + .495\ X_5 + .320\ X_6 + 1.060\ X^7$$

where

Y_1 = Percentage by which treatment reduced the weight of surviving vegetation

X_1 = Drops of the tamp during each treatment application

X_2 = Percentage of plot vegetation composed of

species other than grasses and trailing raspberry

X_3 = Percentage of sunlight during the growing season

Y_2 = Logarithm of the dry weight, in grams, of vegetation clipped from a treatment plot

X_4 = Logarithm of drops of the tamp, plus five = $\log(X_1 + 5)$

X_5 = Logarithm of the percentage of plot vegetation composed of grasses and trailing raspberry = $\log(100 - X_2)$

X_6 = Logarithm of the percentage of shade = $\log(100 - X_3)$

X_7 = Logarithm of the dry weight, in grams, of vegetation clipped from the control plot adjacent to the treatment plot on which Y_2 was measured.

For the data subjected to analysis, the equations and their independent variables account, respectively, for 64 and 95 percent of the variance in values of Y_1 and Y_2.

Although the equations presented here serve to demonstrate a technique, they have several limitations. Tamping does not fully represent the variety of factors that damage vegetation on recreation areas. Tamping was applied for only one portion of a growing season and gave no opportunity to study cumulative effects over several years of use. The area studied included only a narrow range of soils and vegetation.

It is of particular importance to note that the equations cannot be applied with confidence beyond the data on which they are based. Plots would have to sample the range of conditions to which the equations would be applied. In addition, statistical inference from the equations is not rigorous because some of the original data were rejected on a subjective basis. On the other hand, the equations developed in this study do suggest variables and hypotheses to examine in developing tools for predicting the durability of vegetation on recreation areas. They also indicate some probable relationships.

To illustrate these probable relationships, values of Y_2 have been computed and plotted as curves in Figure 4. These curves show how changes in four variables could affect the survival of vegetation if all other variables remained constant at their mean values. Plotted values of Y_1 show similar relationships.

Tamping. As shown in Figure 4A, survival of vegetation decreases as the amount of simulated use increases. In the absence of simulated use, however, no damage should occur. Thus the dashed curve was sketched as originated at 45 grams, the average weight of vegetation clipped from the untreated control plots. This dashed curve is believed to show a more realistic relationship than the portion of the computed (solid line) curve it replaces.

For the conditions of this study, there was no apparent threshold beyond which additional tamping caused accelerated site damage. Other areas might respond differently, especially if damaged repeatedly for several years. For the conditions studied, however, Figure 4A indicates that large changes in use may cause only small changes in damage on the highly-developed areas where use is already heavy.

At the other extreme of use intensity, another pattern might hold. In wilderness situations, even a little direct contact by recreationists might cause marked changes in plant composition and appearance. To remain relatively unchanged, most of each wilderness would have to be used so lightly that even the more delicate species could repair themselves and maintain their usual places within communities. To accomplish this, land administrators already are using three procedures: (1) concentrating use on non-wilderness intrusions such as trails and fixed campsites, (2) dispersing use to prevent one area from receiving concentrated or frequent damage, and (3) maintaining barriers of distance and effort so that only genuinely interested persons venture in.

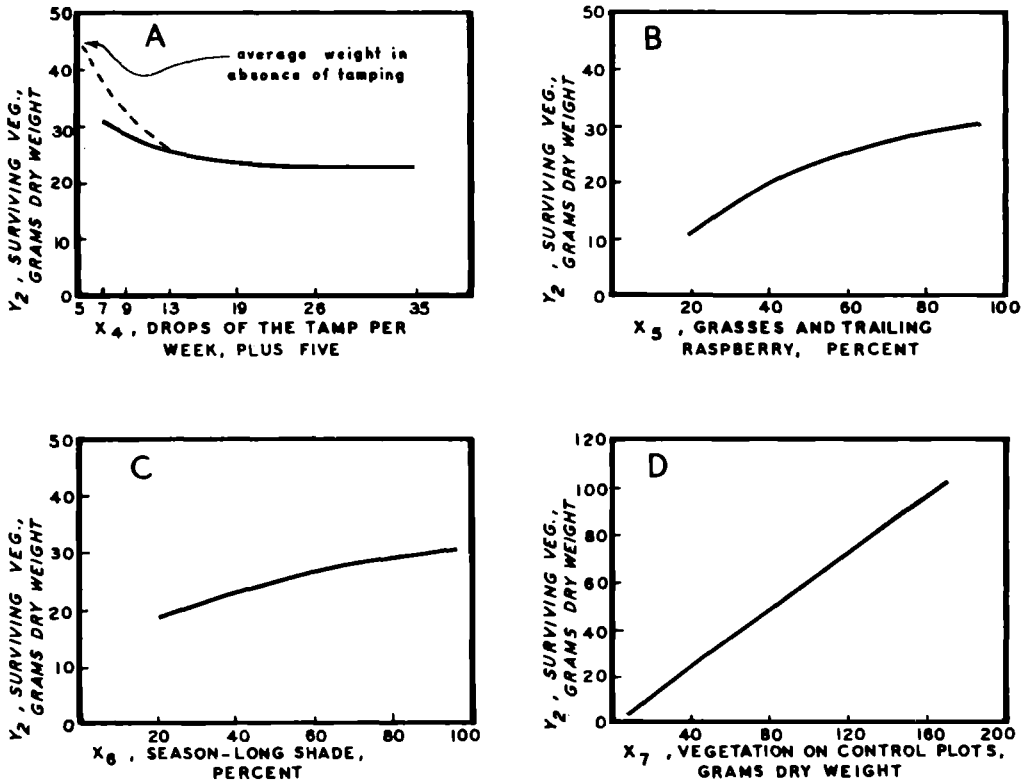

FIGURE 4. *The approximate manner in which survival of ground-cover vegetation is related to: (A) intensity of simulated use, (B) the composition of this vegetation, (C) amounts of shade during the growing season, and (D) the amount of vegetation growing in the absence of simulated use.*

Plant composition. Figure 4B indicates that grasses and such woody vines as trailing raspberry are less damaged by trampling than are dicotyledonous herbs. For recreation areas on which some modification of plant life is acceptable, carrying capacity might be increased by encouraging sod. This is relatively easy in the moist eastern United States but may present difficulties in the more arid West.

Sun and shade. As indicated by Figure 4C, well-shaded plants suffered less damage than those on sunny sites. This is apparently a matter of moisture retention. During the field work it was observed that shaded plants recovered better between treatments than plants exposed to the drying effects of direct sunlight.

A distinction must be made between shade and competition for soil moisture and nutrients. Although shading was associated with decreased damage to the low vegetation that was already established on the study plots, range management studies (Ehrenreich 1959) have shown that the volume and vigor of ground cover can be increased by removal of overstory vegetation. Also, park managers mention that sod is difficult to maintain under trees. This suggests that ground cover would be most durable where a very few trees are arranged to cast the greatest possible amount of shade. In such an arrangement, ground cover would be shaded for protection against excessive drying, but competition from trees would be held to a minimum.

Untreated vegetation. As would be expected, the weight of clippings from treated plots was strongly related to the weight of vegetation clipped from adjacent untreated plots, as shown in Figure 4D. These control plots served to express (1) the amount of vegetation subjected to damage and (2) site conditions for understory vegetation.

Applying prediction equations. The equations developed in this study have only limited usefulness within the area studied. They suggest, however, that relationships expressed as regression equations may be useful for predicting the survival of vegetation from measured site factors and from estimates of expected visitor use. As predictors of the survival of vegetation, such equations could be used: (1) for comparing the relative durability of vegetation on potential development sites, (2) for guiding use restrictions, and (3) for guiding the design and placement of facilities. If the equations were solved for assumed levels of use (expressed as tamping in this study) and measured site variables, the more durable sites would be indicated by higher predicted amounts of surviving vegetation. This, however, is only part of what must be included in defining the level, i.e., the carrying capacity, at which recreational use should be limited.

Plant durability as one of several considerations. Before deciding to limit recreational use, a manager or administrator should consider not only the predicted durability of vegetation but also: (1) other methods of maintaining the quality of recreation, (2) the amount of damage caused by specific recreations and specific groups of recreationists, (3) the level of recreational quality for which people are willing to pay, (4) whether people would rather pay for quality by accepting less use or by some other means, and (5) what future generations are likely to need and desire. Thus equations describing ecological relationships show promise of becoming effective tools, but decisions to limit recreational use must include human as well as biological considerations.

Summary and Conclusions

Many people have wondered whether our increasingly crowded recreation areas have specific carrying capacities at which use should be limited. In exploring the question this paper (1) analyzes the place of recreational carrying capacity in the management of wild lands, (2) considers how increased crowding might affect the quality of wildland recreation, (3) examines ways by which carrying capacities might be increased, and (4) demonstrates that regression equations may be useful in predicting how recreational use will alter vegetation.

During this study it became evident that recreational carrying capacity is a complex matter that requires difficult value judgments and must draw on rather complete statements of the desires of recreationists and the ecology of biotic communities. Unfortunately, such comprehensive statements are lacking. Reasoned analyses partly overcome this lack, and in combination with an ecological experiment, have led the author to ten conclusions.

1. *Recreational carrying capacity is not an absolute value inherent solely in the ecology and original characteristics of each land area.* Rather than a single facet the carrying capacity problem has three major parts: (a) the impact of people on the recreational environment, (b) the impact of the recreational environment on people, and (c) management procedures for modifying these reciprocal impacts.

By directing their attention primarily toward ecological relationships, managers of other wildland resources have been able to prescribe procedures for attaining sustained yields of such products as timber and beef. Similar reasoning has been applied to the recreational resource, but these other land products differ greatly from recreation. They can be

detached from the land; they have obvious utility that does not decrease when competition for them increases; and they can be evaluated without elaborate reference to the psychology and physiology of consumers.

In contrast, the recreationist usually must visit the resource to partake of wildland recreation; crowding and competition can reduce the utility or value of recreation to individual recreationists; and the value received by a recreationist will depend greatly on his training, experience, and alternative opportunities. Thus the production of recreation values depends not only on the condition of the resource but upon the psychology of recreationists.

2. *Limitation of use at some carrying capacity is not an end in itself but is a means to an end.* The final objective is to produce a high and sustained social value in the form of quality recreation for people.

3. *For purposes of determining recreational carrying capacity, the objective of managing wild lands may be stated as the sustained production of the highest quality recreation that is possible at acceptable costs.* In this nation we still hesitate to pay for wildland recreation that has traditionally been free. But as all land uses increase, we cannot avoid the fact that human wants will exceed the capabilities of our resources. The quality of some types of recreation will be maintained only by sacrificing quantity or by forgoing other values. But for any set of circumstances there will be a limit to what people will sacrifice for quality recreation.

4. *Accepting limitation of use is only one of the costs that can be paid for quality recreation.* Other costs include.

a. Giving up products and services that could be produced if recreation were restricted to less land.
b. Paying higher prices for products and services that are less abundant because recreation has been included among land uses.
c. Accepting regulation of conduct and movement.
d. Accepting a different kind of recreational experience.
e. Spending time, money, and effort to reach quality recreation areas that still remain.
f. Paying for acquisition, development, and management of recreation lands through taxes, entrance fees, or other means.

In part, these costs may be substituted for limitation of use and for each other. Thus the carrying capacity of recreation lands will always be relative to the availability of various land values and to the strengths of demands for these values. Carrying capacity would require a sacrifice in quantity as a cost for quality recreation.

5. *Limitation of use will be appropriate only when it is an acceptable cost for quality recreation.* It will be acceptable only when recreationists are willing to pay for quality and find other costs and procedures either more objectionable or inadequate. In wilderness areas or at intensively developed recreation areas, crowding could become so severe that only limitation of use would maintain quality. Recreationists in either case might prefer to accept less recreation rather than accept the reduction in quality that would accompany more development or increased crowding.

6. *In the absence of measured data, it is possible to estimate the effects that increased crowding of a wildland area would have on human judgments of the quality of recreation.* This was done in the present study by considering the relatively few categories of needs and desires that motivate wildland recreations, and then deciding what effect crowding could logically be expected to have on the fulfillment of these needs. It was concluded that needs for exercise, a healthful environment, esthetic enjoyment, understanding, change, and companionship can usually be satisfied amid crowding. But, either directly or by changing the condition of recreation

areas, crowding tends to reduce satisfaction of needs for freedom of choice, early traditions, unspoiled nature, self-reliance, solitude, and the esteem that accompanies unique experiences. Thus the effect of crowding on recreational quality will depend on what needs motivate the particular activity being pursued. Carrying capacity depends ultimately on the needs and value judgments of people.

7. *Management procedures may allow both high-quality recreation and high rates of use if they: (a) reduce conflicts between competing uses, (b) reduce the destructiveness of people, (c) increase the durability of areas, or (d) provide increased opportunities for enjoyment.* These procedures include zoning, engineering, public relations and persuasion, interpretive services, and the management of biotic communities.

By reducing conflicts and efficiently using land resources, zoning can reduce the costs (including limitation of use) that each person must pay for quality in the recreation he pursues. Without zoning, uses, and users with the greatest crowd tolerance and aggressiveness, may drastically reduce the quality and possibility of other types of recreation.

Where some unnaturalness is acceptable, engineering can increase carrying capacity (a) by controlling or limiting the movements of people and therefore the damage they cause, (b) by providing surfaces that withstand tremendous use, and (c) by providing access into little-used areas.

Publicity and other means of persuasion may encourage less destructive habits of recreation. In addition to persuasion, interpretive programs and devices can help people to observe more keenly and to understand and enjoy what they see.

Carrying capacity can also be maintained and increased by techniques that augment the natural durability of biotic communities. As in the case of engineering, these techniques are appropriate only where some unnaturalness is acceptable. Examples include the adding of fertilizers, planting and encouraging durable species of vegetation, stocking of fish, and improving wildlife habitat.

8. *Relationships between vegetation, visitor use, and site factors can be described and show promise as tools for predicting the impact of visitors on recreation areas.* In the experimental portion of this study, recreational use was simulated at various intensities on a series of vegetated plots. Amounts of vegetation surviving on treated plots were compared with amounts of vegetation on adjacent control plots. Site variables were also measured, and multiple regression analysis of the data produced equations that relate the survival of vegetation to simulated use and to site variables.

Although these equations are based on very limited field work and should not be applied, they show the possibilities of research to provide formulas that will allow area managers to measure site variables, perform a few simple computations, and predict how various amounts of recreational traffic would affect vegetation on a given area.

9. *Once determined, carrying capacities can be applied in a variety of ways.* The design and spacing of such facilities as parking lots automatically limit use on a first-come, first-served basis. Some visitors would be discouraged by charges to cover management costs or to match other land revenues forgone because of recreation. In addition to limitation of use, testing and certification would train recreationists to use areas carefully and skillfully. Barriers of distance and the considerable effort required to reach the areas keep crowds from overrunning and changing the quality of most wilderness areas.

Recreationists are already accepting limitations on use when convinced that the advantages justify the restrictions. Drawings for limited hunting licenses have been common for many years for such scarce species as bighorn sheep and

pronghorned antelope. Several states (Bednark 1957) now have controlled shooting areas for waterfowl. Hunters are assigned shooting privileges either by lottery or on a first-come, first-served basis. Choice shooting locations will be available to each hunter only a limited number of times.

10. *Finally, it is concluded that, while research can provide various types of information for guidance, final definitions of recreational carrying capacity must be of an administrative nature.* Ecological studies can show how biotic communities will change with use, but someone must decide how much change is acceptable. In a similar manner, use of research surveys and other tools from the social sciences can measure current public opinion and analyze human motivation. But such motivation and opinion will seldom be based on a thorough understanding of availability and productivity of the resource. Someone must decide which combination of needs and desires it is most desirable to satisfy from our limited resources.

On public land, which provides much of our wildland recreation, policy decisions should be by legislative directives and by public servants striving to achieve the public good. Recreational quality gained by limiting use must be weighed against values lost when such limits reduce the number of people served. Present values must be weighed against values for future generations.

As competition for land increases, the limitation and allocation of uses will leave many special-interest groups unhappy. And much as public officials might wish to shift the burden to impersonal equations, the formulas devised by researchers can guide but not supplant human judgment.

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