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THE CARRYING CAPACITY OF WILD LANDS FOR RECREATION

by
John Alan Wagar

A dissertation submitted in partial fulfillment
of the requirements for the degree of
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Doctoral Committee:

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PREFACE

Drawing on my training and experience in timber management, and with additional examples from range management, I approached this study with the view that the carrying capacity of recreation lands could be determined primarily in terms of ecology and the deterioration of areas. It soon became obvious, however, that limiting or reducing the numbers of recreationists creates problems not encountered in limiting timber harvests or numbers of livestock. People become discontented when turned away from recreation areas, and certainly the goal of recreation management is not to make large numbers of people unhappy.

With recognition of human needs and desires, the resource-oriented view of carrying capacity became clearly inadequate. This dissertation includes an ecological field study and discussions of ecological relationships. But in weighing the advantages and disadvantages of limiting the numbers of recreationists, it also enters into an analysis of the objectives and values of using land for recreation. This evaluation goes beyond available data and beyond the possibilities of reasonably small experiments. Thus much of the study is at an abstract level at which conclusions are based on logical analysis rather than measured data.

Perhaps the main contribution of this dissertation is its organization and analysis of the factors which determine the carrying capacity of wild lands for recreation. The subject has been elusive and has proved to be much different than it seemed to be when I began to study it. With the identification of management objectives, several notions about recreational carrying capacity proved to be untenable. Their rejection is a clarification of the problems of managing recreation lands.

With sincere gratitude I wish to thank those who have contributed to this undertaking. For comments, advice, and encouragement which have strengthened this study from the first outline to its final form, I am especially grateful to my doctoral committee: Professors Grant W. Sharpe, Stanley A. Cain, Kenneth P. Davis, G. Robinson Gregory, and Harlow O. Whittemore. The Division of Parks, Michigan Department of Conservation, granted permission to conduct a field study on its Brighton Recreation Area. Leonard W. Bierlein, who was then manager of the area, was very helpful. The Northeastern Forest Experiment Station of the U. S. Forest Service provided several weeks of on-the-job time for writing one draft of the manuscript and provided use of an automatic calculator for the computations required by the field study. Of Forest Service personnel, Hubert D. Burke reviewed the entire study, and C. Allen Bickford and Kenneth D. Ware reviewed my handling of the statistical data. All three contributed helpful comments. 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, I am indebted to my father, J. V. K. Wagar, who for many years has stimulated my thinking about the management of wild lands and from whom I have probably borrowed even more heavily than I realize.

I have selected, interpreted, and omitted ideas from the wealth of material suggested by these people, and in this undertaking, the responsibility for any errors is entirely mine.

J. A. W.

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CHAPTER I

INTRODUCTION AND TERMINOLOGY

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. That we still crave, at least vicariously, these frontier-type adventures is easily demonstrated by an evening's viewing of television. Moreover, in recent years 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 U. S. have ceased to accept the "cut out and get out" exploitation of timber, many of them still have an attitude of exploitation when it comes to wildland recreation. National traditions hold that such recreation is free, is a "right" and "heritage," and is available in undiminished quality to all who seek it. But quality in wildland recreation is no longer assured for all who travel. When too many people reach the same area, some traditional wildland values are lost. Adams (1930), Meinecke (1932), and Leopold (1934) wrote of this even

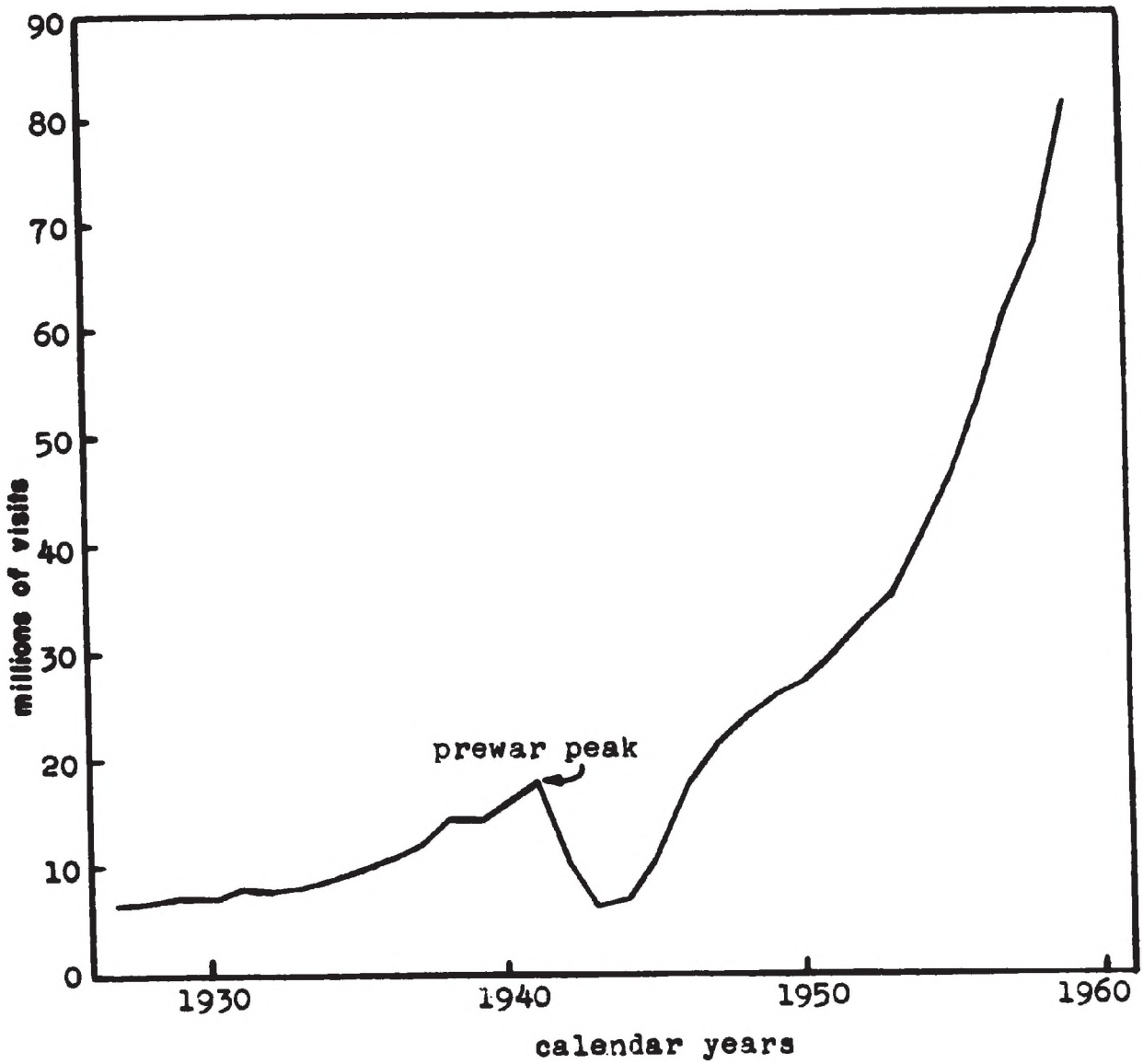


Fig. 1.--Recreational use of the national forests (adapted from Operation Outdoors, U. S. Forest Service, 1957).

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) are increasingly frequent.

Swamped with visitors, the National Park Service launched Mission 66 in 1956 to meet 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. In these cases the questions arise: 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 used 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 in recent years the carrying capacity of wild lands for recreation has been identified as an area in

need of study. 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) has 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 dissertation are: (1) to identify and analyze the main factors which 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 demonstrate the potential advantages of using regression analysis techniques to develop equations for predicting the durability of vegetation subjected to recreational use.

The first two of these purposes require a broad organization and analysis of the scope and objectives of wildland recreation. This organization and analysis begins in Chapter II, which, after sketching the history of the carrying capacity concept, shows how carrying capacity fits into the management of recreation lands.

Chapter III examines the motivation of recreational pursuits and shows how crowding may change the quality of recreation by changing possibilities for the satisfaction

of human needs and desires. This occurs (1) directly, as people react to the presence of others, and (2) indirectly, as the impact of people alters the condition and character of recreation areas.

If recreation areas can be maintained in good condition, many activities remain enjoyable amid heavy use. Chapter IV discusses methods of increasing carrying capacity and methods of offsetting the decline in quality which frequently accompanies increased crowding.

To decide what measures are essential to maintain attractive wildland areas, managers need to know the durability of vegetation. Although this is only one of the factors determining carrying capacity, it lends itself to experimental investigation. Chapter V applies regression analysis techniques to demonstrate a method of predicting and comparing the relative durabilities of vegetation on different areas. Although the regression equations resulting from this study are of little immediate value to land managers, they demonstrate the possibilities of a technique by which research can provide managers with tools that may have great value. For example, it required two months of field work and several hundred hours of machine computations to develop the equations of this study, and it would take much longer to develop equations that could be used with confidence over a sizable region. But once the researcher has developed such equations, managers could apply them by making a few measurements and a few simple

calculations.

Chapter VI states the conclusions of this dissertation.

Terminology

Several of the terms which follow are subject to more than one interpretation, but in this dissertation they are used as interpreted below.

Wild lands are non-urban areas which 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 which are under management and are not truly wild. But through long usage it has come to apply to lands which are sparsely settled and which present a fairly natural appearance. Forests, deserts, mountains, grasslands, and other extensive lands are normally included.

Recreation, as the term is used in this study, refers primarily to creative leisure-time activities (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, [these activities] . . . must be based on self-choice, initiative, and spontaneity."

Wildland recreation is recreation characteristic of wild lands and, as used in this study, includes activities

ranging from typical state park recreations to wilderness travel. This range includes such enjoyments and activities as picnicking, hiking, nature study, and viewing extensive scenery but not such activities as ping-pong, dancing, and bridge, which have no necessary connection with wild lands.

Recreational quality is the degree to which a recreational experience or area normally contributes to the physical and psychic well-being of recreationists. Thus for most people, a hike during cold, rainy weather contributes little to enjoyment and well-being and is of lower quality than a hike during pleasant weather. By the same reasoning a thoroughly worn area usually offers lower recreational quality than areas presenting a fresh and natural scene.

Points of view differ, and what is high quality recreation to one person may be considered low quality by others. For example, some recreationists consider backpacking a good adventure or at least a means to adventure. Others consider it ridiculous now that we have machines to carry our burdens. It is a high quality experience 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 constant and sustained quality of recreation. Defining this capacity is rather like defining how many people one pie will serve. In either case it is necessary to consider

the portion allotted each person.

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

CHAPTER II

THE CONCEPT OF CARRYING CAPACITY--ITS HISTORY AND ITS UTILITY IN WILDLAND RECREATION

Man has faced the limited carrying capacity of land since prehistoric times. Usually the problem has been one of enough food; but men have also considered carrying capacity in relation to good government, morality, and recreation.

Food and Other Crops from the Land

Just as adequate range can be a limiting factor for wildlife populations, so it must have been for primitive men. Haddon (1927) wrote that the movements of peoples . . . [are] caused by an expulsion and attraction, the former nearly always resulting from a dearth of food or from over-population." Spoehr (1956) wrote that man had spread into every major land area by 10,000 or perhaps 20,000 B. C.--indicating many migrations and thus many food shortages. Before civilization and technology advanced, the earth's limitations must have constantly threatened human populations. In 1751 Benjamin Franklin (as reported by Sparks, 1856) wrote that "Europeans found America as fully settled as it well could be by hunters."

And Brown (1955) estimated that, at the hunting and gathering level of existence, the earth would support no more than 10 million people.

Ancient writings contain many references to hunger, famine, and limitations of the land. Of these the best known is probably the story of Joseph and the seven years famine in Egypt (Genesis 40:26 to 45:11). Although the original manuscripts have been lost, later translations and copies cite writings which included this story and which dated back to about 850 and 750 B. C. (Bennett, 1904). In Genesis 13:5-6 we find: "And Lot also, which went with Abram, had flocks, and herds, and tents. And the land was not able to bear them.

Closely related to carrying capacity is the concept of sustained yield, written recognition of which dates back at least to 621 B. C. (Robinson, 1907) as found in the verses of Deuteronomy (22:6-7) which decree:

> If a bird's nest chance to be before thee in the way, in any tree or on the ground, with young ones or eggs, and the dam sitting upon the young, or upon the eggs, thou shalt not take the dam with the young: thou shalt in any wise let the dam go, but the young thou mayest take unto thyself;

In the fifth century B. C., Herodotus (Godley translation, 1931) wrote of a persistent famine in Lydia during which "their king divided the people into two portions, and made them draw lots, so that the one part should remain and the other leave the country." In writing of a "bald race beyond the Scythians" Herodotus said, "For they

have but few of smaller cattle, the pasture in their land not being good."

Lucretius (Latham translation, 1951) was expounding a philosophy that some things must decay that others may grow into their prime but may have reflected the thinking of his time (ca. 55 B. C.) when he wrote:

> The same earth in her prime spontaneously generated for mortals smiling crops and lusty vines, sweet fruits and gladsome pastures, which now can scarcely be made to grow by our toil. We wear down the oxen and wear out the strength of husbandmen, and the ploughshare is scarcely a match for fields that grudge their fruits and multiply our toil.

About 60 A. D., Columella disagreed but indicated the opinions of others by writing (Simkhovitch, 1916):

> I began my former book by refuting the ancient opinion of nearly all agricultural writers, and by rejecting as false their idea that the soil, worn out by long cultivation and exhausted, is suffering from old age.

During the ninth century in Japan (Fernow, 1911) edicts recognized the need of protecting watersheds and "fear of a timber famine led even to planting in the provinces of Noto." In Europe under the feudal system (Greeley, 1953) the forest was considered a fief to be "passed on to the next heir or vassal unimpaired in productiveness." It was this system of entail which formed the basis of sustained yield in forestry. 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."

The principle was more fully developed during the last half of the nineteenth century.

In France it was recognized very early that unlimited grazing might destroy whole forests, and beginning in 1318 (Buttrick, 1926) royal edicts restricted the area of public forests on which grazing was permitted. By the Ordinance of 1669 forest officers were given authority to limit livestock numbers "to a point not to tax the yield capacity of the forest."

American settlers tended to forget the experiences of Europe in the abundance of a new continent, but as early as 1670 (Ise, 1920) "a Plymouth order . . . stated that several towns of the colony were already much straitened for building lumber." Although grazing had caused severe damage in the Old World, the U. S. did not profit from the example, and destruction and overgrazing of range lands were occuring in the eighteen sixties (Stewart, 1936). By the eighties the problem was generally recognized, but many areas are still overstocked. Nor is this problem 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."

Good Government and Morality

Written references to the effects of human numbers

on government are nearly as old as those relating to food. Both Plato and Aristotle dealt with the subject in the fourth century B. C., and in his Politics (Jowett translation, 1885) Aristotle wrote:

> Experience shows that a very populous city can rarely, if ever, be well governed; since all cities which have a reputation for good government have a limit of population . . . For law is order, and good law is good order; but a very great multitude cannot be orderly . . . Clearly then the best limit of the population of a state is the largest number which suffices for the purposes of life, and can be taken in at a single view.

Over two thousand years later, in 1787, Thomas Jefferson (as reported by Ford, 1904) wrote to Madison:

> I think our governments will remain virtuous for many centuries; as long as they are chiefly agricultural; and this will be as long as there shall be vacant lands in any part of America. When they get piled upon one another in large cities, as in Europe, they will become corrupt as in Europe.

In an essay of 1798 Malthus argued that population in excess of food supplies is a major factor contributing to vice, misery, and poverty.

Recreational Carrying Capacity

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 a fear that too many hunters would reduce the quality of the sport.

During his visit to the Orient in the thirteenth century, Marco Polo found such measures as food patches, cover control, and hunting restrictions being used to increase the yield of game lands belonging to Kublai Khan (Leopold, 1939). 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 invented, and especially since the end of World War II, outdoor recreation in the U. S. has increased tremendously, and managers of overcrowded areas face the problem of recreational carrying capacity.

On the basis of experience, several guides have been developed for the space requirements of recreationists. The U. S. Forest Service (1957) uses 100 feet as a standard for the distance between family camping units and believes that this spacing gives adequate privacy and protects soils and vegetation. Allowing for roads and toilets, such spacing permits about 3 campsites per acre. The National Park Service (1960) has generally placed between 4 and 7 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 people try to pitch two tents per site if 40-foot spacing is used (Wintermute, 1960).

To estimate space requirements for summer camps, the Boy Scouts of America (1950) use one acre per boy for the maximum weekly attendance expected. For every 1000 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 of statewide significance, and 200 acres of national significance. A standard of one man-day of use per season on each 3 acres of wilderness has been suggested. This intensity of use is less than that now found on the most heavily-used Forest Service wilderness areas.

In addition to effects of visitors on the site, determinations of carrying capacity must consider the effect of crowding on the recreationists. Gebler (1956) reported a study of interpretive walks in Yellowstone National Park and found that the number of questions per visitor tended to decrease as the group size increased--especially when the group number reached approximately thirty. Some studies of visibility by Whittemore (1960) suggest that, if people are not noisy, a sense of solitude is possible when there is not more than one small party per 160 acres of open country, 40 acres of sparsely wooded country, or 10 acres of heavily wooded country.

Even though the idea of carrying capacity has been with us for centuries, its meaning is often unclear--particularly when applied to recreation.

The Place of Carrying Capacity in the Management of Wild Lands for Recreation

In every statement of carrying capacity there must be, at least implicitly, a statement of purpose, a management objective. Consider range land for example. If its carrying capacity is exceeded, production of animal products may show an immediate gain at the expense of range quality (the resource) and future yields. But this is undesirable for a rancher who wants to stay in business and wants to pass a productive ranch property to his descendants. His management objective may be the production of animals at that level which can be sustained indefinitely and which yields the greatest continuous profit. To reach this management goal he would set a carrying capacity which will not reduce range quality below the level this goal requires. If a heavy level of stocking is chosen, such measures as irrigation and fertilization may be needed to maintain range quality.

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. As given in Chapter I, recreational carrying capacity is the level of use at which quality remains constant. But quality could be constant at high or low levels. For example, a small picnic area may hold 100 people per day throughout a season 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 100 persons per day. But we can put 200 people per day into the same area. Some of the vegetation will be killed, and the area may become less pleasant (a decline in quality), but a new equilibrium will be reached at which quality no longer declines. By definition, carrying capacity is now 200 people per day. Crowding might be continued until all the vegetation and soil were lost and mobs of people rendered the barren place 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 land, and our limited land resource can not produce everything people want. 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 that is possible at acceptable costs. On public land, which provides most wildland recreation, decisions as to what costs are acceptable will have to be

made by elected representatives and public servants striving to achieve the public good.

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

1. Giving up 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 on the Adirondack Forest Preserve.

2. Paying higher costs for products and services which 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. 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.

In this country wildland recreation has traditionally been inexpensive, and many of our attitudes toward it were developed when the country was still sparsely settled. Land

was abundant and quality recreation cost little but the effort of getting to it. But as the U. S. becomes more fully settled, and as demands for land 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 recreations, unrestricted use may prove even more objectionable by reducing the quality and enjoyment of recreation. The degree to which use should be limited will depend on (1) the natural durability of wildland areas, (2) the effectiveness of various methods of 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. To provide a basis for deciding what carrying capacity is justified, the next chapter examines the effects of crowding on human enjoyment and judgments of quality.

CHAPTER III

CROWDING AND RECREATIONAL QUALITY

Quality and the Satisfaction of Needs

Wildland recreation is motivated by a variety of needs and desires. The quality of this recreation and thus the benefit derived from it will depend on how well these needs are satisfied. Because the objective of recreation is to provide benefit and enjoyment for people, managers of recreation areas must consider how management procedures will affect the satisfaction of human needs and desires. To decide whether it is appropriate to define a carrying capacity and to limit use, they must know how satisfaction 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 the same experience would provide the same satisfaction for another person or for the same person at another time. Fishing is fun--for a while and for some people. But after a month or two, fishing would not give the same satisfaction it did with the first strike of the season--even for the most avid angler.

Although satisfaction is not measurable, its relation

to numbers of people can be estimated and described. As a basis for evaluating the recreational carrying capacity of wild land, this chapter discusses the effects of crowding on the satisfaction of 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 inherent and acquired drives. Symonds (1958) organized these into the following list which includes an earlier list proposed by Tolman (1951):

1. Fundamental characteristics of adjustment.

   (a) Drive toward success.
   (b) Drive toward the familiar.
   (c) Drive toward new experiences.

2. Appetites and aversions (Tolman's list).

   (a) Food-hunger.
   (b) Sex-hunger.
   (c) Excretion-hungers.
   (d) Specific contact-hunger.
   (e) Rest-hunger.
   (f) Sensory-motor-hungers (i. e., the esthetic and play hungers).
   (g) Fright (injury-avoidance).
   (h) Pugnacity (interference-avoidance).

3. Derived drives.

   (a) Desire to be with other persons.
   (b) Desire for attention from other persons.
   (c) Desire for praise and approval.
   (d) Desire to be a cause.
   (e) Desire for mastery.
   (f) Desire to maintain the self.
   (g) Desire for security, protection.
   (h) Desire for affection, tenderness, intimacy, sense of belonging.
   (i) Curiosity (reaching, grasping, manipulation, exploration).

Recognizing that some needs must be at least par-

tially fulfilled before others become important, Maslow (1954) developed a theory of motivation which organizes needs into a hierarchy with the following "order of prepotency":

4. Physiological needs.
5. Safety needs.
6. Belongingness and love needs.
7. Esteem needs.
8. The need for self-actualization.
9. Preconditions for the basic need satisfactions. (Maslow includes "freedom to do what one wishes so long as no harm is done to others, freedom to express oneself, freedom to investigate . . .")
10. Desires to know and understand.
11. Esthetic needs.

Many other lists of needs have been or could be compiled. As units for analyzing recreational quality, the following categories of needs and desires have proved useful and are examined in this chapter. (Numbers identify similar or related categories from the lists given above.):

Exercise (2f, 4).

Healthful environment (4).

Self-esteem and social prestige (1a, 3b, 3c, 7).

Esthetic enjoyment (2f, 11).

Understanding (3i, 10).

Freedom of choice (9).

Perpetuation of early traditions and conditions (10, 11).

Self-reliance (3d, 3e, 8).

Change and escape (1c).

Companionship (3a, 3b, 3h, 6).

Cooperative endeavor (9).

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 recreations. This requires that each need be abstracted from specific activities and be examined as a fundamental force which 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 which commonly motivate it.

The effects of crowding on satisfactions are illustrated by graphs for each of the needs discussed in this chapter. For example, Fig. 2 represents satisfaction of the need for exercise as being unchanged by crowding. It must be emphasized that these figures are freehand curves drawn to illustrate discussions and are not supported by measured data. Although axes have been labeled, there has been no attempt to assign units.

At the end of this chapter, after the following discussions of specific needs, examples are given to show the diversity of recreations these needs can motivate.

Exercise.--Modern occupations tend increasingly to involve mental activity and precise work with the small

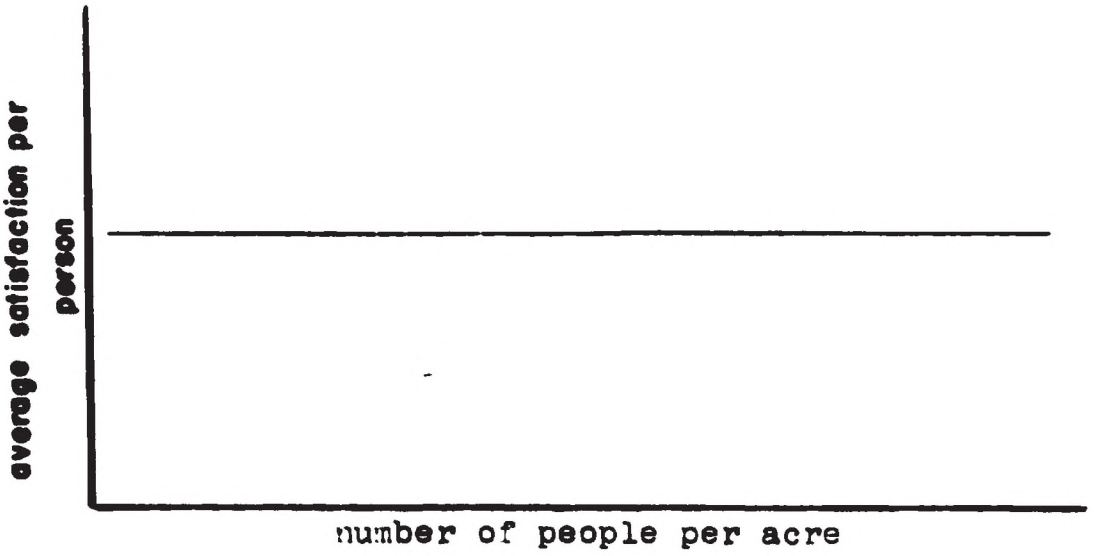


Fig. 2.--Satisfaction of the need for exercise. The horizontal line represents satisfaction as remaining unchanged with increased crowding.

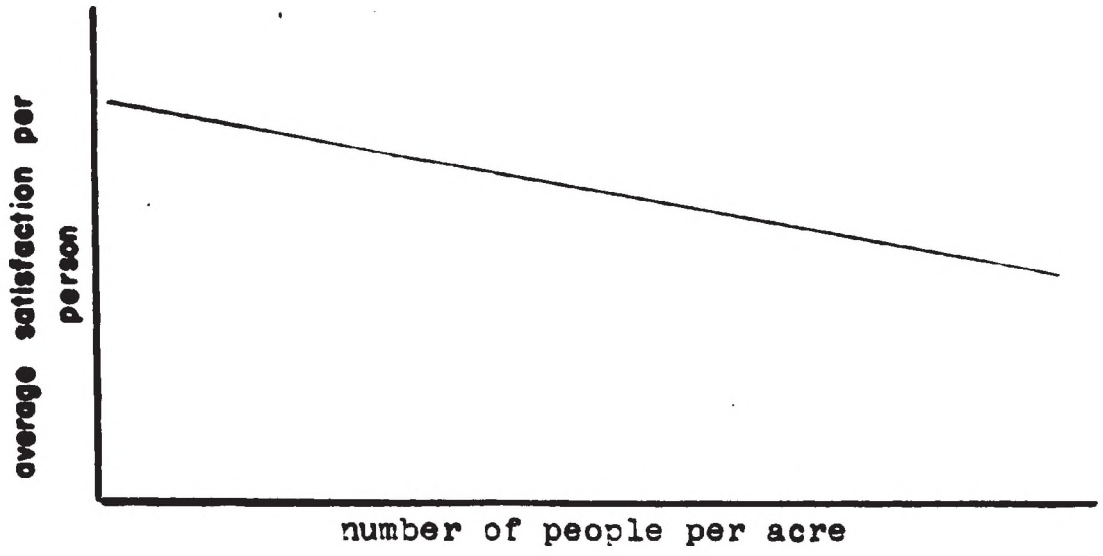


Fig. 3.--Satisfaction of the need for a healthful environment. The downward sloping line represents satisfaction as decreasing gradually with increased crowding.

muscles of the hands. Yet man evolved as a running, jumping, throwing creature that used all its 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 more important in our play, and the same society that scorns heavy work admires and emulates people who perform muscular feats--especially skillful 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?

As illustrated by Fig. 2, satisfaction from exercise need not decrease with crowding, because vigorous use of the muscles requires little space. Hiking, 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.

Healthful environment.--Clean, unpolluted surroundings are one of the attractions of wildland recreation--especially now that we are a nation of city dwellers. Many centers of population are smoky, humid 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 as represented by Fig. 3, each person's satisfaction from healthful surroundings would decrease gradually as he was joined by increased numbers of people. 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. Local areas may begin to smell. Climate is more durable, and blue skies and pleasant temperatures are not apt to be lost even when population density approaches that of urban areas.

With careful management healthful conditions can be maintained at high levels. Water supplies can be developed and even purified. Facilities for waste disposal can be installed and custodians hired to clean up after careless and irresponsible people. Intensity of management could be matched to levels of use until it became offensive in

itself, and healthful conditions need not deteriorate very far. But no cleanup measures would remove all pollution instantly, and minor deterioration would 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.

The classic answer to "Why climb a mountain?" is "Because it's there." A more complete answer would be "It is a challenge to the strength, endurance, courage, and skill of the climber. If he accepts the challenge and conquers the peak, he gains the personal joy of a victory achieved and wins the admiration of others."

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, Fig. 4 shows satisfaction of needs for esteem and prestige as falling rapidly when increasing numbers of people achieve the same goal. Thus, even though it is in the 14,000-foot class, few people gain much prestige from driving to the top of Pike's Peak. Almost anyone can do it and many have. The relatively few people who climb Long's Peak or Mount Rainier have a better basis for pride.

Crowding can also reduce chances for prestige and esteem by destroying places for doing unique things. If, for example, a wilderness were dissected by roads to accommodate more people, many wilderness experiences would no longer be possible there.

Although each person's satisfaction of needs for prestige and esteem would normally decrease rapidly with increased crowding on wildland areas, even commonplace achievements contribute to some self-respect, and a person can excel even when the range of opportunities is narrow. Thus satisfaction would never reach zero.

Esthetic enjoyment.--Many wildland areas are treasured for their beauty, and a desire for esthetic things attracts many visitors. If even a small part of what visitors photograph is beautiful, one has only to look at the number of dropped film wrappers to know how scenic our wild lands are. In fact it has been suggested, facetiously,

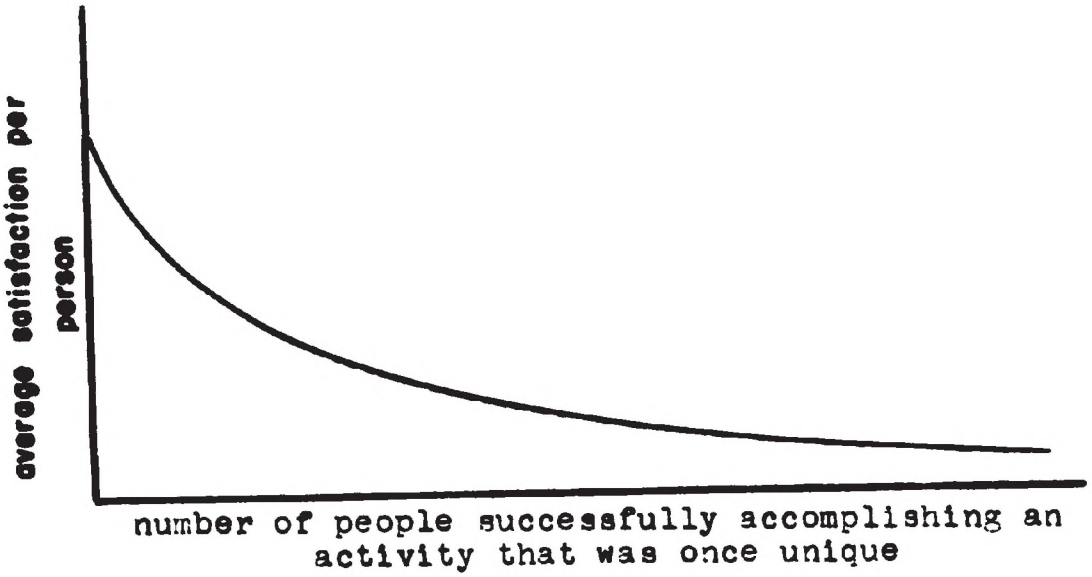


Fig. 4.--Satisfaction of needs for self-esteem and social prestige as it would change when increasing numbers of people meet the same standards of accomplishment.

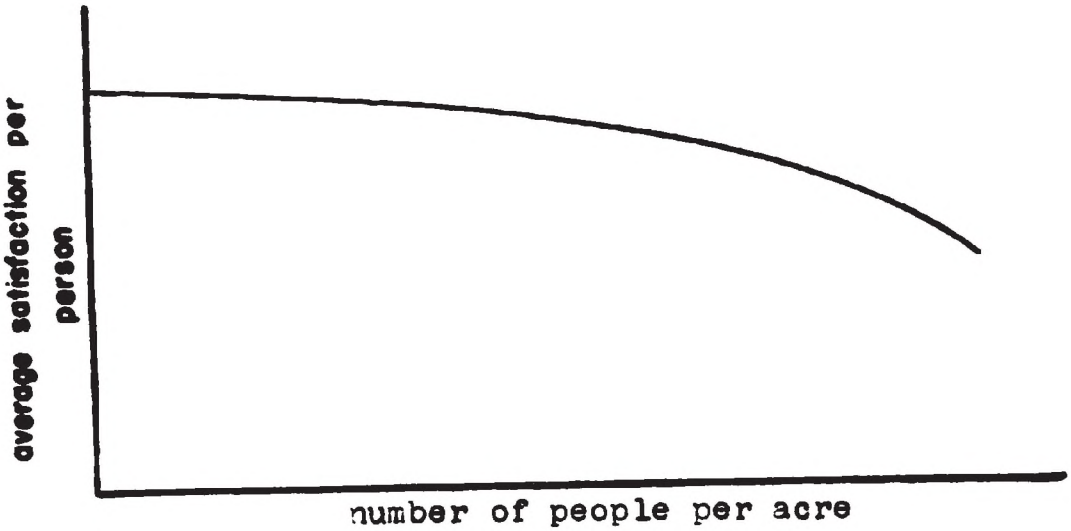


Fig. 5.--Satisfaction of the need for esthetic enjoyment as it would change with increasing numbers of people.

that the outlawing of color photography would solve the problem of crowding in our parks.

As represented by Fig. 5, possibilities for esthetic appreciation can be maintained in spite of increasing numbers of recreationists as long as 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.[1]

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 the attractiveness of an environment, and debris left by thoughtless visitors detracts from the general scene. 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, satis-

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

faction of an individual's need for esthetic enjoyment need not decline greatly until extremely heavy use is reached. But at very high levels of use, either recreationists or provision of facilities may damage the resource or interfere with its enjoyment. Esthetic enjoyment would then decline.

Understanding.--People are basically 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 interpretive lectures, and ask questions of rangers and guides. Among the recreational agencies, the National Park Service has specialized in meeting this need.

As illustrated by Fig. 6, satisfaction of the need for understanding could either decrease gradually or increase and then decrease under conditions of increasing crowdedness. As mentioned earlier for interpretive walks, Gebler (1956) found that the number of questions per visitor tended to decrease with an increase in the size of visitor groups. However, in a well informed group, members would probably exchange information, and understanding would probably increase with group size up to the point where crowding interfered 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 con-

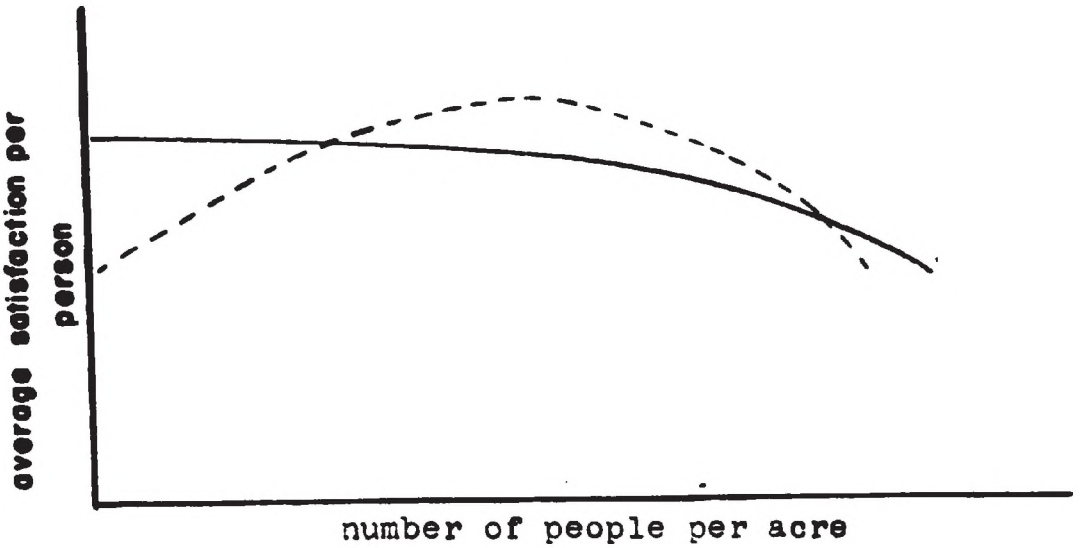


Fig. 6.--Two ways in which crowding might change satisfaction of needs for understanding. The solid curve would apply to most groups which are dependent on expert guidance. The dashed curve would be more appropriate for describing well informed groups in which members exchange information.

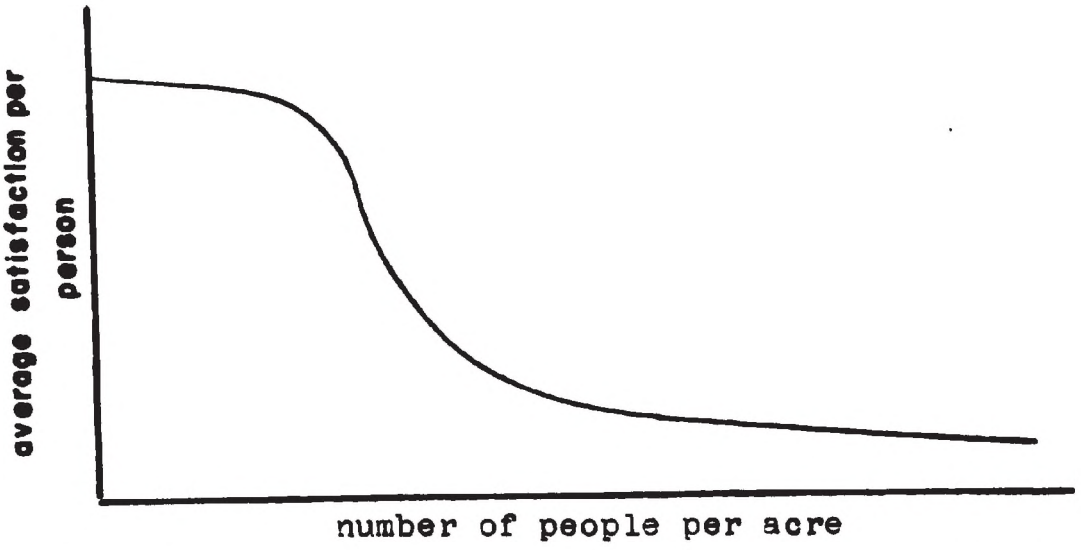


Fig. 7.--Satisfaction of needs for freedom of choice and perpetuation of early traditions as it would change with increasing numbers of people.

tinue 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. 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 perishable attractions of wild lands is the freedom of choice they allow. Continued existence of such areas broadens the range of total recreational choices, and recreationists with access to wild land can choose such activities as hiking, hunting, fishing, and skiing in addition to the usual selection of urban recreations.

At one time wild lands were free from stop signs, civil laws, and other restrictive paraphernalia of a civilized society. But as these lands become more heavily used, such complete freedom can no longer exist. Early campers made bough beds, 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 can not enjoy all that the few enjoyed. This may be undemocratic but is an unavoidable fact.

Satisfaction of each person's desire for freedom of

choice will decrease as wild lands become more crowded, and Fig. 7 represents the relationship. This curve is sigmoid--dropping only gradually at the beginning and end but falling rapidly in the middle. 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, David Crockett, 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 pioneering merit badge 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.

These wild lands are often valued as remnants of original America. A few visitors want to hear the sounds, know the solitudes, and meet the tests of the wilderness. Most visitors, however, are satisfied just to see samples of the land as it existed when the first white men saw it. And even though they do not venture far themselves, they

often want to know that a few places still exist as they have always been.

Crowding would affect satisfaction of needs for freedom of choice and for traditional wildland activities and conditions in approximately the same way. Thus Fig. 7 is used to illustrate both this and the previous discussion. Because many early day experiences depended on the way vast spaces challenged and moulded a mere handful of men, increased numbers of visitors on our dwindling wild lands decrease the possibility of experiencing many things known by earlier generations.

Advancing civilization has reduced the extent and many of the dangers of wild lands, and heavy recreational use further changes their original character. Whether on horseback, walking, or in canoes, modern wilderness travellers normally use routes marked by others and campsites built by others. During their wanderings they meet other people or signs of other people. However, a residual assortment of conditions and activities can probably be retained. Though 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 wholely a matter of enjoyment in the sense of entertainment or idle diversion, self-reliance is a genuine need that helps to motivate 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, and Fig. 8 indicates the probable relationship.

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) wrote:

> Men who love sport will reap therefrom no small advantage for they will gain bodily health, better sight, better hearing and a later old age . . . Such men, if required to make a trying march . . . will not break down . . . In advance against an enemy they will be competent both to attack and to obey their orders . . . If they are in the van, they will stick to their posts, for they will have learned steadfastness . . . Men like these . . . have rallied and fought against the victorious enemy . . . and have beaten them by their courage and their endurance.

A recent radio program provided an example of an individual motivated by attitudes of self-reliance. Some years ago an early snow stranded two men in a cabin in the Maine Woods. They had food, fuel, and a cribbage board and were in no great danger. However, after a few days one of the men became restless and decided to make some skis rather than wait for a thaw.

With the tools and materials at hand he fashioned

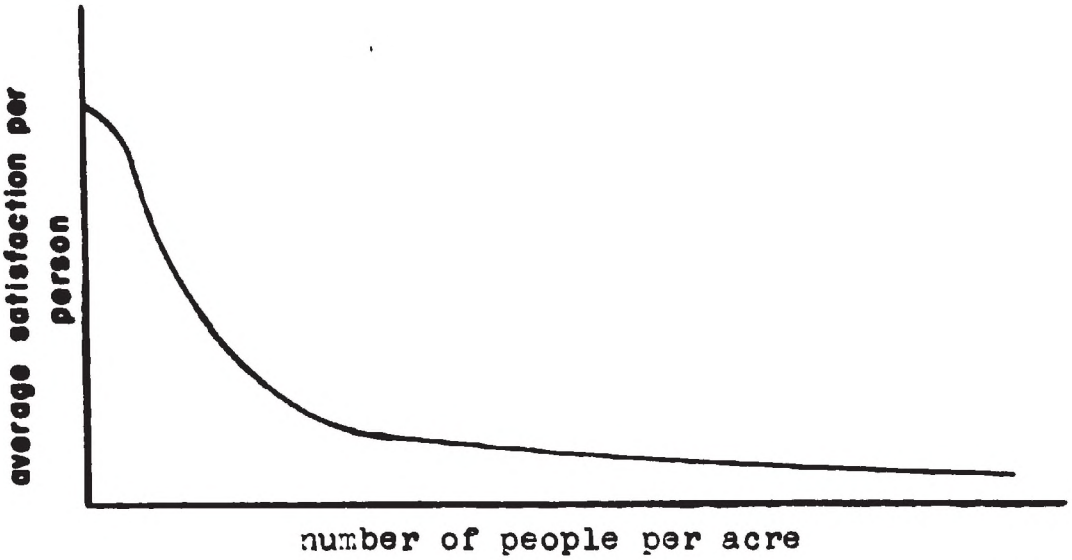


Fig. 8.--The effect of crowding on satisfaction of the need for self-reliance.

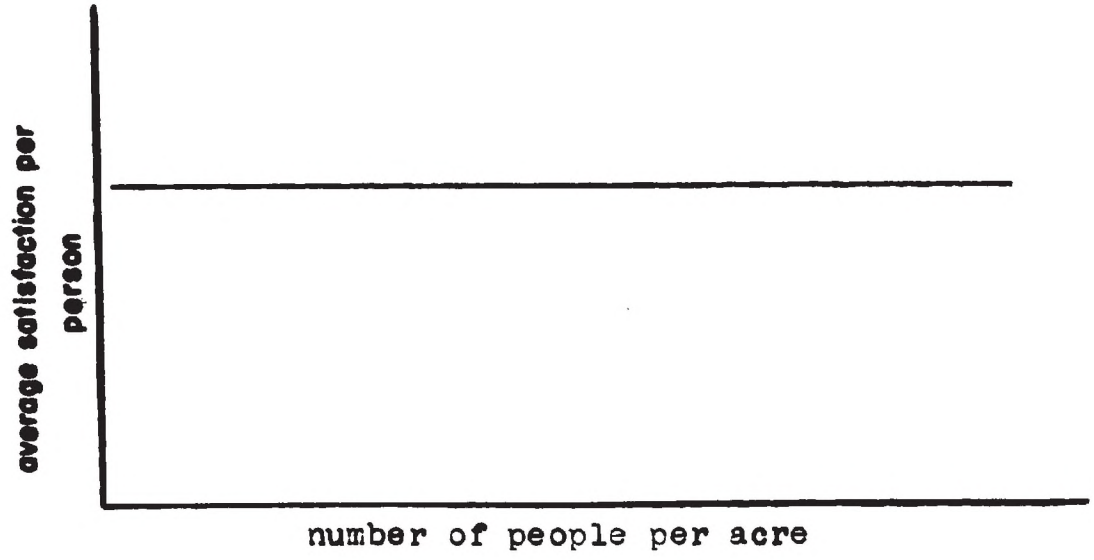


Fig. 9.--Satisfaction of the need for change and escape. The horizontal line represents satisfaction as being undiminished by increasing numbers of people.

two pairs of crude skis, and the two men started out.

It happened that a man in the nearest village--approximately 30 miles away--owned one of the first snowmobiles and had heard that the men were overdue. He decided to investigate and arrived on the scene just as the marooned men were starting out. Driving up to them he flung open a door and called, "Taxi?"

One man immediately threw away his skis and got in. The other refused. He said he had built skis to get out, was rather looking forward to the trip, and was going to see it through. He did and arrived in town several hours after the snowmobile.

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 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 because 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 increasing numbers, and the relationship is represented by a horizontal line in Fig. 9.

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, and Fig. 10 represents the relationship.

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 several families. The manager of an eastern state park (Wintermute, 1960) 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 uncommon in towns and cities.

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, Fig. 11, would rise to a maximum and then remain fairly constant until groups became so crowded that they interfered with each other. With such crowding, satisfaction would decline.

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. 12. Such thinking is common at resorts, but visitors to more natural areas frequently mention enjoying the people they encounter.

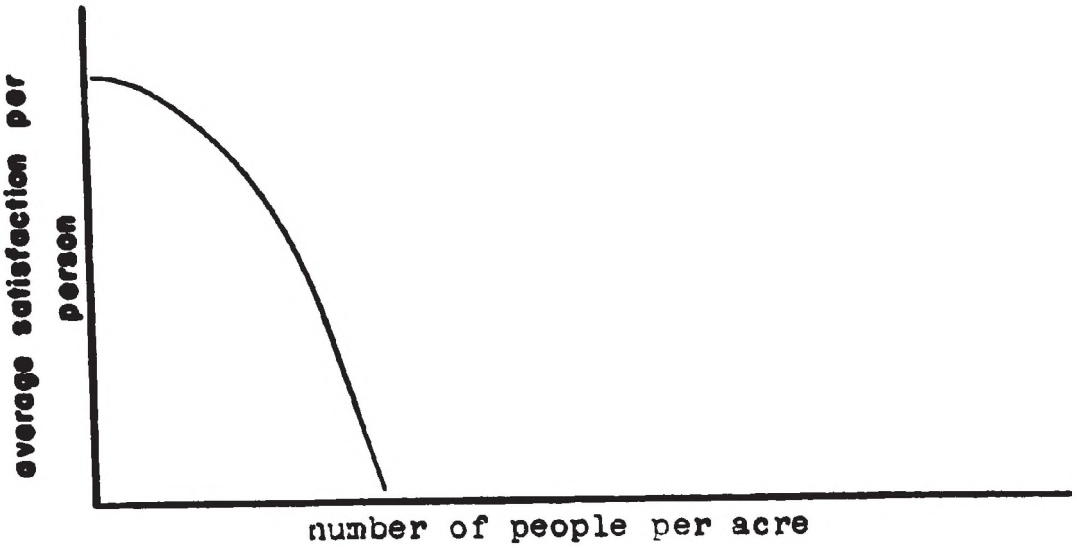


Fig. 10.--The effect of crowding on satisfaction of the desire for solitude or escape from people

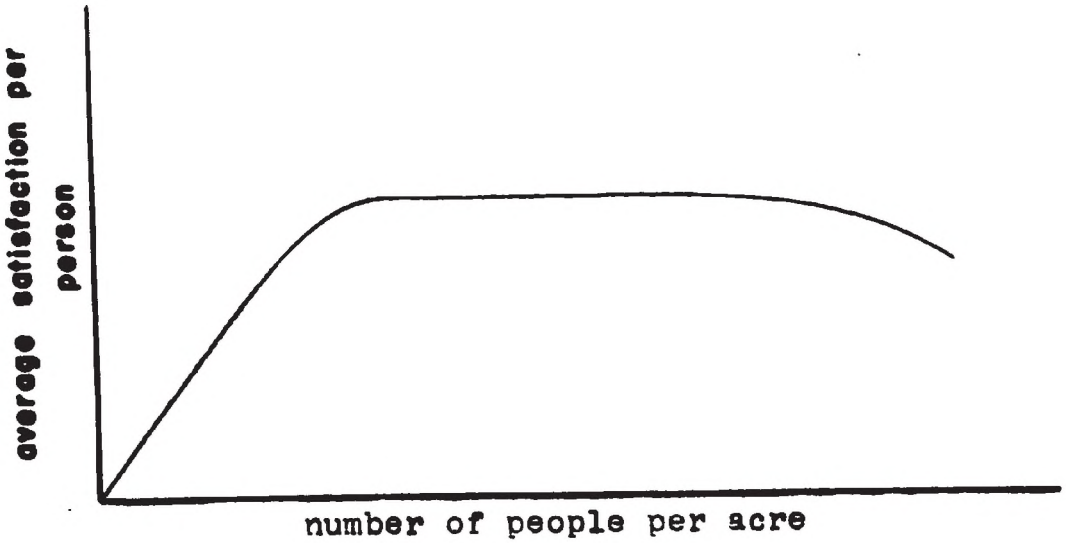


Fig. 11.--The effect of crowding on satisfaction of the need for companionship.

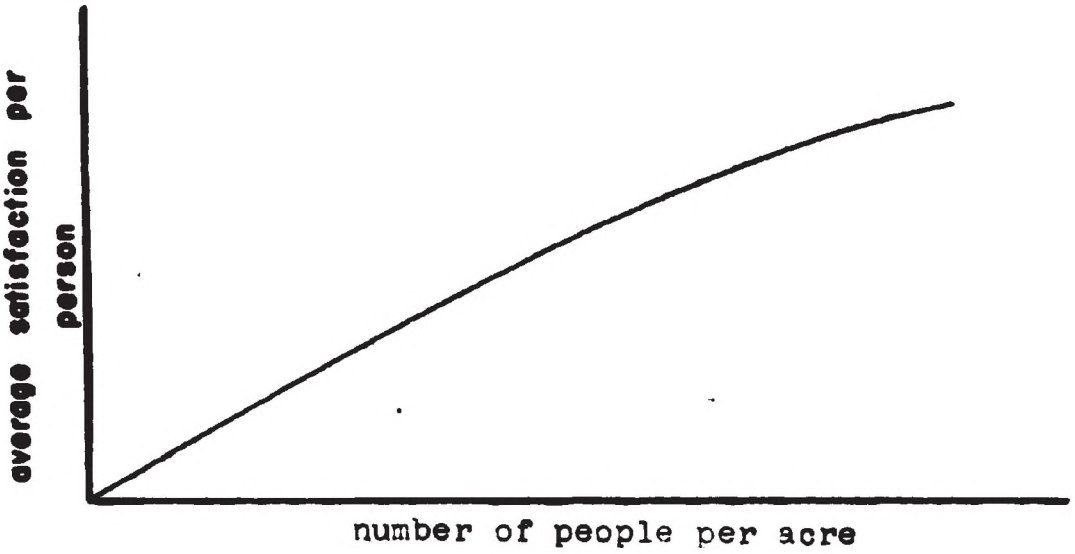


Fig. 12.--The effect of crowding on satisfaction of the need for new companionship.

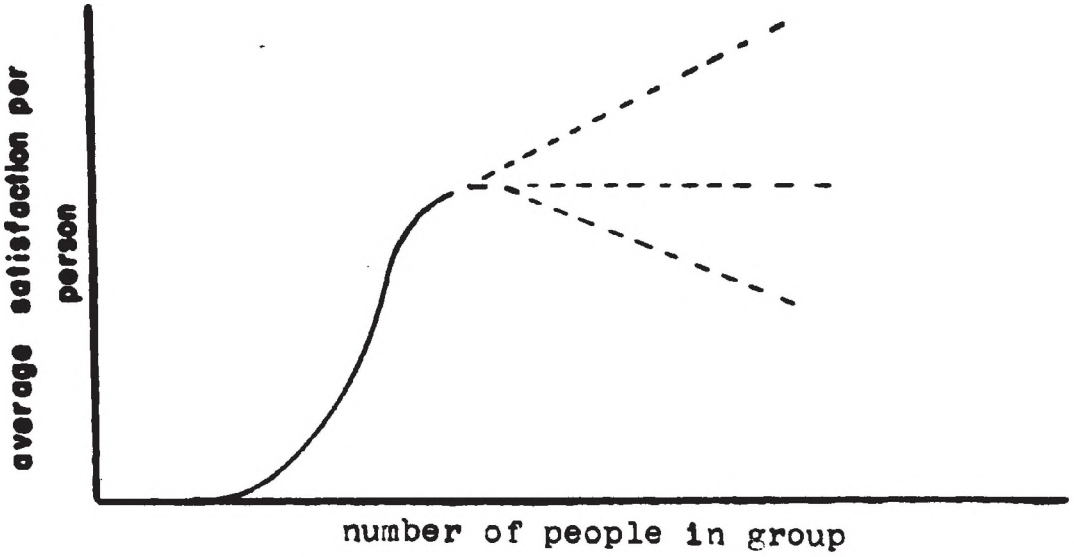


Fig. 13.--The effect of increasing numbers of people on satisfactions arising from cooperative endeavors. The spreading dashed curves indicate that excessive numbers would have different effects for different activities.

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 usually are not or else can not be pursued alone. Examples are mountain climbing and game drives.

Unless an activity is possible it provides no satisfaction. For example, the National Park Service requires at least five persons in parties attempting to climb Mount McKinley. Four climbers would gain little pleasure from a climb they were forbidden to make. Or, 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 be adequate for an efficient and 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, Fig. 13, would remain low until enough people were gathered to attempt the objective. Satisfaction would then rise rapidly till the optimum number was reached. Beyond this it could continue to rise, become approximately unchanged, or decline--depending on the activity at hand.

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 showing a variety of recreations motivated in part by each of the other needs and desires discussed in this chapter. Such lists would include everything from desires for crowded beaches, group picnics, and fully-developed trailer sites at one extreme to 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 in Alaska. Of the campers who were sampled, 27 percent said they would prefer to camp away from others, 68 percent indicated a desire to camp near a few others, and only 5 percent answered that they would prefer to camp in a large campground near many others. Yet a few miles from Ithaca, New York, people enjoy camping in rows of lots only 25 to 35 feet wide. Visitors to the wilderness of McKinley seek and expect something different from what is 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. Occasionally the distant buzzing of outboard motors interrupted the escape from civilization and diluted wilderness sounds. But wolves were heard one night and compensated for such non-wilderness intrusions. 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 people.

By contrast, there are several lodges on Basswood Lake where the canoe trip ended, and the lodge guests that were encountered seemed well satisfied with their more populous and developed environment. Even if heavily used, such a lake could provide 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 products and services, the ultimate measure of proper use must be its provision, on a sustained basis if possible, 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 will have on the fulfillment of human needs and the 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.

CHAPTER IV

PROVIDING QUALITY RECREATION FOR MORE PEOPLE

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

Although developed recreation areas are considered by many to be over-used, we have vast areas with no recreational development, and devoting more land to this use would do much to alleviate crowding. But recreation is only one of the products and services we want from a limited land resource, and it is not yet known what people will pay or sacrifice for high-quality experiences. Except for arguing that recreation fulfills specific human desires and is a legitimate land use, this study gives no guidance for the relative emphasis that should be given to competing land uses. Dedication of more land to recreation is simply recognized as one possibility for maintaining quality. Research in land management may eventually guide judgments of

what pattern of land uses will provide society with the greatest sustained "good."

As shown in the last chapter, the quality of a specific recreation depends on how well it satisfies the needs that motivate it; and 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 which is consistent with a chosen level of recreational quality. The techniques required are zoning, engineering, persuasion, interpretation, and management of biotic communities.

Zoning

As recreationists increase in numbers, they tend to interfere with each other's activities. In Florida, hook and line fishermen resent the effectiveness of spear fishermen. Canoeists irritate trout fishermen wading in Michigan's Au Sable River, and water skiers in many places irritate or endanger fishermen, boaters, and swimmers (Anonymous, 1960b). With zoning, opportunities for competing activities can continue to exist. But without zoning, one activity may destroy the possibility of enjoying another.

When different groups of people will accept different

levels of solitude or spacing, the most tolerant (or least discretionary) groups may determine levels of crowding for all unless there is zoning. This becomes increasingly true as the total number of recreationists increases. Wilderness activities are especially spoiled by the invasion of excessive numbers, mechanized transport, and competing land uses. The wilderness controversy is largely a struggle on the one hand to preserve undeveloped zones for present and future wilderness enthusiasts, and on the other hand, to keep sufficient areas open to non-wilderness recreations, commercial uses, and the production of material wealth.

While zoning can perpetuate a range of recreational opportunities, it can also contribute to efficient land use, and competition for wilderness areas provides an example. Robert Marshall, a founder of the Wilderness Society, wrote (1933) that "the primeval area exhibits primitive conditions of growth whereas the wilderness area exhibits primitive conditions of transportation." So defined, wilderness and primeval meet sets of needs which 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 yield higher levels of satisfaction. On temporary roads, timber management and other commercial uses could be allowed on 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 less area would be barred to commercial uses. The Superior National Forest is zoned in a pattern approaching this (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 which withstand tremendous use, and (3) by providing access to areas which 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 which leads where they want to go. Rocks or logs can also channel people's movements and can be placed such that few visitors recognize them as unnatural (Taylor and Hansen, 1934). Where necessary, more elaborate guard rails and fences can be erected.

A large amount of recreation requires no physical contact with the resources on which it is based, and many people are content to view a scene without touching it. Even if construction of such facilities as roads, trails, and walks destroys part of a recreational resource, it can protect the remainder by concentrating use on surfaces that

can withstand it. The Anhinga Nature Trail in Everglades National Park provides an excellent example. Here an elevated walk has been built over a slough and 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.

Stabilization of archeological ruins provides another example of engineering to reduce wear. At Mesa Verde National Park the impact of visiting crowds began to damage the ruins which had been slowly crumbling over centuries of disuse. For their own safety, visitors had to be barred from some ruins. Other structures were reinforced with concrete in such manner that the concrete does not show, and parts of the ruins were actually rebuilt. Although a few visitors are disappointed to learn that modern men have interfered, many are unaware of such measures.

While concentrating traffic on durable surfaces, facilities can also provide improved access. In these times of hurried living and vicarious entertainments, many people expect to see things without expending the effort or

acquiring the skills that were once necessary. In fact, such efforts and skills are impossible for some people. But our nation is rich in scenic things, and it is desirable to provide easy access to a large part of these resources if sufficient undeveloped areas are left to preserve the values that are lost with easy access. The following policy statement (National Park Service, 1957) demonstrates such thinking:

> The guiding principle behind the national park road program is that, as a rule, only sufficient roads will be provided to take the motorist to a representative assortment of interesting or distinguished features. These roads will be supplemented by good trail systems which will enable the visitors who wish to do so to savor the wilderness that comprises all but a small percentage of the major parks.

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

It is important to recognize that engineering and easy access may greatly alter the type of recreation an area offers. Compare, for example, the conducted tours in a well-lighted Carlsbad with the gloomy wanderings of ex-

ploring speliologists. Or, contrast touring on a modern highway with a 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 change 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 (Batterson, 1960) estimated that his costs for roadside litter removal dropped from $2500 down to $700 per year as the result of anti-litter efforts. Much of this improvement he attributes to the 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. Rocky Mountain National Park has signs asking motorists not to drive on to meadows. Switzerland's National Park in the Lower Engadine (Hall, 1929) is open to all visitors as long as the stay on the trails, but "only those holding cards issued by the Commission are permitted to wander at will over the park."

In Alaska the highway at Mount McKinley National Park passes across Sable Pass, from which motorists can expect to see Dall sheep, moose, caribou, foxes, and grizzlies. Because a few overly-zealous photographers harassed the animals and began driving them from the pass, signs and regulations now prohibit people to leave the road along a 5-mile zone which encompasses Sable Pass. This restriction maintains recreational quality for highway-bound visitors without seriously interfering with photographers and hikers, who are free to leave the road everywhere else. At Carlsbad Caverns the author heard a guide politely but firmly explain why visitors must not break or touch formations. This was part of a prepared interpretive talk and effectively made the point without offending the visitors.

In the United States certification of outdoorsmen has been suggested as a method of training recreationists to take care of outdoor areas (J. V. K. 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 U. S. a few states (Anonymous, 1960a) require new hunters to pass a course in firearm safety, 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 tiny percentage of 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 (Batterson, 1960) says that a record and reputation of getting 98 percent convictions on arrests have kept the need for such arrests to a minimum. Such cooperation from law enforcement officials serves as a strong deterent to improper conduct, and in combination with

other means of persuasion, helps 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 Park Service areas and in some state parks there are illustrated talks, tours, nature walks, and campfire programs. Depending on the attractions at hand, these may explain fossil remains, prehistoric people, the life histories and ecology of plants and animals, cave formation, erosion, vulcanism, or other phenomena. 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, and in

many streams where fishing pressure is heavy, a high percentage of hatchery-reared trout are caught within a few days after stocking.

Wildlife managers use a variety of techniques to increase the abundance of game. In the Southwest 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, and on game lands in Pennsylvania, hardwoods are felled so that the stem is left connected to the stump. This allows the top to survive and produce both deer browse and small game cover for several years. Other techniques for encouraging wildlife include controlling water levels on waterfowl nesting areas, and planting vegetation for food and cover.

Management techniques can also increase the abundance and durability of vegetation. Liming, fertilization, and irrigation are used for lawns on some of the more highly-developed outdoor recreation areas and 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, and thinning operations can increase resistance to abuse for trees as well as understory vegetation. The next chapter discusses the durability of understory vegetation in much greater detail.

Where wild lands are valued primarily for their

naturalness, the management possibilities considered above may be less acceptable as "costs" for quality recreation than is 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, and manipulation of living things can be used to provide quality recreation for more people.

CHAPTER V

PREDICTING THE DURABILITY OF BIOTIC COMMUNITIES

As methods of keeping recreation areas in good condition, this study has considered limitation of use, education and regulation of people, development of facilities, and management of biotic communities. These methods may be used singly or in combination and become necessary when recreational use overburdens the natural capacity of wildland areas to repair themselves. For a given level of use, the extent to which such procedures are needed will depend on (1) the amount of change people are willing to accept in wildland areas and (2) the recuperative power of wild lands --particularly the recuperative power of plant communities, which form a dominant part of the recreational environment.

In considering such recuperative power, this chapter discusses the ability of living things to repair themselves and demonstrates the possibility of using regression analysis to develop equations for predicting the durability of vegetation subjected to recreational use.

The Capacity for Self-repair

The composition of living communities results from the interplay of many forces--including 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 composition are seldom constant and are often adverse, most of the species which have survived are able to withstand moderate disturbances. Thus rabbits reproduce in such numbers that they can feed predators and still maintain their populations, and plants often scatter thousands of times as many seeds as will have opportunity to germinate and grow to maturity. Plant food storage and photosynthesis are usually so ample that moderate loss of leaf material to animals or other plants does not endanger chances for survival. As Meinecke (1932) 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 living materials. When the damaging force is reduced sufficiently, species tend to regain any loss in community position. Graham (1956) cites "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 which 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 various amounts of direct contact with recreationists.

To demonstrate one method of predicting such changes, a field study was conducted during the summer of 1959. The following pages describe this investigation and show that the condition of plant communities can be predicted on the basis of site variables and the amount of use these communities receive.

A Technique for Predicting the Durability of Understory Vegetation Subjected to Recreational Traffic

To study the effect that foot traffic would have on recreation areas, simulated recreational use was applied to a series of vegetated plots, and by multiple regression analysis, amounts of surviving vegetation were related to the following variables: (1) amount of simulated use, (2) composition of plot vegetation, (3) amount of sunlight (or shade--depending on the regression model used), and (4) (for one regression model only) the amounts of vegetation on control plots adjacent to each of the treated plots. Although the resulting equations do have a limited application to the area on which the experiment was conducted, the primary purpose of this study was to test a technique rather than provide land managers with a tool for immediate use. Results show that regression techniques are applicable and might now be used on specific areas to develop equations by

which managers can predict the durability of plant communities.

Study area.--Field work for this study was accomplished on the wooded pothole area lying in the north half of section 11, T 1 N, R 5 E, Michigan Meridian, near Bishop Lake on the Brighton Recreation Area. This land is administered by the Michigan Department of Conservation and lies approximately five miles southwest of Brighton.

The immature soils forming the irregular hills of this region were deposited by continental glaciation and range from sands and gravelly sands to loamy sands. In a few places organic stain extends to depths of several inches, but no signs of horizon development were detected.

Forest cover is primarily of red and white oaks (Quercus rubra L., Q. alba L., and Q. spp.) with lesser amounts of aspen (Populus tremuloides Michx. and P. grandidentata Michx.), smooth sumac (Rhus glabra L.), black cherry (Prunus serotina Ehrh.), hickories (Carya spp.), sassafras (Sassafras albidum [Nutt.] Nees), witch-hazel (Hamamelis virginiana L.), and serviceberry (Amelanchior spp.).[1]

Ground cover consists of grasses (primarily Poa compressa L., P. pratensis L., Andropogon scoparius Michx., and Panicum sp.) and a variety of other herbaceous plants. Common among these are strawberry (Fragaria virginiana Duchesne), goldenrods (Solidago spp.), asters (Aster spp.),

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[1]Scientific names for trees and shrubs follow Little (1953); those for other plants follow Fernald (1950).

violets (Viola spp.), yarrow (Achillea Millefolium L.), flowering spurge (Euphorbia corollata L.), dogbane (Apocynum androsaemifolium L.) and bracken fern (Pteridium aquilinum [L.] Kuhn). Trailing raspberry (Rubus hispidus L. and its hybrids with other species of Rubus) is also common.

Study methods.--The design of this study required that one or more treated plots be compared with an adjacent control plot, and that vegetation be reasonably uniform throughout each of these groupings within which plots would be compared. This uniformity was sought by using small, 16- by 64-inch plots--two or more of which would be located within the small stands of ground vegetation that were judged to be uniform. Groups of plots were established as follows with one control plot in each group:

38 groups of 3 =	76 treatment plots and	38 control plots
5 groups of 2 =	5 treatment plots and	5 control plots
2 groups of 4 =	6 treatment plots and	2 control plots

This gave a total of 87 treatment plots.

As the growing season progressed it became obvious that many of these treated plots differed in plant vigor from the control plots with which they were matched, and all plot data were not included in the final regression analyses.

Because of the time that its measurement would have required, actual recreational use was not included in this study, but damage effects similar to those resulting from recreational use were produced and studied. For this investigation it was considered more important to know relative rates of energy application than it was to duplicate

the exact effects of foot traffic.

Energy to simulate recreational traffic was applied to treatment plots by dropping a square tamp, Fig. 14, measuring 16 inches on a side and weighing 8.98 pounds. The frame over this padded square fixed the height to which it could be raised at 1.59 feet, and when dropped it applied approximately 8 foot-pounds of energy per square foot of surface area.[1] The tamping surface and the feet of the frame can be tilted such that the frame and tamp handle are always vertical. This allows the tamp to drop straight down and apply constant energy per surface area with each drop--even on steep slopes. To conform to slight irregularities of the ground surface and to avoid extreme bruising of vegetation, the tamp surface is padded with half an inch of foam rubber, and this is covered with carpeting.

Treatments of 2, 4, 8, 14, 21, and 30 drops of the tamp were assigned systemmatically so that each severity of treatment was applied to approximately the same number of plots. In the 3-plot groups the center plot was always used as the control, and the remaining two plots were assigned treatments three numbers apart in the above series. Thus a 2-drop treatment was paired with a 14-drop treatment, 4 with 21, and 8 with 30. In the 2-plot groups the control plot was selected by tossing a coin. Arrangement of the 4-plot

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[1] $\frac{\text{height of drop} \times \text{weight of tamp}}{\text{tamp area in square feet}} = \frac{1.59 \times 8.98}{(4/3)^2}$

= 8.03 foot-pounds per square foot.

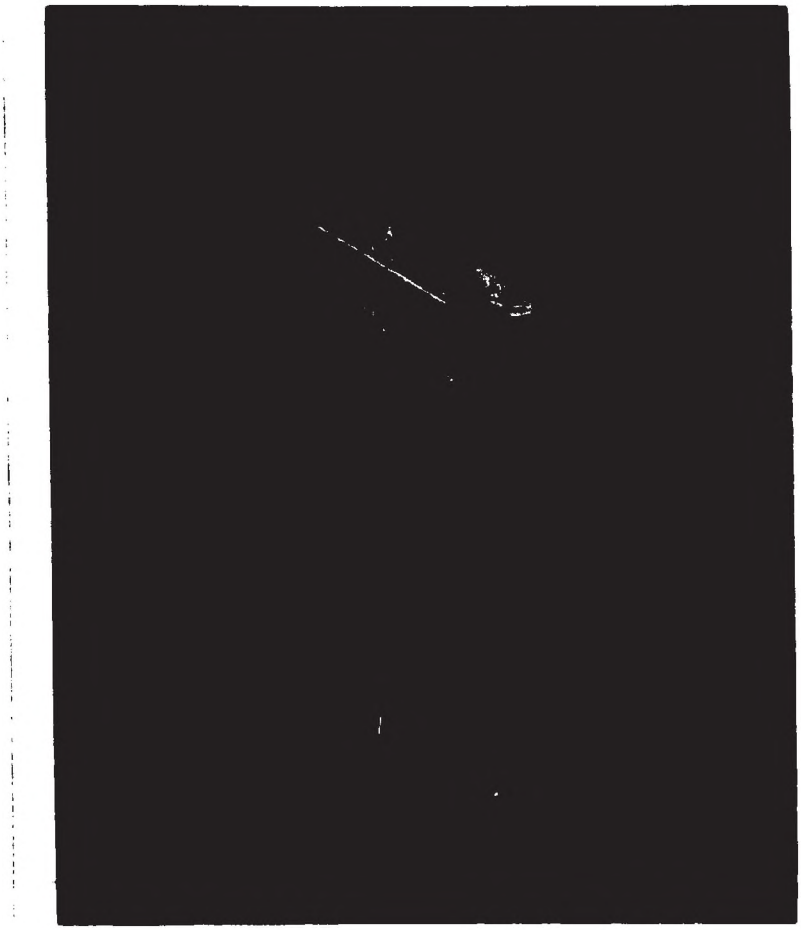


Fig. 14.--The tamp used to simulate recreational traffic on the experimental plots. Each time it is dropped from full height it applies approximately 8 foot-pounds of energy per square foot of surface area. The handle is attached to the square tamping foot and slides vertically through the two cross pieces of the frame. Note that the handle and uprights are adjustable and allow the tamp to drop vertically regardless of slope.

groups was similar to the 3-plot groups except that either of the center plots could be selected as a control.

The assigned treatments were applied six times, or approximately weekly, during the period June 29 to August 10, 1959. Treatment was not applied during the week of July 20 because heavy rains had soaked the soil. It was assumed that treatments during such conditions would be more damaging than those during drier periods and would not be representative of recreational use. Few visitors venture into the woods when the soil and vegetation are wet.

Plot locations were selected to include a wide range of topography and vegetation, and for each location, site variables (the independent variables in the regression models) thought to be associated with the vigor and durability of understory vegetation were measured as listed below:

Plant composition.--Prior to treatment the species composition of each plot was estimated by eye and was expressed as the percentage (on the basis of area occupied) of total plot vegetation composed of each species. Because grasses and trailing raspberry were exceptionally resistant to treatment, the percentages of these species were combined and used as a variable in one regression model. In another regression the percentages of remaining species (100 minus grasses and raspberry) were used as a variable. Amounts of grasses and trailing raspberry ranged from 15 to 100 percent among the plots of this study.

Slope.--This was measured by placing a board along the steepest slope at each plot location and then measuring its angle with an Abney level. Because the level used has a topographic scale, slope was expressed in feet of vertical rise per 66 feet of horizontal distance, and values ranged from 3 to 42.

Percentages of sun and shade.--These values were measured by a grid, Fig. 15, which superimposes 100 dots on the swath of sky through which the summer sun passes. For each plot location, sun was expressed as the number



Fig. 15.--The insolation grid used to measure season-long values of sunlight and shade on the experimental plots. The theory and construction of this instrument are discussed in Appendix A.

of dots coinciding with open sky and ranged from 3 to 94 percent. Shade was expressed as the number of dots coinciding with vegetation, hills, or other objects which would block direct sunlight. The grid was designed and built especially for this study and is discussed more fully in Appendix A.

Slope position.--The position of each plot group was expressed as a percentage of the paced distance from the foot to summit of the slope on which the plot group was located, and percentages of slope distance ranged from 0 to 100.

Organic stain.--After the soil profile had been exposed with a vertical shovel cut, the depth of organic stain was measured with a ruler and expressed to the nearest half inch. Depths ranged from 0.5 to 7.0 inches. No other indications of horizon development were visible.

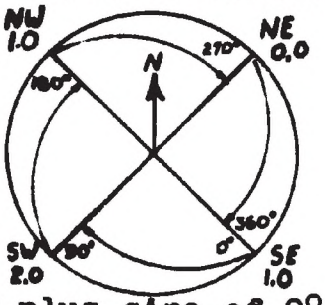
Soil texture.--This was measured by the hydrometer method of mechanical analysis and was expressed as the percentage of soil composed of silt and clay at a depth of 4 to 6 inches. Combined percentages of silt and clay ranged from 7 to 28.

Basal area.--It was estimated that trees on 1/40 acre circles concentric with plot groups would compete with the ground vegetation under study. Thus trees within a radius of 18.6 feet were measured, and their basal area was expressed as square feet per acre. Values ranged from 0 to 326.

Aspect, or direction of slope.--This was measured with a hand compass and was coded as one plus the sine of the azimuth from southeast (Gaiser, 1951).[1] All quadrants of the compass were well represented.

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[1] When coded as compass direction, values of aspect do not plot in a linear manner against expected temperatures on various exposures. But when aspect is coded as 1.0 plus the sine of the azimuth from southeast, the result is an approximately linear progression of values from cool northeastern exposures to warm southwestern exposures. The sine of 0° is 0.0 and increases to 1.0 at 90°. It decreases back to 0.0 at 180°, continues decreasing to -1.0 at 270°, and then increases back to 0.0 at 360°. When these values are added to 1.0, the sum for a cool northeastern exposure is 0.0 (1.0 plus sine of 270°). Coded values increase to 1.0 for northwestern and southeastern slopes (1.0 plus sine of 180° and 1.0 plus sine of 0°). Coded values continue to increase and reach a maximum of 2.0 for a southwestern exposure (1.0 plus sine of 90°).



On August 18, 1959 all vegetation was clipped from a 14- by 62-inch area within each treated plot and within each control plot. These clippings were oven dried and weighed, and their weights served as a basis for values of dependent variables in the regression analyses.

Of several regression models tried, only two related dependent and independent variables closely enough to be useful in prediction. The first regression emphasizes the vigor and durability of plant communities and relates site variables (independent) to the percentage by which treatments reduced the dry weight of surviving vegetation. This percentage (the dependent variable) was computed from the weights of dried plot clippings by the formula:

$$Y_1 = \frac{\text{control plot weight - treated plot weight}}{\text{control plot weight}} \times 100$$

The second regression model emphasizes the actual weight of vegetation surviving treatments and relates site variables (independent) with the dried weights of clippings (dependent variable) from treated plots. In this second regression, clipping weights from control plots are included as an independent site variable which indicates the amount of vegetation that treated plots would have produced if not subjected to simulated recreational traffic.

Although vegetation appeared uniform within plot groups during the spring when they were selected, at the time they were clipped some of the groups had a visible gradient of plant volumes and vigor extending across the plots and adjoining vegetation. Dry weights showed addi-

tional plot groups that lacked uniformity. This was evident when the clipping weights of grouped plots did not decrease, as expected, but actually increased with increased severity of treatments. It is highly improbable that treatment could have stimulated additional growth--especially during the near-drouth conditions which prevailed for the first three weeks of the treatment period. These groups were therefore assumed to be non-uniform, and their data were not used in computations.

A preliminary regression showed damage per drop to be much greater for treatments of a few drops than for treatments of many drops. This trend was so strong that only four plot groups differed markedly from it. The vegetation on these groups was comparable to that on other plot groups, and during the treatment period there was no evidence of a threshold beyond which additional treatment caused a rapid degeneration of plants. Because many plot groups already had proved to be non-uniform, it is believed that deviation from the usual pattern by these four plot groups was the result of non-uniform plots rather than a different response to treatment. Thus these four plot groups were also discarded as heterogeneous.

Of the original 87 treatment plots, 41 were judged usable and their data were analyzed by multiple regression methods to give two prediction equations. Equation One is:

$$Y_1 = 12.901 + \underset{(.167)}{.670}\, X_1 + \underset{(.068)}{.389}\, X_3 + \underset{(.057)}{.255}\, X_5$$

with $R^2 = 0.64$.

Equation Two is:

$$\log Y_2 = -1.559 - \underset{(.049)}{.217} \log X_2 + \underset{(.066)}{.495} \log X_4 + \underset{(.074)}{.320} \log X_6 + \underset{(.049)}{1.060} \log X_7$$

with $R^2 = 0.95$.

Where:

Y_1 = The percentage by which treatments reduced the weight of surviving vegetation.

Y_2 = Dry weight of vegetation clipped from treated plots.

X_1 = Treatment in drops of tamp per week.

X_2 = Drops of tamp per week plus five = $X_1 + 5$.

X_3 = Percentage of plot vegetation composed of species other than grasses and trailing raspberry.

X_4 = Percentage of plot vegetation composed of grasses and trailing raspberry = $100 - X_3$.

X_5 = Percentage of sun.

X_6 = Percentage of shade = $100 - X_5$.

X_7 = Dry weight of vegetation clipped from control plots--each of which is adjacent to a treated plot.

Complete sets of the variables used to develop these equations are given in Appendix B.

Standard errors for the partial regression coefficients are given in parentheses under each coefficient and show that all are highly significant. For example, test of the coefficient for X_2 gives a value of t equal to .217/.049 = 4.43. At 36 degrees of freedom (41 cases minus 5 variables) a table of t shows that this great a value would occur by chance less than one percent of the time. This allows us to infer, with 99 percent certainty,

that Y_2 is related to X_2 in a negative manner.

The R^2 values show that, for the data of this experiment, the equations and their independent variables account respectively for 64 and 95 percent of the variance in the dependent variables Y_1 and Y_2. This "goodness of fit" is shown graphically in Figures 16 and 17.

Limitations of the Experiment

Before the implications of results are considered, the limitations of this experiment must be acknowledged. Tamping was applied for only part of one season, and the study does not show cummulative effects that might occur over longer periods. For example, damage to plants in one season might interfere with photosynthesis, food storage, and reproduction to the extent they are less durable in subsequent seasons. Knowledge of these effects might be adapted from range management which has long recognized that plants cannot remain productive when over-grazed but must be left a "metabolic reserve" for future performance (Dasmann, 1945).

This study applied only to a very narrow range of soils on one small area, and these sandy soils proved to be almost non-compactable. On other soils the cummulative effects of compaction might interfere with plant vigor. Other climates and the weather of other years might produce different results. Most of the treatment period was unusually dry.

The tamping in this study served only to provide a

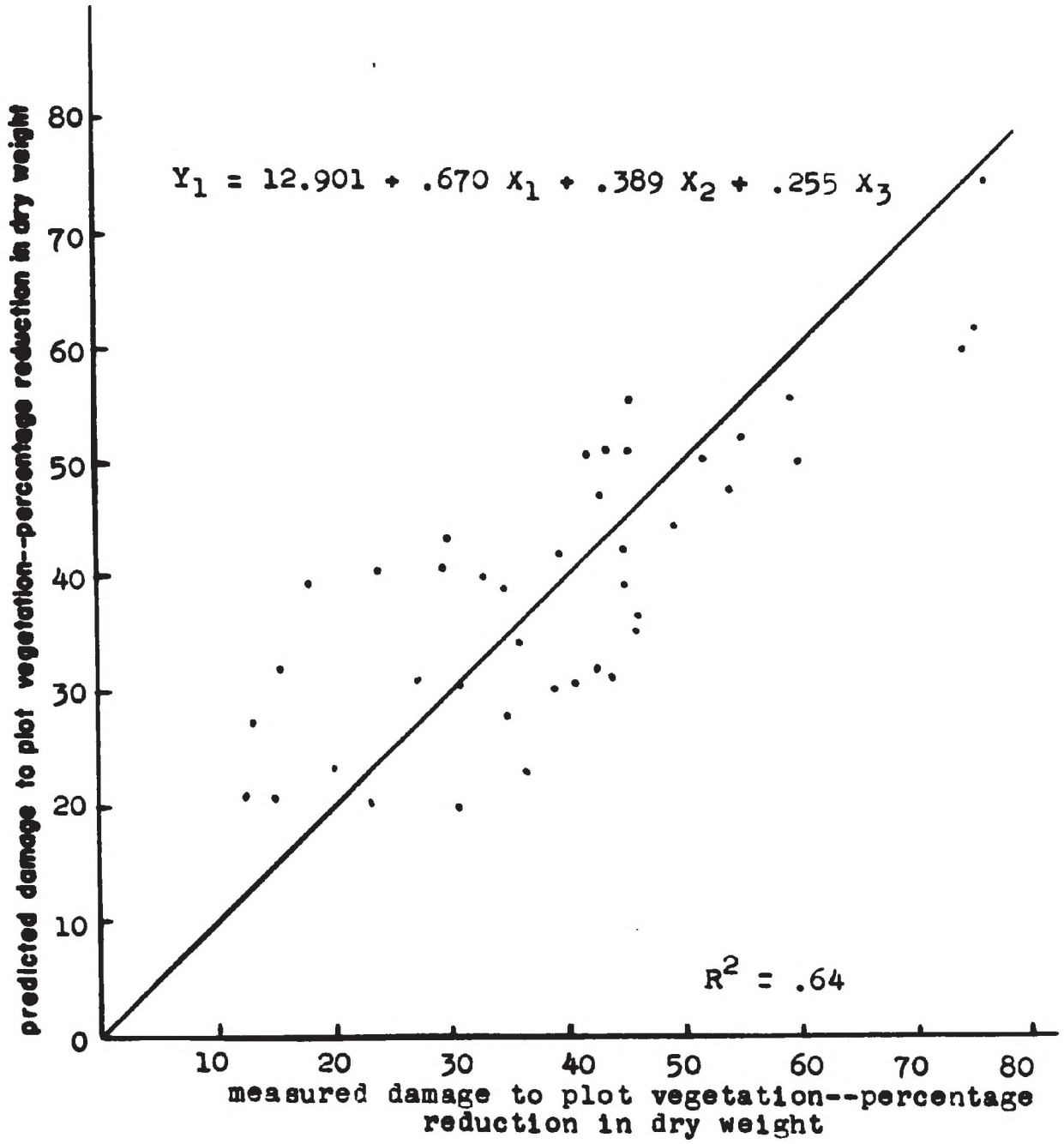


Fig. 16.--A scatter diagram showing how well Equation One fits the data on which it is based.

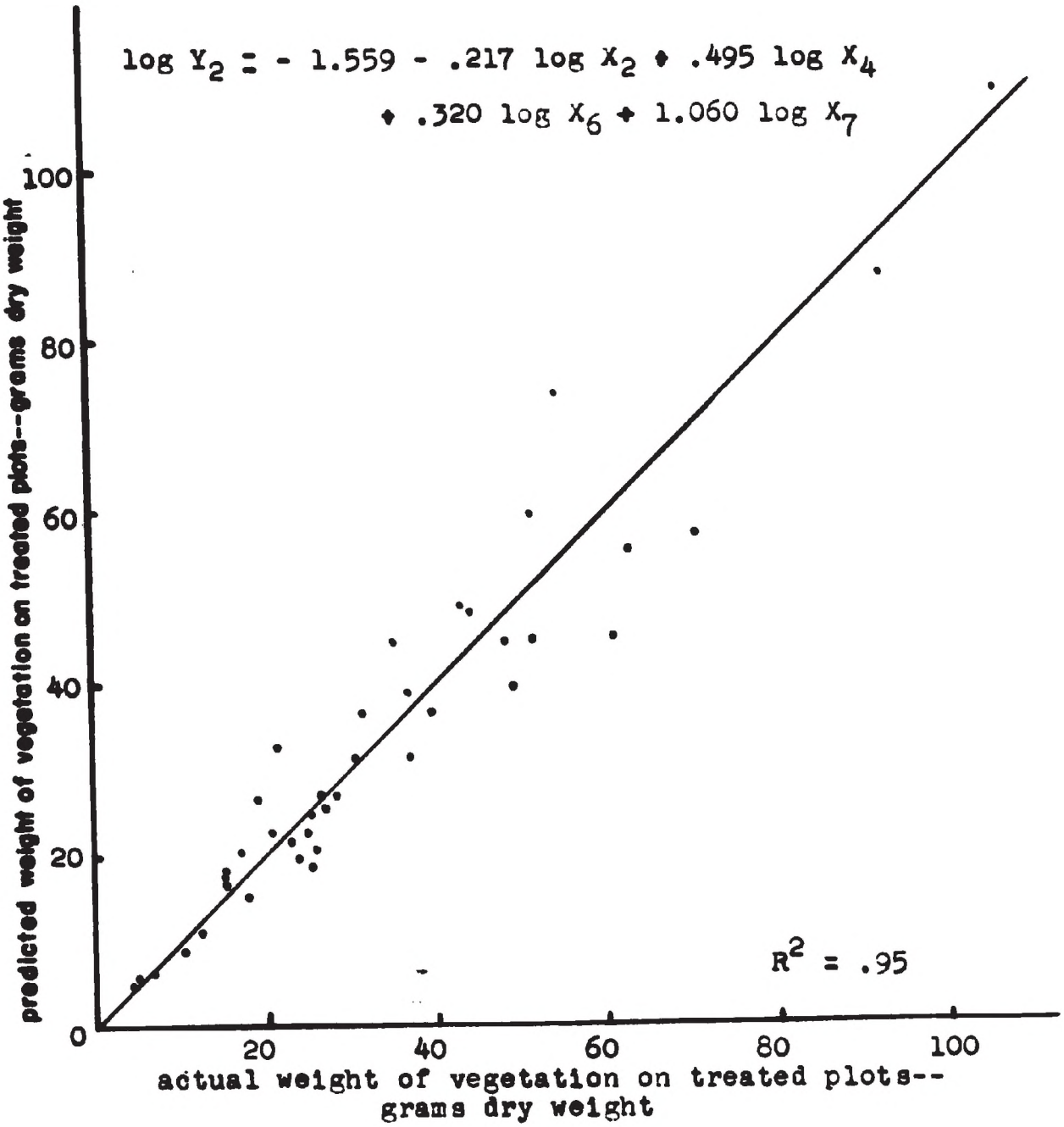


Fig. 17.--A scatter diagram showing how well Equation Two fits the data on which it is based.

controlled disturbance which allowed the durabilities of plant communities to be compared. The wear and tear of actual recreation could be quite different--including the scuffing of feet, poisoning by petroleum products dripping from automobiles, campfires on tree roots, excessive shading from tents, and a variety of other factors.

Finally, because the weight of undisturbed vegetation was included as a site variable in Equation Two, and because plant composition was determined before treatments, these equations have little applicability to recreation areas already in heavy use.

Discussion of Results

These experimental results demonstrate that multiple regression methods may be useful in developing equations to predict the effects of recreational use on the condition of understory vegetation. The same methods might also be used to predict the effects of recreational use on the vigor of trees, soil porosity, or some other dependent variable which would indicate deterioration of an area.

Values computed from Equations One and Two have been plotted in Figs. 18 through 21. These curves show how changing each site or treatment variable could affect the survival of vegetation if all other variables remained constant at their mean values. Because the site variables are not independent of each other, it is somewhat unrealistic to assume that one can be changed while the others remain constant. Therefore these curves must be considered as

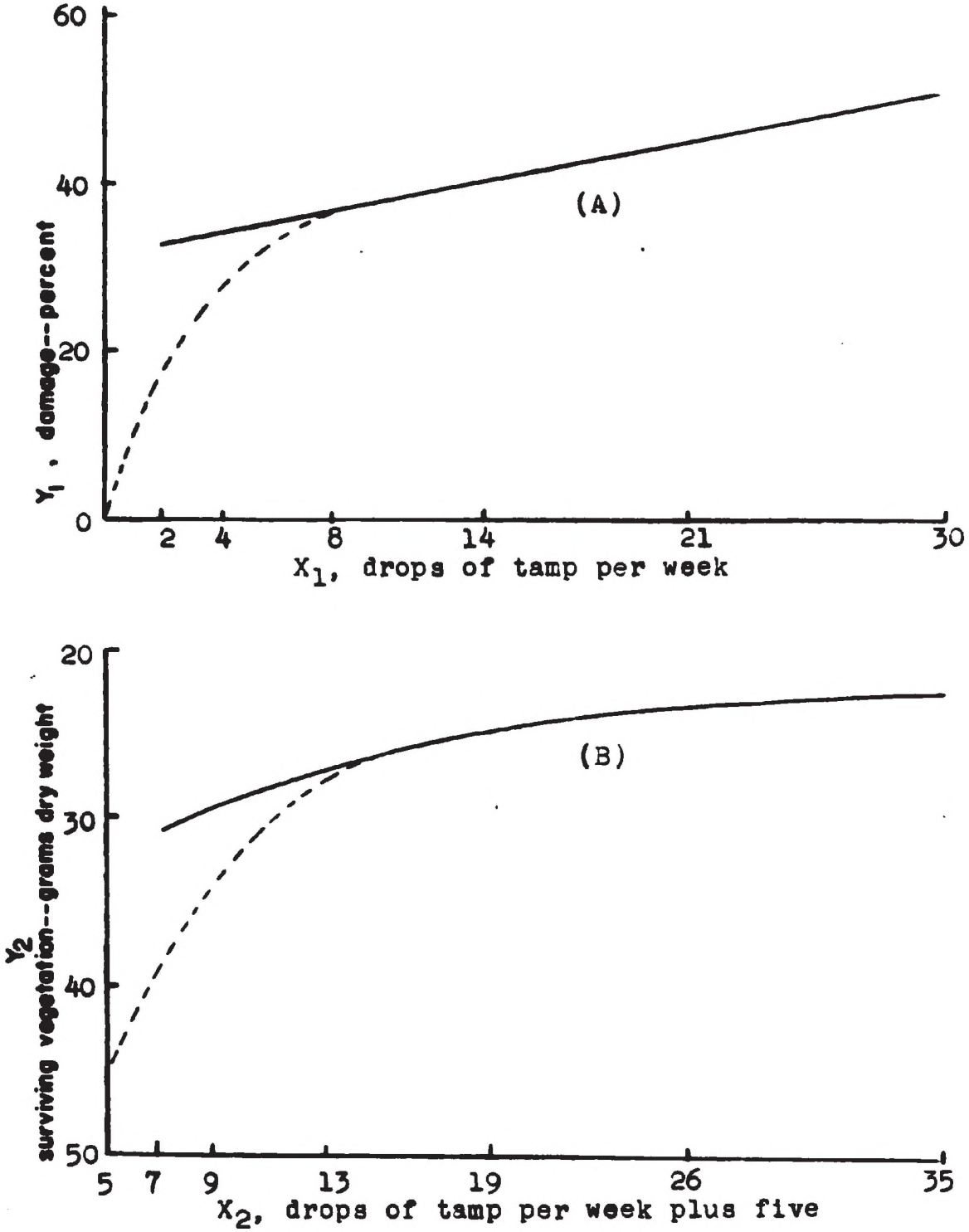


Fig. 18.--The approximate effect simulated recreational traffic would have on amounts of surviving vegetation if all other variables remained constant at mean values--(A) as computed by Equation One, (B) as computed by Equation Two. Because no damage should occur when there is no tamping, dashed curves have been sketched in as originating (A) at zero percent, and (B) at 45 grams (the average weight of vegetation on untreated plots).

trends rather than precise relationships. To facilitate comparision of curves computed from the two equations, curves resulting from Equation Two have been inverted so that an upward increase in the ordinate always indicates an increase in damage.

Tamping.--Computed curves for X_1 and X_2 are shown as solid lines in Fig. 18. However, because tamping was used to cause damage, no damage should occur when there is no tamping, and the dashed curve in Fig. 18a was sketched as starting from zero. In Fig. 18b a dashed curve was sketched as originating at 45 grams, the average weight of untreated control plots. These dashed curves probably show a more realistic relationship than the portions of solid curves they replace.

For the conditions of this study there was no apparent threshold beyond which additional treatment caused a rapid deterioration of the site. On the contrary, initial tamping caused pronounced changes in plot vegetation while additional tamping produced much smaller additional changes. Other vegetated areas could respond much differently, but this pattern of damage would have management implications for any outdoor recreation area on which it applies. On highly-developed areas, such as many state parks, use is already heavy. If applicable, Fig. 18 shows that, from the standpoint of vegetation, no precise point would clearly mark maximum allowable use, and large changes in use would cause only small changes in damage here on the "flat" ends of the curves.

At the other extreme of the wildland recreation scale, another pattern would hold. If the dashed curves in Fig. 18 apply to wilderness plant communities, then even a little direct contact by recreationists would cause marked changes in plant composition and appearance. If such wildernesses were to remain relatively unchanged, use over most of their areas would have to be at such rates that even the more delicate species could repair themselves and maintain their normal places within communities. To acomplish this the impact of recreationists could be minimized by (1) concentrating use on non-wilderness intrusions--such as trails and fixed campsites, (2) dispersing use so that no area received concentrated or frequent damage, and (3) maintaining barriers of distance and effort such that only genuinely interested persons ventured in. All of these methods are now being used.

Plant composition.--Curves for X_3 and X_4 are given in Fig. 19 and show that more vegetation survived on plots which included a high percentage of grasses and trailing raspberry than on plots with less of these species. The woody vines poison ivy (Rhus radicans L.) and woodbine (Parthenocissus sp.) also were little affected by treatment but occurred only on a few plots that did not enter into the analysis. The remainder of the vegetation on treated plots was made up predominantly of dicotyledonous herbs which proved much less durable than grasses and woody vines.

Three succulent species suffered especially severely

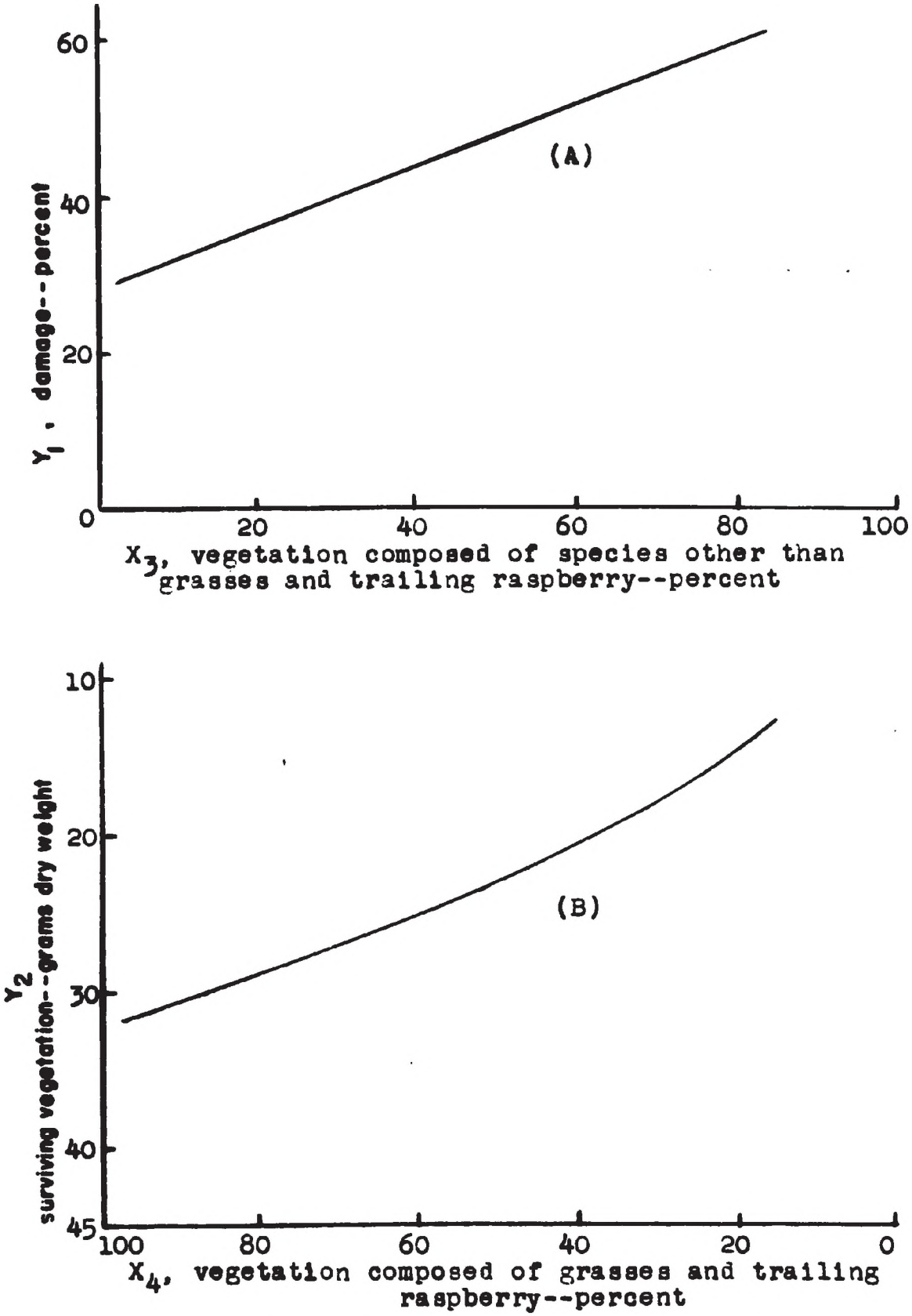
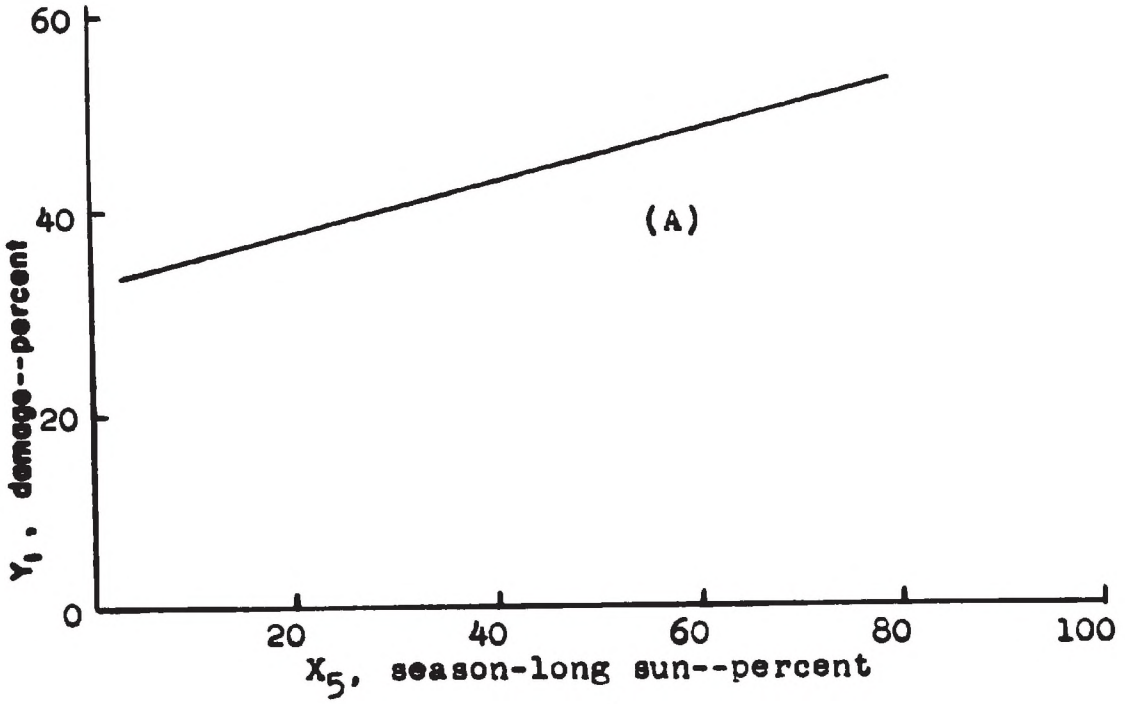


Fig. 19.--The approximate effect plant composition would have on amounts of surviving vegetation if all other variables remained constant at mean values--(A) as computed by Equation One, (B) as computed by Equation Two. Note that percentages of grasses and raspberry decrease towards the right along the X-axis of each graph.

from the treatments. Water horsetail (Equisetum fluviatile L.) showed nearly 100 percent mortality after a single treatment. Yellow pimpernel (Taenidia integerrima [L.] Drude) and northern bedstraw (Galium boreale L.) also proved delicate and showed few signs of life after the first weeks of treatment.

For forest recreation areas on which some modification of plant life is acceptable, carrying capacity might be increased by encouraging sod. In the moist eastern United States a good sod cover often comes in when the hardwood canopy is opened and the weeds discouraged by mowing. And in the East a great many forest recreation areas have a sod cover that requires little maintenance except periodic mowing. In the more arid West, lack of moisture and accumulations of coniferous litter often discourage sod. However, if consistent with windfirmness and other silvicultural considerations, heavy thinning might encourage grass in some places.

Sun and shade.--Curves for X_5 and X_6 are given in Fig. 20 and indicate that, for the same amount of tamping, well-shaded plants suffered less damage than those on sunny sites. This is apparently a matter of wilting and moisture retention. During the field work it was observed that shaded plants recovered better between treatments than those exposed to the drying effects of direct sunlight. In no case was shade so dense that plants became extremely succulent.



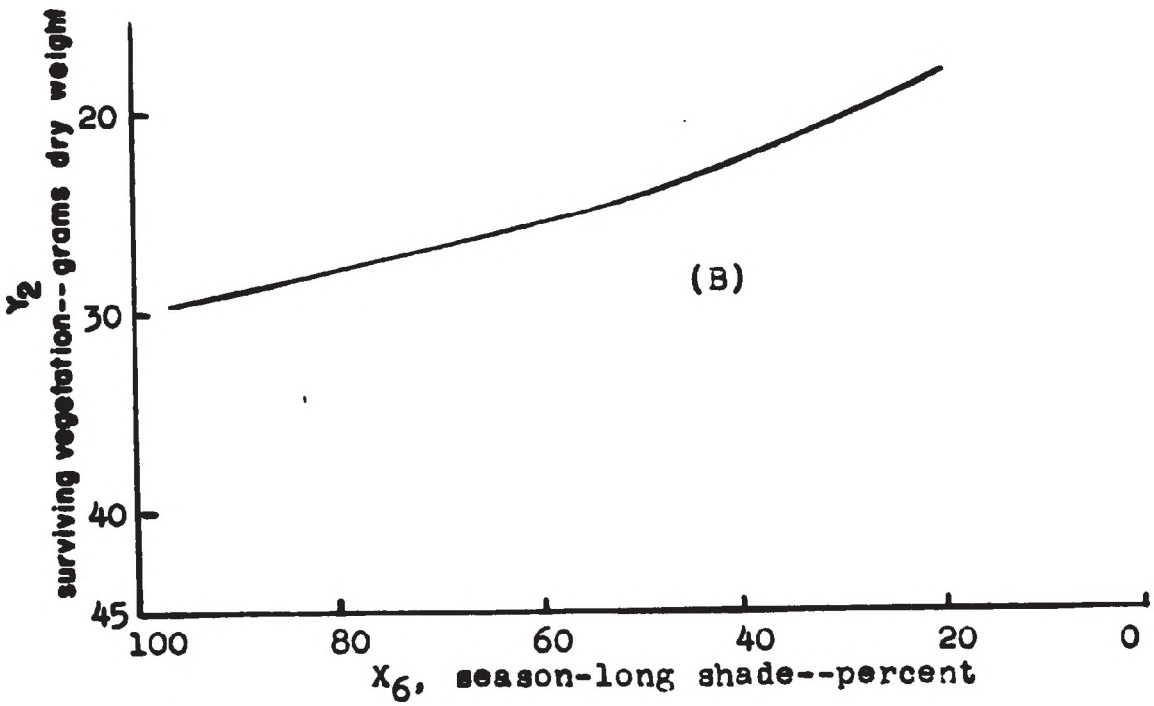


Fig. 20.--The approximate effects sunlight and shade would have on amounts of vegetation that would survive trampling if all other variables remained constant at their mean values--(A) as computed by Equation One, (B) as computed by Equation Two. Note that percentages of sun increase toward the right along the X-axis of each graph.

If the effects of sunlight and shade apply in a similar manner on other areas, then the resistance of ground cover to trampling might be increased by manipulation of the tree canopy. Range management studies (Ehrenreich, 1959) have shown that the volume and vigor of ground cover can be increased by removing overstory competition, and park managers mention that sod is difficult to maintain under trees. This suggests the desirability of cutting in such patterns that a few trees cast a great amount of shade. This could be accomplished by cutting to create small openings and might be similar to some of the experimental cutting patterns used to increase snow accummulation on watersheds (Niederhoff and Dunford, 1942).

Control plot weight.--The curve for X_7 is given in Fig. 21, and as would be expected, the weight of clippings from treated plots is strongly related to the weight of vegetation clipped from adjacent untreated plots. In the regression model for Equation Two, control plot weight serves to express (1) the amount of vegetation subjected to damage and (2) site conditions for understory vegetation.

Applying Regression Equations to the Management of Recreation Areas

Managers of recreation areas could use equations of the type developed in this chapter: (1) for comparing the relative durability of vegetation on potential development sites and (2) for guiding use restrictions and the design and placement of facilities. To compare the durability of

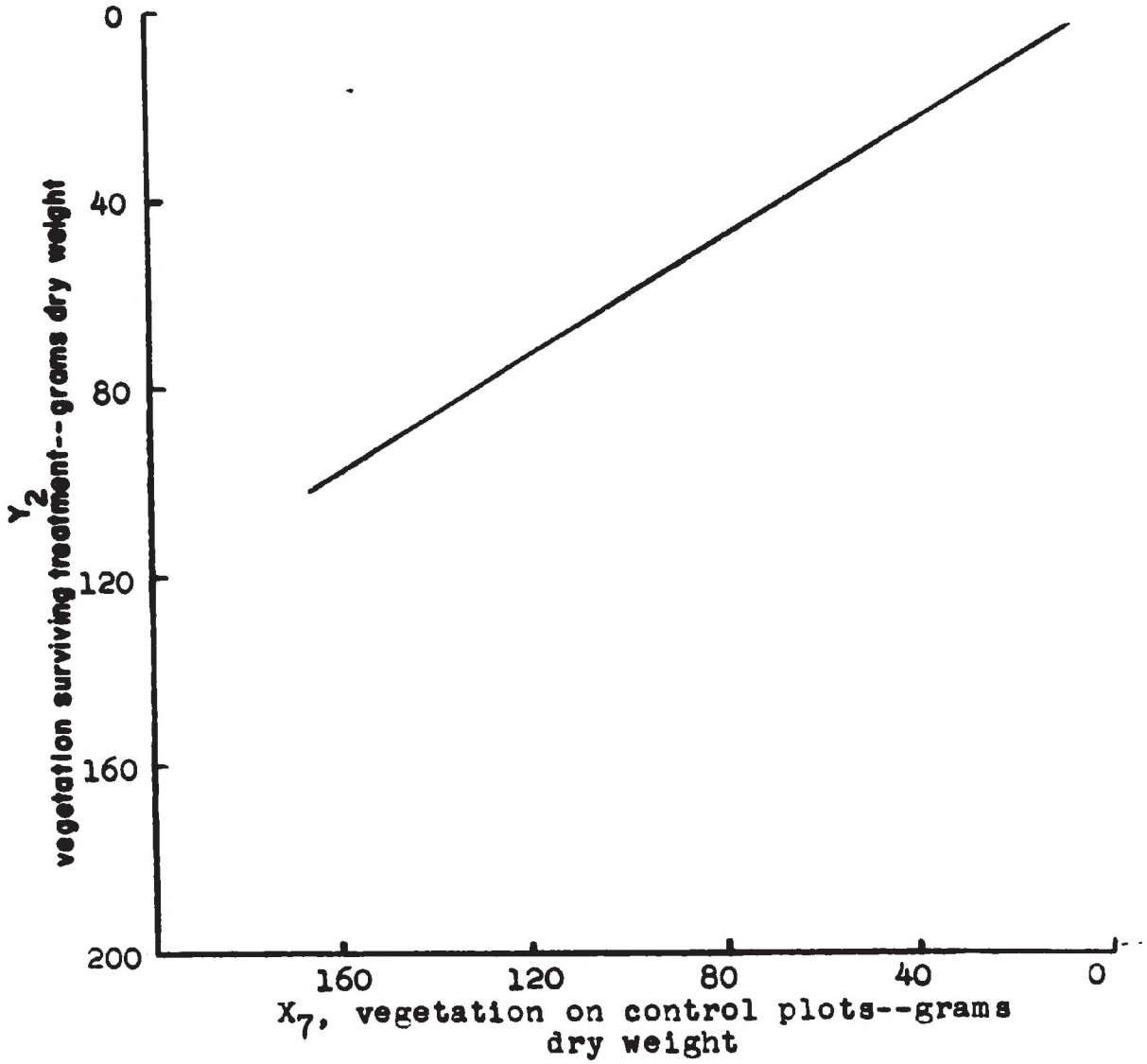


Fig. 21.--The approximate relationship between control plot vegetation and vegetation surviving on treated plots--assuming that all variables but control plot weight are held constant at mean values. Equation Two was used to compute this curve.

several sites, a manager would simply measure site variables on each area, assume an appropriate rate of use (expressed as tamping in this chapter), substitute these values into the equation, and solve for values of Y--which would express the amounts of vegetation that would survive the assumed rate of use. The more durable sites would be indicated by higher predicted amounts of surviving vegetation. This, however, is not equivalent to predicting carrying capacity.

Before deciding to limit recreational use, a manager or administrator would need to consider: (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 apt to need and desire. Thus equations describing ecological relationships show promise of becoming effective tools but can not be used alone for the direct computation of use limits.

CHAPTER VI

CONCLUSIONS

As increasing numbers of recreationists visit wildland areas, some values are lost or diluted to the extent that many people have wondered whether these areas have specific carrying capacities at which recreational use should be limited. In exploring the question this dissertation (1) analyzes the place of recreational carrying capacity in the management of wild lands, (2) considers how increasingly crowded areas 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 subject which 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. Logical analyses partly overcome this lack and, in combination with an ecological experiment, have led the author to ten conclusions about the recreational carrying capacity of wild lands.

1. Carrying capacity is not an absolute value inherent solely in the ecology and original characteristics of each land area. Rather than this 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. Like a tripod, the subject falls if any of its three components is removed.

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. It is understandable that similar reasoning has been applied to the recreational resource. But these other land products (a) can be detached from the land, (b) have obvious utility that does not decrease when competition for them increases, and (c) can be evaluated without elaborate reference to the psychology and physiology of consumers.

In contrast (a) the consumer usually must visit the resource in person to harvest wildland recreation, (b) crowding and competition can reduce the utility or value of recreation to individual consumers, and (c) the value received by a consumer will depend greatly on his training and experience and will be relative to his opportunities. If no better experience is available, or if he has known nothing better, he may value a badly-worn area very highly.

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 sustained social value in the form of quality recreation for people. Because the value of recreation is social, the continuing needs of society are the final criteria by which recreational values must be judged.

3. 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. In this nation we still hesitate to pay for wildland recreation that has traditionally been free. But as all land uses increase, recreation is rapidly catching up with the fact that human wants are unlimited but resources are not. With increasing competition for land, the quality of some recreations can 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 which are less abundant because recreation has been included among land uses.

c. Accepting regulation of conduct and movements.

d. Accepting a different kind of recreational experience.

e. Spending time, money, and effort to reach quality recreation areas which 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 supplies of various land values and to the strengths of demands for these values. Far from being a panacea, 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. For example, limitation of use would be especially appropriate for areas having their greatest value as museum specimens of undisturbed natural communities. To maintain natural conditions, recreationists might accept restriction of their numbers, conduct, and movements so that the areas would remain undisturbed except perhaps for corridors sacrificed for access. As a second example, the carrying capacity of an area reserved for wilderness travel could be increased many times if it were

converted into a resort area. But the change in type of recreation offered would be an unacceptable cost for present and future recreationists who desire a wilderness experience. As a final example, even on areas where intensive development is acceptable, crowding could become so severe that only limitation of use would maintain quality. Recreationists in any of these three situations might prefer to accept less recreation rather than accept the reduction in levels of quality that would accompany more development or increased crowding.

6. 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 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 tolerance and aggressiveness (least discretion and thoughtfulness, by some points of view) tend to determine the quality available to everyone--especially as recreation lands become more crowded. For example, water skiers can tolerate fishermen more easily than fishermen

can tolerate water skiers.

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

With sound public relations and persuasion, many thoughtless or uninformed people who do unncessary damage will change to less destructive habits of recreation. In addition to persuading, interpretive programs and devices can help people to observe more keenly and to understand and enjoy what they see.

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

7. It is possible to predict the effects that recreational use will have on the biotic communities which are part of the recreational resource. As part of this study a field experiment was conducted in which recreational use was simulated at various levels on a series of vegetated plots. Amounts of vegetation surviving on treated plots were compared with amounts of vegetation on adjacent control

plots. Site varaibles were also measured, and multiple regression analysis of the data resulted in equations which relate the survival of vegetation to simulated use and to site variables. These equations are:

$$Y_1 = 12.901 + .670 X_1 + .389 X_3 + .255 X_5 \quad \text{and}$$

$$\log Y_2 = - 1.559 - .217 \log X_2 + .495 \log X_4 + .320 \log X_6 + 1.060 \log X_7$$

Where:

Y_1 = The percentage by which simulated use reduced the weight of vegetation surviving on treated plots.

Y_2 = Dry weight, in grams, of vegetation clipped from treated plots.

X_1 = Simulated traffic in drops of a tamp per week.

X_2 = Drops of tamp per week plus five = $X_1 + 5$.

X_3 = Percentage of plot vegetation composed of species other than grasses and trailing raspberry.

X_4 = Percentage of plot vegetation composed of grasses and trailing raspberry = $100 - X_3$.

X_5 = Percentage of direct sunlight (on season-long basis).

X_6 = Percentage of shade = $100 - X_5$.

X_7 = Dry weight, in grams, of vegetation clipped from control plots--each of which was adjacent to one or more treated plots.

For these equations the values of R^2 are .64 and .95 respectively, and all coefficients tested as statistically significant at the one percent level of probability.

Although these equations are based on very limited field work and should not be applied, they show the possibilities of research to provide formulas which 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.

8. 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 this 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. Surveys now (1960) in progress by the Outdoor Recreation Resources Review Commission may add greatly to our knowledge of the recreational desires of people in the U. S. and may provide a rational basis for zoning and establishing priorities among recreational uses.

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, and some visitors would be discouraged by charges to cover management costs or to match other land revenues forgone because of recreation. In addition to limiting use, testing and certification would offer the advantage of training recreationists to use areas carefully and skillfully. Barriers of distance and effort keep crowds from overrunning and changing the quality of most wilderness areas.

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. Examples are Ohio's Magee Marsh, where hunters are assigned shooting reservations by lottery, and Michigan's Swan Creek Wildlife Experiment Station, where shooting stations are assigned on a "first come, first served" basis, but where each hunter may use the restricted zone only three times per season. Thus recreationists are already accepting limitations on use when convinced that the advantages justify the restrictions.

10. Finally, it is concluded that, while research can provide a variety of information for guidance, final decisions to limit recreational use 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, survey

research and other social sciences can measure current public opinion and analyze human motivation. But this motivation and opinion will seldom be based on a thorough understanding of resource availability and productivity. Someone must decide which combination of needs and desires it is most desirable to satisfy from our limited resources.

On public land, which provides most wildland recreation, policy decisions should be by elected representatives and 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, any limitation and allocation of uses will leave many special-interest groups unhappy. But much as public officials might wish to shift this burden on to impersonal equations, formulas devised by researchers can guide but not supplant human judgement.

APPENDIX A

THEORY, DESIGN, AND USE OF THE INSOLATION GRID

The Need

During the field study of the resistance of ground cover to trampling, a value was needed that would express the approximate amount of sunlight received by plants during the entire growing season. Existing equipment would have given short-term readings but would not furnish season-long values without unjustified expenditures of time and effort. The insolation grid--Fig. 15, page 66--was built to meet this need.

The Approach

The simplest method of estimating summer sunlight seemed to be to view, through a grid, that portion of the sky through which the sun passes during the summer. Values from the Air Almanac (U. S. Naval Observatory, 1958) show the positions through which the summer sun passes, and Physical Meteorology (Johnson, 1954) shows the pattern in which insolation on a horizontal surface increases with the sun's angle of incidence. Design and construction required only this information plus an approximate application of geometric relationships.

Design and Construction

For a latitude of 42° north, the approximate position of the Brighton Recreation Area, the sun's zenith reaches an angle of 71° above the horizon on June 21 but only 49° on September 23. During the same period the azimuth (from north) for the rising sun changes from 063° to 095° on the horizon, and that of the setting sun changes from 297° to 265°. This defines a swath through the sky from horizon to horizon and 22° wide.[1]

A frame was constructed by attaching a semicircular form at an angle of 48° with a base board. This angle (90° minus latitude) is such that, when the completed instrument is positioned for use (base board horizontal and semicircular form slanting due south), the semicircle lies in a plane parallel to a plane through the earth's equator and thus parallel to all planes through which the sun appears to pass as the earth rotates, Fig. 22. To this frame was attached a strip of celluloid which covers a 22° swath of sky when viewed from the "center point," which is the center of curvature for the semicircular form. Pieces of cardboard were then cut with angles of 170, 160, 150, 140, 130, and 120 degrees.

Each of these angular pieces was then placed per-

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[1]Actual readings at a latitude of 42° should give maximum elevations of 71½° at the summer solstice and 48° at the equinoxes. This would define the proper 23½° swath determined by the inclination of the earth's axis. Through rounding errors this was computed from the almanac as 22°, and the instrument was built accordingly. The effect on readings is negligible.

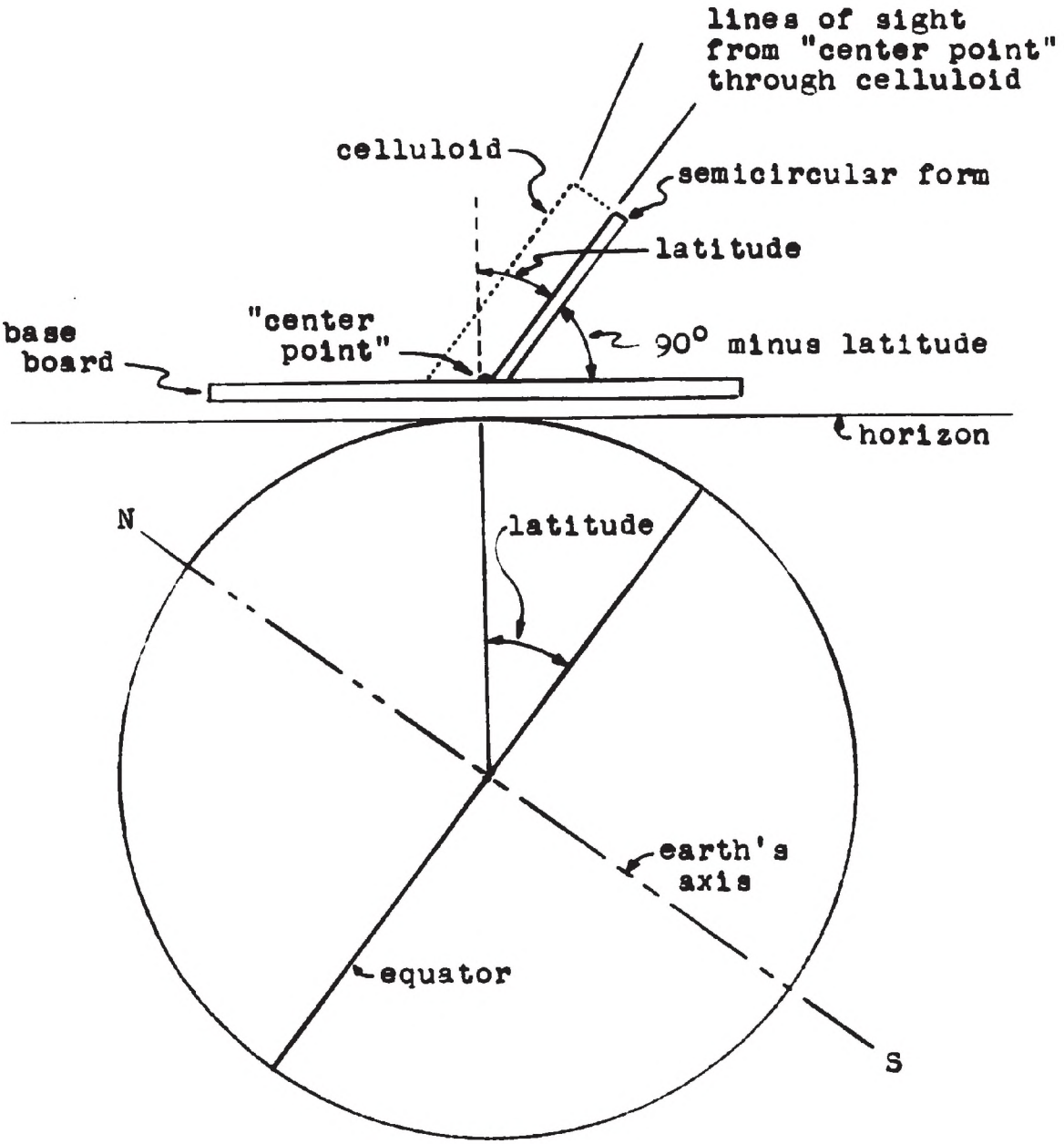


Fig. 22.--A diagram illustrating why proper positioning of the insolation grid matches the celluloid band with the swath of sky it represents. When base board is horizontal and semicircular form is slanting due south (toward the equator), then a plane through the semicircle is parallel to a plane through the equator. The celluloid band, as viewed from the "center point," then covers the portion of sky through which the sun will pass as it climbs between the vernal equinox and the summer solstice and then descends between the solstice and the autumnal equinox.

pendicular to the base board with its apex at the "center point" and one edge against the base board. By rotating these pieces about an axis perpendicular to the base board at the "center point," lines could be drawn with a grease pencil at angular elevations of 10, 20, 30, 40, 50, and 60 degrees from the base board as measured at the "center point."

When positioned for use the base board of the instrument is horizontal. Thus the celluloid was now divided into bands representing ten-degree intervals of elevation above the horizon. The purpose of these bands was to guide the placing of dots in such a pattern that readings from the completed instrument would be corrected for the greater energy received from the sun at high angles of incidence. The celluloid was then removed from the frame and placed over a sheet of graph paper, and approximate areas within each band were determined by counting squares.

For increasing intervals of 10 degrees above the horizon, solar energy received on a horizontal surface increases in the approximate pattern 2, 4, 5, 6, 7, and 8. It was assumed that, during the summer, the sun spends equal time in each part of the 22° swath (which is not the actual case but serves as an approximation), and the area of each band was multiplied by the solar energy values as follows:

Band	Area	Solar Energy	Product	No. of Dots
60-70°	15	8	120	19
50-60°	23	7	161	26
40-50°	22	6	132	21
30-40°	21	5	105	17
20-30°	18	4	72	12
10-20°	17	2	34	5
		Totals	624	100

To make the grid read in percentage of direct sunlight, only 100 dots were desired. Each of the values in the product column was therefore divided by 6 and adjusted so the dots totalled 100. Within the bands on the celluloid strip the prescribed number of dots were evenly distributed and marked with India ink (acetate ink would have been better). Grease pencil lines were removed, and the strip was again mounted on the frame.

To be handy for field use the grid was made small enough that the eye could not actually be placed at the "center point" for viewing. To overcome this difficulty a mirror and peep sight were arranged to position the line of sight as if it originated at the "center point." To complete the instrument a hole was bored in the underside of the base board to allow attachment to a camera tripod.

Use of the Insolation Grid

When used the grid must be positioned with the base board horizontal and the semicircular form slanting due south. This matches the grid with the portion of the sky it represents. As a user looks through the peep sight and rotates the mirror, he can see the complete set of 100 dots. Dots seen as superimposed on open sky are counted, and those superimposed on hills, foliage, or other obstructions are not. The total count is an estimated percentage of possible direct sunlight that is received at the sampling point during the growing season.

If the mirror is swung and a single dot is viewed as

it is reflected by different parts of the mirror, it will appear to shift slightly through the sky. This difficulty can be minimized by using only the center portion of the mirror, and reading might have been easier if the unused part of the mirror had been masked.

Results and Limitations

The fact that grid readings tested as significant variables in two regression equations indicates that this device gives a usable approximation of sunlight effects. Certain limitations do exist, however, and should be discussed. As already mentioned, the sun does not occupy each part of the 22° swath for the same period of time. Prior to June 21 it will be climbing higher each day. After this date it will climb less high each day. Because the growing season doesn't begin with the vernal equinox (March 21) in this latitude but often includes the autumnal equinox (September 23), only part of the 22° swath will be covered twice by the sun during the growing season. Because the celluloid grid is part of a cylinder rather than a sphere, areas of the grid do not represent parts of the sky in exact proportion to grid areas.

Summer clouds undoubtedly build up more often in the afternoons than in mornings and would decrease the amount of solar energy reaching the ground. On the otherhand, the dryness of southwesterly aspects indicates that some effects of afternoon radiation are greater because of higher temperatures. The effects of clouds and temperature are of oppo-

site direction and were assumed to cancel.

Although it gives only approximate readings, the insolation grid should be useful for making rapid estimates of total seasonal insolation in ecological studies where such information is important.

APPENDIX B

Table B-1.--Data used to develop Equation One in Chapter V.

Plot	Y_1 Weight loss of treated plots (percent)	X_1 Simulated use (drops per week)	X_3 Species other than grasses & raspberry (percent)	X_5 Season-long sun (percent)
1A	42	21	10	80
1B	33	4	10	80
4A	60	4	85	6
4B	76	21	85	6
5A	29	8	40	27
5B	46	30	40	27
6A	46	14	40	53
6B	30	2	40	53
7A	16	21	10	4
7B	13	4	10	4
16A	27	4	40	4
16B	39	21	40	4
18A	45	14	30	17
18B	38	2	30	17
19A	43	21	50	23
19B	23	4	50	23
22	15	4	10	4
23	35	30	10	8
24	13	14	10	3
25A	59	21	65	16
25B	49	4	65	16
26A	77	30	60	70
26B	74	8	60	70
27A	31	2	10	5
27B	35	14	10	5
28	31	21	5	7
30A	41	14	20	4
30B	37	2	20	4
31A	44	14	20	5
31B	20	2	20	5
34A	46	4	5	73
34B	54	21	5	73
36A	45	14	2	76
36B	36	2	2	76
37	55	30	5	67
38A	52	30	35	14
38B	46	8	35	14
40A	23	4	10	3
40B	43	21	10	3
42A	43	14	60	6
42B	18	2	60	6

Table B-2.--Data used to develop Equation Two in Chapter V.

Plot	Y_2 Veg. on treated plots (grams dry wt.)	X_2 Simulated use (drops per week ÷ 5)	X_4 Grasses & raspberry (percent)	X_6 Season-long shade (percent)	X_7 Veg. on control plots (grams dry wt.)
1A	61.0	26	90	20	104.7
1B	70.3	9	90	20	104.7
4A	25.0	9	15	94	63.0
4B	15.3	26	15	94	63.0
5A	62.9	13	60	73	88.9
5B	48.0	35	60	73	88.9
6A	39.8	19	60	47	73.4
6B	51.6	7	60	47	73.4
7A	26.0	26	90	96	31.0
7B	27.1	9	90	96	31.0
16A	12.5	9	60	96	17.1
16B	10.5	26	60	96	17.1
18A	31.8	19	70	83	57.8
18B	35.6	7	70	83	57.8
19A	36.6	26	50	77	64.3
19B	49.5	9	50	77	64.3
22	22.6	9	90	96	26.6
23	28.1	35	90	92	43.1
24	23.9	19	90	97	27.6
25A	25.2	26	35	84	60.9
25B	31.1	9	35	84	60.9
26A	19.3	35	40	30	84.6
26B	21.7	13	40	30	84.6
27A	54.5	7	90	95	78.9
27B	51.6	19	90	95	78.9
28	26.6	26	95	93	38.7
30A	4.3	19	80	96	7.3
30B	4.6	7	80	96	7.3
31A	4.6	19	80	95	8.3
31B	6.6	7	80	95	8.3
34A	43.3	9	95	27	80.1
34B	37.0	26	95	27	80.1
36A	92.5	19	98	24	167.1
36B	106.5	7	98	24	167.1
37	44.1	35	95	33	98.3
38A	15.5	35	65	86	31.9
38B	17.4	13	65	86	31.9
40A	20.7	9	90	97	26.8
40B	15.2	26	90	97	26.8
42A	18.0	19	40	94	31.4
42B	25.8	7	40	94	31.4

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