DISPERSED RECREATION IN FOREST RESOURCE ALLOCATION: A COMPUTER MODEL

by

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ABSTRACT

A computer model for forest land use planning is developed which computes dispersed recreation outputs as a consequence of development and preservation scenarios. The model, the Recreation Allocation Routine, provides a framework for foreseeing and resolving potential conflicts between planned forest management practices and sustained availability of recreation opportunity.

The model, which is termed the Recreation Allocation Routine, is comprised of three submodels: opportunity, participation, and suitability submodels. The simulation of future recreation opportunity incorporates two locational factors, adjacency and minimum management unit size, in response to projected land use changes included in the scenarios. This is done using computer cartographic techniques, i.e. employing computer analysis of maps. Participation is projected as an extension of trends in population, age shifts, destination substitutions, and activity preference shifts, guided by limits determined through informed judgement. The projection is neither constrained nor enhanced by future opportunity. The suitability submodel calculates the carrying capacity of the simulated recreation opportunities using both size-dependent and feature-dependent capacity coefficients. Carrying capacity is compared to projected levels of participation yielding the excess or deficit of dispersed recreation outputs.

The Recreation Allocation Routine has been developed as a prototype and tested for a study area, Skykomish Ranger District (U.S. Forest Service), in Washington State. Two scenarios are modelled, one development-oriented and one preservation-oriented, both comprised of a small set of impacts on recreation opportunity: road construction, road closure, land exchanged, and trails which become heavily used. The impact of timber harvesting is subsumed by the impact of associated road construction. The results indicate road-based recreation opportunity is in marked oversupply through 1995 under both scenarios. Primitive recreation opportunity becomes undersupplied by 1995, with participation 90% greater than capacity under the preservation scenario and 140% greater than capacity under the development scenario.

The prototype model is judged to perform well in the case study. Suggestions are made for further model development, which would enable the model to operate in a computerized planning environment.

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CHAPTER I

INTRODUCTION

Forest managers strive to provide and maintain suitable outputs of recreation opportunity into the future. Given the complexity of performing land allocation tradeoffs for the use of forest resources, systematic analysis of the impacts of forest management alternatives on recreation outputs is needed as a basis for rational decision making. Currently, information about the future availability of recreation opportunity is provided to forest planners through manual analysis of maps. Such an approach to public forest planning for outdoor recreation is unduly cumbersome and unsystematic.

This study seeks to determine whether a computer model can effectively simulate future recreation opportunity in a way that is useful for analyzing future recreation quality. The model, named the Recreation Allocation Routine (RAR), is designed as a planning tool which estimates the effect on dispersed recreation of forest management alternatives. The study pertains to a type of outdoor recreation, dispersed recreation, which occurs over extensive forest settings as scattered, individual activities normally not identified with the facilities characteristic of developed recreation. As an experimental modeling effort, a particular case study has been used to guide the development and testing of the Recreation Allocation Routine. A subsidiary objective has been to develop the model for possible future incorporation in more general forest planning processes.

Until recently, dispersed recreation in North America received only incidental management attention beyond the project-oriented efforts of game management and trail construction. As the scarcity of certain types of dispersed recreation settings has increased, more comprehensive allocation procedures have included dispersed recreation in the planning process. Participation in dispersed recreation presently accounts for approximately 50 per cent of the recreational use of U.S.National Forests, and outdoor recreation along with timber are the two major uses of the forest resource. This participation, which reflects the active interests of tens of millions of outdoor recreationists, represents a variety of dispersed recreation activities and a wide spectrum of recreation opportunities. Recreation opportunity is defined as "the availability of a real choice for a user to participate in a preferred activity within a preferred setting, in order to realize those satisfying experiences which are desired."(USDA, 1980c) The recreational land-base may be classified into opportunity settings on the basis of physical, social, and managerial attributes. Dispersed recreation settings range from road-based to more primitive opportunity types.

Indications are that dispersed recreation participation will continue to increase at a fast rate. At the same time the supply of available dispersed recreation settings is limited by the size of public land holdings. In the U.S., the bulk of the land base appropriate for many dispersed recreation activities is managed by the U.S. Forest Service. As well as the increasing recreational demand, nonrecreational resource uses are placing increasing demands on U.S.Forest Service lands, demands which are incompatible in some ways with recreational resource uses.

Forest allocations must be based on a thorough analysis of a range of management alternatives. Each management alternative will have various effects on different types of dispersed recreation opportunity. For example, the consequence of an alternative yielding high levels of timber production might result in an increase in road-based opportunities and a reduction of more primitive opportunities. With the expected increase in demand for dispersed recreation, forest management will be pressed to more directly account for the impact of proposed allocations on dispersed recreation.

The goal of dispersed recreation management is the achievement and maintenance of a high level of recreation outputs, i.e sustained recreation outputs. The concept of sustained recreation outputs has not been adequately defined, in part due to the difficulty of specifying the interrelationship between recreation quality and the physical, social, and managerial attributes of the settings which recreation experiences depend on. The quality of recreation experiences is essential to the satisfaction of recreationists. Sustaining recreation outputs thus implies that experience levels are maintained at high levels. Thus, management policy and planning techniques for dispersed recreation must be placed in the context of qualitative, as well as quantitative, outcomes.

For purposes of land allocation, a concept of sustained recreation outputs which is to serve as a standard of high recreation quality must include a factor of demand. A dilemma is faced by recreation managers who may institute access restrictions as a means to control congestion. Both congestion of recreation settings and access restrictions tend to decrease the quality of recreation experiences. Dispersed recreation on public lands is characterized as a common pool resource, i.e. a resource that is under public ownership, available for use by all, and use of which by one person affects any other person's use. Managing for dispersed recreation, as a common pool resource, is beset with the problem of how to regulate use in order not to exceed recreation capacity.

Planning analysis must foresee future impacts to dispersed recreation opportunity if recreation quality is to be maintained at high levels. But forecasts of recreation opportunity are not sufficient information on which to base land-allocation decisions. The suitability of land allocations to dispersed recreation depends in part on the demand for recreation opportunity. A greater allocation of land to any particular opportunity type is not inherently better, but might be warranted when participation is expected to exceed the capacity of the available recreation opportunity, i.e. when future congestion is expected. Conversely, a smaller allocation to a particular opportunity type might be warranted if there is an oversupply anticipated, i.e. when the capacity of available opportunity settings is greater than participation.

The character of recreation opportunities is not static, but changes in response to the use, both recreational and nonrecreational, of the forest resource. For example, constructing a road into a roadless area for hauling timber detracts from primitive recreation opportunities but enhances road-based recreation, while closing a road may have the opposite effect. The dynamics of impacts upon dispersed recreation opportunity may be conceptualized as a process of invasion - succession - recovery, by which impacting uses 'invade' the character of an existing recreation opportunity and cause a 'succession' to a different opportunity type; the possibility exists for a 'recovery' to the former opportunity type, e.g. by the closing of the road in the above example. Although the process may proceed either towards invasion of more primitive or more developed opportunities, expanding timber harvesting has historically predominated with the continuous decrease of primitive recreation opportunity as a consequence.

The more primitive recreation opportunities are especially sensitive to the immediate and at-a-distance spatial impacts of forest management practices. The presence of a clearcut or a road is often incompatible to a primitive recreationist. More subtle is the intrusion of the primitive recreation experience that results from the transmission of sounds over distance and the sight of human developments in the distance. Thus the character of adjacent land uses must be coordinated in the land allocation process to account for at-a-distance impacts. Other sensitive characteristics of dispersed recreation which are discussed in this study include: the minimum size of certain opportunity settings; the asymmetric relationship of impacts both among opportunity types and between recreational and nonrecreational resource uses; and the implication of irreversible consequences to future recreation opportunity.

This leads to the main elements of the model: future opportunity is simulated; participation is projected; and the suitability is calculated by comparing the capacity of the opportunity with participation. Recreation opportunity is simulated using cartographic techniques in accounting for the spatial consequences of impacting actions. In simulating future opportunity, computer representations of maps are overlayed and otherwise dealt with in a computer map analysis. In doing so, aspects of the U.S. Forest Service Recreation Opportunity Planning process are incorporated. Participation is projected as based on population increases, age factors, destination substitution, and shifts in activity preferences. Capacity coefficients are employed to express recreation opportunity in terms of the number of recreationists that might have their recreational needs satisfied by the available settings and features. The capacity of recreation opportunity and the participation are then compared over the simulated time period to yield a net surplus or deficit of available opportunity for each of several opportunity types.

Each run of the model is driven by a different scenario which simulates impacting conditions. Each scenario is based on a management alternative plus foreseeable external impacts, e.g. the impact of increasingly busy hiking trails. In the case study, two scenarios are evaluated: a preservation and a development scenario.

The information from each scenario run as to surplusses and deficits of recreation opportunity may be evaluated by forest managers in selecting a preferred management alternative. The model determines the tradeoffs in terms of the number of recreationists potentially satisfied or unsatisfied as a result of each alternative. This is done as a locational analysis using capacity coefficients and not an economic analysis based on monetary benefits and costs, due to the intangible, nonmarket character of dispersed recreation outputs. From this analysis inferences may be drawn about sustained recreation outputs and recreation quality.

The implications of the study results are explored. Outcomes of the two scenarios provide indications of potential management situations for dispersed recreation in Skykomish Ranger District, the case study area. Also, the role which the Recreation Allocation Routine might play in ongoing planning for forest allocations is discussed. It has been the aim of the study to develop a computer technique which lends a more systematic and explicit approach to recreation opportunity planning than is currently available.

CHAPTER II

PLANNING FOR THE SUSTAINED AVAILABILITY OF RECREATION OPPORTUNITY

Within a planning context of shifting demand and supply, recreation managers strive to provide opportunities suitable for maintaining the quality of recreation experiences. The recreation manager must assess the public's desires and needs and compare these to the opportunities available for meeting such needs in order to allocate recreation resources. Maintaining the quality of the recreation opportunity is a complex, but by no means hopeless, planning task. The principle of sustained productivity applied to dispersed recreation may help forest managers to maintain the quality of recreation experiences.

The sustained yield principle is commonly applied in planning timber allocations, although for dispersed recreation the principle must be given a different interpretation. In order to incorporate a sustained yield principle for recreation, both the nature of recreation quality and of the forest planning process must be well understood. This study considers these factors for the U.S.Forest Service, the agency responsible for managing the case study area. In developing a computer model useful in recreation planning, U.S.Forest Service planning guidelines and criteria have been followed. Also, U.S.F.S. data have been used to test the model's performance.

In allocating forest land, recreation opportunity planning is placed within a broader context of forest land allocation. As well as deciding how to allocate land for the different and often conflicting interests of recreationists, land allocations must be made for nonrecreational resource uses and services. Timber, range, fish and wildlife, watersheds, and environmental quality, as well as outdoor recreation must be provided suitable land bases.

Such complementary management is the essence of multiple use, or integrated resource management. With a number of conflicting interests placing demands on the land base, the forest resource is too scarce to either declare one use as dominant or to section off the entire land base to large exclusive use zones, in the way that one divides up a pie.

More diverse benefits, and presumedly greater total benefits, derive from the forest resource by integrating compatible interests where possible, so that several goods, services, and amenities are designated to flow from the same unit of land. For example, forest areas where roads serve timber harvesting or mining also serve recreationists driving about for pleasure and trail bikers, while roadless areas maintain natural environmental quality and fish and wildlife habitats, as well as providing opportunities for backcountry hikers.

SUSTAINED AVAILABILITY OF RECREATION OPPORTUNITY

The U.S.Forest Service is guided by the concept of maintaining the productivity of the forest resource over the long term. This is generally termed the sustained yield principle. The goal is to ensure the renewability of all the benefits stemming from the forest resource on behalf of an enduring public welfare, i.e. in recognition of the rights of future generations. Unfortunately, the principle has not been applied by the Forest Service to outdoor recreation, or even developed conceptually, possibly due to the fact that dispersed recreation is a noncommodity. While there is voluminous literature on sustaining timber output levels in volumes of board feet or cubic feet, there is scant literature on sustaining recreational outputs. However, the substantial literature on two related topics, that of maintaining the quality of recreation and the allied topic of recreation carrying capacity, is of use in developing the principle in a manner that applies to dispersed recreation.

Defining sustained recreation outputs.

Recreation outputs, as well as timber outputs, are to be sustained from the National Forests under U.S.F.S. jurisdiction (Multiple-Use Sustained-Yield Act, 1960). As applied to timber management, the sustained yield principle has been interpreted in different ways. Towards maintaining a high level of productivity, the sustained yield principle may be construed to mean that either the potential to attain high yields at some future time is not diminished (i.e. yield is sustainable) or that the yield is more or less maintained in each time period (i.e. yield is actually achieved). The U.S.Forest Service has followed the latter interpretation for timber management. As stated in the Multiple Use-Sustained Yield Act (1960), sustained yield means "the achievement and maintenance in perpetuity of a high-level annual or regular periodic output of the various renewable resources ...."(Appendix A). Thus, the forest manager is directed to maintain recreational outputs 'in each time period'.

There are many ways in which recreational outputs may be measured, some being more appropriate than others. Planning analysis requires that recreation outputs are quantifiable, and yet quantitative analysis must not overshadow the goal of managing for recreation quality.

For the purposes of forest planning, the availability of recreation opportunity may be equated with the quality of recreation experiences, where the quality of recreation experiences depends on the success with which the motivations and objectives of recreationists are fulfilled (Stankey, 1972). Recreationist satisfaction depends on two factors: (1) sufficient availability of favorable circumstances, or opportunity, to meet the needs of recreationists; and (2) the capability of the recreationists to match their desires with the appropriate circumstances. The latter factor is not of direct importance to planning, although the recreation manager has a role in informing recreationists of the opportunities that are available. Of more relevance is the fact that the recreationist will not be satisfied if the appropriate type of opportunity is not available to a degree sufficient to meet demand.

Thus, the definition of sustained yield most appropriate to recreation opportunity planning is 'the sustained availability of recreation opportunity, relative to demand'. The utility of this concept hinges on the ability to measure recreation opportunity in a manner that may be compared to recreation demand.

Measuring recreation opportunity.

Defining the nature of recreation outputs as a comparison between available opportunity and participation levels differs from traditional approaches. While recreational outputs have often been measured in terms of numbers of campsites, boat docks and moorage, or visitor information centers, counts of facilities are not relevant to dispersed recreation. As well, an overemphasis on such measures of recreation quantity has raised some alarm, as the quality of experience appears to be declining as a result of crowding and use conflicts (LePage, 1979).

A behavioral link is needed between the recreation experience and the measure of it. Such a behavioral link might be established in reference to anyone of four types of recreation preferences: (1) for activities; (2) for environments or settings; (3) for types of satisfaction; and (4) for subsequent benefits (Brown et.al., 1978). For example, in typifying user satisfactions, Hendee et.al. (1971) categorized preferences as: appreciative-symbolic, extractive-symbolic, passive freeplay, sociable-learning, and active-expressive. Although useful for certain avenues of recreation research (Stankey, 1974; Marcin and Lime, 1974; Jackson and Schinkel, 1981), this typology has not been incorporated into forest planning for land allocations. Subsequent work developed a method of typifying the environments and settings of recreation opportunity, in a system termed the Recreation Opportunity Spectrum (ROS) (Brown et.al., 1978; Driver and Brown, 1978; Clark and Stankey, 1979; Brown, 1979). In this method, characteristics of settings favorable to different types of recreation experiences are categorized. The ROS system is directly linked to recreation supply (for which recreation managers have a direct ability to plan), while the above typology of user satisfactions is linked more to recreation demand than supply.

In the ROS system, recreation opportunities are classified along a spectrum from modern-urban to primitive opportunity (Table 1), which range in degree of six factors: accessibility,

TABLE 1

RECREATION OPPORTUNITY SPECTRUM (ROS)
SETTING CHARACTERISTICS

Primitive	:Area is characterized by essentially unmodified natural environment of fairly large size. Interaction between users is very low and evidence of other users is minimal. The area is managed to be essentially free from evidence of human induced restrictions and controls. Motorized use within the area is not permitted.
SemiPrimitive NonMotorized	:Area is characterized by a predominately natural or natural-appearing environment of moderate-to large size. Interaction between users is low, but there is often evidence of other users. The area is managed in such a way that minimun on-site controls and restrictions may be present, but are subtle. Motorized use is not permitted.
SemiPrimitive Motorized	:Area is characterized by a predominately natural or natural-appearing environment of moderate-to large size. Concentration of users is low, but there is often evidence of other users. The area is managed in such a way that minimum on-site controls and restrictions may be present, but are subtle. Motorized use is permitted.
Roaded Natural	:Area is characterized by predominately natural appearing environments with moderate evidences of the sights and sounds of man. Such evidence usually harmonize with the natural environment. Interaction between users may be low to moderate, but with evidence of other users prevalent. Resource modification and utilization practices are evident, but harmonize with the natural environment. Conventional motorized use is provided for in construction standards and design of facilities.

TABLE 1 (cont.)

Rural	:Area is characterized by subatantially modified natural environment. Resource modification and utilization practices are to enhance specific recreation activities and to maintain vegetative cover and soil. Sights and sounds of humans are readily evident, and the interaction between users is often moderate to high. A considerable number of facilities are designed for use by a large number of people. Facilities are often provided for special activities. Moderate densities are provided far away from developed sites. Facilities for intensified motorized use and parking are available.
Urban	:Area is characterized by a substantially urbanized environment, although the background may have natural-appearing elements. Renewable resource modification and utilization practices are to enhance specific recreation activities. Vegetative cover is often exotic and manicured. Sights and sounds of humans, on-site, are predominant. Large numbers of users can be expected, both on-site and in nearby areas. Facilities for highly intendified moter use and parking are available with forms of mass transit often available to carry people throughout the site.

Source: Adapted from U.S.D.A., Forest Service, 1980, Recreation Input to Land and Resource Management Planning, FSH 1909.12, Chapter 500, draft.

compatibility with nonrecreational resource uses, onsite management, frequency of social interaction, visitor impacts, and regimentation (Clark and Stankey, 1979). Dispersed recreation occurs in opportunity settings that range from roaded natural, to semiprimitive and primitive types, thus excluding the modern-urban and rural classes (Figure 1). An ROS delineation of the land base zones the resource according to opportunity types. As well, the character of recreation experiences sought is related to appropriate settings, so that a behavioral link is formed. The ROS system improves on traditional activity quantification by including a conception of satisfaction, or quality.

The ROS system serves as a basis from which to measure the recreational outputs of the forest resource. The potential satisfaction available from a specific opportunity setting can be derived by calculating the capacity of the setting to satisfy recreationists. When the capacity is compared to expected demand, the available recreation opportunity is deemed to be either sufficient or insufficient to meet the expressed demand. When the capacity of recreation opportunity of each class is sufficient to meet demand, recreation outputs are sustained.

FIGURE 1

RECREATION OPPORTUNITY SPECTRUM

Modern Urban	Rural	Roaded-Natural	Semi-Prim. Motorized	Semi-Prim. Non-Motor.	Primitive
MU	RU	RN	SPM	SPNM	PR

|---------->> Dispersed Recreation

<u>A demand-related sustained yield principle.</u>

The implications of including demand in a concept of sustained yield warrant further discussion. There is a possible dilemma in sustaining recreational outputs where the final output is quality recreation experiences. Historically, dispersed recreation opportunities of all types have not been scarce in Western North America and recreation quality has been maintained at high levels. Thereby, recreationists have come to value two characteristics of recreation settings: 1) freedom of access; and 2) lack of congestion. Increasingly, the supply of primitive opportunities is becoming scarce. With open access to limited recreation opportunity settings, congestion may result as demand increases either for recreation opportunity or nonrecreational resource uses.

The crux of the problem for dispersed recreation management is that of any common pool resource. For a common pool resource, every member of the group of users has free access and equal rights of usage, and one person's use affects that of other persons. Consider the case of a dispersed recreation setting. There is a rate of use which the setting has the capacity to sustain without recreation quality diminishing. But as with a common pool resource there is nothing to keep usage from exceeding this limit if additional recreationists desire to use the setting. For additional recreationists, the benefits of their activity will accrue to them personally while the costs of diminished satisfaction to others will be shared among all other users. The result is excessive site degradation or congestion.

This situation is often taken to be a dilemma where either access must be restricted or congestion allowed, with recreationist satisfaction, and therefore recreation quality, being diminished either way (Lime and Stankey, 1971). There are at least two possible management courses which circumvent the dilemma: the available opportunity might be better utilized, or more recreation opportunity might be made available. For the latter, tradeoffs would be involved among allocations to recreation opportunity classes or between recreational and nonrecreational resource uses.

Managing for sustained recreational outputs implies that opportunity is supplied at levels sufficient to meet the needs

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The <u>res nullius</u> concept of common property is used in economic literature in a manner similar to common pool. The legal sense of common property <u>res communes</u> is not implied here. (See Howe, 1979; Ciriacy-Wantrup and Bishop, 1975; Randall, 1981.)

of future recreation participants. In choosing away several alternatives, evaluation includes determining the likely future recreation demand and supply for each option. Changes in either the expressed demand (participation) or the recreation opportunities effect the sustainability of recreation outputs. First, consider the supply of recreation opportunity as held constant through time. In that case, changes in future participation may result in either a shortfall or a surplus of recreation opportunity. Decreasing participation leads to greater opportunity available to remaining participants. On the other hand, with increasing participation there is less opportunity available to recreationists, and congestion may result or worsen.

Now, consider the effect of a changing supply of recreation opportunity. Changes to recreation opportunity are bound to occur from the implementation of a comprehensive forest management plan, as a consequence of road construction, timber harvesting, reforestation, road closure, and so forth. For example, extending a road might change a primitive setting into a roaded setting, thus decreasing primitive opportunity and increasing road-based opportunity. By later closing the road and undertaking some natural restoration, management could return the setting to a primitive type. Where participation and opportunity are steadily changing over the planning horizon, four general possibilities may result. A base year condition of surplus opportunity may be maintained, or may change to become a deficit. Similarly, a base year condition of deficit opportunity may remain a deficit, or may become a surplus due either to decreasing participation or an increasing supply of opportunity, or a combination of both.

Changes in participation result from many factors including the opportunity available. Greater availability of opportunity may lead to greater participation, and less availability may lead to less participation (Clawson and Knetsch, 1966; Hendee and Campbell, 1969; Knetsch, 1974). This effect of opportunity on participation is sometimes not considered in recreation planning (USDA, 1981), possibly in part because it is taken as unethical to pursue a policy of selling or barricading the forests to recreationists during the allocation stage of planning. This is the view taken in the present study. In effect, the past management situation is thus taken as a norm. By doing so projected participation may be used as a standard against which to compare management alternatives.

Where opportunity is classified according to the ROS system, participation and opportunity comparisons should be considered for each opportunity class. As a result of impacting management practices, opportunity of one type might decrease while another increases. If the outcome of one alternative plan results in increases to an already plentiful opportunity type and decreases to congested opportunity types, the recreation manager would prefer an alternative plan which more evenly balances opportunities to need.

While maintaining recreation quality is certainly better than allowing the steady erosion of quality, doing so does not imply that recreation outputs are sustained. Sustaining recreation outputs is defined as maintaining recreation quality at high levels, not necessarily the current or any future level. Recreation quality might increase over time, as indicated from the above method, and yet the supply of opportunity may be inadequate to fully meet demand. Thus recreation outputs would not be sustained. The opposite might also be the case, where recreation quality decreases, but recreation outputs are sustained. The level of sustained dispersed recreation outputs provides a more absolute benchmark from which to measure change.

The forest manager, to maintain the quality of recreation experience sought, must plan for increasing availability of recreation opportunity when an increasing demand is projected. By increasing the supply in this way, the nature of the experience sought will not slowly degrade. Furthermore, the public needs, which the forest resource is called on to provide, will be fulfilled. This is a fundamentally different concept of sustained yield than that for timber, in which demand is not considered. In both cases, the level of output, or productivity, is to be maintained, it is the nature of the outputs which is substantially different.

MANAGING FOR DISPERSED RECREATION QUALITY

In the context of managing for the various goods and services of the forest resource, much is unique to managing for dispersed recreation services. Recreation involves human experiences, thus dispersed recreation is managed for experience levels which are not readily quantified or evaluated in monetary units. Nonetheless, recreationist satisfaction depends on the quality of the experiences, and thus dispersed recreation should be managed for the resulting experience levels. In order to manage for dispersed recreation quality, it is important to understand those aspects of recreation quality subject to change and the mechanisms effecting change, as well as to have a method for monitoring such changes.

Processes impacting dispersed recreation quality.

The quality of dispersed recreation settings and experiences is sensitive both to the negative impacts stemming from use conflicts, and to erosion due to causes inherent in our society. The inherent susceptibility is briefly considered here from three perspectives: as a common pool resource, as an economic resource, and as a political resource. The aspects of dispersed recreation sensitive to use conflicts include:

1) adjacency;

2) minimum management unit size;

3) asymmetrical impacts;

4) the invasion-succession process; and

5) the problem of irreversible consequences.

Resource use on an adjacent unit of land may impact on the recreational use of a given management unit. The recreational experience is adversely affected by factors which may be far removed from the recreation setting. A conflict may occur between recreation and nonrecreation resource uses, for example, a clearcut tract visible to a wilderness hiker a mile away. Or, at-a-distance conflict can occur among recreationists, such as between a motorboater and a canoeist.

In a situation of conflict, impacts are often not reciprocal whether the impacts are at-a-distance, such as for the above adjacency conflicts, or immediate. The motorboater affects the canoeist more than vice versa. There is an asymmetry in which, generally, the more development-orientated and active use or user transmits much greater negative externalities upon less development-orientated or passive uses and users, than vice versa. Among recreationists, the symbolic-appreciative recreationists are more sensitive to such impacts than are the active-expressive recreationists (Heberlein, 1977).

The size of a primitive recreation setting must be greater than some minimum size in the thousands of acres if a satisfactory primitive opportunity is to be provided. Given its dependency on vast areas of forested land, dispersed recreation is inherently spatially consumptive. The expansiveness of the physical surroundings is valued by recreationists, especially the primitive recreationist.

As a result of management practices, the character of a recreation setting may change over time in inappropriate ways. For example, constructing a road as access to a pristine, secluded lake may lead to crowds of people, increased litter and vandalism, ecological damage, and increased management regimentation, thereby drastically changing the character of the recreation setting. If the road were closed and thus made less accessible, the recreation setting might recover in time to its former state. The invasion by recreationists with different expectations results in a succession of opportunity characteristics, and probably displaces the former recreationists to other, less developed settings. This process can proceed in the other direction, though this is less likely to happen without management intervention due to the asymmetry of impacts.

In some ways, the recreational resource is a irreplaceable resource. The demand for primitive and semiprimitive recreation settings is increasing at the same time that the supply of such recreation opportunities is decreasing. Development, whether it be roads, timber harvesting, mining, or even heavy recreational use, can adversely affect the natural environment upon which dispersed recreation depends. The character of a primitive recreation setting is especially sensitive to the impacts of human developments, so much so that as a consequence important attributes of primitiveness may be irreversibly lost. Species may become extinct; evidence of man-induced erosion or reclamation persists. Starting from restocked old growth forests take hundreds of years to return from restocked forest units it can take hundreds of years to develop certain old growth conditions, such as the variation in tree sizes and degree of understory patchiness, the number of large living and dead trees, the composition of plant and animal species, and the high retention of limiting nutrients (Franklin et.al., 1981).

The object of managing for these factors is to maintain recreation quality. Even then, dispersed recreation quality is susceptible to erosion due to more encompassing causes. The quality of dispersed recreation, especially primitive recreation, is susceptible as viewed from three perspectives, namely as: a common pool resource, an economic resource, and a political resource.

<u>Common pool resource</u>. Public forest lands have the characteristics of a common pool resource and are therefore subject to the abuses that befall common pool resources (Hardin, 1968; Hardin and Baden, 1977). All members of a society have certain rights to use public forest lands. In doing so, a subset of users can have adverse effects on other users. While some users would develop the resource, others would preserve it, and while some recreationists desire roads or snowmobile trails,

others hike miles to be remote from such influences.

As a common pool resource with a mix of products, public forest lands must be protected from the exploitation of certain uses for the sake of other uses. Take the example of a timber company and a wilderness society which each desire to have the responsible government agency allocate use of a certain tract of land in a way that favors their own interests. Even though the wilderness society might represent a larger number of people, the society would face much more difficulty in raising funds and organizing the public support necessary to persuade the government agency in their behalf. Simply informing a large number of supporters of the issues and desired responses entails sizeable transaction costs. Furthermore, a certain number of supporters would become 'free riders', believing that the support of others will suffice and that their support could not have much significance. The timber company, on the other hand, is not confronted to the same degree with the problems of transaction costs and free riders. The government agency would likely favor a timber allocation, other things being equal, since the timber interests would apparently have more public support.

The inevitable outcome is the slow depletion of the common pool as a primitive recreation opportunity. Additional roaded settings and timber harvesting sites are available from the store of semi-primitive settings, and increasingly heavy recreation use or expanding roaded settings can transform a primitive setting to a semi-primitive setting. But there is no source of additional primitive settings. Thus management practices which don't protect against this flow of the invasion - succession process, lead to a box canyon effect, where more is being taken from a finite resource that may not be replenishable.

The susceptibility to adverse social and physical effects arising from user interdependence varies for different components of the forest resource. In general, uses which derive their value from inherent, qualitative characteristics of the resource are effected more than extractive, utilitarian uses; and the symbolic-appreciative recreationist more than the active-expressive recreationist (see discussion of asymmetrical impacts above). In a tragedy of the commons scenario, management practices serve to exploit intrinsic values for the sake of instrumental benefits, and the long-term interest for the sake of short-term gain. The sustained yield principle, if applied to intrinsic as well as instrumental values, can serve to curtail this process.

Economic resource. Viewed as an economic resource, the quality of dispersed recreation is again susceptible to erosion. This is unfortunate when economic analysis has a central function in determining land use tradeoffs. Evaluating economic benefits, although highly questionable for nonmarket goods such as dispersed recreation, is frequently done in planning analysis.

Using an economic approach to land allocation, the forest manager selects that management alternative which maximizes the net benefits deriving from present and future use of the land. Thus, for each alternative, the stream of future benefits net future costs must be determined for each use. Pragmatic limitations towards such evaluation arise from three factors: the intangible nature of outputs such as dispersed recreation, wildlife, and environment quality; the difficulty of determining and weighting future risks associated with some courses of action; and the uncertainty arising from the unpredictable nature of economic activity, technological development, and scientific knowledge.

Monetary valuations are supplied by commodity markets for goods such as timber. On the other hand, less tangible services such as dispersed recreation are not valued in the market. Without a market-derived value, other approaches may be used to value the benefits of dispersed recreation in monetary units. Unfortunately, such approaches have many shortcomings.

Probably the most recognized approach, is the travel cost method for deriving a demand curve and, hence, the consumer surplus, which was developed by Clawson (1959). This method uses travel cost as a 'shadow price' indicating the value of the recreation experience to recreationists. While ingenious, the travel cost method skims over many peculiar features of dispersed recreation, namely: the time taken up in order to participate in recreation activities, the value some nonparticipants derive from existence of an opportunity (option value), broader social values to public health and welfare, (merit value), and, more fundamentally, the whole issue of quality.

In addition, the risks and uncertainties associated with management alternatives, even if perceived to some degree, are not readily expressed in monetary units. How does one value the opportunity foregone as a result of irreversible damages to the environment? For example, what is the monetary cost resulting from the extinction of a species or the diminished diversity of natural settings?

Our valuation of nature is related to our capacity to understand it and describe it in scientific terms (Brooks, 1976). As our scientific knowledge about ecological and behavioral aspects of the forest resource continues to expand, our valuation of nature will change. A cautious planning approach is warranted if options are to be foreclosed which might in the future be of much greater value than is presently anticipated.

While timber as a market good is readily evaluated in monetary as well as physical units, less tangible outputs are difficult to measure in physical units, and even more difficult to evaluate in monetary units. Usually, in plan evaluations, the monetary units are compared directly and the physical units are merely listed, so that development is favored (Sewell, 1973). Implicit tradeoffs will be made in the planning process, unavoidably placing greater emphasis in areas where the market provides some measure of productivity. "By implication of Downs' thesis [Downs, 1967] we would expect to see different effects in those areas where the service [U.S.Forest Service] has a market for its output and those where it does not." (Robinson, 1975)

Political resource. Due to the highly contentious nature of forest land allocations the process of making tradeoffs has become increasingly political (Forest Policy Project, 1980). In the political arena, as elsewhere, there is an asymmetrical bias against those resource aspects which are difficult to measure or which do not offer tangible economic rewards, such as dispersed recreation. Factors underlying this vulnerability are incrementalism, political mobilization, and the political rate of time discount.

While an agency may decide time and time again not to harvest an area of timber, with one decision to harvest the area is lost as a primitive setting for centuries. Furthermore a series of small decisions can lead to a consequence of such large proportions to which no one decision would be given approval - thus, the tyranny of small decisions (Kahn, 1966). This process underscores the importance of long-term planning, although the inherent tendency is towards an incremental approach to decision-making (Ingram, 1973).

In a political forum, the decision maker's attention is attracted by those interests which are highly mobilized. Private interests with benefits relatively fixed over the short run have strong incentives to organize. The incentive for public consumers to organize is weaker due to the nature of the benefits sought (free-rider problems), and the size of the group (transaction cost problems). Thus, the large industrial consumers can be more readily mobilized than the diverse direct consumers of natural values (Baden et.al., 1974).

The political actor also has a high discount rate of time preference which militates against long-term benefits. Politicians, and bureaucrats responsible to them, desire tangible results which indicate their active and beneficial role. Thus distortions exist in the way that an organization treats different outputs. As Etzioni (1964) has observed, most organizations:

> "are eager to measure their efficiency. Curiously, the very effort ... often has quite undesired effects from the point of view of the organizational goals. Frequent measuring can distort the organizational efforts because, as a rule, some aspects of its output are more measurable than the others. Frequent measuring tends to encourage over-production of highly measureable items and neglect of the less measurable ones."

Looking at these broader susceptibilities of dispersed recreation highlights specific shortcomings of certain approaches to decision making. These shortcomings need counterbalancing if the social benefits deriving from the forest are to be maximized. A clear distinction must be made between resource outputs which behave significantly like private goods in the marketplace and those outputs which are beneficial to more collective interests, i.e. between the more tangible and the less tangible outputs. Principles that guide management decisions and techniques and evaluations employed in planning must vary accordingly.

Dispersed recreation quality components.

The quality of recreation opportunity has many facets that combine to form a satisfying opportunity for the recreationist. Viewing recreation quality in components serves to focus planning efforts on aspects which are both fundamental to recreationist satisfaction and prone to deterioration. Components of recreation quality which recreation managers find useful to consider include: (1) lack of congestion, relative to the opportunity type; (2) freedom of access; (3) diversity of opportunities; and (4) appropriate settings for the experiences sought.

The model considers in a fundamental sense, though not completely, the diversity and appropriateness of opportunity settings by incorporating the ROS system. The bulk of the recreation manager's planning problem is then to provide sufficient opportunity of each type to meet the current and future expressed demand. The issue most relevant to recreation quality is congestion. Congestion in turn might lead to management imposition of access restrictions. In the model, the sustainability of recreation outputs under any particular management scenario is measured by outputs which indicate the potential for congestion.

Lack of congestion. Congestion is the most important component of recreation quality, the most contentious and the most in need of analysis. Congestion is present where negative impacts (externalities) are transmitted from one agent to another, and is thus the outcome of use conflicts. The factors considered as leading to congestion are (Stankey, 1972):

1) intensity of use,
2) character of encounters,
3) spatial-temporal aspects of use, and
4) destructive visitor behavior.

For this study, congestion is considered to be dependent only on the intensity of use. If the second factor is assumed to remain constant, and the third and fourth factors are assumed to remain proportional to the intensity of use, a changing degree of congestion is then simply a function of changes in intensity of use.

An intensity of use which is perceived as congestion in a primitive setting might not be congestion in a semi-primitive or roaded setting. Recall that less social interaction characterizes the more primitive end of the recreation opportunity spectrum. Therefore, congestion must be considered relative to opportunity class. The notion of congestion involves a complex interplay of spatial and social factors, in which greater intensity of use does not necessarily imply congestion. For many recreation experiences, social interaction is important and the recreationist prefers the presence of others over isolation. A bathing beach might be crowded without being congested.

But given a situation where congestion is present, if the intensity of use is reduced over time, then congestion is decreased and recreation quality is enhanced. On the other hand, if intensity of use increases, congestion increases and quality deteriorates, ceteris paribus.

Where recreational density, i.e. participation per unit of opportunity, is used as a measure of intensity of use, congestion is left as a function of density of use. The relationship between density of use and congestion is nonlinear (see below). Recreational use density is in turn a function of participation and opportunity, both of which are determined by the model.

The model outputs projected participation and simulated future recreation opportunities. In comparing projected participation with the amount of opportunity, the model may be used to indicate when, where, and to what degree congestion will likely result, and the resulting effect on recreation quality.

Freedom of access. Freedom of access has been a privilege for so long that many recreationists consider it a right. Management prescriptions, such as quotas and permits, limit access. Different informative and regulatory techniques (Mitchell, 1979; McCool, 1976) which limit access affect recreationists' satisfactions to varying degrees (Stankey, 1973). Quality is diminished where access restrictions are negative impacts upon the recreationists experience. This might be counterbalanced to a degree by the positive quality of less congestion, although overall quality would be greatest without the congestion or access restrictions.

In the modeling exercise, the existing level of access freedom is sustained through time. By doing so, a full indication of potential surplusses and shortfalls of recreation opportunity is given. Evaluating the effect of permits, quotas, fees, etc. is left to managerial discretion.

Diversity of opportunity. By providing a spectrum of recreation opportunity, diverse recreational experiences may be fulfilled. In this way, more recreationists find their recreation experiences satisfying than if only the most popular opportunity type were provided, in which case only average tastes would be satisfied (Wagar, 1966). A diversity of opportunity types is implied by the ROS categorization. Other considerations of diversity, including vegetative, topographical, and feature diversities, are considered secondary and not addressed in the study.

Appropriate settings. Roads, information displays, and off-road vehicles are inappropriate in a wilderness area, and yet may be appropriate in places like popular fishing spots or scenic viewpoints. Specific setting characteristics are appropriate to each recreation opportunity class (Table 1). The ROS system goes a long way in segregating features and activities as to appropriate opportunity settings.

In addition, there are other aspects of appropriateness which are not considered by the model. Certain types of behavior and certain activities, e.g. stadium sports events, would simply be inappropriate for National Forest settings, and so are not considered in this component of quality. The question of whether one large opportunity area would be more appropriate than several smaller areas is left to management discretion. The negative impact along aircraft flight lanes is not considered. The distance necessary for a recreationist to travel is another factor determining the appropriateness of a setting. For travel distance, the study area is deemed a single unit of area, i.e. a single destination; this factor would be more significant for a study done at a broader scale. As a last example, a hunter would consider a setting unsatisfactory in which game was not available. Certainly, most National Forest land is managed to satisfy this type of recreationist. The model does not go to such detail in indicating changes in quality, but could be readily extended if the effort were deemed warranted.

There is a hazard inherent in separating recreation quality into components. While useful at certain stages of planning, the manager must maintain an overview of the consequences for dispersed recreation. Tribe (1976) related an anecdote in which plastic trees line a Los Angeles boulevard, thereby providing satisfactory shade and screening, and the appropriate greenish color. And yet, important qualities are missing; there has been a change in quality in substituting plastic trees for real ones.

Certain components of quality might be enhanced, at the same time that other qualities are detracted from.

At this point, it is enough to state as an overriding principle, that ultimately decisions involving qualitative tradeoffs necessitate human judgement. Criteria and guidelines have a way of becoming "golden numbers" and "golden rules" (Socolow, 1976) on which too much reliance is often placed. Where quality is concerned, the finer, less apparent points distinguish between plastic and live trees, between satisfying management objectives and satisfying recreationists. The decision-maker must remember the goal of maintaining quality and not let categories and criteria overshadow the finer points of recreation quality.

Recreational carrying capacities.

Recreational carrying capacities are used to determine the level of recreation use at which congestion and significant physical deterioration are initially present. Forest lands have a limited capacity to supply the demand for various uses and yet retain the land's productivity. Used in the context of a large scale, long-term productivity this is the sustained yield principle. When an operational viewpoint is taken at a smaller scale, the recreation manager uses the term carrying capacity as a limit to recreation use. Wagar (1961) defines recreational carrying capacity as "the level of recreational use an area can withstand while providing a constant and sustained quality of recreation."

Therefore, the definition given to recreation quality determines the carrying capacity. Determining which portion of the user population to aim at satisfying is critical in arriving at capacity coefficients. Otherwise, an area might be managed for the tastes of an inappropriate user group, displacing those recreationists whose behavior is more in keeping with the opportunity type. For example, primitive opportunities should be managed for the satisfaction of those backpackers, mountain climbers, and other primitive recreationists who are 'purists' (Stankey, 1972). To do otherwise would jeopardize the quality of the primitive recreational experience.

Carrying capacities can be used to estimate how much opportunity a setting can provide, and is thus a cornerstone in measuring potential recreation outputs. Managers can use the concept of recreational carrying capacity in monitoring the opportunity available from the current recreation situation, and in determining the future capacity of outputs under various management alternatives.

Unfortunately, determining the quantitative values implied by the term carrying capacity is not straightforward. There is no inherent carrying capacity for a recreation area. On the contrary, the approach usually taken is to categorize the carrying capacity into significant parts. The effects of too many recreationists may degrade the opportunity for all, in any of three ways: (1) from the crowding of too many recreationists in one area at the same time (social); (2) from adversely impacting the wildland ecology (physical); or (3) by necessitating intrusive managerial constraints (managerial). Thus three carrying capacities of relevance to recreation opportunity planning are: physical, social, and managerial.

Excessive biological or physical deterioration of the recreational setting occurs when the physical carrying capacity is exceeded. For example, trampling and tree-branch stripping around a frequently used campsite may exceed the regenerative growth of the vegetation; or heavy trail usage and braiding may create localized erosion. A social carrying capacity signifies a limit to social impacts of recreational use, such as the number and type of encounters and destructive behavior, beyond which there is congestion. Recreation quality is diminished when the degree of managerial regimentation becomes dissatisfying to the recreationist. Managerial carrying capacity is merely introduced as a concept for recreation managers to be aware of; no coefficients for this are used in the study.

The manager must be aware of the possibility of better utilizing a recreation area, and thereby reducing physical stress and congestion, through actions such as better spatial or temporal balancing of use, screening, or addition of trails. Such practices serve to increase the carrying capacities of a setting.

The tolerances of different opportunity settings to impacts varies, so that while a crowded beach is appropriate in an urban setting, the presense of a few neighboring campsites in a primitive setting is not (Lucas, 1964; Heberlein, 1977). Road-orientated recreationists tend to be more tolerant to site deterioration, the number of encounters, and methods of management regimentaion, than are primitive recreationists (Clark and Stankey, 1979). Thus, in a general statement, the carrying capacities of opportunity settings decrease in ranging towards primitive opportunities.

Whether the social, physical, or managerial carrying capacity will be most restrictive will vary with the opportunity type and ecological characteristics of the setting. In roaded natural settings, a physical carrying capacity will likely be reached before social or managerial capacities. In primitive settings, social or managerial conditions are likely to limit recreational capacity before there is an excessive degree of physical deterioration. Thus, the manager should not put equal effort into determining or monitoring each capacity coefficient for an opportunity type.

While greater physical, social, and managerial impacts result from greater use of a recreation area, the impacts are nonlinear, as reported in the conceptual work of Wagar (1961) and empirical studies of Lucas (1964). Evidence suggests that in many cases, as use increases to carrying capacity, the impact accrues quickly at first and then more gradually (Merriam et.al., 1973; Frissell and Duncan, 1965). The implication for the recreation manager is that close monitoring and quick response are necessary to maintain recreation quality. Once the impact creates a small problem the forces are in motion to soon make it a large problem.

Furthermore, caution must be exercised in comparing the projected outcomes of various management alternatives. While user density varies in linear proportions to the number of participants and the acres of opportunity available, congestion does not. Congestion is not present until the social carrying capacity is reached. However, the degree of congestion generally increases with increasing use in the range of user densities which exceed the social carrying capacity. In this range, congestion is taken to be a steadily increasing function of recreational density.

Since there exists no way of fully specifying relationships between amount of impact and amount of use, it is inappropriate to compare the impacts of various alternatives as interval data. That is, twice (half) the use does not imply that congestion is twice (half) as great. But ordinal comparisons of impacts resulting from various scenarios are appropriate. Thus, comparing congestion levels as greater than or less than one another is not misleading.

DISPERSED RECREATION IN FOREST SERVICE PLANNING

Throughout this century there has been a continuous shift in public forest land management away from a staunch development ethic and towards a more balanced multiple use concept. Initially proceeding in an *ad hoc* manner, this movement took the form of set asides such as National Parks, increased management for game animals, protection status for certain municipal watersheds, and the construction and maintenance of trails. As the diversity of demands on public lands intensified, more comprehensive land management planning was instituted. It is only in the last decade, however, that dispersed recreation as distinguished from outdoor recreation has received formalized recognition in management planning. Now that dispersed recreation has been elevated from its former incidental status, allocative tradeoffs between dispersed recreation and other resource uses must be carefully considered.

Certain legislative acts have in particular reflected and shaped Forest Service policy on dispersed recreation (Appendix A). The Multiple Use - Sustained Yield Act (1960) mandated that the Forest Service manage the National Forests for multiple use and sustained yield. The Forest Service requested that Congress legislate such management principles, which the agency was already incorporating (Robinson, 1975). This was the first piece of U.S. legislation to mention recreation as a forest resource (Brockman and Merriam, 1979). The Wilderness Act of 1964, provided a procedure for reserving Congressionally approved tracts of land for more primitive (untrammelled) forms of recreation. In 1974, recognizing the need for comprehensive, long term decision making, the Forest and Rangeland Renewable Resources Planning Act (RPA) was passed. Terms of this act promoted management for dispersed recreation rather than recreation at developed sites.

The Land Management Planning process.

Subsequently, the National Forest Management Act of 1976 (NFMA), written as an amendment to RPA, extended comprehensive planning to all local administrative units of the National Forest System. The Forest Service is directed to provide a broad spectrum of dispersed recreation, and to examine the interactions among recreation opportunity and other multiple uses, in the formulation and analysis of alternatives (36CFR 219.12(i); FSM 1922.35b). In response to the 1976 National Forest Management Act, the Forest Service has developed the Forest Land and Resource Management Planning (LMP) process (FSM Chapter 1920 - Land and Resource Management Planning).

The LMP process develops a set of broad alternatives which emphasize various forest resource uses, then evaluates the alternatives in order to select a preferred alternative, and finally implements and monitors the plan. This planning process closely parallels the steps of general planning theory (Bare and

Kitto, 1980). The ten steps identified in this process can be grouped as to analysis of the current management situation (four steps), evaluation in which management alternatives are formulated and evaluated in selecting a preferred alternative (four steps), and implementation and monitoring (two steps). The evaluation is to be an objective process in which "each alternative will be described with regard to effects upon the sustained yield of all resources." (USDA, 1980a)

Recreation Opportunity Planning.

Internal to the LMP process are use-specific planning processes, e.g. Recreation Opportunity Planning (ROP) and Timber Management Planning. Alternatives developed individually in each of these parallel planning processes must be evaluated for their consequences upon other uses of the forest resource. For example, the spatial and social impacts of a timber-oriented alternative upon dispersed recreation need to be determined. The use-specify planning processes are integrated in arriving at U.S.Forest Service forest plans.

Particularly important stages of recreation opportunity planning are the determinants of supply and demand, both current and future. The demand process takes data on current participation and projects future participation rates by opportunity class. In a supply process, recreation opportunities are delineated as to ROS class. In addition, estimates are made of the capacities of each opportunity class. Thus, outputs of the supply and demand processes determine the recreation situation. Such information is used in the LMP process in analyzing the current management situation and in formulating alternatives.

Within the planning process, the Recreation Opportunity Spectrum (ROS) classification provides a basis for (USDA, 1980c):

1) establishing management objectives for the recreation resource,
2) trade off analysis,
3) monitoring outputs,
4) guiding project plans.

Trade-off analysis is performed in the evaluation phase of the LMP process. It is at this stage that the model presented in this study is of use in integrating nonrecreational resource uses with dispersed recreation. "Because the OROS system specifies the resource conditions ... for each RO [recreation oopportunity] class, one can determine the effect of management for other resource outputs on recreation outputs."(Brown, 1979)

Iteration in evaluation.

Planning for the best mix of public forest resource uses has been termed a "wicked system" (Rittel and Webber, 1973; Liebman, 1976; Bare and Kitto, 1980). No comprehensive set of nonconflicting objectives can be arrived at where resource uses are on equal footing. Economic approaches are insufficient due to lack of a commonly appropriate numeraire; usually a monetary valuation is used as a numeraire, while dispersed recreation benefits are significantly intangible. Furthermore, the LMP process involves conflicting political factors which thwart attempts at optimization, such as special interest input through public participation and legislative mandates, e.g. mandates for multiple use and sustained yield (Culchane and Friesema, 1979; Forest Policy Project, 1980).

Lacking a clear set of objectives, an optimal solution to the allocation problem is unattainable. A second best solution must be accepted for a wicked system, involving public participation, a variety of planning emphases, and decision-maker discretion. Since decisions must be accountable to public review, as much of the planning process as is technically and financially reasonable should be systematized and reproducible.

Because planning for the integration of forest uses is an exceedingly complex task, not all factors can be considered at once, and simplification is necessary. Generalization of resource information is greatest in the early stages of planning. At these stages, it is unlikely that all resource uses will be given equal treatment, since any particular type of analysis used will tend to support the strong aspects of some uses while giving little consideration to critical aspects of other uses. As this is to be expected, the conclusions of one planning stage should be evaluated from a different perspective at a subsequent planning stage. As a result, modification may be warranted at earlier stages in the planning process. In other words, internal evaluation during the planning process may lead to iteration which feeds back from the more specific to the more general stages of planning.

The flow of iteration in the LMP process is outlined in Forest Service guidelines for the analysis phase, and mentioned as important throughout the process (USDA, 1980b). In evaluating the effects of alternatives upon dispersed recreation, locational analysis has an important role in the possible reformulation of alternatives. However, the locational analysis currently employed is unsystematic.

Locational analysis performed.

The objective of the evaluative phase of the LMP process is to provide information as to the consequences of resource-use interactions to assist forest managers in selecting a preferred alternative. In order to minimize conflicting interactions among resource uses, incompatible uses should be assigned separate spatial or temporal allocations. This necessitates the integration of all such assignments over the management unit.

In preparing a Land Management Plan, a linear programming model, called FORPLAN for Forest Planning Model, assists forest managers in making forest-wide decisions. As a linear programming routine, aggregates of cells are assigned optimal use allocations, based on the optimization of numerous variables through the year 2030, i.e. with a 50 year time horizon. As different constraints are added or deleted, various management situations can be modeled. While linear programming techniques are useful in planning the temporal integration of uses, they are largely inept at spatial coordination, often treating a whole National Forest as a small number of discrete areas.

Further locational analysis which is performed as a manual map analysis may be warranted to determine the effects upon dispersed recreation settings. It may be apparent from the FORPLAN outputs that reaggregation of assignments is necessary. The ensuing manual map analysis will require the use of many overlay maps in applying aspects of Recreation Opportunity Planning in a more detailed manner than is done with FORPLAN.

It is relatively recently that the Forest Service has deemphasized spatial analysis (Hagestedt, 1980). A lack of coordination across the whole forest was a problem with the unit planning approach used by the Forest Service in the early 1970's. The present LMP process appears to place greater emphasis on economic analysis than locational analysis which is unfortunate. Ignoring the spatial extent of individual land uses and their relative location with respect to neighboring uses will likely result in avoidable use conflicts to which dispersed recreation is especially sensitive (see section II.B above).

PRESENT DEFICIENCIES OF THE PLANNING PROCESS

Important themes of special significance for dispersed recreation planning are spatial coordination and the intangible nature of dispersed recreation. Planning for an adequate supply of present and future recreation opportunity is basically a spatial problem, with the need to consider the two aforementioned locational factors: adjacency and minimum management unit size. The task is compounded by the intangible nature of benefits derived from dispersed recreation opportunities, making identification and measurement of recreation quality difficult. Where points such as these are inadequately dealt with in arriving at land use allocations, implicit tradeoffs will skew the outcome of the planning process, confounding the nominal outcome of the management plan. If forest managers are ill-informed as to the planning requirements of dispersed recreation, this is inevitable.

It appears to be the case that certain special characteristics of dispersed recreation deserve more attention by public forest managers. There are three aspects to this:

1) sustained yield is ill-defined;
2) quantification employed in FORPLAN is inappropriate; and
3) spatial coordination is inadequate.

The concept of sustained yield of dispersed recreation (as well as other noncommodities) has yet to be defined clearly in any Forest Service publications. In practice, sustained yield is determined as part of the 'supply analysis' (USDA, 1980a). Thus projected demand is apparently not utilized in determining future sustained recreation outputs. The implications for the quality of dispersed recreation services are grave, as participation is expected to increase 55 to 108 percent by 2030. A definition of sustained recreation outputs which includes demand would provide a benchmark from which to measure tradeoffs.

Of course, the efficacy of the planning process depends on the quality of data, but in addition, it depends greatly on data which can be quantified. There are numerous hazards in relying on quantification. The LMP process is targeted to attain quantified goals (RPA goals) for outdoor recreation, in millions of recreation visitor days (RVD's). These goals do not distinguish between opportunity classes. Therefore, in maximizing RVD's, the tendency would be to bias against acres with low participation capacities. The overall effect could be the allotment of fewer acres to outdoor recreation, with primitive opportunities probably being most effected. Also, it is unclear how well these RPA goals reflect society's preferences, or even the land's productive capacity, since they are set in a top-down process.

U.S.Forest Service projections (Schafer and Lucas, 1979).

These RPA goals are, in turn, used to determine the objective function (quantified goals with weighted parameters attached) which FORPLAN is to maximize. The results are used in assessing what can feasibly and economically take place throughout the forest resource, and when. FORPLAN enters the Forest Service planning process during the analysis phase of LMP. Output from FORPLAN is subsequently used in the evaluation phase (Helfand and Stahl, 1981).

Furthermore, FORPLAN determines an optimum by maximizing net benefits (total present net value) using dollars as the numeraire. At best, the value placed on a recreationists experience will be a crude estimate. Furthermore, the objective function does not include goals for water, fish and wildlife, and the other noncommodity uses. Not including some valuation of these uses, which have 'common dependencies' on the land along with dispersed recreation, will understate the value of outdoor recreation. The future role that FORPLAN will assume is yet being determined through the experiences of the first round of Land Management Planning. The problems of inappropriate quantification in FORPLAN qualify the role such an assessment can serve.

Also, as a linear programming technique, FORPLAN gives inadequate consideration to neighboring land uses (the adjacency factor), and to the aggregate contiguous size of land use allocations (minimum management unit size). Linear programming techniques are not suited to the treatment of spatial coordination (Haqestedt, 1980; Helfand and Stahl, 1981). Some attempt is made in FORPLAN to mitigate this deficiency by grouping similar, contiguous parcels of land into 'analysis areas'. In doing so, forest managers must be parsimonious in the number of analysis areas they select, a practical constraint due to reasonable computer limitations. For an area of the size of the present study area, in the order of 50 subareas would be discretely contrained, while 21,450 cells of area are discretely manipulated in this study.

The limited number of analysis areas that can be delineated on a FORPLAN run indicates that the spatial resolution will be crude and the spatial coordination elementary. More sophisticated spatial coordination and better resolution requires many overlays, which must each be highly detailed. Considering the many impacts upon recreation opportunity (RO), "it is likely several alternative mixes of resource allocations will be tried before an allocation is chosen. If this happens, several changes in the RO area map and recalculations of RO capacities will be likely." (Brown et.al., 1979)

Outputs of FORPLAN will require manual checking by forest managers in order to regroup and disaggregate those areas which were not truly homogenous when grouped for the computer run. Manual overlaying and redrawing of maps is cumbersome as well as prone to registration errors. Furthermore, great care in making manual analysis explicit and reproduceable is necessary and apt to be overlooked.

Given the large number of factors to be considered, such an unsystematic approach in the LMP process is inappropriate, with the result that a complex planning step becomes unduly oversimplified. As a result, manager judgement will be exercised at a critical stage. At this stage, decision makers will respond to their perception of the situation rather than the actual situation (Bartee, 1973). Hall (1963) states that it "is common knowledge that one Ranger may be 'recreation conscious', another may be fascinated by opportunities to improve wildlife habitat, ... [and] still another may be a 'timber beast'." The Forest Service cannot adequately ascertain the provision of sustained recreation opportunity without further considering the spatial coordination of various uses of the forest resource. Tradeoffs could be more explicitly made with an appropriate systematic analysis.

Efforts to make Recreation Opportunity Planning more systematic include recent research in which computer programs for delineating ROS classes have been developed (Berry, 1979; Berry, 1980; Manfredo and Brown, 1980). These programs, which utilize the Map Analysis Package (Tomlin, 1980), have been the basis of programming done in the present study. While the research cited has modelled a static ROS situation, the analysis involved in arriving at forest plans is dynamic in involving the future interactions of recreational and nonrecreational resource use. The present study has addressed this dynamic component of Recreation Opportunity Planning.

Taken together, the above deficiencies indicate that more internal evaluation is warranted, and suggest the characteristics that an evaluation tool might include. This would provide a greater degree of systemmatic evaluation, feeding back to earlier steps of the planning process. While the LMP process is a hierarchal system incorporating a certain degree of iteration, the process could benefit from internal feedback which gives particular regard to spatial coordination. Also, while FORPLAN can serve important roles in long-term planning for timber, the intermediate term consequences to recreation opportunity need to be assessed.

CONCLUSIONS

In this chapter, the case has been presented that it is the quality of the experience, and therefore the recreation opportunity, relative to demand, which must be maintained in sustaining dispersed recreation outputs. Planning which determines land-use tradeoffs should incorporate cartographic analysis, since dispersed recreation quality is especially sensitive to spatial factors. Tradeoffs of dispersed recreation outputs should be discerned by opportunity class to ensure that a diversity of opportunities are being appropriately managed for.

Present methods used in developing forest plans give inadequate regard to the planning needs of dispersed recreation.

Two planning stages at which the nature of recreation outputs must be given critical consideration are in formulating and, subsequently, evaluating alternatives. Although FORPLAN assists planners in formulating management alternatives, this linear programming model is inept at considering spatial coordination in enough detail to account for impacts upon dispersed recreation outputs. Manual map analysis techniques currently employed in Recreation Opportunity Planning are cumbersome, prone to errors, and may not yield results which are reproduceable.

Recreation planning must account for the intangible nature of dispersed recreation. While commodity outputs are amenable to quantitative analysis, noncommodity outputs are inherently prescriptive. Therefore, there is the need for careful evaluation, with auxillary planning tools not so heavily steeped in quantitative analysis. However, the complexity of the planning problem requires a systematic and somewhat quantitative approach.

Planning requires a fine balance between objective quantification and judgement. In providing the forest manager with better information, planning tools must respect this balance in matching the needs of different uses. Where quantitative criteria and parameters are used, provision should be allotted for iteration between stages of the planning process, and for sensitivity tests of subjective aspects such as carrying capacity, accessibility, and the quality of opportunity provided, in general. It is the business of management to make judgements; it is the public's right that these tradeoffs be as explicit as possible.

A method more systematic than manual map analysis is needed to account for the impacts of management alternatives upon dispersed recreation. Computer simulation modeling could be employed to address this shortcoming. In fact, computer modeling has been applied to dispersed recreation planning, although to static, and not dynamic, aspects. Whereas this chapter has discussed the planning and management context in which such a model would fit, the next chapter discusses the conceptual framework for a dynamic simulation model.

CHAPTER III

MODELING THE SUITABILITY OF DISPERSED RECREATION OPPORTUNITY

The goal of forest planning is to allocate the forest resource among uses so that supply best matches the current and future demand for those uses. Thus, forest managers wish to make a comparison between demand and supply factors. A comparison between demand and supply information which provides information about the tradeoffs made in land-use decisions is termed a suitability analysis by the Forest Service.

For dispersed recreation a suitability analysis may also be used to determine whether recreation outputs are being sustained relative to demand, i.e. whether recreation quality is being maintained at high levels, both in the current management situation and in forest plans. The tradeoffs involved in Recreation Opportunity Planning are in terms of the availability of opportunity in different ROS classes and the number of RVD's thus supplied. By comparing recreation participation (demand) and recreation opportunity (supply), a determination is made as to whether or not the recreation opportunity is available in sufficient quantity to meet demand.

The number of overlays required as base data, and the number of alternative mixes of forest outputs to be formulated and then evaluated, affords the type of situation in which computer models are expedient and cost effective. Computer modeling also offers a systematic approach to evaluation. While computer modeling is sometimes considered to be a black box approach, the manager retains an intuitive understanding of the analysis if analysis steps are represented as computer maps. Maps may be displayed at any point in the procedure to inform the manager of how an impact was accounted for.

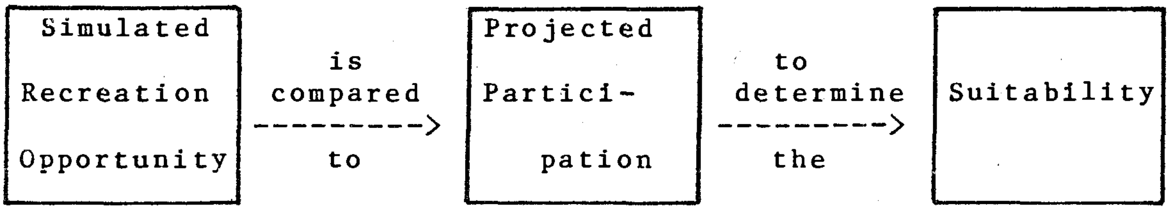
For this study, a model has been developed that determines and compares future recreation participation and opportunity for each recreation opportunity class for a specific area. The Recreation Allocation Routine evaluates the impact of nonrecreational resource uses upon dispersed recreation opportunity by determining the availability of future recreation opportunity. Future recreation opportunity is simulated as the consequence of a management alternative, which in turn is modelled as a sequence of impacting actions incorporated in a scenario. In this study, two scenarios revelant to Skykomish Ranger District are used to test the model. The resulting outputs of recreation opportunity are compared to the participation projected for the area in order to determine the suitability (Figure 2). Winter dispersed recreation is not included in the study as it is not well systematized in U.S. Forest Service planning at the present time.

Impacts on dispersed recreation over time are simulated using computer cartographic techniques, which perform a map analysis on computer representations of the forest land base. The impacts of timber harvesting and road construction, for

FIGURE 2

FRAMEWORK OF MODEL

For Each Alternative:



example, on different opportunity settings would lead to a readjusted spatial delineation of recreation opportunity in a computer file.

The functions of the Recreation Allocation Routine may be described at three levels: (1) to perform as a planning tool in dispersed recreation suitability analyses; (2) to provide information in evaluating and monitoring sustained recreation outputs; and, in the broadest terms, (3) to assist the recreation manager in maintaining recreation quality.

Such a model would complement FORPLAN (or other linear programming techniques) which looks further into the future, but is inept at spatial coordination. Where FORPLAN is used to aid in the formulation of alternatives, the model would give an estimation of the effects of alternatives upon dispersed recreation opportunity. This would be of assistance in formulating a final set of alternatives, and in estimating the effects of these alternatives upon dispersed recreation. After dispersed recreation tradeoffs are more specifically determined, managers could reformulate alternatives if so desired. When a wide range of constraint complying alternatives have been formulated, the outputs of such a resource specific evaluation tool would assist in comparing tradeoffs.

The Recreation Allocation Routine projects recreation participation for the study area, simulates the recreation opportunity available as a consequence of each scenario, and compares these results by determining the capacity of the recreation opportunity. This chapter discusses the factors that need to be considered in each of these three aspects of a suitability analysis.

PROJECTING RECREATION PARTICIPATION

Any participation projection is constrained by the nature of the data available, the form in which the projected data is desired, the time horizon of the projection, and the use to which the projection is to be put. Participation data for the study area are tabulated by activity-types, while the end result of the projection is participation by opportunity class. In this study, recreation opportunity is simulated to a 15 year time horizon. Thus, the participation projection is a mid-range projection in being greater than 5 to 10 years (short-range) and less than 25 years (long-term).

The method of projection selected must have wide applicability to be of general use in dispersed recreation planning, and therefore should be simple enough so that forest managers may retain intuitive confidence in the results, without incorporating so much judgement that personal biases have overwhelming effects. Also, the projection should highlight differences among opportunity classes, since information is needed upon which to base tradeoffs among opportunity classes.

Finally, participation is taken as neither constrained nor enhanced by supply factors. Although participation levels in part reflect the opportunity available, the influence of future availability of recreation opportunity is minimized in the study projection. This is done so that projected participation may be used as a standard against which to measure the impact of planned changes in the area's recreation opportunity. Furthermore, the influence of changes to recreation opportunity in areas beyond the manager's jurisdiction, i.e. intervening opportunities, is considered too complex to model due to problems of coordination, and is, therefore, left for the manager to weigh into his decisions. Therefore, a complex modeling of recreationist behavior is unnecessary. Caution must be voiced that approaches to forecasting recreation demand are no more accurate than the data that goes into them. Here again, a simpler approach probably fairs better.

Extension of causal factors.

Many approaches can be taken to projecting, forecasting, or estimating future forest recreation participation. Moeller and Echelberger (1974) discuss several methods representing a range of complexity and diversity of purpose:

1) extension of past participation trends;
2) informed judgement;
3) extension of trends in basic causal factors;
4) regression on demographic and socioeconomic characteristics of users, and/or recreation substitutes available (supply factor);
5) resource capacity models for a specific resource;
6) models based on supply features of a specific resource;
7) gravity models;
8) systems models.

These approaches offer various advantages and disadvantages for the purpose at hand. As has been stated above, an approach to participation projection is desired which does not consider supply factors. Next, resource capacity models assume infinite demand, and would not assist the manager in making tradeoffs among recreation types that a suitability analysis must serve to do.

The third approach, extension of trends in basic causal factors, while accounting for factors not accounted for in extensions of past participation trends, offers simplicity as compared to regressions, gravity models, and the even more sophisticated systems models. Sufficient data is generally available for projecting basic causal factors through an intermediate time range without the need to conduct additional surveys. Furthermore, some informed judgement as to reasonable saturation limits may readily be incorporated so that ridiculous results are avoided, such as every U.S. citizen boating on reservoirs thousands of times each year (an example in Clawson and Knetsch, 1966). Also, causal factors may be chosen to discern any disproportionate increase in participation among opportunity classes.

For these reaons, the method of extension of trends in basic causal factors was chosen, with a judicious element of informed judgement added. The underlying assumption of extending past trends is that relationships among causal factors will remain the same. This is tempered with informed judgement as to the most likely ways in which the relationships will change.

Causal factors considered.

The relevant factors expected to accompany growth in recreation participation must be determined in order to employ the method of extending trend factors. Two aspects of recreation participation growth are looked for in projecting participation: (1) growth in the overall participation of all dispersed recreation activities; and (2) the growth in participation of some activities relative to others. The relative significance of different factors is not at all clear. There may be a high degree of correlation among what appear to be demand generating factors. Furthermore, the degree of future growth of some factors may be highly uncertain. Therefore, the best course is probably to consider only a few causal factors which, not only can be expected to show change, but for which the data may be readily projected and which will give a broad accounting of all factors.

A few factors in particular have been traditionally incorporated in recreation participation projections. Population growth is one of several factors traditionally considered, others being disposeable income, leisure time, education, and mobility.

The anticipated population growth is expected to be a major factor in overall increases in recreation participation nationally. The magnitude of population growth will vary from region to region, with some areas experiencing negative growth. Thus, more localized population forecasts would be preferred to broader regional or national forecasts.

Rising personal incomes have traditionally been a significant factor attributing to increased recreation participation. While this trend may be less if high inflation continues, at least one source notes that any leveling of personal income will be countered by growth in dual income households (Maquire and Younger, 1980). However, a study by Mealey (1981a) in the Pacific Northwest region found no distinction in activity participation rates on the basis of income except for alpine skiing. Therefore, in addition to not presenting a clear causal relationship to future recreation participation, income levels will probably not be a significant factor in discerning future participation growth among activities. Increases in leisure time and educational levels have probably reached saturation levels for the intermediate range (Mealey, 1981b), and are not used as causal factors. Finally, the steadily increasing mobility of recreationists over the last few decades is uncertain to continue due to the cloudy future energy picture. Of the causal factors on which projections are traditionally based, none present reliable future trends for the purpose at hand except population growth. Furthermore, population forecasts prepared for a multitude of applications are available for most geographic regions.

There has been a weakening in the significance of these traditional factors and a new role taken on by contemporary factors. These include family structure, urban stress, the sex of participants, age, and energy costs. As family structure changes towards single generation families, fewer children, and individual-adult households, there will be less restrictions on time. Recreation might then take on a stabilizing role that family structure and community ties once fulfilled. Rising urban stress levels might result in more people seeking psychic refurbishing in outdoor settings. In addition, women have been taking on new roles as recreationists. Unfortunately, the effect these factors will have on recreation participation is not at all clear. Without more research as to the impacts on recreation participation, inclusion of these factors in the projection is not warranted.

The age-class structure of our society on the other hand, is largely built in over the next generation and will continue unfolding in predictable ways as the baby boom generation ages. This disproportionately large group, born in the decade following World War II, is now at a prime age for outdoor recreation. For example, the average age of backpackers is 33 (Van Doren, 1980). Over the twenty years to the year 2000, the average age of people in the U.S. will increase from around 30 years to around 35 years (USDI, 1980). Furthermore, although changing age roles are extending the life cycle of participation in activities, the shift to older age is generally accompanied by participation shifts away from active-expressive and towards more appreciative-symbolic activities (Marcin and Lime, 1974). Where there will be a significant degree of age structure shifting in a population, age is expected to be an important factor in structuring overall participation growth, as well as relative growth among activities. As stated in the Washington State SCORP report (State of Washington, 1979), "it was determined that age has a strong influence on the extent of participation in various activities."

The effect of rising energy costs on recreationist mobility may be important in varying activity participation. Motorist fuel costs increased 67.9% in the U.S. in 1979 alone (Van Doren, 1980). Fuel costs for a recreation trip are especially significant for resource-based recreation which is in general distant from the population centers where most recreationists reside. While Fulcher (1977) has found outdoor recreation to be highly price inelastic, Mealey and Kruhar's (1981) more recent study for two counties of western Washington State (which include the area of this study) concludes that the effects will be significant.

While overall participation would likely decrease with increasing travel costs, ceteris parabis, the effect locally could be an increase in participation. The more removed an area is from population centers, the more participation might decrease. While this is somewhat dependent on the mode of travel, it is especially the case for areas where the user-group travels to and fro by automobile. Thus areas intermediate between city and the more remote areas could experience increases as recreationists who previously travelled hundreds of miles shorten their trip.

The impact of such destination substitution is taken to vary among activity types. Two factors are combined to arrive at the relative impact of destination substitution among various activities: (1) a local effect based on present destinations and origins of recreationists, and (2) the component that travel cost is of the total cost incurred in participation. This approach was taken in consultation with Robert Mealey (1981b), Recreation Program Data Manager, Pacific Northwest River Basin Commission.

An area which currently receives more participants in an activity than it generates (net exporter), may expect participation in that activity to decline as recreationists travel less. On the other hand, if the area is a net importer for a particular activity and generates more participants than it receives, then increases in activity participation might be expected as future recreationists stay closer to home. Recreationists are thus expected to make destination substitutions and the effect may be a gain or loss in activity participation depending on whether the area is currently a net exporter or importer of participants in that activity.

The other aspect to consider is the component that travel costs are of total costs. For an activity for which travel costs are small relative to other costs, such as equipment, increasing travel costs will have less effect on particpation than if travel costs comprised most of the total cost to the participant. By considering both the local effect and component costs, the manager has some indication of the effect of destination substitutions on future activity participation.

Certain activities enjoy an anomalous rise in popularity for a time, which serves to teach the necessary recreational skills, establish habits of activity choices, and provide a widespread availability of good equipment. At a future date, other activities are the rising stars of popular recreational past times. Such shifts in activity preferences are reflected in equipment sales, instructional classes, and participation surveys. As a result, the relative growth in activity participation is effected. Such activity preference shifts are also considered as a causal factor.

Incorporating the causal factors.

A reasonable approach to combining all the basic causal factors of significance, i.e. population, age, destitution substitution, and activity preference shifts, is to employ two stages. Population by age class can be projected with relative reliability. In fact, it is assumed that as a base projection for an activity, change in participation by participant age class is proportional to change in population (by age class). Then in a second stage, factors whose magnitude cannot individually be determined as definately are considered as varying the base projection.

In the first stage, the current participation for the study area is disaggregated by age class for each activity. These base year participations are projected year-by-year as increasing in linear proportions to increases in population by age class. Thus for this study, participation for each of the five age classes of 20 individual activities is projected for each of 15 years.

The forecasts of population used are those for the market area of the study area, i.e. the area from which the bulk of recreationists originate whose destination is Skykomish Ranger District.

In the second stage, the two factors of destination substitution and activity-preference shifts are combined as a net effect for each activity. When these factors are combined, each activity may be classified as to stable, moderate, or fast per capita growth expected (no negative per capita growth rates were needed in this study). Magnitudes are then assigned to each of these relative growth classes based on the informed judgement of recreation experts. A similar technique was used in the latest Washington State SCORP report (State of Washington, 1979). In a Delphi session in 1974, magnitudes of per capita growth in recreation participation from 1975 to 2000 were assigned as: 70% (fast), 37% (moderate), and 0% (stable). Geometric proportions of these percentages were adopted for this study giving classes of growth over 15 years as: 37.5%, 17%, and 0%.

Projected participation for an activity is then the product of current participation, proportional population growth of participant age classes, and an adjustment factor for relative growth. Finally, the projected activity-participation figures are converted to participation-by-opportunity class. In this study, for example, projected participation for 20 dispersed recreation activities is converted to four recreation opportunity classes. To do this, breakdowns are used giving the proportion of each activity's participation belonging to each recreation opportunity class. For example, 50% of camping activity reported may occur in Roaded Natural settings, 30% in Semi-Primitive settings, and 20% in Primitive settings. The result of this conversion is participation projected year-by-year for each recreation opportunity class.

Many uncertain factors enter into making the projections, no matter what approach is used. Technological innovations and shifts in participant tastes are especially uncertain. There were no snowmobiles and few trail bikers twenty years ago. The last twenty years has seen a tremendous, and largely unanticipated, rise in the popularity of backpacking and snow activities. It could be that a sedate picnic in a developed campsite will be the boom activity of the next twenty years. Also, much depends upon the state of the economy. This study assumes a steady, though slow, economic growth and a steady rise in the real cost of energy. Therefore, the calculated projection should be interpreted as having a range of confidence. The projection approach presented here offers a balance between simplicity which ignores too much and complexity which confounds managers who are to use the results.

SIMULATING FUTURE RECREATION OPPORTUNITY

The current supply of dispersed recreation opportunity may be delineated across the forest resource. In doing so, every acre of the forest resource may be mapped as to ROS classification by applying a small set of criteria, along with judgement as to resource conditions. As a first approximation, the resulting zones of dispersed recreation opportunity spread across the land base in a concentric pattern surrounding the system of roads. A band of Roaded Natural setting centered on the road is bordered by a band of Semi-Primitive setting at a greater distance from the road, with Primitive settings existing at the greatest distance from the roads if the road network is not too dense to preclude them. In actuality, the ROS delineation is sensitive to many more features and conditions than only the presence of roads.

Conditions across the forest change over time, and, as a result, the ROS delineation changes to account for the affect of resource conditions which impact upon recreation opportunity. Fortunately for the sake of planning, the types of impacting actions and conditions which lead to significant changes in the delineation of recreation opportunity are relatively few in number. By determining the likely future course and extent of impacts upon dispersed recreation opportunity, future opportunity may be simulated.

Delineating Recreation Opportunity.

An ROS delineation includes almost every acre of the forest resource, without regard to land ownership, wilderness designation, or other political or administrative boundaries. In fact, a Wilderness Area (U.S.), having administrative boundaries, may include some Roaded Natural setting or more Semi-Primitive Non-Motorized than Primitive setting.

In classifying a setting as to ROS type, physical, social, and managerial factors are considered. Associated with each of these factors are criteria to be applied in mapping the forest resource by ROS class.

Because dispersed recreation is sensitive to the character of surrounding land uses, the spatial impacts of other uses must be accounted for. Two locational factors are of importance in accounting for physical impacts upon dispersed recreation opportunity: adjacency and minimum management unit size.

The external effects of some forest management actions impact on dispersed recreation settings miles removed. These at-a-distance impacts necessitate the consideration of what are termed adjacency factors, a term alluding to the importance of the relative location of different uses. Adjacency is accounted for by applying the remoteness criteria and criteria for evidence of humans.

A small number or exceptions include Research Natural Areas (RNA's).

Forest Service remoteness criteria state that a Roaded Natural setting occurs within 1/2 mile of a road; the Semi-Primitive classes extend from 1/2 mile to 3 miles distance from the road;, and the Primitive class extends from a distance greater than 3 miles (Table 2). A Semi-Primitive Non-Motorized setting is distinguished from a Semi-Primitive Motorized setting by the nature of management restrictions as to the use of trail bikes, four-wheel drives, and other motorized modes of transportation. Thus a Semi-Primitive setting is removed from the immediate presence of the road, and a Primitive setting is beyond the distance that most day hikers will travel. Primitive opportunity should be removed from the sights and sounds of man (USDA, 1980c).

These stated distances are adjusted to account for the varying effects of vegetation and terrain in screening out sights and sounds, and in restricting movement. Dense vegetation and steep trails more effectively provide isolation and solitude than do sparse vegetation and smooth terrain. On the other hand, recreationists will travel extra distance and tend to congregate around the general area of attractive features such as waterfalls, campgrounds, and major mountain peaks. The distance criteria should be adjusted to account for attractive features as well inhibiting features.

Another criterion for ROS classification is the evidence of human impacts. The degree of evident human impact which is permissible is incorporated as a percentage of the opportunity

TABLE 2

REMOTENESS CRITERIA *

Primitive	An area designated by a line which is 3 miles from all roads, railroads or trails with motorized use.
Semi-Primitive Non-Motorized	An area designated by a line which is 1/2 mile from all roads, railroads or trails with motorized use; can include the existence of primitive roads and trails if usually closed to motorized use.
Semi-Primitive Motorized	An area designated by a line which is 1/2 mile from primitive roads or trails used by motor vehicles; greater than 1/2-mile from roads which are better than primitive roads.
Roaded Natural	An area designated by a line which is 1/2 mile from roads which are better than primitive roads and railroads.
Rural	No distance criteria.
Urban	No distance criteria.

*The criteria can be modified to conform to natural barriers and screening, or other relevant features of local topographic relief and vegetative cover. This fits the criteria to the actual Forest landscape.

Source: Adapted froU.S.D.A., Forest Service, 1980 Recreation Input to Land and Resource Management Planning, FSH 1909.12, Chapter 500, draft.

setting on which there is irreversible evidences of mans activities, renewable resource modifications, or buildings and other man-made features (Table 3). Old mining operations might have resulted in irreversible changes (practically speaking) to a mountain face. Timber harvesting, past and present, is an obvious form of renewable resource modification, especially when the harvesting method is clearcutting.

TABLE 3

EVIDENCE OF HUMANS

Primitive	:Setting is essentially an unmodified natural environment. Evidence of humans would be unnoticed by an observer wandering through the area. Evidence of trails is acceptable, but should not exceed standard to carry expected use. Structures are extremely rare.
Semi-Primitive Non-Motorized	:Natural* setting may have subtle modifications that would be noticed butnot draw the attention of an observer wandering through the area. Little or no evidence of primitive roads and the motorized use of trails and primitive roads. Structures are rare and isolated.
Semi-Primitive Motorized	:Natural* setting may have moderately dominant alterations but would not draw the attention of of motorized observers on trails and primitive roads within the area. Strong evidence of primitive roads and the motorized use of trails and primitive roads. Structures are rare and isolated.
Roaded Natural	:Natural* setting may have modifications which range from being easily noticed to strongly dominant to observers within the area. However from sensitive** travel routes and use areas these alterations would remain unnoticed or visually subordinate. There is strong evidence of designed roads and/ or highways. Structures are generally scattered, remaining visually subordinate or unnoticed to the sensitive** travel route observer. Structures may include power lines, microwave installations and so on.

TABLE 3 (cont.)

Rural	:Natural* setting is culturally modified to the point that it is dominant to the sensitive** travel route observer. May include pastoral, agricultural, intensively managed wildland resource landscapes, or utility corridors. Pedestrian or other slow moving observers are constantly within view of culturally changed landscape. There is strong evidence of designed roads and/or highways. Structures are readily apparent and may range form scattered to small dominant clusters including power lines, microwave installations, local ski areas, minor resorts and recration sites.
Urban	:Setting is strongly structure dominated. Natural or natural-appearing elements may play an important role but be visually subordinate. Pedestrian and other slow moving observers are constantly within view of artificial enclosure of space. There is strong evidence of designed roads and/or highways and streets. Structures and structure complexes are dominant, and may include major resorts and marinas, national and regional ski areas, towns, industrial sites, condominiums or second home developments.

* In many sourthern and eastern forests what appears to be natural landscapes may in actuality have been strongly influenced by humans. The term natural-appearing may be more appropriate in these cases.

** Sensitivity level 1 and 2 travel routes from Visual Management System, USDA Handbook 462.

Source: U.S.D.A., Forest Service, 1980, _Recreation Input to Land and Resource Management Planning_, FSH 1909.12, Chapter 500, draft.

The size of management units is another important locational factor in recreation opportunity planning. Backcountry recreationists seek out vast tracts of untrammelled land, gaining satisfaction from extensive remoteness and solitude. Areas managed for the more primitive opportunities must then be of a rather large minimum size. Forest Service size criteria state that a Semi-Primitive setting is to be at least 2,500 acres in size, and a Primitive setting at least 5,000 acres in size (Table 4).

However, smaller size limits are appropriate where contiguous settings supplement the degree of primitiveness. If what would otherwise be a Semi-Primitive setting is undersized (less than 2,500 acres) but borders a Primitive setting, a Semi-Primitive designation might be appropriate. Similarly, a marginally sized Primitive area may be surrounded by extensive areas of Semi-Primitive Non-Motorized and nearby Primitive settings. Thus, the neighborhood characteristics of a setting must be considered.

Adjacency factors and minimum management size are two types of locational factors which considered together account for the physical component of ROS mapping. Social factors must also be considered.

To map the social component of ROS classification requires determination of the number and nature of encounters between recreationists that should be allowed to occur in each type of opportunity setting. User density is the criterion associated

TABLE 4

SIZE CRITERIA BY OPPORTUNITY CLASS

Primitive	Semi-Prim. Nonmotor.	Semi-Prim. Motorized	Roaded Natural	Rural	Urban
5,000 acres*	2,500 acres**	2,500 acres	No size crit.	No size crit.	No size crit.

*May be smaller if contiguous to Semi-Prim. Nonmotor. class.
**May be smaller if contiguous to Primitive class.

Source: U.S.D.A., Forest Service, 1980 Recreation Input to Land and Resource Management Planning, FSH 1909.12, Chapter 500, draft.

with the social component (Table 5), since high user densities will lead to congestion which detracts from the satisfaction of recreationists.

Although user density is in terms of numbers of users, the nature of the encounters is also of consequence. Hiker dissatisfaction from a trail encounter is less than that reported from having to camp next to another party (Stankey, 1972). The size of parties and mode of travel (horse, foot, etc.) are also important parameters of impact. In this study, these additional social factors are assumed to be accounted for in applying the user-density criteria.

Finally managerial factors are considered. An allowable degree of management regimentation is associated with each opportunity class (Table 6). In mapping the managerial component, a setting with noticeable on-site management might be delineated as Roaded Natural, but a Primitive delineation would

TABLE 5

SOCIAL SETTING CRITERIA *

Primitive	Usually less than 6 parties per day encountered on trails and less than 3 parties visible at campsite.
Semi-Primitive Nonmotorized	Usually 6-15 parties per day encountered on trails and 6 or less parties visible at campsite.
Semi-Primitive Motorized	Low to moderate contact frequency.
Roaded Natural	Frequency of contact is: moderate to high on roads; low to moderate on trails and away from roads.
Rural	Frequency of contact is: moderate to high in in developed sites, on roads and trails, and water surfaces; moderate away from developed sites.
Urban	Large numbers of users onsite and in nearby areas.

*These criteria apply during the typical recreation use season. Peak days may exceed these limits.

Source: Adapted from U.S.D.A.,Forest Service, 1980 Recreation Input to Land and Resource Mgt. Planning, FSH 1909.12, Chapter 500, draft.

be inappropriate. More subtle forms of control, such as permits, queues, and fees, are used in managing Primitive areas, although use of such methods is highly contentious. Though such control is not on-site, neither is that part of the recreational experience which proceeds entering a primitive area; furthermore, actual enforcement of such visitor restrictions would probably occur on-site in Primitive settings. Excessive constraint is the antithesis of opportunity.

TABLE 6

MANAGERIAL SETTING CRITERIA *

Primitive	On-site regimentation is low with controls* primarily off-site.
Semi-Primitive Nonmotorized	On-site regimentation and controls* present but subtle.
Semi-Primitive Motorized	On-site regimentation and controls* present but subtle.
Roaded Natural	On-site regimentation and controls* are noticeable, but harmonize with the natural environment.
Rural	Regimentation and controls* obvious and numerous, largely in harmony with the man-made environment.
Urban	Regimentation and controls* obvious and numerous.

*Controls can be physical (such as barriers) or regulatory (such as permits).

Source: U.S.D.A., Forest Service, 1980 Recreation Input to Land and Resource Management Planning, FSH 1909.12, Chapter 500, draft.

When the physical, social, and managerial components are compared to determine a composite ROS delineation, 'inconsistencies' may exist in categorizing recreation opportunity. Although classified as a Primitive opportunity with regard to physical factors, a setting might have the social characteristics of a Semi-Primitive Non-Motorized opportunity. Where this presents difficulties in categorizing a setting, a classification which implements long term management objectives will foster the desired prescription.

For certain purposes, the basic categories may be subdivided, thus providing greater discernment of opportunity settings. A Primitive-Restoration classification might apply to a primitive setting in which man-induced inconsistencies are present to which restoration to a natural state is planned. The Roaded Natural classification might be subdivided to include harvested sites in a Roaded Modified category, thus indicating the extent of such renewable resource modification.

Dynamic impacts upon dispersed recreation.

An initial ROS delineation is subject to change due to dynamic factors, largely brought about by management actions and changing recreation participation levels. A process of 'invasion - succession - recovery' (see section II.B above) is occuring to manifest changes to recreation opportunity. For example, as roads are developed and timber sites are harvested, opportunities requiring a primitive setting are infringed upon more than opportunities in road-based settings. The more primitive areas are 'invaded' and, thereafter, 'succession' occurs towards more developed forms of recreational activity. Over time, the potential exists for partial 'recovery' through forest regrowth and road closure. This process may also proceed in the other direction with the invasion of road-based settings, although the asymmetry of impacts makes this less likely. The process may be set in motion by inter-use conflict, intrarecreational conflict, or a combination of both.

Management practices undertaken for nonrecreational resource uses of the forest resource affect dispersed recreation opportunity to various degrees. There is little impact upon dispersed recreation opportunity from management for wildlife, fish, watersheds, and environmental quality. In this way, dispersed recreation shares 'common dependencies' upon the forest resource with these resource services. The presence of wildlife, fish, pure waters, and amenities enhances the satisfaction of dispersed recreation experiences. If anything the adverse effect of recreationists upon these other resource services is more substantial than vica versa.

The primary impacts upon dispersed recreational use of the forest resource result from timber management. Logging and recreational use are meeting head on. As receationists desire to drive less due to the cost of gasoline and therefore seek lower elevations, loggers are having to log in higher elevations after having logged much of the lower elevation forests. In the process, logging operations and the haul roads associated with logging are moving into formerly roadless areas.

Even after the logging operation is finished (with attendant noise and truck activity) the harvested sites remain as a visual reminder, wildlife habitat is effected in many deleterious ways for up to 150 years (Franklin et.al., 1981), and fishing streams may have increased sedimentation and temperatures (Hyde, 1981). Most primitive recreationists would lament the longer drive, the probable higher user densities, the squeeze to higher elevations and a shorter use season, and the probable loss of wildlife. The area could be restored to primitive conditions although this takes an extremely long time. Regrowth of harvested sites to an appreciable size takes 60-100 years or longer, depending on site conditions. Even then, the stand might be conspicuous, because of its monoculture, even-aged appearance. Roadways can be closed, scarified, and in other ways reclaimed to minimize their distractive appearance and restrict use of motorized vehicles, although this can be an expensive undertaking. In wetter areas of the Pacific Northwest, a canopy of trees and the action of natural erosion may remake the road into an overly wide trail with very gentle grades in 40-60 years time.

On the other hand, gathering elderberries or other foods may be furthered by timber harvesting, and, in low snowfall areas, habitat for certain browsing animals such as deer may be improved. The presence of smaller clearcuts is viewed as consistent and acceptable to most road-based recreationists (Downing and Clark, 1979). The haul roads would usually be available for road-based recreationists to continue using, increasing their accessibility to road-side camping spots, fishing spots, lake recreation, etc.

Other conflicts with dispersed recreation are less significant, although present. Conflicts with dispersed recreation arise from livestock grazing, mining activity, reservoirs (which are more a setting for developed recreation), linear developments such as utility right-of-ways, and communications relay towers. Such impacts are important where they occur, although they occur with less frequency than timber harvesting and road construction.

A few additional management actions other than those attributable to nonrecreational resource use are significant in affecting recreation opportunity. Land exchanges with other land owners, e.g. for the purpose of land consolidation, may result in a gain or loss of recreation opportunity supplied by the Forest Service. Trail construction affords a way of supplementing recreation opportunity.

Road closure resulting from either management action or natural forces may significantly affect recreation opportunity. The closure may either be temporary with the management intention of reopening the road, or permanent with plans for reclaiming the road setting back to a natural state. A temporary road closure still leaves the road as evidence that vehicular traffic and probably logging activity will return. In fact, it is difficult to effectively close a road to all motorized use, and the road-based characteristics of the setting will persist. When a road is to be permanently closed, the long-term opportunity classification should prevail in order to avoid unwanted 'invasion-succession' effects such as the spreading effect of a campground. The degrading road would exist as an 'inconsistency' in the primitive area for some time; however, primitive recreationists would find the road much more acceptable if it is known that the road is returning to a natural state (Clark, 1981).

Changes in the nature of management regimentation of recreationists will change the character of recreation opportunities. Primitive opportunities are the least tolerant of the opportunity types to management regimentation. For example, instituting user permits, queues, or fees detracts from the freedom of accessibility to these areas with the result that a degree of ′primitiveness′ is lost. Such management regulations are often instituted as a method of curtailing or redistributing recreational usage.

The impacts of relatively few of the above management actions are of primary importance for dispersed recreation planning. In the Pacific Northwest, the management actions which most affect dispersed recreation over an intermediate time frame are road construction, timber havesting, trail construction, land exchange, road closure, and management restrictions on recreationists. Other types of impacting management actions occur much less frequently and with less overall impact upon dispersed recreation.

In addition to management actions, there are other conditions which may change a setting′s recreational characteristics. Heavy recreational use may effect the classification of dispersed recreation opportunity. In certain instances, primitive hiking trails may receive such popular use that they become inconsistent with the character of a Primitive setting, possibly warranting reclassification of land alongside the trail to a Semi-Primitive opportunity setting. Hiking trails are expected to become busier as recreation participation increases, especially if available Primitive opportunity continues to decrease. Also certain common natural events may affect recreation opportunity. Flood occurrences occasionally wash away sections of roadway; rock slides can block or carry away sections of roadway.

Changes to recreation opportunity will also result due to highly uncertain factors. In some instances these effects will be natural in origin, although rare, such as floods, volcanoes, and fires. The eruption of Mt.Saint Helens has in all likelihood led to the redirecting of some recreationists away from the area at the same time that the area is a major attraction to others. The uncertainty of planning and political options is a further consideration in land management planning. How likely is it that the necessary money will be available to implement a plan? If the money is not available to support an ambitious program of timber harvesting and reforestation, recreation opportunity will also be affected. As another example, budgetary cuts might reduce road maintenance and thus lead to road closures. Decisions to designate additional lands as Wilderness Areas might have the local effect of intensifying harvesting on surrounding lands.

Developing scenarios of impacts.

Scenarios of impacting actions and conditions may be developed and simulated, in order to foresee the effects of various impacts on dispersed recreation opportunity. Parsimony is a cardinal rule in simulation; attempting to include every possible factor is a waste of preparatory time and computing money, yielding results that belie the model's validity (Holling, 1979). Management scenarios made up of only the most significant impacting factors will model the future in enough detail to provide forest managers with information that is of assistance in making allocation decisions. As discussed above, a list of significant impacting factors would include:

1) road construction;
2) permanent road closure;
3) trail construction;
4) trails which become heavily used;
5) land exchanges (in ownership or jurisdiction);
6) natural and planning factors.

Other less usual factors such as construction of a power line through a more primitive area could be included where anticipated.

Sites of timber harvesting are not included in the above list. Even though much different in character, the impact of timber harvesting may be subsumed for the purposes of zoning by the impact of the roads present to haul the timber. The successful extraction of logs from the forest requires the proximity of roads. Even helicopter logging is generally limited to within a half mile of a haul road. If the impact of timber harvesting is inadequately subsumed in a particular instance by the impact of associated roads, this could be incorporated.

Management restrictions on recreationists are not included. If included, these would be a constraint on participation, which would conceal the full extent of tradeoffs of recreation quality. An indication of such tradeoffs is needed at the allocation stage of planning as an estimation of the effects of alternatives.

Dealing with uncertain natural and planning factors poses a special problem in developing a scenario. Highly uncertain, though probable, occurrences such as natural road closures might be included if the impact is likely to persist for a long time. On the other hand, such uncertain factors would be much less significant if they were of short duration. Recreationists may not significantly alter their habits in the short term (Downing and Clark, 1979). For example, if a road is closed for only a few years some motorized recreationists may ignore the closing in order to reach a favorite spot, while primitive recreationists may be slow to discover any new de facto wilderness which may result. Furthermore, infrequent, though devastating, events such as extensive forest fires or pest infestations are better left external to the modeling, and considered by the forest manager in giving a long-term interpretation to the simulated outcomes.

In all cases, it is not only the length of roads constructed, the amount of land exchanged, or other such quantities which are of significance. The scheduling and location of the impacts is of primary importance in determining the consequences to dispersed recreation opportunity. The current management direction or any of a variety of management alternatives might form the basis for developing a scenario. The impacting factors composing the scenario should be as specific to time and location as warranted by the temporal and spatial resolution of the model.

DETERMINATION OF SUITABILITY

The effects of different management alternatives upon dispersed recreation outputs may be compared. An alternative which emphasized extensive timber harvesting would be expected to result in greater Roaded Natural opportunity and less Primitive opportunity. Whether the recreation quality of any opportunity classes would be decreased as a result of such an alternative depends upon the expected participation. Other alternatives would in all likelihood effect the availability of recreation opportunity in a different way. In order to compare scenario outputs, it is necessary to determine the capacity of the recreation opportunity available.

Information as to the projected participation and the capacity of simulated opportunity are compared in determining whether the supply would be adequate to meet the demand. Where the supply is adequate to meet the demand, the availability of dispersed recreation opportunity, relative to demand, is being sustained. On the other hand, the consequence of undersupplying a particular opportunity type is conflict. Such intra-opportunity class conflict may be between recreationists and the physical, social, or managerial environments. The result could be fewer fish per fisherman; wildlife populations that are too small to be viewed by those who seek to; or a situation in which more backpackers have relatively less available opportunity with the consequence being more congestion or more management regimentation; and so forth. This is only a problem where supply does not meet demand, i.e. where recreation capacities are going to be exceeded.

<u>Attributes determining carrying capacity.</u>

Carrying capacity coefficients are used to convert spatial measures of recreation opportunity to recreation capacity in numbers of participants. Thus the potential number of users that could be satisfactorily handled at capacity is determined. Then the potential number of users that the recreation setting could sustain may be compared to the expected number of users, for each opportunity class. Two approaches to determining recreation capacity are employed in the model: a size-dependent and a feature-dependent approach.

Many principal factors affect recreation capacity, including land types, vegetation, recreationist behavior, access, attractiveness, and patterns of use. Generally, capacities are lower in open landscapes or where soil or vegetation is fragile, and lower the more primitive the class along the Recreation Opportunity Spectrum.

A theoretical maximum recreation capacity for a setting would consider limitations posed by the physical tolerance of the setting and the level of social congestion appropriate for an opportunity class. Such a theoretical maximum overstates the useable capacity of the recreation resource. Not all acres are equally accessible, with some areas being relatively inaccessible due to steep slope, dense vegetation, or lack of trails, for example. Furthermore, the recreationist is constrained as to the times that are suitable for participation. Time constraints result from the season of use, e.g. the snowfree season for hikers and the migratory patterns of fish and game animals for fishermen and hunters; and the greater freedom of time for recreation on weekends. Capacity coefficients for these factors of accessibility and temporal patterns of use adjust the theoretical maximum capacity downward, resulting in a practical maximum capacity. The practical maximum capacity recognizes the characteristic of peak loading in recreational use.

However large the capacity of the opportunity settings, accessibility might be limited by the capacity of roads leading to the settings. The transportation system might prove to be a limiting factor as an increasing future demand is constrained by a road system of insufficient capacity. For this reason, forest managers should separately compare road capacity standards with the computed capacities served by the road network to check for potential bottlenecks.

Over time, values for the capacity coefficients may change. However, coefficients should not be changed without conducting thorough research. Changing certain capacity coefficients (e.g. user density) would indicate a management belief that recreationists' standards of recreation quality are changing. Unfortunately, this could be the result of degrading setting conditions and not the desire of recreationists. This is because recreationists' expectations will lower as a consequence of the floating baseline phenomenon if, for example, excessive congestion or management restrictions persist. Other future occurances could effectively increase recreation capacity. Socio-economic phenomena such as the lengthening of the school year and introduction of flexible work weeks could lead to a smoothing out of peak demand and an alleviation of congestion. The prototype Recreation Allocation Routine makes no changes to capacity coefficients over time, because the factors leading to

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A road simulation model has been developed by Ron Hendricks, Land Management Section, Mt.Hood National Forest, Supervisor's Office, Portland.

changes in capacity and the degree of their effect are highly uncertain.

Size-dependent capacities.

Ideally, an in place inventory of every acre could be made in arriving at recreational capacity. More practically, a broad per-acre capacity coefficient is used, which is based on certain factors affecting capacity, such as the eco-class. The total capacity of an opportunity class is then primarily a function of the size of opportunity setting belonging to that class.

Two approaches are employed by the U.S.Forest Service which use either a recreation visitor day (RVD) coefficient or a person-at-one-time (PAOT) coefficient. Both approaches consider physical and social factors of capacity, although both coefficients emphasize different aspects. The PAOT coefficient affords a more direct application of the social criterion for density of users, while the RVD coefficient has in practice varied with the ecological subclassification of an ROS setting. (See USDA (1980c) for another discussion of these approaches.) This study employs the PAOT approach used for Mt.Baker -

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A computer-cartographic approach could readily compute capacities for each grid cell, if the capacity were defined as a function of resource attributes such as vegetation, slope, soils, ROS class, proximity to trails, etc. (Berry, 1980). However, the appropriate capacity coefficients have not been determined. It would be impractical to compute so many capacity figures by hand.

One recreation visitor day (RVD) is the recreational use of an area for a total of 12 hours by one person.

Snoqualmie National Forest, in which the study area is located.

At the present time arriving at PAOT coefficients is highly judgemental, although a number of explicit setting factors are considered. A coefficient from within a general range of coefficients (Table 7) is selected, based on the percentage of acres which are useable considering slope, vegetation, attractiveness, and access limitations. Thus the practical limitations of accessibility are incorporated in the PAOT coefficient (except for the accessibility as limited by the transportation system).

The PAOT coefficient for an ROS class is then adjusted by factors specifying the temporal pattern of use. These include the length of the managed season (MS), the relationship between the average weekend use and average weekday use of areas (PU, for pattern-of-use), the average length of time the area is occupied in hours (LOS), and a constant for 12 hours, i.e. 1 RVD:

$$RVD's = PAOT \times MS \times PU \times LOS/12.$$

By adjusting the PAOT coefficient by these factors, the number of RVD's/acre/year is arrived at, giving the capacity of each acre as a potential number of participants per year. The total acres of each opportunity class multiplied by the RVD's/acre/year equals the number of users potentially supplied in RVD's/year.

TABLE 7

CAPACITY COEFFICIENT RANGES *
(in PAOT/Acre)

	Primitive	Semi-Prim. Nonmotor.	Semi-Prim. Motorized	Roaded Natural	Rural
High:	.025	.083	.083	2.500	7.500
Low:	.002	.008	.008	.083	.830

*Specific ranges must be developed to meet Regional or Forest conditions.

Source: Adapted from U.S.D.A.,Forest Service, 1980 Recreation Input to Land and Resource Management Planning, FSH 1909.12, Chapter 500, draft.

In the above formula, the length of season factor, MS, glosses over the actual seasonal variation in use. Hunters may prefer the early part of the hunting season when game is most available; many outdoor recreationists plan their more extended outings over the longer holiday weekends of summer, during the months that school is recessed, and in mid-summer when the weather is more reliably favorable. A better correspondence with the practical time limitations facing recreationists would be afforded by a seasonal pattern-of-use factor, SPU, analogous to the weekly pattern-of-use factor above (PU). First the problems of averaging seasonal patterns-of-use for all activities would have to be overcome. Then, the significance of this revision could be tested. Such studies have not been undertaken, and the MS factor and not a SPU factor is used in this study.

Feature-dependent capacities.

Another approach to calculating the capacity of recreation opportunity is not based on the acreage of each opportunity type, but on the recreational features present in an opportunity setting. Feature-dependent capacities are calculated for the number of lakes, miles of trails and roads, number of mountain peaks, and so forth, that are present in the settings of each opportunity class. Thus, capacity is determined on or close to a few clearly recognizable feaures, plus a small amount for surrounding areas. PAOT and temporal pattern-of-use coefficients similar to those used in the size-dependent approach are used in this approach.

The feature-dependent approach, in offering the advantage of determining PAOT coefficients for each feature separately, is probably more accurate than when considering all features en masse, especially over time as ROS delineations change. Also, the judgements that go into arriving at capacity coefficients are more explicit than with the PAOT approach.

Disadvantages of this approach are that all relevant features may not be considered, and, secondly, that aggregating all the feature-dependent capacities within an opportunity class is somewhat inappropriate. More appropriately, feature-related capacity would be compared with the demand for each feature, not

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This approach is being developed by William Fessel and Paul Frankenstein, Recreation Planners, Supervisor's Office, Mt. Baker - Snoqualmie National Forest, Seattle.

the demand for an opportunity class as a whole. This aggregation assumes that activity substitution within an opportunity class is completely plastic. For example, such a comparison would be blind to a situation within an opportunity class in which the capacity for fishermen is high, but few fishermen are expected, while there is little capacity for campers and many campers are expected. The feature-dependent approach is incorporated for only the last time step of the Recreation Allocation Routine, due to its developmental nature.

Interpreting the comparison.

Once the capacity which a management alternative could supply is calculated, a comparison may be made with the projected participation. The difference between the simulated capacity and the projected participation (both measured in RVD's per year) will indicate anticipated undersupply or oversupply within each opportunity class. An oversupply implies a situation in which recreation opportunity is not only being sustained, but in which there is a superfluous lauo allocation which could possibly be used to supply an undersupplied opportunity class. An undersupply implies that the opportunity-type is not being sustained, and that ways to increase the supply of that particular opportunity class should be considered. An adequate supply implies that recreation opportunity is being sustained, relative to demand.

Affects upon recreation quality may be inferred from such information, specifically recreation quality as dependent upon the degree of congestion. Since an undersupply implies congestion, a decrease (increase) in the degree of undersupply over time would imply that congestion decreases (increases). Also, an increase in the degree of oversupply implies that while user density would be decreasing recreation quality would not necessarily be greater, since an oversupply implies that congestion is not present. In fact, recreation quality might actually decrease for those recreationists who value a certain degree of social interaction, a trait which is more common among road-based recreationists than primitive recreationists. Therefore, the satisfaction of the road-based recreationist might be greater if the oversupply of Roaded Natural opportunity is decreased, up to the point where supply is adequate to meet demand. Such statements are made for the recreationist who represents a norm for a particular opportunity class. The Primitive recreationist would be indifferent, technically speaking, to a decrease in oversupply of Primitive settings, since when congestion is not present their satisfaction is not significantly changed whether more or less people are present.

Caution should be exercised in interpreting these outcomes, since the figures for projected participation and simulated capacity have an error associated with them. Participation projections and simulations of recreation opportunity out of necessity make assumptions about a future which is full of uncertainties; also, determination of capacity coefficients is always going to be in part a judgemental process, as are all decisions about quality. Analogously, timber sustained yield levels are sensitive to uncertain factors such as estimates of stand age, site productivity, success of reforestation, effect of thinning and fertilization, and even the units of measurement (Forest Planning, 1982). Therefore, the forest manager should consider the outputs as having a range of confidence associated with them when making interpretations like those above.

The dispersed recreation outputs of each scenario which has been simulated may be compared to the level of sustained recreation outputs, thus indicating affects upon recreation quality, in particular, recreation quality as dependent upon congestion. An oversupply of recreation opportunity is a bank account which may be drawn upon in making tradeoffs with other opportunity classes or with nonrecreational resource uses. An undersupply is a deficit which the forest manager should only incur with caution when the deficits to other opportunity classes or with nonrecreational resource uses is in some sense greater.

CHAPTER IV

MODEL STRUCTURE AND ORGANIZATION

The model structure of the Recreation Allocation Routine (RAR) naturally breaks into three submodels: opportunity, participation, and suitability submodels (Figure 3). Projected participation and simulated opportunity are compared to indicate the suitability of the resource to provide the recreation opportunity needed to meet demand. To do so, future demand and supply information for dispersed recreation opportunity is compared in common units of recreation visitor days (RVD's). Participation is projected to determine the number of future RVD's demanded (Figure 5). Supply is simulated as the consequence of different management scenarios yielding outputs of recreation opportunity (Figure 4). Using capacity coefficients, the capacity in RVD's of the opportunity outputs is calculated (Figure 6). The available opportunity should have the capacity to supply the projected demand, if outputs are to be sustained and/or quality maintained.

The Recreation Allocation Routine is the prototype of a model which could be developed for more general use. The user supplies the data bases for the opportunity and participation submodels, the scenarios which are to be compared, and a few parameters for the suitability submodel. The model is driven by a management scenario. It is not oriented to a policy level, but

FIGURE 3

INTERRELATION OF SUBMODELS;
WITH DATA REQUIREMENTS

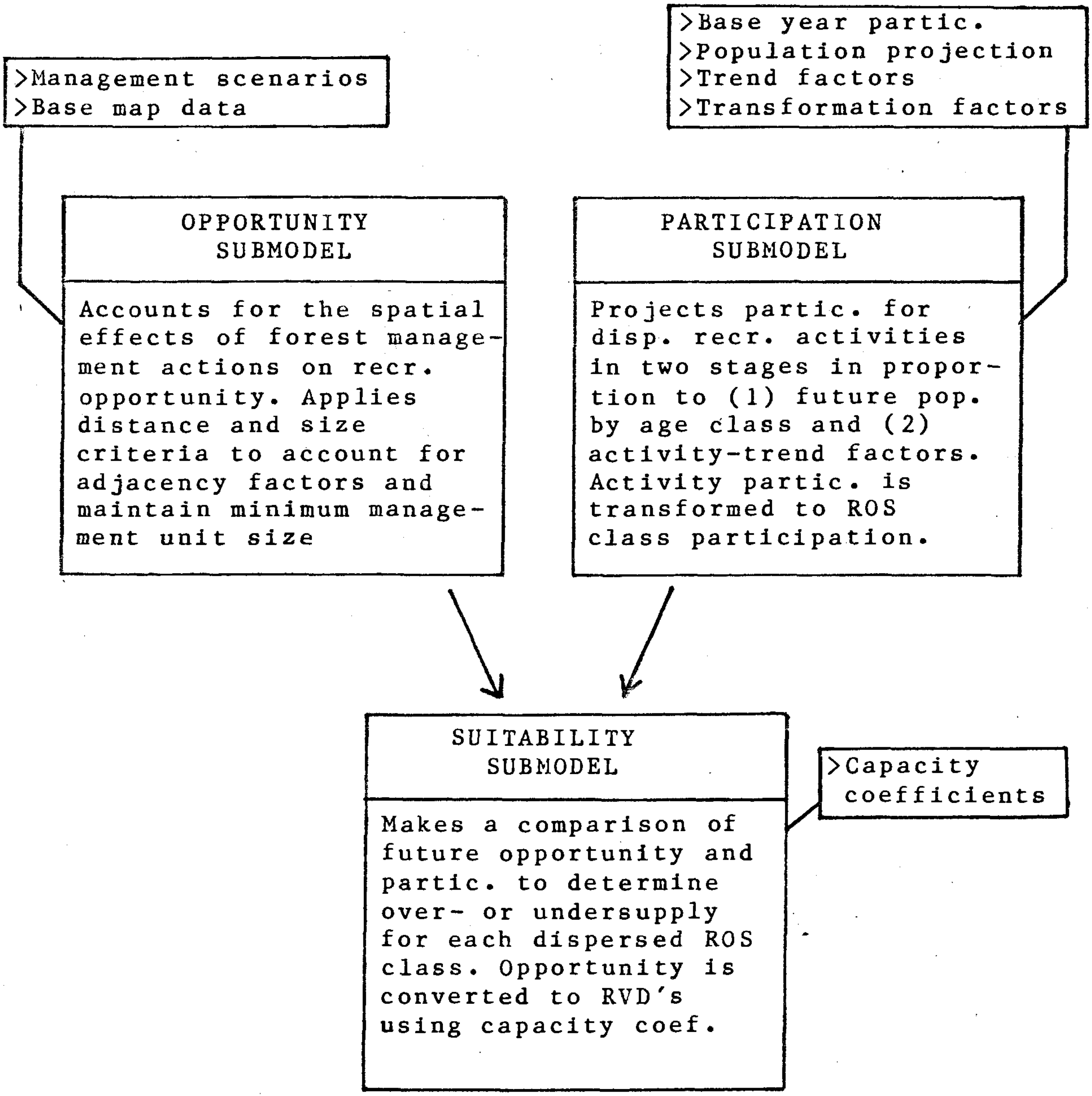


FIGURE 4

FLOW DIAGRAM OF OPPORTUNITY SUBMODEL

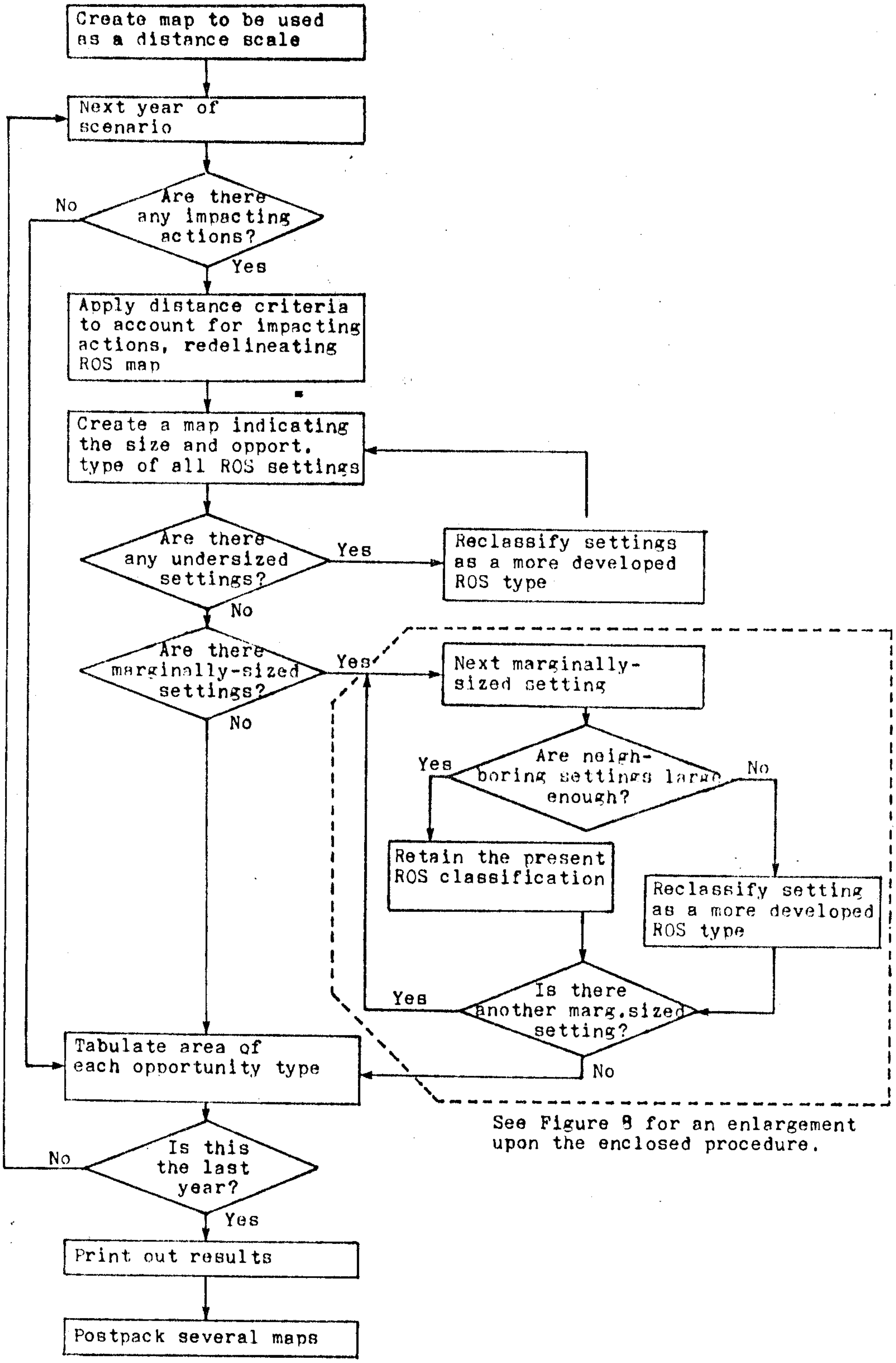


FIGURE 5
FLOW DIAGRAM OF
PARTICIPATION SUBMODEL

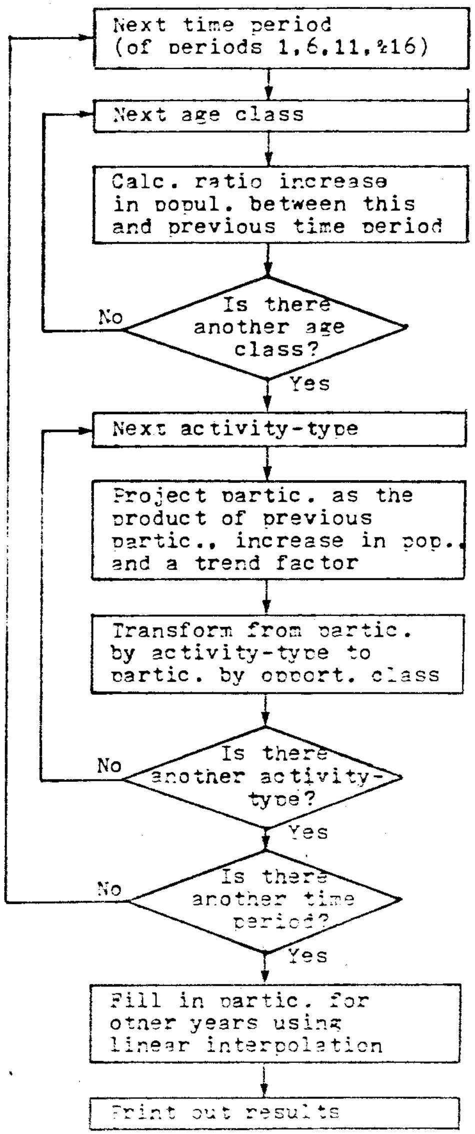
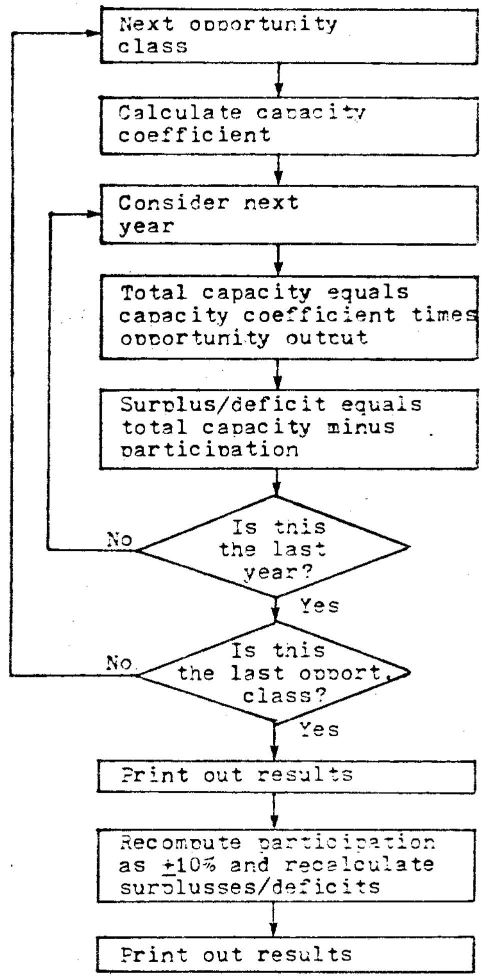


FIGURE 6
FLOW DIAGRAM OF
SUITABILITY SUBMODEL



to an operational level, so scenarios are comprised of location-specific actions. Each scenario run would proceed through RAR without user interaction, opportunity submodel first, followed by the participation submodel, and finally the suitability submodel. Interpretation of and comparison between scenario runs is done by the user.

All programming has been written by the author in FORTRAN and in the user-oriented language of the Map Analysis Package (MAP), which has been developed at the Yale School of Forestry and Environmental Studies (Tomlin, 1980) (Appendix C). Programming for the participation and suitability submodels is in FORTRAN, and that for the opportunity submodel is written partly in the MAP language and partly as modifications and extensions to the base code of MAP (which is written in FORTRAN) (Appendix B). The MAP package is highly useful in cartographic modeling and forms the basis of programming for the Recreation Allocation Routine. Alterations as listed in Appendix C were made to the MAP package to more effectively model this dispersed recreation problem.

OPPORTUNITY SUBMODEL

The opportunity submodel is the most complex submodel, and also the most developed in the prototype version of RAR. It simulates the invasion, succcession, recovery process, detailing the manner in which forest management actions effect three classes of dispersed recreation opportunity: Roaded Natural, Semi-Primitive Non-Motorized, and Primitive. As a prototype model developed for a particular study area, the model is not presently capable of accounting for the impacts upon Semi-Primitive Motorized opportunity. No attempt has been made to model winter dispersed recreation use, as winter opportunity is not in conflict with three-season opportunity and winter dispersed recreation planning has not yet been made as systematic as three-season dispersed recreation planning.

Spatial factors involved in the invasion, succession, recovery process are accounted for using cartographic modeling techniques. Cartographic modeling uses the information on maps in a systematic analysis of locational characteristics. In a computer representation of a map, the spatial content is retained as an implicit grid work of cells, so that each cell is associated with a pair of Cartesian coordinates. A grid of 20,000 cells, for example, represents 20,000 row-and-column coordinates of information, uniformly sampled across a study area.

The data base for the opportunity submodel consists of a small number of computer maps. The necessary data are organized by themes, with one theme represented on each computer map, or map layer. For example, water features are on one map layer, slope on another, ROS classification on a third. Eight map layers were used for the data base of the case study (Table 8). Thematic information associated with each grid cell is represented as a numerical code, e.g. on the ROS map layer, 1 represents Rural opportunity setting; 2 represents Roaded Natural; 3: Semi-Primitive Motorized; 4: Semi-Primitive Non-Motorized; and 5: Primitive. In a similar manner, other data base themes are encoded on map layers. Similarly, a management scenario is organized by years so that each year of a scenario is one map layer. The impacting actions for the year are simply encoded as a numerical code attached to the cells in which they occur.

The map analysis proceeds as a form of map algebra (Berry and Manfredo, 1981). Operations in this map algebra are performed on one, two, or more maps to create or update a map. Beginning with base data maps, each step in the process involves map retrieval, operation on the map, and map storage. Analogous to an algebraic process, the simulation may be viewed as a set of nested parentheticals made up of operations which alter map layers (Figure 4). The sequence of evaluation proceeds from the innermost parenthesis outwards. In this process, additional map layers are stored as modeling steps create them. At other

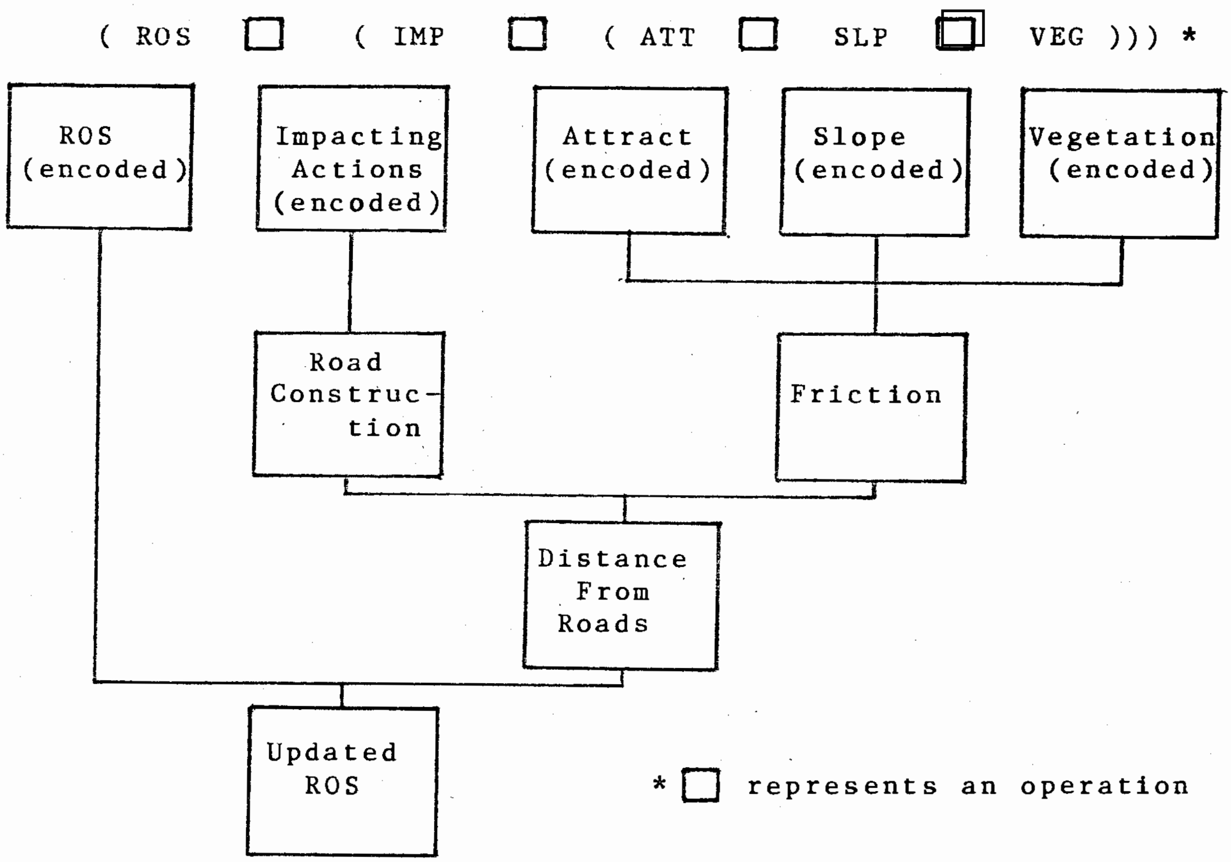
TABLE 8

MAP LAYERS COMPRISING DATA BASE
FOR OPPORTUNITY SUBMODEL

Map	Values	Categories
ROSBASE	1	Rural
	2	Roaded-Natural
	3	Semi-Primitive Motorized (not present in study)
	4	Semi-Primitive Non-Motorized
	5	Primitive
ACCESS	1	Highways
	2	Arterials
	3	Collectors
	4	Locals
	5	Primitive roads
	6	Closed roads
	7	Busy trails
	8	Trails, general
	9	High routes
OWNERSHIP	1	Skykomish Ranger District, non wilderness
	2	Skykomish Ranger District, wilderness
	3	Other National Forest land
	4	Other ownership
SLOPE	0	Flat (not present in study)
	1	Less than 35%, smooth
	2	35%-80%, intermediate
	4	50%-90%, rugged, 35-100% outcrops and talus, or a dense drainage pattern
VEGETATION	0	<20% vegetation coverage, e.g. water, rocks
	1	Low and dense, or somewhat open, e.g. meadows
	2	High and somewhat open, e.g. alpine forest
	3	High and dense, e.g. regrowth
ATTRACT	0	(not present in this study)
	1	Normal for the area
	2	Diverse
	3	Special features, e.g. campgrounds, major peaks
WATER	1	1-12 acre lake
	2	12-25 acre lake
	3	Larger lake, most of grid cell covered
	4	Larger lake, about half of grid cell covered
FEATURES	1	Major peaks

FIGURE 7

AN EXAMPLE OF MAP ALGEBRA



modeling steps, existing map layers are progressively updated. The operations which create and update maps belong to four classes: reclassification, overlaying, measurement of cartographic distances, and characterization of cartographic neighborhoods (Tomlin, 1980). In performing an operation, it is the codes of map layers which are manipulated.

Modeling scenario actions.

For each year of the scenario, the consequences of impacting actions upon dispersed recreation opportunity are calculated using map-algebra techniques. The scenario directs which map layers are to be combined using which operations. Thus, program flow depends upon the type, number, and sequence of impacting actions present in the scenario.

At the end of each year, the scenario map layer has been read (invasion), and adjacency manipulations have been made (succession), including those resulting from road closure (recovery), thereby updating the ROS map layer. The manner in which impacting actions are accounted for is critical to the validity of the model. The usefulness of modeling is in simplifying reality and yet retaining the essential aspects. Oversimplification or misconstruing the essential aspects would lead to results which are useless, if not misleading.

Each type of impacting action requires a different modeling approach (Table 9). For land exchanges, the appropriate cells are simply reclassified on the ownership map layer. Recreation capacity is affected by adding to or subtracting from the study area land base. Trail construction requires reclassification of the appropriate cells on the access map layer. Sections of busy trails crossing Primitive (PR) settings are reclassified as Semi-Primitive Non-Motorized (SPNM) to a distance of 1/2 mile to either side of the trail. (All distances given in this section

TABLE 9

SCENARIO ACTIONS AND THEIR AFFECT ON DISPERSED RECREATION OPPORTUNITY

Impacts	Effect on Opportunity *
Linear development Harvest sites	Reclassification of a corridor of land from PR to SPNM. (Could otherwise be treated as an inconsistency.)
Road construction	Reclassification to either side of the road of a 1/2 mile corridor of land to RN bordered by a 2 1/2 mile band of land reclassifiied to SPNM.
Road closure-permanent	Area is reclassified as if closed road does not exist. Usually there would be loss of RN settingh and a gain of SPNM and possibly PR settings.
Trail construction	Addition of trail to 'ACCESS' map will affect feature-dependent capacity.
Busy trail	Reclassification of a corridor of land from PR to SPNM.
Land ownership-in Land ownership-out	May effect land of any opportunity type, but the addition or loss of RN setting is more common.

* No SPM setting is present in study area.

should be understood as average noneuclidean distances, which take into account the varying resistances to transmission of impacts and to movement of recreationists; this is discussed below with respect to modeling the criteria.) Although not needed in this case study, linear developments and harvest sites similarly require reclassification of a band of land 1/4 mile to either side, such that effected PR settings are reclassified as SPNM.

In modeling the impact of road construction, two distance criteria are used. One criterion delineates a Roaded Natural (RN) classification from a Semi-Primitive Non-Motorized (SPNM) classification; the second separates a Semi-Primitive Non-Motorized classification from a Primitive (PR) classification. In a zone extending to 1/2 mile from the constructed or reopened road, cells on the ROS map layer are reclassified as RN; from 1/2 mile to 3 miles, the cells are reclassified as SPNM (any existing RN classification takes priority); beyond 3 miles from the road, cells are classified as PR (existing SPNM and RN classifications take priority).

For permanent road closures, the area is reclassified as if the permanently closed road does not exist. However, remaining roads in the vicinity of the permanently closed road do impact recreation opportunity, and must be accounted for. Cells on the ROS map layer within a zone 6 miles from the closed road are reclassified to account for open roads, linear developments, and busy trails. As a result, there is the possible outcome of fewer RN cells, or less RN opportunity. The 6 mile distance is needed for those cells within 3 miles of the closed road which might be effected by remaining roads which are up to 3 miles further away; thus the 3 mile criterion must be doubled.

Modeling the criteria.

Through application of the remoteness and size criteria, the impact of scenario actions on the recreation opportunity of adjacent lands is accounted for. Remoteness criteria are used in reclassifying the ROS map layer to account for the at-a-distance effects of impacting actions. Next, after all actions of a particular scenario year are dealt with, size criteria are applied to the resulting ROS areas. Outputs of the opportunity submodel are sensitive to the way in which the remoteness and size criteria are modelled.

A noneuclidean measure of cartographic distance is used in modeling the spatial extent of scenario impacts upon recreation opportunity. The relative resistance to movement, or 'cost', that is associated with different slopes, vegetation types, and attracting features varies from place to place. In the model, the relative 'cost' of these factors in units of distance is placed on a map called FRICTION. Thus each cell of FRICTION contains the value of the relative cost, or friction, required to move through that cell. This is a friction to the external effects of impacting actions, as well as to the movement of recreationists. By incorporating FRICTION as a distance scale, local variations in noneuclidean distance may be accounted for.

The approach taken in developing the FRICTION map was to combine the resistances of slope and vegetation and the attractions of diverse landscapes and special features. The weighted sum of the codes from the slope, vegetation, and attraction maps give the appropriate distance measurement for each cell:

[(2 x SLOPE) + VEGET - ATTRACT] x 10 = FRICTION

The friction distance has been normalized to the euclidean distance scale. In doing so, the weighted sum of the means of the codes actually present on the map layers for slope, vegetation, and attraction represents a distance of approximately .22 miles per cell, which is the average distance of travel across a cell. Thus, the mean noneuclidean unit of measure is set equal to the euclidean unit of measure, and the variation in noneuclidean measurement accounts to some degree for environmental variation.

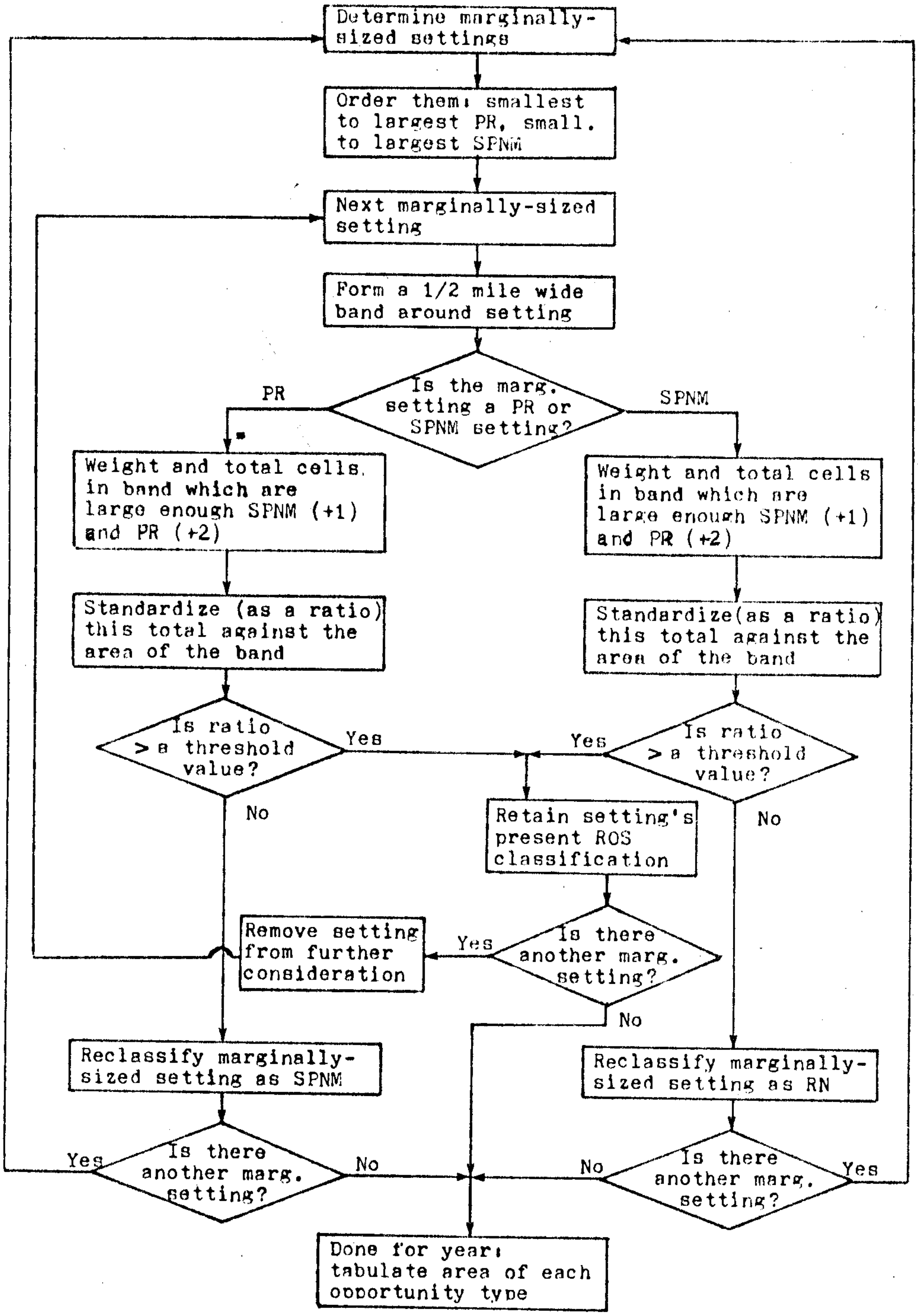
The size criteria are applied to the opportunity settings on the ROS map after applying the remoteness criteria. Any splinter areas created in applying the remoteness criteria are joined to a contiguous setting using reclassification operations. Then settings which are marginally undersized according to the size criteria are considered (Figure 8).

The neighborhood of the marginally-undersized setting needs to be characterized. Whether or not the setting is large enough depends on the type and size of neighboring opportunity settings. The neighboring settings may be of a type and size which would sufficiently complement the recreationist's perception of an expansive backcountry environment.

The factor of 10 produces the magnitude appropriate for the necessary MAP command.

FIGURE 8

PROCEDURE TO HANDLE
MARGINALLY-SIZED SETTINGS *



*See Figure 4 for the placement of this procedure within opportunity submodel.

The approach taken in modeling this fairly subjective matter is to weight the codes for ROS type and setting size of those grid cells within 1/2 mile of the marginally-sized setting by their ROS type and setting size. For a marginally sized SPNM setting for example, a neighboring cell belonging to a large Primitive setting is given a high (plus) weighting and a cell belonging to a Roaded Natural setting is given a low (minus) weighting. The weighted sum of such codes is divided by the number of cells in the band to yield a ratio independent of the size of the band surrounding the setting in question. The resulting ratio must be greater than a standard ratio for the setting to be considered large enough.

The order in which the size criteria are applied to undersized and marginally-sized settings is important, since reclassifying the ROS class of a setting might effect the subsequent testing of another setting. The undersized and marginally sized settings are considered in an order that minimizes the number of modeling steps required.

The evidence of humans criteria are not considered due to the insignificant degree of impact which has resulted from past mining operations, settlements, and other miscellaneous developments in the study area, and the close association of harvest sites with roads. Similar conditions are probably widespread throughout the West, where development is yet expanding into the forests.

Submodel programming and structure.

The necessary cartographic modeling is programmed using a modified version of the Map Analysis Package (MAP). MAP is a general, adaptive computer package designed to be used in a variety of applications suited to cartographic modeling. Thus, MAP is structured as a number of commands written in a user-oriented language which directs how operations are to be performed on user-supplied maps. The user simulates his problem by determining the appropriate sequence of commands, i.e. by programming in the MAP language.

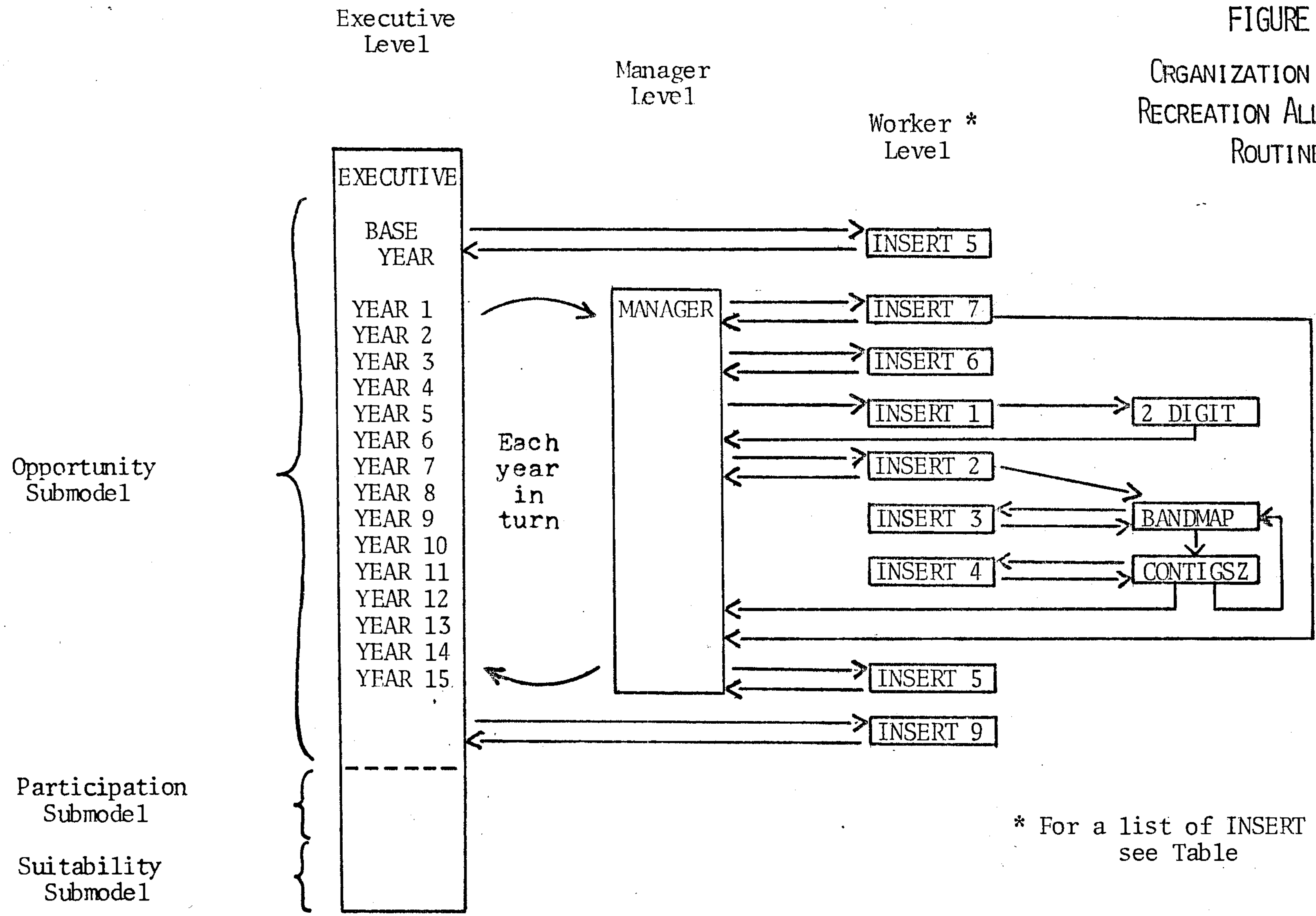
In turn, the Map Analysis Package is written in FORTRAN. In developing the Recreation Allocation Routine, modifications were made to the FORTRAN programming of the MAP program to suit this modeling problem. This was primarily done using a provision of the Map Analysis Package for the addition of user-defined operations which are addressed with the INSERT command.

In structure, the opportunity submodel is conceptually organized into three levels: executive, managerial, and worker (Figure 5). The three levels interact with each other in a hierarchical fashion as alluded to by the choice of names for each level. This analogue has a tangible basis in Recreation Allocation Routine programming, which is organized into files attached to different input-output (IO) units.

At the executive level, preliminary work is performed such as reading in the data base and scenario maps, creating a few

FIGURE 9

ORGANIZATION OF THE RECREATION ALLOCATION ROUTINE



* For a list of INSERT functions see Table

maps which are used repeatedly as parameters, and tabulating base year data. The executive level primarily directs the year to year flow of scenario maps to the managerial level, and performs final tabulations at the end of the scenario.

At the managerial level, the necessary directing within each modelled year is performed to account for the impact of scenario actions. Program flow is directed to the worker level to perform reclassification operations and apply the remoteness and size criteria in proper sequence. Both the executive and managerial levels are written entirely in the MAP command language, with the programming placed in files named EXEC and MANAGER (IO unit 10), respectively.

The worker level consists of a number of separate working units. Some working units at the worker level are written as subroutines using the MAP language which are placed in files named: DIGIT2 (IO unit 11), BANDMAP (IO unit 14), and CONTIGSZ (IO unit 15). Other working units are written in FORTRAN and then addressed using the INSERT operation of the Map Analysis Package. Nine different INSERT commands were programmed in FORTRAN by the author specifically for the Recreation Allocation Routine.

The INSERT operation performs essential functions in the Recreation Allocation Routine (Table 10). All branching of program flow occurs while executing an INSERT command. This is because the MAP language has no commands such as 'if statements' which branch program flow as a result of intermediate outcomes.

TABLE 10

FUNCTION OF THE 'INSERT' WORKING UNITS

INSERT 1:	Tests for existence of undersized areas.
INSERT 2:	Tests for existence of marginally-sized areas.
INSERT 3:	Marginally-sized areas are ordered in a hierarchy and dispensed one at a time to INSERT 4.
INSERT 4:	Determines whether a particular undersized area is large enough due to neighborhood conditions.
INSERT 5:	Stores the output of the opportunity submodel for each year.
INSERT 6:	Resets variables and a map in preparation for the next year.
INSERT 7:	Distance criteria are applied to update ROSBASE as appropriate for the impacting actions of the scenario year. Others maps are appropriately updated.
INSERT 8:	Feature-dependent carrying capacity is determined in units of RVD's. Results are put into a file and attached to an IO unit.
INSERT 9:	Postpacks a map in run length encoded format appropriate for use in a later run of MAP.

When MAP is used in an interactive mode, the user makes such intermediate decisions. RAR is written to be used in a batch mode, i.e. without user interaction during a run, thus affording substantial reductions in run costs and faster run times, while making the user's task easier. Therefore, internal decisions are made using FORTRAN statements which test for certain conditions while executing an INSERT command.

Certain working units addressed with the INSERT operation determine the next series of MAP commands to be executed, i.e.

how maps are to be altered. These MAP commands are passed from the FORTRAN programming to the executive and managerial levels for execution by using a go-between file, GOPHER (IO unit 17). Other working units store information off of maps and into arrays for later use in the suitability submodel.

The input data in encoded form and the MAP commands needed to store these data as maps are contained in files named MDATA (IO unit 8) and SCEN.D or SCEN.P (IO unit 12). There are three additional files attached to IO units for output data: ROAREAS (IO unit 18), FDDATA (IO unit 19), and FDCAP (IO unit 13).

In a run of the RAR routine, program flow begins at the executive level (EXEC). Run statements enable the MAP package and assign IO units. Execution of the first MAP commands store the encoded data base (MDATA) and a scenario of impacting actions (in this case either SCEN.D or SCEN.P) as computer maps. Using INSERT 5, base year outputs of opportunity in numbers of cells of each ROS class are stored in a FORTRAN array. Then each time step of the simulation is considered in turn, with the impacting actions for the year first being transferred to a map (WKMGTACT).

Control then moves to the managerial level (MANAGER). MANAGER first directs the program flow to INSERT 7, which checks WKMGTACT to see if there are any impacting actions for the year. If not, a number of records in MANAGER are skipped so that the outputs for the year are recorded (the same as the previous year), and control is then passed to EXEC to continue with the next time step. If there are impacting actions for the current time step, a sequence of MAP commands are stored in GOPHER which account for the effect of impacting actions by applying distance criteria and updating maps. When control returns to MANAGER, GOPHER is read to execute these operations.

As directed from MANAGER, the sizing procedure is then begun. INSERT 6 simply resets three flags used in subsequent programming. The program flow moves to DIGIT2 which is a file of MAP commands used to create a map of recreation opportunity (RO) settings represented as two-digit codes: the first digit indicates the RO class and the second digit indicates the size. Then, undersized RO settings must be reclassified and marginally-sized RO settings must have the character of their surrounding settings tested, in order to complete the sizing procedure.

Undersized settings are passed to INSERT 1 on a map. These settings are reclassified so that their RO classification is that of an appropriate neighboring setting. This requires two stages, therefore a second pass is made through the commands in DIGIT2 and INSERT 1.

Next marginally-sized RO settings are passed to INSERT 2 on a map. If there are no marginally-sized settings, the sizing procedure is complete and the year-end outputs are stored. In that case, control is passed back to EXEC to contiuue with the next time step. If there are marginally-sized settings, a procedure is started which considers the size and type of neighboring RO settings (Figure 8).

In this procedure, MAP commands, which are passed from INSERT 2 to MANAGER, create a map of four-digit codes uniquely identifying the marginally-sized settings. Then, INSERT 3 is used to order the marginally-sized settings for consideration one at a time. They are considered in a specific order to minimize the redundant use of programming and computing time: smallest to largest PR settings, followed by smallest to largest SPNM settings.

Next, a series of MAP commands are returned to BANDMAP from INSERT 3 via GOPHER. These commands create a map comprised of a band of cells surrounding the marginally-sized setting. The codes in this band identify the size and type of neighboring RO settings.

The information on this map is used in INSERT 4 to derive a coefficient which is subsequently compared to a standard (BRATIO), thereby indicating whether the marginally-sized setting is large enough. If it is large enough, the ROS classification does not change. If it is not large enough, MAP commands which reclassify the setting are passed from INSERT 4 to CONTIGSZ to be executed. Either way, the procedure is repeated for the next marginally-sized setting in queue by first returning to INSERT 3 in order to create a new map of surrounding cells. Once all the marginally-sized settings are checked, the sizing procedure is complete and control is returned to MANAGER.

At this stage, the accounting for the effects of impacting actions for the scenario year is complete. The outputs for the year are stored in an array using INSERT 5. Control is then passed from MANAGER to EXEC in order to get the impacting actions for the next year, which are considered in a similar course of program flow.

After the last year of the scenario is simulated, the run of the opportunity submodel is complete except for a few concluding tasks. Certain maps are postpacked in run-length encoded form using INSERT 9 for later plotting and for use in a subsequent run of the program which calculates feature-dependent capacities. These postpacked maps are stored in FDDATA. The size-dependent outputs are stored in ROAREAS. Throughout the run, line-printer displays of maps are made. At the end of the run, a map (ROSCHANGE) is displayed of those cells which are different in ROS classification from the base year. The first digit of the codes on the map give the ROS classification at scenario's end and the second digit indicates the base year ROS classification.

Programming in the opportunity submodel of the RAR routine has been based in part on developmental programming done by Berry (1979). The approaches of forming two-digit maps for use in sizing RO settings and of applying distance criteria using MAP commands are taken from Berry. As extentions to this programming for the present operational case study, marginally-sized areas are dealt with and, as a minor point, noneuclidean distance is measured using the FRICTION map. Furthermore, objectives in this study have been to model dynamic scenarios of impacting actions in a program to be used in batch mode, while Berry modelled a static ROS delineation which is dependent on user-intervention.

<u>Outputs of recreation opportunity.</u>

The opportunity submodel determines outputs of dispersed recreation opportunity in two ways: by the size of the opportunity settings of each class, and by the recreation-dependent features within opportunity settings of each class. That is, outputs of recreation opportunity for each opportunity class are either in acres, or in numbers of lakes and mountain peaks, miles of roads and trails, etc. Presently, size outputs are tabulated for each year, while feature-dependent outputs are calculated at the end of the scenario run only. In both cases, only the opportunity within the study area proper is tabulated (Skykomish Ranger District in this study), i.e. lands under other jurisdictions are excluded. By overlaying the ROS map with the ownership map at the end of each scenario year, the result is the ROS classification of only those cells in the study area proper.

With the size-dependent approach, the number of cells of each opportunity type is totalled and stored in an array, at the end of each year. Thus at the end of the scenario run, the array of opportunity outputs contains data for all scenario years. These are the data used by the suitability submodel. For the feature-dependent approach, the necessary data are on maps which must be postpacked using an INSERT operation. These postpacked maps are utilized by another program to determine feature-dependent capacity (see section IV.C below).

PARTICIPATION SUBMODEL

The participation submodel projects future dispersed recreation participation for thestudy area. Because the participation submodel is largely autonomous to the other submodels, user-preferred projections could be substituted. The approach discussed below has been used in the prototype RAR model. The input needed includes: base-year activity participation disaggregated by age class; projected population figures by age class; relative growth factors for each activity type; and coefficients to transform participation by activity type to participation by opportunity class. The output needed from the participation submodel is the number of participants in each opportunity class, for each year; these are input data to the suitability submodel. The approach used starts with base year participation data per activity type (such as U.S.Forest Service RIM data), projects this participation per activity into the future and finally transforms the data to participation by opportunity class.

Base year participation is projected in two stages: first to account for population increases, and then, to adjust for differences in relative growth among activities. For each activity, participation by age class is adjusted by the proportion of population increase for the appropriate age class. This is done for every fifth year only (subsequently figures for intermediate years are interpolated), because population projections are usually tabulated at 5 year intervals at best. These first stage projections are adjusted by relative growth factors, yielding activity-participation projections by age class. Each activity has previously been assigned one of three categories of participation growth relative to the base year participation: stable (0% increase in each 5 years), moderate (5.7% increase in each 5 years), or fast (12.5% increase in each 5 years). When age class figures are totalled for each year, the result is the projected participation in the activity for every fifth year.

Next, the activity participation figure is broken down as to opportunity classes. For example, it might be the case that 60% of the dispersed camping activity occurs in Roaded Natural settings, 20% occurs in Semi-Primitive Non-Motorized, and 20% occurs in Primitive settings. In that case, the transformation factors which disaggregate the camping participation would be: .6 (RN), .2 (SPNM), and .2 (PR). These steps of projection and transformation are repeated for each activity.

Then, for each opportunity class, the number of participants in all activities is totalled. For example, the number of RN camping participants plus the number of RN fishermen plus the number of RN motorcyclists, and so forth, gives the total RN participation. Finally, the participation in years other than every fifth year is interpolated linearly. This projection is used as a standard against which to compare outputs of all scenario runs.

The programming for the participation submodel is written in FORTRAN.

SUITABILITY SUBMODEL

In the suitability submodel, the results of the other submodels are combined, thus providing the forest manager with information as to the deficits and surplusses of future recreation opportunity. Data from the opportunity submodel must first be converted to RVD's of capacity using capacity coefficients which are input to the suitability submodel. The capacity is then compared with the projected participation, for each dispersed recreation opportunity class for each year.

Two approaches to calculating the capacity of the available opportunity have been programmed: (1) size dependent, and (2) feature dependent. In the first approach, the number of acres in each opportunity class is multiplied by capacity coefficients to yield the yearly capacity. In the second approach, since each recreation feature (lake, trail, road, etc.) has a different capacity associated with it, the amount of each feature-type is multiplied by the appropriate capacity coefficients. Using the feature-dependent approach, only the capacities at the end of a scenario run are determined. This method is included in order to demonstrate its implementation and to compare the results with the size-dependent approach, since it is in an early stage of development by staff at Mt. Baker - Snoqualmie National Forest.

Programming for the size-dependent approach is written in FORTRAN. The input data from the opportunity submodel are the number of cells of each opportunity class for each year. These figures are converted to acres. Then the numbers of acres are converted to capacity figures in numbers of participants (RVD's) using the appropriate PAOT/acre coefficients adjusted for seasonal factors, i.e.

RVD's = SIZE x PAOT x MS x PU x LOS/12.

Capacity is then compared to projected participation by subtracting the first figure from the latter, since both are given in RVD's per opportunity class per year. Net surplusses and net deficits are printed out for each opportunity class and year. As well, the total net surplus and total net deficit of all years are printed out by opportunity class. A similar

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PAOT : persons-at-one-time; MS : length in days of managed season; PU : weekday, weekend pattern-of-use; LOS : length-of-stay in hours. All of these coefficients are used in U.S. Forest Service planning (USDA, 1980c).

comparison of capacity is made against participation projections which are 10% greater and 10% less than the initial participation figures. Thus providing the surplusses and deficits of capacity for a range of use estimates.

In the feature-dependent approach, each recreational feature must be specified as to the ROS class it is situated within. The necessary information for the location of features is on the computer maps existing at the end of a scenario run. These maps are postpacked into encoded form for an ensuing run through a program which determines the ROS association and the resulting capacity. This program is written partly in the MAP language, and partly as an INSERT operation written in FORTRAN.

The relevant recreational features are on map layers which are overlain with the recreation opportunity settings of the study area to create a map of multi-digit codes. These codes are enumerated properly in an INSERT routine, giving the total number of each designated feature type per ROS class. The totals are multiplied by PAOT and seasonal adjustment coefficients, thus converting the numbers of features to RVD's of capacity for each feature type in an opportunity class. Totaling the feature-specific capacities of each opportunity class, then gives the total capacity per opportunity class. The feature types and capacity coefficients are those developed by Fessel and Frankenstein (1981). This may then be compared by the manager to the projected participation in a manner similar to that used for the size-dependent approach.

Using either approach, runs of different scenarios will give different results, which the manager may analyze. These figures may be graphed for visual analysis or otherwise compared by the forest manager. No comparison among opportunity classes is made of the surplus and deficit figures since making tradeoffs between opportunity classes requires human judgement.

The Recreation Allocation Routine has been implemented on an IBM 4341 at Simon Fraser University, using the Michigan Terminal System (MTS) as a system language. The program could readily be implemented on many systems, as the Map Analysis Package has been widely and successfully distributed to installations utilizing a diversity of computing environments.

CHAPTER V

SKYKOMISH CASE STUDY

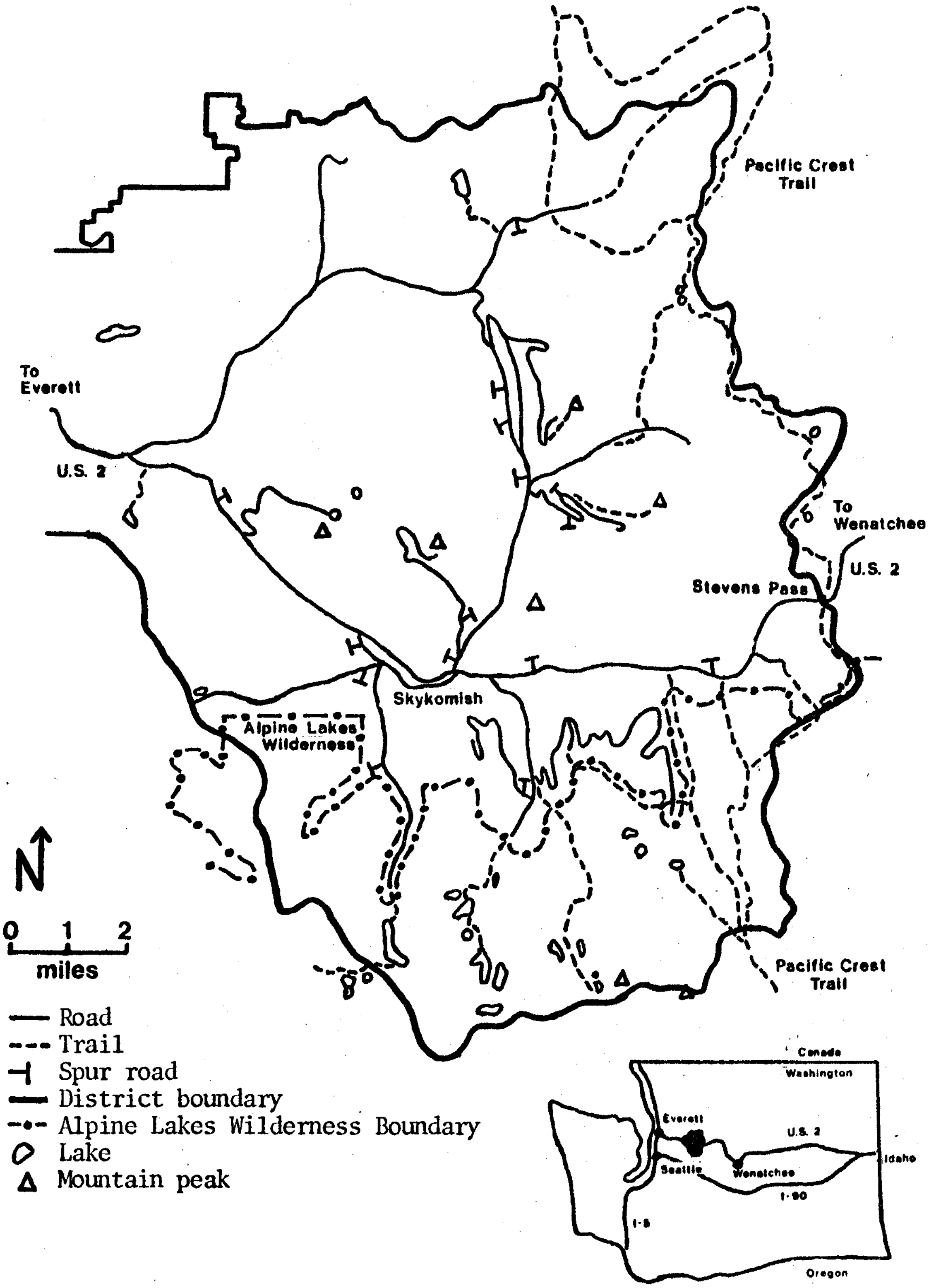
CASE STUDY AREA

The Skykomish Ranger District was selected as a case study area (Figure 6). The case study area provided a more concrete framework in which to develop the Recreation Allocation Routine by providing the base data and scenario data with which to run and test the model in a 'real life' situation. The study area selected, Skykomish Ranger District is in Mt.Baker - Snoqualmie National Forest abutting the west side of the Pacific Crest of the Cascade Mountains in Washington State. The area offers many interesting features for this study:

1. Both valuable timber and high recreational use are present;
2. A good representation of recreation opportunity types exist (except for Semi-Primitive Motorized), including sizeable settings of Primitive opportunity;
3. Several unique recreation planning studies have been done in the area;
4. A major planning decision is impending which forms the basis of the two scenarios;
5. The size of the area is appropriate for a prototype model;
6. There is an interspersed ownership pattern, adding a

FIGURE 10

BASE MAP OF SKYKOMISH RANGER DISTRICT



dimension of complexity;

7. The area is in proximity to the author's university campus.

For the many recreationists in the Seattle area, the District is less than two hours drive along federal highways. The Pacific Crest Trail weaves back and forth across the east border of the District, and a southern fifth of the District is comprised of the Alpine Lakes Wilderness area. Large numbers of recreationists are attracted to the dramatically glaciated landscape, the emerald clear rivers and streams, the hundreds of miles of roads suitable for passenger cars, several day-hikes to vantage points up and down the Cascade Range, as well as many points of access to the Pacific Crest Trail and the numerous lakes of the Alpine Lakes Wilderness.

With mild temperatures and ample rainfall, Skykomish Ranger District also encompasses lands with some of the most productive timber growth rates in North America. Skykomish Ranger District is approximately 305,000 acres in size, one third of which is capable and suitable for timber and two thirds of which is rock and ice. About 60,000 acres (20 per cent) is presently managed for timber, with about half of that as potential for intensive harvesting and half requiring special consideration for streamside and wildlife habitat management. Although there is little current mining activity, the area has good mining potential, with the degree of future activity depending largely on the metals market and government policies. Any mining would be underground, not open-pit operations.

In delimiting the study area, the Sultan Basin has been removed from consideration. Sultan Basin is a detached portion of the Ranger District to the northwest which is mostly a setting for developed (not dispersed) recreation, and which eventually will be traded out in land exchanges.

DEVELOPMENT AND PRESERVATION MANAGEMENT SCENARIOS

The scenarios of future management actions were designed to reflect a land allocation dilemma that Skykomish Ranger District is faced with. Along the west side of the Pacific Crest stretches an expanse of land which is currently roadless and accessible to weekend backpackers from the Seattle metropolitan area. This same land is also highly productive timber land. Much of this is included in the RARE II process and is therefore presently unavailable for timber harvesting. While the average harvest rate has ranged around 500 acres per year for the Ranger District, if the roadless status of this area were preserved, the sustained annual cut would drop to around 200 acres per year. About 60% of the timber volume for the District is on RARE II lands.

If these lands are released by a Congressional decision, the authorization for deciding their allocation becomes the Multiple Use Planning process of the Ranger District, which directs that a detailed forest planning process be completed. Thus, if released as RARE II lands, the status (for development or preservation) of any of these roadless areas would not be 'resolved' until a Forest Plan is completed under the Land Management Planning process. The Forest Plan for Mt.Baker - Snoqualmie National Forest is scheduled for completion in 1983. Plan implementation could then be further delayed if the issue is taken to the courts.

Of the two scenarios modelled in prototype runs of RAR, one reflects the realistic outcome for dispersed recreation if development of timber haul roads into these roadless areas proceeds. The second is a preservation scenario with little road development and much reduced harvesting, but the same land exchanges and future busy trails. Management actions taken on lands neighboring Skykomish Ranger District were not included, implying that the amount of available primitive opportunity probably is a high estimate.

First, the two scenarios were developed in a general verbal form from consideration of present trends in forest management and forest use. The basis for the scenarios was outlined in consultation with James Bartelme (1981a), Acting Chief Ranger of Skykomish Ranger District. From these, modelled scenarios of site-specific actions were developed. Of the eight types of actions impacting dispersed recreation opportunity which the model is programmed to deal with, the scenarios as modelled include only four: road construction, permanent road closure,

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Scheduled timber sales over the first five years were checked for the Ranger Districts to the north and south of Skykomish Ranger District, and indicated no management actions that would effect Skykomish Ranger District.

trails which become heavily used, and land exchanged-in. Then each year of the scenario was encoded as a map layer. Both scenarios are fifteen years in time, running from 1981 to 1995, with 1980 taken as the base year. Descriptions of the scenarios are given here.

Both scenarios include the same schedule of land exchanges and busy trails. Furthermore, the first six years of both scenarios include the same schedule of timber harvesting and road construction, thus reflecting the outcome of factors currently unfolding. The current economic slowdown effects the rate of timber harvesting on sale sites. The effect of either the development or preservation of the RARE II lands becomes significant in 1987.

Land exchange programs reflect an ongoing process of ownership consolidation with many exchanges currently scheduled to occur over the next 10 years. Land exchanges will result in the net addition of thousands of acres to Skykomish Ranger District over the scenario time horizon. Much of this land is property of the State of Washington exchanged for U.S.Forest Service land in other Ranger Districts. The consolidation of ownership is continued in the scenarios for another five years.

It is inevitable that some hiking trails will become much more heavily used in the next 15 years, given preliminary runs of the participation submodel. Three trails which presently cross Primitive settings were selected as likely to become busy enough to necessitate reclassification on abutting land: one in

1990 which accesses the Pacific Crest Trail, another leads to a basin with numerous lakes in the Alpine Lakes Wilderness Area (1992), and the third follows a creek up to a vista-filled mountain ridge (1995)(Bartelme, 1981b).

Only one road closure is scheduled in the modelled scenarios. In the fourth year of the preservation scenario, a section of road which accesses the area currently under RARE II consideration is permanently closed. In doing so, the primitive settings in the area are extended.

In developing the scenarios, a schedule of future harvests has been worked out in order to justify using roads as surrogates for the spatial impact of harvest sites, and to guide in the scheduling of road construction. The sites of previous sales were checked to assure their proximity to roads. The schedule of harvest sales and road construction contained in the 1981-85 Timber Action Plan (USDA, 1980d) was the basis for scheduling harvest sites through 1987. There is customarily a two year delay from sale date to the time of harvesting (the contractee normally has up to five years before defaulting). The current economic slowdown has meant that many timber companies which buy contracts to harvest timber are delaying harvesting in hopes that market conditions will improve. In 1980, the harvest was about 15% of the average of the ten previous years. Thus, the necessity for harvesting in new drainages has been delayed somewhat. The economic slowdown is assumed to slowly turn around in 1982 through 1985.

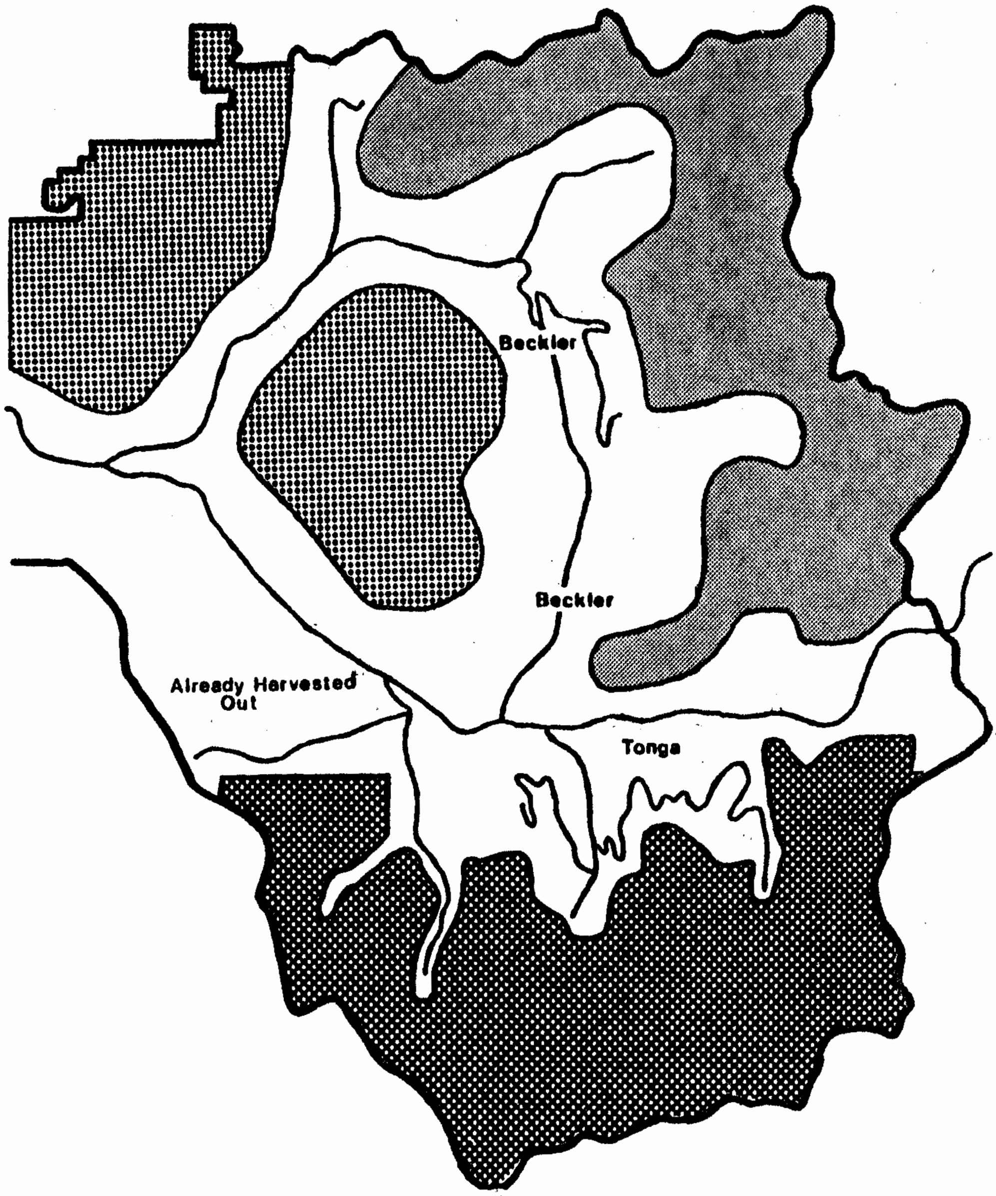
Through the first half of both scenarios, harvesting occurs predominantly in two centrally located areas of the Ranger District: the valley slopes along the Beckler River and in the vicinity of Tonga Ridge. Small amounts of harvesting do occur along the margins of other road system, in addition. In this first seven years, harvesting fills out already existing harvest areas with no significant road construction or other intrusion into roadless areas. Therefore, the spatial impact of the first few years harvesting on recreation opportunity does not extend further than the impact of the existing roads.

For the most part, what is left are two large, but uneconomical, areas to the north and west, the Wilderness Area to the south, an area already heavily harvested in to the southwest, and the RARE II lands to the east and northeast (Figure 7). In other words, there are no major areas that can be moved into that are not in the RARE II process. The Beckler and Tonga areas start becoming depleted around 1987. Beginning in 1987, the two scenarios diverge.

Under the development scenario, the roadless drainages to the east and northeast are opened up to development in 1984. Thus timber sales for 1985 and beyond are affected, with a two year time lag before any harvesting in these areas begins. From 1987 to 1991, there is a transition from the old harvest areas to the new areas, with all harvesting occurring in the new areas beyond 1991. The uneconomical areas are never harvested in.

FIGURE 11

AREAS OF PRODUCTIVE TIMBERLAND



Economical Roadless Area

Uneconomical Roadless Area

Alpine Lakes Wilderness Area

Three major road construction projects open up drainages to harvesting in the roadless area. In doing so, three of the four major drainages in the area are opened up. Two roads are constructed in 1989 and one in 1990. Three other road construction projects also occuring about this time in other areas have less impact upon recreation opportunity.

The pattern of harvesting and road construction is characteristic of the way roadless drainages are opened up to timber harvesting. The main roads are constructed to their full length at the time the first couple sales in each drainage are to be harvested. The first harvest sites are widely dispersed along the new road. In successive years, harvesting fills in sites within a 1/2 mile corridor of the road. A couple spur roads are added to the main roads as needed to reach suitable sites close by.

In the last years of the scenario, there is continued in-filling of harvest sites and one spur road is constructed. In addition, a few hundred acres of land are exchanged into the Ranger District, and two trails become heavily used.

Under the preservation scenario, the Mt.Baker - Snoqualmie Forest Plan would dictate that the roadless drainages to the east and northeast are to be preserved as roadless. In response, the Forest Service permanently closes a road accessing one of the major drainages into the roadless area, a road which is extended several miles in the development scenario. The Forest

Service has already contracted for harvesting which occurs in other areas until 1987. After 1986, the annual timber cut drops dramatically over the next three years to 200 acres per year, in order to fall within sustained yield limits on a markedly reduced and less productive timber land base. The timber productivity of these roadless areas had been included in calculations for the sustained timber yield of Skykomish Ranger District.

Thus, harvesting throughout the Ranger District winds down, especially in the recently productive areas of Beckler and Tonga. During the transition period, one road is constructed earlier than in the development scenario in order to partly compensate for the foregone harvesting. The lengths of two proposed roads are shortened to avoid intrusion onto former RARE II lands. The three major roads opening drainage basins under the development scenario are not constructed. From 1990 to 1995, there is no road costruction, since the harvesting at reduced levels remains associated with existing roads.

In 1989, the northeast corner of the Ranger District (about 15,000 acres) is to receive Congressional designation as a Wilderness Area. This effects the calculation of recreation capacity using the feature-dependent approach, but not with the size-dependent approach.

The primary difference in these two scenarios is the amount of road construction. In the development scenario, three major road segments are constructed into the roadless area situated along the Pacific Crest Trail. In the preservation scenario, these roads are not constructed, and one major approach road is permanently closed.

OPPORTUNITY DATA

In addition to the scenarios discussed above, the data base for the opportunity submodel consists of computer encoded maps (Appendix D). These maps are used as map layers for the cartographic modeling. To establish this data base, questions had to be addressed concerning the map coverage and resolution, the number of map themes and codes on individual maps, sources of data for the map layers, method of encoding, and storage requirements.

Coverage of the area must provide sufficient buffering beyond the study area boundaries to properly 'size' the area of those settings which extend across the boundaries, and to account for the spatial impact of actions in neighboring jurisdictions (if this is done). The requirement of bounding Skykomish Ranger District in this way resulted in a map representing an area 26 miles by 33 miles.

In turn, the total area is broken down into numerous subareas which are grid cells, in the way that a checkerboard is covered with smaller squares. The size of gridcells represents a tradeoff between finer resolution which necessitates a greater number of cells, and the slower data encoding time and computer run time required for a greater number of cells. The minimum resolution in this application must be adequate to account for the 1/2 mile distance criterion, which was deemed the most sensitive spatial measurement needed. The resolution is greater than the unit of measurement (the size of one cell), since a specific ground feature could be located anywhere within a cell. In fact, resolution is theoretically limited to about 2.15 times the cell size, and therefore the cell should be no greater than .23 miles in a linear dimension (.23 miles by 2.15 = .5 miles). The model uses 25 cells to the square mile, or 5 cells to the linear mile, which are .2 miles on a side. (A cell then represents 25.6 acres of forest land.)

Given this cell size, the total area is broken down into 130 columns (26 miles by 5 cells/mile) by 165 rows (33 miles by 5 cells/mile). Thus, locations on each map layer (as a gridwork of cells) may be referenced by their column-row position. With the above cell size, each map layer is comprised of 21,450 cells (130 columns by 165 rows). Another way of thinking about this is that each thematic map consists of 21,450 points uniformly sampled across the study area.

There are eight map layers in the data base (Table 8). Two of these, the feature and water map layers, are only used with the feature-dependent approach of determining capacity. Each map theme has 1 to 9 codes associated with it. A grid cell identified with a coded attribute has that code stored in the computer for the correct column and row position. All codes used identify the presense of a particular attribute in the associated grid cell. In addition, the codes on the three map layers which comprise the FRICTION map are used as weights, i.e. the slope, vegetation, and attraction map layers.

Except for the slope, vegetation, and attraction map layers, data for the map layers were taken from U.S.Forest Service maps for Mt.Baker - Snoqualmie National Forest, at a scale of 1/2 inch to the mile. U.S. Forest Service line-printer, computer printouts (at a scale of 1 inch to the mile) were used for the data needed for slope, vegetation, and attraction. The Forest Service has encoded the latter information in computer format for use with FORPLAN. For the vegetation map layer, U.S.F.S. codes for size class and vegetation type required reformatting to fewer codes using simple aggregation. Information on the attraction map layer for special features was added to the computer map for locations with campgrounds, major peaks, and sites that are identified on the public distribution maps of the National Forest as special interest points, such as waterfalls.

In operation, the Recreation Allocation Routine requires storage for 30 map layers, or 30 x 21,450 two-byte integers. Some additional storage is needed for the map names and categories on each map, as well as the object code. Much less space is needed for permanent storage as there are only the eight map layers of the data base which furthermore are prepacked in a condensed form.

PARTICIPATION DATA

Implementing the participation projection required that many diverse sources of information be combined, i.e. various base data were combined to form the input data to the submodel, which includes: base year participation by age class; projected population by age class; trend factors; and transformation coefficients (Appendix E). Recreation participation data for the study area, compiled by activity-types, were taken from the U.S. Forest Service Recreation Information Method (RIM) survey. The projection is based on diverse sources of data for population, age, destination substitution, and activity preference shifts. These data came from sources outside the U.S.F.S. Finally, projected participation by activity is transformed to participation by opportunity class using Skykomish Ranger District information. Reference should be made to section III.C above to adequately comprehend the function of the types of data which follow.

Since the data inventories and surveys were not designed for this study, reaggregations and transformations were undertaken to reformat the data. An initial restructuring of activity data and the final transformation to participation by opportunity class have been similarly applied in previous Forest Service work, notably in developing the final environmental impact statement for the Land Management Plan for Alpine Lakes

Basin (USDA, 1980e), which is partly in Skykomish Ranger District. Other mid-stage reaggregations are more unique to this approach of projecting causal factors of recreation participation. (The Alpine Lakes Basin study projected participation by linear extrapolation.)

Skykomish Ranger District surveys of dispersed recreation participation are based on electronically-recorded vehicle counts supplemented by spot samplings performed by Ranger District personnel. The information is tabulated in the U.S.F.S.RIM system (in RVD's) by broad activity type, and crosstabulated as to resource types. For this study, RIM data for 15 activity-types (30 subactivities) were used, which excluded activities for developed recreation and winter dispersed recreation. Participation in the Sultan Basin, which was excluded from the study area, was subtracted out after being identified as the only reservoir-related recreation participation in Skykomish Ranger District. Although the accuracy of the data may be questioned, it is the best available for the purpose and is the basis of Forest Service recreation demand projections. A linear regression on this RIM data for 3 years (1978-1980) was performed to yield base year (1980) data, thereby smoothing yearly fluctuations somewhat.

Base year participation by RIM activities was reaggregated to 20 dispersed recreation activity-types better suited for the subsequent projection and transformation. This was done in

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U.S.F.S. is restricted in data collection by the Office of Budget and Management, so as to not intrude on recreationists.

consultation with a Recreation Planner at the Supervisor's Office (Seattle), as guided by the definitions of activities contained in the RIM code book.

In the next stage, the figures were disaggregated by age class. Data were used from the State of Washington SCORP report (State of Washington, 1979) which give recreation participation by age class for the whole of Washington. For each activity, the participation in a particular age class represents a fraction of the total participation for that activity. This fraction was used as a coefficient in factoring the RIM-derived figures as to age class. It was assumed that the data were comparable given some differences in activity definitions, units of measurement, and jurisdictions included.

These input data for each activity's participation by age class were then projected by the participation submodel. Population projections are contained in a State of Washington (1977) source for each county of the State and by age class. The two counties which include Skykomish Ranger District (King and Snohomish) were taken to be the origin of participants. Delimiting the usershed in this way was done in consultation with Robert Mealey (1981b), Recreation Data Program Manager, Pacific Northwest River Basins Commission. King County contains the Seattle metropolitan area, from which the bulk of the study area recreationists originate. A gravity model developed by the River Basins Commission could have been used to specify the base year market area in more detail. However, it was decided that over the time of the projection origins would shift significantly due to the degree of destination substitutions anticipated, thus negating the validity of highly specifying the market area.

In running the submodel, this projection was adjusted for the growth rates of individual activities relative to each other. As input data, individual activities were assigned one of the three growth factors. These trend factors were based on the influence of destination substitution and the forecasted popularity of activities.

Future destination substitution is assumed to result from the effect of higher energy costs (relative to discretionary income) as indicated by two factors: (1) the price sensitivity of participation in an activity, and (2) the degree to which participation is currently local or regional. Data on price sensitivity came from a study (Mealey and Krukar, 1981) of outdoor recreation in King and Snohomish counties which determined the cost of recreation travel as a component of total costs. Each activity was scaled as to sensitivity to rising costs of travel. For the present study, a high sensitivity is taken as implying greater potential for destination substitution, and vice versa.

Another study (Pacific Northwest River Basins Commission, 1978) provided data on the number of participants received and the number generated in King and Snohomish counties for each of 11 relevant activities. Again each activity was scaled as to the influence on potential destination substitution. The relative strengths of the factors for price sensitivity and local effects were combined to indicate the potential of each activity to undergo destination substitution serving to increase the participation in Skykomish Ranger District.

A few activities, namely camping, extended hiking, water sports, nonmotorized boating, horseback riding, and mountain climbing, are forecasted to outpace other activities in participation growth (USDI, 1980). Insufficient indication was found that any activities would experience a decline in participation relative to population growth. After combining this factor with the above factor for destination substitution, each activity was categorized with a trend factor as to fast, moderate, or stable relative-growth.

After the adjustment for the relative growth is made, the projection is complete. Finally, the data is transformed to opportunity classes using transformation coefficients arrived at in consultation with James Bartelme (1981a), Acting Chief Ranger of Skykomish Ranger District. Relationships between all data are assumed to remain static over the time horizon of the study, except for those that are obviously taken to be dynamic, i.e. population growth and the three categories of relative growth.

SUITABILITY DATA

Other than the data supplied by the participation and opportunity submodels, input data for the suitability submodel consist of capacity coefficients. These coefficients are the person-at-one-time (PAOT) coefficient and the seasonality factors, i.e. length of managed season (MS), weekly pattern-of-use (PU), and length of stay (LOS). For the size-dependent approach to determining capacity, each opportunity class has different values for these coefficients (Table 11). For the feature-dependent approach, each feature type within an opportunity class has different values for these coefficients.

Ranges of values for the size-dependent PAOT coefficients have been listed in U.S.Forest Service planning guidelines (USDA, 1980c). William Fessel(1981), Recreation Planner at the Mt.Baker - Snoqualmie National Forest Supervisor's Office, was consulted in arriving at the middle of the range values used in this study. The values used in the Alpine Lakes Basin Study (USDA, 1980e) for the MS and PU coefficients were adopted for this study. James Bartelme (1981b), Acting Chief Ranger of Skykomish Ranger District provided the LOS values for each opportunity class. All values for the feature-dependent coefficients were taken from the developmental work of Fessel and Frankenstein (1981). These values are applicable to the National Forest as a whole and not the Skykomish Ranger District

TABLE 11

CAPACITY COEFFICIENTS USED IN CASE STUDY FOR CALCULATING SIZE-DEPENDENT CAPACITY

Capacity Coefficient	ROS Class RN	SPNM	PR	
PAOT	1.60	.035	.009	persons-at-one-time /acre
MS	150	120	90	managed season in days
PU	1:4 / .45	1:3 / .50	1:1.5 / .80	weekday:weekend pattern of use (as a ratio and as a decimal)
LOS	6	10	15	length-of-stay in hours

specifically. All coefficient values were held constant throughout the study time horizon.

CHAPTER VI

IMPLICATIONS FOR SKYKOMISH RANGER DISTRICT AND U.S.FOREST PLANNING

Two avenues of discussion are followed in interpreting the study results: (1) an interpretation of the model outputs as an indication of future recreation quality in Skykomish Ranger District; and (2) an evaluation of the model's potential role in forest planning. The implications for Skykomish Ranger District are based on the outputs of the two scenarios tested, i.e. the preservation and development scenarios. The Recreation Allocation Routine has provided highly detailed estimates of the amount and location of future recreation opportunity, and the degree to which the capacity of this opportunity could match future participation. The model also indicated the relative impact that different actions could have on recreation opportunity.

As a prototype, the Recreation Allocation Routine appears to have performed well in simulating the effects of alternative management directions. In using such results, a manager could weigh the tradeoffs of dispersed recreation outputs that are involved with either of the two management alternatives considered. Such information could be evaluated along with estimates of the tradeoffs of nonrecreational resource uses in order to select a preferred alternative for Skykomish Ranger

District.

Evidence of the model's more general usefulness in forest planning has been gained by investigating the planning process of the U.S.Forest Service. No automated approach to analyzing the spatial interrelationships of alternative resource-use allocations is currently available. With further development, the Recreation Allocation Routine could provide such an analysis for dispersed recreation. The final section of this study discusses how the Recreation Allocation Routine could be integrated into the planning process and the direction that further development might take.

CASE STUDY OUTCOMES

The case study indicated likely future conditions for dispersed recreation in Skykomish Ranger District. In the base year, Semi-Primitive Non-Motorized and especially Roaded-Natural opportunities were oversupplied, and Primitive opportunity was at a sustained level with capacity approximately equal to participation. By 1995, Roaded-Natural and Semi-Primitive Non-Motorized opportunities remained oversupplied under both scenarios even though participation in these settings increased markedly. Primitive opportunity became extremely undersupplied by 1995, with participation almost twice the available capacity for the preservation scenario and almost two and one half times the available capacity for the development scenario. While

Primitive participation showed a greater percentage increase than the other opportunity types, the available opportunity decreased, especially with the development scenario. Thus, for both scenarios Roaded-Natural and Semi-Primitive Non-Motorized opportunities were sustained, and Primitive opportunity was far from being sustained.

For both scenarios of the case study, each submodel produced outputs which may be analyzed. The participation submodel yielded the projected participation in recreation visitor days (RVD's) per year. This projection was the same for both scenarios since participation was projected as independent of opportunity. The opportunity submodel provided the quantity of future recreation opportunity of each Recreation Opportunity Spectrum (ROS) class in acres and in feature types, along with maps which showed the location of settings. The suitability submodel calculated the capacities of the recreation opportunity and subsequently tabulated the deficits and surplusses of capacity in each class.

All opportunity classes are similar in showing large increases in participation, with the increase being greater, the more primitive the opportunity class. Projection of U.S.F.S. RIM participation data (Table 12) indicated participation increases in 1995 from 1980 levels of 67% for Roaded Natural (RN), 72% for Semi-Primitive Non-Motorized (SPNM), and 76% for Primitive (PR) opportunities. (There is little demand for Semi Primitive Motorized settings in the study area, and no Semi-Primitive

TABLE 12

PARTICIPATION AS PROJECTED BY PARTICIPATION SUBMODEL
(in RVD's)

YEAR	ROS Class		
	RN	SPNM	PR
1980	152,290	72,149	50,432
1981	158,827	76,479	52,818
1982	165,362	79,807	55,203
1983	171,897	83,135	57,588
1984	178,432	86,463	59,973
1985	184,967	89,791	62,358
1986	191,551	93,192	64,842
1987	198,133	96,593	67,322
1988	204,715	99,994	69,802
1989	211,297	103,395	72,282
1990	217,879	106,796	74,762
1991	225,288	110,628	77,579
1992	232,697	114,456	80,393
1993	240,106	118,284	83,207
1994	247,515	122,112	86,021
1995	254,924	125,940	88,835

Motorized settings exist.) These are clearly substantial increases in fifteen years time.

The approximate magnitude of the participation growth for all opportunity classes in aggregate was foreseeable. Informed judgement was purposely incorporated to establish a reasonable ceiling to the projection figures. Between 1980 and 1995, the population of King and Snohomish counties is forecast to increase by 34% (State of Washington, 1977), accounting for a large part of the above increases. This growth in demand is augmented through the effects of destination substitution. It was assumed that dispersed recreationists will increasingly seek recreation settings closer to home, and Skykomish Ranger

District is favorably located within the one-day recreational usershed of metropolitan Seattle. If past projections of the recreational use of U.S.National Forests are any guide (Clawson and Knetsch, 1966), the figures might be too low.

The differences in participation increases among opportunity classes resulted from the differential effects of age-class structure, destination substitution, and preference shifts. The contribution these factors would have to the increases in individual opportunity-class participation levels were not obvious before the submodel was run. All data input to the submodel pertained to recreation activities. Participation in most activity types occurs on two or more types of opportunity settings. The participation-by-activity figures were divided among the three opportunity types at the final step in the projection. Thus, the outcome of the projection was in a sense 'blind'.

Considered by themselves, these projected increases, while large, provide the recreation manager with little indication of future conditions for dispersed recreation in Skykomish Ranger District. Future recreation opportunity was simulated in order to determine the degree to which the needs of future recreationists are matched by each scenario.

Outputs from the opportunity submodel (Table 13) indicated substantial increases in the size of RN settings and small increases in SPNM settings over the study time horizon under both scenarios. The size of PR settings decreased with both

TABLE 13

CASE STUDY OUTPUTS FROM OPPORTUNITY SUBMODEL IN CELLS*

A. DEVELOPMENT SCENARIO

ROS CLASS	YEAR 1980					1985					1990					1995
RN	4582	5037	5151	5151	5151	5181	5271	5312	5444	5699	5895	6122	6214	6214	6214	6238
SPNM	4748	4791	4797	4797	4797	4792	4818	4829	4758	5062	4964	4836	4921	4921	4921	4954
PR	2446	2446	2446	2446	2446	2446	2435	2435	2435	1901	1901	1901	1809	1809	1809	1752

B. PRESERVATION SCENARIO

ROS CLASS	YEAR 1980					1985					1990					1995
RN	4582	5037	5151	5151	4974	4994	5084	5125	5367	5395	5493	5592	5684	5684	5684	5684
SPNM	4748	4791	4797	4797	4946	4891	4917	4928	4747	4744	4817	4817	4902	4902	4902	4962
PR	2446	2446	2446	2446	2474	2524	2513	2513	2513	2513	2440	2440	2348	2348	2348	2288

* 1 cell is equivalent to 25.6 acres

scenarios, with a much larger decrease under the preservation scenario. Analyzing the data as to net changes in opportunity provided an insightful summary (Table 14). With the development scenario, the acreage of RN setting increased markedly (+36%) from 1980 to 1995, while the acreage of PR settings decreased markedly (-28%). The size of SPNM settings showed a small increase (+4.3%). With the preservation scenario, the acreage of RN settings still increased substantially (+24%) from 1980 to 1995, i.e. a full two-thirds of the increase under the development scenario; the net increase in size of SPNM settings (+4.5%) was about the same as with the development scenario; while the net reduction in PR acreage (-6.5%) was only about one-fourth of the decrease under the development scenario.

Maps produced by the opportunity submodel were helpful in analyzing the spatial impacts to recreation opportunity and the impacting actions responsible. The base year ROS map (Figure 8) may be visually compared with the final ROS maps of the development scenario (Figure 9) and the preservation scenario (Figure 10). The greatest changes occurred in the eastern part of the study area. Two additional maps highlighted these changes and were useful in analyzing the outcomes. For each scenario run a map (ROSCHANGE) was printed out indicating only those cells whose ROS classification in 1995 was different than the 1980 cell classifications (Figures 11 and 12). Using these maps

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The submodel produced line printer maps which were later converted to the plots included here, by using a Hewlett Packard plotter.

TABLE 14

CHANGES IN ACRES OF OPPORTUNITY
UNDER TWO SCENARIOS (1980 to 1995)

Scenario	ROS Class			Type of Comparison
	RN	SPNM	PR	
Development	+42,394	+5,274	-17,766	Net acres
	+36%	+4.3%	-28%	Percentages
Preservation	+28,211	+5,478	-4045	Net acres
	+24%	+4.5%	-6.5%	Percentages

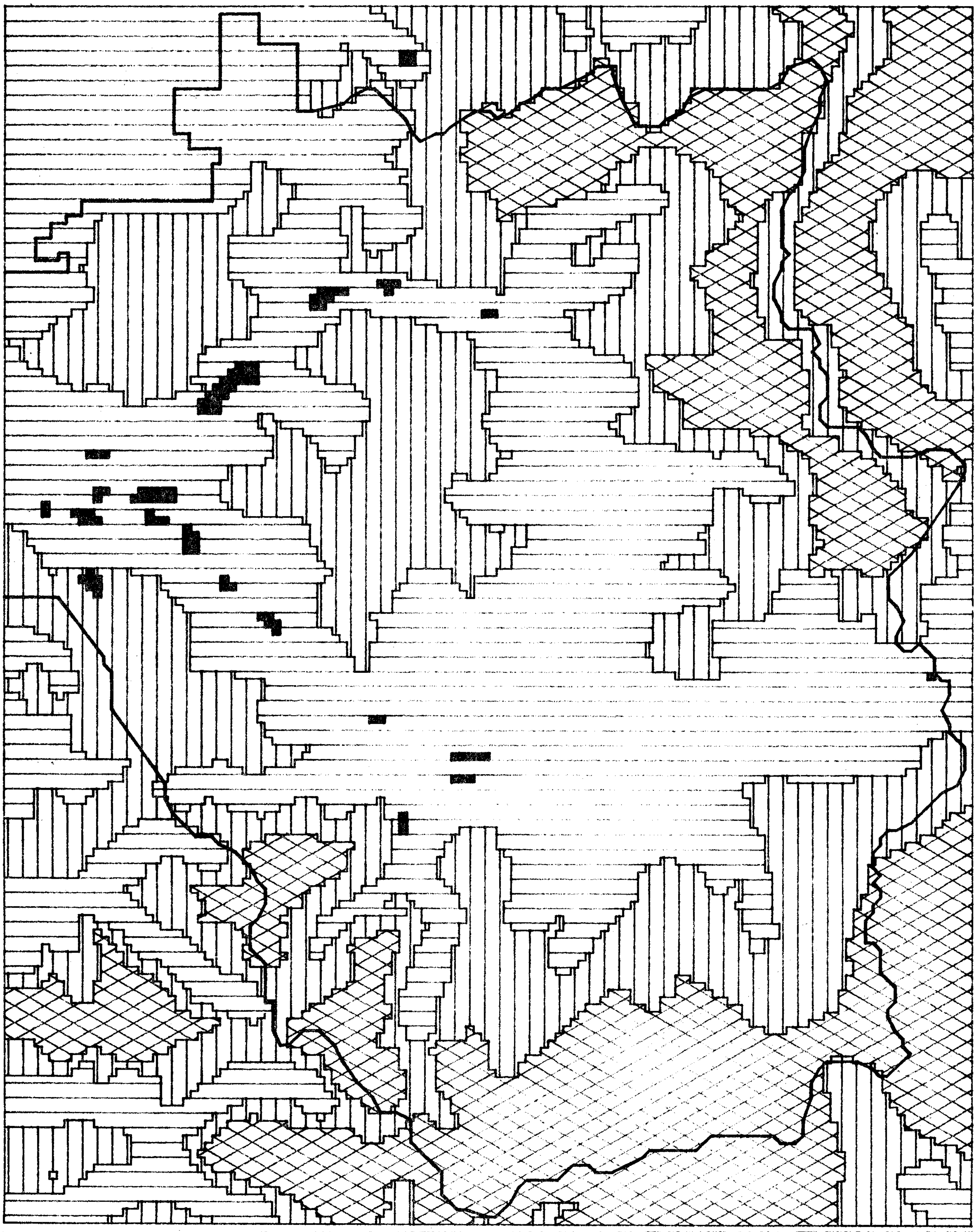
together with the locations of scenario actions, the impacting factors responsible for increases and decreases of opportunity were identified for both scenarios.

The major policy decision incorporated in the development scenario was the opening up of large roadless areas in the east and northeast parts of Skykomish Ranger District to timber harvesting. Thus, a major management action was road construction carried out in developing these areas. Significant changes to ROS classifications resulted from this road construction, and, in addition, from land exchanged and trails which became heavily used.

The three opportunity types were affected differently by the impacting actions. Most of the net increase in RN settings resulted from land exchanged into the Ranger District. This accounted for more than 25,000 acres added to RN settings. Substantial additional reclassification to RN opportunity

FIGURE 12

BASE MAP FOR RECREATION OPPORTUNITY



RURAL

ROADED NATURAL

SEMI-PRIMITIVE NON-MOTORIZED

PRIMITIVE

FIGURE 13

1995 ROS MAP, DEVELOPMENT SCENARIO

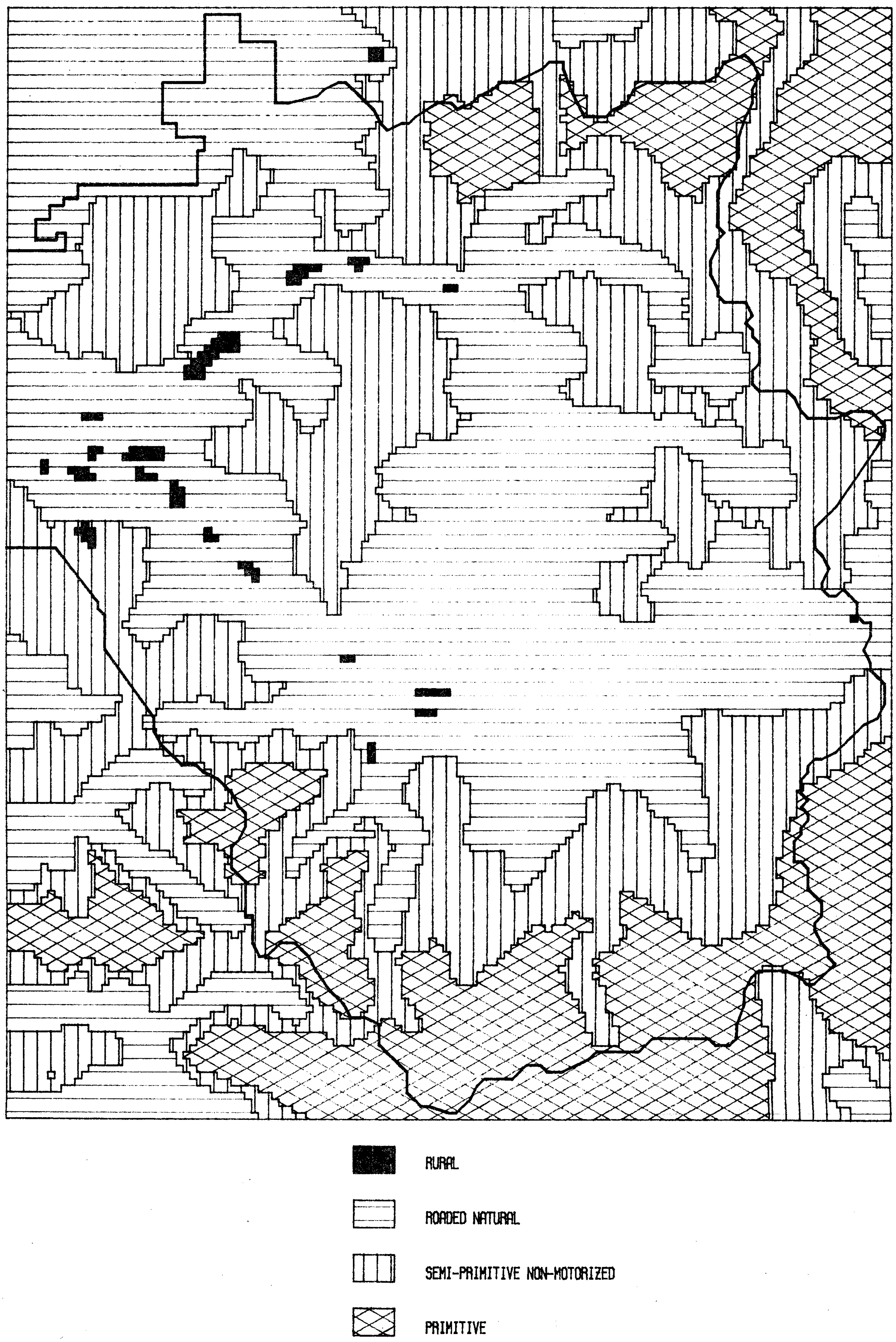


FIGURE 14

1995 ROS MAP, PRESERVATION SCENARIO

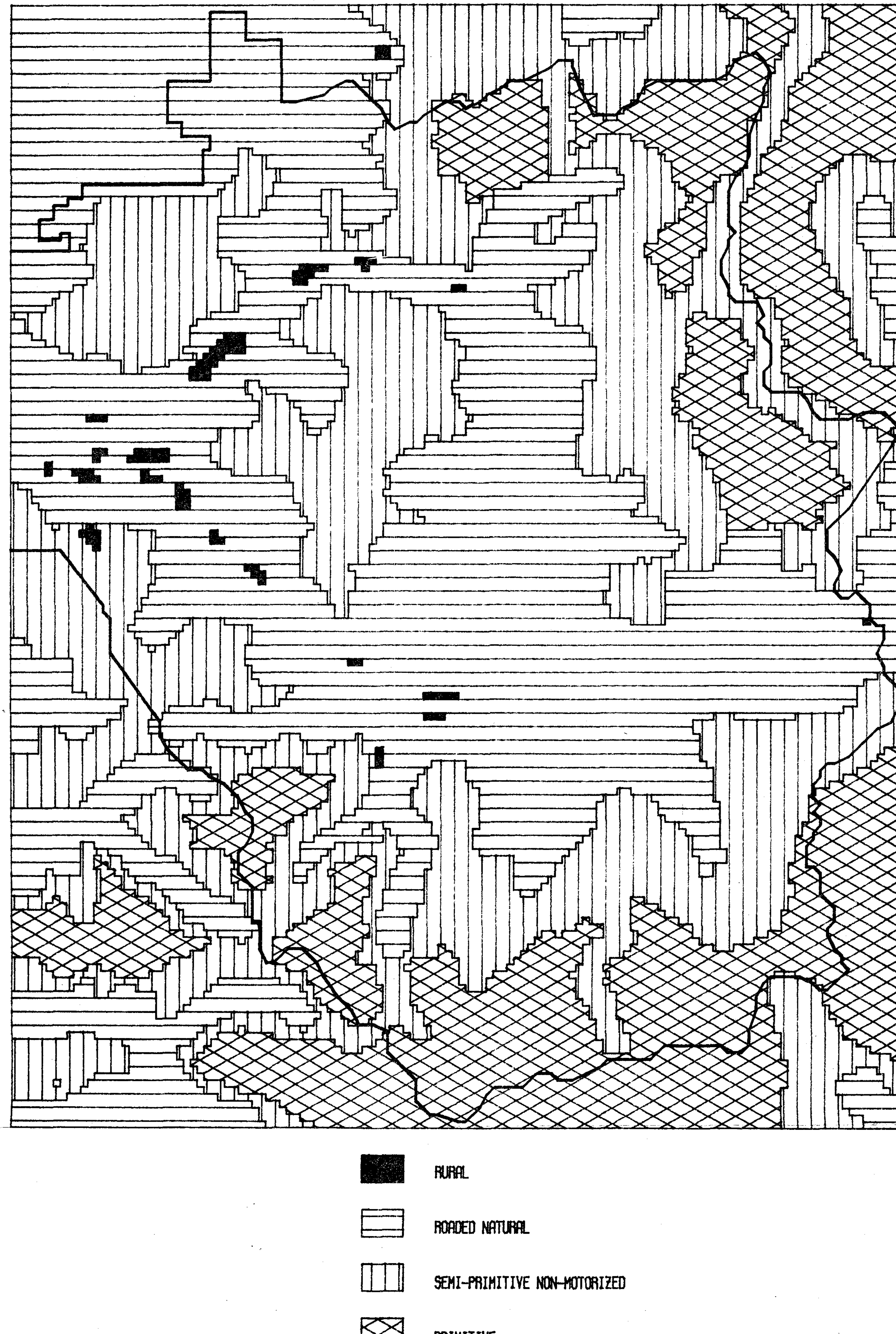


FIGURE 15

MAP OF CHANGED CLASSIFICATIONS, DEVELOPMENT SCENARIO

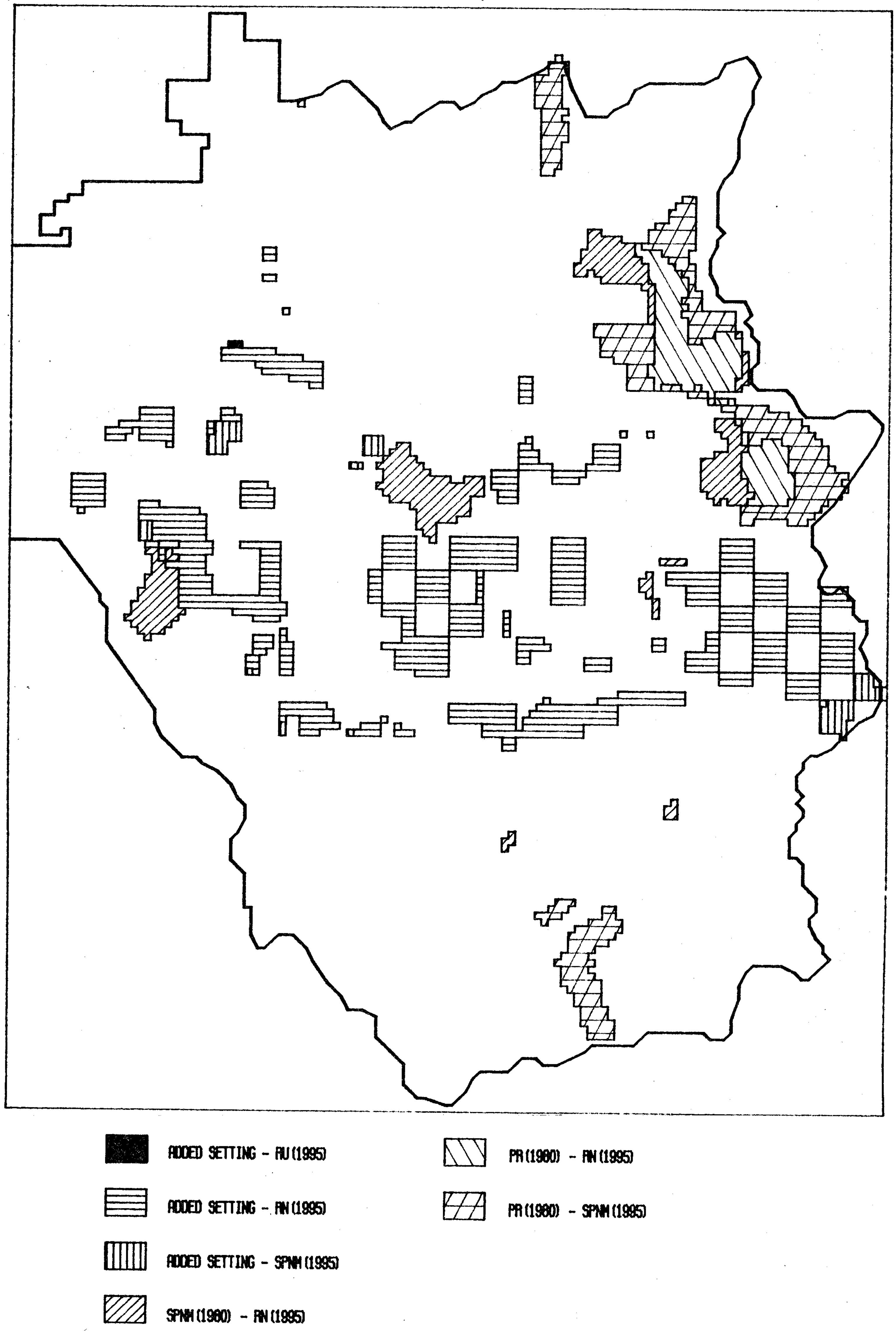
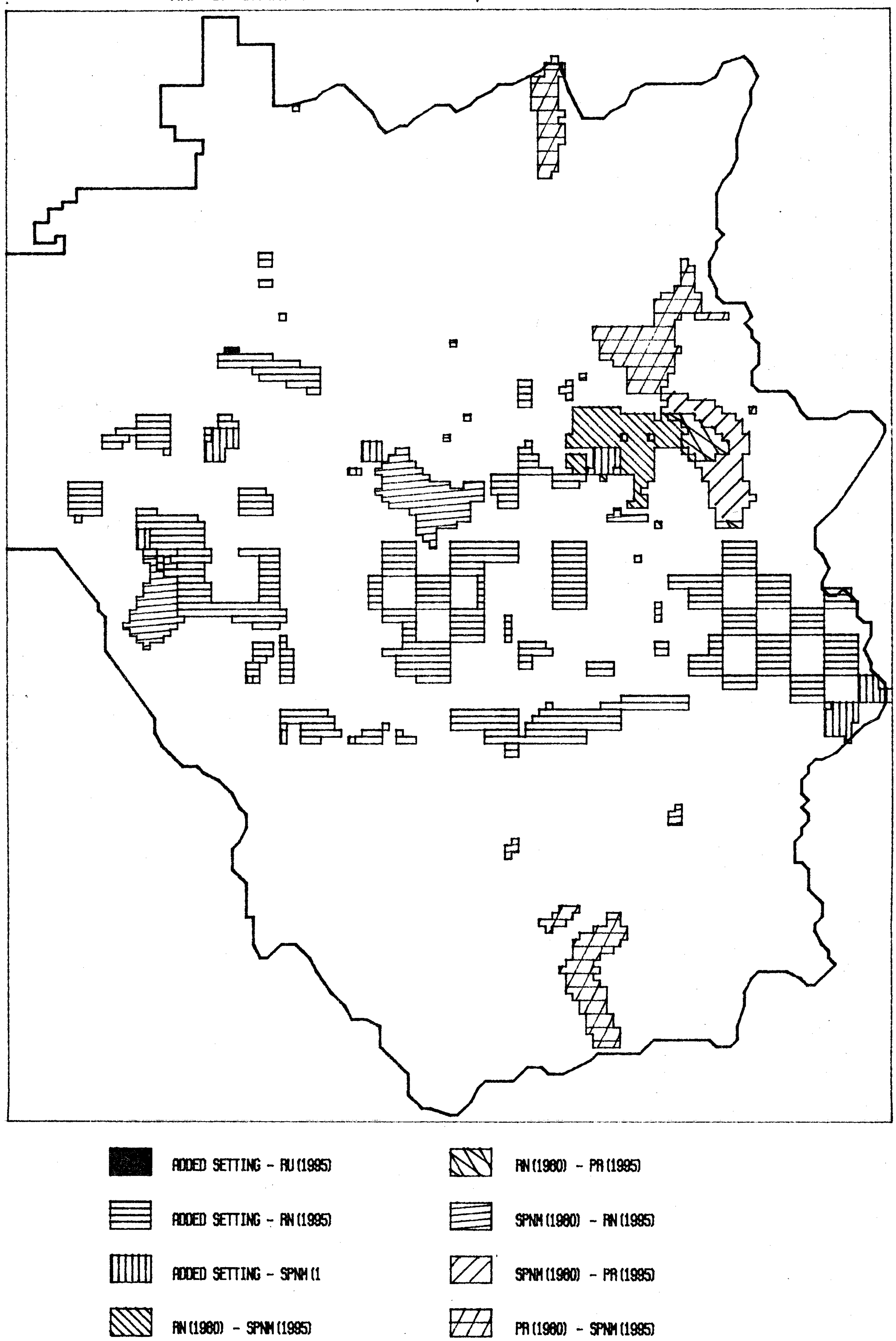


FIGURE 16

MAP OF CHANGED CLASSIFICATIONS, PRESERVATION SCENARIO



resulted from road construction. The decrease in PR opportunity resulted primarily from road construction, and secondarily from the added busy trails. In one location, a constructed road crossed an added busy trail, thus obscuring the absolute acreages of change attributable to any particular impacting action. SPNM opportunity reclassified to RN setting as a result of road construction was in a sense balanced by the PR settings which were reclassied to SPNM. Thus, most of the added SPNM opportunity was attributable to the impact of added busy trails.

Under the preservation scenario, the roadless areas in the east and northeast parts of the District were left intact and, in fact, were added to by the permanent closure of a road. The significant impacting actions were land exchanged and added busy trails, which were the same as for the development scenario, and a small degree of road construction, as well as the permanent road closure.

Again, an ROSCHANGE map was used to discern the relative effects of different impacting actions in the preservation scenario. Most (about 80%) of the increase in the size of RN settings resulted from land exchanged, which did not effect any decrease in PR settings. A small amount of road construction resulted in the remaining gain in RN opportunity. The modest increase in SPNM opportunity resulted from the mixed effects of road construction (loss of 5,273 acres), road closure (gain of 666 acres), land exchanged-in (gain of 2,483 acres), and added busy trails (gain of 7603 acres). The sizeable decrease of PR settings even with the preservation scenario may seem surprizing. In fact, the effect of those impacting actions under management control resulted in a small net gain in PR setting. Most of the net decrease in size of PR settings resulted from added, busy trails in the last five years of the scenario, and is thus a consequence of anticipated congestion along these busy trails. However, as seen from the discussion which follows, congestion would not be limited to these trails.

From calculations performed in the suitability submodel, projected participation and simulated opportunity were compared, thus indicating for which opportunity classes recreation outputs were sustained. First the capacity of the simulated opportunity was calculated in terms of RVD's, and then compared with the RVD's of projected participation. In this way, the degree of oversupply or undersupply of each opportunity type was determined.

Capacity was calculated using both a size-dependent (Table 15) and a feature-dependent (Table 16) approach. Calculating capacity in the latter way is potentially more sensitive than the size-dependent approach to the affect of changing ROS delineations, since the capacity coefficients are more location-specific. However, wide discrepancies between the two approaches appeared even in the base year. This approach to determining capacities is in an early stage of development, and was primarily included to demonstrate its implementation using computer cartographic techniques. Many more capacity

TABLE 15

CASE STUDY OUTPUTS FROM SUITABILITY SUBMODEL
OF SIZE-DEPENDENT CAPACITY
(in RVD's)

Year	ROS Class					
	RN		SPNM		PR	
	D*	P*	D*	P*	D*	P*
1980	6756426		212710		50720	
1981	7427350	7427350	214636	214636	50720	50720
1982	7595450	7595450	214905	214905	50720	50720
1983	7595450	7595450	214905	214905	50720	50720
1984	7595450	7334453	214905	221580	50720	50720
1985	7639686	7363944	214681	219116	50720	51300
1986	7772397	7496654	215846	220281	50492	52110
1987	7832853	7557110	216339	220774	50492	52110
1988	8027494	7913953	213158	212665	50492	52110
1989	8403507	7955241	226777	212531	39419	52110
1990	8692521	8099749	222387	215801	39419	50596
1991	9027246	8245729	216652	215801	39419	50596
1992	9162905	8381389	220460	219609	37511	48688
1993	9162905	8381389	220460	219609	37511	48688
1994	9162905	8381389	220460	219609	37511	48688
1995	9198294	8381389	221939	222970	36329	47444

* D: Development scenario
P: Preservation scenario

TABLE 16

CASE STUDY OUTPUTS OF
FEATURE-DEPENDENT CAPACITIES
(in RVD's/year)

ROS Class	1980	1995	
		Development Scenario	Preservation Scenario
RN	82023	112706	97194
SPNM	131666	152745	154165
PR	39030	29353	31968

coefficients are used in the feature-dependent approach, and there is little empirical research on which to base these coefficients. Fessel and Frankenstein (1981) arrived at the coefficient values by assuming that participation matched capacity in the base year (Fessel,1981). Thus, feature-dependent coefficients are currently more subjectively determined than are size-dependent coefficients. The discrepencies between the two approaches were not investigated further, other than to perform a quick manual check of some computer calculations. The model appeared to perform well in implementing the feature-dependent approach. Only the size-dependent capacities were analyzed further.

The outputs from the suitability submodel were analyzed to yield the percentage either of excess capacity over participation or excess participation over capacity, for both the base year and 1995 (Table 17). For example, the capacity of RN settings in 1980 was calculated as 4300% percent greater than the RN participation. Also, the 1995 PR participation was almost twice as great (90 percent) as the PR capacity, for the preservation scenario.

Analyzed in this way, the results of the two scenarios were quite similar, except for the undersupply of PR opportunity. From the table, it can be seen that RN opportunity was oversupplied by a very large factor at all times; SPNM opportunity was oversupplied with close to twice the needed capacity in 1995; and PR opportunity became markedly

TABLE 17

PERCENTAGES OF OVERSUPPLY (+) OR UNDERSUPPLY (-)
OF OPPORTUNITY UNDER TWO SCENARIOS (1980 and 1995)

Scenario	ROS Class					
	RN		SPNM		PR	
	1980	1995	1980	1995	1980	1995
Development	+4300%	+3500%	+190%	+80%	supply equals demand	-140%
Preservation		+3200%		+80%		-90%

undersupplied by 1995 from a situation of adequate supply in 1980. The size of PR settings would have to increase almost 80% from 1980 to 1995 in order to sustain primitive recreation outputs. Instead the size of PR settings decreases. The most significant difference between scenario outcomes was that for PR opportunity. The degree of undersupply of PR opportunity in 1995 was 55% greater for the development scenario than for the preservation scenario.

IMPLICATIONS FOR SKYKOMISH RANGER DISTRICT

From the tabulations in Table 17, inferences may be made as to future oversupply and undersupply of opportunity types, and thus the degree to which recreation outputs are sustained and the resultant impacts upon recreation quality. RN opportunity is excessively oversupplied and likely to remain so for a long time. This implies that there will be negligible crowding among

RN participants, except possibly on such peak-load occasions as holidays or the opening days of hunting and fishing seasons. SPNM opportunity is oversupplied throughout the study time horizon, although the factor of oversupply was halved by 1995. Thus, RN and SPNM opportunities were sustained relative to demand under both scenarios. These outputs would be sustained even if the ranges of confidence in the participation projection and the opportunity simulation were quite large, and a worst case was considered of higher participation and lower supply.

On the other hand, PR opportunity was far from being sustained. PR opportunity showed a deficit of supply after the first year of either scenario, which increased throughout the scenario runs. This implies that crowding among PR recreationists will become much worse by 1995, with two or three recreationists seeking the recreation opportunity that one recreationist would fill at capacity. The effect would be a steady decrease in primitive recreation quality. If recreation quality is allowed to diminish, recreationists' expectations will lower as a consequence of the floating baseline phenomenon. Furthermore, conditions of undersupply with resultant dissatisfacton would likely lead to the displacement of primitive recreationists, possibly to SPNM settings, or to a more distant or less appealing PR setting on fewer occasions. Here, ranges of confidence would have to be very large for these recreation outputs to be sustained even in the best case of lower participation and greater opportunity.

If the objective is to maintain the recreation quality of all opportunity types, there is little question as to which scenario would be preferred. The important tradeoff between the scenarios lies in the amount of primitive opportunities supplied. The percentage of undersupply of PR recreation outputs is 55% greater with the development scenario than with the preservation scenario. There is little difference in SPNM capacity between the scenarios. Furthermore, the oversupply of RN opportunity is substantially less given the preservation scenario. The preservation scenario offers a better balance in the recreation capacity supplied. In addition, the preservation scenario retains much more of an irreplaceable land base on which primitive opportunity depends.

Unfortunately the choice is in some ways the lesser of two evils. Even under the preservation scenario, the capacity of primitive opportunity in 1995 is a mere half of the projected demand. Looking further into the future, the yearly deficit is likely to continue to increase. While demand will probably continue to grow, the supply is boxed in by the impacts of development. Conflicting politcal pressures upon managers of PR settings may be expected to mount in the future both for more restrictive access which will lessen on-site congestion and for less stringent criteria for user density which will 'authorize' more congested conditions. Large numbers of primitive recreationists will likely be displaced as a result of extremely crowded settings or excessive management restrictions, possibly including advance bookings of several months. The political pressure for preservation of more primitive settings would likely increase at the same time, as the scarcity of primitive lands increases their value to society. But preservation efforts will then be too late to a large degree - the direct and external impacts of development upon primitive opportunity are not readily reversible, at least in the short-time.

If dispersed recreation opportunity of all types is to be sustained in Skykomish Ranger District, immediate steps must be taken to increase the effective supply of primitive opportunity. Two ways in which effective supply of recreation opportunity may be increased are through better utilization of existing settings and by increasing the size of the settings. Existing settings might be better utilized if users were better informed about which were congested and uncongested, or if additional trails were constructed.

Providing information about the unbalanced use of PR settings would help to even out use. However, the model implicitly assumes that use is spread evenly over accessible parts of the settings for each opportunity type. Model outputs indicated that PR settings taken as a group were undersupplied, so that even if use were spread evenly over these settings there would be congestion. Similarly, an assumption in using the temporal capacity coefficients is that use is scheduled evenly through the managed season, except for weekday-weekend use patterns which most recreationists are unable to alter. If use was unbalanced, better information could benefit those users desiring to take advantage of it, but for planning purposes PR opportunity is still undersupplied. If equally accessible and attractive PR settings which were also uncongested existed outside the study area, the manager could take this into consideration in choosing among alternatives.

Trail construction is another method of better utilizing existing PR settings, although the trail network is already fairly dense in the vicinity of the Pacific Crest Trail and throughout the Alpine Lakes Wilderness Area. Ironically, where one standard delineating a PR setting is the distance that the average day-hiker will walk, trail deterioration in the form of leaving fallen trees and localized washouts could serve to further the isolation of PR settings, thus alleviating crowding and the need for management restrictions. But trail deterioration is a form of demand constraint (discussed below) and not a means for increasing the supply.

The size of PR settings could be increased by restoring SPNM and RN settings to more natural conditions. As stated above, the size of PR settings in 1995 would have to be 80% greater than in 1980 to sustain PR outputs. By decreasing the land base available to harvesting, natural restoration would be in direct conflict with timber production, unless methods of intensive timber management could decrease the amount of land required for timber.

Whatever the options for sustaining recreation outputs, further conversions of PR settings will only exacerbate the problem. Even so, a choice between scenarios would not be clearcut for the forest manager, who is also weighing the effects upon timber production, grazing, wildlife habitat, and so forth. A scenario which favors the productivity of certain resource uses will likely lead to a decreased production of some other uses. For example, while more diverse and extensive wildlife habitats would probably be maintained with the preservation scenario, the sustained allowable cut of timber would be greater with the development scenario.

If the selected management plan indicated that PR recreation outputs were not going to be sustained, then tradeoffs between constraining demand and allowing congestion would be considered. Constraining demand is not an answer to sustaining recreation outputs, since constraints imply turning people away and therefore decreasing the quality of recreation experiences. In planning for land-use allocations, the management question should be how to match recreation needs, not how to curtail those needs.

After allocations are made and if a shortfall were indicated, model outputs would give managers an idea of how pressing the need for demand constraining measures would be. There are many approaches to constraining demand, including: selective trail nonmaintenance, cutting back roadheads, fitness or knowledge qualifications, first-come-first serve, advance reservations, random selection through a lottery, peak load pricing, and auctioning permits (Irland, 1979). The administrative costs and acceptability-to-users of these methods vary. Where SPNM opportunity was oversupplied and PR opportunity was undersupplied, as in the case study, measures which favored those users desiring lower user-densities would complement the management objectives for PR settings while turning away recreationists who have substitute opportunities available to them.

THE MODEL'S POTENTIAL ROLE IN FOREST PLANNING

A broader study objective has been to establish the model's utility in an ongoing planning process. The model in this capacity would have a role in assisting the forest manager in estimating dispersed recreation tradeoffs under various management alternatives. The degree to which different management alternatives would yield sustained recreation outputs is determined by modeling the likely resource use interactions of alternatives for their effect on dispersed recreation outputs. Decision makers would be informed of the degree of undersupply and oversupply of dispersed recreation outputs and thus the future potential for congestion of dispersed recreation settings. Sustained availability of recreation opportunity, relative to demand, could be used as a benchmark against which to measure tradeoffs.

In order to fulfil this broader role, the model must fit into the forest management framework, both conceptually and pragmatically. Use of the Recreation Allocation Routine in the development of multiple-use forest plans could provide internal evaluation in alternative formulation, and additionally offer a systematic approach to estimating the effect of alternatives on dispersed recreation. An important attribute of the model in doing so is the greater spatial coordination that could result within plans. Of course, the model should produce believable and valid outputs, and compare favorably with the time and monetary costs of presently used methods.

The iterative approach necessary in formulating alternatives means that there are many changes to recreation opportunity maps and recalculations of capacities (Brown et.al., 1979). As a computer model, RAR would provide ready feedback, especially in a planning environment which is already highly computerized. If RAR were linked with FORPLAN in an iterative manner in the Forest Service LMP process, greater spatial coordination would result in the formulation of alternatives which match a constraint such as to sustain recreation outputs at certain levels.

By handling a spatial problem with a spatially-oriented technique, impacts upon dispersed recreation quality may be better assessed as to the location, time, cause, and extent of the impact. As discussed in an earlier chapter, dispersed recreation opportunity is especially sensitive to spatial factors arising from the external impacts of forest resource uses. RAR accounts for land uses adjacent to each recreation setting by implementing the ROS system. Furthermore, RAR simulates the dynamics of the invasion, succession, recovery process using cartographic modeling techniques. With this modelled foresight, the nature of prescriptive actions needed to mitigate future erosions of recreation quality may be included in the allocation process.

Furthermore, RAR could help in making plan analysis more systematic by ensuring the explicit consideration of impacts to dispersed recreation outputs. Many of the mapping and map analysis tasks that RAR could perform are presently done in Recreation Opportunity Planning using manual techniques. Modeling could lend an extra degree of explicitness and reproduceability which might be overlooked in a manual analysis. The RAR routine is straightforward to use, and in operation is transparent to the user who may 'freeze the action' by displaying maps at intermediate stages of a run.

Thus, in addition to supplying output data, implementation of the Recreation Allocation Routine would assist in clarifying the goals and criteria, in making the analysis explicit and reproducible, and in providing a vehicle for internal evaluation in the planning process through iteration. The model could be of most use in helping to formulate alternatives and in estimating the effects upon dispersed recreation of chosen alternatives. In place of the two scenarios used in this case study, the planning team would develop a scenario for each alternative to be evaluated. Running these scenarios through the model would provide maps of simulated recreation opportunity and tables of quantified data for each alternative.

In arriving at predictions of future management situations, the issue of model verification arises: does the model perform as expected? The model outputs are desired as information on which to base decisions for land-use allocations. The value of these predictions in a rational process of forest-resource allocation is only as good as the accuracy of the assumptions and predictions. There are four aspects of the modeling for which the accuracy is most open to question and which warrant scrutiny. An error in any one of these could alter model outputs significantly. These aspects are:

1) the calculation of capacities;
2) the appropriateness of the participation projection;
3) the structure of the scenarios; and
4) the application of the ROS criteria.

There is a judgemental component involved in determining the capacity coefficients (Table 11). The possibility exists that a large oversupply or undersupply of opportunity is not so much a factor of the size of the settings as it is a factor of the capacity coefficients used. Capacity coefficients used in this study were selected in consultation with a Recreation Planner for the Mt.Baker - Snoqualmie National Forest (Fessel, 1981). Both the criteria and capacity coefficients are those used by the Forest Service in their Recreation Opportunity Planning (ROP) process. Although the ROP process is still in a developmental stage, these parameters are the result of the combined efforts of academics and public forest managers, and are widely accepted as the best presently available.

A second point to be considered is the participation projection. The participation projection is based on many assumptions, even though the method of projection is relatively simple. One assumption is that the base year data for ROS class participation is a reasonable reflection of demand in an economic sense and does not overly reflect available opportunity. For example consider the case study results. Since use of PR opportunity is near capacity in the base year, PR participation is presumedly not a reflection of oversupply. On the other hand, RN opportunity is oversupplied. Since RN participants value peace and quiet (Downing and Clark, 1979), there is the possibility that some would value these characteristics to such a degree that, if RN opportunity were not oversupplied, they would be displaced to more primitive settings. If this were the case, base year participation in the more primitive settings would err in not reflecting this aspect of demand by being too low, and correspondingly RN participation would be too high. For the case study, participation data were taken at face value.

To be objective, the projection must not favor any particular opportunity class, nor inflate the overall recreation demand with an overly high projection of participation. As stated above, this projection was somewhat 'blind' to biasing of any particular opportunity class. Ultimately, the reasonableness of the projection's assumptions must be judged by those using the results.

As a third point, the scenarios of impacting actions may be questioned as to completeness and scheduling. Development of these scenarios is somewhat subjective and scenarios could be designed which bias the outcomes. Exclusion of a type or degree of a significant impacting action would lead to an error in ROS delineation, and therefore a miscalculation of the resulting opportunity. For this study, the expertise of a U.S.Forest Service manager was consulted in developing the two scenarios (Bartelme, 1981a), thus providing a standard of objectivity.

Finally, there is the question of the model's performance in accurately applying the physical criteria of remoteness and minimum management unit size, and thus accurately delineating the recreation opportunity classes. At times, manager judgement of the setting conditions might lead to an ROS delineation different than that arrived at by the computer application of these criteria. A routine check of the computer output maps would uncover most such discrepancies when they occur. Using the map which displays cells whose ROS classification has changed, planners may identify those cells for which the reclassification is judged to be inappropriate, and then make the necessary adjustments.

A discrepancy could occur in applying a size criterion. For example, the planner might decide that a marginally-sized PR setting which the model has reclassified as an SPNM setting should retain a PR classification due to conditions of imposing terrain which effectively secludes the area. In the unusual cases where such a situation occurred, the corrective adjustments to either the model or the opportunity submodel outputs are simple to make.

A more frequent misclassification occurs in application of the remoteness criteria to account for the impact of road closure. This may arise due to the difference in distance that the model measures using the FRICTION map as a scale, and that the planner would delineate based on first-hand knowledge of the area. Such occurances would usually be apparent upon visual inspection of the map of changed classifications. In the case study run of the preservation scenario, a narrow strip of cells were reclassified along a busy trail in a manner that conflicted with the Forest Service classification. The acreage represented by these cells was simply added and subtracted at the appropriate places in the output data, with no further adjustment needed.

To more adequately assess the accuracy of the model's ROS delineations a study would be needed which compared hand drawn maps with the computer maps. Manfredo and Brown (1980) have completed such a study of computer maps delineated by a program employing the MAP package in a way similar to the RAR opportunity submodel. They concluded that the accuracy of their computer maps compared favorably with manually drawn maps.

None of these aspects are entirely unique to the modeling of the Recreation Allocation Routine. U.S.Forest Service Recreation Opportunity Planning as it is currently performed faces similar limitations. RAR employs the same coefficients in order to determine capacity that the Forest Service uses. In projecting participation, RAR includes three factors not incorporated by the Forest Service, i.e. age class, destination substitution, and activity-preference shifts. Otherwise, the approaches are quite similar. Both approaches need to translate the outputs of the mathematical analysis from FORPLAN runs to spatially-delineated impacts which make up the scenarios. Also, the criteria must be mapped either way, which is done manually in current Recreation Opportunity Planning. The major difference in technique is the more automated approach that RAR uses in specifying the scenario and in applying the criteria. Thus, aside from possible differences in the degree of explicitness in analysis, the two approaches primarily differ in the way that time and monetary costs are incurred.

Manfredo and Brown (1980) compared computer and hand drawn techniques for delineating ROS classifications of the Steens Mountain Recreation Lands (U.S.Bureau of Land Management) in eastern Oregon. The computer technique that was tested used the analytical operations of the MAP package, which are employed in the Recreation Allocation Routine, in a programming approach similar to the RAR opportunity submodel. Their results showed the "computer mapping less likely to result in classification errors, but more costly to conduct." However, they then state that if the cost of setting up the data base were eliminated, "there could be little difference in the cost of computer versus hand mapping." Indeed, the costs of setting up the data base for RAR would be small, given the fact that much of the data base is already computer encoded. All other needed data are available on sheet maps. Once the data base was computer encoded, it could be repeatedly used for runs of RAR in analyzing the current management situation, in formulating alternatives, and in comparing alternatives.

Although an operational test of the Recreation Allocation Routine has been completed, further testing that is beyond the scope of this study is warranted. The prototype model does present certain limitations, namely: the size of the study area tested as a subpart of a National Forest, and the intermediate time horizon of the simulation as compared to rotation periods. In addition, the model might be modified to calculate recreation capacities in a way that would be impractical to do by hand, or to incorporate aspects of visual resource management or winter dispersed recreation planning. Without the opinion of Forest Service planners and the results of further tests of model performance, a discussion of the model's role in forest planning remains conjectural.

Further research could address the feasibility of building upon the prototype Recreation Allocation Routine. The size of the area considered is practically limited by the number of grid cells the computer can deal with at one time. If an area much larger than the present study area proved to be impractical to consider as a unit, the area might be subdivided with overlapping subareas that are subsequently patched together. Alternatively, the size of the grid cell might be increased if the loss in resolution was not too great. A reduction from five to four cells per linear mile would yield a 36% reduction in the number of cells.

The one-year time steps of the simulation might be an unnecessarily fine resolution of time. Perhaps grouping the scenario actions into every fourth or fifth year would suffice, thereby reducing computing costs. The changes to recreation opportunity did not vascillate as much as was anticipated at the onset of the study. With five-year time steps, a fifty year time horizon might be covered with little or no increase in computer time above the run times of the case study. Extending the time horizon might necessitate that certain consequences of impacting action, such as inconsistencies, would have to be programmed in greater detail than in the prototype model.

Including additional recreation opportunity classes, such as Roaded Modified and Semi-Primitive Motorized, would require programming for a different type of criterion (or criteria). Opportunity classes are distinquished by the remoteness and size criteria in the prototype model. However, these criteria are the same for Roaded Natural and Roaded Modified opportunities and for the motorized and nonmotorized Semi-Primitive opportunities.

An approach to calculating capacity which was more location-specific than the size-dependent approach and not as related to activity types as the feature-dependent approach might yield more appropriate results in a situation of changing ROS delineations. Berry's (1980) work suggests how each cell of the study area's gridwork might be assigned physical capacity coefficients based on slope, terrain, and soils. In addition, capacity could vary as to ROS type, land use, proximity to roads and trails, and so forth. The numerical values of such composite coefficients have not been developed. In fact, it might prove impractical to assign, for example, capacity coefficients to five classes each with four states, i.e. 4 * 4 * 4 * 4 * 4 capacity coefficients. This is an approach not taken in a manual suitability analysis because of the large number of cell-by-cell calculations required.

Visual resource management is closely allied to dispersed recreation management in forest planning, and might be incorporated to some degree in the model. The Map Analysis Package includes an operation which maps the viewshed from any given point. Programming in MAP could then overlay sensitive visual management areas with the view from visually impacting sites, and thus produce a coefficient which could be compared to some standard.

Finally, winter dispersed recreation might need to be incorporated if the model were to be applied in certain areas. However, current winter dispersed use does not present allocation problems in most areas. Also, criteria for delineating winter opportunity have not been systematized.

In conclusion, the way in which dispersed recreation is dealt with in public forest-land planning agencies results in shortcomings which are surmounted by the prototype model to a degree. By considering more systematically the allocations and the implications of undersupply and oversupply of opportunity types, forest managers will have better information with which to foresee and resolve future conflicts, and, more importantly, will be better able to provide for public recreation needs. The model would assist in doing so by accounting for the near-term impacts of planned forest management on recreation opportunity, resulting in a comparison of future recreation opportunity with participation.

There are benefits in making an explicit determination of sustained dispersed recreation outputs; namely, that we are given a point from which to compare broader changes. Forest policy mandates that the various forest uses be sustained, and therefore that management "maintain and achieve high levels of ...output" of dispersed recreation (Multiple-Use Sustained-Yield Act, 1960; U.S.D.A., 1980a). A definition of sustained yield that is suitable for dispersed recreation has been advanced in this thesis, that of 'sustained recreation opportunity, relative to demand.' This definition is predicated upon the objective of maintaining recreation quality by maintaining experience levels. By indicating the likely future levels of congestion (the most contentious aspect of recreation quality), RAR could serve a role in monitoring divergencies from sustained recreation output levels.

APPENDIX A: SELECTED LEGISLATION AND FOREST SERVICE GUIDELINES

1. Forest Service Multiple Use and Sustained Yield Act of 1960.

   Authorized the Secretary of Agriculture "to develop and administer the renewable surface resources of the national forests for multiple use and sustained yield of the several products and services obtained therefrom." Stipulated as multiple uses were: outdoor recreation, range, timber, watershed, and wildlife and fish. "'Sustained yield of the several products and services' means the achievement and maintenance in perpetuity of a high-level annual or regular periodic output of the various renewable resources of the national forests without impairment of the productivity of the land.'"

2. National Environmental Protection Act of 1969.

   Required every federal agency to prepare and circulate an environmental impact statement (EIS) "on proposals for legislation and other major federal actions significantly affecting the quality of the environment." In response, the Forest Service established interdisciplinary planning teams and incorporated a degree of public participation.

3. Forest and Rangeland Renewable Resources Planning Act of 1974 (RPA).

   Written as a 894 page EIS, this was an attempt at comprehensive long-term, rational decision making at the national level of the Forest Service. It required an inventory of all uses and the projection of likely future demands.

4. National Forest Management Act of 1976 (NFMA).

   Principal authorities for this Act include the above statutes. Written as an amendment to RPA, this Act reaffirmed that Forest Service management was to be guided by the multiple-use and sustained-yield doctrines. Comprehensive land use planning was extended to all <u>local</u> adminstrative units of the National Forest System. Greater public participation in Forest Service decision making was mandated. Regulations are contained in Section 6 (36 CFR 219 Subpart A); some of these regulations are included below.

5. Interim Directive No.6 (March 10, 1980) was issued by the

Forest Service to guide implementation of the National Forest Management Act regulations. The directive addresses Chapter 1920 - Land and Resource Management Planning, of the Forest Service Manual. It was reissued early in 1981. Selected parts of the directive follow:

> FSM 1922.35a Dispersed and Developed Recreation:
> "Section 219.12, Forest Planning Actions (of 36 CFR 219, subpart A, FSM 1950)
> (i) A broad spectrum of dispersed and developed recreation opportunity in accordance with identified needs and demands will be provided.
> (3) Alternatives will include consideration of ... recreation opportunity responsive to current and anticipated user demands.
> (4) In formulation and analysis of alternatives ... interactions among recreation opportunities and other multiple uses will be examined. This examination will consider the impacts of the proposed recreation activities on other uses and values and the impacts of other uses and activities associated with them on recreation opportunities, activities, and quality of experience."

> FSM 1920.84a - Supply Analysis:
> "...
> The purposes of assessing the planning area's supply are:
> 1. To estimate the legal maximum sustained yield of the planning area to provide each output, as well as the expected costs associated with these estimates.
> ...
> The determination of management prescriptions that maximize supply must follow these guidelines:
> 3. Determine the sustained yield of each resource output or use in aggregate for the planning area in combination with all other outputs and uses from the area at the current yield level or greater."

6. A set of proposed rules (February 22, 1982) have initiated from the Executive Branch in an effort to 'streamline' the regulations of the National Forest Management Act. These proposed regulations would place greater emphasis on

maximizing present net value as determined in monetary terms.

APPENDIX B: RECREATION ALLOCATION ROUTINE

The Recreation Allocation Routine consists of programs placed in nine files. Many of these programs are quite short (some being two lines) but serve important functions in switching the direction of program flow and in interfacing MAP programming and FORTRAN programming. The largest of the files contains the FORTRAN code for the MAP package.

The programming is listed in the following order: EXEC, MANAGER, DIGIT2, BANDMAP, CONTIGSZ, source code for the INSERT operations, source code for the participation submodel, source code for the suitability submodel, and FESSEL. A listing of MAP is not included, although modifications made to MAP for RAR are either described or listed here. EXEC, as the main program, includes run statements for all of the submodels as well as some of the programming for the opportunity submodel.

Programming for the opportunity submodel is in the first six files listed above. The first two run statements implement the MAP package, by reserving the necessary disc storage space (-VALS: map values; -MAPS: map names; -CATS: map categories) and making IO unit assignments. The IO unit assignments are listed in the second run statement. MDATA and SCEN.D or SCEN.P contain input data; ROAREAS, FDDATA, and FDCAP are for output data (see Chapter IV). Other files in the second run statement contain segments of MAP programming. One program file calls another through the MAP command READ ON XX, where XX is the IO unit number.

The last run statement in EXEC implements the participation and suitability submodels. Input data for these submodels are placed in the file PCDATA. In addition, ROAREAS contains the outputs of recreation opportunity which are input data for the suitability submodel. With these three run statements, size-dependent recreation outputs are determined for a particular scenario and printed out.

In order to determine feature-dependent outputs, the statements in FESSEL are executed. Input data to FESSEL are contained in the file FDDATA and consists of maps postpacked at the conclusion of the opportunity submodel. The capacities of feature-dependent outputs are stored in FDCAP and printed out.

Various modifications were made to the MAP program in developing RAR. The two most significant alterations were the addition of nine INSERT operations and of a IO stacks for reads.

Several hundred lines of FORTRAN programming were added to the MAP programming to enable the INSERT operations. Thus, the INSERT command, like all MAP commands, causes execution of segments of FORTRAN programming in the modified MAP package. Unlike other MAP commands, however, subsequent RAR program flow may branch during execution of an INSERT operation as a result of information on a map. The sequence of MAP commands which are to be executed next may depend on the result of tests performed on a map. The correct sequence is placed in GOPHER (attached to IO unit 17), and upon returning to the file which called the INSERT operation, a READ ON 17 command causes this sequence to be executed.

The ability to stack the IO read units was added to accommodate the hierarchal structure and the flexible flow of control of RAR. Control returns to the next command in the calling routine (a file attached to an IO unit) when an end of file is read in the called routine (also a file attached to an IO unit). The calling routine might have been in turn called by a routine to which control must return. The IO stack keeps track of the order in which routines are called.

A few additional facts are presented here about the calculation of feature-dependent capacities, since the programming written to calculate these capacities is an appendage to the three basic submodels. Feature-dependent capacity is calculated using capacity coefficients and the feature-related data that is stored on computer maps. The quantified feature-type (in miles, acres, or items) is multiplied by capacity coefficients similar to those used in the size-dependent approach, yielding the capacity in RVD's. Feature-types, formulas, and coefficient values outlined by Fessel and Frankenstein (1981) served as a quide for the programming.

Transforming the data for feature-types off of computer maps and into the formulas added a couple steps not included in Fessel and Frankenstein's procedure. The feature-types were aggregated on maps as access-related, landform-related, and water-related in order to condense the information for subsequent calculations. In addition, the conversion from grid-cell codes to miles or acres required a conversion factor, CF. Thus the general formula for calculating feature-dependent capacity is:

$$RVD's = (\text{number of cells of feature-type}) \times CF \times (PAOT \times MS \times LOS / 12)$$

The conversion factors were determined from the miles of road, trail, or stream or the acres of lake surface that are represented by an average grid cell containing the road, trail, stream, or lake. These distance conversion-factors were subjectively valued so that they ranged around .22 miles, the average distance across a grid cell. For example, a grid cell represents .19 miles of arterial road and .24 miles of trail, since a trail generally meanders more in a given distance.

EXECUTIVE

```
$SIGNON  AACL PRIO=D T=20M PAGES=150
$CRE -VALS SIZE=321P
$CRE -CATS SIZE=13P
$R MAPSET.O 1=-VALS 2=-MAPS 3=-CATS
$R IO.O+MFO+INSO+MMO+MBO 1=-VALS 2=-MAPS 3=-CATS 8=MDATA 10=MANAGER 11=DIGIT2-
  12=SCEN.D 14=BANDMAP 15=CONTIGSZ 17=GOPHER 18=ROAREAS 19=FDDATA 13=FDCAP
QUIET
WRITE ON 6
READ ON 8
READ ON 12
MAP 10 FOR 10MAP
MAP 100 FOR 100MAP
NOTE
NOTE   THE NEXT SEVERAL STMTS CREATE FRICTION
NOTE
MAP 2
MULTIPLY SLOPE BY THATMAP
ADD VEGET TO THATMAP
SUBTRACT THATMAP MINUS ATTRACT
MULTIPLY 10MAP BY THATMAP FOR FRICTION
DIS FRICTION
ZAP SLOPE
ZAP VEGET
ZAP ATTRACT
NOTE
NOTE   ROSSKY IS AN ROS MAP OF THE STUDY AREA; 'SAVESZ' IS SIMPLY CREATED
NOTE
RENU OWNERSHIP FOR SKYLAND A 0 TO 3 THR 4 AND 1 TO 1 THR 2
MULTIPLY SKYLAND BY ROSBASE FOR ROSSKY
COPY ROSSKY FOR YR1ROS
ZAP SKYLAND
INSERT ROSSKY ONTO 5
READ ON 17
ZAP ROSSKY
MAP 0 FOR SAVESZ
NOTE
NOTE   EACH YEAR'S MANAGEMENT ACTIONS ARE CONSIDERED IN TURN
NOTE
COPY MGTACT1 FOR WKMGTACT
ZAP MGTACT1
READ ON 10
COPY MGTACT2 FOR WKMGTACT
ZAP MGTACT2
READ ON 10
COPY MGTACT3 FOR WKMGTACT
ZAP MGTACT3
READ ON 10
COPY MGTACT4 FOR WKMGTACT
ZAP MGTACT4
READ ON 10
COPY MGTACT5 FOR WKMGTACT
```

```
DES WKMGTACT
ZAP MGTACT5
READ ON 10
COPY MGTACT6 FOR WKMGTACT
ZAP MGTACT6
READ ON 10
COPY MGTACT7 FOR WKMGTACT
ZAP MGTACT7
READ ON 10
COPY MGTACT8 FOR WKMGTACT
ZAP MGTACT8
READ ON 10
COPY MGTACT9 FOR WKMGTACT
ZAP MGTACT9
READ ON 10
COPY MGTACT10 FOR WKMGTACT
ZAP MGTACT10
READ ON 10
COPY MGTACT11 FOR WKMGTACT
ZAP MGTACT11
READ ON 10
COPY MGTACT12 FOR WKMGTACT
ZAP MGTACT12
READ ON 10
COPY MGTACT13 FOR WKMGTACT
ZAP MGTACT13
READ ON 10
COPY MGTACT14 FOR WKMGTACT
ZAP MGTACT14
READ ON 10
COPY MGTACT15 FOR WKMGTACT
ZAP MGTACT15
READ ON 10
DIS ROSBASE
INSERT ROSCHANGE ONTO 9
INSERT ROSBASE ONTO 9
INSERT OWNERSHIP ONTO 9
INSERT ACCESS ONTO 9
STOP
$R PART.O 8=PCDATA 18=ROAREAS
$SIGNOFF
```

MANAGER

```
INSERT WKMGTACT ONTO 7
READ ON 17
RENU SAVESZ FOR SAVESZ A 0 TO 1
INSERT SAVESZ ONTO 6
READ ON 11
RENU 2DIGIT A 0 TO 10 THR 59 AND 1 TO 41 TO 51 THR 55
DES THATMAP
INSERT THATMAP ONTO 1
READ ON 17
RENU 2DIGIT A 0 TO 10 THR 59 AND 1 TO 51
INSERT THATMAP ONTO 1
READ ON 17
RENU 2DIGIT A 0 TO 10 THR 41 TO 44 THR 55 TO 59
DES THATMAP
INSERT THATMAP ONTO 2
READ ON 17
ZAP TARGET
DIVIDE 2DIGIT BY 10MAP FOR ROSBASE
RENU OWNERSHIP FOR SKYLAND A 0 TO 3 THR 4 AND 1 TO 1 THR 2
MULTIPLY SKYLAND BY ROSBASE FOR ROSSKY
ZAP SKYLAND
INSERT ROSSKY ONTO 5
READ ON 17
ZAP ROSSKY
```

DIGIT2

```
CLUMP ROSBASE FOR ROAREAS
DES ROAREAS
SIZE ROAREAS FOR SZAREAS
SLICE SZAREAS INTO 8 FROM 41 THR 195 FOR SZAREAS
RENU SZAREAS FOR SZAREAS A 1 TO 0
MULTIPLY ROSBASE BY 10MAP
ADD THATMAP TO SZAREAS
ZAP SZAREAS
COPY THATMAP FOR 2DIGIT
DES 2DIGIT
```

BANDMAP

```
INSERT THATMAP ONTO 3
READ ON 17
```

CONTIGSZ

```
INSERT THATMAP ONTO 4
READ ON 17
```

```
********************************************************************************
********************************************************************************
****   IIIIIII   NN       NN    SSSSSS    EEEEEEE    RRRRRR     TTTTTTT  ****
****     III     NN NN    NN   SS         EE         RR    RR     TTT    ****
****     III     NN   NN  NN    SSSSS     EEEEE      RRRRRR       TTT    ****
****     III     NN    NN NN        SS    EE         RR   RR      TTT    ****
****   IIIIIII   NN       NN   SSSSSS     EEEEEEE    RR    RR     TTT    ****
****************************************************************************  ****
********************************************************************************
      SUBROUTINE INSERT(JCL,IU,IV,ERRORS)
      COMMON/SAM/NP,NI,NCL,NC,NR,NMAPS,NBPM,NBUF,NWIDE,NCPB
      INTEGER ERRORS,UNDRSZ(5,4),O,BSZ,BTOT,ROAREA(5,16)/80*0/,
     +        IYEAR/0/,WKMA(9),NONYR/0/,LINE(26)
      INTEGER ICNT/0/,CCRN,CCSP,CCPR,CRN(9),HRT/1/,
     +        HRTN(10)/10*0/,TTCAP(5)/5*0/
      REAL  CSP(9),CPR(9)
      INTEGER*2 IA(21450)
      CALL FILE (JCL,IV,1,IA)
      GO TO (100,100,300,400,500,600,700,800,900), IU
C*************** IA IS ** 51-55 MAP ** OR ** 42-58 MAP ******* INSERT 1 , 2
  100 DO 110 I = 1,JCL
        IF (IA(I).NE.0) GO TO (111,122), IU
  110 CONTINUE
      GO TO 999
  111 IF (IFLAG.EQ.2) GO TO 112
      WRITE (17,1110)
 1110 FORMAT (' RENU 2DIGIT A 40 TO 21 TO 51 THR 55 AND 50 TO 41     '/
     +        ' DIVIDE THATMAP BY 10MAP FOR ROSBASE                   '/
     +        ' READ ON 11                                            ')
      IFLAG = IFLAG + 1
      GO TO 999
  112 WRITE (17,1120)
 1120 FORMAT (' RENU 2DIGIT A 20 TO 51                               '/
     +        ' DIVIDE THATMAP BY 10MAP FOR ROSBASE                   '/
     +        ' READ ON 11                                            ')
      GO TO 999
  122 WRITE (17,1220)
 1220 FORMAT (' MULTIPLY THATMAP BY 100MAP                           '/
     +        ' ADD THATMAP TO ROAREAS                                '/
     +        ' READ ON 14                                            ')
      GO TO 999
C*************** IA IS A 4 DIGIT MAP OF CANDIDATE 42-58 ********** INSERT 3
CCC   MARGINALLY SIZED AREAS ARE ORDERED IN A HIERARCHY AND
CCC   DISPENSED ONE AT A TIME TO INSERT 4
  300 IF (JUMP.GT.0) GO TO 357
      IS = 0
      NLEFT = 0
      K = 0
      L = 0
      M = 0
      N = 0
      O = 0
```

```
      DO 320 J = 1,4
        DO 310 I = 1,5
          UNDRSZ(I,J) = 0
  310   CONTINUE
  320 CONTINUE
CCC        THIS SECTION (TO 350) PUTS AREA #'S OF CANDIDATE AREAS IN THE
CCC        ARRAY UNDRSZ, WHICH HAS A HIERARCHAL ORDERING.
      DO 350 I = 1,JCL
        IF (IA(I).LT.4200) GO TO 350
        IVAL = IA(I) / 100
        IF (IVAL.LT.43) GO TO 322
        IF (IVAL.LT.44) GO TO 323
        IF (IVAL.LT.57) GO TO 326
        IF (IVAL.LT.58) GO TO 327
        IF (IVAL.LT.59) GO TO 328
  322   KOX = IA(I) - 4200
          IF (K.EQ.0) GO TO 342
          DO 332 KO = 1,K
            IF (KOX.EQ.UNDRSZ(5,KO)) GO TO 350
  332       CONTINUE
  342     K = K + 1
          UNDRSZ(5,K) = KOX
          GO TO 350
  323   KOX = IA(I) - 4300
          IF (L.EQ.0) GO TO 343
          DO 333 KO = 1,L
            IF (KOX.EQ.UNDRSZ(4,KO)) GO TO 350
  333       CONTINUE
  343     L = L + 1
          UNDRSZ(4,L) = KOX
          GO TO 350
  326   KOX = IA(I) - 5600
          IF (M.EQ.0) GO TO 346
          DO 336 KO = 1,M
            IF (KOX.EQ.UNDRSZ(1,KO)) GO TO 350
  336       CONTINUE
  346     M = M + 1
          UNDRSZ(1,M) = KOX
          GO TO 350
  327   KOX = IA(I) - 5700
          IF (N.EQ.0) GO TO 347
          DO 337 KO = 1,N
            IF (KOX.EQ.UNDRSZ(2,KO)) GO TO 350
  337       CONTINUE
  347     N = N + 1
          UNDRSZ(2,N) = KOX
          GO TO 350
  328   KOX = IA(I) - 5800
          IF (O.EQ.0) GO TO 348
          DO 338 KO = 1,O
            IF (KOX.EQ.UNDRSZ(3,KO)) GO TO 350
  338       CONTINUE
  348     O = O + 1
```

```
          UNDRSZ(3,0) = KOX
  350     CONTINUE
      NLEFT = K + L + M + N + O
      WRITE (NP,3500) NLEFT
 3500 FORMAT (' NUMBER OF CANDIDATES IN UNDRSZ THIS PASS = ', I2)
      WRITE (6,3505) ((UNDRSZ(I,J),J=1,4),I=1,5)
 3505 FORMAT (5(4I5/))
  356 IS = IS + 1
      JS = 0
  357 JS = JS + 1
      IF (JS.EQ.5) GO TO 369
      IF (UNDRSZ(IS,JS).EQ.0) GO TO 356
      NX = UNDRSZ(IS,JS)
CCC            NX IS A ROAREA AREA #
CCC            NEXT, WRITE COMMANDS TO CREATE A 'BAND' MAP OF '2DIGIT',
CCC            CONTIGUOUS NEIGHBORING CELLS.
      WRITE (17,3600) NX
 3600 FORMAT (' RENU ROAREAS FOR TARGET A 0 TO 1 THR 99 AND 1 TO  ', I2/
     +        ' SPREAD TARGET THR FRICTION TO  7                    '/
     +        ' RENU THATMAP A 0 TO  7 AND 1 TO 1 THR  6            '/
     +        ' MULTIPLY 2DIGIT BY THATMAP                          '/
     +        ' DES THATMAP                                         '/
CCC                  A BAND OF 2DIGIT #'S AROUND TARGET 'NX' ZONE.
     +        ' READ ON 15                                          ')
      JUMP = 1
      GO TO 999
  369 WRITE (NP,3700)
 3700 FORMAT (' POSSIBLE ERROR IN NOT DEALING WITH AN UNDERSIZED AREA.')
      GO TO 356
C*************** IA IS THATMAP: BAND ***************************** INSERT 4
CCC    DETERMINES WHETHER A PARTICULAR UNDERSIZED AREA IS LARGE ENOUGH
CCC    DUE TO NEIGHBORHOOD CONDITIONS
  400 NLEFT = NLEFT - 1
      BSZ = 0
      BTOT = 0
      IF (IS.GT.3) GO TO 436
CCC            THE NEIGHBORING CONDITIONS OF 50'S CONDIDATES ARE DETERMINED HERE.
      DO 410 I = 1,JCL
        IF (IA(I).EQ.0) GO TO 410
        BSZ = BSZ + 1
        IF (IA(I).LT.44) GO TO 410
        BTOT = BTOT + 1
        IF (IA(I).LT.59) GO TO 410
        BTOT = BTOT + 1
  410 CONTINUE
CCC        NEXT STMT STANDARDIZES THE BAND TOTAL AGAINST THE BAND SIZE
CCC        (WHICH VARIES DUE TO 'FRICTION', AND 'TARGET' SIZE)
      ABSZ = BSZ
      BRATIO = BTOT / ABSZ
CCC        TEST IF CANDIDATE AREA HAS LARGE ENOUGH NEIGHBORS
      IF (BRATIO.GT.(1 - IS *.05)) GO TO 466
CCC        IF NOT, THE 50'S CANDIDATE IS TOO SMALL SO:
CCC        REPLACE 50'S CANDIDATE WITH 40'S ON '2DIGIT'
```

```
      JUMP = 0
      WRITE (17,4200)
 4200 FORMAT (' MAP 40                                                 '/
     +       ' MULTIPLY TARGET BY THATMAP                              '/
     +       ' COVER 2DIGIT WITH THATMAP FOR 2DIGIT                    ')
CCC        CHECK TO SEE IF THIS WAS THE LAST CANDIDATE AREA FOR THE YEAR
      IF (NLEFT.EQ.0) GO TO 999
      WRITE (17,4300)
 4300 FORMAT (' DIVIDE 2DIGIT BY 10MAP FOR ROSBASE                     '/
     +       ' READ ON 11                                              '/
     +       ' RENU 2DIGIT A 0 TO 10 THR 59 /                          '/
     +       '        AND 1 TO 42 TO 43 TO 56 THR 58                   '/
     +       ' SUBTRACT THATMAP MINUS SAVESZ                           '/
CCC              DON'T CONSIDER THE SAVE AREAS
     +       ' MULTIPLY THATMAP BY 2DIGIT BY 100MAP                    '/
     +       ' ADD THATMAP TO ROAREAS                                  '/
CCC              A NEW 4 DIGIT MAP OF 42-58 HAS BEEN CREATED
     +       ' READ ON 14                                              ')
      GO TO 999
CCC     THE NEIGHBORHOOD CONDITIONS OF 40'S CANDIDATES ARE DETERMINED HERE
  436 DO 440 I = 1,JCL
        IF (IA(I).EQ.0) GO TO 440
        BSZ = BSZ +1
        IF (IA(I).LT.42) GO TO 440
        BTOT = BTOT + 1
        IF (IA(I).LT.55) GO TO 440
        BTOT = BTOT + 1
  440 CONTINUE
CCC              STANDARDIZE THE BAND TOTAL AGAINST THE BAND SIZE
      ABSZ = BSZ
      BRATIO = BTOT / ABSZ
CCC              TEST IF CANDIDATE AREA HAS LARGE ENOUGH NEIGHBORS
      IF (BRATIO.GT.(2.2 - IS *.17)) GO TO 466
CCC              IF NOT, THE 50'S CANDIDATE IS TOO SMALL SO:
      JUMP = 0
      WRITE (17,4400)
 4400 FORMAT (' MAP 20                                                 '/
     +       ' MULTIPLY TARGET BY THATMAP                              '/
     +       ' COVER 2DIGIT WITH THATMAP FOR 2DIGIT                    ')
      IF (NLEFT.EQ.0) GO TO 999
      WRITE (17,4300)
      GO TO 999
CCC        CANDIDATE IS LARGE ENOUGH; DON'T CONSIDER IT AGAIN; TEST NEXT AREA
  466 IF (NLEFT.EQ.0) GO TO 999
      WRITE (17,4700)
 4700 FORMAT (' MAXIMIZE TARGET VERSUS SAVESZ FOR SAVESZ               '/
     +       ' READ ON 14                                              ')
      GO TO 999
CCC          NO MORE UNDERSIZED AREAS TO CONSIDER; DO YEAR END CALCS
C***************** IA IS ROSSKY *********************************** INSERT 5
CCC          STORES THE OUTPUT OF THE OPPORTUNITY SUBMODEL FOR EACH YEAR.
  500 IYEAR = IYEAR + 1
      DO 520 I = 1,JCL
```

```
        IOPP = IA(I)
        IF (IOPP.LT.2) GO TO 520
        ROAREA(IOPP,IYEAR) = ROAREA(IOPP,IYEAR) + 1
  520 CONTINUE
      WRITE (NP,5100) (ROAREA(IOPP,IYEAR), IOPP=1,5)
 5100 FORMAT (' ROS AREA IN # OF CELLS = '/5I10)
      IF (MOD(IYEAR,5).NE.1) GO TO 999
      WRITE (17,5200)
 5200 FORMAT (' DISPLAY ROSSKY                                         ')
CCC             AT END OF RUN PRINT ROAREA
      IF (IYEAR.NE.16) GO TO 999
      WRITE (18,5300) ((ROAREA(IOPP,IYEAR),IYEAR=1,16),IOPP=1,5)
 5300 FORMAT (5(16I5/))
      WRITE (17,5400)
 5400 FORMAT (' MULT YR1ROS BY 10MAP                                  '/
     +        ' ADD THATMAP TO ROSSKY                                 '/
     +        ' RENU THATMAP FOR ROSCHANGE A 0 TO 11 TO 22 TO 33 / '/
     +        '                TO 44 TO 55                            '/
     +        ' DIS ROSCHANGE                                         ')
      GO TO 999
C****************** IA IS SAVESZ *********************************** INSERT 6
CCC         RESETS VARIABLES IN PREPARATION FOR THE NEXT YEAR
  600 JUMP = 0
       IFLAG = 1
      NONYR = 0
      RETURN
C****************** IA IS WKMGTACT ********************************** INSERT 7
CCC         DISTANCE CRITERIA ARE ACCOUNTED FOR IN UPDATING 'ROSBASE'.
CCC   WKMA :   1:LINEAR DEVEL.       2:HARVEST SITE      3:ROAD CONSTRUCTION
CCC            4:ROAD CLOSURE-TEMP  5:RD.CLOSURE-RSTR   6:TRAIL CONSTR.
CCC            7:BUSY TRAIL         8:LAND OWNERSHIP IN 9:LAND OWNERSHIP OUT
  700 DO 705 I = 1,9
        WKMA(I) = 0
  705 CONTINUE
      DO 710 I = 1,JCL
        IF (IA(I).EQ.0) GO TO 710
        WKMA(IA(I)) = IA(I)
CCC  NONYR = 1 FOR NO; 0 FOR YES, THERE ARE NO MGT ACTION THIS YEAR
        NONYR = 1
  710 CONTINUE
CCC   IN NONYEARS, SKIP 16 STMTS IN MANAGER FILE
      IF (NONYR.EQ.1) GO TO 715
      READ(10,7005)
 7005 FORMAT(///////////////)
      RETURN
CCC       ACCOUNT FOR IMPACT OF LINEAR DEVELOPMENTS AND HARVEST SITES
C      IF (WKMA(1).EQ.1 .OR. WKMA(2).EQ.2) WRITE (17,7100)
C 7100 FORMAT (' RENU WGMGTACT A 0 TO 3 THR 9 AND 1 TO 2                '/
C    +        ' SPREAD THATMAP THR FRICTION TO 3                      '/
C    +        ' RENU THATMAP FOR MA12 A 5 TO 3 AND 4 TO 0 THR 2       '/
C    +        ' MINIMIZE ROSBASE VERSUS MA12 FOR ROSBASE              '/
C    +        ' ZAP MA12                                              ')
CCC       ACCOUNT FOR THE IMPACT OF ROAD CONSTRUCTION ON ROS
```

```
  715 IF (WKMA(3).EQ.3) WRITE (17,7300)
 7300 FORMAT (' RENU WKMGTACT A 0 TO 1 THR 2 TO 4 THR 9              '/
     +        ' SPREAD THATMAP THR FRICTION TO 20                      '/
     +        ' RENU THATMAP A 5 TO 20 AND 4 TO 4 THR 19 /             '/
     +        '              AND 2 TO 0 THR 3                          '/
     +        ' MINIMIZE ROSBASE VERSUS THATMAP FOR ROSBASE            '/
     +        ' RENU WKMGTACT A 4 TO 3                                 '/
     +        ' COVER ACCESS WITH THATMAP FOR ACCESS                   ')
  717 IF (WKMA(4).EQ.4. OR .WKMA(5).EQ.5) GO TO 740
CCC         IF NO ROAD CLOSURES,ADD TRAILS LIKELY TO HAVE BECOME QUITE
CCC        HEAVILY USED TO 'ACCESS'; CHANGE 'ROSBASE' TO ACCOUNT FOR IMPACT
      IF (WKMA(7).NE.7) GO TO 780
      WRITE (17,7700)
 7700 FORMAT (' RENU WKMGTACT A 0 TO 1 THR 6 TO 8 THR 9              '/
     +        ' COVER ACCESS WITH THATMAP FOR ACCESS                   '/
     +        ' SPREAD THATMAP THR FRICTION TO 3                       '/
     +        ' RENU THATMAP A 4 TO 0 THR 2 AND 5 TO 3                 '/
     +        ' MINIMIZE ROSBASE VERSUS THATMAP FOR ROSBASE            ')
      GO TO 780
CCC        ACCOUNT FOR THE IMPACT OF ROAD CLOSURE ON ROS
  740 WRITE (17,7450)
 7450 FORMAT (' RENU WKMGTACT FOR MA45 A 0 TO 1 THR 3 TO 6 THR 9     '/
     +        ' SPREAD MA45 THR FRICTION TO 40                         '/
     +        ' RENU THATMAP FOR WINDOW A 0 TO 40 AND 1 TO 0 THR 39 ')
CCC           TEMPORARY ROAD CLOSURES ARE TREATED DIFFERENTLY THAN
CC            THAN THOSE WITH RESTORATION PLANNED.
      IF (WKMA(5).EQ.5) WRITE (17,7456)
 7456 FORMAT (' RENU THATMAP A 5 TO 0 THR 19 AND 0 TO 20 THR 40      '/
     +        ' MAXIMIZE ROSBASE VERSUS THATMAP FOR ROSBASE            ')
C      IF (WKMA(4).EQ.4) WRITE (17,7451)
C 7451 FORMAT (' RENU MA45 A 0 TO 5                                   '/
C    +        ' SPREAD THATMAP THR FRICTION TO 4                       '/
C    +        ' RENU THATMAP FOR MODFCN A 2 TO 0 THR 3 A 5 TO 4        ')
      WRITE (17,7452)
 7452 FORMAT (' RENU MA45 A 6 TO 4 TO 5                              '/
     +        ' ZAP MA45                                               '/
     +        ' COVER ACCESS WITH THATMAP FOR ACCESS                   '/
     +        ' RENU ACCESS A 1 TO 1 THR 4 AND 0 TO 5 THR 9            '/
CCC           THEN OUTLINE THE REMAINING ROADS IN THE WINDOW SURROUNDING
CCC           THE CLOSED ROAD; ROADS OUTSIDE THE MASKING ARE NOT CONSIDERED
     +        ' MULTIPLY WINDOW BY THATMAP                             '/
     +        ' SPREAD THATMAP THR FRICTION TO 20                      '/
CCC           NEXT THREE STMTS RECLASSIFY ROS IN A WAY APPROPRIATE
CCC           FOR ROADS WHICH UNDERGO NATURAL RESTORATION
     +        ' RENU THATMAP A 5 TO 20 AND 4 TO 4 THR 19 /             '/
     +        '              AND 2 TO 0 THR 3                          '/
     +        ' MULTIPLY THATMAP BY WINDOW                             '/
     +        ' RENU THATMAP A 5 TO 0                                  '/
     +        ' MINIMIZE ROSBASE VERSUS THATMAP FOR ROSBASE            ')
CCC         ADD TRAILS LIKELY TO HAVE BECOME QUITE HEAVILY
CCC         USED TO 'ACCESS'; THE ROAD CLOSURES ARE STILL BEING DEALT WITH
      IF (WKMA(7).EQ.7) WRITE (17,7453)
 7453 FORMAT (' RENU WKMGTACT A 0 TO 1 THR 6 TO 8 THR 9              '/
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```
     +          ' COVER ACCESS WITH THATMAP FOR ACCESS                       ')
CCC        ACCOUNT FOR ALL BUSY TRAILS AND PRIMITIVE
CCC        ROADS WITHIN THE WINDOW
      WRITE (17,7454)
 7454 FORMAT (' RENU ACCESS A 0 TO 1 THR 9 AND 1 TO 7 TO 5                   '/
     +          ' MULT THATMAP BY WINDOW                                     '/
     +          ' ZAP WINDOW                                                 '/
     +          ' SPREAD THATMAP THR FRICTION TO 3                           '/
     +          ' RENU THATMAP A 4 TO 0 THR 2 AND 5 TO 3                     '/
     +          ' MINIMIZE ROSBASE VERSUS THATMAP FOR ROSBASE                ')
CCC        RECLASSIFIES IN A WAY APPROPRIATE FOR TEMPORARY ROAD CLOSURE;
CCC        EVERYTHING OUTSIDE THE WINDOW RETAINS PREVIOUS ROS DESIGNATION.
C     IF (WKMA(4).EQ.4) WRITE (17,7455)
C 7455 FORMAT (' MINIMIZE ROSBASE VERSUS MODFCN FOR ROSBASE                 '/
C    +          ' ZAP MODFCN                                                 ')
CCC        ACCOUNT FOR TRAIL CONSTRUCTION BY ADDING TO ACCESS
C     IF (WKMA(6).EQ.6) WRITE (17,7600)
C 7600 FORMAT (' RENU WKMGTACT A 0 TO 1 THR 9 AND 8 TO 6                    '/
C    +          ' ADD THATMAP TO ACCESS FOR ACCESS                           ')
CCC        ACCOUNT FOR OWNERSHIP CHANGES; LAND EXCHANGE IN AND OUT OF
CCC        THE STUDY AREA.
  780 IF (WKMA(8).EQ.8 .OR. WKMA(9).EQ.9) WRITE (17,7800)
 7800 FORMAT (' RENU WKMGTACT A 0 TO 1 THR 7 AND 1 TO 8 AND 4 TO 9    '/
     +          ' COVER OWNERSHIP WITH THATMAP FOR OWNERSHIP                 ')
      WRITE (17,7990)
 7990 FORMAT (' ZAP WKMGTACT                                                 ')
      GO TO 999
C****************  IA IS CAPA, CAPB, OR CAPC  **************** INSERT 8
CCC     FEATURE-DEPENDENT CARRYING CAPACITY IS DETERMINED IN UNITS OF
CCC     RVD'S. RESULTS ARE PUT INTO 'TTCAP' FILE & ATTACHED TO AN IO UNIT
  800 DO 810 I=1,9
        CRN(I) = 0
        CSP(I) = 0.0
        CPR(I) = 0.0
  810   CONTINUE
      ICNT = ICNT + 1
      GO TO (820,840,860), ICNT
CCC                                                          +--¬ACCESS
CCC     'ACCESS' DEPENDENT CAPACITIES ARE CALCULATED        XX
CCC                                                          +---ROS
  820 DO 830 I=1,JCL
        NUM = IA(I)
        LDGT = NUM - (NUM/10 * 10)
        IF (LDGT.EQ.0 .OR. NUM.LT.20) GO TO 830
        IF (NUM.LT.30) GO TO 822
        IF (NUM.LT.50) GO TO 824
        IF (NUM.LT.60) GO TO 825
        GO TO 830
  822   CRN(LDGT) = CRN(LDGT) + 1
        GO TO 830
  824   CSP(LDGT) = CSP(LDGT) + 1.0
        GO TO 830
  825   CPR(LDGT) = CPR(LDGT) + 1.0
```

```
 830   CONTINUE
      WRITE (NP,8200) ((CRN(I),CSP(I),CPR(I)), I=1,9)
 8200 FORMAT ('-CAPA,B,&C #''S FOR',7X,'RN',9X,'SPNM',8X,'PR'/
     +          9( 23X, I5, 6X, F8.2, 3X, F8.2 /))
CCC        CAPACITIES ARE CALCULATED 1) FOR RN: ARTERIAL TRAVEL, COLLECTOR
CCC        TRAVEL, LOCAL TRAVEL, ROADSIDE CAMPING, HUNTING, AND TRAILS;
CCC        2) FOR SPNM: TRAILS (INCLUDING BUSY TRAILS) AND TRAIL-ASSOCIATED
CCC        CAMPING; AND 3) FOR PR: TRAILS AND TRAIL-ASSOCIATED CAMPING
      CCRN = CRN(2) *.19*150*3*.0035*165
      CCRN = CRN(3) *.20* 50*3*.007 *150 + CCRN
      CCRN = CRN(4) *.22* 20*3*.014 *150 + CCRN
      CCRN = (CRN(3)*.20 + CRN(4)*.22) *2*75*14/12*3*.45 + CCRN
      CCRN = (CRN(3)*.20 + CRN(4)*.22) *.5*90*8/12*.43 + CCRN
      CCRN = CRN(8) *.24*12*10/12*150*.43 + CCRN
      CCSP = (CSP(7) + CSP(8)) *.24*6*10/12*120*.65 * (1+.5*63/37*.67)
      CCPR = CPR(8) *.24*1.5*10/12*90*.8 * (1+63/37*.67)
      RETURN
CCC                                                                  ++---FEATURES
CCC     'FEATURE' DEPENDENT CAPACITIES ARE CALCULATED:   XXX
CCC       (MOUNTAIN PEAKS AND HIGH ROUTES)                           +-----ROS
 840 DO 850 I=1,JCL
        NUM = IA(I)
      IF ((NUM - NUM/100*100) .EQ. 0) GO TO 850
      NRO = NUM / 1000
      IF (NRO .LT. 3) GO TO 850
      NWD = NUM/100 - NUM/1000*10
      NHG = NUM - NUM/10*10
      HRT = NHG + 1
      IF (HRTN(HRT) .EQ. NHG) GO TO 845
        HRTN(HRT) = NHG
        NNWD = NWD + 2
        IF (NRO .EQ. 4) CSP(NNWD) = CSP(NNWD) + 1
        IF (NRO .EQ. 5) CPR(NNWD) = CPR(NNWD) + 1
 845 NMT = NUM/10 - NUM/100*10
      IF (NMT .EQ. 0) GO TO 850
        IF (NRO .EQ. 4) CSP(NWD) = CSP(NWD) + 1
        IF (NRO .EQ. 5) CPR(NWD) = CPR(NWD) + 1
 850   CONTINUE
CCC        CAPACITIES ARE CALCULATED 1) FOR SPNM: MTN PEAKS (NONWILD AND
CCC        WILDERNESS) AND HIGH ROUTES; AND 2) FOR PR: THE SAME THINGS
      CCSP = (CSP(1) + .5*CSP(2)) *18*10/12*180*.65 + CCSP
      CCSP = (CSP(3) + .5*CSP(4)) *12*90 + CCSP
      CCPR = (CPR(1) + .5*CPR(2)) *18*10/12*180*.65 + CCPR
      CCPR = (CPR(3) + .5*CPR(4)) *12*90 + CCPR
      WRITE (NP,8200) ((CRN(I),CSP(I),CPR(I)), I=1,9)
      RETURN
CCC                                      WILDERNESS OR NOT ---+ +---WATER TYPE
CCC     'WATER' DEPENDENT CAPACITIES ARE CALCULATED:     XXXX
CCC                                                   ROS ---+ +---TRAIL CLOSEBY
 860 DO 870 I=1,JCL
        NUM = IA(I)
        LDGT = NUM -(NUM/10 *10)
        IF (LDGT.EQ.0) GO TO 870
```

```
      IF (NUM.GT.4000) GO TO 863
      IF (NUM.LT.2000) GO TO 870
  862 CRN(LDGT) = CRN(LDGT) + 1
      GO TO 870
CCC     SECOND DIGIT = 0 FOR NEARBY TRAIL, 1 FOR NO TRAIL NEARBY
CCC      THIRD DIGIT = 0 FOR NONWILDERNESS, 1 FOR WILDERNESS; IN THE R.D.
  863 DGT2 = ((NUM/10) - (NUM/100 * 10))
      TRAIL = 1.- DGT2*.67
      DGT3 = ((NUM/100) - (NUM/1000 * 10)) - 1
      WILD = 1.- DGT3*.33
      IF (LDGT.NE.6) GO TO 864
        TRAIL = 1.
        WILD = 1.
  864 IF (NUM.GT.5000) GO TO 865
      CSP(LDGT) = CSP(LDGT) + WILD*TRAIL
      GO TO 870
  865 CPR(LDGT) = CPR(LDGT) + WILD*TRAIL
  870 CONTINUE
     WRITE (NP,8200) ((CRN(I),CSP(I),CPR(I)), I=1,9)
CCC     CAPACITIES ARE CALAULATED 1) FOR RN: STREAM FISHING, LAKE FISHING,
CCC     MISC., AND TOTAL FOR RN; 2) FOR SPNM: LAKESIDE CAMPING (INCLUDING
CCC     DAY USE), MISC., STREAM FISHING, AND TOTAL FOR SPNM; AND 3) FOR PR:
CCC     LAKESIDE CAMPING (INCLUDING DAY USE), MISC., AND TOTAL FOR PR
     CCRN = CRN(6) *.24*86 + CCRN
     SZLAK = (.25*CRN(1) + .75*CRN(2) + CRN(3) + .5*CRN(4)) * 25.6
     CCRN = SZLAK *9.8 + CCRN
     TTCAP(2) = CCRN * 1.05
     CMPSPT = CSP(1)*5 + CSP(2)*10 + (25.6*CSP(3) + 12.8*CSP(4)) *.2
     CCSP = CMPSPT *136.5*1.413 + CCSP
     CCSP = CCSP * 1.1
     CCSP = CSP(6) *.24*86 + CCSP
     TTCAP(4) = CCSP
     CMPSPT = CPR(1)*3 + CPR(2)*6 + (25.6*CPR(3) + 12.8*CPR(4))*.2
     CCPR = CMPSPT *126*1.38 + CCPR
     TTCAP(5) = CCPR * 1.05
     WRITE (13,8800) (TTCAP(I), I=1,5)
 8800 FORMAT (5I10)
     WRITE (NP,8900) (TTCAP(I), I=1,5)
 8900 FORMAT('-FEATURE-DEPENDENT CARRYING CAPACITIES ARE CALCULATED',
    +        ' AS:' //14X,'RN',17X,'SPNM',7X,'PR',//5I10)
     RETURN
C*************** IA IS A MAP AT YEAR 15 ******************* INSERT 9
CCC      THIS POSTPACKS A MAP IN RUN LENGTH ENCODED FORMAT
CCC      APPROPRIATE FOR USE IN A LATER RUN OF 'MAP'
  900 DO 930 IR=1,165
        LINE(1) = IR
        LINE(2) = IA((IR-1)*130 + 1)
        LVAL = LINE(2)
        L = 3
        DO 910 IC=2,130
          NVAL = IA((IR-1)*130 + IC)
          IF (NVAL.EQ.LVAL) GO TO 910
          LINE(L) = IC - 1
```

```
         IF (L.EQ.25) GO TO 905
         LINE(L+1) = NVAL
         L = L + 2
         LVAL = NVAL
         GO TO 910
  905    WRITE (19,9200) (LINE(I), I=1,25)
         LINE(1) = 0
         LINE(2) = NVAL
         LVAL = NVAL
         L = 3
  910    CONTINUE
       LINE(L) = 130
       L = L + 1
       DO 920 I=L,26
         LINE(I) = 0
  920    CONTINUE
       WRITE (19,9200) (LINE(I), I=1,25)
 9200  FORMAT  (25I3)
  930 CONTINUE
      RETURN
  999 ENDFILE 17
      REWIND 17
      RETURN
CCC     ARE YOU HAVING FUN?
      END
```

```
C***************************************************************************
C**                                                                      ***
C**   PARTICIPATION SUBMODEL: GIVES PROJECTED PARTICIPATION BY RECREATION  ***
C**   OPPORTUNITY CLASS FOR EACH YEAR.                                    ***
C**                                                                      ***
C***************************************************************************
C
      DIMENSION PRATIO(6), TREND(20), TRNSFM(20,5)
      INTEGER   POP(6,4), PARTIC(20,6), ACPART, FUPART(5,16)/80*0/, CHA, YRCHA
      READ (8,1000) ((POP(IAGE,IY), IY=1,4), IAGE=1,6),
     +              ((PARTIC(IACT,IAGE), IAGE=1,6), IACT=1,20),
     +              (TREND(IACT), IACT=1,20),
     +              ((TRNSFM(IACT,IOPP), IOPP=1,5), IACT=1,20)
 1000 FORMAT (6(4I7/), 20(6I6/), 20F4.3/ 20(5F4.2/))
C  CALCULATIONS OF FUTURE PARTICIPATION FOR IYEAR=1,6,11,16; THEN FILLED IN
C  FOR OTHER IYEARS
      DO 170 IY=1,4
        IYEAR = 5 * IY - 4
        IF (IY.EQ.1) GO TO 116
C            POPULATION CHANGE BY AGE CLASS
        DO 110 IAGE = 1,6
          FUTPOP = POP(IAGE,IY)
```

```
          PRATIO(IAGE) = FUTPOP / POP(IAGE,IY-1)
  110    CONTINUE
  116    DO 140 IACT = 1,20
          ACPART = 0
CCC         TOTAL PROJECTED PARTICIPATION FOR EACH ACTIVITY, ACCOUNTING FOR
CCC         POPULATION CHANGES AND TRENDS
          DO 120 IAGE = 1,6
            IF (IY.EQ.1) GO TO 117
            PARTIC(IACT,IAGE)=PARTIC(IACT,IAGE)*PRATIO(IAGE)*(1+TREND(IACT))
  117       ACPART = ACPART + PARTIC(IACT,IAGE)
  120     CONTINUE
CCC  ACTIVITY PARTICIPATION TRANSFORMED TO OPPORTUNITY CLASS PARTICIPATION
          DO 130 IOPP = 1,5
            FUPART(IOPP,IYEAR) = FUPART(IOPP,IYEAR) + TRNSFM(IACT,IOPP) *
     +                           ACPART
  130     CONTINUE
  140    CONTINUE
CCC       THIS FILLS IN THE OTHER YEARS
        IF (IY.EQ.1) GO TO 170
        DO 160 IOPP = 1,5
          CHA = FUPART(IOPP,IYEAR) - FUPART(IOPP,IYEAR-5)
          YRCHA = CHA / 5
          DO 150 NY = 1,4
            FUPART(IOPP,IYEAR-NY) = FUPART(IOPP,IYEAR) - NY * YRCHA
  150     CONTINUE
  160   CONTINUE
  170 CONTINUE
        WRITE (6,1100)
 1100   FORMAT ('-FUTURE PARTICIPATION IN RVD''S IS PROJECTED AS:',
     +         //11X,'YEAR', 11X, 'RN', 19X, 'SPNM', 18X, 'PR'//)
      DO 180 IYEAR = 1,16
        NY = 1979 + IYEAR
        WRITE (6,1200)  NY, (FUPART(IOPP,IYEAR), IOPP = 1,5)
 1200   FORMAT (' ',10X, I4, 3X, I1, 3X, I8, 8X, I1, 6X, I6, 15X, I6)
  180 CONTINUE




C************************************************************************
C**                                                                   ***
C**  SUITABILITY SUBMODEL: OUTPUTS FROM THE OPPORTUNITY AND PARTIC.   ***
C**  SUBMODELS ARE COMPARED FOR DEFICITS AND SURPLUSSES OF RECREATION ***
C**  OPPORTUNITY (BY ROS CLASS) AFTER CONVERSION OF ACRES TO RVD'S    ***
C**                                                                   ***
C************************************************************************
      INTEGER*2  MS(5), LOS(5), ROAREA(5,16)
      INTEGER*4  TCAP(5,16)/80*0/, DIF, TDIF, TDEF(5)/5*0/,
     +           DEF(5,16)/80*0/,TSURP(5)/5*0/, SURP(5,16)/80*0/
      REAL       WPU(5), PAOT(5),POPL/1.0/
      READ (8,2000)  (MS(IOPP), IOPP=1,5), (WPU(IOPP), IOPP=1,5),
```

```
     +                (LOS(IOPP), IOPP=1,5), (PAOT(IOPP), IOPP=1,5)
 2000 FORMAT (5I4/ 5F5.2/ 5I3/ 5F6.3)
      READ (18,2100)  ((ROAREA(IOPP,IYEAR), IYEAR=1,16), IOPP=1,5)
 2100 FORMAT (5(16I5/))
       WRITE(6,2110) ((ROAREA(IOPP,IYEAR), IYEAR=1,16),IOPP=1,5)
 2110 FORMAT ('-TOTAL GRID CELLS (25.6 ACRES PER CELL) OF RO AREA ARE:'
     +        /5(16I5/))
      IFLAG = 0
  201 DO 220 IOPP = 1,5
        IF (IOPP.EQ.1.OR.IOPP.EQ.3) GO TO 220
        ADJFTR = MS(IOPP) * WPU(IOPP) * LOS(IOPP) / 12
        PCOEF = PAOT(IOPP) * ADJFTR
        DO 210 IYEAR = 1,16
          TCAP(IOPP,IYEAR) = PCOEF * ROAREA(IOPP,IYEAR) * 25.6
C       WRITE(6,2120) TCAP(IOPP,IYEAR),PCOEF
C 2120 FORMAT (' ',I10, F8.3)
          NY = 1979 + IYEAR
          DIF = FUPART(IOPP,IYEAR) - TCAP(IOPP,IYEAR)
          IF (DIF.LT.0) GO TO 205
          TDEF(IOPP) = TDEF(IOPP) + DIF
          DEF(IOPP,IYEAR) = +DIF
C       WRITE (6,2150) TDEF(IOPP),DEF(IOPP,IYEAR)
          GO TO 210
  205     TSURP(IOPP) = TSURP(IOPP) - DIF
          SURP(IOPP,IYEAR) = -DIF
C       WRITE (6,2150) TSURP(IOPP),SURP(IOPP,IYEAR)
C 2150 FORMAT (2I15)
  210   CONTINUE
  220 CONTINUE
      IF (IFLAG.EQ.0) WRITE (6,2175)
     +            ((TCAP(IOPP,IYEAR), IOPP=1,5), IYEAR=1,16)
 2175 FORMAT ('-CARRYING CAPACITIES ARE PROJECTED AS:'/ 16(5I7/))
      TDIF = TSURP(2) - TDEF(2)
      WRITE (6,2200) TDIF
 2200 FORMAT ('-THE TOTAL (SURPLUS+ / DEFICIT-) OF ROADED NATURAL',
     +        ' OPPORTUNITY IS PROJECTED AS', I10, ' RVD''S')
      TDIF = TSURP(4) - TDEF(4)
      WRITE (6,2210) TDIF
 2210 FORMAT ('-THE TOTAL (SURPLUS+ / DEFICIT-) OF SEMI-PRIMITIVE ',
     +        'NON-MOTORIZED OPPORTUNITY IS', I10, ' RVD''S')
      TDIF = TSURP(5) - TDEF(5)
      WRITE (6,2220) TDIF
 2220 FORMAT ('-THE TOTAL (SURPLUS+ / DEFICIT-) OF PRIMITIVE OPPORTUNITY IS',
     +        I10, ' RVD''S')
      IF (IFLAG-1) 235,285,299
  235 WRITE (6,2300)
 2300 FORMAT ('-DEFICITS IN RECREATION OPPORTUNITY ARE PROJECTED AS:')
      DO 250 IOPP = 1,5
        GO TO (250,256,250,257,258), IOPP
  256   WRITE (6,2500)
        GO TO 259
  257   WRITE (6,2510)
        GO TO 259
```

```
 258    WRITE (6,2520)
2500    FORMAT(20X, 'IN ROADED NATURAL OPPORTUNITY:')
2510    FORMAT (20X, 'IN SEMI-PRIMITIVE NON-MOTORIZED OPPORTUNITY:')
2520    FORMAT (20X, 'IN PRIMITIVE OPPORTUNITY:')
 259    DO 240 IYEAR = 1,16
          NY = 1979 + IYEAR
          IDEF = DEF(IOPP,IYEAR)
          IF (IDEF.NE.0) WRITE (6,2400) IDEF, NY
2400      FORMAT (' ', 40X, I7, ' RVD''S IN', I5)
 240    CONTINUE
 250  CONTINUE
      WRITE (6,2550)
2550  FORMAT ('-SURPLUSSES IN RECREATION OPPORTUNITY ARE PROJECTED AS:')
      DO 270 IOPP = 1,5
        GO TO (270,276,270,277,278), IOPP
 276    WRITE (6,2500)
        GO TO 279
 277    WRITE (6,2510)
        GO TO 279
 278    WRITE (6,2520)
 279    DO 260 IYEAR = 1,16
          NY = 1979 + IYEAR
          ISURP = SURP(IOPP,IYEAR)
          IF (ISURP.NE.0) WRITE (6,2600) ISURP, NY
2600      FORMAT (' ', 40X, I8, ' RVD''S IN', I5)
 260    CONTINUE
 270  CONTINUE
 285  DO 290 IYEAR = 2,16
        DO 280 IOPP = 1,5
          FUPART(IOPP,IYEAR) = FUPART(IOPP,IYEAR) * 1.1 * POPL
 280    CONTINUE
 290  CONTINUE
      IFLAG = IFLAG + 1
      IF (IFLAG.EQ.1) WRITE (6,2900)
2900  FORMAT ('-THE NEXT THREE LINES ARE WITH A POPULATION '/
    +         ' PROJECTION 10% HIGHER THAN ABOVE.')
      IF (IFLAG.EQ.2) WRITE (6,2910)
2910  FORMAT ('-THE NEXT THREE LINES ARE WITH A POPULATION '/
    +         ' PROJECTION 10% LOWER THAN THE FIRST ABOVE.')
      POPL = .818
      DO 295 IOPP = 1,5
        TDEF(IOPP) = 0
        TSURP(IOPP) = 0
 295    CONTINUE
      GO TO 201
 299  STOP
      END
```

FESSEL

```
$SIGNON  AACL PRIO=N
$CRE -VALS SIZE=321P
$CRE -CATS SIZE=13P
$R MAPSET.O 1=-VALS 2=-MAPS 3=-CATS
$R 10.O+MFO+INSO+MMO+MBO 1=-VALS 2=-MAPS 3=-CATS 8=FDDATA 13=FDCAP
WRITE ON 6
READ ON 8
NOTE
NOTE     FEATURE - DEPENDENT CARRYING CAPACITY
NOTE
MAP 10 FOR 10MAP
MULT ROS16 BY 10MAP FOR 10ROS16
RENU OWNER16 FOR SKYLAND A 0 TO 3 THR 4 AND 1 TO 2
MULT SKYLAND BY ACC16 FOR CAPA
ADD 10ROS16 TO CAPA FOR CAPA
DES CAPA
NOTE
NOTE   CAPA IS FOR ACCESS RELATED CAPACITY
NOTE   INSERT 8 CALCULATES CAPACITY IN RVD'S PER YEAR
INSERT CAPA ONTO 8
ZAP CAPA
NOTE
NOTE    CAPB IS IS A 4 DIGIT FEATURE CAPACITY MAP
NOTE   ROS TYPE, WILDERNESS OR NOT, MTN PEAK, HIGH ROUTE
NOTE
RENU ACC16 FOR HGRT A 0 TO 1 THR 8
ADD 10ROS16 TO HGRT
RENU THATMAP A 0 TO 10 TO 20 THR 30 TO 40 TO 50
CLUMP THATMAP AT 3 FOR CAPB
DES CAPB
MULT SKYLAND BY FEATURES BY 10MAP
ADD THATMAP TO CAPB FOR CAPB
MAP 100 FOR 100MAP
RENU OWNER16 A 0 TO 3 TO 4
MULT THATMAP BY 100MAP FOR 3DWILD
MULT 10ROS16 BY 100MAP FOR 4DROS16
ADD 3DWILD TO 4DROS16 TO CAPB FOR CAPB
INSERT CAPB ONTO 8
ZAP CAPB
NOTE
NOTE    CAPC IS A 4 DIGIT WATER CAPACITY MAP
NOTE  ROS TYPE, WILDERNESS OR NOT, NEARBY TRAIL OR NOT, WATER-TYPE
NOTE
MULT SKYLAND BY WATER FOR CAPC
RENU ACC16 A 0 TO 1 THR 9 AND 1 TO 7 TO 8
SPREAD THATMAP TO 2
RENU THATMAP A 0 TO 1 AND 1 TO 2
```

```
MULT THATMAP BY 10MAP
ADD CAPC TO THATMAP TO 3DWILD TO 4DROS16 FOR CAPC
INSERT CAPC ONTO 8
STOP
$SIGNOFF
```

APPENDIX C: MAP ANALYSIS PACKAGE

The following write-up is taken from documentation provided with the Map Analysis Package (MAP). This computer package is being developed in fulfillment of doctoral requirements by C.D.Tomlin (1980). MAP is available from Yale University School of Forestry and Environmental Studies.

The Map Analysis Package is a set of computer programs which provide for the encoding, storage, analysis, and display of cartographic information. Use of the package is generally analogous to the use of traditional techniques involving conventional geographic maps. Data processing capabilities are organized as a series of primitive operations which may be flexibly combined to perform a variety of complex map analyses. Operations are specified in an intuitive manner through a user-oriented command language of English-like phrases which does not require formal knowledge of computer programming.

The Map system is written in FORTRAN IV and may be implemented for either or both interactive and batch processing. The system uses a grid-cell data structure and sequential processing of primitive operations which are functionally independent, but applied to a common data base. By controlling the order in which these operations are executed and using the common data base to store intermediate results for subsequent processing, a wide array of analytical cartographic models may be implemented. Input data may exist in the form of grid-cells, digitized points, lines or polygons output may be produced in the form of pageprint maps of line-plotter graphics.

The operations which make up the Map Analysis Package are listed below.[Table 18] Note that each is associated with one of five major groups according to the way it relates to the flow of information between programs, data files and input or output media. The analytical operations are sub-grouped with respect to the major classes of reclassifying map categories, overlaying maps, measuring cartographic distance and connectivity, and characterizing cartographic neighborhoods.

TABLE 18

MAP COMMANDS BY TYPE

DATA STORAGE	DATA ANALYSIS OPERATIONS (By Class) (RECLASSIFY)	(OVERLAY)	(DISTANCE)	(NEIGHBORS)	DISPLAY	PROGRAM CONTROL	USER-DEFINED
expose	copy	add	radiate	clump	contour	overlook	insert
point	ruler	average	spread	differentiate	display	read	
identify	renumber	cover	stream	orient	describe	remember	
label	size	cross		profile	echo	remit	
map	slice	divide		respace	explain	stop	
protect	survey	expo-nentiate		scan	flowchart	write	
rename		maximize		span	screen		
scale		minimize			inform		
strip		multiply			list		
trace		score			note		
grid		subtract			outline		
zap					quiet		
					print		
					shade		

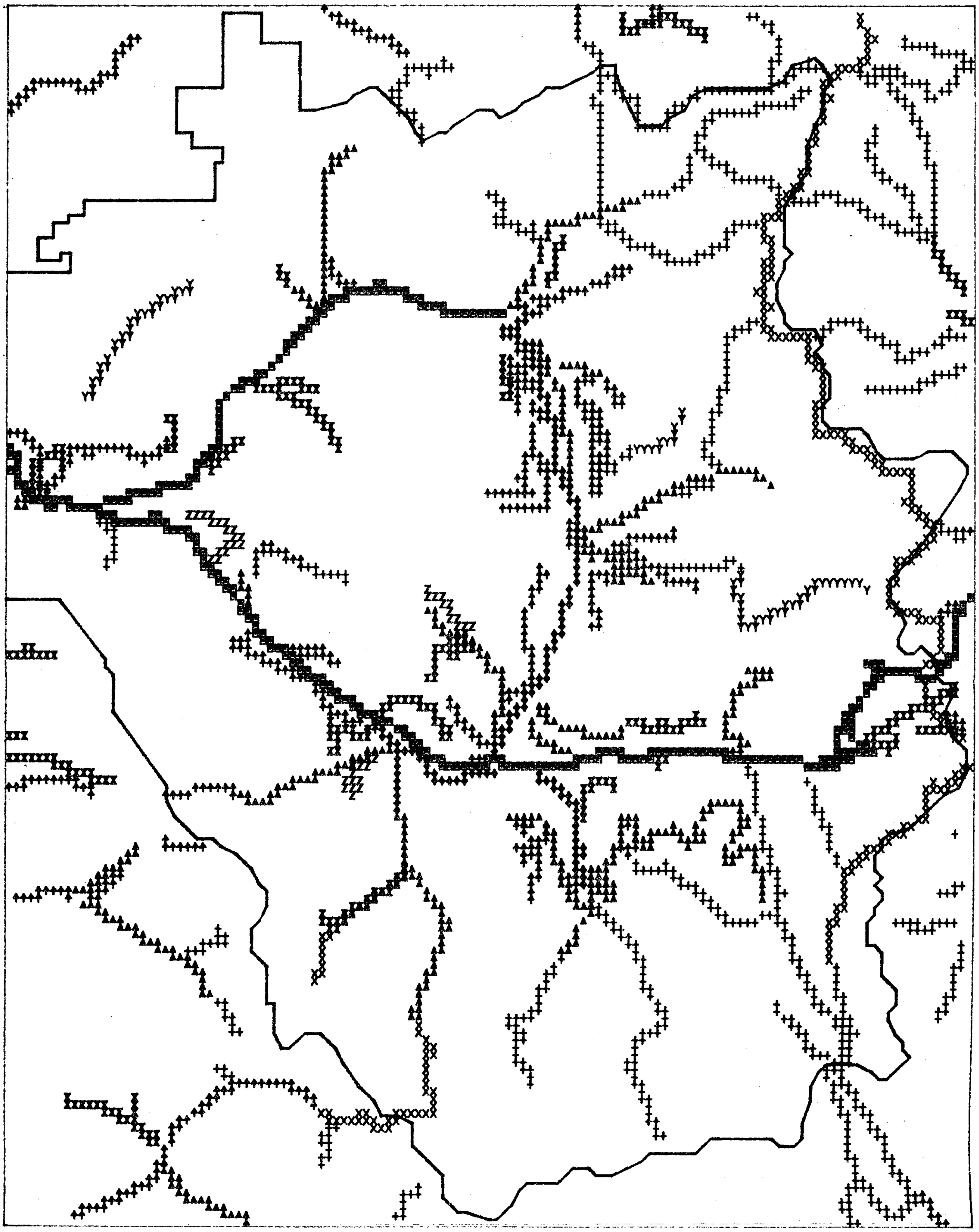
APPENDIX D: BASE MAPS FOR THE OPPORTUNITY SUBMODEL

As a cartographic model, the opportunity submodel of the Recreation Allocation Routine uses computer representations of maps as input data. (Table 8 lists the map names, codes, and categories.) These maps are analyzed in a grid cell form using operations of the Map Analysis Package. Each map is represented as a grid work of 21,450 cells arrayed in 165 rows and 130 columns. As displayed by the MAP package, a line printer types a symbol in each cell space on the output page. The resulting map has a vertical exaggeration due to the rectangular shape of a print character, does not have the boundaries of subareas drawn in, and is often cluttered in appearance. Employing other conputer facilities, the base data maps included here have been plotted in a more appealling form with a Hewlett Packard plotter. The ROS base map appears earlier in the thesis (Figure 8). Other base maps appear in this appendix in the following order:

1) ACCESS;
2) OWNERSHIP;
3) SLOPE;
4) VEGETATION;
5) ATTRACTIVENESS;
6) WATER; AND
7) FEATURES.

FIGURE 17

BASE MAP FOR ACCESS



⊞ HIGHWAY
♦ ARTERIAL
▲ COLLECTOR
✝ LOCAL ROAD
ẍ PRIMITIVE ROAD

Z CLOSED ROAD
X BUSY TRAIL
+ TRAIL, GENERAL
Y HIGH ROUTE

FIGURE 18

BASE MAP FOR OWNERSHIP

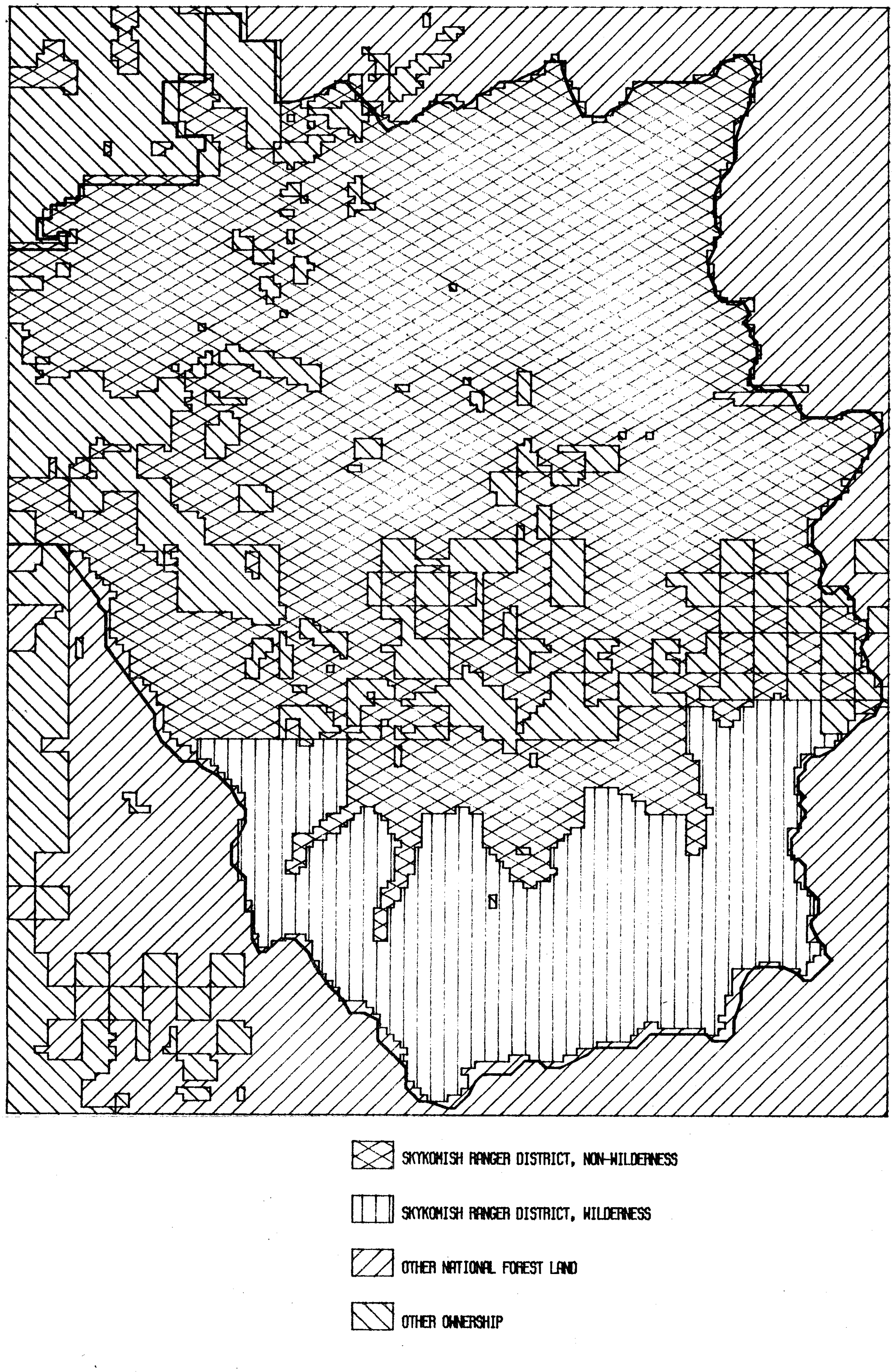


FIGURE 19

BASE MAP FOR SLOPE

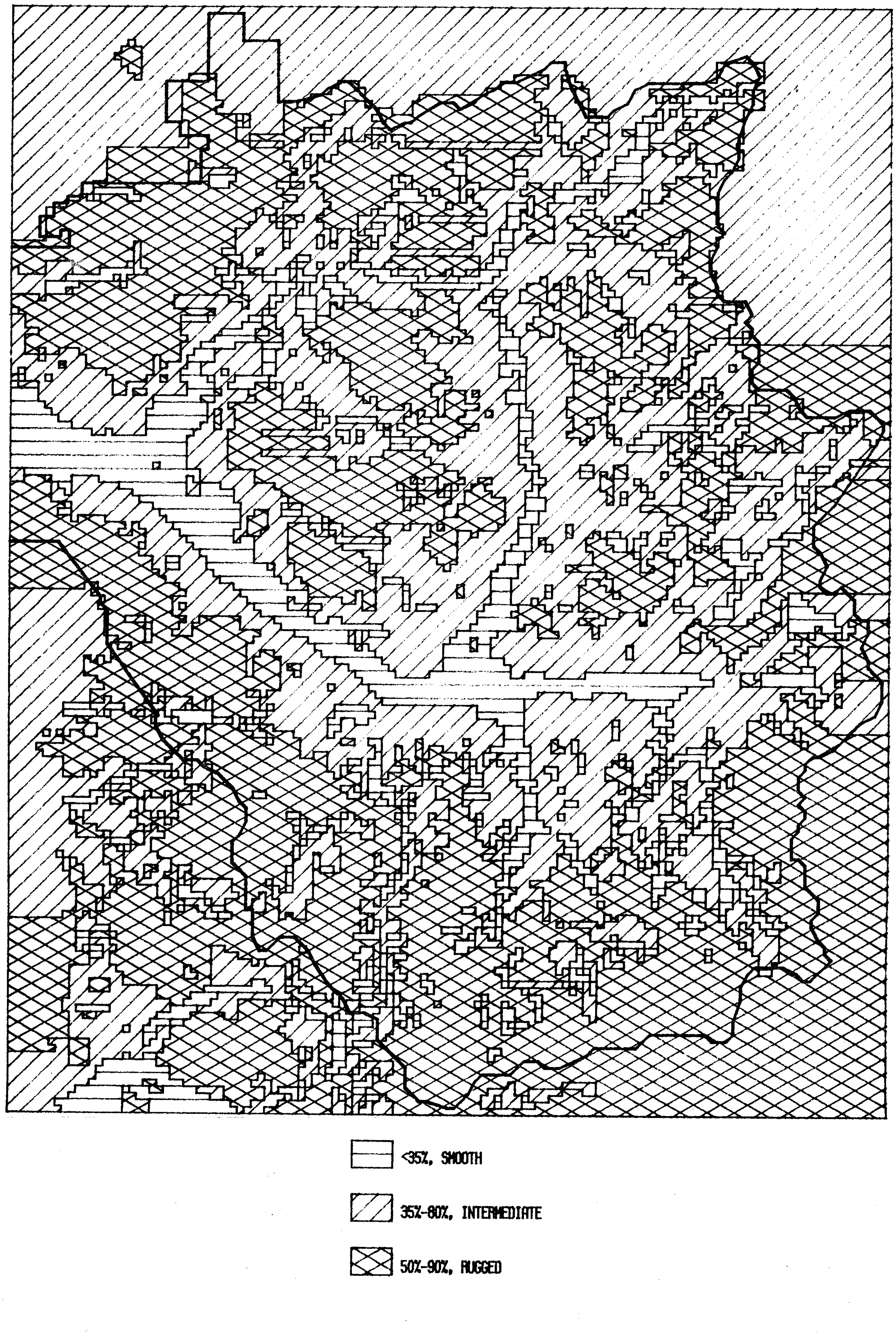


FIGURE 20

BASE MAP FOR VEGETATION

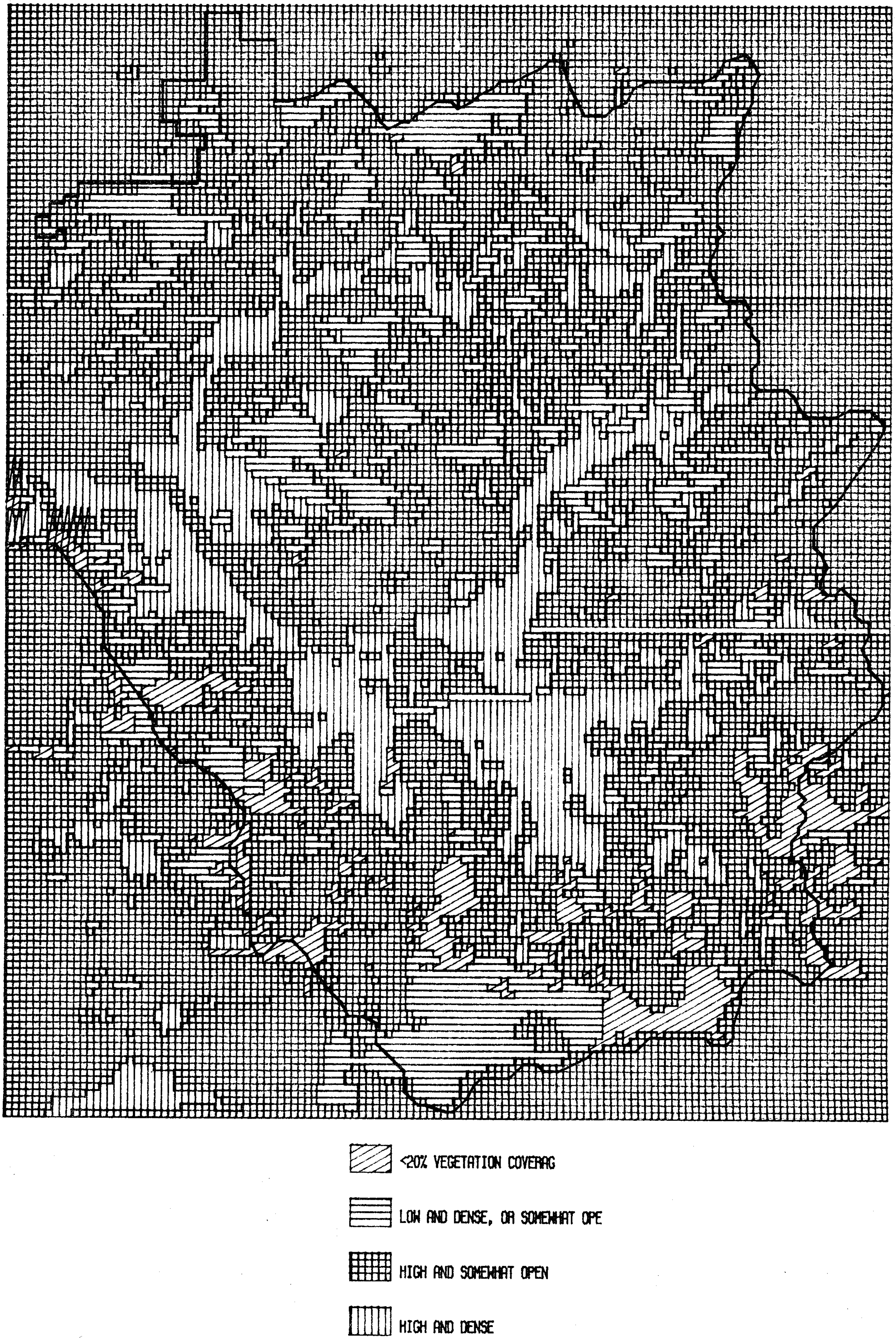


FIGURE 21

BASE MAP FOR ATTRACTIVENESS

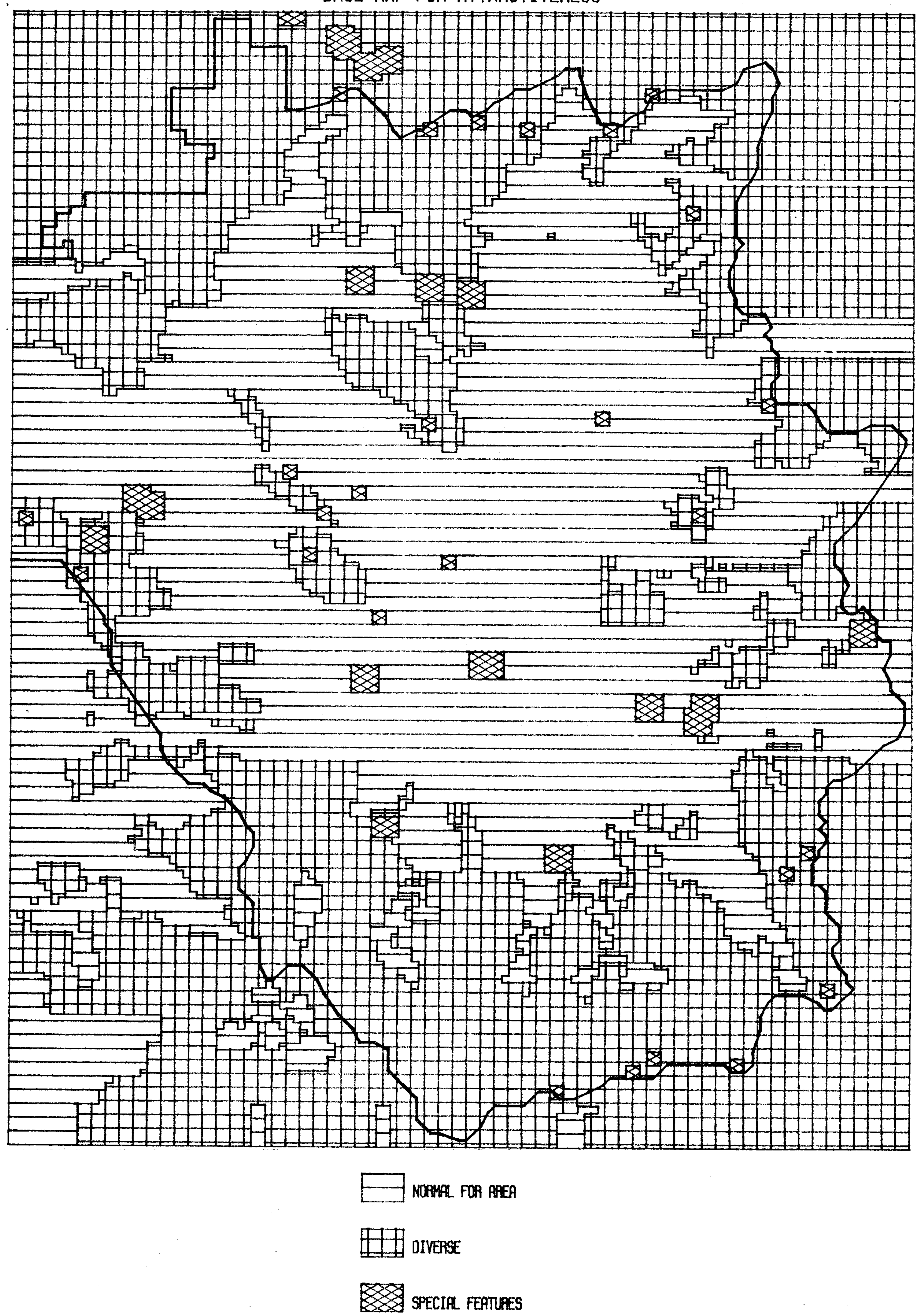
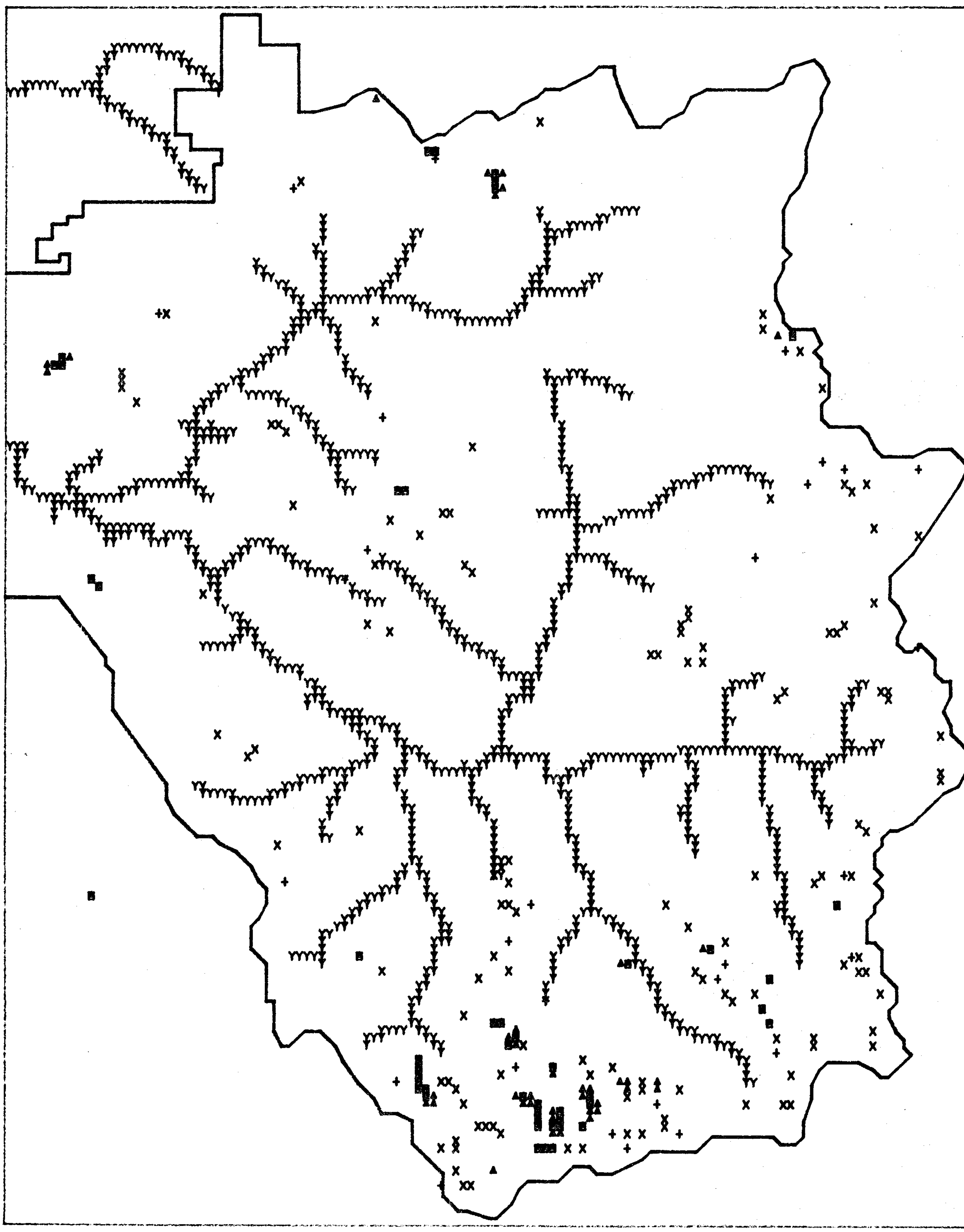


FIGURE 22

BASE MAP FOR WATER



× 1-12 ACRE LAKE

\+ 12-25 ACRE LAKE

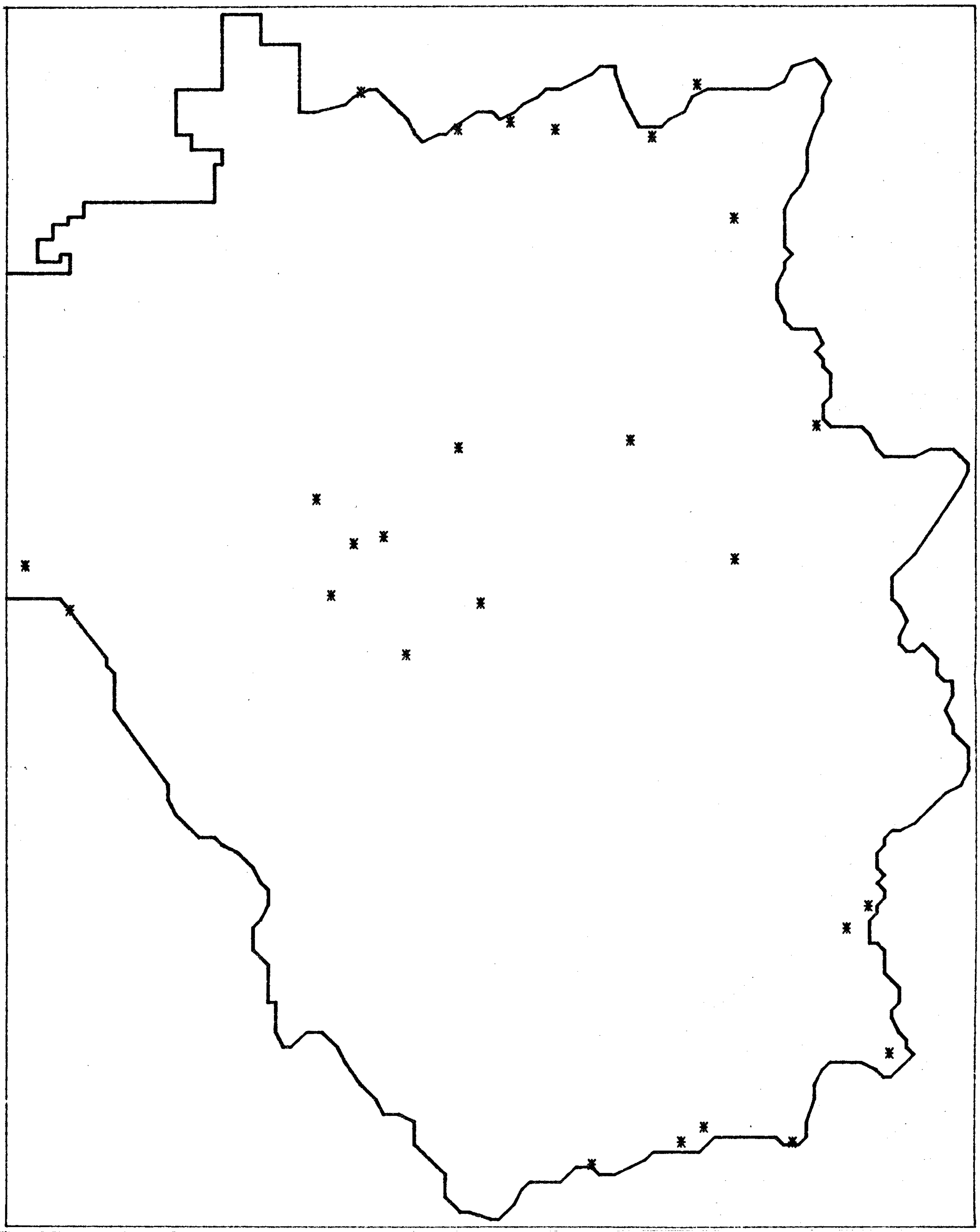
▣ LARGER LAKE, MOST OF GRID CELL COVERED

▲ LARGER LAKE, ABOUT HALF OF CELL COVERED

Y FISHABLE STREAM

FIGURE 23

BASE MAP FOR FEATURES



* MAJOR PEAK

APPENDIX E: INPUT DATA TO PARTICIPATION SUBMODEL

Input data for the participation submodel of the Recreation Allocation Routine consist of four arrays. One array contains the base year recreation participation for each of twenty activity types broken down into five age classes (Table 19). At each time step, participation is projected and tabulated. In the first stage of the projection, the participation data are increased in proportion to increases in population by age class (Table 20). The participation as totalled for each activity is further increased by trend factors which account for destination substitution and activity-preference shifts (Table 21). Transformation factors (Table 22) are then used to disaggregate the participation per activity into opportunity classes. Then the participation is totalled for each opportunity class.

TABLE 19

BREAKDOWN OF BASE YEAR (1980) RECREATION PARTICIPATION BY AGE CLASS

Activity	Base Year Partic. *	Breakdown By Age Class (in RVD's) 0-9	10-19	20-34	35-49	50-64	65+
Driving, auto	413	45	41	161	66	58	37
Driving, 4wd	none	-	-	-	-	-	-
Driving, cycle	102	1	34	58	7	1	1
Bicycling	none	-	-	-	-	-	-
Hiking, day	11996	1559	1679	4079	2159	1559	960
Hiking, extended	32338	2587	3881	14875	8408	2264	646
Horseback riding	4751	475	1283	1900	808	190	95
Fishing	19109	2102	2866	5924	4013	2102	1911
Hunting	6340	190	697	2916	1395	634	507
Nature study	1446	58	145	636	1157	174	145
Picnicking	6198	930	806	2541	1054	434	372
Camping	64467	7736	11604	21274	14183	6447	3868
Collecting	7000	1120	840	2380	1330	840	490
Viewing, exhibits	103	4	10	45	21	12	10
Viewing, wildlife	1446	58	145	636	289	174	145
Viewing, scenery	130459	5218	13046	57402	26092	15655	13046
Boating, motorized	none	-	-	-	-	-	-
Boating, nonmotor.	2066	165	393	930	351	123	83
Water sports	2582	439	852	903	258	103	26
Climbing	1859	-	297	1078	409	74	-

* From U.S.Forest Service RIM data for dispersed recreation in Skykomish Ranger District.

TABLE 20

FORECASTED AGE CLASS POPULATION
FOR KING AND SNOHOMISH COUNTIES (1980-1995)

Age Class	1980	1985	1990	1995
0-9	237,408	278,210	319,239	333,986
10-19	259,290	246,730	251,416	291,773
20-34	479,040	533,825	534,199	507,401
35-49	274,334	357,496	457,568	554,401
50-64	211,213	214,047	219,435	257,609
65+	145,758	167,638	188,110	204,289
Total	1,607,043	1,797,946	1,969,967	2,149,748

Source: Washington Office of Financial Management, 1977 Washington State, County Population Forecasts By Age and Sex - 1970-2005, Population, Enrollment, Economic Studies Division, State Printing Office, Olympia, Washinghton

TABLE 21

FIFTEEN YEAR TRENDS DUE TO DESTINATION
SUBSTITUTION AND PREFERENCE SHIFTS

Activity	Assigned Trend Factor
Driving, auto	17%
Driving, 4wd	0%
Driving, cycle	0%
Bicycling	0%
Hiking, day	37.5%
Hiking, extended	37.5%
Horseback riding	17%
Fishing	17%
Hunting	0%
Nature study	17%
Picnicking	17%
Camping	37.5%
Collecting	17%
Viewing, exhibits	17%
Viewing, wildlife	17%
Viewing, scenery	17%
Boating, motorized	0%
Boating, nonmotor.	17%
Water sports	17%
Climbing	17%

TABLE 22

COEFFICIENTS USED TO TRANSFORM PARTICIPATION BY ACTIVITY TO PARTICIPATION BY OPPORTUNITY CLASS (in percentages)

Activities	ROS Class RU	RN	SPNM	PR
Driving, auto	10	90		
Driving, 4wd		100		
Driving, cycle	5	95		
Bicycling	30	70		
Hiking, day	10	35	55	
Hiking, extended		5	50	45
Horseback riding		20	50	30
Fishing		45	30	25
Hunting		70	15	15
Nature study	35	45	15	5
Picnicking	50	40	10	
Camping		65	15	20
Collecting	35	45	15	5
Viewing, exhibits	40	60		
Viewing, wildlife	20	60	10	10
Viewing, scenery	10	60	20	10
Boating, motorized		100		
Boating, nonmotor.		70	20	10
Water sports	45	30	15	10
Climbing		20	40	40

APPENDIX F: GLOSSARY

A number of terms used repeatedly in the study are defined here for the convenience of the reader:

Dispersed recreation is scattered, individual outdoor recreation activities normally not identified with developed facilities. Recreation "refers to the human emotional and inspirational experience arising out of ... activity (or planned inactivity) undertaken because one wants to do it." (Clawson and Knetsch, 1966)

Recreation opportunity is defined as "the availability of a real choice for a user to participate in a preferred activity within a preferred setting, in order to realize those satisfying experiences which are desired." (USDA, 1980c)

"A recreational experience is the psychological and physiological result from engaging in a specific recreation activity within a specific setting."(Driver and Brown, 1978) A recreational engagement, i.e. the recreational experience in a broader sense, is a bundle of recreational experiences deriving from anticipation and preparation for, travel to, on-site activity during, travel from, and recall of a recreational occasion (Clawson and Knetsch, 1966).

The quality of recreation experience is "the degree to which a recreation experience ... normally contributes to the physical or psychic well-being of recreationists."(Wagar, 1961) Stankey (1972) gives a similar definition with the phrase "the extent to which the motivations and objectives of the visitor are fulfilled." As Stankey states, judging the extent of such fulfilment "hinges upon identifying the appropriate portion of the user population which specifically seeks each opportunity type."

Planning and management are closely allied terms. Management sets objectives (policy level) and implements practices (operational level), and within this setting planning is done to specify how to meet the objectives. Forest management is taken as the manipulation of the forest environment to produce the mix of products desired by the owners. Also, it is the "organized, intelligent attempt to select the best available alternatives to achieve specific goals." (Goddard, 1972)

Participation and opportunity are parallel terms to economic demand and economic supply, respectively. Where demand and supply are schedules of utility-quantity relationships, a level of participation (opportunity) would be a point on a schedule, or curve, of demand (supply). While the appropriate demand and supply relationships would be cumbersome to use, if available, figures for participation and opportunity are convenient to collect and to use. It should be kept in mind that: participation figures do not reflect demand that goes unexpressed for some reason, i.e. latent demand; participation is to some degree dependent on the type, location, and amount of opportunity available; and some of the opportunity available may be ineffective in that it is not known about, or is inaccessible. The terms demand and supply are used interchangeably in this study with participation and opportunity, respectively, except where the economic meanings are noted.

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