



A natural resource analysis system for outdoor recreation
by Paul Eric Nordstrom

A thesis submitted to the Graduate Faculty in partial fulfillment of the requirements for the degree of
DOCTOR OF PHILOSOPHY in Crop and Soil Science
Montana State University
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Abstract:

Increasing public demand for outdoor recreation, coupled with public concern for proper land use and land management, has strengthened the role of natural resource analysis in the outdoor recreation planning process. The natural resource analysis system, developed by this research, presents guidelines for establishing a relationship between natural resources and individual outdoor recreation activities. For each individual outdoor recreation activity: the natural resource factors critical to the activity are identified and weighted through literature review, the ranges of natural resource suitability (quality or quantity) for each resource factor are identified and weighted through literature review, these natural resource requirements are compared to inventoried site data, and from this comparison a suitability rating of the site's natural resources (for the individual outdoor recreation activity) is obtained and mapped.

An important characteristic of the system is that it allows for adaptability within its procedural framework.

Applicability of the proposed system was tested by analyzing the physical natural resource suitability of sites within the Gallatin Canyon of Montana for stream trout fishing and trail hiking. For stream trout fishing, a 40-mile section of the West Gallatin River in Gallatin County, Montana, was subdivided into 58 unit tracts for inventory and evaluation. For trail hiking, 4 1/2 sections in the West Gallatin River Drainage, Gallatin County, Montana, were subdivided into 72 unit tracts for inventory and evaluation.

This research presents a system that incorporates critical natural resource requirements, based on sound research findings, into the outdoor recreation and comprehensive planning process. Use of this system should minimize development and maintenance costs in outdoor recreation sites by identifying those tracts of land within a given site having the highest (or moderate, or lowest) natural resource suitability for a specific outdoor recreation activity; and the system provides a means of identifying those natural resource characteristics which should be protected or developed by proper land management practices to enhance outdoor recreation site suitability.

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Although this section of the thesis is brief in relation to the overall content, it reflects the heart of my graduate work. It would be extremely difficult, if not impossible, to achieve a meaningful goal without the help of others. Throughout my graduate program, which is culminated by this thesis, I have been the recipient of innumerable instances of kindness and assistance.

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ABSTRACT

Increasing public demand for outdoor recreation, coupled with public concern for proper land use and land management, has strengthened the role of natural resource analysis in the outdoor recreation planning process. The natural resource analysis system, developed by this research, presents guidelines for establishing a relationship between natural resources and individual outdoor recreation activities. For each individual outdoor recreation activity: the natural resource factors critical to the activity are identified and weighted through literature review, the ranges of natural resource suitability (quality or quantity) for each resource factor are identified and weighted through literature review, these natural resource requirements are compared to inventoried site data, and from this comparison a suitability rating of the site's natural resources (for the individual outdoor recreation activity) is obtained and mapped. An important characteristic of the system is that it allows for adaptability within its procedural framework.

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This research presents a system that incorporates critical natural resource requirements, based on sound research findings, into the outdoor recreation and comprehensive planning process. Use of this system should minimize development and maintenance costs in outdoor recreation sites by identifying those tracts of land within a given site having the highest (or moderate, or lowest) natural resource suitability for a specific outdoor recreation activity; and the system provides a means of identifying those natural resource characteristics which should be protected or developed by proper land management practices to enhance outdoor recreation site suitability.

INTRODUCTION

If a single word were to typify this nation in the past decade, the word would very likely be "change". To some individuals, change may indicate growth and prosperity; while to others, it indicates decline and adversity. As with all elements of change, success or failure may be dependent upon human understanding and subsequent control exercised by the human element. Orville Freeman, U. S. Secretary of Agriculture, expressed the following opinion, "Man is but one element, but he is a dominant element. Emerging now is a special challenge of fitting man's activities and needs harmoniously into his total environment". (Freeman 1967.)

Regardless of the subject area being considered or the individual doing the considering, the following statement by Jack Hayes would be valid; "Change is always with us and yet sometimes we should take stock". (Hayes 1970.) Therefore, from this milieu of national change, let us precipitate the single area of outdoor recreation.

It is not the intent of this thesis to examine in any detail the word change, but rather to express a recognition that change constitutes a basic thread of the fabric of outdoor recreation. From a review of the changing field of

outdoor recreation, this thesis identifies a subject area that is deserving of: examination, revision of methodology, and incorporation into the planning process. This area is Recreation Natural Resource Analysis - a basis for outdoor recreation* planning.

PLANNING IN OUTDOOR RECREATION - The greatest impetus toward outdoor recreation planning came from the federal government when Congress passed the Outdoor Recreation Resource Review Act, which was signed by President Dwight D. Eisenhower on June 28, 1958, (Fitch 1970). The objectives of the Act were to appoint a Commission which would study and evaluate national outdoor recreation wants, needs, available resources, policies, and programs. The final product of this Commission was a summary document, Outdoor Recreation For America, which was submitted to the President on January 31, 1962. Fitch and Shanklin (1970) in a brief tribute to the Commission called their work a landmark in outdoor recreation history, which would have enduring influence on state and federal participation in outdoor recreation planning.

As a result of a proposal made by the Commission, the Bureau of Outdoor Recreation was created on April 2, 1962.

*See Appendix I, page 134.

On September 2, 1964, the Bureau was given a means by which outdoor recreation could be advanced - the Land and Water Conservation Fund Act. It provided matching funds to state and local agencies for acquisition, development, and planning of outdoor recreation.

As a result of the encouragement provided by this federal funding assistance, numerous state and local planning efforts were initiated. Various planning processes have been used in guiding these efforts. By reviewing random planning publications, (Lynch 1962, Sargent 1967, Case 1969, Kerr 1967, VanMeter 1969, Hyppa 1970, Strong 1965), it is possible to abstract the basic steps found in most planning processes. These steps, a foundation for most outdoor recreation plans, are: 1. Inventory (of the site's physical resources and human objectives); 2. Analysis (of the inventories data); 3. Plan formulation and implementation (on the basis of the analysis determinations and budgeting considerations); and, 4. Updating the plan over time.

However, many agencies found that outdoor recreation was not an easy area to plan. Factors which needed to be considered in the planning process are generally classified as economic, social, political, man-made physical resources, and natural resources; but in recreation these areas have

presented numerous problems in value identification and analysis. Therefore, in outdoor recreation there is often an unavailability of criteria for evaluation. The lack of natural resource criteria presents a critical problem in the area of outdoor recreation, since by definition the field is natural resource based. If nature is to be accepted as a process that offers both opportunities and limitations to human use, the natural environment will provide one important set of considerations for outdoor recreation planning.

REVIEW OF EXISTING RESOURCE ANALYSIS SYSTEMS USED IN OUTDOOR RECREATION - Some recreation planners chose to deal with natural resource analysis problems by treating natural resources only superficially. For example, a publication explaining the process used by a state agency in recreation area planning stated: "... 2. Next, an informal inventory is taken of the resources of a proposed site. From this evaluation, it can be determined how the site may best satisfy a portion of the recreation demand in that vicinity. 3. After the ground is acquired ..." (Hyppa 1970.) In this case it would appear only an informal resource inventory is necessary prior to acquisition. Other recreation planners were alarmed by the minimal concern being given to the environmental aspects of planning. Attempts were made to

develop new techniques in identification, inventory, and classification of the natural resources. Three of the better known individuals who have made significant contributions to resource analysis and environmental planning are Ian McHarg, Philip Lewis, and G. Angus Hills.

In general, each of the approaches proposed by these individuals was: (1) designed to relate natural resources to land use suitability; (2) designed to consider recreation as one of the land uses, if not the only land use; and (3) designed for regional application.

Ian McHarg believed that an area of land or water represented a number of interacting natural phenomena, (e.g. geology, soils, climate). He recognized that these phenomena create an intrinsic suitability for certain land uses. To determine a site's suitability, it was necessary to identify those ecological factors (e.g. Physiographic: land features, slope, etc; Pedology: drainage, erosion, etc.) and their values, which are important to the land uses being considered. Therefore, the system involved matching an inventory of site resource data to the value system based on the relationship of resource factors to land use. Areas possessing intrinsic suitability (and therefore low social cost) for a single or multiple land use are thus identified.

McHarg's approach is presented in some detail in his book, Design With Nature. (McHarg 1969.)

Philip Lewis based his analysis procedure upon identifying patterns of unique quality for recreation and conservation. Criteria were established by utilizing visual contrast and diversity. Various types of landscape resources (natural and man made) that met the use criteria were identified. (e.g. Natural Features: wetlands, topography, etc; Extrinsic Features: dams, camps, trails, etc.). Lewis found that many of the elements of the landscape could be combined into linear patterns or "environmental corridors". By assigning values to the major features within the corridors, he was able to establish "nodes of interest". An example of Lewis' approach is presented in The Upper Mississippi River Comprehensive Basin Study. (Lewis 1969.)

G. Angus Hills developed a detailed land classification system. He identified site units according to land (or water) features and climate. Then use activities were related to physical requirements. The basic uses were subdivisions of the general use categories of Agriculture, Wildlife, Forestry, and Recreation. Then a capability rating was established for the site unit, which related the physical resources of the site to the intended use. The rating

indicated the natural capability of the land (or water) site to support the highest intensity and quality of any given use, under an assumed level of management. The final rating is adjusted by incorporating a consideration of: 1. Use suitability (the amount of labor and investment necessary to attain the use capability, e.g. installation of facilities and/or management) and, 2. Use feasibility (considering present and future social and economic factors, e.g. accessibility to populations). An adaptation of the Hills system is used in The Canada Land Inventory, a land capability classification, under the authority of the Agricultural Rehabilitation and Development Act. (Canada 1970.)

In review it may be stated that the approaches used by these three individuals would be representative of many of the approaches found in the spectrum of resource analysis. As Laurie (1971) noted, these individual approaches represented attempts to give emphasis to sorely neglected environmental factors and resources in the planning process.

Agencies, as well as individuals, have attempted to devise methods of incorporating natural resource data into the planning process. One of the earlier inventory and resource analysis systems to be applied on a national level, was the National Forest Outdoor Recreation Resources Review

of 1959, (U. S. Forest 1959) sometimes referred to as the National Forest Recreation Survey, (N.F.R.S.). This was to be a two year review of all outdoor recreation resources of the National Forests and other lands administered by the Forest Service. The objective of the survey was to evaluate the outdoor recreation resources and to formulate policies and plans needed to meet future recreation demands. The survey was to include an analysis of recreation demand, an inventory, and an analysis of the inventory findings. The inventory, a major part of the entire survey, consisted of selection, examination, and quality evaluation of the recreation land and water resources. As a key part of the inventory process, the quality evaluation was to systematically evaluate the quality of sites or areas (for certain types of recreation) on the basis of various sets of criteria. The evaluation would determine an outstanding, good, or fair quality rating for the site.

Although the work plan for the N.F.R.S. never achieved handbook status and detailed findings of the survey were never published, the survey was an imaginative and massive undertaking; and a positive step in the direction of resource analysis for recreation.

A more successfully implemented analysis system began

1966. The National Association of Soil and Water Conservation Districts (N.A.C.D.), in cooperation with the Soil Conservation Service of the Department of Agriculture, developed a system to appraise the potentials of county areas for outdoor recreation developments (U. S. Soil 1966). The ARDA system provided, for counties, a systematic approach to appraising its potentials for future outdoor recreation developments. Basically, twelve general kinds of recreation developments (e.g. vacation, cabins, winter sports areas, golf courses) were related to ten resource conditions or "key elements" (e.g. climate, scenery, soils, population, ownership). These key elements were weighted in relation to the influence they exerted on the proposed recreation development or enterprise. The key elements were also weighted in relation to the quality of the element in the county area. The final result was a scored rating for each activity considered. The system is adaptable to local development interests and resource factors. It may be stated that the NACD system has been widely implemented and appears to have provided many county areas with some measure of outdoor recreation development potential.

The preceding review exemplifies the more representative resource analysis systems being applied in many outdoor

recreation planning processes. However, as thorough as many resource analysis systems appear, they unfortunately possess inherent characteristics which prevent their practical application in many outdoor recreation situations.

THE PROBLEM

LIMITATIONS OF EXISTING OUTDOOR RECREATION RESOURCE

ANALYSIS SYSTEMS - Planners today, for the most part, are willing to accept the fact that natural resources are a relevant factor in outdoor recreation planning. As a result, natural resource data is generally accepted as a desirable input into the decision making process. This improvement in natural resource awareness, however, does not simplify value identification and evaluation of natural resources critical to specific types of outdoor recreation.

At the present time; individuals, agencies, or governments wishing to identify natural resource suitability of a given area for a specific type of recreation activity, usually attempt to adapt existing regional multi-use analysis systems to the local situation. Most existing resource analysis systems when applied to outdoor recreation possess some, if not all, of the following limitations:

1. In many resource analysis systems, recreation is broadly defined and is assumed to include numerous, often undefined, recreation activities. In other words, all types of recreation activities are encompassed by the one land-use title - "Recreation". In some cases, Recreation is divided

into subunits. However, these too are often general categories, such as Active Recreation or Passive Recreation as proposed by McHarg (1969) and Lewis (Harvard 1967). Also the NACD Study (U. S. Soil 1966), had such divisions as Water Sports (skin diving, boating, etc.), and Winter Sports Areas (snow skiing, ice skating, etc.). Conventional wisdom indicates that different types of recreational activity (e.g. river rafting, lake swimming, snowmobiling) will possess different natural resource requirements. Obviously, snow skiing and lake swimming relate to different types and ranges of natural resource factors. An active-passive subdivision of Recreation does not solve the disparity found in recreation natural resource requirements. For within most general subtitles, such as "passive recreation" or "active recreation", there remains a variety of activities, each having somewhat different natural resource requirements for maximum suitability. Therefore, resource analysis systems that liberally identify and analyze many, if not all, recreation activities under one title are grossly oversimplifying the recreation-natural resource relationship.

2. Even in resource analysis systems where recreation activities are more specifically identified, generalization often remains a weakening factor. Generalization in the

wording of rating criteria is extremely common. For example, the National Forest Recreation Survey (U. S. Forest 1959) included rating criteria such as "excellent hunting - 3 points, good hunting - 2 points, fair hunting - 1 point". Other NFRS rating terms included, "easy walking... low cost... some recreation potential". Interpretation of terms such as easy, low, some, excellent, are extremely susceptible to differences of opinion. "Low" or "easy" to one individual may be "high" or "difficult" to another. Instructions explaining the meanings of such ambiguous terms (such as low, difficult, etc.) are lacking. Therefore, many resource criteria have no specific ranges or limits to guide interpretation.

3. The susceptibility to variation in interpretation due to generalized criteria is compounded by the fact that local, often untrained personnel were used in relating the resource criteria to the site. Many evaluation systems (such as the NFRS (U. S. Forest 1959), the NACD (U. S. Soil 1966), and the Lewis system (Harvard 1967), are dependent upon local personnel to apply the inventory and analysis. Therefore, the validity of the resource evaluation often depended upon the competences (and biases) of a wide variety

of evaluators; evaluations often lacking any special interpretive training or interpretive instructions.

4. Another limitation of existing resource analysis systems is that of "purpose". Many systems are designed for a purpose or purposes which limit their use in other situations. If one of the purposes of the analysis system is to evaluate large (county or state areas) quickly, then the generalizations mentioned previously become quite common if not necessary. For example, Lewis (Harvard 1967), had to analyze the environmental resources of the state of Wisconsin in one year, a feat which does not lend itself to specificity. It seems logical to assume that criteria used for evaluation as well as format to be followed would tend to be shaped by the purpose of the study. For example, the Hills system (Harvard 1967), and The Canada Land Inventory (Canada 1970), base their rating classification on intensity of use the land will withstand or the quantity of recreation sustained per unit area. In other words, "quality" of a site is dependent upon high concentrations of use. Another example of survey purposes affecting a system's adaptability would be the NACD Study (U. S. Soil 1966). This system, primarily concerned with private recreation development, selected only those

recreation activities of primary interest to developers. In addition, although the system does relate resources to activities, this relationship is highly simplified and the reasoning for the weight given the "resource-activity" relationships is never explained in any detail. This presents interpretation problems to anyone wishing to expand the system's use - not only to other activities but also to change any of the "resource-activity" rating relationships.

In summary it might be stated that most existing resource analysis systems do possess certain weaknesses or limitations. The same will undoubtedly be true of future systems. Yet this should not dampen the researcher's enthusiasm for attempting to develop "The Ideal System" which would correct limitations of existing systems and also hopefully be adaptable to future change.

PROCEDURE - THE PROPOSED RECREATION
NATURAL RESOURCE ANALYSIS SYSTEM

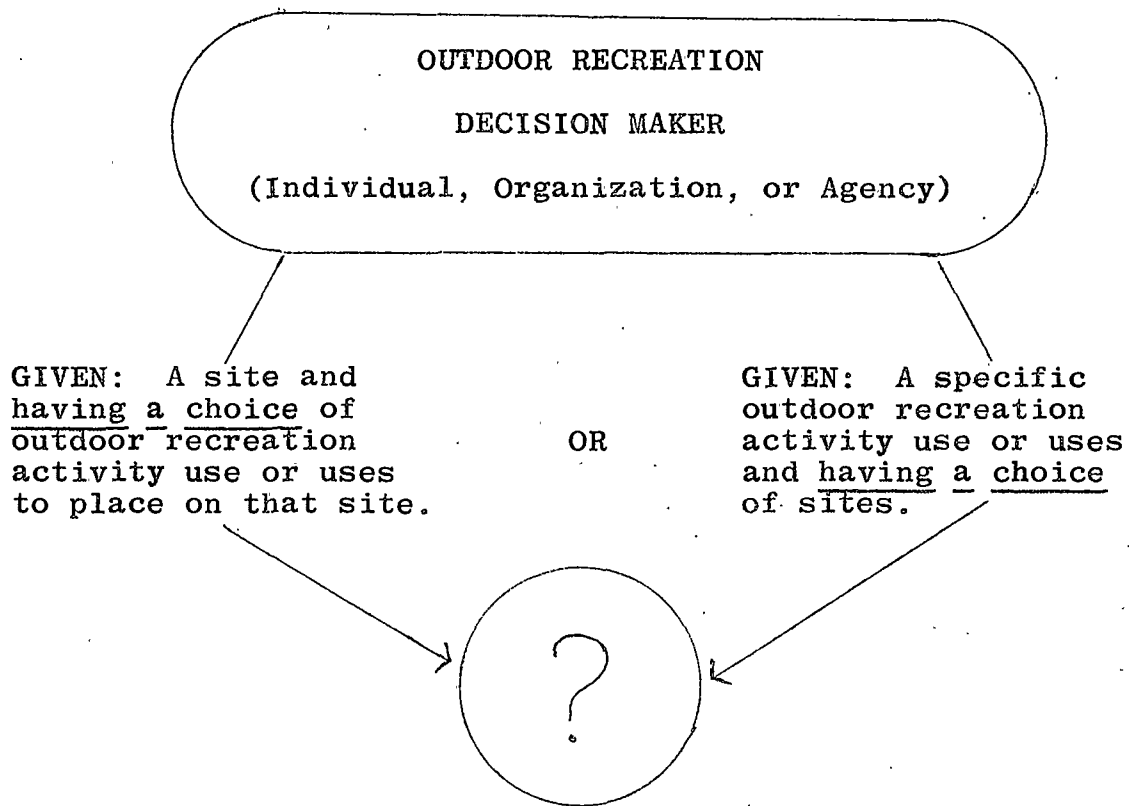
OBJECTIVES OF THE PROPOSED SYSTEM - It is the intent of this research project to relate only to the physical natural resource aspect of the resource analysis process. Although physical natural resources are but one of the resource factors in a total analysis system, they represent a basic consideration. The use of natural resource criteria as a foundation for consideration is based upon the relative permanence of natural resources. To base a classification system upon the permanent physical land characteristics (upon which economic and social classification may be later superimposed) is in agreement with principles expressed by Jacks (1946), Marbut (n.d.), and Davis (1971).

Application of this natural resource analysis procedure will identify those tracts of land within a given site, which have the highest (or moderate, or lowest) natural resource potential (suitability) for a specific recreation activity. Rating of potential sites and/or tracts within a site is accomplished by placing a number value on ranges or qualities of resource factors. The rating will establish a qualitative measure of the suitability (or potential) of a site (or tract) for one type of outdoor recreation activity.

City, county, and state funds for outdoor recreation are often limited, and it appears this will remain so for some time. Therefore; inventory, acquisition, and development of outdoor recreation areas will tend to be selective. This proposed analysis system would be a method for identifying "best" sites for outdoor recreation endeavors.

In addition, this proposed analysis system, by identifying those natural resources and their ranges of quantity or quality most beneficial to specific outdoor recreation activities, will identify those natural resource characteristics which should be protected or developed by proper land management practices. Also, man-made improvements may be created in order to provide the critical natural resource requirements for a particular outdoor recreation activity, once those requirements are known. If the procedure is applied to a number of outdoor recreation activities, it will ultimately allow for identification of sites or tracts of land which possess complimentary or competitive natural resource capabilities for those various recreation activities.

In summary, the fundamental guidelines establishing general relationships between: (1) an individual outdoor recreation activity, (2) natural resource requirements for that activity, (3) inventoried site data, and (4) analysis rating conclusions; are illustrated in Figures 1 through 8.



1. Is this site suitable for _____ * _____ ?
2. What tracts within this site are best suited for _____ * _____ ?

*A specific outdoor recreation activity or combination of activities.

1. and/or 2. =

WHAT IS THE SITE SUITABILITY FOR A SPECIFIC OUTDOOR RECREATION ACTIVITY?

Figure 1. THE BASIC QUESTION

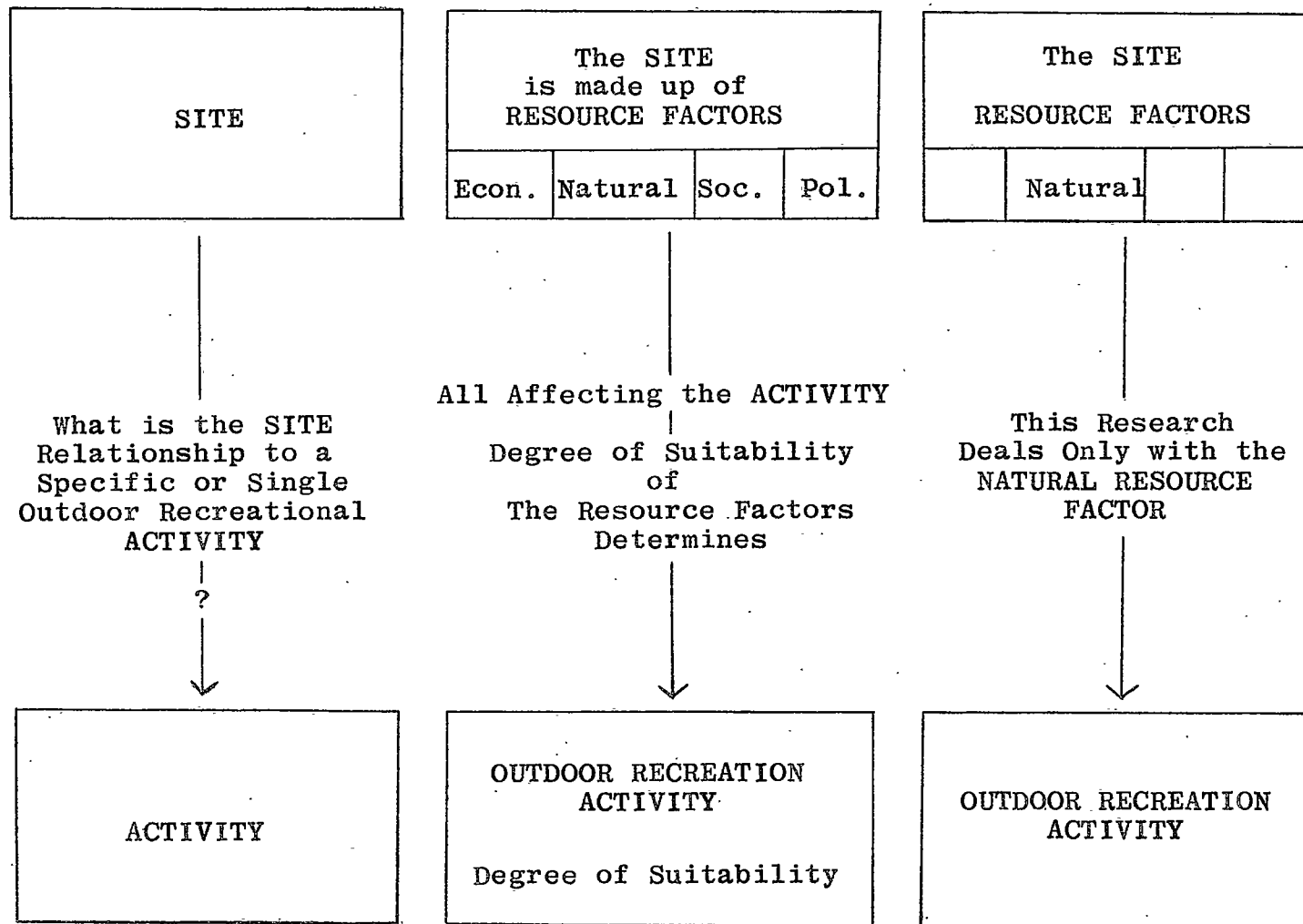


Figure 2. THE SITE-ACTIVITY RELATIONSHIP

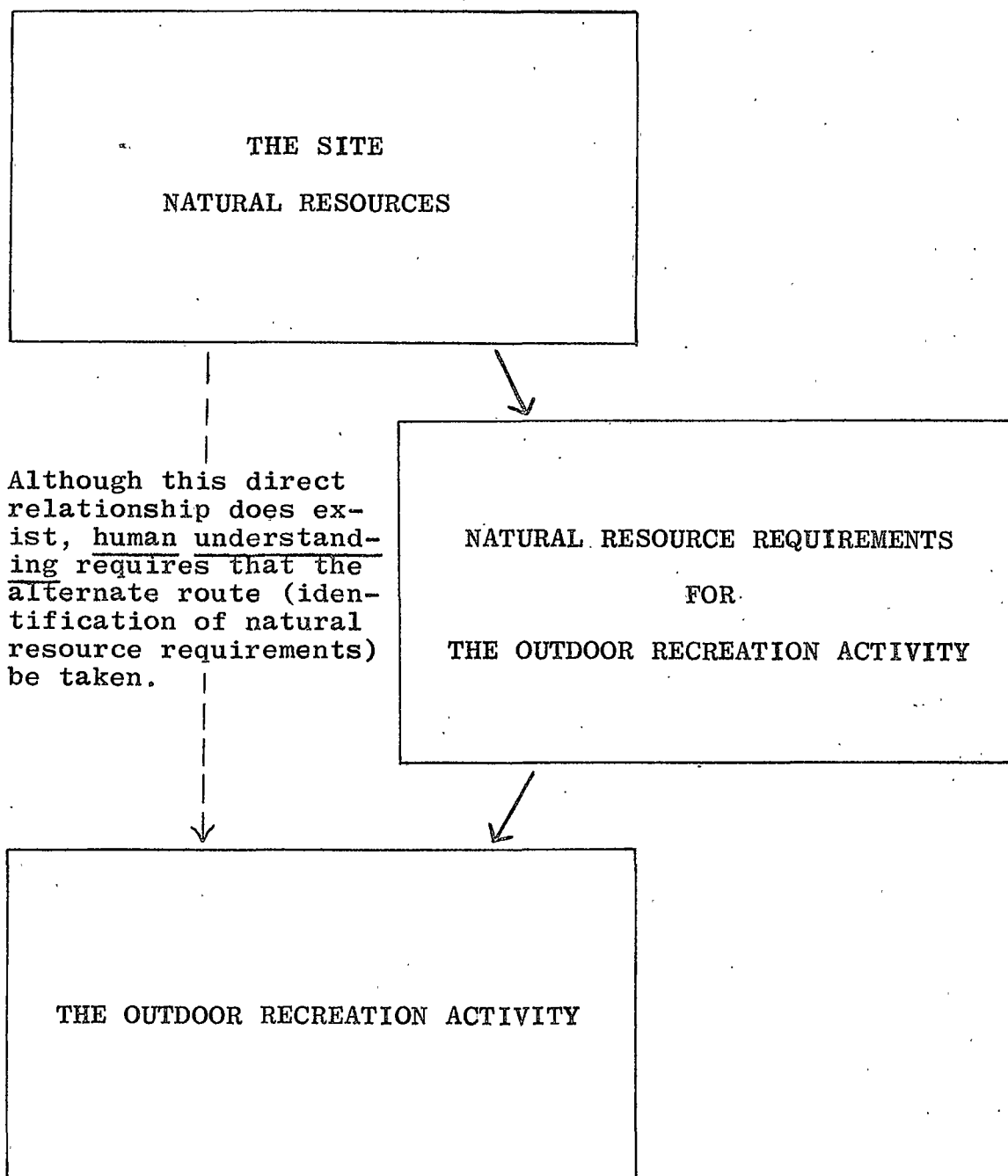


Figure 3. THE SITE - NATURAL RESOURCE - ACTIVITY RELATIONSHIP

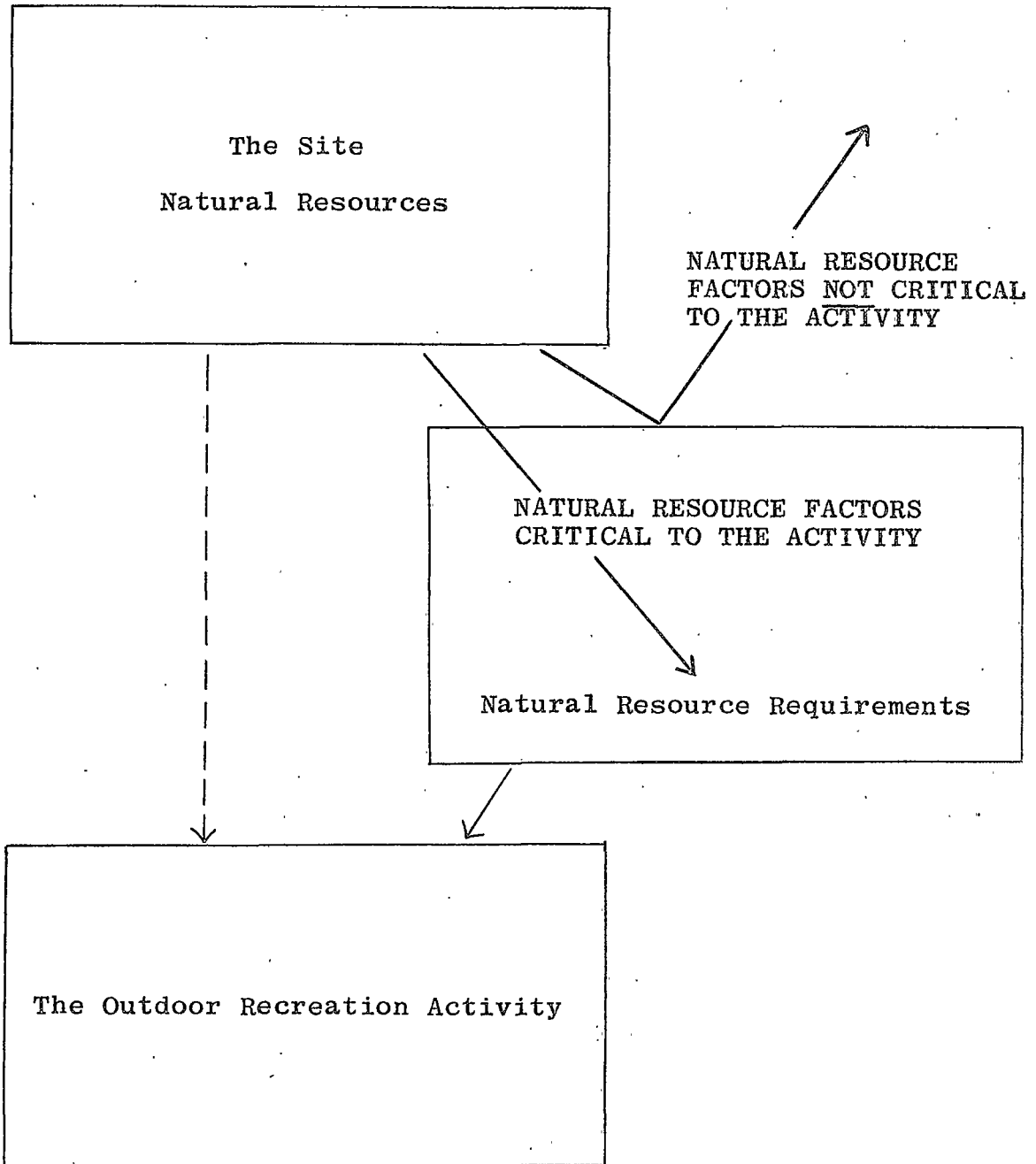


Figure 4. CRITICAL NATURAL RESOURCE FACTORS (A PART OF THE SITE - NATURAL RESOURCES - ACTIVITY RELATIONSHIP)

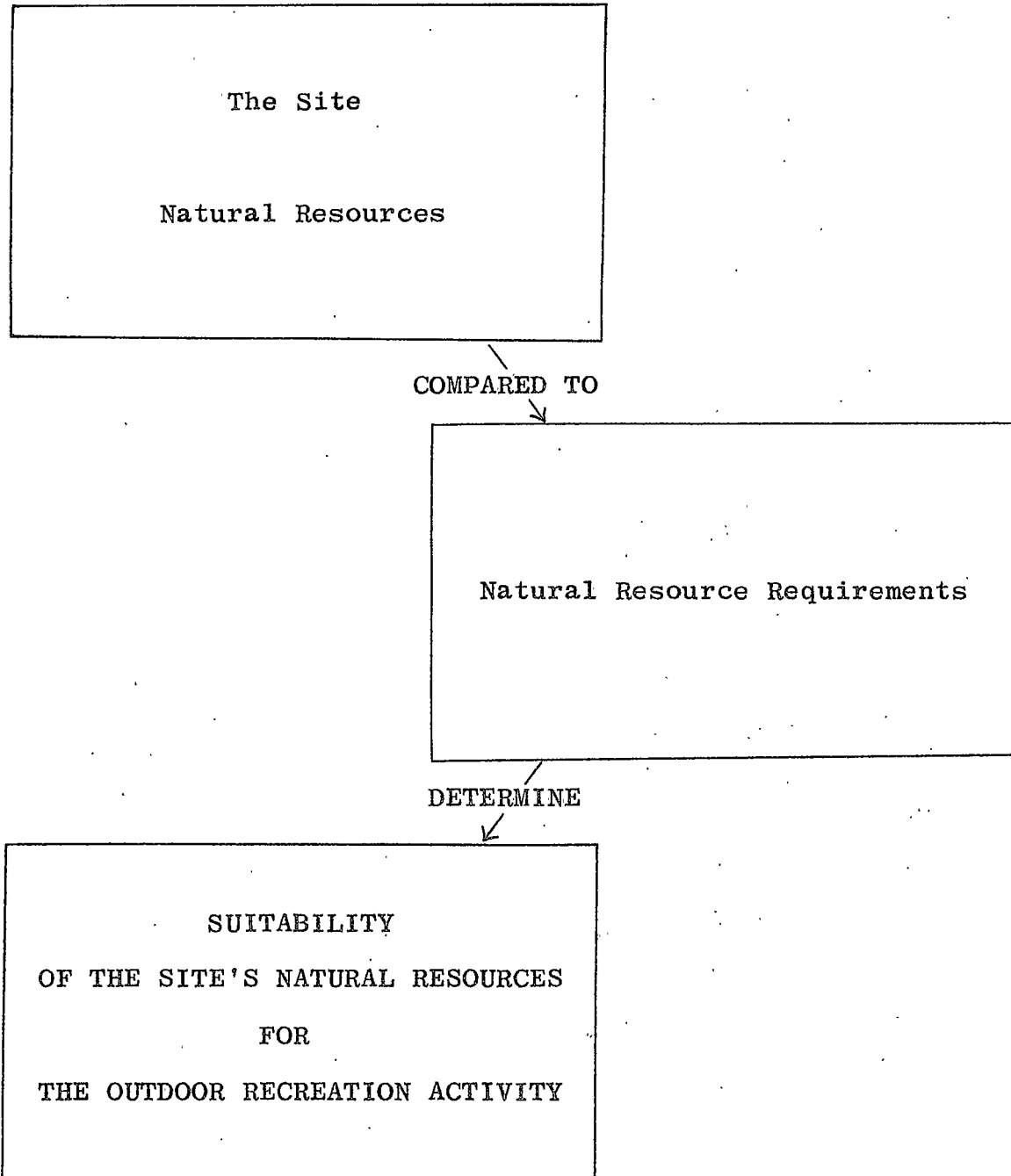


Figure 5. THE SUITABILITY RELATIONSHIP

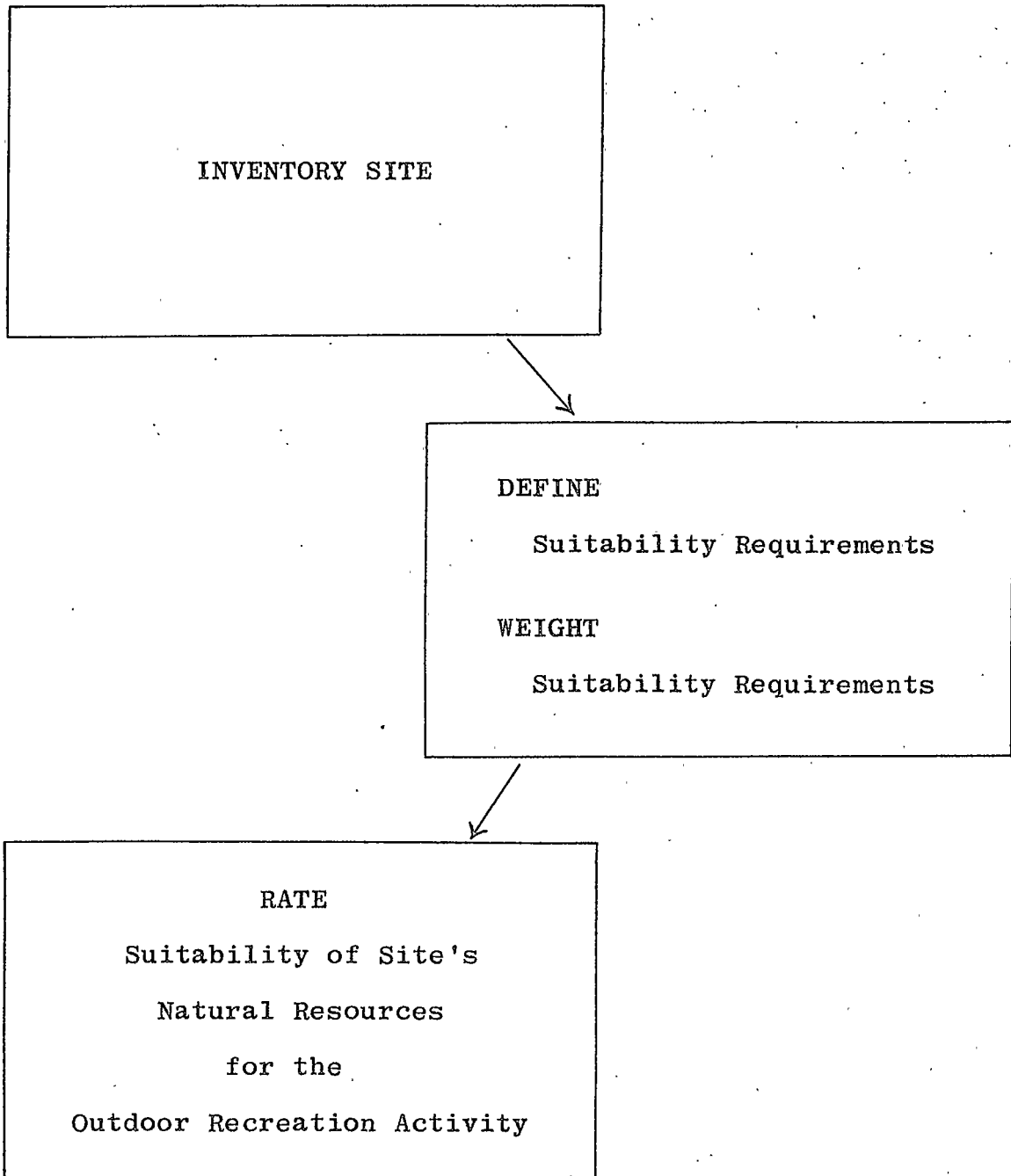


Figure 6. THE FUNDAMENTAL ACTION RELATIONSHIPS OF THE PROPOSED RECREATION NATURAL RESOURCE ANALYSIS SYSTEM

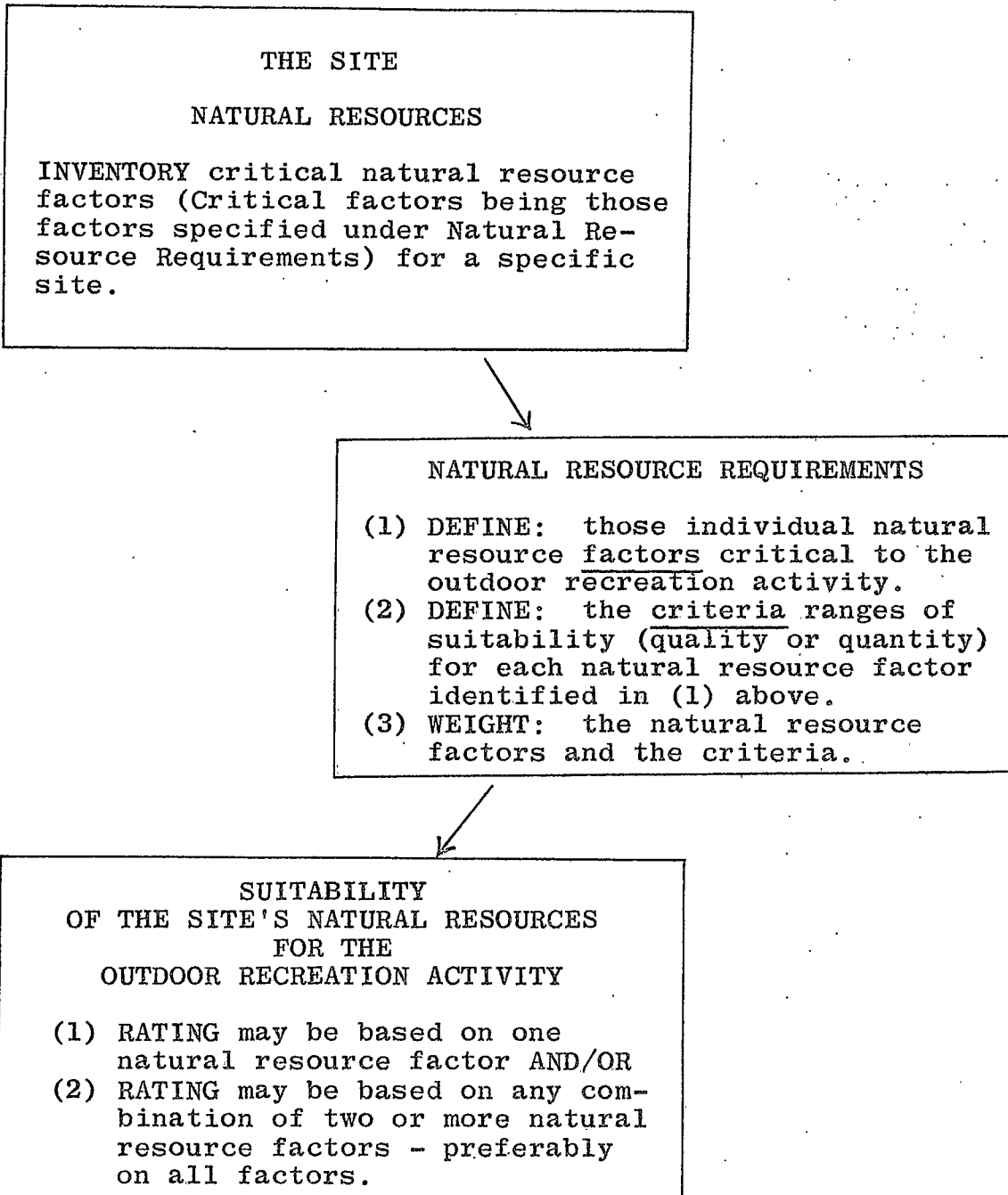


Figure 7. AN EXPLANATION OF THE PROPOSED SYSTEM'S FUNDAMENTAL ACTION RELATIONSHIPS

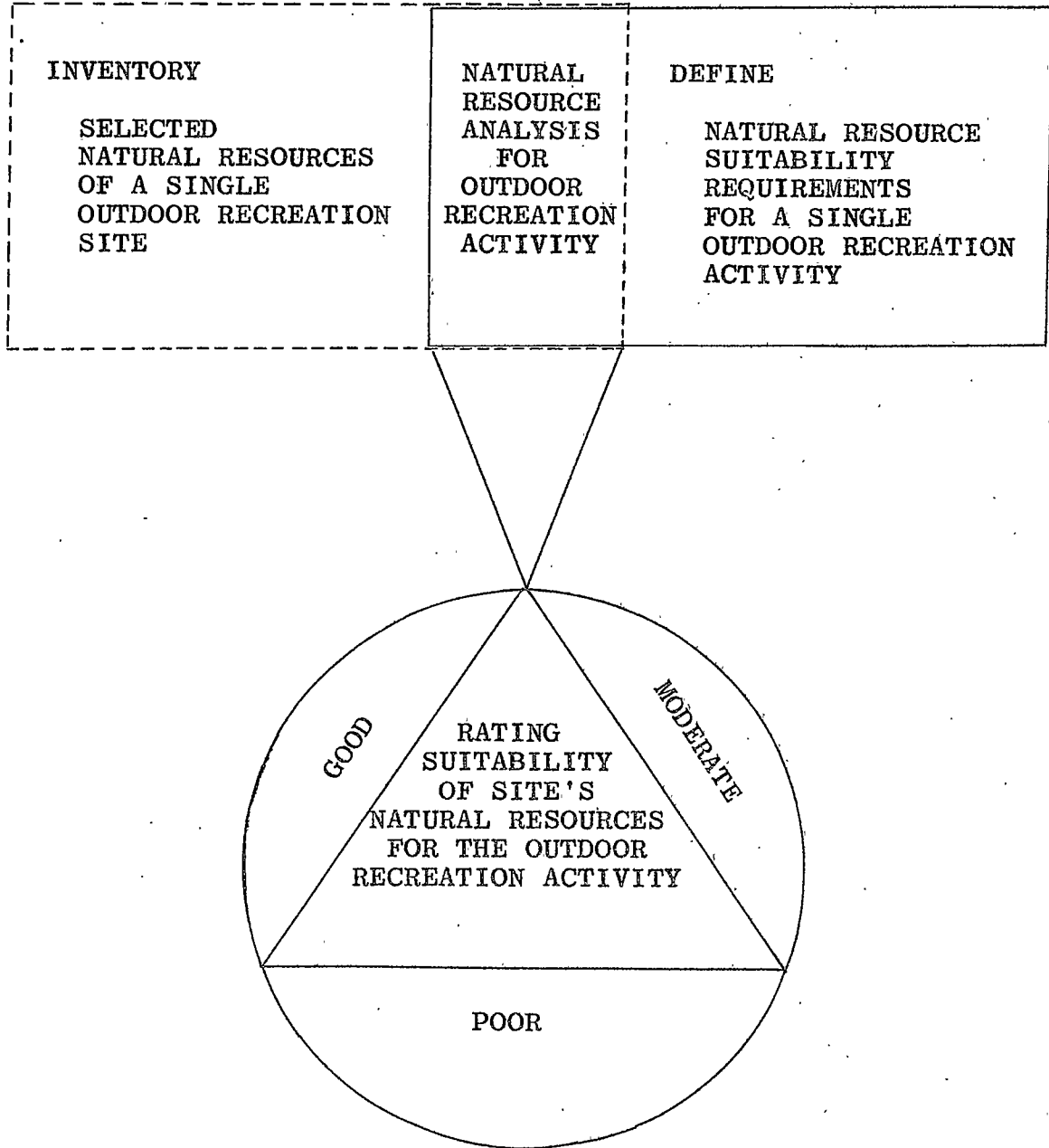


Figure 8. THE PROPOSED RECREATION NATURAL RESOURCE ANALYSIS SYSTEM

PROCEDURAL GUIDELINES FOR THE PROPOSED SYSTEM - The fundamental relationships introduced in Figures 1-8 may now be expanded upon. A diagrammatic explanation of the principles involved in the proposed analysis system is presented in Figure 9. Using this diagrammatic format, an applied example is given in Figure 10. It may be observed that again three basic general areas are involved: (1) Inventory of the Site, (2) Establishment of the Natural Resource Requirements, and (3) A Numerical Evaluation.

To determine the quantity and/or quality of natural resources present on the site constitutes the inventory portion of the analysis procedure. The site data may be acquired by reviewing existing inventories done of the site and extracting the data needed. However, since the inventoried data must relate to the ranges established in the natural resource requirements, many of the existing surveys may not contain the data needed. Therefore, it will be the responsibility of the individual or agency (interested in rating the site's natural resource suitability) to perform the natural resource inventory. The method of inventory is left to the discretion of the inventorying agency. If the total project were to involve a relatively small area or if unlimited personnel were to be available to assist in the analysis, then perhaps a

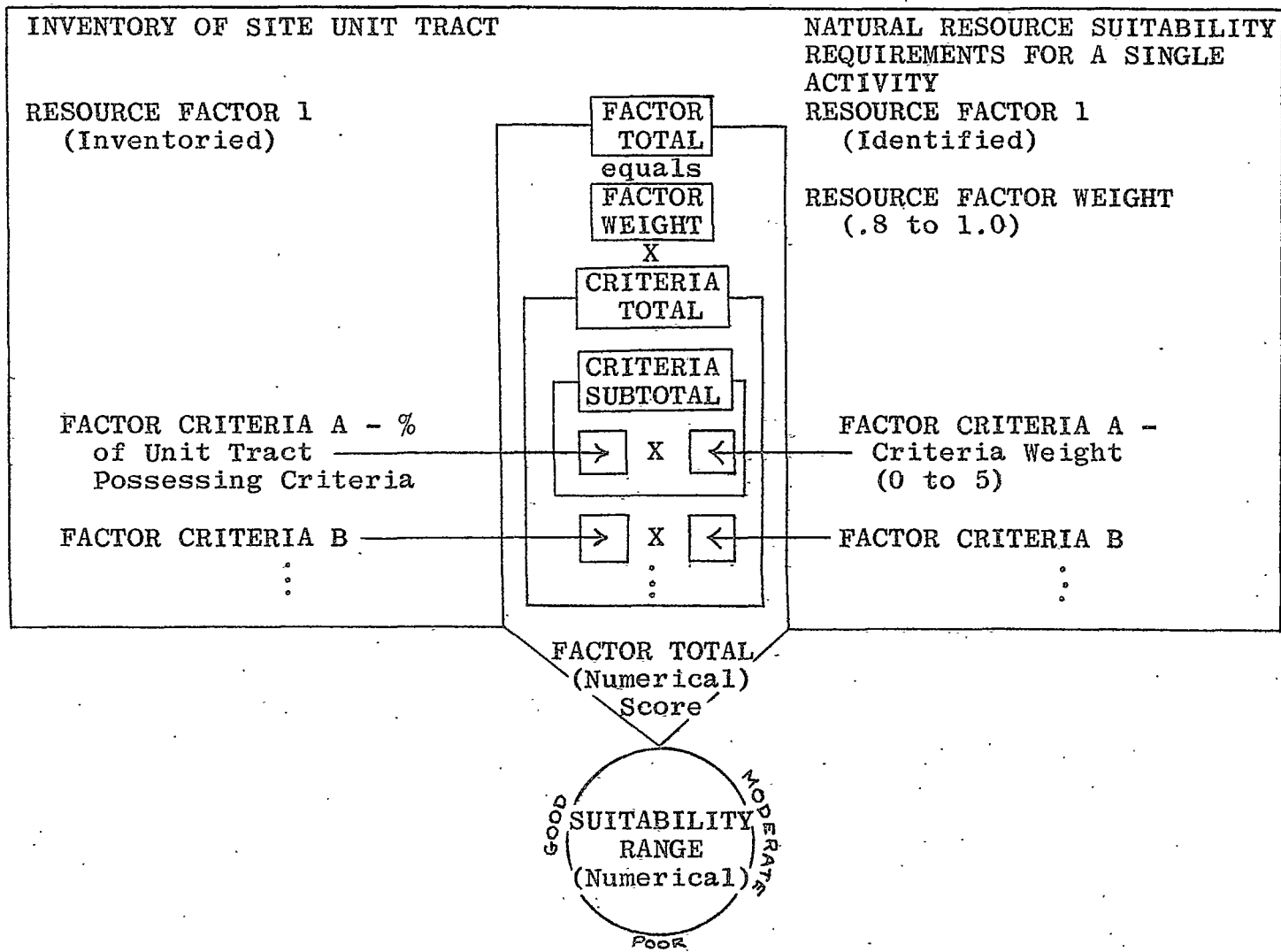


Figure 9. APPLICATION DIAGRAM OF THE PROPOSED RECREATION NATURAL RESOURCE ANALYSIS SYSTEM NOTE: Using Only One Natural Resource Factor

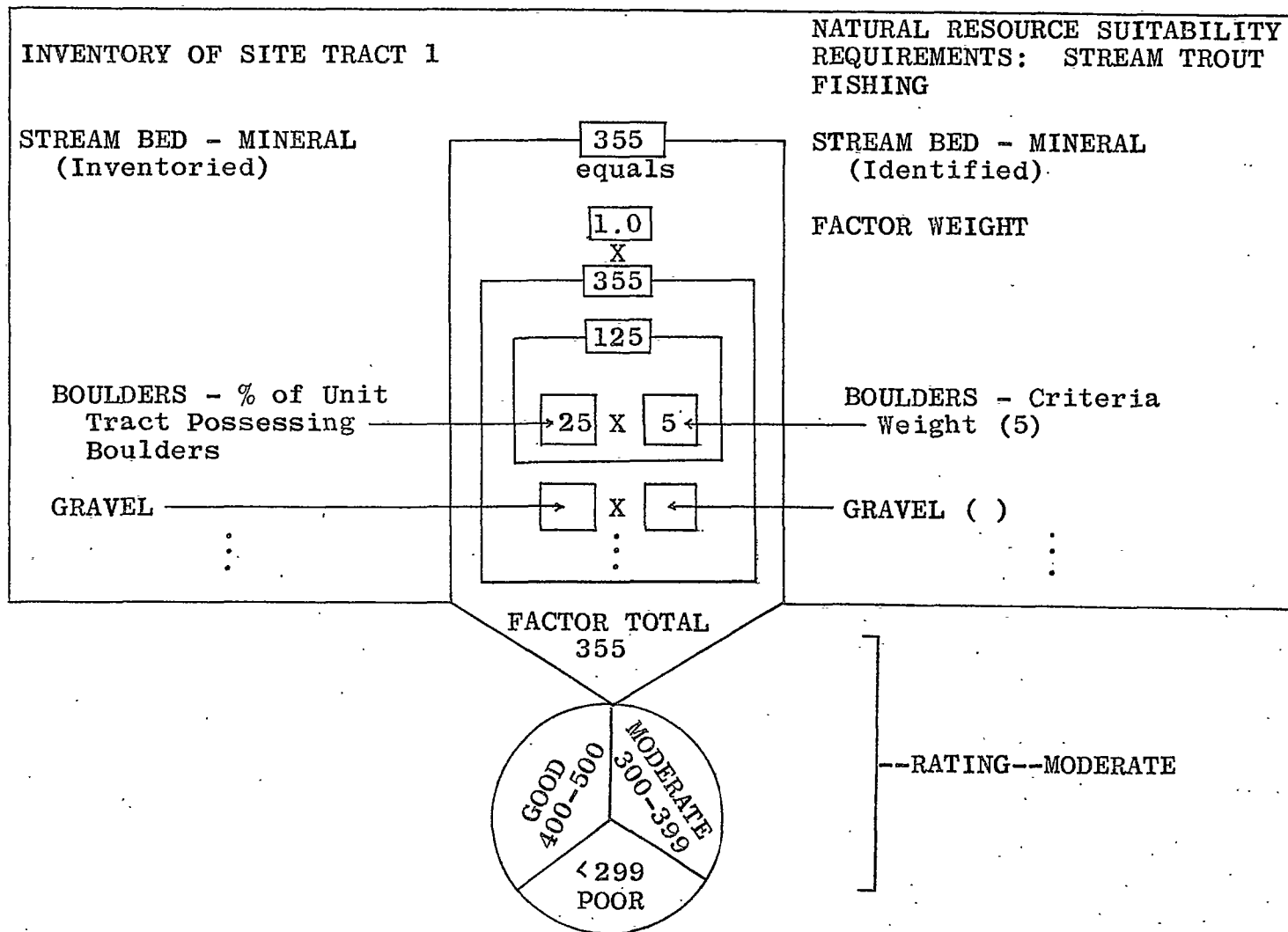


Figure 10. APPLICATION DIAGRAM (Example)

detailed on site analysis would be possible and desirable. This unfortunately, is not often the case. Rather, the areas to be analyzed are often large and the personnel available are limited. Therefore, inventory procedures that supplement a personal on-site inventory are often desirable. For example, the use of aerial photographs is an excellent means of supplementing on-site surveys (see the methods applied in the fishing analysis). For some recreation activities, the site inventory may be of the total area as a single unit; while for other activities, the site inventory may involve the separate inventory of unit tracts (a unit tract is defined as that land area that is individually and independently inventoried). The inventory procedure involved in the proposed system requires that percentages be determined, each representing that part of the unit tract which possesses a particular natural resource criteria. A visual aid which may be used in determining on-site percentages is the illustrated Chart for Estimating Proportions of Mottles and Coarse Fragments (Appendix II).

The size of areas to be individually evaluated (rated) is also flexible, depending upon the intent of the evaluator. The size of the tract to be evaluated may be the same size as the total area, or it may be the size of an inventoried

unit tract, or it may be an average of two or more inventoried unit tracts. In Figures 9&10, pages 27&28, it is assumed the area being evaluated is the same size as the area inventoried. The size of area being evaluated (and/or graphically presented) depends in part upon: (1) the intent of analysis (for example, whether the analysis is to determine one overall suitability rating such as for an entire river; or to determine suitability ratings for smaller units, within a larger area, for comparative purposes such as selecting best access sites along a river), and (2) the method of data output (for example, perhaps a computer program or project unity dictates that ratings be made in designated sized unit tracts).

In any case, it is important to note in both inventory and evaluation that analysis is possible of small unit tracts, of large areas, or of combined unit tracts.

The proposed recreation natural resource analysis system is designed to incorporate numerical weighting of the natural resource requirements. This weighting will ultimately determine the suitability rating of the site for the specific outdoor recreation activity. Two general natural resource items may be weighted: (1) the resource factor criteria (subdivisions of the resource factor, and

(2) the resource factor.

In weighting the natural resource factor criteria (subdivisions of the resource factor), the criteria are established from review of existing research literature. The weighting values range from 0 (a criteria which in excessive quantity has the potential to destroy the site's suitability for that activity) to 5 (a criteria that has excellent suitability for the activity). The criteria weighting is a judgement made by the individual or agency who initially establishes the guidelines for that activity. It is based on the "best knowledge" available at that time. A "spread" of criteria is established for each resource factor. The spread is intended to encompass best (weight 5) to worst (weight 0 or 1). These limits are determined by interpretation of research data. In some cases, it may be possible from review of research data to establish only one of the limits. In any case, any values (2, 3 or 4) assigned to criteria between limits represent further interpretations of the research data, and an attempt to establish a range of values between limits. Once the weights are established, they should remain constant (for anyone using the system for that activity) until better knowledge becomes available (see the Section, "Adaptability", page 127. To apply the

criteria weighting, the criteria weight (0 to 5) which is established for each resource factor criteria is multiplied by the percentage of the "unit tract" (the tract of the site being inventoried at one time) which possesses that factor criteria (refer to Figures 9 & 10).

The other item to be weighted was the resource factor. The weighting range for resource factors was from .8 to 1.0. The purpose of this weighting is to allow the individual or agency using the system, some flexibility when grading the relative importance between resource factors; as well as a means of indicating the strength of the research basis used for criteria identification. For example, if the resource factor and its relationship to the outdoor recreation activity is well established by research, then a weighting of 1.0 should be given that factor. On the other hand, if the resource factor's relationship to the outdoor recreation activity is not well documented or if this factor is of less importance than other factors, then a .8 or .9 weighting may be used. Therefore, a .8 or .9 weighting of the resource factor will indicate either a relatively less important factor in the activity rating and/or a lack of resource criteria documentation based on research findings. See Figure 11, page 33, for a detailed explanation of this

WEIGHT REASONS

1.0 = I (1) A

.9 = I (1) B, I (2) A

.8 = I (2) B

FACTOR NOT USED = I (1 or 2) C

RESOURCE FACTOR

RESOURCE FACTOR CRITERIA

I. KNOWN,

(1) AS IMPORTANT AS
OTHER FACTORS
- OR -
COMPARATIVE IM-
PORTANCE UNKNOWN

(2) LESS IMPORTANT
WHEN COMPARED TO
OTHER FACTORS

A. SPECIFICALLY IDENTIFIED
BY RESEARCH STUDY

B. NOT SPECIFICALLY IDEN-
TIFIED BY RESEARCH
STUDY - RATHER BASED
ON: A BROAD GENERALIZED
IDENTIFICATION ESTAB-
LISHED BY RESEARCH WHICH
IS HYPOTHETICALLY SUB-
DIVIDED INTO SPECIFIC
CRITERIA

C. NOT GENERALLY OR
SPECIFICALLY IDENTIFIED

Figure 11. FACTOR WEIGHTING

weighting. To apply the resource factor weighting, the factor weight (.8, .9, or 1.0) is multiplied by the total criteria value (criteria value = criteria weight multiplied by the % of unit tract possessing that criteria; and total criteria value = sum of all criteria values established within that one resource factor; refer to Figures 10 & 11).

On the basis of the principles presented, it is possible to establish step-by-step guidelines for applying the proposed Recreation Resource Analysis System to any recreation activity on any chosen site. These guidelines are presented in Figure 12. Although only one natural resource factor is used in explaining the Guidelines, the same principles would be applied if more than one factor is used.

Step 1. SPECIFIC OUTDOOR RECREATION ACTIVITY.

DEFINE A SPECIFIC INDIVIDUAL OUTDOOR RECREATION ACTIVITY

(Example)

Fishing - Stream Trout.

Step 2. RESOURCE FACTOR

DEFINE A NATURAL RESOURCE FACTOR CRITICAL TO THE ACTIVITY

(Example)

Stream Bed Mineral Material

Step 3. RESOURCE FACTOR WEIGHT

ASSIGN FACTOR WEIGHT (.8 to 1.0)

(Example)

1.0

Step 4. CRITERIA

SUBDIVIDE FACTOR INTO SEPARATE NATURAL RESOURCE CRITERIA

(Example)

- A. Boulders
- B. Gravel
- C. Fractured Bedrock
- D. Solid Bedrock
- E. Sand, Silt, Clay

Figure 12. GUIDELINES FOR APPLICATION OF THE PROPOSED RECREATION RESOURCE ANALYSIS SYSTEM (Examples)
NOTE: Using Only One Natural Resource Factor

Step 5. WEIGHTS

FROM CONCLUSIONS DRAWN FROM LITERATURE REVIEW -
ASSIGN WEIGHTS TO CRITERIA

(Example)

A. 5
B. 4
C. 3
D. 2
E. 0

Step 6. SITE PERCENTAGES

PERCENT OF UNIT TRACT THAT POSSESSES THAT
CRITERIA

(Example)

A. 25
B. 50
C. 10
D. 0
E. 15

Step 7. CRITERIA SUBTOTAL VALUE

MULTIPLY PERCENTAGE (#6) BY CRITERIA WEIGHTS
(#5)

(Example)

A. 125
B. 200
C. 30
D. 0
E. 0

Step 8. CRITERIA TOTAL VALUE

ADD CRITERIA SUBTOTALS

(Example)

125
200
30
0
0
355

Step 9. RESOURCE FACTOR TOTAL

MULTIPLY CRITERIA TOTAL VALUE (#8 BY RESOURCE FACTOR WEIGHT (#3)

(Example)

$355 \times 1.0 = 355$

Step 10. RESOURCE FACTOR SUITABILITY RATING

COMPARE RESOURCE FACTOR TOTAL (#9) TO SUITABILITY RATING SCALE (S)

(Example)

(S) Suitability Rating Scale

400-500 = Good

300-399 = Moderate (355 = Moderate Rating)

< 299 = Poor

THE STREAM BED MINERAL MATERIAL HAS A MODERATE SUITABILITY RATING IN THE UNIT AREA JUST CONSIDERED*

*COMMENTS CONCERNING THE FINAL RATING

1. It is important to note that in the Guidelines Example, only 1 Natural Resource Factor was considered. A more common application of the System would be to total the Factor Values of all Natural Resource Factors critical to the activity, and thus determine a total Natural Resource Suitability Rating for each of the unit tracts.
2. The size of the numerical range which is subdivided to determine (good, moderate, or poor) ratings: is obviously dependent in part upon whether one or more than one factor value is used, and is also dependent upon the intent of the rating (refer to Fishing).
3. It would be possible to combine the individual ratings (good, moderate, or poor) for unit tracts and obtain a single suitability rating for a larger area. The final rating of the larger area would be the majority unit tract rating within the larger area.

PROCEDURE APPLIED

A basic prerequisite in applying the recreation natural resource analysis system is the designation of a specific or single outdoor recreation activity. The proposed natural resource analysis system is primarily applicable to any specific outdoor recreation activity.

The means of subdividing to determine activity identification is somewhat flexible (see Figure 13). What is of prime importance is that the recreation activity finally identified, be as singularly defined as possible or as deemed important by the outdoor recreation planning agent or agency. For example, the activity entitled skiing should be more singularly defined as either alpine skiing or as cross country skiing; since these activities do differ in their resource requirements. However, it would generally not be necessary to subdivide alpine skiing into beginning alpine, intermediate alpine, expert alpine; or into competitive alpine and non-competitive alpine. These activities are usually considered only as they relate to the total alpine skiing recreation activity.

For the purposes of this research, two outdoor recreation activities were selected. One activity was Fishing -

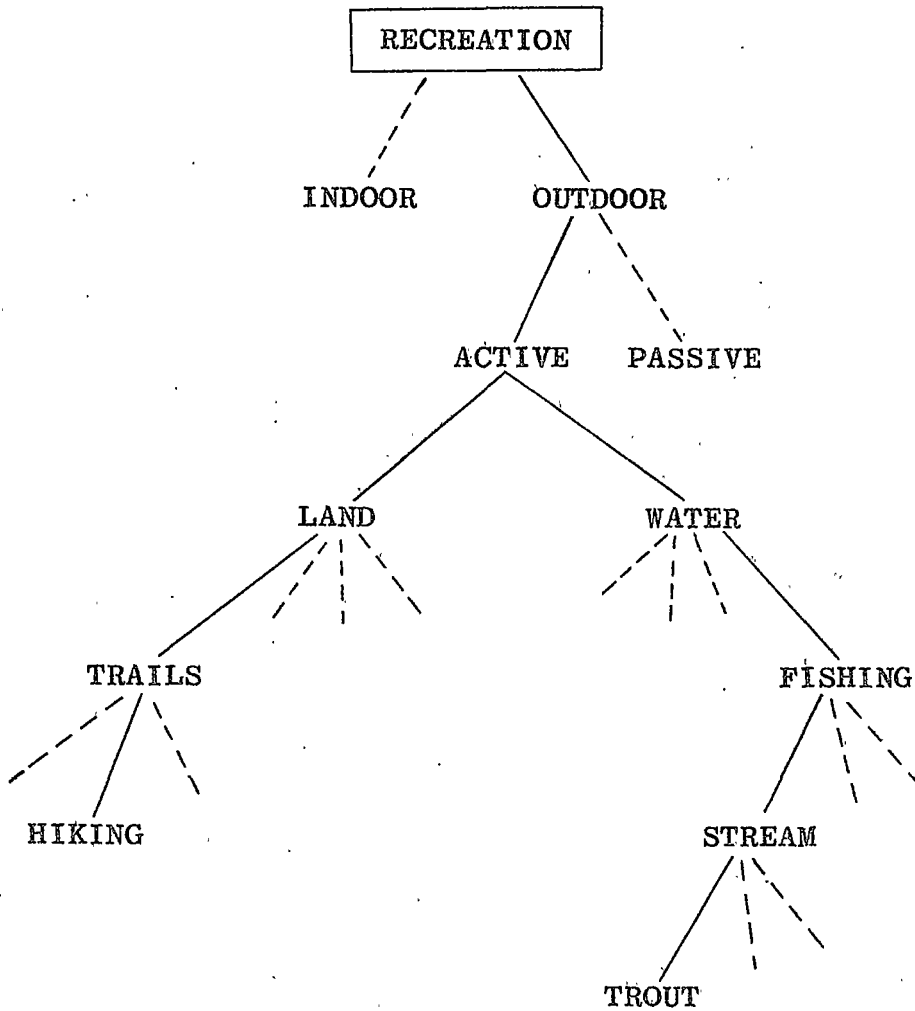


Figure 13. AN EXAMPLE OF SUBDIVIDING TO IDENTIFY SPECIFIC OUTDOOR RECREATION ACTIVITIES

stream trout fishing; the second activity was Trails - hiking.

Fishing was selected for trial application in the system because it is water based, was the activity having the highest Montana resident participation in 1970 (Montana 1970), and is an outdoor recreation activity where much of the natural resource data necessary for establishing natural resource suitability criteria is found in basic research publications not primarily intended for outdoor recreation application.*

Trail hiking, as the second trial activity, was selected because it is a land based activity, is recorded as having rapid national growth. Smythe (1970) indicated from 1960-2000 the projected growth in hiking to be 611%. Trail hiking is an outdoor recreation activity where much of the natural resource data necessary for establishing natural resource suitability requirements is often found in applied (rather than basic) research publications.

*It can be noted at this point that much of the data that may be used in establishing the natural resource suitability requirements part of the analysis system is obtained from basic research. This basic research is often not intended for outdoor recreation or other practical type applications; rather it is of a more technical nature, designed to increase man's basic understanding. It is the role of applied research to incorporate this basic research data for more practical purposes. (Clarke 1970.)

STREAM TROUT FISHING - INTRODUCTION - To test the applicability of the proposed outdoor recreation natural resource analysis system, a specific outdoor recreation activity must be designated. The first outdoor recreation activity (of two) selected to test the system's applicability was stream trout fishing. As was noted in a previous section, fishing was selected for trial application in the system because it is water based,* was the activity having the highest Montana resident participation in 1970, and is an outdoor recreation activity where much of the natural resource data necessary for establishing natural resource suitability requirements is found in basic as opposed to applied research publications.

When determining the natural resource suitability requirements (resource factors and criteria) for stream trout fishing, it is necessary to consider two general areas: (1) those natural resource factors affecting the fish and (2) those natural resource factors affecting the fisherman. In the first general area, it is necessary to identify those

*Kimball (24) stated in 1962 there were over 66 million outdoor recreation hobbyists, and most of these would be engaged in activities oriented on or adjacent to water.

natural resource factors (and their criteria) essential for survival, growth, reproduction, and general well being of the aquatic organism necessary to the activity - the trout. Mills (37) stated that it is frequently necessary to assess the fishing potential of streams and because of the strong relationship between fishing and the condition of fish habitat, it is essential to record fish habitat characteristics. However, it is generally recognized that to establish natural resource ranges of suitability for fish habitat is an extremely complex undertaking, even for those professionals having a wide knowledge of fish needs (27). The varied chemical, physical, and biological characteristics of fish species, the problem of duplicating natural conditions in an artificial research laboratory, and the lack of stability of stream characteristics (5) are just some of the difficulties encountered in establishing natural resource suitability requirements for fish.

However, it is an accepted fact that fish do exhibit definite habitat preferences and that populations of fish species are self-limiting, based on the quality of their habitat (1, 6, 37). This knowledge has encouraged identification of physical parameters or ranges of suitability for fish species. Even researchers who discourage general

listing of chemical and physical values to define water quality for fish, still see fit to note those resources that could conform to criteria quantification (27).

Perhaps as a result of this difficulty in evaluation of fish habitat, the resource evaluation criteria that have been established for fishing tend to negate the importance of evaluating fish habitat. For example, Craighead, et al (45) in a thirteen step evaluation criteria, allotted only one step to habitat; and the U. S. Soil Conservation Service (44) in a format designed to appraise the outdoor recreation potential for fishing development, ignored habitat entirely. It would appear that establishment of some natural resource criteria for fish habitat, even though this establishment would tend to oversimplify the complex nature of the situation, would be far better than discounting or ignoring these factors. Any resource system consists of complex interrelationships; yet this does not, and should not prevent examination and identification of the system's component parts.

Another problem sometimes encountered in establishing suitability requirements for fish habitat, is the hesitancy to delve into the apparent domain of the fish biologist. Doudoroff (19) addresses himself to this problem by

indicating that the biologist should render scientific judgement with regard to probable biological consequences of changes in aquatic environment. Whereas, the administrator is to select criteria based on this scientific knowledge and decides on methods of application. If a detailed study of fish habitat is desired, it cannot be accomplished using this system, but would require study by a qualified fish biologist or limnologist.

The second general area to be considered in determining natural resource suitability requirements for fishing, are the factors affecting the fisherman. In most cases these factors are quite nebulous. Brooks (33) states that a fisherman may think that he selects a stream to fish on the basis of best opportunity to catch fish, yet his real reason may be otherwise. Brooks defines trout fishing as a search for contentment. The psychological factors that create a fisherman and provide enjoyment for him are not within the scope of this treatise. It may be conceded that some fishermen do not participate in the fishing activity to catch fish, but rather for the physical and mental relief and enjoyment it provides. However, it is assumed that the majority of fishermen do participate to catch, whether they desire larger fish, or whether they desire greater numbers

of fish is not of primary importance. What is of primary importance would seem to be, is the stream of proper quality to present the fisherman with a good opportunity to catch fish. Although fishing pressure and ability of the fisherman may have some influence upon "good opportunity", the basic consideration for "good opportunity" rests with good fish habitat, and this may be supplemented by fisherman considerations.

It should be noted that this research will consider only the physical natural resource requirements, although in some cases there may appear to be a physical-biological overlap (e.g. streamside vegetation). Chemical factors and purely biological factors (such as biological material in the water) although important to the activity, were not within the scope of this research. It is believed that most of the important physical natural resource factors have been noted, although some physical factors may not be listed because of a lack of research data on the factor or because of difficulty in determining the necessary site data. However, as was stated previously, the system does allow for adaptability in this area. If it is deemed appropriate at some later date to add, delete, or change a resource factor this may be accomplished without a change

in the procedural guidelines established in the proposed system.

METHODS OF INVENTORY AND EVALUATION - Application of the proposed analysis system involves following the Guidelines established in Figure 12, pages 35 - 38. Through a review of literature, outlined in Table 1, pages 48 - 57, it is possible to identify and establish the natural resource factors, criteria, and weights; these are presented in their final form in Table 2, pages 58 - 63. Anyone questioning the basis for the established natural resource requirements in Table 2, should examine the literature cited in Table 1.

The next phase in application of the proposed analysis system is to inventory the site. The total site selected to be inventoried was a section (approximately 40 miles long) of the West Gallatin River starting at the northern boundary of Yellowstone National Park and terminating at the Spanish Creek inlet. The West Gallatin River, which originates in the Park, flows from south to north and is generally centrally located within the Gallatin Canyon area of Gallatin County in the State of Montana. By examination of aerial photographs, it was possible to identify areas of apparent general homogeneity, based upon apparent similarity

Table 1. LITERATURE REVIEW USED TO ESTABLISH THE NATURAL RESOURCE REQUIREMENTS FOR STREAM TROUT FISHING

Stream BED Factors

RESOURCE FACTOR 1: STREAM BED MINERAL MATERIAL

RESOURCE CRITERIA	RELATIONSHIP TO FISHING (+ positive, - negative)	FISHING BIBLIOGRAPHY REFERENCE NUMBER
Boulders	Provides Cover +	31, 33, 35
	Provides Turbulence +	5
Rubble	Reduces Footing Safety - (for fishermen)	31
	Provides Visual Isolation and Cover +	8, 33
	Provides Turbulence +	8
	Provides Velocity Increase +	8
Gravel	Improves Spawning +	7, 12, 27, 31
	Provides Nursing Area +	28
	Provides Fish Food +	11, 31, 33
	Generally Required +	35
Fractured Bedrock	Provides Cover +	33
Sand	Fills Holes -	7, 31
	Inhibits Reproduction -	7, 27, 35
	Buries Cover -	7, 31
	Buries Food -	7, 31
	Produces Little Food -	11
	Buries Gravel -	7, 31

Table 1. CONTINUED

Silt and Clay	Produces Turbidity -	7, 18, 31
	Reduces Trout Quantity -	10
	Smothers Spawn -	7, 18, 31
	Smothers Food -	7, 18, 31
	Smothers Cover -	7, 18, 31

RESOURCE FACTOR 2: BED VEGETATIVE MATERIAL

RESOURCE CRITERIA	RELATIONSHIP TO FISHING (/ positive, - negative)	FISHING BIBLIOGRAPHY REFERENCE NUMBER
Adequate	Food Production /	31
Weed Beds	Cover and Food /	33
Excessive	Produces Extreme Oxygen Fluctuations -	31
	Temperature Fluctuations -	31
	Excessive is Often Unnatural, Pollution Caused -	35

Stream CHANNEL Factor

RESOURCE FACTOR 3: HORIZONTAL DISTANCE FROM BANK TO EDGE OF STREAM
(At Normal Flow)

RESOURCE CRITERIA	RELATIONSHIP TO FISHING (/ positive, - negative)	FISHING BIBLIOGRAPHY REFERENCE NUMBER
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Table 1. CONTINUED

Where The Stream Channel Has Been Widened (By Occurrences Such As Flooding Or Grazing) And During Normal Flow The Water Does Not Reach The Bank	Warms Water - Causes Greater Erodability - Causes Siltation - Less Shelter and Shade -	7, 13, 31 7, 13 7, 13 7, 13
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Stream BANK Factors

RESOURCE FACTOR 4: BANK PARENT MATERIAL

<u>RESOURCE CRITERIA</u>	<u>RELATIONSHIP TO FISHING (+ positive, - negative)</u>	<u>FISHING BIBLIOGRAPHY REFERENCE NUMBER</u>	1 50 1
Sand and Gravel	Ground Water Discharge Maintains a Low Summer Water Temperature +	31	
Silt or Clay	Creates Turbidity Reduces Food and Trout Production -	18, 31	

RESOURCE FACTOR 5: BANK STRUCTURE - UNDERCUT

<u>RESOURCE CRITERIA</u>	<u>RELATIONSHIP TO FISHING (+ positive, - negative)</u>	<u>FISHING BIBLIOGRAPHY REFERENCE NUMBER</u>
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Table 1. CONTINUED

Undercut or Overhanging Banks	Provide Cover ↗ Increase Production ↗	3, 28, 31, 33, 42 3, 28
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RESOURCE FACTOR 6: BANK STRUCTURE - VERTICAL HEIGHT

RESOURCE CRITERIA	RELATIONSHIP TO FISHING (↗ positive, - negative)	FISHING BIBLIOGRAPHY REFERENCE NUMBER
High Banks	Hazard To Fishermen - Difficult To Fish, May Cause Rapid Increases In Water Depth, Hamper Access	31, 33

RESOURCE FACTOR 7: BANK STRUCTURE - BOULDERS

RESOURCE CRITERIA	RELATIONSHIP TO FISHING (↗ positive, - negative)	FISHING BIBLIOGRAPHY REFERENCE NUMBER
Boulders	Provide Cover ↗	31, 33, 35

RESOURCE FACTOR 8: BANK VEGETATIVE

RESOURCE CRITERIA	RELATIONSHIP TO FISHING (↗ positive, - negative)	FISHING BIBLIOGRAPHY REFERENCE NUMBER
Vegetated With Brush Overhanging The Water	Higher Trout Pop. ↗ Shade and Lower Temp. ↗ Cover ↗	13, 33, 34 7, 8, 27, 35 9, 13, 33, 35, 42

Table 1. CONTINUED

	Stability /	35
	Reduces Additions Of Sand, Silt, Clay /	28, 31
	Reduces Channel Width Alteration /	13
Vegetated But No Brush Overhanging The Water	Stability /	35
	Reduces Additions Of Sand, Silt, Clay /	28, 31
	Reduces Channel Width Alteration /	13

RESOURCE FACTOR 9: BANK - ADDITIVE VEGETATIVE

RESOURCE CRITERIA	RELATIONSHIP TO FISHING (/ positive, - negative)	FISHING BIBLIOGRAPHY REFERENCE NUMBER
Debris (Dead Branches, Trees, Twigs Lodged In Stream Channel)	Cover / Reduces Siltation /	13, 31, 33, 42 28

STREAMSIDE Factors

RESOURCE FACTOR 10: STREAMSIDE VEGETATION - EDGE OF BANK TO 50 FT.
FROM BANK

RESOURCE CRITERIA	RELATIONSHIP TO FISHING (/ positive, - negative)	FISHING BIBLIOGRAPHY REFERENCE NUMBER
(50 Feet From Bank-----Representative Of Streamside Vegetative Condition		7)

1
52
1

Table 1. CONTINUED

Good Arrangement Of Trees, Shrubs, Grass	Improves Trout Production /	28
	Controls Erosion /	7
Good Ground Cover	Even Water Flows And Temperatures /	5
Vegetated	Improves Trout Production /	13
	Improves Streamside Stability /	35
	Reduces Siltation /	28

WATER Factors

RESOURCE FACTOR 11: WATER TEMPERATURE - SUMMER MAX.

<u>RESOURCE CRITERIA</u>	<u>RELATIONSHIP TO FISHING (/ positive, - negative)</u>	<u>FISHING BIBLIOGRAPHY REFERENCE NUMBER</u>
Water Temp.	Critical Factor In Growth, Respiration, Reproduction Of Trout	35, 39
Low Summer Temp.	Favorable To Propagation	3
65°F (18.3°C)	Positive Trout Influence	13
57-58°F (14-14.4°C)	Incubation Of Eggs	5, 27
48-65.3°F (9-18.5°C)	Ideal For Rainbow Trout Fingerlings	27

Table 1. CONTINUED

55-65°F (12.8-18.3°C)	Optimum Growth And Survival	7, 39
59-64°F (15-18°C)	Best For Salmonid Growth	27
59°F (15°C)	Max. Activity Of Brook Trout	17
60-70°F (15.5-21°C)	Summer Habitat Of Brown Trout	12
>70°F (21°C)	Good For Trout	33
66°F (19°C)	Best Midsummer For Brook Trout	5
32-70°F (0-21°C)	Range For Intolerant Coldwater Species	30
>70°F (21°C)	For Extended Periods - Food, Oxygen Loss	7
70°F (21°C)	Max. Limit For Cold Water Fish	31
68°F (20°C)	Max. Limit For Salmonid	27
70.7-77.2°F (21.5-25.1°C)	Upper Limit For Salmonid	29
73.4-77°F (23-25°C)	Upper Limit Brook Trout	29
75°F (24°C)	Highest Limiting Brook Trout	5, 27
75°F (24°C)	Max. Limit For Rainbow Fingerlings	27

Table 1. CONTINUED

75-80°F (24-26.6°C)	Max. Summer Daily For Brown Trout	5
81-82.5°F (27-28.3°C)	Max. Limit For Brown Trout	5, 27
No Lower Limit	For Brook Trout	33
32°F (0°C)	All Trout Species Can Tolerate	17
<55°F (12.8°C)	Too Cool For Best Trout Growth	5, 33

RESOURCE FACTOR 12: WATER TURBIDITY

RESOURCE CRITERIA	RELATIONSHIP TO FISHING (+ positive, - negative)	FISHING BIBLIOGRAPHY REFERENCE NUMBER
No Turbidity	Improves Productivity +	30
Turbidity	Reduces Food Production -	7, 15, 18, 19, 31, 42
	Interferes With Trout Feeding -	31
	Smothers Spawn And Spawning Sites -	7, 18, 19, 27, 28, 42
	Smothers Cover And Pools -	7, 15
	Habitat Damage -	18
	Reduces Fishing Attractiveness -	18
	Harms Fish Gills -	27

RESOURCE FACTOR 13: WIDTH OF WATER SURFACE

Table 1. CONTINUED

RESOURCE CRITERIA	RELATIONSHIP TO FISHING (✓ positive, - negative)	FISHING BIBLIOGRAPHY REFERENCE NUMBER
>15 Feet Wide	Top Quality Trout Mainstream ✓	46
<15 Feet Wide	Top Quality Trout Feeder Stream But Difficult To Fish Because Of Small Size	46
Approximately 70 Feet	Distance a Fisherman Can Cast	47

RESOURCE FACTOR 14: WATER DEPTH

RESOURCE CRITERIA	RELATIONSHIP TO FISHING (✓ positive, - negative)	FISHING BIBLIOGRAPHY REFERENCE NUMBER
Depth	Acts As Cover ✓	13, 33
>5 Feet	Cover Even In Clear Quiet Water ✓	33
>2 Feet	Holds Trout ✓	33
3 Feet	Provides Cover ✓	35, 42
2-3 Feet	Can Use Supplementary Vegetation For Good Cover	35, 42
>1.5 Feet	Provides Some Pool Shelter	3, 10

Table 1. CONCLUDED

Shallow Riffles	Produce Bulk Of Trout Food	5
<18 Inches	Trout Spawn	33

Publications 1, 3, 4, 10, 13, 33, define pools, runs, and riffles in relation to water depth and velocity. The publications do vary in their definitions. For example, riffles may be defined as <8 inches deep (3), or <18 inches deep (33).

Most water depths provide some benefit to the fishing activity. The shallower depths (riffles) produce food, spawning areas, and areas for trout fry to survive. While deeper (runs and pods) areas tend to provide cover, shelter, feeding areas for larger fish.

RESOURCE FACTOR 15: WATER VELOCITY

<u>RESOURCE CRITERIA</u>	<u>RELATIONSHIP TO FISHING (/ positive, - negative)</u>	<u>FISHING BIBLIOGRAPHY REFERENCE NUMBER</u>
Fast Flowing Streams (Fast Flow >1 ft/sec, Slow Flow <1 ft/sec)	Trout Require /	35 1)
Fast Flow	Trout Populations Increase /	1, 8
1-4 feet/sec	Good For Trout /	40
<1 foot/sec	Poor For Trout -	40

Table 2. RESOURCE FACTORS AND FACTOR WEIGHTS, FACTOR CRITERIA AND CRITERIA WEIGHTS, FOR THE OUTDOOR RECREATION ACTIVITY OF STREAM TROUT FISHING

RESOURCE FACTOR 1: STREAM BED MINERAL MATERIAL

FACTOR WEIGHT: 1.0

<u>CRITERIA</u>	<u>CRITERIA WEIGHT</u>
Boulders (>12" dia.)	5
Rubble (3-12" dia.) or Gravel (1/8-2.9" dia.)	4
Fractured Bedrock	3
Solid Bedrock	2
Sand, Silt, Clay (<1/8" dia.)	0 *Potential to terminate recre- ational use if present in large quantities.

RESOURCE FACTOR 2: STREAM BED VEGETATIVE MATERIAL

FACTOR WEIGHT: .8

<u>CRITERIA</u>	<u>CRITERIA WEIGHT</u>
Adequate - Natural	
25-50% or Island(s)	5
<25%	4
50-75%	4
Excessive - Natural	
>75%	2
Excessive - A Result of Unnatural Pollution	
>75%	0 *Potential to terminate recre- ational use.

Table 2. CONTINUED

RESOURCE FACTOR 3: STREAM CHANNEL - HORIZONTAL DISTANCE FROM BANK TO EDGE OF STREAM (AT NORMAL FLOW)

FACTOR WEIGHT: .9

<u>CRITERIA</u>	<u>CRITERIA WEIGHT</u>
0 Feet	5
1-3 Feet	4
4-10 Feet	3
>10 Feet (Or where no natural bank has yet established due to recent human disturbances, e.g. construction.)	2

RESOURCE FACTOR 4: STREAM BANK PARENT MATERIAL

FACTOR WEIGHT: .9

<u>CRITERIA</u>	<u>CRITERIA WEIGHT</u>
Predominantly Sand and Gravel	5
Predominantly Silt or Clay	1

RESOURCE FACTOR 5: STREAM BANK STRUCTURE - UNDERCUT

FACTOR WEIGHT: 1.0

<u>CRITERIA</u>	<u>CRITERIA WEIGHT</u>
Bank Undercut Water Reaches Bank	5
Bank Undercut Water Does Not Reach Bank	1

Table 2. CONTINUED

RESOURCE FACTOR 6: STREAM BANK STRUCTURE - VERTICAL HEIGHT (Note: See Definitions, "Vertical Height")

FACTOR WEIGHT: .8

<u>CRITERIA</u>	<u>CRITERIA WEIGHT</u>
< 4 Feet	5
4-8 Feet	3
8-12 Feet	1
>12 Feet	0 *Potential to terminate recreational use.

RESOURCE FACTOR 7: STREAM BANK STRUCTURE - BOULDERS

FACTOR WEIGHT: 1.0

<u>CRITERIA</u>	<u>CRITERIA WEIGHT</u>
Bouldered Bank Water Reaches Bank	5
Bouldered Bank Water Does Not Reach Bank	1

RESOURCE FACTOR 8: STREAM BANK - VEGETATIVE

FACTOR WEIGHT: 1.0

<u>CRITERIA</u>	<u>CRITERIA WEIGHT</u>
Vegetated With Brush Overhanging The Water Surface	5
Vegetated But No Brush Overhanging The Water Surface	3

Table 2. CONTINUED

RESOURCE FACTOR 9: STREAM BANK - ADDITIVE VEGETATIVE

FACTOR WEIGHT: .8

<u>CRITERIA</u>	<u>CRITERIA WEIGHT</u>
Debris - Of a Semi-permanent Nature (Evidence of Lasting Approximately 1 Year)	5

RESOURCE FACTOR 10: STREAMSIDE VEGETATIVE - EDGE OF BANK TO 50 FEET FROM BANK

FACTOR WEIGHT: .9

<u>CRITERIA</u>	<u>CRITERIA WEIGHT</u>
Mixed Arrangement (of 3 types) of Trees, Shrubs, Grasses	5
Mixed Arrangement (of 2 types) of Trees or Shrubs and Grasses	4
Vegetated With (of 1 type) Trees or Shrubs or Grasses	3
Devegetated	1

Table 2. CONTINUED

RESOURCE FACTOR 11: WATER TEMPERATURE (SUMMER MAX.)

FACTOR WEIGHT: 1.0

<u>CRITERIA</u>	<u>CRITERIA WEIGHT</u>
45-65°F (7.2°-18.3°C)	5
66-70°F (19.9-21°C)	4
32-44°F (0.0-6.7°C)	3
71-80°F (21.7-26.7°C)	2
<32°F (0.0°C)	1
>80°F (26.7°C)	0 *Potential to terminate recreational use.

RESOURCE FACTOR 12: WATER TURBIDITY

FACTOR WEIGHT: .9

<u>CRITERIA</u>	<u>CRITERIA WEIGHT</u>
Little or No Turbidity From July - April	5
Periodic Turbidity From July - April	3
Continuous Turbidity From July - April	0 *Potential to terminate recreational use.

Table 2. CONCLUDED

RESOURCE FACTOR 13: WIDTH OF WATER SURFACE

FACTOR WEIGHT: .8

<u>CRITERIA</u>	<u>CRITERIA WEIGHT</u>
>70 Feet Wide	5
15-70 Feet Wide	4
3-15 Feet Wide	3
<3 Feet Wide	1

RESOURCE FACTOR 14: WATER DEPTH

FACTOR WEIGHT: .9

<u>CRITERIA</u>	<u>CRITERIA WEIGHT</u>
>3 Feet	5
6 Inches - 3 Feet	3
<6 Inches	1

RESOURCE FACTOR 15: WATER VELOCITY

FACTOR WEIGHT: .9

<u>CRITERIA</u>	<u>CRITERIA WEIGHT</u>
1-4 Feet/Second	5
>4 Feet/Second	3
<1 Foot/Second	1

in vegetative patterns, stream water surface patterns, and geomorphic characteristics. On the basis of this examination, this selected portion of the West Gallatin River was subdivided into fifty-eight homogeneous unit tracts for inventory and evaluation (see Figure 14).

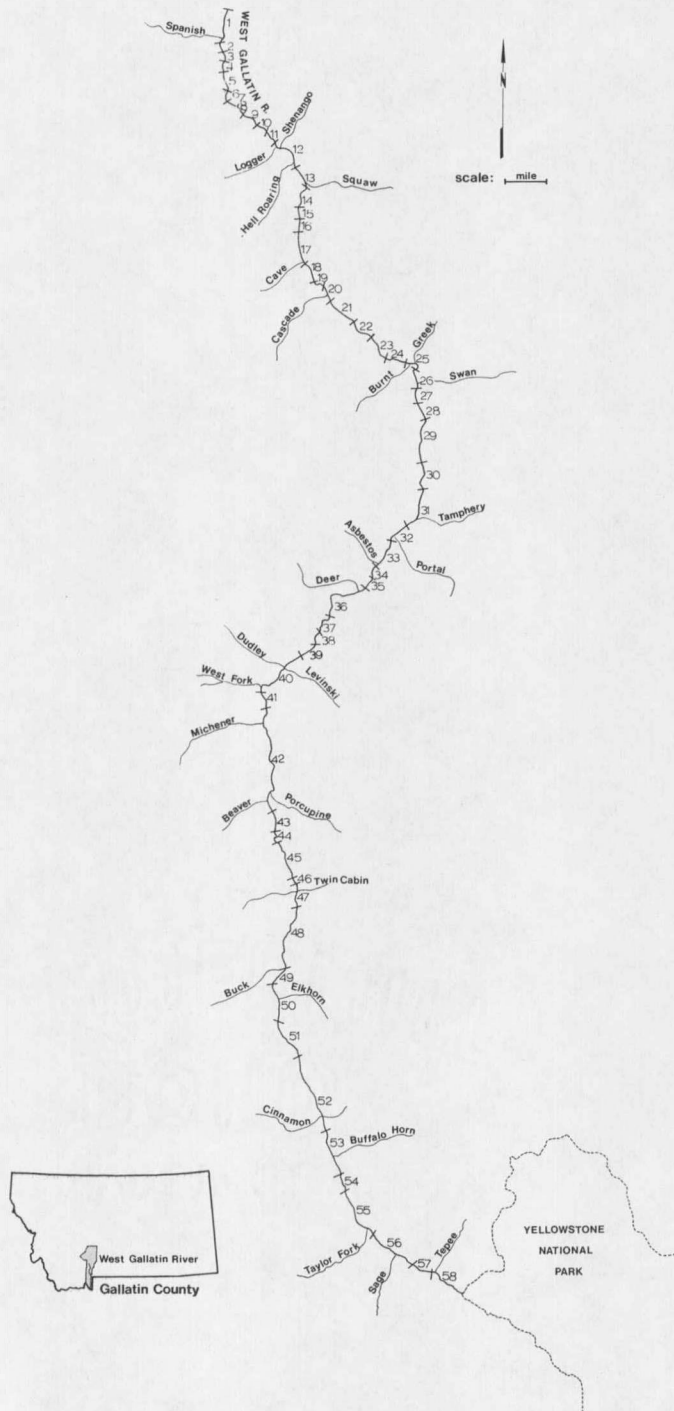


Figure 14. STUDY AREA AND LOCATION OF INVENTORIED TRACTS FOR STREAM TROUT FISHING

The following comments are observations made by the author concerning the established natural resource requirements (Table 2) and/or the inventory of the site as it applies to the established natural resource requirements:

- (A) Since the inventory was done by visual analysis, it was found advantageous to observe the unit tracts from a good visual vantage point such as a bridge or high bank when determining the percentages for the inventory. Aerial photographs and binoculars were valuable aids. For this research, approximately 80% of the entire site was visually observed on the site.
- (B) In estimating percentages of each natural resource characteristic, it is very helpful to use the illustrated Charts For Estimating Proportions of Mottles and Coarse Fragments (Appendix II) for comparative purposes.
- (C) The average time needed to inventory each of the 58 unit tracts was approximately 20 minutes. In many cases it was necessary to examine the unit tract from two or more different locations before determining inventory figures for the total unit tract. The inventory by the author began April 18, 1972, and concluded April 29, 1972.

- (D) Fifteen natural resource factors were identified by literature review (with each resource factor being subdivided into a number of criteria). Data for thirteen of the factors was gathered in visual site inventory, by the author. Data for Resource Factor 11 (Water Temperature, Summer Max.) was extracted and extrapolated from unpublished research data gathered by Mr. Gary Bissonnette (48). Data for Resource Factor 12 (Water Turbidity) was based upon general observations of the author and other residents of the area over a period of three years (1969-1972).
- (E) A helpful practice when inventorying a unit tract was to mentally identify the five major areas of the typical stream; the bed, the channel, the bank, the stream side, and the water (Figure 15). The greatest difficulty in identifying the five major areas occurs where the stream has been changed by unnatural causes (e.g. human construction).
- (F) Stream Bed Mineral Material (Resource Factor 1) has Boulder Criteria rated as more favorable than Gravel Criteria. This is based upon the author's judgement that the unique character of boulders in a stream add

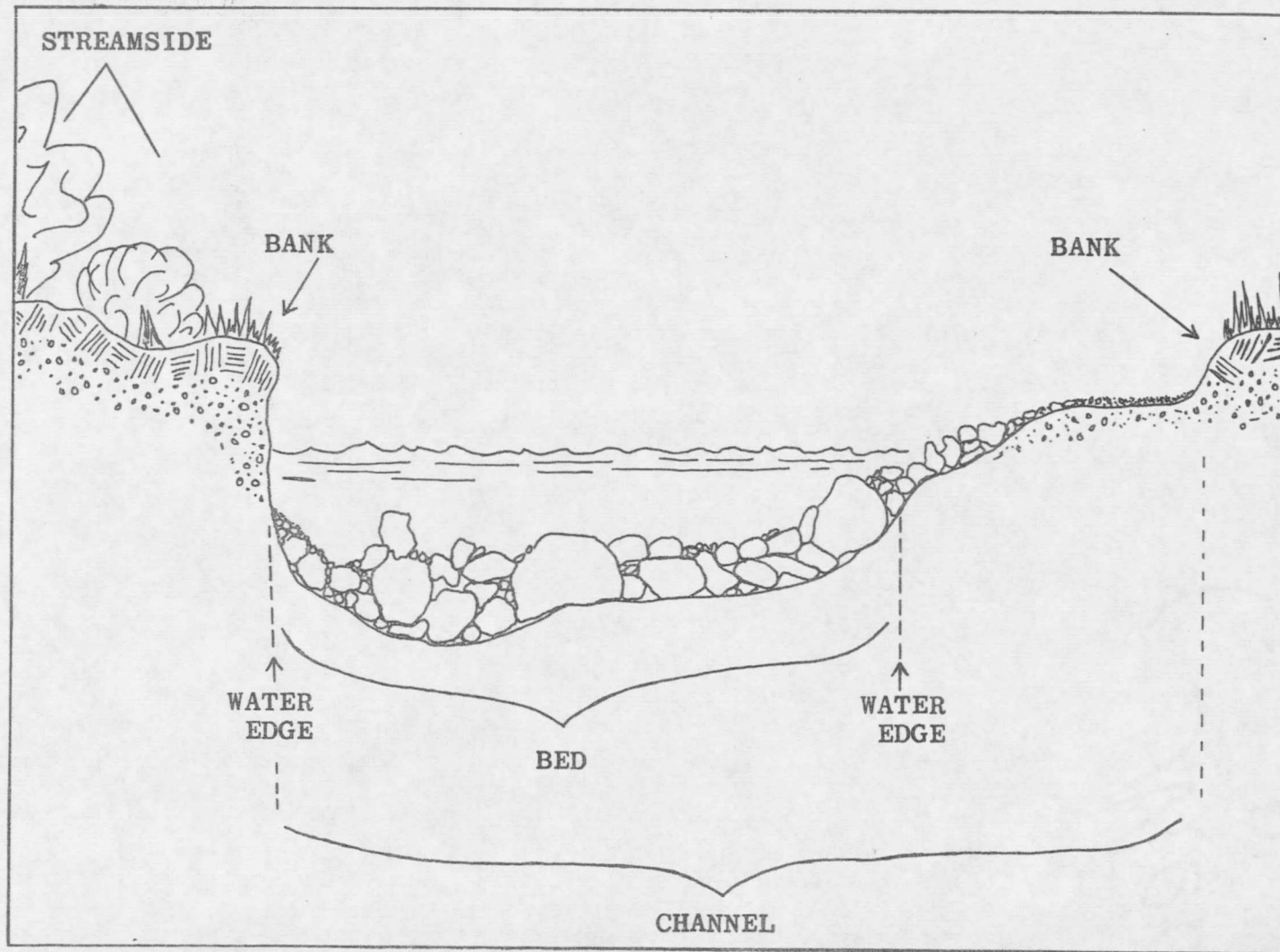


Figure 15. TYPICAL STREAM CROSS SECTION

fisherman interest as well as creating positive habitat conditions.

- (G) Criteria having a 0 weight have the potential to terminate recreation use if they are present in sufficient quantities. An example of this would be sand, silt, or clay in the stream bed.
- (H) Stream Bed Vegetative Material (Resource Factor 2) represents a measure of the density of vegetative material found in the stream bed. Islands are listed under this factor as they do represent a vegetative addition in the stream section. Islands are generally considered a favorable factor to the fishing activity, therefore a 5 weight is given. There is no differentiation made between islands having different densities of vegetation upon them.
- (I) Aerial photos are extremely helpful in providing percentages on islands (Factor 2) and streamside vegetation (Factor 10).
- (J) Stream Bank Structure - Boulders (Resource Factor 7) would include solid rock cliffs forming the bank in some locations. In many instances the percentage of boulders in the bank does not compare to the percentage of boulders in the stream bed, often the percentage of

boulders is less in the bank due to soil coverage.

- (K) Stream Bank - Vegetative (Resource Factor 8) was sometimes adversely affected by the effect of wild animal browsing. This reduced the amount of overhang in many areas. Also it should be noted that long grass may be classified as overhanging brush (see Definitions).
- (L) Stream Bank - Additive Vegetative (Resource Factor 9) includes debris in the stream channel, especially that lodged around the islands.
- (M) Streamside Vegetative - Edge of Bank (Resource Factor 10) is a very general inventory of different surface coverages of the three types of plant materials. It should be remembered that where the road is part of the streamside, then that particular percentage is devegetated.
- (N) Water Temperatures - Summer Maximum (Resource Factor 11) is a factor that has been the subject of much research. It appeared that low temperatures were not considered as detrimental to fish as were high temperatures, even though it was noted that continued cold was a factor in reduced fish sizes. Therefore, the summer maximum temperature was the factor used in the inventory. A moderate high summer temperature (45-65°F was considered best with a decrease in

criteria weight as the summer high temperature increased. It should be noted where the summer high temperature was relatively low, this was weighted as less desirable than a more moderate summer high temperature. Temperature data that is available from records covering a number of years is obviously to be desired.

- (O) Water Turbidity (Resource Factor 12) contains criteria that are generally worded. Although turbidity is recognized as an important factor in fishing, it appears that specific turbidity intensities and their relative influences on the fishing activity need further documentation.
- (P) Water Depth (Resource Factor 14) was inventoried by visual analysis, which may to some extent diminish its validity. Although there may be some dispute between fishermen concerning the optimum water depth for good fishing; the criteria, as weighted, favor the deeper sections of the stream.
- (Q) Water Velocity (Resource Factor 15) is another factor whose validity is reduced because the inventory was done visually. There is no doubt that visually gauging water velocity, even by experienced persons, is difficult at best. No existing instrument survey

data for water velocity was available for this section of the West Gallatin River. Yet the water velocity factor appeared to be important and the established criteria ranges appeared to be valid. Therefore, rather than take the negative approach of ignoring this factor, an attempt was made by the author to visually survey the water velocity. The survey was based upon relative appearances of gradients and water surface characteristics, as well as generally gauging velocities of materials moving on the water's surface. Perhaps the final inventory of this factor might be considered a relative comparison of fast and slow portions of the stream.

- (R) A review and understanding of the fishing definitions, pages 87-89, is strongly suggested prior to implementation of the inventory.

RESULTS: - The percentage values obtained from the inventory are presented in Table 3. The computation of the percentages into resource factor values is presented in Table 4. Also presented in Table 4 is a total of all 15 resource factors for each inventoried unit tract.

Table 3. SITE INVENTORY VALUES OF THE WEST GALLATIN RIVER
(From the Yellowstone National Park Boundary to the Spanish Creek Inlet)
FOR THE OUTDOOR RECREATION ACTIVITY OF STREAM TROUT FISHING

RESOURCE FACTOR	FACTOR WEIGHT	CRITERIA	CRITERIA WEIGHT	UNIT TRACT NUMBERS																															
				1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29			
No. 1 STREAM BED MINERAL MATERIAL	1.0	BOULDERS	5	50	50	30	60	70	35	40	30	25	20	50	65	15	20	12	30	55	45	40	40	25	20	35	15	20	20	40	30				
		RUBBLE OR GRAVEL	4	40	35	60	35	30	45	55	65	73	75	40	32	80	75	76	45	40	50	60	55	75	70	65	75	65	65	65	50	55			
		FRACTURED BEDROCK SOLID BEDROCK SAND, SILT OR CLAY	3 2 0	10	15	10	5		4	16	5	5	2	5	10	3	5	5	12	25	5	5		5		10		10	15	15	15	10	15		
No. 2 STREAM BED VEGETATIVE MATERIAL	.8	25-50% OR ISLAND(S)	5	2																															
		<25%	4	98	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100			
		50-75%	4																																
		>75% >75% POLLUTED	2 0																																
No. 3 STREAM CHANNEL HORIZONTAL DIS- TANCE FROM BANK TO EDGE OF STREAM	.9	0 FEET	5	5						40	20	20			2																				
		1-3 FEET	4	2	2					5						30																			
		3-10 FEET >10 FEET	3 2	43	20	15	50		5	5	10	60	10	15	53	10	35	5	15	10	15	5	30	50	20	5	30	30	50	70	90	65			
No. 4 STREAM BANK PARENT MATERIAL	.9	PREDOMINANTLY SAND AND GRAVEL	5	100	100	100	100	100	100	100	100	100	100	100	100	100	100	95	100	100	100	100	100	100	100	100	100	100	100	100	100				
		PREDOMINANTLY SILT OR CLAY	1																5																
No. 5 STREAM BANK STRUCTURE - UNDERCUT	1.0	UNDERCUT - WITH WATER	5																					3											
		UNDERCUT - WITHOUT WATER	1	5	1														2	15						20									
No. 6 STREAM BANK STRUCTURE - VERTICAL HEIGHT	.8	<4 FEET	5	40	80	45	15	10	20	25	50	75	40	75	30	40	100	20	40	30	60	35	40	90	97		95	90	85	90	90				
		4-8 FEET	3	50	20	50	80	85	80	70	10	25	30	25	70	80		20	50	15	50	25	35	10			5	3	5	5	10	5			
		8-12 FEET >12 FEET	1 0	10		5	5	5	5	5		40				10			40	10	5	20	20	20			3	45	2	5	10		5		
No. 7 STREAM BANK STRUCTURE - BOULDERS	1.0	BOULDERED - WITH WATER	5	2								20			2			2	15																
		BOULDERED - WITHOUT WATER	1	50	50	30	50	20	25	10	5	15	15	40	25	15	15	5	40	50	40	30	20	20	15	30	5	10	15	10	10	25			
No. 8 STREAM BANK VEGETATIVE	1.0	VEGETATED - WITH BRUSH OVERHANGING WATER	5	2					2						15			20	15							15	5		7	5	10	15	10	10	
		VEGETATED - BUT NO BRUSH OVERHANGING WATER	3	90	95	95	95	90	95	100	60	100	50	90	85	70	79	70	100	98	95	80	85	85	95	90	82	92	85	80	90	85			
No. 9 STREAM BANK ADDITIVE VEGETATIVE	.8	DEBRIS	5	2			2	1	2																										
No. 10 STREAMSIDE VEGETATIVE	.9	MIXED (3 types)	5	70	40	50	85	30		70	45	50	10	55	70	30	15	40	40	5	40	30	40	40	40	45	40	50	70	50	70	70			
		MIXED (2 types)	4	25	30	38	15	65	80	30	15	40	40	35	30	55	80	35	45	20	35	30	25	35	25	10	35	25	10	40	20	15			
		ONE TYPE NONE	3 1		20	10	2		30	20	10	20	10	30	10	3	10	10	85	15	20	25	20	3	10	5	15	10	5	5	5	10	5		
No. 11 WATER TEMPERATURE (SUMMER MAX.)	1.0	45-65°F	5	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100			
		66-70°F	4																																
		32-44°F	3																																
		71-80°F	2																																
		<32°F >80°F	1 0																																
No. 12 WATER TURBIDITY	.9	LITTLE OR NONE (July-April)	5																																
		PERIODIC (July-April) CONTINUOUS (July-April)	3 0	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100		
No. 13 WIDTH OF WATER SURFACE	.8	>70 FEET	5	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100			
		15-70 FEET 3-15 FEET <3 FEET	4 3 1																																
No. 14 WATER DEPTH	.9	>3 FEET	5	25	40	10																													
		3 FEET-6 INCHES	3	60	55	85	95	95	80	95	90	85	80	60	75	84	65	55	75	49	77	80	88	85	94	90	75	90	90	90	75	90			
		<6 INCHES	1	15	5	5	5	5	15	5	10	5	15	15	5	15	22	10	15	8	1	3	5	14	14	5	10	23	5	5	5	10			
No. 15 WATER VELOCITY	.9	1-4 FEET/SECOND	5	75	60	95	95	70	85	100	98	65	90	63	80	94	88	80	75	50	90	70	83	99	93	60	90	90	80	80	85				
		>4 FEET/SECOND <1 FOOT/SECOND	3 1	15	25	5	3	30	5	10	2	35	5	30	20	15	5	7	20	10	5	3	2	1	5	5	5	10	5	10	10	5			

Table 3. Concluded.

SITE INVENTORY VALUES OF THE WEST GALLATIN RIVER
(From the Yellowstone National Park Boundary to the Spanish Creek Inlet)
FOR THE OUTDOOR RECREATION ACTIVITY OF STREAM TROUT FISHING

RESOURCE FACTOR	FACTOR WEIGHT	CRITERIA	CRITERIA WEIGHT	UNIT TRACT NUMBERS																															
				30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58			
No. 1 STREAM BED MINERAL MATERIAL	1.0	BOULDERS	5	30	20	30	15	20	38	15	15	5	5	20	5	30	35	15	15	30	20	20	35	30	30	35	40	40	30	15	7	3			
		RUBBLE OR GRAVEL	4	63	75	65	65	65	60	70	80	85	70	75	90	68	60	75	80	70	60	70	55	65	68	63	58	50	50	80	83	87			
		FRACTURED BEDROCK	3																																
		SOLID BEDROCK SAND, SILT OR CLAY	0	7	5	5	20	15	2	15	5	10	25	5	5	2	5	10	5		20	10	10	5	2	2	2	10	20	5	10	10			
No. 2 STREAM BED VEGETATIVE MATERIAL	.8	25-50% OR ISLAND(S) <25%	5	10			30	10		2	10			15	20	5	5	20			20					5	2	2	2	10	40	35	50		
		50-75%	4	90	100	100	70	90	100	98	90	100	100		85	80	95	80	100	100	100	100	100	100	100	100	100	100	100	100	90	60	65	50	
		>75%	4																																
		>75% POLLUTED	0																																
No. 3 STREAM CHANNEL HORIZONTAL DIS- TANCE FROM BANK TO EDGE OF STREAM	.9	0	5	10		1	35	5	30	10	20	20	5	25	30	40	45	10	15	40			15	35	50	10	40	50	80	60	35	70	45	85	
		1-3 FEET	4	5	5	45	15	10	10	20	30	30	5	35	40	40	35	40	30	50			85	40	30	30	30	25	10	30	25	20	10	10	
		3-10 FEET	3	30	40	50	15	20	40	55	30	40	30	20	20	15	40	30	10	18	20	15	15	20	15	10	8	10	20	10	15	3	3	3	
		>10 FEET	2	55	55	4	35	55	20	15	20	50	10	10																					
No. 4 STREAM BANK PARENT MATERIAL	.9	PREDOMINANTLY SAND AND GRAVEL	5	100	100	100	100	100	100	100	100	70	50	85	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	
		PREDOMINANTLY SILT OR CLAY	1										30	50	15																				
No. 5 STREAM BANK STRUCTURE - UNDERCUT	1.0	UNDERCUT - WITH WATER	5	5		1	15	1		3	1	2	15	20	15	40	10	10	5		3	10	5	5	10	5	60	50	10	60	30	85			
		UNDERCUT - WITHOUT WATER	1	5	5	1	15			10			2	10	50	15	30	15	10	10		2	25	5	25	5	25	10	20	5	15	10	5		
No. 6 STREAM BANK STRUCTURE - VERTICAL HEIGHT	.8	<4 FEET	5	90	75	55	30	40	15	60	60	50	50	75	80	95	95	65	100			70	85	95	40	80	90	95	60	95	60	100			
		4-8 FEET	3	8	20	40	30	40	70	40	35	20	50	25	20	5	5	5				30	30			15	15	5	5	20	3	40			
		>12 FEET	0	2	5	5	10		15		5	30						30			10	90			15	5	10		2	2					
No. 7 STREAM BANK STRUCTURE - BOULDERS	1.0	BOULDERED - WITH WATER	5	5		1	1	2	15			5		5	5	15	5	2	2		2	5	15	20	20	20	30	30	20	5	2				
		BOULDERED - WITHOUT WATER	1	15	15	50	5	15	20	10	5	1	2	20	5	10	10	3	3	30	2	10	15	20	20	20	5	5	5	1	5	1			
No. 8 STREAM BANK VEGETATIVE	1.0	VEGETATED - WITH BRUSH OVERHANGING WATER	5	10	5	5	20	5	5	1	15	5	15	15	20	30	10	5	35			15	15	10	5	20	25	70	60	30	75	35	85		
		VEGETATED - BUT NO BRUSH OVERHANGING WATER	3	90	90	90	70	90	90	90	75	70	80	85	80	70	90	70	65	70	75	80	85	80	75	65	25	40	65	18	55	15			
No. 9 STREAM BANK ADDITIVE VEGETATIVE	.8	DEBRIS	5	2	1		5	2	1		3		1		1		5	1		2	2	1	1	1	1	1	5	1							
		NONE																																	
No. 10 STREAMSIDE VEGETATIVE	.9	MIXED (3 types)	5	70	80	40	25	20	50	35	50	20	70	75	15		50	45	70		30	65	80	40	45	60	15	70	25	5					
		MIXED (2 types)	4	15	15	40	30	25	10	15	10	20	25	20	5	5	30	15	10	15	40	20	20	15	15	25	15	80	20	40	28	50	20		
		ONE TYPE	3	5	3	10	15	20	15	25	20	20	5	5	25	5	20	25	15	10	40	5	5	15	15	15	3	10	25	65	45	80			
		NONE	1	10	2	10	30	35	25	25	20	40			10						50	10	10	30	15	10	2	10	2	5					
No. 11 WATER TEMPERATURE (SUMMER MAX.)	1.0	45-65°F	5	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100		
		65-70°F	4																																
		32-44°F	3																																
		71-80°F	2																																
		<32°F	1																																
No. 12 WATER TURBIDITY	.9	LITTLE OR NONE (July-April)	5																																
		PERIODIC (July-April)	3	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100		
		CONTINUOUS (July-April)	0																																
		NONE																																	
No. 13 WIDTH OF WATER SURFACE	.8	>70 FEET	5	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100			
		15-70 FEET	4																																
		3-15 FEET	3																																
		<3 FEET	1																																
No. 14 WATER DEPTH	.9	>3 FEET	5	5	2	1	40	10	5	20	1	20	5	5	1	2																			
		3 FEET-6 INCHES	3	85	90	94	50	75	94	75	94	60	75	80	90	85	80	75	70	94	80	90	85	75	74	60	75	80	80	63	65	85	5		
		<6 INCHES	1	10	8	5	10	15	1	5	5	20	20	15	9	13	20	25	30	5	15	8	15	20	25	40	15	15	10	35	25	10			
No. 15 WATER VELOCITY	.9	1-4 FEET/SECOND	5	90	80	78	75	75	79	92	95	55	100	80	95	85	85	92	90	80	90	85	90	95	90	90	90	100	85	90	85	93			
		>4 FEET/SECOND	3	5	15	20	5	20	20	2	25	25	20	2	17	3	14	14	5	5	20	5	10	5	10	10	10	10	15	10	10	10	2		
		<1 FOOT/SECOND	1	5	5	1	20	5	1	5	5	20			3	2	1	1	3	5															

Table 4. RESOURCE FACTOR VALUES FOR STREAM TROUT FISHING

AS COMPUTED FROM THE SITE INVENTORY OF THE WEST GALLATIN RIVER

RESOURCE FACTOR NUMBER	MAXIMUM VALUE POSSIBLE	INVENTORIED UNIT TRACT NUMBERS															
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	
1	500	410	390	390	440	470	363	420	410	417	400	410	453	395	400	364	
2	400	322	320	320	320	320	320	320	320	320	320	320	320	320	320	320	
3	450	236	202	194	225	180	194	184	297	297	243	194	287	189	329	149	
4	450	450	450	450	450	450	450	450	450	450	450	450	450	450	450	450	
5	500	5	1	-	-	-	-	-	-	-	-	-	-	-	-	2	
6	400	288	368	304	256	248	276	272	224	360	248	360	288	304	400	160	
7	500	60	50	30	50	20	25	10	5	15	115	40	35	15	25	80	
8	500	280	285	285	285	270	295	300	180	300	150	270	330	210	337	285	
9	400	8	-	-	8	4	8	-	-	-	-	-	-	-	-	-	
10	450	410	351	391	437	374	306	423	329	396	270	401	423	365	365	347	
11	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	
12	450	270	270	270	270	270	270	270	270	270	270	270	270	270	270	270	
13	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400	
14	450	288	333	279	261	261	252	261	252	279	252	288	297	245	254	315	
15	450	387	351	432	437	396	405	450	446	387	423	371	414	464	416	378	
TOTAL	6800	4314	4271	4245	4339	4163	4064	4260	4083	4391	4041	4274	4467	4127	4466	4020	
16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33
330	435	425	440	420	425	380	435	375	360	360	360	400	370	402	400	410	335
320	320	320	320	320	320	320	320	328	336	320	320	320	340	328	320	320	344
194	189	195	185	216	285	342	188	299	333	270	288	270	306	243	225	309	315
432	450	450	450	450	450	450	450	450	450	450	450	450	450	450	450	450	450
15	-	-	-	20	15	-	-	10	25	10	10	30	55	30	5	6	90
288	160	304	216	260	384	388	48	237	372	352	384	384	376	381	352	320	216
40	50	40	55	25	45	40	30	30	25	15	60	10	25	40	15	55	10
300	294	285	240	255	330	310	270	281	301	305	315	320	305	320	295	295	310
-	-	-	-	-	-	-	8	4	12	12	-	4	8	8	4	-	20
374	279	356	315	347	365	325	279	374	365	387	387	405	401	392	424	360	288
500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500
270	270	270	270	270	270	270	270	270	270	270	270	270	270	270	270	270	270
400	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400
261	286	358	301	288	247	247	263	252	232	270	270	270	279	261	259	263	324
387	351	427	396	416	446	428	369	423	414	423	396	396	414	423	405	410	369
4111	3984	4330	4088	4187	4482	4400	3830	4233	4395	4344	4410	4429	4499	4448	4324	4368	4241

Table 4. Concluded.

RESOURCE FACTOR VALUES FOR STREAM TROUT FISHING

AS COMPUTED FROM THE SITE INVENTORY OF THE WEST
GALLATIN RIVER

RESOURCE FACTOR NUMBER	MAXIMUM VALUE POSSIBLE	INVENTORIED UNIT TRACT NUMBERS															
		34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	
1	500	360	430	355	395	365	305	400	385	422	415	375	395	430	340	380	
2	400	328	320	322	328	320	320	332	336	324	324	336	320	320	336	320	
3	450	230	315	293	315	239	338	351	378	378	315	284	387	189	302	360	
4	450	450	450	450	450	342	270	396	450	450	450	450	450	450	450	450	
5	500	5	-	25	5	12	85	150	90	230	65	60	35	-	17	75	
6	400	272	228	336	316	248	320	360	368	392	392	272	400	8	352	340	
7	500	25	95	10	5	26	2	45	30	85	35	13	13	30	12	35	
8	500	295	295	275	300	235	315	330	340	360	320	235	370	210	300	315	
9	400	8	4	-	12	-	-	4	-	4	-	20	4	-	8	8	
10	450	266	324	302	333	252	419	423	324	356	387	324	410	216	324	387	
11	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	
12	450	270	270	270	270	270	270	270	270	270	270	270	270	270	270	270	
13	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400	
14	450	261	277	297	266	270	243	252	256	250	234	225	216	263	252	259	
15	450	414	410	428	432	333	450	409	437	421	421	430	423	414	423	414	
TOTAL	6800	4084	4318	4263	4327	3812	4237	4622	4564	4842	4528	4194	4593	3700	4286	4513	

49	50	51	52	53	54	55	56	57	58	HIGHEST SCORE OF ALL 58 TRACTS	LOWEST SCORE OF ALL 58 TRACTS	MEAN OF ALL 58 TRACTS
395	410	422	427	432	400	350	395	367	363	470	305	395
320	320	320	324	322	320	328	352	348	360	360	320	325
383	279	356	369	421	405	338	414	351	430	430	149	284
450	450	450	450	450	450	450	450	450	450	450	270	444
30	50	55	50	310	270	55	315	160	430	430	0	50
380	236	360	376	392	392	302	387	336	400	400	8	311
90	120	120	120	155	155	105	26	15	1	155	1	44
305	265	325	320	425	420	345	429	340	470	470	150	302
4	4	4	4	4	20	4	-	-	-	20	0	4
428	302	347	374	365	414	333	301	306	288	428	216	354
500	500	500	500	500	500	500	500	500	500	500	500	500
270	270	270	270	270	270	270	450	450	450	450	270	279
400	400	400	400	400	400	400	320	320	320	400	320	396
243	243	227	198	261	252	270	211	243	261	333	198	263
423	414	432	432	450	423	432	432	414	428	464	333	414
4621	4263	4588	4614	5157	5091	4482	4982	4600	5151	5157	3700	4363

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The final step (Step 10) is to determine a suitability rating. Although it is possible to rate each of the 15 individual resource factors in each of the 58 unit tracts, this would tend to be a quite lengthy process and is not within the scope of this thesis. Rather, since an intent of the thesis is to show that the resource factors may be rated, the rating portion of the proposed system will be shown by totaling the values for the 15 resource factors in each of the 58 unit tracts; therefore obtaining for each unit tract a total natural resource value which is compared to a suitability rating scale to obtain a rating. Thus the rating obtained, in this case, would represent the suitability of the combined natural resource factors in this unit tract for the outdoor recreation activity of stream trout fishing.

A suitability rating shall be given as either: (1) poor, (2) moderate, or (3) good. The numerical limits, or rating scale, established for each rating level (good, moderate, or poor), is flexible. Two rating scales will be presented in this thesis. In both scales, a numerical range is divided into thirds. The lower third receives a poor rating, the middle third a moderate rating, and the upper third a good rating.

In the first rating system, Figure 16, the total :

From Lowest Total Resource Factor Value (3700)
to
the
Highest Total Resource Factor Value (5157)
=
Numerical Range

Lower 1/3 of Numerical Range = Poor Suitability Rating
3700 to 4186

Middle 1/3 of Numerical Range = Moderate Suitability Rating
4187 to 4672

Upper 1/3 of Numerical Range = Good Suitability Rating
4673 to 5157

Figure 16. RATING SYSTEM 1, FOR STREAM TROUT FISHING
(For Local Application)

resource values for all inventoried tracts are considered. From the lowest total resource value for a single inventoried tract to the highest total resource value for a single inventoried tract constitutes the numerical range. This range is divided into thirds; the lower numerical third is given a poor rating, the middle numerical third is given a good rating. Finally each total resource value for each inventoried tract is compared to this rating scale to obtain a suitability rating for each inventoried tract. This rating system is more applicable to a local situation, since the numerical range is usually smaller and also because the range is based upon factor values actually obtained at the local area it tends to provide for some diversity in the suitability ratings.

In the second rating system, Figure 17, the maximum value possible for each resource factor is computed (maximum percentage (100%) multiplied by the maximum criteria weight (5) multiplied by the given resource factor weight (.8, .9, or 1.0) equals the maximum value possible for each factor). Maximum values for each resource factor are added to obtain a total maximum value possible. From 0 to the total maximum value possible constitutes the numerical range. This range is divided into thirds; the lower

From 0 to the Total Maximum Value Possible

=

Numerical Range

(0 to 6800)

Lower 1/3 of Numerical Range = Poor Suitability Rating

0 to 2267

Middle 1/3 of Numerical Range = Moderate Suitability Rating

2268 to 4534

Upper 1/3 of Numerical Range = Good Suitability Rating

4535 to 6800

Figure 17. RATING SYSTEM 2, FOR STREAM TROUT FISHING
(For Regional-Multistate Application)

numerical third is given a poor rating, the middle numerical third is given a moderate rating, and the upper numerical third is given a good rating. Then, as in the first rating system, each total resource value for each inventoried tract is compared to this rating scale to obtain a suitability rating for each inventoried tract. This rating system would be more applicable to a regional or multi-state situation, where a standardized approach, rather than local diversity of suitability ratings, is desired.

It should be noted, that adaptability in the rating system is possible, without revising the procedural guidelines. This may be desirable in local situations to divide the range into different sized numerical groupings. For example, the lower one fourth is given a poor rating, the middle two fourths is given a moderate rating, and the upper one fourth is given a good rating.

The suitability ratings for the 58 inventoried unit tracts using Rating System 1 are given in Table 5, and using Rating System 2 are given in Table 6.

Mapping of the established suitability ratings could have involved just transferring the ratings to the unit tracts on the map. However, for this research, it was necessary that the ratings conform to a 40 acre grid map

Table 5. RATING SYSTEM 1 FOR STREAM TROUT FISHING
(Suitability Ratings of Unit Tracts)

TRACT NUMBER	TOTAL RESOURCE VALUE	SUITABILITY RATING FOR STREAM TROUT FISHING	TRACT NUMBER	TOTAL RESOURCE VALUE	SUITABILITY RATING FOR STREAM TROUT FISHING
1	4314	Moderate	30	4448	Moderate
2	4271	Moderate	31	4324	Moderate
3	4245	Moderate	32	4368	Moderate
4	4339	Moderate	33	4241	Moderate
5	4163	Poor	34	4084	Poor
6	4064	Poor	35	4318	Moderate
7	4260	Moderate	36	4263	Moderate
8	4083	Poor	37	4327	Moderate
9	4391	Moderate	38	3812	Poor
10	4041	Poor	39	4237	Moderate
11	4271	Moderate	40	4622	Moderate
12	4467	Moderate	41	4564	Moderate
13	4127	Poor	42	4842	Good
14	4466	Moderate	43	4528	Moderate
15	4020	Poor	44	4194	Moderate
16	4111	Poor	45	4593	Moderate
17	3984	Poor	46	3700	Poor
18	4330	Moderate	47	4286	Moderate
19	4088	Poor	48	4513	Moderate
20	4187	Moderate	49	4621	Moderate
21	4482	Moderate	50	4263	Moderate
22	4400	Moderate	51	4588	Moderate
23	3830	Poor	52	4614	Moderate
24	4233	Moderate	53	5157	Good
25	4395	Moderate	54	5091	Good
26	4344	Moderate	55	4482	Moderate
27	4410	Moderate	56	4982	Good
28	4429	Moderate	57	4600	Moderate
29	4499	Moderate	58	5151	Good

Table 6. RATING SYSTEM 2 FOR STREAM TROUT FISHING
(Suitability Ratings of Unit Tracts)

TRACT NUMBER	TOTAL RESOURCE VALUE	SUITABILITY RATING FOR STREAM TROUT FISHING	TRACT NUMBER	TOTAL RESOURCE VALUE	SUITABILITY RATING FOR STREAM TROUT FISHING
1	4314	Moderate	30	4448	Moderate
2	4271	Moderate	31	4324	Moderate
3	4245	Moderate	32	4368	Moderate
4	4339	Moderate	33	4241	Moderate
5	4163	Moderate	34	4084	Moderate
6	4064	Moderate	35	4318	Moderate
7	4260	Moderate	36	4263	Moderate
8	4083	Moderate	37	4327	Moderate
9	4391	Moderate	38	3812	Moderate
10	4041	Moderate	39	4237	Moderate
11	4271	Moderate	40	4622	Good
12	4467	Moderate	41	4564	Good
13	4127	Moderate	42	4842	Good
14	4466	Moderate	43	4528	Moderate
15	4020	Moderate	44	4194	Moderate
16	4111	Moderate	45	4593	Good
17	3984	Moderate	46	3700	Moderate
18	4330	Moderate	47	4286	Moderate
19	4088	Moderate	48	4513	Moderate
20	4187	Moderate	49	4621	Good
21	4482	Moderate	50	4263	Moderate
22	4400	Moderate	51	4588	Good
23	3830	Moderate	52	4614	Good
24	4233	Moderate	53	5157	Good
25	4395	Moderate	54	5091	Good
26	4344	Moderate	55	4482	Moderate
27	4410	Moderate	56	4982	Good
28	4429	Moderate	57	4600	Good
29	4499	Moderate	58	5151	Good

of the area. Therefore, each rating is mapped in 40 acre sections.

Obviously, only those sections containing any portion of the rated stream were given ratings. If a rating changes within a section, the entire section was given whatever rating was in the majority. The mapped natural resource suitability ratings for the outdoor recreation activity of stream trout fishing is given in Figure 18, (using Rating System 1) and Figure 19, (using Rating System 2).

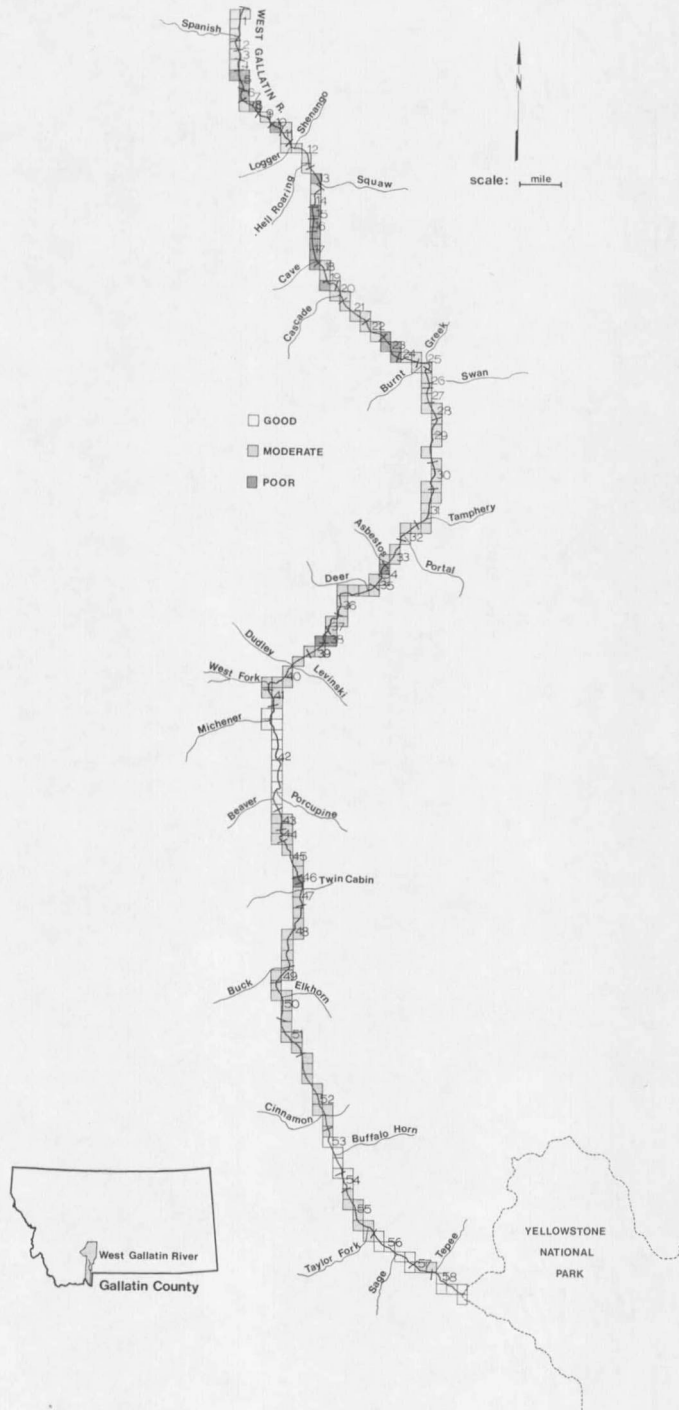


Figure 18. MAPPED NATURAL RESOURCE SUITABILITY RATINGS USING RATING SYSTEM 1 (For Stream Trout Fishing)

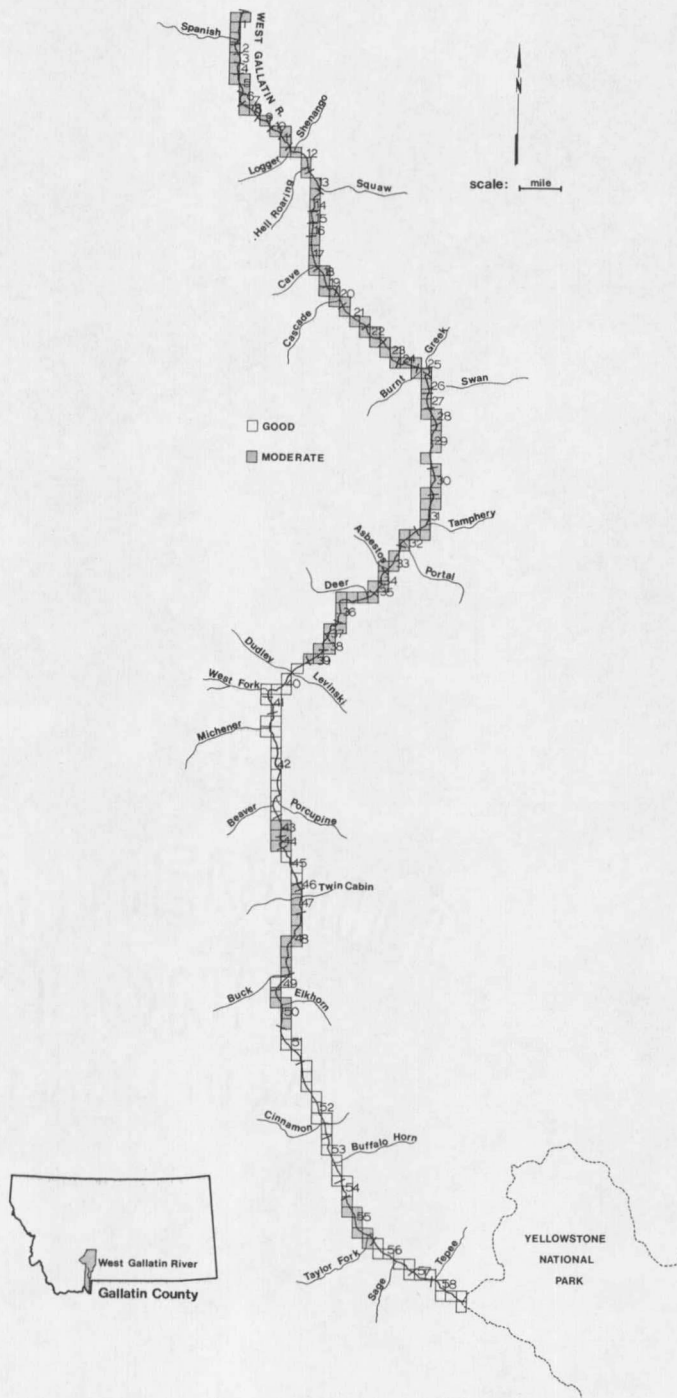


Figure 19. MAPPED NATURAL RESOURCE SUITABILITY RATINGS USING RATING SYSTEM 2 (For Stream Trout Fishing)

DEFINITIONS -

- BED ROCK:** Unbroken solid rock or mineral material, generally originally overlaid by soil or rock fragments.
- BOULDERS:** A fragment of mineral material, usually rounded, greater than 12 inches in diameter.
- CLAY:** Particles of mineral material less than 1/8 inch in diameter.*
- DEBRIS:** Dead vegetative material lodged in stream channel.
- DEVEGETATED:** A land surface lacking any visible (living) plant materials. Visual examination to be made during a season when plant materials would normally be actively growing and/or visible.
- FRACTURED:** Broken by interconnecting cracks.
- GRAVEL:** A fragment of mineral material, 1/8 to 2.9 inches in diameter.
- ISLAND:** Parcel of land in stream bed surrounded by water.
- MINERAL:** Inorganic material.
- MULTICHANNELED:** Having more than one channel containing moving water during the period of normal summer flow.
- NORMAL SUMMER FLOW (or NORMAL FLOW):** That stream flow unaffected by spring runoff (melting snow) and periods of precipitation. In the Gallatin drainage it is generally from August through April.
- OVERHANGING BRUSH:** Any vegetation above the water and less than ten feet from the water surface.

*Sand, silt, and clay are considered to be of equal dimensions for the purpose of this research. This practice does not comply with soil classification standards, but it is a practice commonly used in stream sampling. (See Reference 42.)

PARENT MATERIAL: The weathered rock or partly weathered soil material which underlies the stream bank, and streamside area.

RUBBLE: A fragment of mineral material, 3 to 12 inches in diameter.

SAND: Particles of mineral material less than 1/8 inch in diameter.*

SILT: Particles of mineral material less than 1/8 inch in diameter.*

STREAM: A body of flowing water or a body of water in motion.

STREAM BANK: The rising ground which borders the stream. If rising ground constituting a bank is not readily definable, then the bank is that ground where permanent vegetation has begun to establish along the stream channel. In cases where banks are not readily definable and vegetation is lacking, then the bank is that ground along an imaginary line connecting the areas of continuous permanent vegetation and generally following the course of the stream channel. If the stream is multichanneled then only the two outermost banks are rated (see Multichanneled). (There may be areas where human disturbances of the bank, such as recent construction, have destroyed the existing bank and no new bank has yet established - for purposes of this survey, the criteria rating should be listed as greater than 10 feet.)

STREAM BED: The floor or bottom part of the stream which is covered by water, when the stream is at its normal summer flow.

STREAM CHANNEL: That trench or depression in the earth's surface where a natural stream of water runs. Parts of the channel may be covered with water only during times of the year (during high flow). The stream bed may be a part or all of the stream channel.

*See Footnote, page 87.

STREAMSIDE: The land area from the stream bank generally perpendicular to and away from the stream.

SURFACE RUNOFF: Water which flows on the surface of the soil. Rapid or very rapid runoff may present a moderate to very high water erosion hazard.

TRIBUTARY: A stream which contributes water to another stream. For this applied research, it is a stream contributing water to the Gallatin River. Must have continuous flow all year and not be intermittent.

TROUT: Rainbow Trout (Salmo gairdneri), Brown Trout (Salmo trutta), and Brook Trout (Salvelinus fontinalis).

TURBIDITY: A cloudy, muddy, opaque condition in the stream as the result of particles of extraneous matter in the water.

UNNATURAL POLLUTION: A dirty, unclean condition as the result of artificial causes (such as improper agricultural, industrial, or residential uses).

VEGETATION: Any plant materials (mosses, grasses, shrubs, trees, etc.).

VERTICAL HEIGHT: At normal flow: (1) if water meets the bank then vertical height is the up and down distance from water to top of bank, or (2) if water does not meet the bank then vertical height is the up and down distance from the water level to the bottom of the bank.

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TRAIL HIKING

INTRODUCTION - The second outdoor recreation activity (of two) selected to test the system's applicability is trail hiking. Trails have long been considered a vital part of America's tradition; a part as old as America itself (3, 8). The first trails were those formed by wild animals and by North American Indian tribes (15, 19). Later trails were built primarily for fire protection, forest management, livestock use, or just general access (15, 19, 20, 23). Their use was of a utilitarian, rather than recreational, nature.

However, in the last decade, increasing attention has been given to the use of trails for public outdoor recreation. The United States Bureau of Outdoor Recreation stated that trails represent a major opportunity for satisfying outdoor recreation demands, and afford a low concentration, dispersed type of recreation that is much sought after today (3, 15). In 1965 Lyndon B. Johnson, President of the United States, called hikers one of "the forgotten outdoorsmen", and indicated the need for more trails (1, 15). In 1965, Ashbaugh (2) in a National Audubon Society Publication, called trails one of the most effective methods of providing opportunities for first hand experience in

the outdoors.

This increasing attention being given to trails and hiking is no doubt prompted by the increase in public participation in that activity. Graham, in 1967 (1), indicated that hikers in the United States national forests were increasing at the rate of 11% per year. A 1965 survey by the U. S. Bureau of Outdoor Recreation (3) indicated that walking for pleasure had increased faster in the previous five years than any other major outdoor recreation activity. The Bureau of Outdoor Recreation (21) projected hiking participation to increase 78% from 1965 - 1980 and 206% from 1965 - 2000.

To meet the need of increasing trail oriented outdoor recreation, trail establishment and/or expansion has been encouraged in all of the three general types of trails (3, 10, 15, 23): (1) National Scenic Trails - primarily designed for hiking and other uses compatible to hiking (e.g. The Appalachian Trail and The Pacific Crest Trail), (2) National Recreation Trails or Metropolitan Area Trails - primarily designed to serve urban areas, and not necessarily scenic trails (e.g. The Gabrielino National Recreation Trail near Pasadena, California), and (3) Park and Forest Trails - most of which are built or improved in state or

federal parks or forests.

For purposes of this research, only hiking trails will be considered. Hiking being defined as walking of a substantial nature in which a pack containing provisions and/or shelter is carried by at least one member of the party (23). Since the trail areas to be considered in this research are not of a national scope and are not near urban areas, they would be considered a park-forest trail type.

An obvious ingredient essential to the success of any trail program is planning. Proper trail planning in its initial stages, primarily implies the selection of proper trail routing. Too often trail routes are arbitrarily selected, with a resource inventory of the trail route being accomplished after the route has been selected. It is proposed that a more proper trail selection would depend upon determination of the physical natural resource characteristics of the site. The trail route might then follow those areas possessing the most physical resource amenities and the least physical resource disamenities. This author is in agreement with the United States Forest Service (20) when it states that speed of travel in trails is not an important factor; and in agreement with

Lucas (23) when he states that a good trail need not lead to a specific destination, since trails can be an end in themselves.

METHODS OF INVENTORY AND EVALUATION - Application of the proposed analysis system involves following the Guidelines established in Figure 12, pages 35 - 38. Through a review of literature, outlined in Table 7, pages 100 -105, it is possible to identify and establish the natural resource factors, criteria, and weights; these are presented in their final form in Table 8, pages 106-109. Anyone questioning the basis for the established natural resource requirements in Table 8, should examine the literature cited in Table 7. It should be noted that relatively little research has been done on trail hiking, a fact confirmed by Lucas (28). Therefore, identification of natural resource requirements by literature review is limited in the case of trail hiking, at this date.

The following comments are clarifications concerning some of the established natural resource requirements (Table 8):

- (A) Factor 1 deals with slope or grade. The criteria, as established, refer to natural slopes existing on the site. It was realized, that with proper trail routing,

Table 7. LITERATURE REVIEW USED TO ESTABLISH THE NATURAL RESOURCE REQUIREMENTS FOR TRAIL HIKING

RESOURCE FACTOR 1: SLOPE

RESOURCE CRITERIA	RELATIONSHIP TO HIKING (+ positive, - negative)	HIKING BIBLIOGRAPHY REFERENCE NUMBER
Topography	A Physical Amenity +	13
Steep Hillsides	Cause High Runoff And Erosion -	18
Follow Contours	Easier Travel And Less Erosion +	11
Grade	A Primary Design Consideration	20
Less Grade	Reduces Need For Switchbacks +	9
10% or Less	Recommended +	2, 4, 20
<9%	A Good Objective +	20
7%	An Average Grade For A Total Trip +	20
Sustained 8%	Good For Gaining Altitude +	20
4%	An Easing Off Grade +	20
>15%	Undesirable -	4, 20
0-15%	None To Slight Trail Limitations +	26

Table 7. CONTINUED

15-25%	Moderate Trail Limitations	26
>25%	Severe Trail Limitations -	26
Cliffs	Dangerous -	26

RESOURCE FACTOR 2: SOIL SURFACE TEXTURE

RESOURCE CRITERIA	RELATIONSHIP TO HIKING (+ positive, - negative)	HIKING BIBLIOGRAPHY REFERENCE NUMBER
Soil Structure And Texture	Affects Erosion Potential And Maintenance Costs	18
Sandy Loam, Fine Sandy Loam, Very Fine Sandy Loam, Loam, Or Silt Loam	None To Slight Trail Limitations As Affecting Trafficability, Dust, Design, Or Maintenance +	26
Silty Clay, Sandy Clay, Clay, Loamy Sand	Moderate Trail Limitations As Affecting Trafficability, Dust, Design, Or Maintenance	26
Sandy Clay, Silty Clay, Clay, Sand, Organic Soils	Severe Trail Limitations As Affecting Trafficability, Dust, Design, Or Maintenance -	26

Table 7. CONTINUED

RESOURCE FACTOR 3: COARSE MINERAL FRAGMENTS OF SURFACE

RESOURCE CRITERIA	RELATIONSHIP TO HIKING (/ positive, - negative)	HIKING BIBLIOGRAPHY REFERENCE NUMBER
No Loose Rocks >3 Inches Dia.	Better For Trail Surfaces /	6
0-20%	None To Slight Trail Limitations (Limitations such as difficulty in walking on such areas and in constructing trails in such areas.) /	26
20-50%	Moderate Trail Limitations	26
>50%	Severe Trail Limitations -	26
Talus Rockslides	Difficult For Trail Grading And Maintaining Trails In These Areas -	20

RESOURCE FACTOR 4: DRAINAGE

RESOURCE CRITERIA	RELATIONSHIP TO HIKING (/ positive, - negative)	HIKING BIBLIOGRAPHY REFERENCE NUMBER
Good Drainage	Reduces Wet Areas /	11, 13

Table 7. CONTINUED

Excessive, Somewhat Excessive, Well And Moderately Well*	None To Slight Trail Limitations /	26
Somewhat Poor*	Moderate Trail Limitations	26
Poor And Very Poor*	Severe Limitations -	26

RESOURCE FACTOR 5: VEGETATIVE COVER

<u>RESOURCE CRITERIA</u>	<u>RELATIONSHIP TO HIKING (/ positive, - negative)</u>	<u>HIKING BIBLIOGRAPHY REFERENCE NUMBER</u>
Vegetation	Is A Physical Amenity /	13
Through Trees	Stable Areas, Provide Shade, And Cover /	2, 4, 18, 20
Variety	See Trail Variety, Page 105	

RESOURCE FACTOR 6: BODIES OF WATER

<u>RESOURCE CRITERIA</u>	<u>RELATIONSHIP TO HIKING (/ positive, - negative)</u>	<u>HIKING BIBLIOGRAPHY REFERENCE NUMBER</u>
Creeks, Brooks	Always Popular /	2, 20

*Refer to Appendix III: SOIL-DRAINAGE CLASSES

Table 7. CONTINUED

Ponds, And Marshes	Special Trail Features /	11
	But May Be Difficult To Cross	18
Variety	See Trail Variety, page 105	

RESOURCE FACTOR 7: OPPORTUNITY TO VIEW SCENIC FEATURES

RESOURCE CRITERIA	RELATIONSHIP TO HIKING (/ positive, - negative)	HIKING BIBLIOGRAPHY REFERENCE NUMBER
The Spectacular, The Showy, The Highest, The Deepest, The Widest, The Most Beautiful	People Using Trails Seek These Things /	19
Emphasize Special Features	Included In A Well Laid Out Trail /	11
Commanding Vistas Of Natural Features	Included In Carefully Planned Trail /	2
To Catch A Glimpse Of A Beautiful Scene	Is Of Interest To Most Hikers /	7
Scenery	A Physical Amenity /	9, 13
Ridgetop Routes	Provide Access To Interesting And Attractive Scenery /	20
Enjoyment Of Scenery And Aesthetics	Rates High With All Hikers /	23

Table 7. CONCLUDED

Seek Out Views; Vistas	Opportunity For Aesthetic Experiences	23
Observer Position	May Be Consciously Selected In Trail Routing /	29
Superior Observer Position (An over- view is possible.)	Least Restrictive To View, Minimizes Visual Blockage, An Aerial Type View /	29

A COMMON RESOURCE FACTOR - TRAIL VARIETY

(A Common Factor For Consideration When Determining Some Resource Criteria
And Weights)

RELATIONSHIP TO HIKING (/ positive, - negative)	HIKING BIBLIOGRAPHY REFERENCE NUMBER
Three Out Of Four Persons Felt Trails Should Be Varied, Thus Satisfying Varied Interests	4
Trails Should Be Along Routes With Varied Features And Scenery	9
Attempt To Include A Variety Of Experiences In A Trail	11
Environmental Variety Should Predominate Over Engineering Efficiency	23
The Need Is For Diversity And Variety In Trail Systems	23

Table 8. RESOURCE FACTORS AND FACTOR WEIGHTS, FACTOR CRITERIA AND CRITERIA WEIGHTS FOR THE OUTDOOR RECREATION ACTIVITY OF TRAIL HIKING

RESOURCE FACTOR 1: SLOPE

FACTOR WEIGHT: 1.0

<u>CRITERIA</u>	<u>CRITERIA WEIGHT *</u>
<9%	5
9-15%	4
15-30%	2
30-60%	1
>60%	0 *Potential to terminate recreational use if present in large quantities.

RESOURCE FACTOR 2: SOIL SURFACE TEXTURE

FACTOR WEIGHT: 1.0

<u>CRITERIA</u>	<u>CRITERIA WEIGHT</u>
Sandy Loam, Fine Sandy Loam, Very Fine Sandy Loam, Loam, or Silt Loam	5
Silty Clay Loam, Sandy Clay Loam, Clay Loam, or Loamy Sand	3
Sandy Clay, Silty Clay, Clay, Sand or Organic Soils	1

*See page 31 for explanation of weighting values.

Table 8. CONTINUED

RESOURCE FACTOR 3: COARSE MINERAL FRAGMENTS ON SURFACE

FACTOR WEIGHT: .9

<u>CRITERIA</u>	<u>CRITERIA WEIGHT</u>
Coverage <20%	5
Coverage 20-50%	3
Coverage >50%	1

RESOURCE FACTOR 4: DRAINAGE

FACTOR WEIGHT: 1.0

<u>CRITERIA</u>	<u>CRITERIA WEIGHT</u>
Excessive, Somewhat Excessive, Well and Moderately Well*	5
Somewhat Poor*	3
Poor and Very Poor*	1

*Refer to Appendix III: SOIL-DRAINAGE CLASSES

Table 8. CONTINUED

RESOURCE FACTOR 5: VEGETATIVE COVER

FACTOR WEIGHT: .9

<u>CRITERIA</u>	<u>CRITERIA WEIGHT</u>
>75% of the Major Types of Vegetative Cover Commonly Found in the Regional Area are Present in the Unit Tract	5
51-75% of Major Types are Present	4
26-50% of Major Types are Present	2
<26% of Major Types are Present	1

RESOURCE FACTOR 6: BODIES OF WATER AND ACCESSIBILITY

FACTOR WEIGHT: .9

<u>CRITERIA</u>	<u>CRITERIA WEIGHT</u>
Moving Water and Lakes*	5
Moving Water*	4
Lakes*	3
Accessible Area But Without Water Bodies	1
Not Accessible	0 *Potential to terminate recreational use.

*Accessible to the trail user.

Table 8. CONCLUDED.

RESOURCE FACTOR 7: OPPORTUNITY TO VIEW SCENIC FEATURES

FACTOR WEIGHT: .9

<u>CRITERIA</u>	<u>CRITERIA WEIGHT</u>
*ABC	5
AB, or AC, or BC	4
A, or B, or C	3
None	1

*A = Unit tract possesses openness for viewing.

B = Unit tract elevations are higher than majority of surrounding unit tracts.

C = Possible to view one or more unique features from the unit tract. (A unique feature is any natural feature that has been identified on a standard U. S. Geological Survey topographic map of the area.)

a trail may traverse a natural slope in such a way that the percentage of slope on the trail itself is less than the natural slope. Nevertheless, it was held that the greater the natural slope, the more difficult and costly would be the design, construction, and maintenance of the trail. In addition, extreme percentages of natural slope tend to present a danger to the trail user, as well as high erodability.

- (B) Factor 2 deals with the texture of the soil surface. Trails that have predominant clay, sand, or organic textures are undesirable. Clays become sticky when wet and dry slowly. Sands tend to be loose and unstable when dry. Organic soils tend to compact when walked upon which retards vegetative growth and also may provide unstable footing.
- (C) Factor 5 deals with cover vegetation. In establishing the criteria, emphasis was placed on variety. It was assumed that those areas having a variety of vegetation to view and walk through would be more desirable than areas that had a uniform vegetation type. Since areas do vary in the number of varieties of natural vegetation cover present, it was considered appropriate

to use percentages of total area varieties as criteria. The designation of "major types" of vegetation is dependent upon the planning agent and his designation should be given as part of the survey. Designation of "major types" could be based on any sized area, from partial county to multistate. It would often be practical to use the major types of cover vegetation found within the total study area.

- (D) Factor 6 deals with bodies of water and accessibility. Moving waters (such as springs, streams, rivers) were judged to be most desirable and lakes (and ponds) were judged to be slightly less desirable. This ranking was based on the greater variety usually offered along a stream course (for example: riffles, runs, and pools of most streams offer varying audio and visual effects to the trail user). As variety was desirable, a combination of the two water body types was given the highest weight. The other item to be considered as part of this resource factor is accessibility. It should be noted that the water bodies to receive high criteria weights must be accessible to the trail user. Areas that are accessible but lack water bodies are given a low criteria weight. Areas that are not

accessible, such as unit tracts which happen to be situated entirely on water or stream sections channeled between cliff-like banks, are given no criteria weight since this criteria has the potential to terminate recreational use for that activity. However, water bodies not accessible to the trail user may have scenic value.

- (E) Factor 7 which deals with scenery, is a difficult factor to classify into criteria. It is one thing to inventory scenic features, and yet another to evaluate those features. Evaluation tends to be the more difficult to accomplish. Many considerations, such as personal preferences which would depend in part upon the visual awareness of the observer, and transitory effects such as seasonal or climatic scenic changes; complicate a scenic evaluation system. The criteria as established are very general in nature and could be adapted by future research findings.

The next phase in the application of the proposed analysis system is to inventory the site. The site selected to be inventoried consisted of four and one half sections within T7S, R4E: Section 14, Section 15, East 1/2 Section 16, Section 22, and Section 23; in the West Gallatin River

Drainage, Gallatin County, Montana. Each of the sections was divided into 40-acre unit tracts to be inventoried and mapped (Figure 20). A full section contains 16 of the 40-acre unit tracts. Specifying 40 acres as the unit tract size conforms to the grid being used in other research in this area. A considerable amount of inventoried data existed for this area, and it was possible to incorporate existing inventoried data into the analysis procedure. The study area has variety in natural resource characteristics, has existing trails and trail use, and has been subject to recent concern over proper land use practices.

The following comments concern the actual inventory of the study area:

- (A) Slope data was obtained from material compiled at Montana State University as part of the National Science Foundation RANN Program, Project No. GI-29908X.
- (B) Soil texture, mineral fragments on the surface, and drainage data was obtained from soil survey material compiled by J. A. Olsen, B. F. Leeson, and G. A. Nielsen, from their Soil Interpretations publication (25). Some unpublished detailed soil survey data, of this area, compiled by B. F. Leeson was also used.

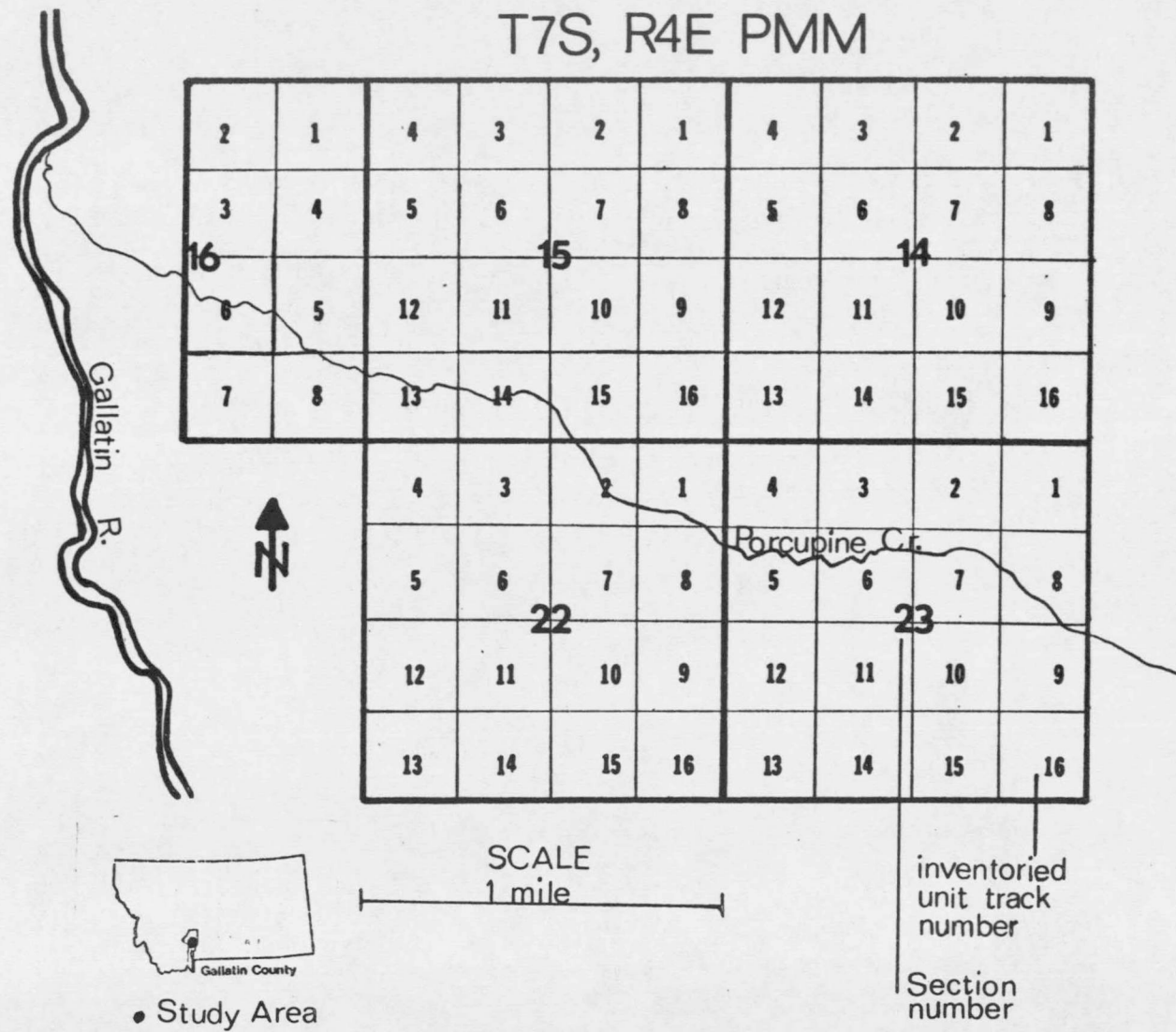


Figure 20. STUDY AREA AND LOCATION OF INVENTORIED TRACTS FOR TRAIL HIKING

- (C) Vegetative cover data was obtained by analysis of 1961 and 1962 USDA Gallatin National Forest Aerial photographs, and by use of 1950-1957 USDA Gallatin National Forest Timber Inventory Maps. No logging has been done in the study area, nor has there been any fire loss; therefore, present conditions are approximated by the earlier photographs and maps.
- (D) For the purposes of this research, four major types of vegetative cover were designated for the study area: (1) Lodgepole pine, (2) Douglas Fir, (3) Deciduous trees, and (4) Shrubs and grassland.
- (E) Bodies of water and access, as well as scenic data, were obtained by use of USDA Gallatin National Forest aerial photographs and by use of the U. S. Geological Survey Topographic Map - Crown Butte Quadrangle.
- (F) Random checks were made on the site by the author in order to establish "ground truth" or ground observations to compare with aerial photographs and mapped data.

RESULTS - The percentage values from the inventory are presented in Table 9. The computation of the percentages into resource factor values is presented in Table 10. Also presented in Table 10 is a total of all 7 resource factors for each inventoried unit tract.

The next step is to assign a suitability rating to each of the unit tracts. Although it is possible to rate each of the 7 individual resource factors in each of the 72 unit tracts, this would tend to be a quite lengthy process and is not within the scope of this thesis. Rather, the rating for each of the 72 unit tracts will be a total of all 7 resource factor values. A suitability rating shall be given as either: (1) poor, (2) moderate, or (3) good. The numerical limits, or rating scale, established for each rating level (good, moderate, or poor) may be flexible. In the case of trails (as in Rating System 1 for stream trout fishing) the total resource values for the inventoried tracts are considered. The numerical range is from the lowest total resource value for a single inventoried tract to the highest resource value for a single inventoried tract. This range is divided into thirds; the lower numerical third is given a poor rating, the middle numerical third is given a moderate rating, and the upper numerical third is given a

Table 10. RESOURCE FACTOR VALUES FOR TRAIL HIKING, AS COMPUTED FROM THE SITE INVENTORY

RESOURCE FACTOR NUMBER	INVENTORIED UNIT TRACT NUMBERS																
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	
Section 14																	
1	200	100	100	100	100	100	100	100	100	100	200	400	200	100	200	200	
2	440	420	460	380	440	400	300	300	340	340	380	500	500	500	500	390	
3	414	342	414	360	396	378	378	378	360	360	342	396	387	378	396	342	
4	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	
5	360	180	180	180	90	180	180	180	180	180	360	90	90	180	90	180	
6	450	360	90	90	90	90	360	90	90	90	360	90	90	360	90	90	
7	360	450	360	450	360	360	270	450	360	270	360	360	360	360	450	360	
TOTAL	2724	2352	2104	2060	1976	2008	2088	1998	1930	1840	2502	2336	2127	2378	2226	2062	
Section 15																	
1	100	200	200	400	200	100	200	200	200	200	100	200	100	200	200	200	
2	300	500	500	500	500	500	500	500	500	500	500	500	430	390	460	500	
3	216	396	360	342	396	306	360	378	378	396	369	288	243	252	306	288	
4	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	
5	180	180	180	180	90	90	90	90	90	90	90	90	360	180	180	90	
6	90	360	360	360	90	90	90	90	90	90	90	90	360	342	342	90	
7	450	450	450	450	450	360	450	360	360	450	360	270	270	270	360	450	
TOTAL	1836	2586	2550	2732	2226	1946	2190	2118	2118	2226	2009	1938	2263	2134	2348	2118	
Section 16 (East 1/2)																	
1	200	200	400	400	200	100	100	100									
2	500	500	500	500	500	500	500	500									
3	324	279	324	333	342	288	252	252									
4	500	500	500	500	490	480	500	500									
5	180	360	90	90	180	360	180	360									
6	90	90	360	360	360	360	90	360									
7	360	360	450	360	360	360	270	270									
TOTAL	2154	2289	2624	2543	2432	2448	1892	2342									
Section 22																	
1	200	200	200	100	100	100	200	200	500	400	400	200	200	200	200	400	
2	500	420	380	500	500	480	400	480	460	410	500	500	500	500	300	450	
3	360	342	342	423	423	405	297	414	414	387	423	414	396	423	315	360	
4	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	
5	90	180	180	180	180	180	180	180	180	180	360	180	180	90	360	360	
6	360	360	90	90	90	90	90	90	90	90	90	90	90	90	90	90	
7	360	360	360	270	270	360	360	360	360	360	360	360	450	270	360	360	
TOTAL	2370	2362	2052	2063	2063	2115	2027	2224	2504	2327	2633	2244	2316	2073	2125	2520	
Section 23																	
1	100	200	200	200	400	500	400	200	500	400	500	200	200	400	500	500	
2	400	450	400	400	450	350	400	400	420	430	500	500	470	470	440	430	
3	342	369	333	324	432	387	387	387	387	414	432	432	423	414	423	405	
4	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	
5	360	180	180	180	360	360	360	360	180	180	90	180	180	180	180	180	
6	360	90	90	360	360	360	360	360	90	90	360	360	90	360	270	270	
7	360	360	360	360	360	360	360	360	360	360	360	360	450	360	450	360	
TOTAL	2422	2149	2063	2324	2862	2817	2767	2567	2437	2374	2742	2532	2313	2684	2763	2645	
Summary Statistics																	
RESOURCE FACTOR NUMBER	MAXIMUM VALUE POSSIBLE	HIGHEST SCORE OF ALL 72 TRACTS	LOWEST SCORE OF ALL 72 TRACTS	MEAN OF ALL 72 TRACTS													
1	500	500	100	226													
2	500	500	300	449													
3	450	432	216	363													
4	500	500	480	500													
5	450	360	90	193													
6	450	450	90	197													
7	450	450	270	368													
TOTAL	3300	2767	1836	2295													

good rating (as shown in Figure 21). Finally, each total resource value for each inventoried tract is compared to this rating scale to obtain a suitability rating for each inventoried tract. Because the range is based upon factor values actually obtained at the local area, it tends to provide some diversity in the suitability ratings.

The natural resource suitability ratings for the 72 unit tracts that were inventoried are given in Table 11. Those natural resource suitability ratings (for the outdoor recreation activity of trail hiking) are mapped in Figure 22. It should be noted that Figure 22 also indicates the location of existing trails. This suitability rating map may be used by the land manager to reroute existing trails into sections with better ratings or to plan new trail routings into sections having good ratings. In either case, trail routing within a particular unit tract and/or selection of unit tracts into which a trail will be routed will be left to the discretion of the planner or land manager. The mapped suitability rating simply indicates those unit tracts possessing natural physical amenities and disamenities for the outdoor recreation activity of trail hiking.

From Lowest Total Resource Factor Value (1836)

to

the

Highest Total Resource Factor Value (2767)

=

Numerical Range

Lower 1/3 of Numerical Range = Poor Suitability Rating

1836

to

2146

Middle 1/3 of Numerical Range = Moderate Suitability Rating

2147

to

2456

Upper 1/3 of Numerical Range = Good Suitability Rating

2457

to

2767

Figure 21. RATING SYSTEM FOR TRAIL HIKING

Table 11. SUITABILITY RATINGS OF UNIT TRACTS USING RATING SYSTEM FOR TRAIL HIKING

TRACT NUMBER	TOTAL RESOURCE VALUE	SUITABILITY RATING FOR TRAIL HIKING	TRACT NUMBER	TOTAL RESOURCE VALUE	SUITABILITY RATING FOR TRAIL HIKING
<u>Section 14</u>			<u>Section 15</u>		
1	2724	Good	1	1836	Poor
2	2352	Moderate	2	2586	Good
3	2104	Poor	3	2550	Good
4	2060	Poor	4	2732	Good
5	1976	Poor	5	2226	Moderate
6	2008	Poor	6	1946	Poor
7	2088	Poor	7	2190	Moderate
8	1998	Poor	8	2118	Poor
9	1930	Poor	9	2118	Poor
10	1840	Poor	10	2226	Moderate
11	2502	Good	11	2009	Poor
12	2336	Moderate	12	1938	Poor
13	2127	Poor	13	2263	Moderate
14	2378	Moderate	14	2134	Poor
15	2226	Moderate	15	2348	Moderate
16	2062	Poor	16	2118	Poor
			<u>E 1/2 Section 16</u>		
			1	2154	Moderate
			2	2289	Moderate
			3	2624	Good
			4	2543	Good
			5	2432	Moderate
			6	2448	Moderate
			7	1892	Poor
			8	2342	Moderate

Table 11. CONCLUDED

TRACT NUMBER	TOTAL RESOURCE VALUE	SUITABILITY RATING FOR TRAIL HIKING
-----------------	----------------------------	---

Section 22

1	2370	Moderate
2	2362	Moderate
3	2052	Poor
4	2063	Poor
5	2063	Poor
6	2115	Poor
7	2027	Poor
8	2224	Moderate
9	2504	Good
10	2327	Moderate
11	2633	Good
12	2244	Moderate
13	2316	Moderate
14	2073	Poor
15	2125	Poor
16	2520	Good

TRACT NUMBER	TOTAL RESOURCE VALUE	SUITABILITY RATING FOR TRAIL HIKING
-----------------	----------------------------	---

Section 23

1	2422	Moderate
2	2149	Moderate
3	2063	Poor
4	2324	Moderate
5	2862	Good
6	2817	Good
7	2767	Good
8	2567	Good
9	2437	Moderate
10	2374	Moderate
11	2742	Good
12	2532	Good
13	2313	Moderate
14	2684	Good
15	2763	Good
16	2645	Good

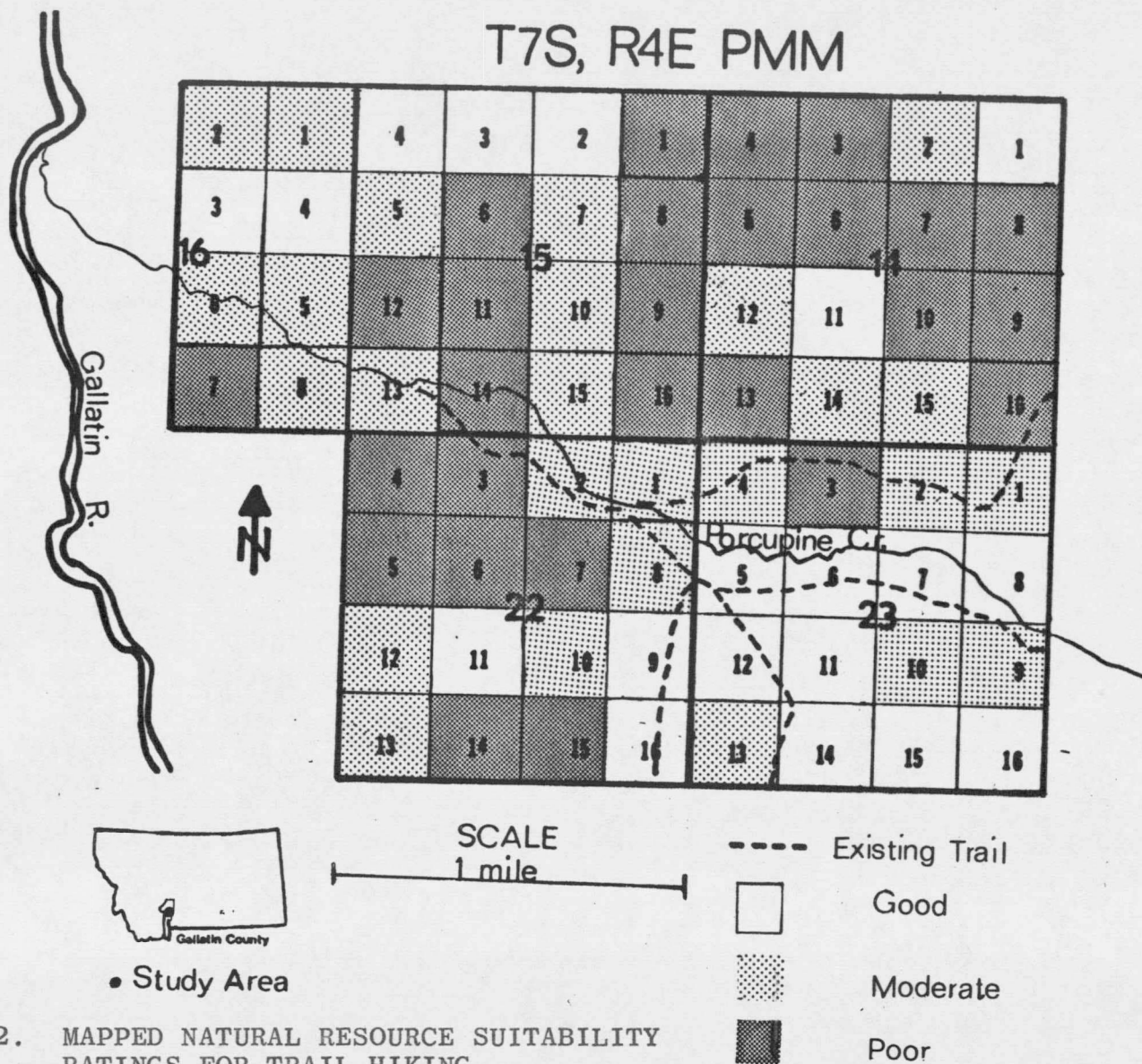


Figure 22. MAPPED NATURAL RESOURCE SUITABILITY RATINGS FOR TRAIL HIKING

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SUMMARY

ADAPTABILITY - An important characteristic of the proposed analysis system is that it allows for adaptability within its procedural framework. The phase of the analysis system which establishes the natural resource suitability requirements is readily adaptable. For example, if new natural resource criteria or requirements, for some individual outdoor recreation activity, are established by new research or research review at some later date; these criteria may be included in the analysis system for that activity. Also, if new research or research review indicates a change or even a total deletion of existing natural resource criteria; this too may be incorporated into the existing analysis system.

Another area of adaptability is in the weighting of the natural resource suitability requirements. If new information should dictate a change in weight values for various resource factors and/or criteria (rather than a change of the factors or criteria themselves), then a positive or negative adjustment in given weights is easily possible.

Adaptability of the final rating is also possible. If the numerical ranges (which govern the final suitability

rating - of good, moderate, poor) are adjusted, a more specific single (good or moderate or poor) suitability range may be identified. For example, if a 300-500 point range for good suitability identifies too great a percentage of land for the intended purposes; then the good point range might be reduced from 300-500 to 400-500. This should reduce the percentage of land having a good suitability classification. If it did not reduce the percentage, then an even smaller range could be used. The same principle may be applied if the percentage of land identified is too small - then the numerical range may be increased. The numerical adjustment is possible in any of the rating ranges - good, moderate or poor. However, for comparative purposes on any level - local to multistate, it would obviously be desirable to maintain standard numerical ranges of suitability. For adaptability in the size of areas being evaluated, see the section "Inventory and Evaluation", page 99.

A final adaptable area in the system would be in the comparison of the natural resource requirements of more than one outdoor recreation activity. Although this research project deals with only two activities, the system will hopefully be applied to other activities. Upon application to a number of activities the system allows for

comparison of natural resource requirements and therefore will aid in identifying compatible as well as competitive outdoor recreation uses.

It may be stated that many adaptations may be performed within the proposed system without having a procedural revision of the system itself.

THE PROPOSED SYSTEM AS PART OF THE COMPREHENSIVE LAND USE PLANNING PROCESS - It has been introduced in the previous section, "Planning in Outdoor Recreation" that natural resource analysis is an integral part of the outdoor recreation planning process. It may further be stated that natural resource analysis is also an integral part of the comprehensive planning process. A graphic illustration of the relationship between the comprehensive planning process and the proposed recreation natural resource analysis system is found in Figure 23. The proposed analysis system is but one segment of the total comprehensive planning process. The system tries to bridge the gap found between generalized approaches used by many comprehensive planners based on little or no scientific data or knowledge and the specific data that seldom, if ever, gains practical application.

Etzioni (1970) criticized a national (United States) information system that knew more about trees than forests,

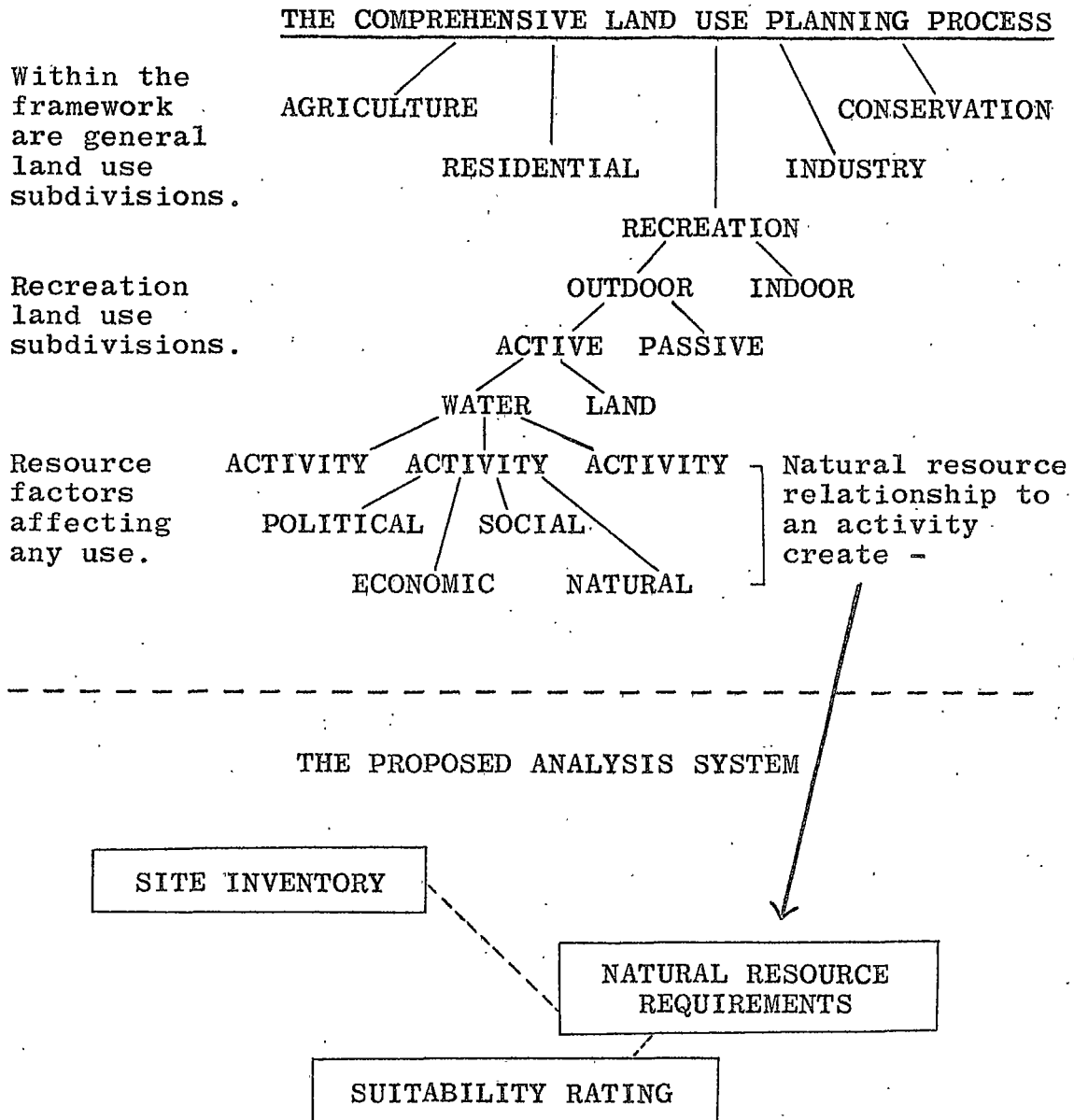


Figure 23. THE PROPOSED ANALYSIS SYSTEM AS PART OF THE COMPREHENSIVE LAND USE PLANNING PROCESS

and a national perspective that knew more about specifics than where those individual specifics could fit a larger plan. The system proposed by this research tries to overcome the imbalance that Etzioni criticizes. The proposed system, in effect, is a review and synthesis of existing bodies of knowledge into the outdoor recreation (and comprehensive) planning process. Although the intent of this research is to relate only one of the resource factors (the natural resource factor) to a specific outdoor recreation activity, the relationship of the other resource factors (political, social, economic) to the activity should also be taken into consideration by the recreation planner when making a final planning decision. The relationship of these other resource factors to the recreation activity and of all resource factors to each other must be considered in good planning. Also, coordination between different land uses must also be considered. This research represents but one of several inputs, in the comprehensive planning process. To consider all inputs in the planning process will require staff level collaboration at all levels.

CONCLUSIONS - The proposed natural resource analysis system for outdoor recreation does provide a method for relating the physical natural resources to specific

individual outdoor recreation activities. Once a specific outdoor recreation activity is specified, then natural resource requirements may be identified for that activity. The activity - natural resource relationship is based upon existing research data. The natural resource requirements are weighted and compared to inventoried site data, which finally establishes a suitability rating of the site's physical natural resources for the specified outdoor recreation activity. As established, the analysis system allows for adaptability within its procedural framework. The proposed analysis system is successfully applied to the activities of stream trout fishing and trail hiking. For each of these activities; natural resource requirements were established, sites were inventoried, and suitability ratings were calculated and mapped.

This research proposes a system which will incorporate critical natural resource requirements, based on sound research findings, into the outdoor recreation planning process. Use of this system should minimize development and maintenance costs in outdoor recreation sites, and aid in identifying those sites best suited to provide quality enjoyment for the greatest number of outdoor recreation activity users.

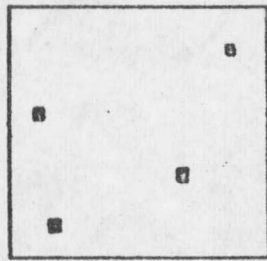
APPENDICES

Appendix I. LEISURE, RECREATION, OUTDOOR RECREATION -
DEFINED

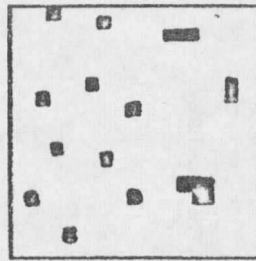
Since terminology has the potential to create misunderstandings and misconceptions, identification of basic terms often becomes a necessity. This is true of the three terms: leisure, recreation, and outdoor recreation. Doell (1969) and Meyer, Brightbill, and Sessoms (1969), as well as others, have defined these terms for use in their various publications. The following condensed definitions of these terms should suffice for the purpose of this thesis.

Leisure is free, discretionary time. Time to do with as an individual pleases. It is not time used for existence (eating, sleeping, or bodily cares), or subsistence (work necessary to provide the necessities of living (food and lodging)). Recreation is the use of that leisure time. It is freely chosen activity, chosen without compulsion present and prompted by the pleasure it creates for the person engaged in that activity, whether that pleasure is physical or mental. Outdoor recreation encompasses those recreation activities which are dependent upon land resources or natural resources for participation.

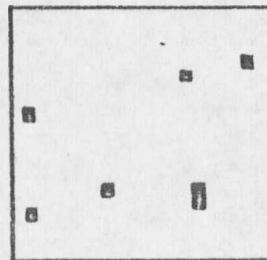
Appendix II CHARTS FOR ESTIMATING PROPORTIONS OF MOTTLES AND COARSE FRAGMENTS



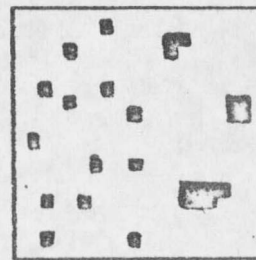
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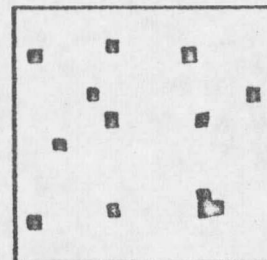
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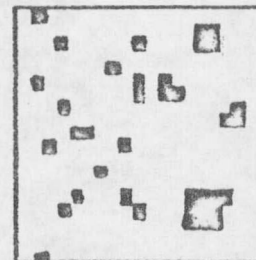
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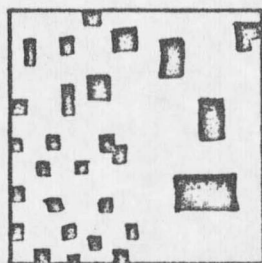
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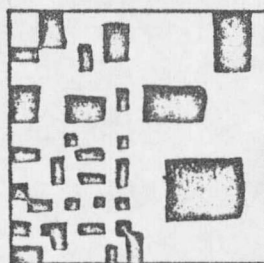
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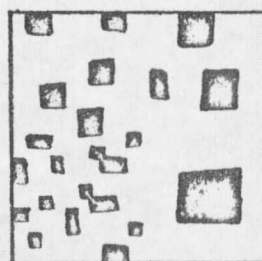
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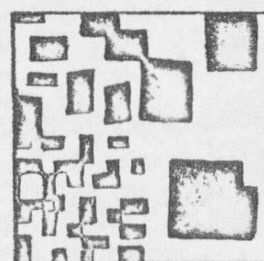
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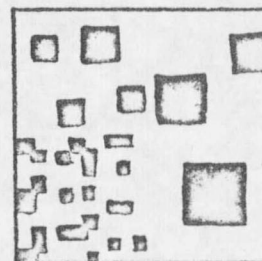
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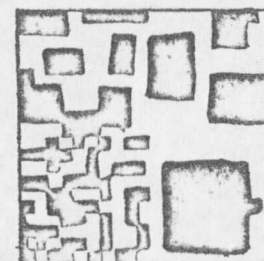
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Charts may be obtained through the International Soil Science Society, 63 Mauritskade, Amsterdam, Netherlands.

Appendix III - SOIL-DRAINAGE CLASSES

(Reference: Soil Survey Staff, 1951)

Excessively drained: Water is removed from soils very rapidly. Commonly lithorols and may be steep, very porous, or both. Also may be shallow soils on slopes.

Somewhat excessively drained: Water is removed from soil rapidly. Many soils have little horizon differentiation, are sandy, and very porous.

Well drained: Water is removed from soil readily but not rapidly. Soils are commonly intermediate in texture. Commonly retain optimum amounts of moisture for plant growth.

Moderately well drained: Water is removed from soil somewhat slowly, so profile is wet for a small but significant amount of the time. Commonly have a slowly permeable layer within or immediately beneath the solum, a relatively high water table, additions of water through seepage, or some combination of these conditions.

Somewhat poorly drained: Water is removed from soil slowly, therefore it is wet for significant periods but not all of the time. Commonly have a slowly permeable layer within the profile, a high water table, additions through seepage, or a combination of these conditions.

Poorly drained: Water is removed from soil so slowly that soil remains wet for large periods of time. Condition commonly due to high water table, slowly permeable layer within profile, seepage, or a combination of these conditions. Water table at or near surface a considerable part of the year.

Very poorly drained: Water is removed from soil so slowly that the water table remains at or on the surface the greater part of the time. Soils usually occupy level or depressed sites and are frequently ponded.

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