RESEARCH TECHNICAL COMPLETION REPORT

RECREATION WATER CLASSIFICATION SYSTEM AND CARRYING CAPACITY

by

J. H. Milligan
C. C. Warnick

Assisted By:

G. L. Bloomsburg
E. P. Osnick
S. R. Wagner

Submitted to

Idaho State Parks and Recreation Department

September, 1973

This project was supported with funds provided by the Idaho State Parks and Recreation Department and the Civil Engineering Department through the Engineering Experiment Station of the College of Engineering. The preparation of this report was financed in part through a comprehensive planning grant from the Department of Housing and Urban Development and the Civil Engineering Department through the Engineering Experiment Station of the College of Engineering.

Water Resources Research Institute
University of Idaho
Moscow, Idaho
J. S. Gladwell, Director

FOREWORD

The Water Resources Research Institute has provided the administrative coordination for this study and organized the interdisciplinary team that conducted the investigation. It is the Institute policy to make available the results of significant water related research conducted in Idaho's universities and colleges. The Institute neither endorses nor rejects the findings of the authors. It does recommend careful consideration of the accumulated facts by those who are assuredly going to continue to investigate this important field.

ABSTRACT

A conceptual study has been made of water recreation areas of lakes and reservoirs to provide a classification system that would be useful in managing recreational resource. An analysis of useful related research literature was made and is summarized. A classification system has been developed using a factor profile approach which is a graphical method of presenting important parameters that relate to the management and allocation problems. This approach was applied to several lakes and reservoirs that are representative of the resource in Idaho. A presentation is also made on the concept of carrying capacity as related to recreation type water, primarily lakes and reservoirs. Emphasis on the brief study has been on developing a conceptual approach and methodology. Additional testing will be required to verify the rating system and its application in determining carrying capacities.

ACKNOWLEDGEMENTS

The authors acknowledge the help of Dr. George Bloomsburg of the Agricultural Engineering Department in studying and visiting specific lakes, E. W. Trihey of the Institute staff for his help in site visits and E. P. Osnick, a graduate student in Geography and S. R. Wagner, a student in Civil Engineering who helped in various phases of the work. General faculty members throughout the University were approached for advice on specific details of the developing of the concept of attribute numbers. This help is gratefully acknowledged as is the good efforts of the secretaries that helped on the project. Special thanks goes to William Hagdorn of the Idaho Parks and Recreation Department for his advice and patience in completing the project.

TABLE OF CONTENTS

CHAPTER PAGE

LIST OF TABLES

LIST OF FIGURES

INTRODUCTION

With growing numbers of people participating in water-based outdoor recreation, water and recreation resource administrators, planners, researchers and citizen groups are increasingly concerned with strategies and management guidelines that will tell them how to properly manage and allocate water related recreation resources. These problems often lead to questions such as: How can the attributes of a water recreation area be described in such a way that the area can be managed according to its potential? or What is the appropriate level of use for any water recreation area? or At what point should sound management indicate that full capacity has been reached?

In an effort to develop some answers to significant questions regarding slack-water classification as related to recreational use and regarding identification of carrying capacity standards a short-term research project was undertaken by the Idaho Water Resources Research Institute in cooperation with the Idaho Department of Parks and Recreation. Objectives of the project were as follows:

1. To review existing literature throughout the country in order to identify classification criteria and management policies and tools used for recreational use of surface waters for boating, water skiing,

fishing and other slack-water related recreational activities.

2. To develop a classification system for identification of those attributes of a water recreation resource which are critical in shaping management policies and practices.

3. To develop carrying capacity guidelines for recreational use of lakes and reservoirs and supporting land areas.

Since the project was developed as a short-term effort without time available for extensive field work the classification and carrying capacity efforts were carried out as conceptual studies. A number of reservoirs and lakes in different areas of Idaho were chosen as examples to illustrate the concepts developed in this study. While the concepts developed in this study were oriented specifically toward recreational use of lakes and reservoirs, it is felt that applications can be developed for stream-related uses as well.

LITERATURE REVIEW

A national information retrieval service - the Water Resources Scientific Information Center of the Office of Water Resources Research, was utilized for the purpose of surveying existing literature dealing with problems of identifying compatible and non-compatible recreational uses of slack water and of development of carrying capacity guidelines or standards. From this information retrieval request, over 150 literature references were received along with abstracts for each reference. From a review of the abstracts, it was determined that fewer than 50 were related to the project objectives even remotely. About 10 of the more than 150 references were found to have a direct bearing upon the project objectives, indicating a scarcity of literature dealing with the problems of classification and carrying capacity as outlined in the project objectives. Therefore, considerable time was spent in searching out related literature using the various library facilities at the University of Idaho and at Washington State University in an effort to supplement the references obtained from the information retrieval request.

Generally, it was found that there is little information in print relating to recreational carrying capacities on reservoirs and lakes. Only slightly more information is available dealing with the classification problem. The literature review of these two problem areas is summarized in this report. Copies of the references and abstracts obtained from the information retrieval request are not included directly in the report. These are available for review at the University of Idaho.

Literature Relating to Classification

The manner in which recreational use of reservoir waters competes with non-recreational uses has been studied by a number of investigators. Morgan and King (1971) studied the effect of reservoir operating policy on recreational benefits. Their conclusion was that for reservoirs which showed widely fluctuating water levels no statistically significant relationship could be shown to exist between water level fluctuations and recreational attendance during peak-use periods in July. Western reservoirs in this study showed fluctuations on the order of 20 to 48 feet of drawdown for the month. Even with such large fluctuations no significant relationship with attendance could be shown.

The relationship between water level fluctuations and recreation benefits has been studied by other investigators, also. Carson (1972) studied several reservoirs in the Little Rock District of the U. S. Army Corps of Engineers. This study also found no quantifiable or empirical relationship between water levels and recreational use. The range of fluctuations studied was up to ten feet of fluctuation in one week. Larger and more rapid fluctuations would seem to have a greater effect, however.

The amount of water which should be maintained for recreational use can be determined by economic trade-offs with storage requirements for other uses. This methodology is described by James (1968).

Other competing uses may be in competition with recreational use due to their effects upon environmental quality. Link (1971) concluded that any industrial siting on lake shorelines would be in competition with recreational uses of the water resource and supporting shorelines due to industrial effects upon the ecosystem either due to air quality degradation, polluted discharges of water, or discharges of large quantities of warm water.

Still other parameters have been identified as necessary for classifying recreational use characteristics. Leonard (1966) identified population densities and proximity to urban development as important classification and management parameters. Myles (1970) identified a number of site quality parameters, such as water odors, water coliform count, wind speed, cloud cover, and air and water temperature, as being related to visitors attitudes and response to use levels. Visitors regard for such factors are useful in classifying potential recreational uses as well as in determining recreational carrying capacities. Stevens (1966) concluded that the quality of water related recreational experiences would be enhanced by maintenance of high levels of water quality. Proximity of competing or alternate reservoirs and reservoir size are additional parameters identified by Grubb and Goodwin (1968) in the process of developing reservoir visitation prediction equations.

Aesthetic parameters are also important in classification of recreational use attributes. Shafer, Hamilton and Schmidt (1969) used factor and regression analysis to develop a predictive equation to relate preferences to a number of important aesthetic parameters. The most important of these are perimeter of distance vegetation, area of intermediate vegetation, area of any kind of water and area of distant non-vegetation. These four parameters could be developed to measure recreational use attributes of lakes and reservoirs as part of a more general aesthetic factor.

Aesthetic parameters were classified and quantified by Leopold (1969) in three different categories: physical features, biological characteristics, and human interest factors. Uniqueness of aesthetic characteristics, as quantified by Leopold would logically provide a measure of the attractiveness of recreational areas, such as lakes and reservoirs.

Development of facilities, access to shoreline, quality and quantity of road access, and ground cover are still other parameters in the determination of reservoir recreation attributes determined by Burby (1971).

The above references deal with many different characteristics or attributes of recreational activity and indicate that numerous factors are involved in the classification of recreational activities. Some method of quantification of the many factors for management use is needed if such a classification is to be useful in managing the activity levels at different lake and reservoir recreation sites.

Literature Relating to Carrying Capacity

James (1970) defines carrying capacity as the capacity of a facility to accommodate visitors and indicates that the limits of carrying capacity may be defined by physical characteristics of a site or by the users' perception of crowding at the facility. Activity capacity coefficients (users per acre) should be determined empirically for any site by observations at the site during peak use periods. At the carrying capacity level determined by crowding the number of visitors have low tolerance to crowding who are leaving the site should be equal to the number of visitors having high tolerance to crowding who are still joining in activities at the site. Such a condition may never occur on lakes or reservoirs located in more remote areas.

Empirically determined carrying capacity coefficients for different activities on reservoirs in the Lower Ohio River Valley are reported by Sirles (1968) with values ranging from 2.5 users per acre for boating to 600 users per acre for swimming. The total capacity of four activity areas at a recreation reservoir was then found by the empirical relationship

$$C = 2.0 \sum_{i=1}^{4} U_i A_i$$

where C - carrying capacity

A - areas for the four activities (swimming, boating, etc.)

U - activity capacity coefficient (users per acre)

The coefficient 2.0 was necessary to account for sightseers and other visitors who did not participate explicitly in the various water activities.

An interview survey was conducted by Lentnek, Van Doren and Trail (1969) of activity-specialized boaters (sailors, water skiers, fisherman, pleasure cruising, non-specialized) to determine a relationship between the kind of boating activity and the distances traveled to the body of water used. The investigators concluded that boaters specializing in the same activity tend to cluster at particular lakes and that fishermen generally travel farther to more remote lakes than sailors or water-skiers. Boaters interested in pleasure cruising traveled distances intermediate between fishermen and water-skiers.

In a study of peak demand, quality and management of recreational parks and beaches, Golden (1971) concluded that four aspects of quality are related to capacity determinations:

1. Proximity to users (more expensive closer to cities)
2. Use intensity - land or water area per user
3. Development - improvements per user
4. Availability to unexpected users (due to unpredictable variables such as weather or publicity)

Each of the four quality aspects of carrying capacity - proximity, use intensity, development, and availability - may be increased at the expense of an increased quantity of a costly input. To increase availability (decrease likelihood of turnaways) the necessary quality input is excess facilities per expected user. In other words, a recreational area which expects to operate at 100 percent of capacity will have turnaways more often than one expecting to operate at 80 percent of capacity, but the latter may require 25 percent more area and improvements per expected visitor. Since the management necessary to provide a higher quality level is costly, it may be optimal to leave some areas unmanaged.

Miller and Kilmer (1968) developed a linear programming model for determination of the optimum size, number and location of recreational reservoirs based on population distribution, Indiana guidelines for recreational areas, and hypothetical reservoir cost data. The optimizing model incidated more urban use of nearby reservoirs in the optimal system than in an existing system of reservoirs for recreation.

Recreational use patterns for different activities on selected lakes in Iowa were studied by Hangen and Sohn (1968) who recommended several capacity management concepts. For example, they recommended that a limit be placed on the number of power boats operating on certain lakes, that swimming activities be isolated from boat launching areas and that lake front property should be acquired for public access. They also recommended zoning of certain portions of a lake as no-wake speed zones for power boats thus providing areas for fishing or canoeing.

Lime and Stankey (1971) define recreational carrying capacity as the character of use that can be supported over a specific time by an area developed at a certain level without causing excessive damage to either the physical environment or the experience of the user. This definition assumes the principal goal in recreation management is to maximize user satisfaction consistent with certain management, budgetary, and resource capacity: (1) management objectives, (2) visitor attitudes, and (3) recreational impact on physical resources.

Ashton and Chubb (1972) report that degradation of aesthetic environment reduces user satisfaction and consequently carrying capacity. User satisfaction was measured in this study by interviewing boating participants followed later in the season by a self-administered questionnaire. A space consumption index and a dispersion index were determined for various activities from aerial photography. Finally, regression analysis was used to relate user satisfaction to the space consumption index. User satisfaction was found to vary between public access users and shoreline property owners. Most public access users accept a higher level of concentration.

In general the literature on carrying capacity deals mainly with factors involved in determination of carrying capacity but very little information is available on actual area requirements for different activities or satisfaction levels, or on possible trade-off relationships among different activities. Equations relating the various factors involved to carrying capacity are not presented in the literature indicating a need for more definitive research in this area.

FACTOR PROFILE APPROACH

In a study that involves data which are to be used for evaluations of classifications not based on economic analysis, some systematic procedure for accomplishing this evaluation is needed. Oglesby, Bishop and Willeke (1970)[1] have proposed a systematic procedure for dealing with such classifications in one particularly troublesome field of public works decision making. Community controversy often develops in the matter of alternative urban freeway locations. These writers list many different types of community impact and suggest that different evaluation units might be applied to each type of impact. The evaluation units are then plotted for all of the alternatives proposed locations on a "factor profile". The "factor profile" thus provides a graphical description of the effects of each proposed freeway location alternative. This graphic profile thus provides a quick visual rating system for evaluating factors which are not usually reduced to comparison on the basis of economic analysis.

It is suggested that a similar "factor profile" approach might be used for classifying the various factors or parameters which might conceivably determine reservoir recreation

---

[1]C. H. Oglesby, A. B. Bishop and G. E. Willeke, 1970, A METHOD FOR DECISION AMONG FREEWAY LOCATION ALTERNATIVES BASED ON USER AND COMMUNITY CONSEQUENCES, Highway Research Record No. 305, Washington D. C. Highway Research Board, pp. 1-14.

carrying capacity and which are also involved in a classification system used for categorizing these various recreational activities on reservoirs and lakes.[2]

In order to develop a factor profile of lake and reservoir recreation attributes, a search was made through the literature in order to determine those factors which are important management factors dealing with management objectives, visitor satisfaction and physical characteristics of a site which act together to determine the recreational carrying capacity of a reservoir or lake. Thus 16 major parameters with several sub-parameters have been developed to create a factor profile of lake and reservoir recreation attributes. A discussion of each of these 16 factors along with guidelines for evaluating each of the factors and subfactors is included in the following section of the report. The basic profile is presented in Figure 1. Note that in this figure the length of each evaluation bar has been marked how the method works.

During the course of this research and at the suggestion of Mr. W. G. Hagdorn of the Idaho State Department,

---

[2]A.B. Bishop, 1972, AN APPROACH TO EVALUATING ENVIRONMENTAL, SOCIAL, AND ECONOMIC FACTORS IN WATER RESOURCES PLANNING, Water Resources Bulletin, V 8, No. 4, pp. 724-734.

Figure 1 FACTOR PROFILE OF LAKE AND RESERVOIR RECREATION ATTRIBUTES

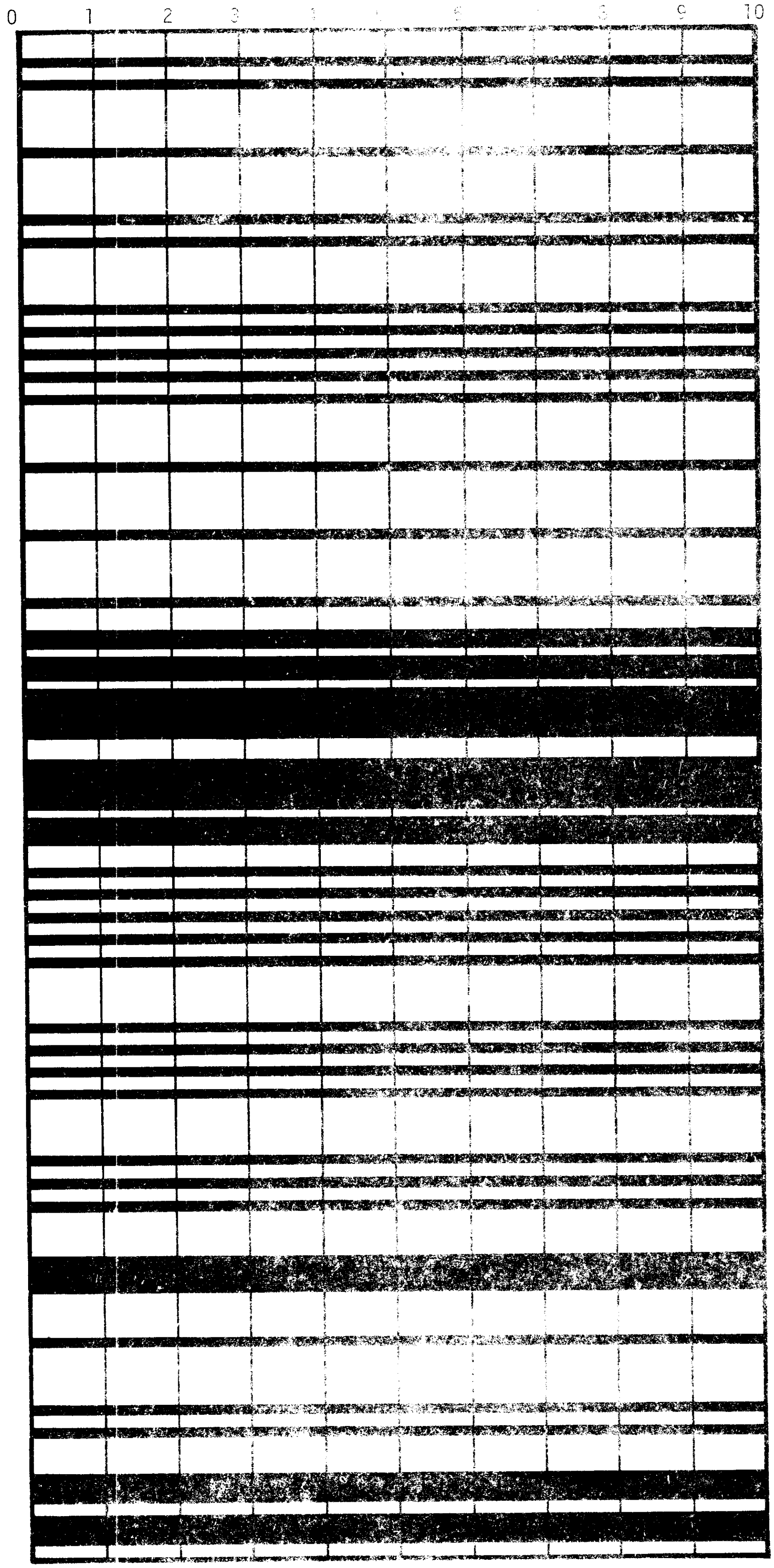
0 1 2 3 4 5 6 7 8 9 10

1. Geometry
   - Length: Width Ratio
   - Shape Index
2. Size
   - Surface Area
3. Characteristic Depth
   - Average Depth
   - Shoreline Depth
4. Water Quality Characteristic
   - Coliform
   - Turbidity
   - Temperature
   - Rooted Aquatic Plants
   - Algal Bloom
5. Wind and Waves
   - Wind Speed & Wave Height
6. Water Level Fluctuations
   - Constancy Pattern
7. Inflow-Outflow Pattern
   - Exchange of Water
8. Public Useability
   - Access
   - Facilities & Services
   - Land Ownership
9. Recreational Use Potential
   - Use Diversity
   - Use Compatibility
10. Aesthetic Setting
    - Vegetative Appearance
    - Unique Backdrop
    - Color Contrasts
    - Shoreline Appearance
    - Atmospheric Quality
11. Wildlife Characteristics
    - Animals
    - Birds
    - Aquatic Life
    - Insect Pests
12. Degree of Development
    - Domestic
    - Commercial
    - Industrial
13. Proximity to Urban Centers
    - Population Zone Density
14. Remoteness
    - Distance to Highway
15. Alternate Lake Availability
    - Within 50 miles
    - Within 100 miles
16. Durability & Resiliency
    - Vegetative Resiliency
    - Land Durability

the importance of each parameter relative to each other was considered. It was recognized that some were more important than others. Yet, no real quantative means of determining how each ranked with respect to each other was possible to be satisfactorily determine in the short time available. Likewise, it was recognized that many of the parameters are interrelated and a study is needed of some sort of regressive analyses to assess the interrelation between parameters and their relative importance. Much of this may rest at best in some kind of value judgment assessment.

It should be pointed out that the advantage of this factor profile methodology is that the users may wish to vary the weighing of parameter. By varying the width of the bar and then summing the area expressed by total bar width and length a single quantative figure could be obtained for expressing the recreation attributes of a lake or reservoir. To illustrate the methodology of this, the basic factor profile has been altered with bar width and emphasis given to some of the parameters that in the judgment of the authors would represent a weighting of importance in Figure 2. Note, emphasis here has been given to items 8, 9, 13, and 16. Within Item 8 a variation between sub-parameter is suggested as an example also.

Figure 2 RELATIVE VALUES



1. Geometry
   - Length: Width Ratio
   - Shape Index
2. Size
   - Surface Area
3. Characteristic Depth
   - Average Depth
   - Shoreline Depth
4. Water Quality Characteristics
   - Coliform
   - Turbidity
   - Temperature
   - Rooted Aquatic Plants
   - Algal Bloom
5. Wind and Waves
   - Wind Speed & Wave Height
6. Water Level Fluctuations
   - Constancy Pattern
7. Inflow-Outflow Pattern
   - Exchange of Water
8. Public Useability
   - Access
   - Facilities & Services
   - Land ownership
9. Recreational Use Potential
   - Use Diversity
   - Use Compatibility
10. Aesthetic Setting
    - Vegetative Appearance
    - Unique Backdrop
    - Color Contrasts
    - Shoreline Appearance
    - Atmospheric Quality
11. Wildlife Characteristics
    - Animals
    - Birds
    - Aquatic Life
    - Insect Pests
12. Degree of Development
    - Domestic
    - Commercial
    - Industrial
13. Proximity to Urban Centers
    - Population Zone Density
14. Remoteness
    - Distance to Highway
15. Alternate Lake Availability
    - Within 50 miles
    - Within 100 miles
16. Durability & Resiliency
    - Vegetative Resiliency
    - Land Durability

Factor Profile Rating Guideline

Each of the factors in the factor profile is rated on a scale from 1 to 10. The ratings are meant to provide a comparative scaling for each factor and are not always meant to indicate desirable or undesirable attributes. Factors such as geometry and size are rated from a small to large. On the other hand, a factor such as water level fluctuations, are rated according to a desirability.

Rating Guidelines - Geometry (1)

The geometry factor, in general, refers to the physical shape characteristics of the body of water. The geometry factor is expected to be particularly useful in determining crowding potential and in planning use classifications for lakes and reservoirs.

The geometry factor is indicated by two sub-factors, namely, length to width ratio and a shape index. The length to width ratio sub-factor was derived to provide a quantitative evaluation of the shape of a lake or reservoir as to whether it is long and narrow or whether it has more of a round shape. The length to width ratio sub-factor is a strictly physical characteristic obtained by dividing the length of the reservoir in miles by the mean width in miles. The mean width of a lake or reservoir is defined as the area of the lake or reservoir in square miles divided by the length in miles. Thus a lake or reservoir with a length to width ratio of 1 would be either round or nearly square. A lake or reservoir with a length ratio of 40 would be a very long and narrow reservoir. The factor profile attribute number for length to width ratios is determined from a conversion table converting the actual length to width ratio to the attribute number which is scaled from 1 to 10.

A second sub-factor under the major factor of geometry is the shape index sub-factor. The shape index is derived by dividing the shoreline length in miles by the surface in square miles. This shape index sub-factor is meant to provide a quantative indication of whether or not the shoreline is characterized by numerous bays and inlets. Thus a lake or reservoir which had a small shape index would be lacking in a great number of bays and inlets; on the other hand, a lake or reservoir which has a large shape index value would be characterized by numerous bays and inlets. The factor profile rating number or attribute number is then derived from a conversion formula converting the actual computed value of the shape index to the attribute number having a scale from 0 to 10. The conversion is shown in the worksheet.

Much of the information needed for quantifying the subfactors under the heading of geometry can be obtained from a Water Resources Research Institute report entitled. EXISTING RESERVOIRS AND POTENTIAL RESERVOIR SITES IN IDAHO, by John J. Peebles. Desirable values of optimum ranges for this attribute number would depend on the expected use of the AN.

Rating Guidelines - Area (2)

The rating guidelines for the water surface area of a lake or reservoir as a part of the factor profile is developed on the basis of maximum surface area of the lake or surface area at maximum normal water surface elevation of a reservoir. The surface area for most reservoir in excess of 100 acres can be found in the report EXISTING RESERVOIRS AND POTENTIAL RESERVOIR SITES IN IDAHO, by John J. Peebles. This report also contains information for those lakes which are operated partially for storage water. A conversion table is then used to convert the water surface area in acres to the profile attribute number. The conversion table for this conversion is provided in the worksheet.

The factor profile attribute number is not intended, in the case of the area parameter, to indicate a good or bad characteristic, but is scaled simply from small to large areas. Of course, a lake with a large area will have a larger carrying capacity than one with a small area, but then area is not the only physical factor in the determination of carrying capacity. Thus optimum ranges for the area AN are not extablished.

Lakes or reservoirs under 100 acres in size are not included in any examples since such small areas are not currently included in management and planning studies for recreational uses.

Rating Guidelines - Water Depth (3)

Two water depth sub-parameters are felt to be important for planning and management purposes. The mean depths of the water body is an indication of the sensitivity of environmental considerations to various kinds of activities. For example, the bottom flora, fauna, and sediments of a reservoir with a mean depth of less than five feet may be disturbed excessively by power boating activity. Or a reservoir that is very deep may not be as productive of game fish as one not so deep. The second sub-parameter, shoreline depth, is meant to give some indication of shoreline activities which could be supported on the lake.

Rating numbers for the factor profile are developed for mean depth by first calculating the mean depth. Mean water depth is defined as the lake or reservoir volume in acre feet divided by the surface area in acres. Then a conversion formula, found in the worksheet, is used to convert the computed mean depth to an attribute number which is plotted on the factor profile.

Since bodies of water that are either too shallow or too deep may have depth limitations, the AN scaling from 1 to 10 does not fit the general indication of increased desirability with increased value of the AN. It is felt that optimum ranges for the mean depth AN would be between 4 and 7.

It should be noted that the mean depth determined in this manner for large lakes currently operated for storage would be the depth of water operated for storage and not the actual mean depth of the lake. This is due to the fact that lake volumes reported for Lake Coeur d'Alene and others are not the actual volumes, but the volume operated for storage. This deficiency could be overcome by determining the actual lake volume.

Rating numbers are determined for the shoreline depth based on information reported in the depth-area curve. Since shoreline depth must be reported at some distances from the shoreline, an arbitrary distance of 150 feet from shoreline was chosen. Most swimming and bank fishing would take place within this shoreline distance. The 150-foot perimeter around the lake represents an area of the lake determined by the formula:

$$\Delta A = 36.4\ (L+W) - 2.07$$

where ΔA = the perimeter area in acres
L = the scaled length of the reservoir in miles
W = the computed mean width in miles

In this case the mean width is computed by dividing the surface area in square miles by the scaled length in miles. The computed value for ΔA is then entered on the area side of the area-elevation curve and the shoreline depth is determined from the differences in elevation on the area-elevation curve. For an assumed area-elevation curve (see figure below) and a computed ΔA of 50 acres, the shoreline depth would be 3180-3164 or 16 feet.

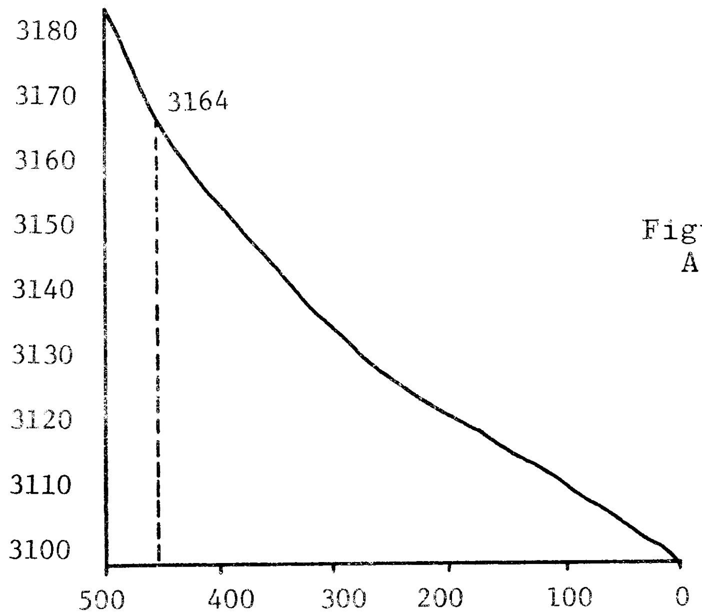


Figure 3 - Assumed Area-Elevation

Area elevation curves for many of the lakes and reservoirs in Idaho can be found in the Idaho Water Resources Inventory published by the Idaho Water Resource Board in 1968.

After computing the shoreline water depth the factor profile attribute number is determined from a conversion formula and plotted on the factor profile. Optimum values of the shoreline depth AN would be 7 or higher.

Rating Guidelines - Water Quality Characteristics (4)

The general criteria of water quality for recreational use should be fairly obvious: freedom from odors, objectionable color, and objectionable floating or suspended materials.

For body-contact recreational activities, the water should be free of pathogens and any other substances which are harmful to swallow.

Specific standards or measures of water quality for recreation are not so easy to establish. Some measure of the following water-quality parameters are felt to be useful in management and planning for recreational use of water: (1) coliform organisms, (2) turbidity, (3) temperature, (4) aquatic plants including algae and rooted plants, and (5) pH.

Coliform Organisms - Even when coliform MPN values are up into several thousand per 100 ml there seems to be no devastating waterborne disease outbreaks among swimmers and other water recreationists. The apparent lack of correlation between high coliform counts and incidents of disease presents some problem in establishing water quality criteria. Based on field studies by the M.S. Public Health Service at a number of swimming beaches, the National Technical Advisory Committee on Water Quality has set a bacteriological limit for water uses during which ingestion occurs, swimming, washing, skiing, and surfing. The limit is based on fecal coliform counts and the standard states that in a minimum of 5 samples in 30 days, the fecal coliforms shall not exceed a logarithmic mean of 200/100 ml, nor shall more than 10% of the total samples in 30 days exceed 400/100 ml.

For a guide based on total coliforms and the report that in such recreational waters the fecal coliforms are about 18 percent of the total coliforms, the total coliform count should not exceed 1000/100 ml for body-contact water recreational activities. Accordingly, a measure of the factor profile attribute number for coliform organisms is proposed as follows:

Coliform (MPN/100 ml)	Attribute Number
4000+	0
4000	1
2000	2
1500	3
1000	4
800	5
600	6
400	7
200	8
100	9
0	10

Turbidity - Turbidity is a measure of the resistance of water to the passage of light through it and is measured optically. The turbidity of water is attributable to suspended and colloidal matter which tend to disturb the clearness of the water and diminish the penetration of light. Turbidity may be from organic or inorganic sources either as a result of natural processes or as a result of waste additions to the water from domestic, industrial or agricultural sources.

Of the available systems for measurement of turbidity only one system has been standardized. The standardized measurement system requires taking samples for laboratory analysis using a laboratory turbidimeter. For purposes of measuring turbidity relative to recreational water quality, perhaps the disc measurement system is sufficient. Using this system of measurement, light penetration is estimated by lowering a Secchi disc in the water until it cannot be seen. The standard disc is 20 cm. in diameter with two white quadrants and two black quadrants.

The proposed rating system for determination of attribute numbers for the factor profile is as follows:

Secchi Disc Reading (ft.)	Attribute Number
2	0
4	1
6	2
8	3
10	4
12	5
14	6
16	7
18	8
20	9
20+	10

Optimum values of the AN would be 7 or higher.

Temperature - Several water quality parameters become important in considering the quality of waters to support forms of life which have recreational values to man. Temperature determines the biological regime which becomes established. Temperature rises and rates of rises determine whether a species stays in a habitat. Temperature also determines the suitability of certain recreational activities such as swimming and water skiing. A measure of both bottom and surface temperatures can also indicate the degree of mixing or stratification taking place in the water body.

For purposes of simplification in using temperature as an indicator of recreational water quality, it is proposed that mid-July surface water temperatures be used to determine the factor profile attribute number. More detailed temperature measurements will undoubtedly be desirable for management purposes.

It is suggested, for example, that temperature measurements be made to indicate a surface temperature to a depth of 10 feet at a distance of 100 feet from shore. Such a procedure would provide a temperature index for shoreline recreation use. Different locations may be desirable if water skiing is the dominant recreation use or if fishing is the dominant recreation use.

The conversion table to convert temperatures to attribute numbers is shown below. Desirable values of the temperature AN would be 7 or above for most uses.

Mid-July Temp. (F^o)	Attribute Number
95+	0
90-95	1
35-45	2
85-90	3
45-50	4
80-85	5
50-55	6
75-80	7

Mid-July Temp. (F°)	Attribute Number
55-60	8
60-65	9
65-75	10

Rooted Aquatic Plants - A major difficulty in describing water quality of reservoirs and lakes is that all of the quality components and interactions cannot be measured correctly. Certain variables are measured that indicate the presence or conditions of phenomena that cannot be measured directly. These indicators reflect the state of any aspect or component of the water environment. Living organisms provide convenient monitors of water quality including component interactions. Biological indicators measure the actual responses of organisms or populations to environmental quality. Biological indicators are integrating devices that show cumulative and interactive effects over periods of time or over some spatial area. Optimum values for the AN would be 7 or higher.

Algal Bloom - Algal production is suggested as such a biological indicator. Water bodies that contain excessive nutrients are usually plagued with nuisance algal blooms. The presence of any algal bloom is undesirable, but many unpolluted lakes produce limited algal blooms of short duration during the spring and fall seasons as a result of normal seasonal thermal turnovers. Serious water quality problems are evidenced when extensive algal blooms are present throughout much of the year.

Localized algal blooms may also indicate a localized source of organic loading. Such a condition warrants further investigation aimed at identifying the source and extent of such loading.

Rooted aquatic weed beds are also useful indicators of lake nutrient levels. Most lakes contain some aquatic weed beds, especially in shallow water. The growth of aquatic weeds is due mostly to the presence of nutrients, especially in the lake sediments. Therefore, weed beds that occur in isolated bays and inlets are common and are of no cause for particular concern. However, an excessive amount of nutrients and nutrient rich sediments entering a lake can rapidly increase the growth of rooted aquatic plants. Extensive growths of rooted aquatic plants in localized parts of a lake away from normal inlets usually indicate a localized source of the problem. The presence of extensive areas of rooted aquatic plants is cause for concern and warrants further investigation.

Evaluation of the quantities of algal bloom and rooted aquatic plants is at best subjective, but it is felt that the parameter is of sufficient importance that it is included in the factor profile. Guidelines for reducing estimated extent of these two indicators to an attribute number for the factor profile are contained in the worksheet. Optimum values for the AN would be 7 or higher.

Rating Guidelines - Wind and Waves (5)

The rating guidelines for wind and wave effects as part of the factor profile are based on the wind data published by the Weather Bureau for ten Idaho weather stations. The published data include both wind speeds and wind directions.

Since water-based recreation is affected by both wind and wave effects, expected wave height has been prepared based on an analytical approach used by engineers to evaluate expected wave height on slack waters for freeboard design and design of physical facilities. The analytical approach is based on the wave height equation:

$$h_w = 0.17\sqrt{VF} + 2.5 - (VF)^{\frac{1}{4}}$$

where h_w = wave height in feet

V = wind velocity in mph

F = fetch length in miles

Maximum wave heights can be attained either from wind blowing in the direction of the maximum fetch or from more intense winds blowing in the direction of shorter fetches. Both possibilities should be evaluated.

The attribute number for wind and waves on reservoirs and lakes is calculated from the formula

$$AN = 13 - \frac{65}{\text{wind velocity and wave height}}$$

where AN is the attribute number.

These calculated values should be rounded to the nearest integer value. The expected range of attribute numbers for wind and waves is from 4 to 10 with the higher values the more desirable values for recreation. Optimum values of the AN would be 8 or higher.

Rating Guidelines - Water Level Fluctuations (6)

Generally water level fluctuations during the prime recreation months of June, July, and August are undesirable. The degree of undesirability depends somewhat on the type of recreational activity and on the type of development that has taken place. For example, if the recreation development is completely public such that all boats are put in and taken out of the water every weekend; fluctuations do not bother a great deal. This fact is borne out by studies of the effects of water level fluctuations on recreation at some U. S. Army Corps of Engineers projects (Carson 1972). However, if the development is essentially private such that many people maintain their own dock facilities, then fluctuations during the recreation season can cause many problems. This is the situation found on such lakes as Hayden Lake, Coeur d'Alene Lake and Spirit Lake.

To assign an attribute number, the average fluctuation during June, July, and August is determined for the most recent available 5-year period. The attribute number was then calculated from the relationship

$$AN = \frac{17}{\text{Ave. Fluctuation}}$$

The constant was selected to give a proper range of values. The attribute numbers for the selected study reservoirs varied from 0.31 to 9.9. The high values were for reservoirs regulated to minimize fluctuations whereas the lower values were found on reservoirs operated primarily for power and irrigation benefits. Optimum values of the AN would be 5 or above.

Rating Guidelines - Inflow-Outflow Pattern (7)

Recreational factors affected by flow through the reservoir are water quality, temperature, and velocities. Of these, water quality is probably of most importance since the temperature of most reservoirs during the summer recreation system is usually in a range for swimming. Also, velocities are not of sufficient magnitude to be detrimental to any water-based recreation except perhaps in the immediate neighborhood of spillway gates.

The effect of discharge, or flow through the reservoir, on water quality is large dependent on the time it takes for the water in the reservoir to be replaced and the quality of the inflow. In order to get some idea of the natural characteristics of the inflow the ratio of peak to average discharge was determined but this number really did not appear to be significant in any way. Therefore, it was decided to determine the turnover time and use this as a measure of desirable recreation characteristics, completely for its effect on flushing pollution out of the reservoir. In other words, a short turnover is desirable - a long time is undesirable.

The turnover time was calculated by dividing the storage volume of the reservoir by the average discharge. This varies from a low of 17 hours for the Ashton Reservoir to 3.5 years for Blackfoot Reservoir.

In Table I is shown the turnover time as well as the capacity ratio (storage volume/annual flow) for all the reservoirs considered in developing the ranges of turnover times and capacity ratios. A high capacity ratio (CR) corresponds to a low turnover time so capacity ratio was converted into an attribute number by the following relationship:

$$AN = \frac{\log(10CR)}{.377}$$

The constants in this equation were selected so that AN varies from 1 to 10 with the highest number (most desirable) corresponding to a low turnover time and the low number corresponding to a high turnover time. (Values of AN are given in Table 1.)

In calculating the capacity ratios for natural lakes the storage volume used is based on the top 30 to 40 feet of the reservoir since this is the only capacity information available. However, when it is considered that this region is the most active as far as pollution, velocities or recreation is concerned, then perhaps the calculated turnover time is a reasonable factor.

Lakes that have a high turnover time are particularly susceptible to pollution since there is slow interchange of

Table 1

Turnover Time and Attribute Number for Inflow-Outflow Pattern Rating of Some Idaho Reservoirs

Reservoir	Capacity Ratio	Turnover Time (hours)	AN
Soda Point	37.6	233	7.1
Dworshak	1.52	5760	3.1
Oxbow	249.7	35	9.0
C.J. Strike	31.8	276	6.5
Crane Creek	1.36	6430	3.0
Black Canyon	48.5	180	7.1
Cascade	1.06	8260	2.7
Payette Lake	7.55	1150	5.0
Little Payette Lake	6.37	1370	4.8
Deadwood	1.03	8500	2.7
Lucky Peak	6.93	1270	4.9
Arrowrock	5.53	1540	4.6
Anderson Ranch	1.18	7420	2.8
Milner	53.0	165	7.2
Lake Walcott	23.8	360	6.3
American Falls	1.88	4660	3.4
Palisades	3.35	2620	4.0
Little Wood River	3.88	2250	4.2
Mackay	4.83	1800	4.5
Salmon Creek	.530	16600	1.9
Lower Goose Creek	.435	20200	1.7
Portneuf	3.08	2840	3.9
Blackfoot	.281	31000	1.2 (low)
Ashton	509.0	1200	9.8 (high)
Island Park	3.27	17	4.0
Henry's Lake	.465	23400	1.8
Coeur d'Alene	19.4	456	6.1
Pend Oreille Lake	10.5	840	5.4
Priest Lake	7.5	1180	5.0
Magic	NA	---	---
Hayden	NA	---	---

water. For instance in Blackfoot Reservoir, it would be possible that a large number of outboard motorboats on the lake could deposit a large amount of oil on the water which would be washed out very slowly, thus affecting desirability of the lake for recreational use.

The usefulness of the inflow-outflow AN is limited, of course, by the quality of the inflow water. For certain lakes or reservoirs which have poor quality water as the major inflow, the AN cannot represent the quality of desirability of the lake water for recreational use. If the quality of the inflow water can be improved, however, then the AN gives an indication of the relative effect and time for effect on the quality of the lake water.

Rating Guidelines - Public Useability (8)

The rating guidelines for the public useability as a part of the factor profile involves items of accessibility, facilities, services, and land ownership patterns. It was the considered judgment of the researchers after surveying the ten sample lakes and reservoirs that facilities and services with $\frac{1}{4}$ mile of shoreline were the important aspects in this parameter as well as land ownership. For the access sub-parameter, it was recognized that some optimum number of access roads per perimeter mile of lake was desirable, that a perimeter road was an important aspect of attribute that contributed to recreation value, and that the number of boat launching and docking facilities per perimeter mile was a measure of usefulenss. Determination of an exact measure of these influences was difficult and so the guidelines for this and the conversion system under the profile worksheet are only suggestive of an approach and additional research is recommended. The worksheet has information illustrative of the methodology.

For the facilities and services sub-parameter of the factor profile observations were carefully made on the ten lake sample in the study to establish a basis for this evaluation. A list of common desirable facilities and services was developed and this list is used in inventorying and arriving at an attribute number for that sub-parameter. The worksheet has the information for preparing this item.

Consideration was given to a very related parameter of public useability, that of ownership of shoreline lands. If all the lands are privately owned, this limits useability of the lake and its shorelines. Ownership maps are often available and could be used to develop a sub-factor for this category. Additional research is needed on this item. The worksheet gives a suggested approach for evaluating this sub-parameter.

This evaluation implies that a site visitation would need to be made, land ownership determined and access characteristics inventoried.

The idea was tested on several of the lakes studied on this project, but real numbers not obtained for the AN's in most cases.

Rating Guidelines - Recreational Use Potential (9)

In considering the guidelines for recreational use, emphasis was directed to recreational activity potential. It was agreed that having a wide diversity of recreational use was desirable. It was recognized that the activity could be associated land-based recreation such as sight-seeing and picnicking and also water-based recreation such as swimming and boating. On this basis an activity inventory was prepared and is the basis for evaluating the attribute number of the factor profile. A high diversity of land-based and water-based recreational activity indicates a high value of the attribute number. The worksheet has the information for preparing this factor profile value.

Use compatability of the degree of conflict between different use activities was recognized as an important factor. The importance of this was stressed by Mr. Hagdorn as necessary to give balance to the aspect of recreation use potential. Here it was discovered late in the study that information on measuring the sub-parameter was not readily available and so two different approaches for making the measurement of the attribute number have been presented in the factor profile worksheet to illustrate a methodology. This definitely needs further testing by professional recreation planners to arrive at an acceptable approach.

Evaluation of these sub-parameters implies a good familiarity with the lake and its immediate area. It is considered that a professional staff member of the Parks and

Recreation Department would do this evaluation.

Rating Guidelines - Aesthetic Settling (10)

The rating guidelines for the aesthetic setting as part of the factor profile was divided into five subratings as follows: (a) vegetative appearance, (b) unique backdrop, (c) color contrasts, (d) shoreline appearance, and (e) atmospheric quality. The scale values have been constructed around rather subjective terms that hopefully identify differing degrees of desireability. These are identified in detail and ratings for attribute number are shown under Item 10 of the worksheet.

To arrive at this evaluation, it is assumed that a site visit would have to be made. Visits were made to 10 specific lakes in an attempt to test the ideas presented for this component of the factor profile. It is considered that a professional staff member of the Department of Parks and Recreation would make this evaluation. Caution is made that this parameter may vary with the eye of the beholder and it may be desirable to use an average of independent evaluations to obtain a measure.

Other persons working with recreation aesthetics have wrestled with the problem of classification and no particularly good method seems to have been developed. The classification methodology characteristics suggested herein adopts most of the important characteristics suggested by Litton (1968). Further development along these lines may be desirable.

Desireable levels for the aesthetic setting sub-parameter ANs would be 6 or above.

Rating Guidelines - Wildlife Characteristics (11)

The rating guidelines for the wildlife characteristics are based on ideas of recreational use that the experience enjoyed is that of seeing wildlife on the occasion of a recreational visit, on a concept that a diversity of wildlife is most desirable and that frequent sightings are also an advantage. An additional concern is the freedom from annoyance of insects on the occasion of a recreational visit. On this basis four subratings have been proposed: (1) animals, (2) birds, (3) aquatic life , and (4) insect pests. For the first three, a list has been prepared in the rating worksheet of more commonly enjoyed animals, birds and aquatic life. This information is identified under Item 11 of the worksheet. In making the rating a rare sighting is given a point total of 1 and occasional sighting a point total of 2, and frequent sighting is a point total of 3. To convert this to a scale of the attribute number for the rating profile to an interger between 1 and 10, a conversion table has been worked out and is part of Item 11 of the worksheet.

The subrating evaluation of the Insect Pests part of the wildlife rating is more subjective and is based on experience of users as to whether it is intolerable, serious, tolerable, occasionally a problem, or no problem. A scale of values from 0 to 10 is included in Item 11 of the worksheet. Desirable levels of the sub-parameter ANs would be 6 or above.

Information is expected to be obtained from experienced visitors in a region and to get conformity it is suggested that regional wildlife and fisheries biologists of the State Department of Fish and Game be used for purposes of this study. Experienced people near the lakes chosen as examples for this study were contacted to arrive at ratings and to illustrate the idea.

Rating Guidelines - Degree of Development (12)

Rating for degree of development as a part of the factor profile was divided into the sub-factors of (1) domestic development, which involved the density of residences and farms as well as recreational home developments within ½-mile of the shoreline, (2) commercial developments which included retail outlets such as stores and gas stations within ½-mile of the shoreline providing goods and services not usually associated with recreation or tourism, (3) industrial development which involved industrial enterprises located within one mile of the shoreline. It is considered that heavy concentration of these three types of developments would reflect low values for attribute numbers. Desirable levels for the sub-factor ANs would be 6 or above.

Information for completing this could be obtained by a site visit or if good aerial photography is available that might be used to make the evaluation. The conversion and system for making the evaluation is contained in the worksheet section.

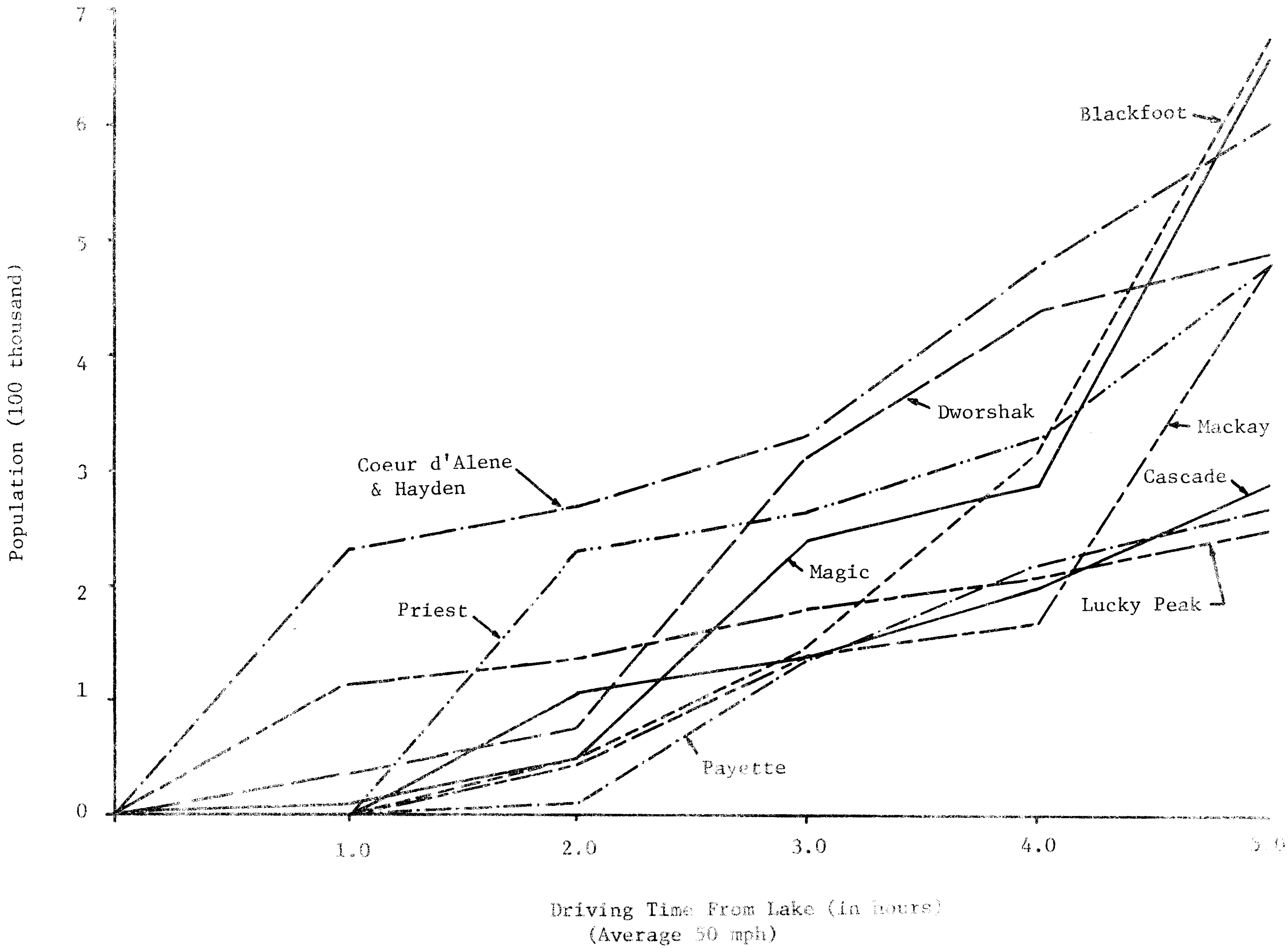


Figure 4: Driving Time and Associated Urban Populations for Ten Study Areas.

Rating Guidelines - Proximity to Urban Area (13)

The proximity of a lake or reservoir to urban centers has long been recognized as an important parameter in determining the expected use intensity. For purposes of developing a measure of this parameter in this study, proximity is measured in terms of driving time rather than miles. The distribution of population with respect to driving time for the study areas is shown in Figure 4.

The attribute number is based upon the population within $2\frac{1}{2}$ hours driving time of the lake. The attribute number is then calculated from the equation:

$$AN = \frac{\text{population}}{30{,}000}$$

The $2\frac{1}{2}$ hour driving time may be somewhat arbitrary but was chosen because it is felt that this is approximately how far a person is willing to drive for a weekend outing. The population and corresponding attribute number for the study areas are given in Table 2.

These attribute numbers may be used to assess the areas that will receive the most pressure for recreational activities. For example, those reservoirs and lakes with higher attribute numbers are more likely to require facilities for picnicking than for camping. The population density curves may also be useful in this regard. Optimum values for this AN are not set since its use is primarily for planning and not so much for assessing desirability.

Table 2

Proximity of Population Attribute Number for Some Selected Reservoirs and Lakes.

Lake or Reservoir	$2\frac{1}{2}$ Hour Population	AN
Lucky Peak	160,000	5.3
Cascade	120,000	4.0
Payette	75,000	2.5
Hayden	300,000	10.0
Blackfoot	100,000	3.3
Mackay	95,000	3.2
Magic	145,000	4.8
Priest	245,000	8.2
Coeur d'Alene	300,000	10.0
Dworshak	190,000	6.3

Rating Guidelines - Remoteness (14)

Lakes and reservoirs which are remote from the standpoint of nearness to major highway routes tend to be used for more specific types of recreation rather than for general recreation activities. Studies indicate, for example, that remote reservoirs and lakes are used more for fishing and camping than for water skiing and that reservoirs not so remote are used more for boating than for camping.

Remoteness does not necessarily correlate with number of visitors expected since the dominant type of recreational activity is such a major consideration. For example, Mackay Reservoir, with a remoteness AN of 9.8, would attract people primarily for camping and fishing activities which will normally draw from a greater distance than other activities.

This accounts for the large number of visitors at Mackay Reservoir which has a 5-hour population of nearly 500,000 (Figure 4). On the other hand, Lucky Peak Reservoir with a remoteness AN of 6.8, would be more likely to attract visitors for boating and water-skiing - activities which draw from lesser distances. The 2-hour or 3-hour population for Lucky Peak Reservoir is much less than the 5-hour population for Mackay Reservoir.

For some lakes, degree of development of some other parameter may make the remoteness - population relationships.

The attribute number describing remoteness is based on distance to the nearest state highway or better type road plus the distance to the nearest principal through route. For example, Blackfoot Reservoir is one mile from the nearest state route and 21 miles from the nearest through route. The attribute number for Blackfoot Reservoir is thus based on a total mileage of 22 miles. The attribute number is determined by the following equation:

$$AN = 10 - \frac{\text{distance}}{2.5}$$

The attribute numbers for remoteness for the study areas range from 0.4 to 10 as seen in Table 3.

The information represented by the attribute number for remoteness may be used as a key to what kind of recreational development should take place at any particular lake or reservoir. That is, it is unlikely that people would often drive to Blackfoot Reservoir for water-skiing or for sightseeing. It is simply too remote for such activity. It is more likely that Blackfoot Reservoir would be highly utilized for fishing. On the other hand, lakes that are encircled by hard surfaced state highways have a great deal more of sight-seeing, water-skiing and related recreational activities.

Table 3

Remoteness Attribute Number for Some Selected Reservoirs and Lakes

Lake or Reservoir	Total Distance (mi)	AN
Lucky Peak	8	6.8
Cascade	0.5	9.8
Payette	0	10.0
Hayden	3	8.8
Blackfoot	22	1.2
Mackay	0.5	9.8
Magic	6	7.6
Priest	24	0.4
Coeur d'Alene	0	10.0
Dworshak	8	6.8

Rating Guidelines - Alternate Lake Availability (15)

The rating guidelines for alternative lake availability as a part of the factor profile was developed to give an indication of the opportunity to enjoy a flat water recreation experience within reasonable travel distances of 50 and 100 miles of the lake being classified. This required obtaining the area of the particular lake and the total lake area within respectively 50 miles radius to the specific lake and 100 miles radius of the specific lake.

Percentages were then calculated of the area the lake under consideration was of the total available lakes area within the prescribed radius of either 50 miles or 100 miles. These were designated P_{50} and P_{100} under Item 15 of the worksheet. A formula was used to convert to the usual 0 to 10 attribute number as shown on the worksheet. This requires good maps of the lakes and data on areas of lakes in the study area.

Rating Guidelines - Site Durability and Resiliency (16)

The site durability and resiliency parameter is subdivided into two categories - vegetative resiliency and land durability. This is to distinguish those sites which have quite different ratings for the two categories from those sites which have comparable ratings. For example, a site might have a low vegetative resiliency, but the land itself is durable enough to stand quite a bit of use; or, the vegetative resiliency is high, but the land durability is low and could cause some problems especially if the land became defoliated.

The vegetative resiliency is judged by rainfall and growing season. Rainfall is the more important factor, and is given seven points out of a possible ten. Frost-free growing season is a secondary factor and is given three points. The following scales were used:

Rainfall	Point Weighting	Growing Season	Point Weighting
> 30"	7	≥ 120 days	3
26" - 29.99"	6	90 - 119 days	2.25
23" - 25.99"	5	60 - 89 days	1.5
19" - 22.99"	3.5	30 - 59 days	0.5
15" - 18.99"	2	< 30 days	0
10" - 14.99"	1		
< 10"	0		

The attribute number would be arrived at by adding the weighting points from both of the above as applicable to a lake area. The land durability rating indicates whether the land is subject to rock-slides, sluffing or erosion. The following scale is proposed as a basis for the attribute number:

10 pts. = stable (e.g. solid rock, sand beach, etc.)

8 pts. = slightly unstable, but of no serious consequence (e.g. sand dunes, etc.)

5 pts. = moderately unstable, which could cause some minor problems.

2 pts. = highly unstable, which could cause serious problems.

A weighting might be accomplished by totaling the percentage of the area within 200 ft. of the shoreline which fell into each of these categories and then computing a weighted average for a given lake of reservoir.

As far as interpretation is concerned, if both resiliency and durability ratings are high the area can stand a high rate of use. If the resiliency is low, and vegetation is desired in the area, care should be taken to protect the existing vegetation. If the durability is low, some stabilization (e.g. retaining walls, blacktop, etc.) may be necessary in areas of high use. If both ratings are low, the area is quite fragile and human use should be kept to a minimum. Very little testing of the validity of these two factor profile parameters was done in this study. It is suggested that a cooperative Extension Service agent would be a good person to help in this factor profile evaluation and would require site visits and reference to such a publication as Bulletin 494 of the Idaho Agricultural Experiment Station entitled, "Spring and Fall Freezing Temperatures in Idaho" by Sterlingson and Everson. Idaho Climatalogical data would also be desirable as a reference.

CARRYING CAPACITY AND CLASSIFICATION

Overuse of a body of water may result in damage to the resource. Equally troublesome in terms of carrying capacity are the conflicts which often develop between recreation water users. Conflicts between recreation water users may be between shoreline users and water users or between water users themselves. These conflicts may be physical or psychological.

Some bodies of water may be more suited to one use than another, while others may be suited to a wide variety of uses. Any water body can accomodate only a limited number of uses and users. Beyond this limit conflicts or perhaps damage to the physical resource can develop due to overload of a single use or due to conflicting interactivities among the various uses.

The ability of a water body to accomodate particular use levels and combinations of uses within acceptable levels of ecological disturbance and use conflicts may be defined as the "carrying capacity" of that water body. Thus carrying capacity depends upon safety considerations, natural physical characteristics, the attitudes and behavior of the users, and upon the management objectives and methods.

To determine the carrying capacity of a water body its physical characteristics (area, shape, water quality, depth, shoreline length, etc.) must be inventoried. These physical characteristics determine the basic suitability of the water body to any particular use. For example, shallow water bodies having a mean depth of less than five or six feet are not suitable for power boating and water-skiing In terms of physical characteristics the relativity of the term carrying capacity should also be apparent. For example, an arm or beach or some reservoir or lake may be managed as a glorified swimming pool with little or no regard for existing aquatic communities and resulting environmental disturbance. Management objectives thus become a part of the carrying capacity.

Recommended water space standards (Department of Interior, Bureau of Outdoor Recreation, 1967, Outdoor Recreation Space Standards) indicate an enormous gap between water space requirements for space conservative activities such as swimming or fishing and those for space consumptive activities such as power boating or water-skiing. For example, one ski boat may require 20 to 40 acres, depending upon the mix of activities, while only 200 square feet of water space may be required for one swimmer (more than 200 swimmers per acre). These numbers indicate an exchange ratio between ski boats and swimmers as high as 8000 to one. Space requirements for any one activity may be vastly different, however, depending upon the particular activity mix of the water body and its physical characteristics. For example, a lake with many bays and inlets might lend itself to activity zoning so that only 20 acres of water might be required for a ski boat instead of 40 acres. Such a lake would have a higher capacity per acre than one where such activity zoning is not possible.

At the present time water surface area needs for various combinations of uses are not particularly well defined and it appears necessary to base carrying capacity coefficients for various activities on broad estimates and empirical information that has been developed through experiences in different areas. Until further information is available it seems desirable to err in the direction of preserving public safety and environmental values.

The approach presented here is based upon the applicability of the factor profile classification system to measures of carrying capacity indicated by safety, physical environmental degradation, and user satisfaction.

Safety as a Capacity Measure

The concern to increase the safety of on-water recreation has been recognized by many states in writing regulations which require a certain minimum distance between boats engaged in various activities. The concern to increase the safety of on-water recreation and to simultaneously facilitate the utilization of a lake by a number of different and incompatible activities is a relatively new concept however. The safety problem is further complicated by consideration of a number of different and incompatible activities simultaneously taking place on a given body of water.

As this problem is analyzed it should become obvious that use intensity as well as area and activity allocations become important factors for consideration of safety of on-water recreation. Jaakson (1971) has suggested zoning to regulate on-water recreation and he further suggests three specific zones for this purpose. The suggested activity zones are (1) a shoreline activity zone, (2) an open water activity zone and (3) a wildlife zone. The shoreline activity zone and the open water zone aim to minimize conflict between on-water recreational activities which are incompatible due to their spatial requirements and speed characteristics. The wildlife zone on the other hand, is calculated to protect the surrounding aesthetic environment and the ecosystem of the lake from adverse consequences produced by recreational activities. The zoning concept is aimed at the problem of area and activity allocations. Jaakson does not indicate, however, the recommenced use intensity for each of the suggested activity zones.

Use intensity measured as land or water zones per user is obviously a function of the space available on the water body as well as a function of the demand for use or the number of users. Demand for use in turn depends on the type of recreational opportunities to be provided by the area in question as well as the recreation opportunities at other sites in the general area. It can also be reasoned that the activity distribution and the number of developments available per user would help to modify use intensity in various areas of the lake.

The application of the attribute numbers used in the factor profile of lake and reservoir recreation attributes to determine safety might conceivably be accomplished by correlating the attribute numbers with some form of a spatial consumption index which might be determined by sequential aerial photography or by specified legal requirements. The factor profile parameters which would affect the determination of safety factor as a measure of capacity are the geometry, size, characteristic depth, wind and waves, proximity to urban centers and remoteness parameters. The concept here, then, is to correlate the factor profile parameters which affect use intensity and the area and activity allocations with some measure of space consumption which is determined by an actual measure of use to determine a safety parameter which is one of the measures involved in capacity determination.

Physical Environmental Degradation

The influence of physical environmental degradation upon carrying capacity has been recognized by several investigators of the recreational carrying capacity. Lime and Stankey (1971) offer several ideas which summarize the concept of wear and tear of the physical resources due to recreational impact. Basically they indicate that any use of a resource will result in some change in the ecosystem involved. The problem is to determine how much wear and tear should be allowed before the manager should say enough.

Most writers dealing with the problem of recreational impact upon physical environment degradation indicate this degradation is determined by use intensity and the degree of site hardening which is provided. Of course, the evaluation of the amount of degradation would depend upon the standards of objectives against which the degradation is measured.

The factor profile parameters identified as affecting physical environmental degradation or indicating a measure of physical environmental degradation would be the geometry, size, characteristic depth, recreational use and proximity to urban centers parameters which are used to determine use intensity as well as the degree of development parameter and the sight durability and resiliency parameters which are intended to measure the degree of site hardening that is provided either naturally or artificially by means of development. In addition, the physical environmental degradation measure of carrying capacity is measured by the factor profile parameters of water quality and inflow and outflow pattern. The interpretations of these last two parameters with regard to degradation has been mentioned in an earlier section of this report.

The interpretation of the factor profile parameters mentioned above in determining the amount of potential physical and environmental degradation at any particular lake or reservoir would be based upon the weighting of the use intensity parameters, the site hardening parameters and the water quality degradation measure of carrying capacity should be further developed by carrying out a number of on-site studies to possibly correlate the factor profile numbers with a subjective evaluation of physical environmental degradation.

User Satisfaction

It is felt by most recreational resource investigators that an adequate measure of user satisfaction can only be evaluated by conducting some sort of survey to measure user satisfaction. Those surveys which have been conducted generally indicate that user satisfaction is determined by the degree of crowding, existence of undesirable developments, surrounding esthetics, the degree of activity availability versus the desired activity availability, site access, and use conflicts.

Crowding again is a function of use intensity, which in turn is a function of land or water area per user of space availability and demand. However, the effect of crowding on user satisfaction is somewhat different than the effect of use intensity on safety. For example, Ashton and Chubb (1972) reported that users generally preferred more space per boat than space requirements for safety would indicate. They also reported that different kinds of users desired different amounts of space. In other words, not every one is a Daniel Boone, although there are bound to be a few.

Even at times when facilities are not crowded to their rated capacities, some potential visitors may not visit the reservoir since they do not wish to chance finding the facilities overcrowded. Still others may not go because they have a Daniel Boone attitude about crowding (a greater than average aversion to crowding). The net result is an actual psychologically determined capacity somewhat lower than the capacity determined by facilities. Evaluation of this difference would, of course, require further research in the form of visitation surveys taken during peak visitation periods.

The relationship between user satisfaction and the factor profile parameters would be expressed in terms of those parameters affecting crowding (geometry, size, access, recreational use opportunity, and proximity to urban centers) as well as those parameters expressing aesthetic evaluation (water quality, water level fluctuation, inflow-outflow, aesthetic setting, and site durability and resiliency). The factor profile could then be used to evaluate user satisfaction. There has not been a sufficient amount of work done in the field yet to evaluate the relationship between user satisfaction and any of the parameters listed. It is suggested that further research be conducted to evaluate this aspect.

Capacity Determination

Once relationships have been established for safety and factor profile values, physical environmental degradation and factor profile values, and for user satisfaction and factor profile values a model should be developed relating space consumption with each of the three factors (safety, physical environmental degradation and user satisfaction). Such a model could be developed by means of aerial photography used to measure space consumption in various actual use situations. This model would then be used to define a final relationship between the factor profile numbers and carrying capacity, which would then enable the determination of carrying capacity based on the factor profile numbers.

Without these models and relationships which must be developed by further research, the factor profile can still be used to qualitatively compare the recreation carrying capacity of different lakes and reservoirs since the factor profile numbers have been developed so that the higher numbers represent the more desirable situation. The factor profile as a whole, thus reflects and integration of all of the relationships suggested above, but it would be difficult or impossible to assign users per acre on the basis of the factor profile numbers without the relationships and models suggested above.

Qualitative evaluation of carrying capacity by using the factor profile is accomplished by interpreting the factor profile parameters having higher ratings (nearer the value of 10) as indications of greater carrying capacity. For example, a lake whose factor profile indicates values for all parameters over 7.5 would have a greater carrying capacity in terms of boats per acre or persons per shoreline mile than a lake whose factor profile ratings are all about 4.5.

It is also suggested that by carrying out a sequential factor profile evaluation from year to year with an associated accounting of visitor intensity or use intensity in terms of boats per acre or other appropriate measure, that a management decision of carrying capacity could be made. For example, if a factor profile rating for any or all parameters began to decrease over time, the decision would be that the carrying capacity was at or near the current use intensity for the particular activity mix at that lake or reservoir.

It should be noted that carrying capacities of those lakes and reservoirs well suited to many uses or activities would be most difficult to evaluate by this or any other method since some assumptions regarding appropriate mixes must be made. The carrying capacity for sightseeing must be included in other activities since this is an activity which mixes with other activities. Similarly many other activities have this mixing or symbiotic relationship. Some other activities such as fishing which depends more on the available fish are not so dependent on other activiites.

The sequential application of factor profile evaluations with corresponding loading or use intensity determinations as mentioned above would seen to provide the advantage of measuring the overall effect on capacity for the particular mix of activities at that site. There would be some danger or extrapolating a carrying capacity determined in this fashion for a particular mix to a different mix at the same site or at other sites.

It has been suggested that the carrying capacity of a site could be increased in some cases by site "hardening". By site hardening is meant modification of physical characteristics or of facilities to reduce undesirable effects of intensive use. It seems reasonable to assume that those sites which could effectively be hardened to increase the carrying capacity are those for which some one or two characteristics constrain any increase in capacity. Site modification could be carried out in a fashion to relax the constraining condition.

The factor profile approach provides a management tool which can be used to identify the site characteristics which would limit increased carrying capacity since such characteristics would be identified as isolated low values on the profile. This application would particularly apply to those characteristics reflecting environmental quality degradation and safety reduction. Human value considerations may be more difficult to identify by this means.

While the above methods for capacity determination may be feasible in time, most states that have published space standards, have done so on the basis of judgment factors. Minnesota space standards, for example, were taken from the "Wisconsin Conservation Outdoor Plan" published in 1968 and from the "Outdoor Recreation Space Standards" published in 1967 by the Bureau of Outdoor Recreation. Data from these sources were modified by judgment factors for application to Minnesota.

The Minnesota State Comprehensive Outdoor Recreation Plan lists the following capacity conversion factors and space standards for the major activities. No indication is given of consideration for activity mixing or activity zoning.

Warm Water Fishing	3.6 persons per acre 8 acres per fishing boat
Swimming (Beaches)	50-100 square feet of water per person 10 sq. ft. supporting beach area per sq. ft. of swimming water.
Boating	15 acres per boat 7.5 acres per person
Water Skiing	20 acres per boat 5.7 acres per person
Picnicking	4 persons per table 10-20 tables per acre plus 20 acres undeveloped for buffer zone per acre
Camping	4 persons per site 6 camping units per acre plus 20 acres undeveloped buffer per acre

Several other states seem to have followed the Minnesota pattern but allow for more or less crowding at facilities. California, for example, allows up to 16 picnicking tables per acre rather than 4 units. California also recommends one launching facility for every 160 acres of boating water and parking space for 75 automobiles and boat trailers for each launching facility. Following this criterion, Lucky Peak Reservoir would need 18 launching facilities; and Cascade Reservoir would need 177 such facilities! Perhaps these examples point out the problems of basing standards for one state on those used for another state, and the need for conducting in-state research to determine actual needs based on field data.

In summary, the capacity determination can be derived by two alternative means, both dependent upon the application of the factor profile. A more desirable method since it could more reliably be extrapolated to other sites and situations depends upon determination of certain models and relationships. The second method depends upon sequential application of the factor profile evaluations over time at a given site. Both of these applications were regarded as outside the scope of this work and are suggested as topics for further work. It is felt that such methods would be superior to capacity determinations adopted from other state standards.

RESULTS

Because much of the study has been focused on conceptual methodology, the previous sections report most of the results. A sample of the factor profile will be used to illustrate the approach. Most of the testing of the methodology was centered on using ten reservoirs and lakes as test cases. The lakes and reservoirs considered were: Lucky Peak Reservoir, Cascade Reservoir, Payette Lake, Hayden Lake, Blackfoot Reservoir, Mackay Reservoir, Magic Reservoir, Priest Lake, Coeur d'Alene Lake and Dworshak. Data from many other lakes and reservoirs were inspected and evaluations made to study ranges of attribute numbers. In several cases it was not possible to obtain complete profile information. Hence, the factor profiles for the 10 test lakes are incomplete. Figure 5, the factor profile for Lucky Peak Reservoir is presented to illustrate the results. Table 5 is a suggested summary table that would permit numerical comparison of the ten lakes. It is easy to see how an extension of this table could compactly represent the classification values in one matrix of all the lakes of a region.

Figure 5 FACTOR PROFILE OF LAKE AND RESERVOIR [illegible] LUCKY PEAK RESERVOIR

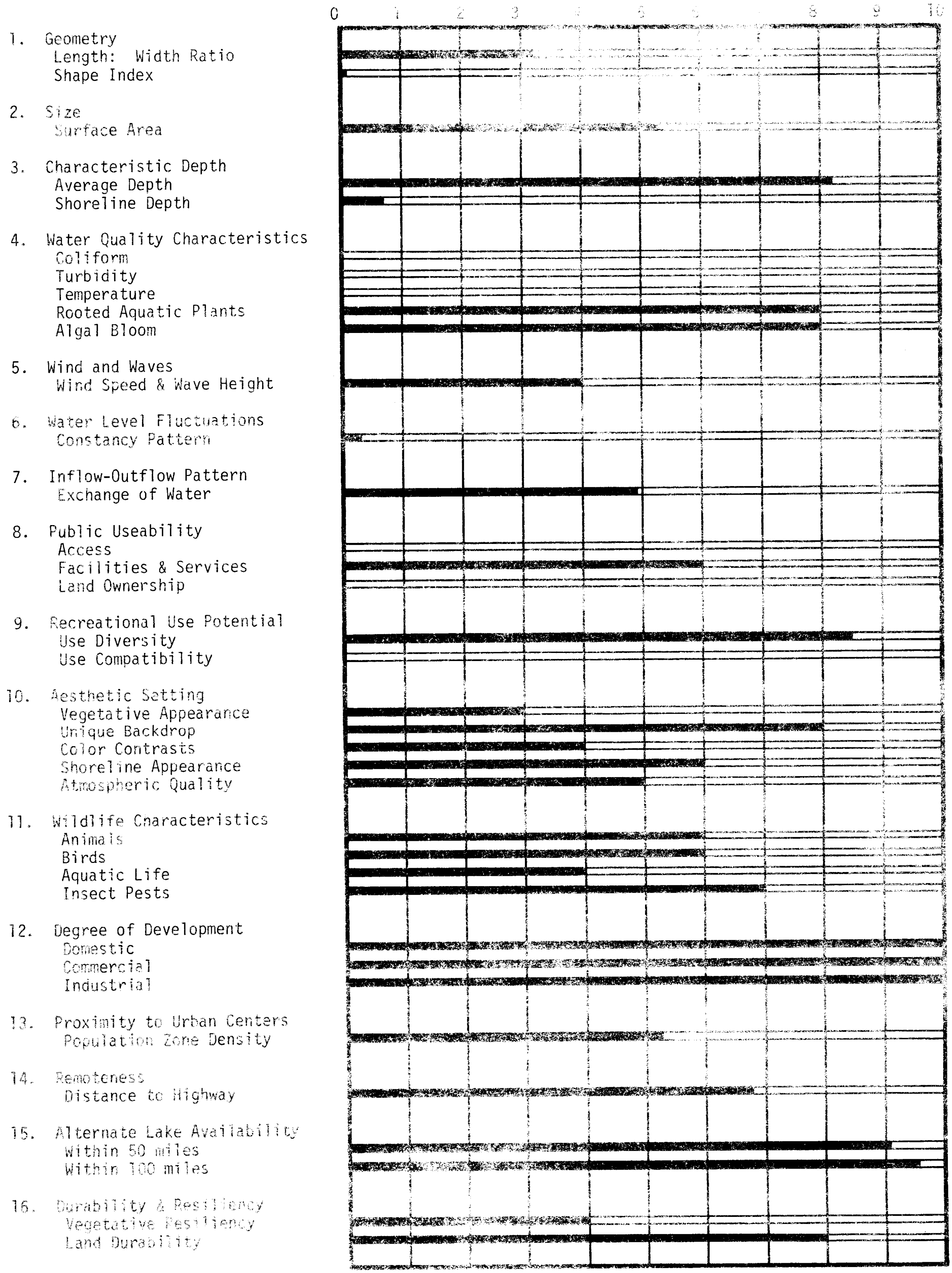


TABLE 4

SELECTED LAKES AND RESERVOIRS OF IDAHO

Profile Parameter	Lake or Reservoir									
	Lucky Peak	Cascade	Payette	Hayden	Blackfoot	Mackay	Magic	Priest	Coeur d'Alene	Dworshak
1. Geometry										
Length: Width Ratio	3.2	5.1	7.0	6.1	5.9	7.2	6.8	6.0	6.0	0.1
Shape Index	0.1	---	---	0.46	---	0.26	---	0.28	---	3.5
2. Size										
Surface Area	5.3	8.4	6.2	5.7	7.8	4.4	5.8	8.6	9.2	7.7
3. Characteristic Depth										
Average Depth	8.2	5.6	3.2	---	5.4	6.0	---	2.4	2.5	9.2
Shoreline Depth	0.7	9.7	7.3	---	9.0	9.0	7.3	9.0	9.0	2.7
4. Water Quality Characteristic										
Coliform	---	---	---	---	---	---	---	---	---	---
Turbidity	---	---	---	---	---	---	---	---	---	---
Temperature	---	---	---	---	---	---	---	---	---	---
Rooted Aquatic Plants	8.0	5.0	7.0	9.0	---	9.0	---	9.0	6.5	9.0
Algal Bloom	8.0	6.0	8.0	8.0	---	9.0	---	8.5	8.0	---
5. Wind and Waves										
Wind Speed & Wave Height	4.0	7.7	7.6	8.2	8.7	8.6	8.4	8.3	8.4	6.1
6. Water Level Fluctuations										
Constantcy Pattern	0.3	2.1	6.6	5.1	3.7	0.6	0.7	9.9	5.7	---
7. Inflow-Outflow Pattern										
Exchange of Water	4.9	2.7	5.0	---	1.2	4.5	---	5.0	6.1	3.1
8. Public Useability										
Access	---	---	---	---	---	---	---	---	---	---
Facilities & Services	6.0	8.0	9.0	7.5	4.0	5.5	6.0	10	10	5.0
Land Ownership	---	---	---	---	---	---	---	---	---	---
9. Recreational Use Potential										
Use Diversity	8.5	8.0	8.5	7.5	6.5	6.5	7.0	7.5	9.5	7.0
Use Compatibility	---	---	---	---	---	---	---	---	---	---
10. Aesthetic Setting										
Vegetative Appearance	3.0	---	9.0	7.0	3.0	3.0	4.0	8.0	9.0	9.0
Unique Backdrop	8.0	8.0	8.0	7.0	5.0	10	4.0	9.0	4.0	5.0
Color Contrasts	4.0	6.0	4.0	3.0	4.0	4.0	2.0	4.0	6.0	6.0
Shoreline Appearance	6.0	10	6.0	6.0	6.0	5.0	2.0	6.0	6.0	6.0
Atmospheric Quality	5.0	5.0	8.0	8.0	5.0	8.0	8.0	8.0	7.0	8.5
11. Wildlife Characteristics										
Animals	6.0	8.0	8.0	4.0	4.0	4.0	4.0	4.0	4.0	6.0
Birds	6.0	10	10	6.0	4.0	4.0	6.0	8.0	8.0	6.0
Aquatic Life	4.0	8.0	8.0	6.0	4.0	2.0	2.0	3.0	3.0	3.0
Insect Pests	7.0	5.0	7.0	7.0	5.0	8.0	7.0	7.0	5.0	5.0
12. Degree of Development										
Domestic	10	3.0	4.0	1.0	6.0	10	6.0	7.0	1.0	10
Commercial	10	10	5.0	10	10	10	10	10	5.0	10
Industrial	10	10	3.0	10	10	10	10	10	3.0	10
13. Proximity to Urban Centers										
Population Zone Density	5.3	4.0	2.5	10	3.3	3.2	4.8	8.2	10	6.3
14. Remoteness										
Distance to Highway *	6.8	9.6	10	8.8	1.2	9.8	7.6	0.4	10	6.8
15. Alternate Lake Availability										
Within 50 miles	9.1	3.9	8.7	9.8	4.9	4.9	7.3	7.7	6.8	0.2
Within 100 miles	9.6	6.1	9.0	9.8	6.3	9.8	9.7	8.6	7.5	9.1
16. The Durability & Resiliency										
Vegetative Resiliency	4.0	5.0	7.5	9.0	4.0	2.3	3.3	8.5	8.7	8.7
Land Durability	8.0	8.0	9.5	6.6	---	---	---	---	---	---

CONCLUSIONS

This report presents an approach to the determination of the recreation carrying capacities for lakes and reservoirs based on an application of factor profiles. More specifically, the report presents discussion in three areas:

1. A review of existing literature throughout the country dealing with the problems of classification of lake and reservoir characteristics and of carrying capacity determination. This review consisted of a search of over 150 computer-selected references and additional library review at two universities. Those references regarded as bearing directly upon the project objectives are briefly summarized in the report. All references reviewed were separately annotated and compiled.
2. A classification system for identification of those water recreation resource attributes critical in determining carrying capacities and in shaping management policies and practices. This classification system is based upon application of a factor profile approach and guidelines for development of the factor profile for lakes and reservoirs are presented and discussed in some detail. Example applications are presented.

3. Alternate methodologies for application of the factor profiles for determination of recreation carrying capacities. Carrying capacities have often been determined on the basis of space requirements for single activities. The methodologies outlines would allow the determination of carrying capacities for a mix of activities. These methodologies are dependent upon application of the factor profile classification system.

RECOMMENDATIONS

Some major and some minor recommendations are indicated by the study. Several of these are suggested in the text and are summarized here.

1. It is recommended that the factor profiles be completed for all of the major (over 100 acres) lakes and reservoirs in the state and that these factor profiles be kept up to date for purposes of determining carrying capacities and for other management purposes.
2. It is suggested that the alternate methodologies outlines in the report be pursued and applied to the recreational lakes and reservoirs in the state.
3. The concept of classification developed herein has merit for application to free-flowing streams as well as to slack water. It is suggested that this application be pursued with the appropriate modifications.
4. Date requirements for the factor profiles suggest that one of the state water agencies take the responsibility of gathering certain water quality data necessary for adequate management of recreational water resources. Specific information needed relates to temperature, turbidity, coliform

and wind data. A systematic sampling program should be developed to implement collection of these data.

5. Access and ownership were lumped into a parameter called public useability. It is felt that these should be separate parameters evaluated in the factor profile. An evaluation method needs to be developed for these factors.

6. Wind and wave information are considered together as a single parameter since it takes wind to make waves. However, wind persistency or duration is also an important aspect of wind for recreation applications. Some evaluation procedure for this aspect of wind should be developed and worked into the factor profile.

7. The current evaluation of the site durability and resiliency parameter is somewhat subjective. This would be a better evaluation if a less subjective procedure could be developed

SELECTED BIBLIOGRAPHY AND REFERENCES

Ashton, Peter G., and Michael Chubb, 1972, "A Preliminary Study for Evaluating the Capacity of Water for Recreational Boating", Water Resources Bulletin, V. 8, No. 3, pp 571-577.

Bishop, A.B., 1972, "An Approach to Evaluating Environmental, Social, and Economic Factors in Water Resources Planning," Water Resources Bulletin, V. 8, No. 4, pp 724-734.

Burby, Raymond J., III, 1971, "A Quantitative Analysis of Factors Influencing Residential Location in Reservoir Recreation Areas", Journal of Leisure Research, V. 3, No. 2, pp 69-80.

Carson, William D., Jr., 1972, "An Investigation of the Determinants of Reservoir Recreation Use and Demand: The Effect of Water Surface Elevation", Research Note No. 2. The Hydrologic Engineering Center, Corps of Engineers, U.S. Army, Davis, California.

Clawson, M. and J.L. Knetch, 1966, "Economics of Outdoor Recreation", Resources for the Future, Johns Hopkins Press, p. 157

Goldin, Kenneth D., 1971, "Recreational Parks and Beaches: Peak Demand, Quality and Management", Journal of Leisure Research, Volume 3, No.2, pp 81-108.

Grubb, Herbert W., and James T. Goodwin, 1968, "Economic Evaluation of Water-Oriented Recreation in the Preliminary Texas Water Plan", Texas Water Development Board Rep. 84, 28 pp.

Haugen, Arnold O., and Arnold J. Sohn, 1968, "Competitive Recreational Uses of Selected Iowa Lakes", Project Completion Report, Iowa State Water Resources Research Institute, 173 pp.

Jaakson, Reiner, 1971, "Zoning to Regulate On-Water Recreation", Journal of Land Economics, Volume 47, No. 4, pp 382-388.

James, L. Douglas, 1970, "Economic Optimization and Reservoir Recreation", Journal of Leisure Research, Volume 2, No. 1, pp 116-129.

Kusler, Jon A., 1972, "Carrying Capacity Controls for Recreation Water Uses", Upper Great Lakes Regional Commission Report, 71 pp.

Lentnek, Barry, C.S. VanDoren, and James S. Trail, 1969, "Spatial Behavior in Recreational Boating", Journal of Leisure Research, Volume 1, No. 2, pp 103-124.

Leonard, Merewitz, 1966, "Recreational Benefits of Water Resource Development", Water Resources Research, Vol. 2, No. 4, pp 625-640.

Leopold, Luna B., 1969, "Landscape Esthetics", Natural History, November, pp 37-44.

Lime, David W., and George H. Stankey, 1971, "Carrying Capacity: Maintaining Outdoor Recreation Quality" in Proceedings of the Forest Recreation Symposium, Syracuse, New York, October 12-14, 1971. pp 174-183.

Link, L.E., 1972, "Power Plant Siting on Lake Michigan" in Proceedings of the Symposium on Social and Economic Aspects of Water Resources Development, Cornell University, Ithaca, New York, June 21-23, 1971, pp 88-90.

Litton, R. Burton, Jr., 1968, "Forest Landscape Description and Inventories - A Basis for Land Planning and Design", U.S.D.A. Forest Service Research Paper PSW-49, Pacific SW. Forest and Range Experiment Station, Berkeley, California, 64 pp.

Miller, W.L., and R.L. Kilmer, 1968, "Reservoir Location for Urban Recreation", in Proceedings, Fourth American Water Resources Conference, New York, 1968, pp 669-678.

Morgan, Joe M., and Paul H. King, 1971, "Effects of Reservoir Operating Policy on Recreation Benefits", Water Resources Bulletin, Volume 7, No. 4, pp 765-773.

Myles, George A., 1970, "Effect of Quality Factors on Water-Based Recreation (In Western Nevada)", Bulletin 24, Agricultural Experiment Station, University of Nevada, Reno, 70 pp.

Oglesby, C.H., A.B. Bishop, and G.E. Willike, 1970, "A Method for Decisions Among Freeway Location Alternatives Based on User and Community Consequences", Highway Research Record No. 305, Washington, D.C., Highway Research Board, pp 1-14.

Patrick, Ruth, 1972, "Aquatic Communities as Indices of Pollution", Chapter in William A. Thomas, Ed. Indicators of Environmental Quality, Proceedings of Environmental Indices Symposium, Oak Ridge, Tenn.. Published by Plenum Press, New York, pp 275.

Shafer, Elwood L., Jr., John F. Hamilton, Jr., and Elizabeth A. Schmidt, 1969, "Natural Landscape Preferences, A Predictive Model", Journal of Leisure Research, Vol. 1, No. 1., pp 1-20.

Sirles, J.E. III, 1968, "Application of Marginal Economic Analysis to Reservoir Recreation Planning", University of Kentucky Water Resources Institute, Research Report No. 12, Lexington, KY.

Stevens, Joe B., 1966, "Recreation Benefits from Water Pollution Control", Water Resources Research, Volume 2, No. 2, pp 167-182.

APPENDIX

FACTOR PROFILE WORKSHEET

The information necessary for preparing the factor profile needs to be organized and gathered in a convenient and easily interpreted manner. An attempt has been made to simplify the measurement data so that it can be quickly transposed. The worksheet in the case of this report has, in some cases, required inserting the conversion system for fitting the data to the 1 to 10 scale. In that respect, it may appear to be somewhat bulky. In practice the forms or worksheets could be shortened. A suggested worksheet format with the explanatory notes follows:

1. Geometry

Lake length L _____ Width W _____ Length-Width Ratio L:W _____

L:W varies 1.07 to 40+

AN = 10 - 5 log (L:W)   AN = attribute number = 9.35 → 0.25

Shoreline length __________ Surface area __________

Shape Index ______________

$$\text{Shape Index} = \frac{\text{(shoreline length, miles) (width, miles)}}{\text{AREA, square miles}}$$

$$\text{Non-optimal=circle: } \frac{\text{circumference (diameter)}}{\text{area}} = \frac{\pi d(d)}{\pi d^2/4} = 4$$

$$AN = \frac{\text{shape index}}{10} \qquad AN = 0.2 \rightarrow 10$$

Source of data ______________________________________

2. Size

Surface area of lake S ______________________________

Attribute number can be calculated from the equation:
$AN = 3 \log S - 5$

Source of data ______________________________

3. Characteristic Depths

Surface area of lake S______ Volume at capacity V ______

(a) Average depth $d = V/S$ ______________________

A conversion table to determine an attribute number from an average water depth is indicated below:

Average Water Depth ft.	Attribute Number AN
less than 10	1
10 - 19	2
20 - 29	4
30 - 39	6
40 - 49	8
50 or greater	10

(b) Shoreline Depth.

Length of lake L ________ Surface area of lake S ________

Mean width $s \div L = W$ ______________

Area - Capacity Curve f(ACC) ______________

$\Delta S = 1.44 \ (L + W - 1.44) = \Delta S$ ______________

Using f(ACC) curve obtain shoreline depth ΔZ ______________

To convert shoreline depth at 150 ft. (from area - capacity - elevation curves) to attribute number use equation:

$$AN = \frac{15}{\text{shoreline depth } (\Delta Z)}$$

AN varies from $10 \rightarrow 0.68$

Source of data ______________________________

4. Water Quality Characteristics

(a) Coliform organisms ________________________ (MPN/100 ml)
Conversion for attribute number is given in text.

(b) Turbidity ________________________
Conversion for attribute number is given in text.

(c) Temperature ________________________
Conversion for attribute number is given in text.

(d) Rooted Aquatic Plants - Percent of area infested ______

To convert percent of area infested and deviation of infestation to an attribute number, use conversion table below:

Percent of Area Infested	Attribute Number AN
35 or more	1
30	2
25	3
20	4
15	5
10	6
5	7
Intermittent, less than 10%	8
Intermittent, less than 5%	9
Rooted Aquatic Plants	10

(e) Algal Blooms Percent of area infested _________

To convert percent of area infested and deviation of infestation to an attribute number, use conversion table below:

Percent of Area Infested	Attribute Number AN
50 or more	1
40	2
30	3
20	4

Percent of Area Infested	Attribute Number AN
15	5
10	6
5	7
Intermittent, less than 10%	8
Intermittent, less than 5%	9
No Algal Bloom	

Source of data ______________________________

5. Wind and Waves

Maximum average wind V_w ____________________ (taken for summer months)

Source from nearest U.S. Weather Station ______________

Height of waves

Fetch F __________________

Velocity of Wind V_w __________________

$H_w = 0.17 \sqrt{V_w F} + 2.5 - (V_w F)^{\frac{1}{4}}$

Wave Height H_w __________________

Source of data ______________________________

6. Water Level Fluctuations

Year	Maximum Level June to August	Minimum Level June to August	Change in Level ΔZ
1971	____________	____________	__________
1970	____________	____________	__________
1969			
1968			
1967			

Average change in water level ΔZ_f ____________________

Source of data ______________________________

7. Inflow - Outflow Pattern

Volume at Capacity V ______________

Average annual runoff inflow R ____________

(either inflow or outflow as best applicable

ΔT Turnover Time V/R ____________________

Source of data __________________________

8. Public Useability

(a) Access Subparameter

Road Access

Number of roads leading to lake __________

Shoreline length ____________

R_A = Road Access/Shoreline length rate _____

Perimeter Road Availability

Percent of shoreline having perimeter road _____

Boat Launching and Docks

Number of boat launching sites and docks _______

Shore length ____________

R_D = Boat Launching/Shoreline length ratio _______

An example of how this subparameter might be rated is presented but no verification has been made on the high and low values.

Road Access

R_A greater than 0.3 $\frac{\text{roads accesses per}}{\text{mile of shore}}$ $\frac{1}{3}$		4 points
R_A = 0.3 - 0.1	"	2 points
R_A = less than 0.1	"	1 point

Perimeter Road Availability

100 - 70% of lake having perimeter road	3 points
70 - 30% of lake having perimeter road	2 points
less than 30% of lake having per. road	1 point
no perimeter road	0

Boat Launching and Docks

R_D = greater than 0.5 $\frac{\text{launching sites}}{\text{miles of shore}}$		3 points
R_D = 0.5 - 0.1	"	2 points
R_D = less than 0.1	"	0

(b) Facilities and Services Subparameter

Check each facility and/or service located within ¼ mile of shoreline . . . Allow ½ point for each checked item (10 points maximum)

FACILITIES & SERVICES

_____ Parking

_____ Toilet Facilities

_____ Drinking Water

_____ Swimming Area

_____ Beach

_____ Bath House, Dressing Rooms, showers, etc.

_____ Picnic Tables

_____ Fire Places

_____ Boat Dock and Ramp

_____ Campground (primitive)

_____ Campground (with utilities)

_____ Game Areas

_____ Availability of signs, maps and information

_____ Rental Services for boats, etc.

_____ Concessions selling recreational equipment, firewood, groceries, etc.

_____ Boat Service, Marinas

_____ Prepared Food Services, Restaurants

_____ Recreational Rules and Regulations and Enforcement of Same

(c) Land Ownership Pattern

____percent of land within ¼ mile of lake in public ownership.

100% - 80% of land resting in public ownership	10-8 pts.
80% - 30% of land resting in public ownership	7-4 pts.
30% - 10% of land resting in public ownership	4-1 pts.
no public ownership	0 pts.

The attribute number is the assigned number as taken from above array of possibilities and points. The spread is given to recognize that important that is the actual sites that are available for public use.

It is recognized that beach areas that are privately owned may severely limit the usefulness of a lake area for recreation.

_____ Cabins

_____ Refuse Containers

_____ Total Factor Profile Points (10 points maximum) = Attribute Number = AN

Inventoried by ____________________ Date __________

9. Recreational Use Potential (½ point given for each activity)

(a) Use Diversity

<u>Land Based</u>

____ Beach - Sun Bathing
____ Picnicking
____ Camping (primitive)(tent)
____ Camping (utilities provided)(motorized)
____ Game Areas (volleyball, tennis, golf, etc.)
____ Hunting
____ Sightseeing
____ Hiking
____ Cycling (motorized & bicycling)
____ Horseback Riding
____ Others

____ Swimming
____ Skin-Diving
____ Fishing
____ Power Boating
____ Pleasure Boating (rowboats, canoes, sail boats)
____ Water-Skiing
____ Waterfowl Hunting
____ Collecting Various Objects (driftwood, shells, etc.)
____ Water based games (other than swimming)
____ Others

Factor profile points are total AN = ______________

Comments: ____

____

____

(b) Use Compatability

The first suggested methodology follows:

Group 1: Evaluation to consider the following mix of activities: Hunting, picnicking, hiking, and beach activities carried on within ¼ mile of the shore.

1. If there is little evidence or chance for conflict between any of these activities at a given lake rate as 5 points
2. If there is moderate chance for conflict between two or more of the activities at the given lake rate as 4 points
3. If there is definite chance for conflict between two or more activities at the given lake rate as 2 points
4. If there is strong possibility for conflict between the activities at the given lake rate as 1 point

Group 2: Evaluation to consider the following mix of activities: Cycling, Horseback Riding, Hiking and Hunting carried on within ¼ mile of the shore.

1. If there is little evidence or chance for conflict between any of these activities at a given lake rate as 5 points
2. If there is moderate chance for conflict between two or more of the activities at the given lake rate as 4 points
3. If there is definite chance for conflict between two or more activities at the given lake rate as 2 points
4. If there is strong possibility for conflict between the activities at the given lake rate as 1 point

Group 3: Evaluation to consider the following mix of activities: Swimming, Power Boating Water Fowl Hunting, Canoeing, and Sailing.

1. If there is little evidence or chance for conflict between any of these activities at a given lake rate as

   5 points

2. If there is moderate chance for conflict between two or more of the activities at the given lake rate as

   4 points

3. If there is definite chance for conflict between two or more activities at the given lake rate as

   2 points

4. If there is strong possibility for conflict between the activities at the given lake rate as

   1 point

Group 4: Evaluation to consider the following mix of activities: Fishing, Water-Skiing, Swimming, and Skin Diving.

1. If there is little evidence or chance for conflict between any of these activities at a given lake rate as

   5 points

2. If there is moderate chance for conflict between two or more of the activities at the given lake rate as

   4 points

3. If there is definite chance for conflict between two or more activities at the given lake rate as

   2 points

4. If there is strong possibility for conflict between the activities at the given lake rate as

1 point

To obtain attribute number (AN) - add points and divide by 2.

The second suggested methodology for measuring use compatability is designed around the use of a matrix showing the most common recreation activities associated with lakes and reservoirs. A sample completion of the matrix has been presented to illustrate how such a rating might be constructed. This is shown in Table 5.

10. Aesthetic Setting. Factor Profile Point totaled for each of 5 sub-factors.

(a) Vegetation appearance (choose one item only - consider vegetation within 500 feet of shoreline)

Points	Description
1	Predominantly bare soil and/or rock
3	Predominantly grass
4	Low brush type vegetation under 3 ft. high
5	Tall brush type vegetation, 3-6 ft. high
7	Mixed deciduous trees
8	Coniferous trees
9	Mixed coniferous and deciduous trees
10	Mixed coniferous and deciduous trees with some shrubs, brush and grass

__________ Total Vegetation Points = AN

(b) Unique Backdrop Mountain backdrop or scenic view within 15 miles of water body except as noted below

Table 5

MATRIX FOR EVALUATING AN ATTRIBUTE NUMBER FOR THE VARIOUS RECREATION ACTIVITIES TO MEASURE USE COMPATIBILITY

		1	2	3	4	5	6	7	8	9	10	11	12
		Beach Activities Sunbathing, etc.	Picnicking	Camping	Hunting	Cycling	Horseback Riding	Swimming	Fishing	Power Boating	Canoeing, Sailing	Water-Skiing	Skin Diving
1.	Beach Activities Sunbathing, Collect.	1											
2.	Picnicking	0.9	1										
3.	Camping	0.9	0.9	1									
4.	Hunting	0.7	0.5	0.6	1								
5.	Cycling	0.9	0.9	0.7	0.7	1							
6.	Horseback Riding	0.9	0.9	0.6	0.5	0.8	1						
7.	Swimming	1	0.8	0.8	0.5	0.9	0.9	1					
8.	Fishing	0.5	0.5	0.9	0.7	0.6	0.8	0.5	1				
9.	Power Boating	0.6	0.8	0.9	0.7	0.9	0.8	0.1	0.4	1			
10.	Canoeing, Sailing	0.9	0.9	0.9	0.6	0.9	0.9	0.9	0.9	0.5	1		
11.	Water-Skiing	0.6	0.8	0.7	0.5	0.9	0.9	0.2	0.4	0.9	0.4	1	
12.	Skin Diving	0.9	0.9	0.9	0.7	0.9	0.9	0.9	0.7	0.5	0.9	0.5	1
	Maximum	12	11	10	9	8	7	6	5	4	3	2	1

The values are illustrative of possible numbers representing the amount of compatibility. Note, if it is the activity itself that you are rating, it rates a 1. To illustrate the idea, note Fishing (No. 8 on the left) and Swimming (No. 7 on top), a value of 0.5 is entered indicating considerable lack of compatibility of the recreation activities associated with lakes. If, in some case, there is definite compatibility between activities, a value of 1 would be entered in the square of the half-matrix.

Points	Description
1	Flat plains
2	Rolling hills, grass or brush covered
3	Rolling hills, forest covered
4	Item one, two, or three with mountains no rugged features, visible from body but greater than 15 miles distant
5	Item one, two, or three and mountains with peaks above timberline, rugged features and/or snow capped, visible from water body, but greater than 15 miles distant
7	Forested ridge and valley terrain
8	Forested mountains, no rugged features
9	Mountains with peaks above timberline, rugged features and/or snow capped
10	Combination of forested hills or ridges with mountains having rugged peaks above timber-line or snow covered.

Choose one for attribute number.

(c) Color Contrasts

(1) Soil and Rock (Choose one item only)

Points	Description
1	Local rock and soil uniform color
2	Some detectable color contrast
4	Considerable color contrast
5	Widespread color contrast, several bright, rich colors

(2) Color Contrast, Vegetation (Choose one item only)

Points	Description
1	No color contrast in vegetation
2	Some detectable color contrast such as varying shades of green or brown
4	Considerable vegetation color contrast
5	Brilliant color contrast, such as occurs during spring or fall seasons

__________ Total Color Contrast Points = AN
Soil and Rock Plus Vegetation

(d) Shoreline Appearance (Choose one item only)

Points	Description
0	Predominantly mud flats and/or excessive shoreline and beach development which detracts from view
2	Predominantly rocky shoreline
4	Predominantly marsh or swamp shoreline
6	Predominantly wave cut shoreline, such as forest or field abruptly ending with a short drop directly to water
8	Considerable sandy or beach type shoreline
10	Any variety of the above mentioned factors

Value selected equals attribute number = AN

(e) Atmospheric Quality (Choose one item only)

Points	Description
0	Strong disagreeable odors present, originating from water body or some nearby source such as a local industry.
2	Occasional presence of the above types of odor
5	Absence of all disagreeable odors
8	Refreshing or pleasant odors
10	Pleasing, fresh, invigorating mountain air, possibly a strong scent of pine or wild flowers

Value selected equals attribute number = AN

11. Wildlife Characteristics

Point Distribution for Species Quantity:

Rare Sighting	1 point
Occasional Sighting	2 points
Frequent Sighting	3 points

For each animal known to exist in the immediate vicinity of the water body, apply the appropriate point rating for the species quantity found above. The above point distribution rating applies to the approximate number of sightings of a particular animal that can be expected during one full day visit (24 hours) to the site. Note that some classifications (beaver, muskrat, etc.) are according to users point of view rather than biological classifications.

Points	Animal	Points	Birds
______	Mountain goat	______	Eagle
______	Mountain sheep	______	Hawk
______	Bear	______	Osprey
______	Deer	______	Owl
______	Elk	______	Pheasant
______	Moose	______	Chukar
______	Antelope	______	Grouse
______	Coyote	______	Quail
______	Cougar	______	Crane
______	Bobcat	______	Heron
______	Raccoon	______	Geese
______	Badger	______	Ducks
______	Ground dwelling rodents	______	Songbirds
______	Total animal points	______	Total bird points

Points	Profile Points
0	0
1- 5	2
6-10	4
11-15	6
16-25	8
25 & over	10

Same for animals or birds

Aquatic Life		Insect Pests (Choose only one)	
Points		Points	
_______	Beaver	0	Intolerable insect problem
_______	Mink	2	Serious insect problem
_______	Muskrat	5	Tolerable insect problem
_______	Otter	7	Occasional insect problem
_______	Reptiles	10	No insect problem
_______	Amphibians		
_______	Crustaceans		
_______	Fish	_____	Insect Pest Points
_______	TOTAL AQUATIC LIFE POINTS	_____	TOTAL INSECT PEST POINTS

TOTAL WILDLIFE CHARACTERISTICS POINTS _____________

Points	Profile Points
0	0
1- 5	2
6-10	3
11-15	6
16-20	8
20-24	10

Evaluated by ______________________________ Date __________

12. Degree of Development

(a) Domestic development - within ½ mile of shoreline

Points	
0	Residential homes, farms, and recreational home development
2- 4	Any two of above mentioned home developments
4- 8	Any one of above mentioned home developments
8-10	No home development present

(b) <u>Commercial development</u> - numbers of kinds of retail outlets within ½ mile of shoreline providing goods and services <u>not</u> usually associated with recreation and/or tourism. Check items found.

___ Gas stations & garages
___ Drug Store
___ Food Store
___ Clothing Store
___ Hardward Store
___ Banking
___ Motels & Hotels
___ Furniture & Appliances

<u>Points</u>

0	If five or more items checked
5	If one to five items checked
10	If no items are checked
___	Total Points Can be Weighted

(c) <u>Industrial development</u> - Consideration to be given development located within 1 mile of shoreline

<u>Points</u>

0	Presence of farm related industry such as canning or packing houses, <u>and</u> some type of extractive industry such as lumber mills or mines, <u>and</u> fabrication industries such as automotive plants, chemical plants, or power plants, <u>and</u> some type of heavy industry such as iron, steel or aluminum plants.
1	Presence of any three of the above mentioned industries
2	Presence of any two of the above mentioned industries.
3	Presence of any one of the above mentioned industries.
10	No industry present
___	Total Points = AN

13. Proximity to Urban Centers - Population within $2\frac{1}{2}$ hours driving time of lake ______________

$$AN = \frac{\text{population}}{30,000} \quad \text{for Idaho}$$

Source of data ________________________________

14. Remoteness

Distance to nearest state highway ________ miles

Distance to prinicpal through highway ____ miles

Remoteness distance = sum of above _______ miles

Source of data ________________________________

15. Alternate Lake availability

Area of given lake - ____________ acres

Total acreage of lakes or reservoirs within 50 miles ___________ acres

Percent given lake is to total acreage ___________ P_{50}

Total acreage of lakes or reservoirs within 100 miles ___________ acres

Percent given lake is of total acreage ___________ P_{100}

For attribute number the following equation should be used:

$$AN = 100 - \% \text{ of total } (P_{50} \text{ or } P_{100}) \div 10$$

Source of data ________________________________

16. Site Durability and Resiliency

(a) Vegetative Resiliency

Average annual rainfall ___________ inches

length of growing season ___________ days duration

Source of data ________________________________

See text for method of computing attribute number, AN

(b) Land Durability
(all ratings for area within 200 ft. of shoreline)

___% of area as stable (solid rock & beach) 10 points

___% of area as slightly unstable 8 points

___% of area as moderately unstable 5 points

___% of area as highly unstable 2 points

WEIGHTED AVERAGE = AN =

$$\frac{\Sigma(\%\text{ of area each category})(\text{points for category})}{100}$$

AN = ____________

Evaluated by:

____ Date ______________