



Application of the vegetation inventory to recreation site planning
by Thomas Patrick Eggersperger

A thesis submitted in partial fulfillment of the requirements for the degree of MASTER OF SCIENCE
in Agronomy

Montana State University

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Abstract:

Recognizing that recreation site planning schemes have failed to incorporate a vegetation inventory and realizing the need for recreation sites which maintain a natural appearance with time, research was conducted to ascertain what value the vegetation inventory could be to recreation site planners.

The endemic vegetation of a potential recreation site was inventoried and selected species were subjectively rated for their contribution to selected recreation activities. Partitioned units within the site were then evaluated for their compatibility with recreation activities. This was done using the vegetation inventory and an inventory of environmental resources. Plant species with indicator value for recreation use compatibility were identified and utilized to predict, employing a computer program, which areas within the site were compatible with declared recreation activities. It was concluded that certain vegetative species show preference for specific biophysical resources and that these species, as indicator species, can be used to select areas of recreation use compatibility.

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TO RECREATION SITE PLANNING

by

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TABLE OF CONTENTS

	Page
VITA	ii
ACKNOWLEDGMENTS	iii
TABLE OF CONTENTS	iv
LIST OF TABLES	v
LIST OF FIGURES	vii
ABSTRACT	ix
INTRODUCTION	1
LITERATURE REVIEW	3
MATERIALS AND METHODS	14
RESULTS AND DISCUSSION	46
<u>Inventory Discussion</u>	46
<u>Cell Evaluation Methodologies</u>	51
<u>Selection of Indicator Species</u>	59
<u>Application of Research</u>	69
CONCLUSIONS	72
APPENDIX I	74
APPENDIX II	76
APPENDIX III	80
LITERATURE CITED	82

LIST OF TABLES

	Page
Table 1. Characteristics of three homogeneous zones established within the study area.	22
Table 2. Tolerance levels of four environmental factors for six recreational activities.	24
Table 3. Criteria used to evaluate a species for its contribution to recreational activities with respect to the species display value and traffic tolerability.	26
Table 4. Table of values for contribution individual species made to camping as a recreational activity.	27
Table 5. Table of values assigned for contribution individual species made to picnicking as a recreational activity.	28
Table 6. Table of values assigned for contribution individual species made as a resource in establishing trails.	29
Table 7. Table of values assigned for contribution individual species made as a resource in establishing play areas.	30
Table 8. Analysis of biophysical characteristics of zones established within Hyalite Canyon Study Area.	48
Table 9. Occurrences (O) and frequencies of occurrence (F) data (%) for commonly occurring species within zones of Hyalite Canyon study area.	49
Table 10. Relative suitabilities of three zones considering biophysical factors for three recreation activities camping, picnicking and trails.	52

LIST OF TABLES CONTINUED

	Page
Table 11. Relative suitabilities of vegetational conditions for recreation activities	56
Table 12. Recreation activity compatibility averages and cell threshold values for three zones of Hyalite Canyon Study Area.	58
Table 13. Indicator species chosen for three zones.	60
Table 14. Results of interzone comparisons of species occurring uniformly within zones of Hyalite Canyon Study Area.	61
Table 15. Abbreviated table of selected interzone comparisons for indicator species.	63
Table 16. Suggested biophysical preferences for indicator species.	70

LIST OF FIGURES

	Page
Figure 1. Location of study area in Hyalite Canyon near Bozeman, Montana used in evaluating the application of the vegetation inventory to outdoor recreation site planning. (From USDA FS series, Gallatin Ranger District, Montana. 1971)	15
Figure 2. Representation of grid system used to partition study area. (Scale 1 cm = 50 m)	18
Figure 3. Blank cell map utilized to delineate concentrated distributions of species within a cell. (Scale 1 cm = 50 m)	20
Figure 4. Extent and location of three homogeneous zones established within the study area. (Scale 1 cm = 5 m)	23
Figure 5. Flow chart showing procedure for determining individual species rating for each recreation activity within each cell.	31
Figure 6. Flow chart for determining relative recreation activity compatibility potential for each cell.	34
Figure 7. Distribution map of <u>Arnica cordifolia</u> . (Scale 1 cm = 5 m)	37
Figure 8. Distribution map of <u>Lupinus sericeus</u> . (Scale 1 cm = 5 m)	38
Figure 9. Distribution map of <u>Vaccinium scoparium</u> . (Scale 1 cm = 5 m)	39
Figure 10. Distribution map of <u>Rudbeckia occidentalis</u> . (Scale 1 cm = 5 m)	40
Figure 11. Distribution of <u>Trifolium sp.</u> (Scale 1 cm = 5 m)	41
Figure 12. Distribution map of <u>Potentilla gracilis</u> . (Scale 1 cm = 5 m)	42

LIST OF FIGURES CONTINUED

	Page
Figure 13. Distribution map of <u>Geranium richardsonii</u> . (Scale 1 cm = 5 m)	43
Figure 14. Distribution map of <u>Poa pratensis</u> . (Scale 1 cm = 5 m)	44
Figure 15. Distribution map of <u>Delphinium occidentale</u> . (Scale 1 cm = 5 m)	45
Figure 16. Regression line showing relationship of indicator species score vs cell averages for camping in Zone I.	65
Figure 17. Regression line showing relationship of indicator species score vs cell averages for picnicking in Zone II.	66
Figure 18. Regression line showing relationship of indicator species score vs cell averages for establishment of trails in Zone III.	67
Figure 19. Computer output display indicating which cells of Hyalite Canyon Study Area were compatible with three recreation activities camping (C), picnicking (P) or trails (T).	68

ABSTRACT

Recognizing that recreation site planning schemes have failed to incorporate a vegetation inventory and realizing the need for recreation sites which maintain a natural appearance with time, research was conducted to ascertain what value the vegetation inventory could be to recreation site planners.

The endemic vegetation of a potential recreation site was inventoried and selected species were subjectively rated for their contribution to selected recreation activities. Partitioned units within the site were then evaluated for their compatibility with recreation activities. This was done using the vegetation inventory and an inventory of environmental resources. Plant species with indicator value for recreation use compatibility were identified and utilized to predict, employing a computer program, which areas within the site were compatible with declared recreation activities. It was concluded that certain vegetative species show preference for specific biophysical resources and that these species, as indicator species, can be used to select areas of recreation use compatibility.

INTRODUCTION

Of the many recreation areas available to recreationists, few have been able to foster a pristine appearance and escape the telltale signs of overuse manifested in vegetative reductions and degradation of physical resources. Realizing that it is nearly impossible to maintain an unspoiled environment, it is questioned what can be done to improve recreation areas through either rehabilitation or improved planning techniques. It is obvious that the better solution lies with improved planning techniques.

In researching planning techniques it became apparent that most schemes failed to incorporate the vegetation inventory in their methodology. Considering the initial sign of recreation site overuse is a vegetative reduction, it appears that a site planning scheme utilizing the vegetation inventory in a manner which selected site compatible recreation use areas, would yield a more natural appearing site with normal recreation use.

This research attempted to answer two questions. First can site durability predictions be made utilizing a vegetation inventory and rating species for their inherent compatibility with various recreation activities. Secondly, can indicator species be identified which rapidly indicate site compatible recreation use areas.

The research was conducted within an area of Hyalite Canyon, south of Bozeman, Montana, which had potential for development as a recreation site. By conducting a vegetation inventory and evaluating the vegetation

and site resources, it was hoped to develop an additional tool for recreation site planners.

LITERATURE REVIEW

The importance of outdoor recreation has reached a level where its documentation is no longer necessary, while research of the recreation site and recreation site users has just begun to be reported. Two approaches were observed in outdoor recreation research, 1) examination of interactions between recreationists and 2) examination of the effects recreationists have on the biophysical environment of the recreation site.

Lucas and Stankey (30), in their survey of the social carrying capacity for backcountry recreation found that recreationists desired solitude and valued campground privacy highly. Clark (8), observing the modern camping culture revealed that campers valued the emotional satisfaction of solitude and tranquility and gaining an awareness of unspoiled beauty. As part of the Gallatin Canyon Study, aimed at evaluating the impacts of large recreational developments upon semi-primitive environments, researchers Dick, Williams, Ballas and Gilchrist (13) typed campers as to their preferences and attitudes as an aid in management decisions. They noted the occurrence of recreation succession where repetitive site users migrate to secluded more primitive sites as the population of new campers to an area increased.

Recreationist interaction research provides a profile of site users, inherently obvious observations that are only conjectural until proven valid. Understanding the users of a recreation site is important to providing a recreation site that will best serve their needs.

Recreation research on the interaction between recreationists and the recreation site considers the impact of recreationists on the site resources. Recreational use of forest and wildlands, according to James (23), was an estimated 450 million visitor days in 1972. When man returns to the same site repeatedly, he has a cumulative impact on the soils and vegetation of a recreation site. It is on these two elements that man's activities exert the most effect. Researchers have studied this effect, and how it can be diminished, by either restoration of the natural amenities of a site or their preservation gained through utilizing effective site planning and design schemes. The importance of research concerning the impact of the recreation site user is cited by many researchers in rationalizing the need for research. Burden and Randerson (6), working in England, emphasized the paucity of studies documenting the precise effects of recreation on the vegetation and soils of semi-natural areas. William Ruckelshaus (39), in an address to the Society of American Foresters, emphasized the shift in what is fashionable in recreation, the return to outdoor activities, and how this added pressure posed a burden on our forests. We should be prepared to deal with aerial contamination, littering, trampling of ground cover, erosion of soils and the alteration of entire bio-communities.

Considering the effects of use on the various elements of the recreation site, LaPage (25) gave one of the first accounts of increased

soil compaction which accompanied prolonged use of a site. Dotzenko (14) verified this increase in soil compaction and also noted decreased water infiltration rates, increased runoff and increased soil erosion. Researching established campgrounds in Rocky Mountain National Park, and using soil bulk density as a compaction indicator, Dotzenko found that soils from a heavily used site had a 55.3% greater bulk density than soils from lightly used sites. The compaction effect of intensive use was most pronounced in the 0-2 inch soil layer.

Settergren and Cole (40) recorded decreases in both the moisture field capacity of the soil and in the percent water present at the wilting point of the soil. They found this to be characteristic of soils of heavily used sites. A consequence of water erosion removing the finer particles of the soil matrix was an accumulation of rock at the surface of the site.

Lutz (31), in one of the first reported examinations of soil alteration on picnic grounds in public forest parks, observed that the most intensive changes occur on picnic and campground sites and that wind was an important factor, exhibiting a tendency to sort finer particles from larger sand sized particles.

The value of knowing the impact of recreational use on the soils of a site is important in considering engineering capabilities of selected soils for varying types of recreational use. Soil compaction also has an effect on the vegetation of the site, being the rooting medium for

plants. A compacted soil restricts root growth. Root impedance can be viewed as an indirect consequence, resulting from soil compaction occurring after a loss of vegetative ground cover. The quantitative loss in vegetation is the common direct consequence of recreation use pressure.

The impact of recreationists on the natural vegetation of the site can be measured in two ways. First it can be gauged as a direct loss in percentage of original vegetation or it can be examined as changes in the nature of the vegetation.

Bates (3) examined the vegetation of paths and sidewalks and observed a repeated continuum of Poa pratensis, Lolium perenne and Trifolium repens perpendicular to the path. P. pratensis exhibited the most resistance to trampling, which Bates attributed to the morphology and growth characteristics of the species. The conduplicate stem and folded leaf presented a flatter surface to the crushing action of the foot. Bates' research is one of few to relate physical characteristics of a plant to the plant's ability to withstand or succumb to recreation traffic.

Dale (11), examining the vegetation associated with trails in the Madison Range in Montana, found a vegetational gradient perpendicular to the trail. He rated several species on the basis of whether trail use caused no change, an increase, a decrease, or an increase and a decrease in species presence in three habitat types. Dale made observations as

to why a particular species reacted as it did to trail use.

Burden and Randerson (6) looked at three different and separate types of trampling pressure. Considering the short term effect and looking at areas of light, medium and heavy trampling pressure, the researchers arrived at an equation by regression analysis for predicting the loss of vegetation at a chosen intensity of trampling pressure. The equation employed variables for the intensity of trampling pressure, the degree of soil compaction and a grazing factor along with two regression coefficients. The resulting value was expressed as dry weight of a particular species or plant fraction.

Bogucki (4) studied the impact of short term camping on ground level vegetation. Preceding activity there was a prevalence of moss/lichen and blueberry associations. Two days later, following the use of the site for a group camp, there was a decline in moss/lichen and blueberry occurrences and an increase in the amount of bareground and bedrock exposed.

In 1963 LaPage (26) began a continuing study to record changes in the vegetation on 17 units of a newly established campground in the Allegheny National Forest. Following the first year of use the average loss of plant cover for all camp sites measured 45 percent. A correlation between camper-days of use and loss in vegetation cover was attempted and it was found that 200 camper days of use was a feasible maximum to minimize native cover loss. LaPage did not consider the

number of camper-days of use a very good tool to estimate vegetative cover loss. In noting the relative occurrences of several species over three years of the study, LaPage gave a ranking of tolerance to trampling levels for several plant species. Two conclusions drawn by LaPage were:

- (1) An initial and inevitable heavy loss of ground cover follows the onset of camping use and the extent of the loss is strongly related to the use intensity the first year.
- (2) Plant species composition of original cover undergoes a gradual rearrangement in which more resistance and drought tolerant species become increasingly abundant.

In a simulated trampling study using a corrugated roller passed over selected plots representing various forest and environmental conditions, Cieslinski and Wagar (7) related surviving vegetation to soil and topographic features by multiple regression. Resulting equations explained 64 percent of the variability in amounts of surviving vegetation, and a positive relationship was observed between the amount of clay in the soil and the amount of surviving vegetation.

Similar research with recreationist effects on ground level and overstory vegetation was conducted by Echelberger (15), Frissell (16), and Wagar (43).

The relevancy of research on the ground cover vegetation of outdoor recreation sites rests with how the research results can be applied to ameliorate undesirable situations. This can be reflected in management

techniques or planning guidelines.

Several rehabilitative procedures have been suggested as a means of site improvement. Appel (2) advocated spreading sawdust and rototilling as a method to improve soil physical properties. This treatment would increase the water holding capacity, lessen the bulk density and increase infiltration rates.

Herrington and Beardsley (21) reported the results of cultural treatments of watering, fertilizing and seeding as a means of improving the ground cover vegetation. With the addition of all three treatments the rehabilitation of the campground was significantly hastened.

Wagar and Beardsley (44) studied the effects of cultural treatments on the ground cover vegetation. Cultural treatments, while being costly, also present an inconvenience to campers and result in an addition to the site of plant species not part of the native floral array.

Hendee and Lucas (20) compared the merits and disadvantages of restricting use of wilderness sites by restricting use to permit only. This philosophy could be applied to forest recreation sites with the result being massive regulation of campers on existing campgrounds and accelerated efforts to establish new campgrounds which would accommodate all recreationists desiring to participate in the camping experience.

A practical method to alleviate the problem of recreation site deterioration lies with better planning and design of facilities to

include elements which will lessen the effect of site users on the natural resources of the site. Orr (35) recognized the importance of planning to the development of a successful campground. He stated that the failure of the public to use a site can be indicative of the developer not knowing the market of users. The physical failure of a site is usually the result of a lack of knowledge about the site.

Lime (28) suggested the incorporation of resistant features into the site design in the form of tent pads and barriers to direct and channel the flow of pedestrian and vehicular traffic.

The implementation of natural resource inventories in site planning has been primarily concerned with utilizing soil inventories or soil surveys. Partain (36) outlined the benefits of a properly interpreted soil map in selecting and planning sites for camping activities.

Stevens (41) discussed the types of interpretations that are possible from an accurate soil survey of the proposed site. He also outlined five areas of soils interpretation research that are needed to maximize the value of soil survey information to the site planner.

James (23) stated that a knowledge of soils and soil characteristics was the most essential element in selection of potential areas for recreation site development. He also developed a puzzle analogy for effective site utilization. Knowledge of soils, the site design, vegetation management and maintenance techniques comprise the pieces to the puzzle, with the border including the control, regulation,

education and interpretation of the site to users.

In researching the application of the vegetation inventory to recreation site planning, it was apparent that there exists a definite lack of research involving its application.

Lindsay (29) discussed using the information that could be gleaned from aerial photos as a site evaluation tool. Using overstory densities as site selectors, possible sites can be inventoried.

Pfister (37) suggested management implications of forest ecosystems according to the habitat type of the site, concluding that management implications of habitat types for recreation have little effective value except as an aid in site selection by the climatic and ecologic conditions suggested by the habitat type.

Wilde and Leaf (46) reported that ground cover vegetation serves as an indicator of site conditions and can often reveal concealed heterogeneity of selected areas. The composition of soil profiles is closely related with both qualitative and quantitative aspects of ground cover vegetation. Plants possessing indicator value have a pronounced tendency to attain maximum density and frequency of distribution on certain soil types.

Layser (27) stated that the ecological classification based on vegetation offers a strong management tool, but little use has been made of indicator plants or plant associations.

McHarg (33) asks us to assess which lands are intrinsically suitable for active and passive recreation, and to view the sustainance of native vegetation as a valuable public resource.

The best application of natural resource inventories encountered was the use of basic soil conditions to predict ground cover persistence. Orr (35) developed a formula for determining a ground cover index by manipulating variables of the potential pedestrian impact, the depth of soil sub surface, the percent of the surface covered by rock, the amount of silt in the substratum, the percent slope and the depth to the water table in inches. The resulting value is a prediction of the amount of site deterioration. Expecting significant soil movement with less than 75 percent of the original ground cover present, the critical value derived from the equation was set at 75.

MacKay (32), in a study of old and new campgrounds on a particular forest soil, stated predictions could be made for which area will stand up best under active recreation based on the ratio of sand/(silt + clay). A low ratio conveyed more desirable conditions than a high ratio.

Wagar (42) developed a simple slide rule method of predicting recreation tolerance which is usable if data is available for the amount of vegetation that will grow on the site in the absence of trampling, the percent cover by grasses and woody vines, and the percent sunlight to the site blocked by shade casting objects. Wagar assumed a constant level of trampling which is unlikely given the various types of

recreation activities that could occur on a recreation site.

MATERIALS AND METHODS

The study area selected to evaluate the potential of applying the vegetation inventory to recreation site planning was located in Hyalite Canyon south of Bozeman, Montana. The legal description placed it partially in Sections 32 and 33 of Township 3S, Range 6E and partially in Sections four and five of Township 4S, Range 6E. Geographically the area was east of Langohr's Campground and Hyalite Creek. Access to the area is gained by a Forest Service road paralleling the east side of Hyalite Canyon and by an abandoned logging road which leaves the Hyalite Canyon road and leads into the study area, traversing its length from south to north (Figure 1). Part of a larger area being utilized for summer livestock grazing, the study area was bordered on the east by the foot slopes of the drainage divide between Hyalite Creek and Bozeman Creek, on the north by Buckskin Creek, on the west by a lateral moraine remnant of a Hyalite Canyon glacier and on the south by the point at which the access logging road turns from running perpendicular to Hyalite Creek and begins to parallel the Creek.

Essentially level on the southern end, the area was dissected on the northern end by previous erosional cycles. Elevations ranged from 6370 feet at the northern end to 6550 feet at the northeast corner. Slopes varied from level to nearly 30 percent and a full complement of aspects was found. The general area was logged during the preceding 50 years and showed evidence of wildfire. The vegetational composition included gramineous species, annual and perennial forbs, woody shrubs,

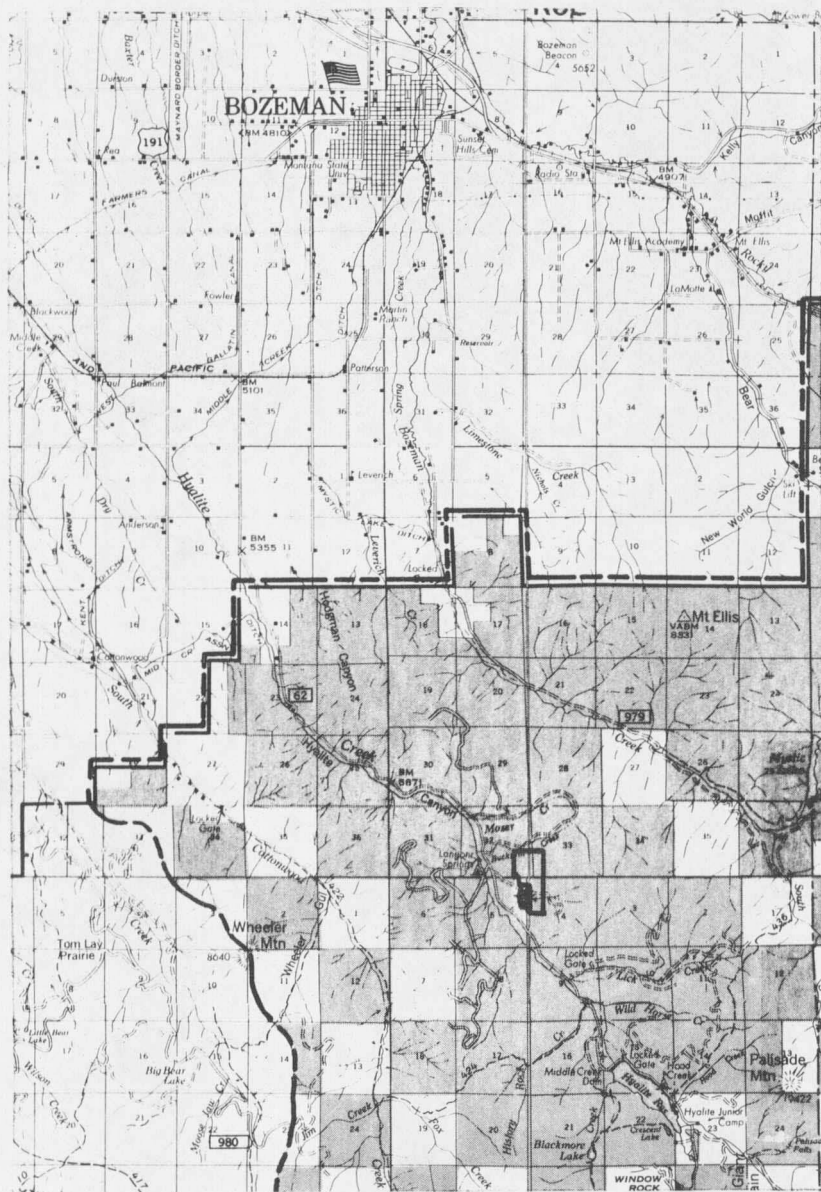


Figure 1. Location of study area in Hyalite Canyon near Bozeman, Montana, used in evaluating the application of the vegetation inventory to outdoor recreation site planning. (From USDA FS series, Gallatin Ranger District, Montana. 1971.)

deciduous trees and evergreens. Soils consisted of deep silty clays with thick silt loam surfaces and inclusions of deep gravelly clay loams with gravelly loamy surfaces and imperfectly drained clayey soils, Alvis (1). A comprehensive soil classification has not been completed for the area. Geologically the study area is underlain by layers of tilted bedrock shale and limestone, Weber (45).

First excursions into the study area were made in early July of 1975 to examine potential areas for recreation activities and to collect frequently and uniquely occurring flora for identification. Identification of species was done by the investigator using appropriate floral identification tests for the area, Booth (5), Craighead (9), and Harrington (18). The identified floral array included 70 shrub, forb, and gramineous species and six tree species (Appendix 1). For brevity, throughout the project the species were coded by combining the first letters of the generic and specific names to form an acronym for each plant species. A list of acronyms and corresponding plant species is found in Appendix 1. The area exhibited a varied array of flora including the saprophytic orchid, Corallorhiza maculata, common mountain plants Geranium viscosissimum and Spiraea betulifolia, water associated plants Juncus sp. and indicators of man's intrusion - Trifolium sp. and Cirsium arvense. The area exhibited a varied ecology of plant communities from which to predicate site planning schemes.

The area was inaccessible only in the spring when the Hyalite road was closed to public travel due to mud. During the fall and winter the area was open for recreational use and was a popular area for cross country skiers and winter camping. Potentially the area offered year around recreation opportunities.

The area was scheduled for timber removal due to the presence of disease among the trees and consequently the area was not designated for use as a recreation site.

To facilitate the vegetation inventory, the study area was partitioned into square cells of 2500 square meters. This was done by establishing a baseline with steel fence posts 50 meters apart, traversing from south to north. Cells were laid out using a compass and two 50 meter cloth surveyor tapes, working east and west of the baseline and back sighting when possible. Cell corners were established with fluorescent flagging attached to lath stakes driven into the ground. Each cell was identified at its southwest corner with a designation on the lath stake for the row and column in which the cell existed. Rows and columns were identified with a number and letter for the relative position of the row or column north and south or east and west of a point of origin. 115 cells were located covering a total area of 28.75 hectares (Figure 2).

The vegetation inventory was conducted during July and August and involved recording occurrence and frequency data for 39 species on

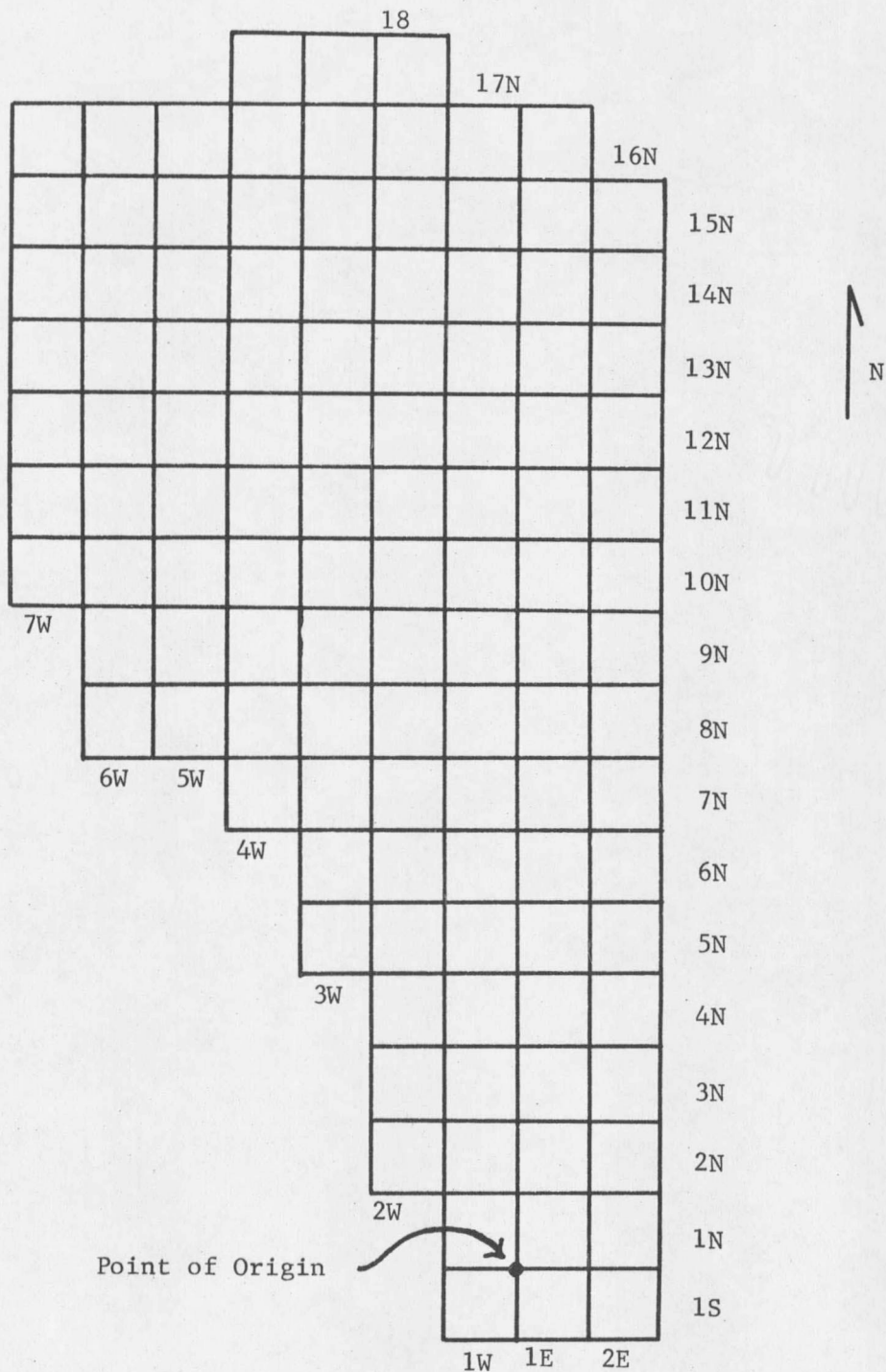
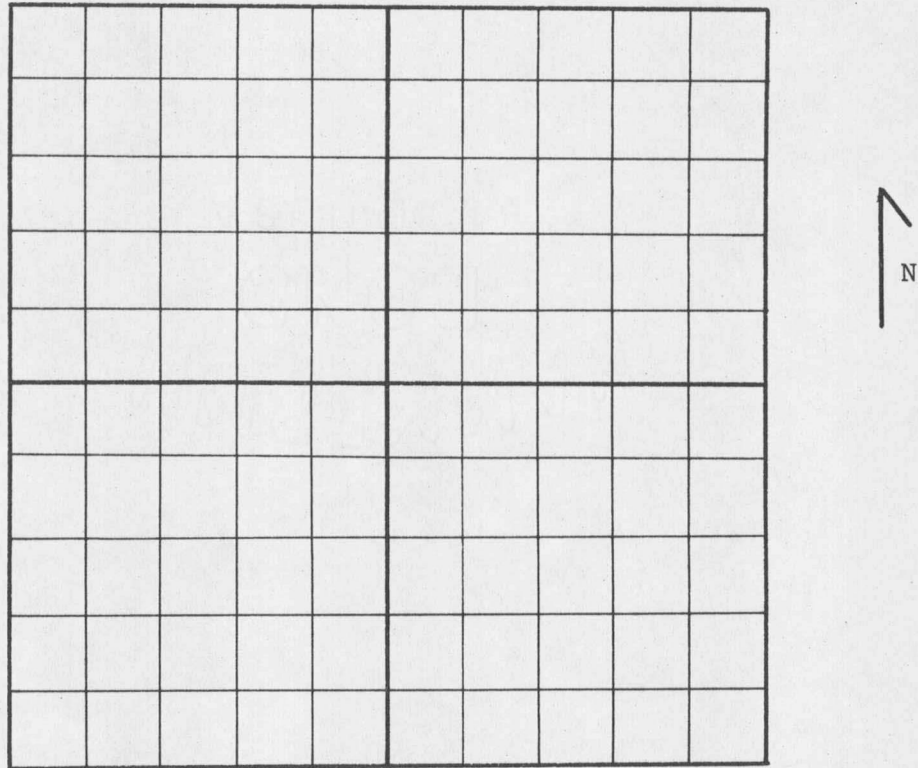


Figure 2. Representation of grid system used to partition the study area. (Scale 1 cm = 50 m)

six different inventory forms. Each inventory form required a separate inventory effort and involved a different set of species (Appendix II).

A pattern was followed in inventorying. Each cell was visually surveyed as a walk was made through the cell in a "W" pattern. After assessing the relative occurrences of species on the inventory form, data was recorded. To assure uniformity of data recording previously inventoried species were often rechecked. Data was recorded as uniform occurrence throughout the cell, restricted occurrence within the cell or presence within the cell. Species recorded as exhibiting restricted occurrence were delineated according to their distribution on a blank cell map (Figure 3). Delineations were also made for a concentrated distribution of a species also occurring otherwise uniformly throughout the cell. For the various tree species, observations were made for successful reproduction, percent canopy, vigor level, and any disease indications. An estimation of the percent coverage exhibited by gramineous species was recorded in addition to notes on topographic features and indications of previous logging activity.

With the accumulated inventory data transferred to representative grid maps of the area, homogeneous areas of species composition with similar slope and aspect conditions were selected for sampling of soil characteristics. Soil samples were taken from the top two inches at several locations within the homogeneous areas. Unique areas were also sampled. Many areas were hand textured in the field and several samples



DATE:

CELL NO. _____ SPECIES _____

Figure 3. Blank cell map utilized to delineate concentrated distributions of species within a cell. (Scale 1 cm = 5 m)

were returned to the lab, dried and analyzed for soil texture and soil reaction. Soil texture was determined by mechanical analysis according to the Bouyoucos method. Soil reaction was determined by the potentiometric method. Soil texture is a significant site characteristic to recreation site planners and soil reaction data could be used to help identify homogeneous areas.

With the inclusion of soils data, three zones were identified which were homogeneous with respect to soil texture, soil reaction, slope, aspect, average number of species per cell, average percent canopy per cell and species composition (Table 1, Figure 4).

As a prerequisite to any site plan it is necessary to identify recreational activities which might occur on the site. Six activities were chosen for this site: camping, picnicking, trails, play areas, natural areas and developed areas. Excluding developed areas it was assumed that each activity should be compatible with existing site resources so as to inflict minimal damage to the natural environment at expected use levels. Developed areas implied alteration of the environment to suit specific facility objectives.

For each activity optimum, moderate and minimum tolerance levels were declared for four environmental factors: slope, aspect, soil texture and percent overstory canopy. Tolerance levels for slope and texture were derived from established planning guidelines, Montgomery (34), Table 2). Levels for percent overstory canopy and aspect were

Table 1. Characteristics of three homogeneous zones established within the study area.

Zone I

Soil pH	5.0 - 5.5
Soil Texture	Silt Loam
Percent Canopy	50
No. of Species	12
Slope	5%
Aspect	East

Zone II

Soil pH	5.5 - 6.5
Soil Texture	Silty Clay Loam
Percent Canopy	42
No. of Species	20
Slope	12%
Aspect	West

Zone III

Soil pH	5.5 - 6.5
Soil Texture	Silty Clay Loam
Percent Canopy	12
No. of Species	16
Slope	5%
Aspect	West

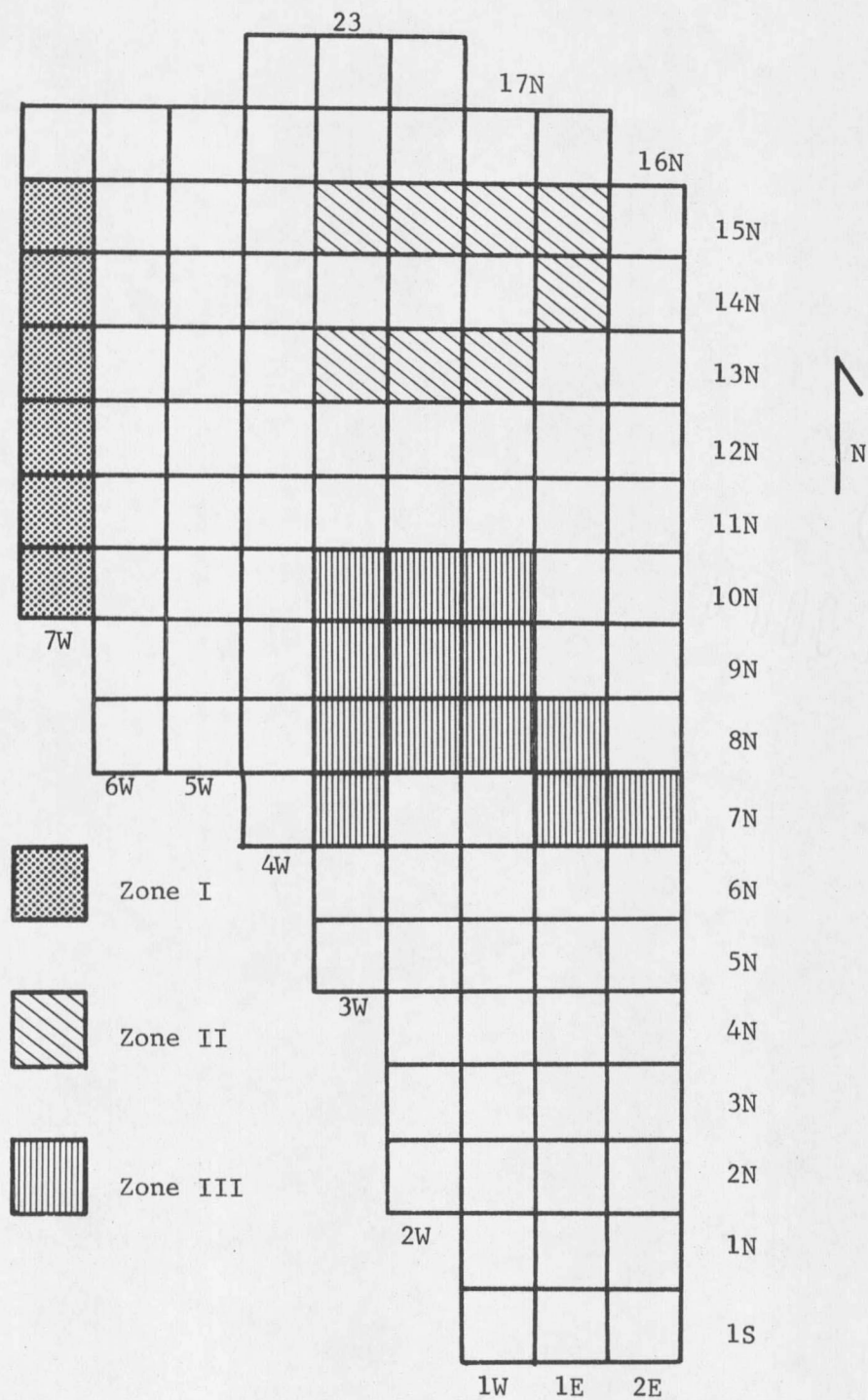


Figure 4. Extent and location of three homogeneous zones established within the study area. (Scale 1 cm = 50 m)

Table 2. Tolerance levels of four environmental factors for six recreational activities.

Activity	Rating ¹	Soil Texture ²	Slope ²	Aspect	Percent Canopy
Camping	Opt	SL, L, LS	0-8 %	E, W	30-50%
	Mod	CL, SCL, SiCL, SiL	8-15%	S	20-30, 50-60%
	Min	SC, SiC	15+%	N	0-20, 60-100%
Picnicking	Opt	SL, L, LS	0-8 %	S, W	10-40%
	Mod	CL, SCL, SiCL, SiL	8-15%	E	40-60%
	Min	SC, SiC	15+%	N	0-10; 60-100%
Trails	Opt	SL, L, LS	0-15%	S, W	
	Mod	CL, SCL, SiCL, SiL, SC, LS	15-25%	E	None
	Min	SiC, C, S	25+%	N	
Play Areas	Opt	SL, L, LS	0-2 %	S, W	0-10%
	Mod	CL, SCL, SiCL, SiL, SC, LS	2-8 %	E	
	Min	SC, SiC, C, S, LS	8+ %	N	10-100%
Natural Areas	Opt				
	Mod	None	None	None	None
	Min				
Development	Opt	SL, L, LS	0-8 %	E, S, W	0-10%
	Mod	SCL, CL, SiCL, SiL, LS	8-15%		10-20%
	Min	SC, C, SiC, S	15+%	N	20-100%

¹ Opt = Optimum; Mod = Moderate; Min = Minimum

² Montgomery, 1966; S = Sand or Sandy, L = Loam or Lomay, C = Clay, Si = Silt or Silty

subjectively assigned. These four factors form a basis for site suitability decisions from the physical resource aspect.

In evaluating a zone from the physical resource aspect, weighting factors were assigned according to how the site characteristics fit the tolerance levels assigned for the different characteristics. Optimum resource levels were assigned a factor of three, moderate levels a factor of two and minimum levels a factor of one. The four resource factor weights were multiplied together to yield a number which rated a zone for its relative suitability for various recreation activities.

A methodology was developed to evaluate recreation site potential considering the endemic vegetation of the site and the contribution the various plant species made to recreation activities. This evaluation scheme was the basis for site compatibility predictions utilizing selected indicator species. It was observed by the researcher that the vegetative contribution is significant: 1) directly by the visual impact of the species and 2) indirectly by the species ability to withstand recreation use. A methodology evolved for classifying a species for each of these contributions categorized as the species display and the species traffic tolerability respectively. The display category was subdivided into three subcategories - foliar, floral and plant form. Subcategories for trampling tolerability were: 1) the species ability to withstand physical trampling, 2) the after trampling esthetic

Table 3. Criteria used to evaluate a species for its contribution to recreational activities with respect to the species display value and traffic tolerability.

SPECIES SUITABILITY CRITERIA

CATEGORY:	DISPLAY	TRAFFIC TOLERABILITY
SUBCATEGORY:	Foliage	Physical
	Floral Display	Esthetic
	Form	Renewability
RATING FACTORS:	Height	Plant Form
	Leaf Size	Root Characteristics
	Leaf Position	Leaf Form
	Flower Size	Stem Features
	Color	Reproduction Mode
		Species Literature

Table 4. Table of values for contribution individual species made to camping as a recreational activity.

ACTIVITY: CAMPING

Species Acronym	DISPLAY ¹				TRAFFIC TOLERABILITY ²			
	Fol	Flo	For	Total	Phy	Est	Ren	Total
Acru	3	3	4	10	3	1	4	8
Alce	4	3	3	10	3	2	4	9
Arco	4	5	1	10	2	1	4	7
Artr	4	2	3	9	4	3	4	11
Basa	3	4	2	9	2	2	4	8
Bere	4	4	4	12	2	2	4	8
Caru	5	5	5	15	5	5	5	15
Cage	5	5	5	15	5	5	5	15
Cami	5	5	3	13	1	1	3	5
Ciar	2	3	2	7	3	2	5	10
Clco	3	5	2	10	1	1	2	4
Clov	3	2	2	7	5	5	5	15
Coli	3	4	2	9	2	3	3	8
Deoc	2	4	2	8	1	1	5	7
Feid	5	5	5	15	5	5	5	15
Geri	3	4	2	9	2	2	4	8
Gevi	3	4	2	9	2	2	4	8
Haf1	2	3	1	6	1	1	4	6
Hesu	3	4	3	10	2	1	5	8
Henu	3	5	2	10	1	1	1	3
Irm1	5	5	5	15	2	2	5	9
Juco	4	2	5	11	4	3	4	11
Libo	5	5	5	15	2	1	4	7
Luse	3	4	4	11	2	1	4	7
Mebu	5	5	5	15	5	5	5	15
Meci	2	3	2	7	3	2	4	10
Popr	5	5	5	15	5	5	5	15
Pogr	2	4	2	8	3	2	5	10
Rimo	2	2	4	8	4	3	3	10
Rowo	3	5	4	12	3	1	4	8
Ruoc	2	2	2	6	2	1	5	8
Sein	2	4	3	9	2	1	4	7
Shca	3	1	3	7	4	2	4	10
Smst	4	3	3	10	2	2	3	7
Spbe	4	2	4	10	3	1	4	8
Syal	4	1	4	9	4	2	4	10
Thoc	3	1	4	8	2	1	3	6
Vasc	3	1	4	8	1	3	2	6

1 Fol = Foliar, Flo = Floral, For = Form

2 Phy = Physical, Est = Esthetic, Ren = Renewability

Table 5. Table of values assigned for contribution individual species made to picnicking as a recreational activity.

ACTIVITY: PICNICKING

Species Acronym	DISPLAY ¹				TRAFFIC TOLERABILITY ²			
	Fol	Flo	For	Total	Phy	Est	Ren	Total
Acru	3	1	1	5	2	1	2	5
Alce	3	5	3	11	3	2	4	9
Arco	5	5	5	15	1	1	3	5
Artr	2	2	3	7	3	3	4	10
Basa	4	4	4	12	2	2	4	8
Bere	4	4	4	12	3	2	5	10
Caru	4	3	5	12	5	3	5	13
Cage	5	3	3	11	5	5	5	15
Cami	3	5	2	10	1	1	2	4
Ciar	2	3	2	7	3	2	5	10
Clco	5	5	5	15	1	1	3	5
Coli	4	4	4	12	1	1	2	4
Clov	4	4	5	13	5	3	5	13
Deoc	2	3	1	6	1	1	5	7
Feid	5	3	5	13	5	5	5	15
Geri	3	5	4	12	2	1	2	5
Gevi	3	5	4	12	2	1	2	5
Haf1	1	4	1	6	2	2	5	9
Hesu	3	4	2	9	2	2	3	7
Henu	4	5	3	12	2	1	3	6
Irm1	5	5	5	15	2	1	4	7
Juco	4	2	4	10	5	3	3	11
Libo	4	5	5	14	1	1	3	5
Luse	3	4	3	10	1	2	4	7
Mebu	5	3	5	13	5	5	5	15
Meci	3	4	4	11	3	1	3	7
Popr	5	2	5	13	5	5	5	15
Pogr	3	5	1	9	3	2	5	10
Rimo	4	1	3	8	4	3	3	10
Rowo	4	4	1	9	3	1	3	7
Ruoc	1	1	1	3	1	1	5	7
Sein	3	4	3	10	2	1	3	6
Shca	3	1	4	8	4	3	4	11
Smst	4	3	4	11	2	1	3	6
Spbe	3	1	1	5	2	1	3	6
Syal	2	1	1	4	2	1	2	5
Thoc	3	1	3	7	2	2	3	7
Vasc	3	1	4	8	1	1	3	5

1 Fol = Foliar, Flo = Floral, For = Form

2 Phy = Physical, Est = Esthetic, Ren = Renewability

Table 6. Table of values assigned for contribution individual species made as a resource in establishing trails.

ACTIVITY: TRAILS

Species Acronym	DISPLAY ¹				TRAFFIC TOLERABILITY ²			
	Fol	Flo	For	Total	Phy	Est	Ren	Total
Acru	4	4	4	12	2	1	2	5
Alce	4	5	5	14	3	2	4	9
Arco	3	5	1	9	1	1	5	7
Artr	2	2	4	8	4	2	4	10
Basa	5	5	4	14	3	3	5	11
Bere	5	4	3	12	4	2	5	11
Caru	2	1	1	4	5	3	5	13
Cage	2	1	2	5	5	5	5	15
Cami	5	5	5	15	1	1	3	5
Ciar	2	3	3	8	3	2	5	10
Clco	3	5	5	13	1	1	4	6
Clov	3	3	4	10	5	3	5	13
Coli	2	3	1	6	2	1	2	5
Deoc	1	5	5	11	3	1	5	9
Feid	4	1	1	6	5	4	5	14
Geri	3	5	3	11	3	1	5	9
Gevi	3	5	3	11	3	1	5	9
Haf1	2	4	3	9	4	3	5	13
Hesu	4	4	2	10	1	1	4	6
Henu	4	5	5	14	2	1	1	4
Irm1	5	5	5	15	2	1	5	8
Juco	5	3	5	13	4	3	5	12
Libo	3	5	2	10	1	1	4	6
Luse	3	4	4	11	3	2	4	9
Mebu	2	1	2	5	5	4	5	14
Meci	3	4	4	11	2	1	3	6
Popr	2	1	1	4	5	4	5	14
Pogr	3	5	3	11	3	2	5	10
Rimo	2	2	3	7	4	2	4	10
Rowo	3	4	4	11	4	3	5	12
Ruoc	3	4	5	12	4	1	4	9
Sein	2	4	4	10	2	1	3	6
Shca	4	2	5	11	3	3	4	10
Smst	4	5	5	14	2	2	4	8
Spbe	2	1	3	6	4	2	5	11
Syal	4	3	5	12	4	2	4	10
Thoc	4	1	4	9	3	2	4	9
Vasc	4	3	2	9	1	2	4	7

1 Fol = Foliar, Flo = Floral, For = Form

2 Phy = Physical, Est = Esthetic, Ren = Renewability

Table 7. Table of values assigned for contribution individual species made as a resource in establishing play areas.

ACTIVITY: PLAY AREAS

Species Acronym	DISPLAY 1				TRAFFIC TOLERABILITY 2			
	Fol	Flo	For	Total	Phy	Est	Ren	Total
Acru	1	1	1	3	1	1	2	4
Alce	3	2	3	8	1	1	3	5
Arco	1	2	3	6	1	1	4	6
Artr	1	1	1	3	2	2	4	8
Basa	2	2	3	7	1	1	2	4
Bere	1	2	3	6	2	2	2	6
Caru	5	5	5	15	4	4	4	12
Cage	5	5	4	14	5	5	5	15
Cami	2	1	1	4	1	1	1	3
Ciar	1	2	1	4	3	2	5	10
Clco	2	1	2	5	1	1	2	4
Clov	5	3	5	13	5	4	5	14
Coli	4	3	5	12	2	1	2	5
Deoc	1	1	1	3	1	1	2	4
Feid	5	5	5	15	5	5	5	15
Geri	1	2	2	5	2	1	3	6
Gevi	1	2	2	5	2	1	3	6
Haf1	1	1	1	3	3	1	3	7
Hesu	2	1	1	4	1	1	2	4
Henu	1	1	1	3	1	1	2	4
Irm1	2	1	1	4	2	1	4	7
Juco	1	1	1	3	4	3	4	11
Libo	3	1	3	7	1	1	1	3
Luse	1	1	2	4	1	1	1	3
Mebu	5	5	5	15	5	5	5	15
Meci	1	1	3	5	2	2	3	7
Popr	5	5	5	15	5	5	5	15
Pogr	1	1	2	4	1	1	3	5
Rimo	1	1	1	3	3	2	4	9
Rowo	1	1	1	3	3	1	4	8
Ruoc	1	1	1	3	1	1	3	5
Sein	2	2	2	6	2	1	2	5
Shca	1	1	1	3	3	2	4	9
Smst	3	1	3	7	1	1	1	3
Spbe	1	1	1	3	2	2	3	7
Syal	1	1	1	3	1	1	2	4
Thoc	2	1	3	6	2	2	3	7
Vasc	2	1	3	6	1	1	2	4

1 Fol = Foliar, Flo = Floral, For = Form

2 Phy = Physical, Est = Esthetic, Ren = Renewability

OCCURRENCE FACTOR		FREQUENCY FACTOR		SPECIES CONTRIBUTION FACTOR		SPECIES RATING FOR A CELL
Varies with each species within each cell		Varies within each species within each cell		Constant for a species but varies with different recreation activities		Two category values for each species and each recreation activity within each cell
	X		X		=	
Uniform = 5		(Daubenmire's coverage classes)				
Restricted = 3						
Present = 1						
		0 - 25% = 1				
		26 - 50% = 2				
		51 - 75% = 3				

Figure 5. Flow chart showing procedure for determining individual species rating for each recreation activity within each cell.

appearance and 3) the species ability to renew itself after trampling. For each recreation activity a numerical value from one to five was assigned for each species in each subcategory. Values were derived by examining vegetative characteristics of each species, with five being a maximum contribution and one being minimum (Table 3, Tables 4-7). Summing the three subcategorical values in each category, totals were obtained which represent the relative contribution of each species to each recreational activity in each category.

To evaluate a cell's compatibility potential for a recreation activity, a cell species rating value was determined by multiplying together factors for species occurrence, frequency of occurrence and the species contribution to the recreation activity. This step is summarized by the flow chart of Figure 5. Uniform occurrence was given a factor of five, restricted occurrence a factor of three and presence of the species a factor of one. Factors for frequency of occurrence were the numerical class designations established for evaluating percent cover exhibited by plant species, Daubenmire (12). These coverage classes were 0-5% coverage, Class 1; 6-25%, Class 2; 26-50%, Class 3; 51-75%, Class 4; and 76-100%, Class 5. The species contribution factors were the sum totals of the three subcategory values for each of the two contribution categories in each recreation activity.

To evaluate an individual cell, the cell species rating values of all inventoried species within the cell were summed for each

category within each recreation activity. These totals were divided by the number of species recorded for that cell to give a cell mean in each category; then for each recreation activity the two category totals were averaged to give the relative suitability of the cell for the various recreation activities expected to occur within that cell. This step is shown in Figure 6.

The cell suitability for various recreation activities was assessed using a threshold value for recreational activity suitability and computing an expected mean for each cell. This mean was derived by multiplying the factor for species occurrence, the factor for frequency of occurrence and the threshold value in each cell. The species occurrence factor was the summed total of all occurrence factors for the inventoried species within each cell. The species frequency factor was the summed total of all frequency factors for all inventoried species within each cell. The threshold value, a constant, was set at eight which was a middle value between the minimum contribution factor of three and the maximum value of fifteen. This total for the cell was divided by the number of species recorded in that cell yielding the expected mean for the cell. This mean was compared to each mean for each recreational activity and the relative recreational activity suitability of the cell could be ascertained.

Evaluating each cell within each zone with respect to vegetation, it was determined that Zone I was best suited for camping, Zone II for

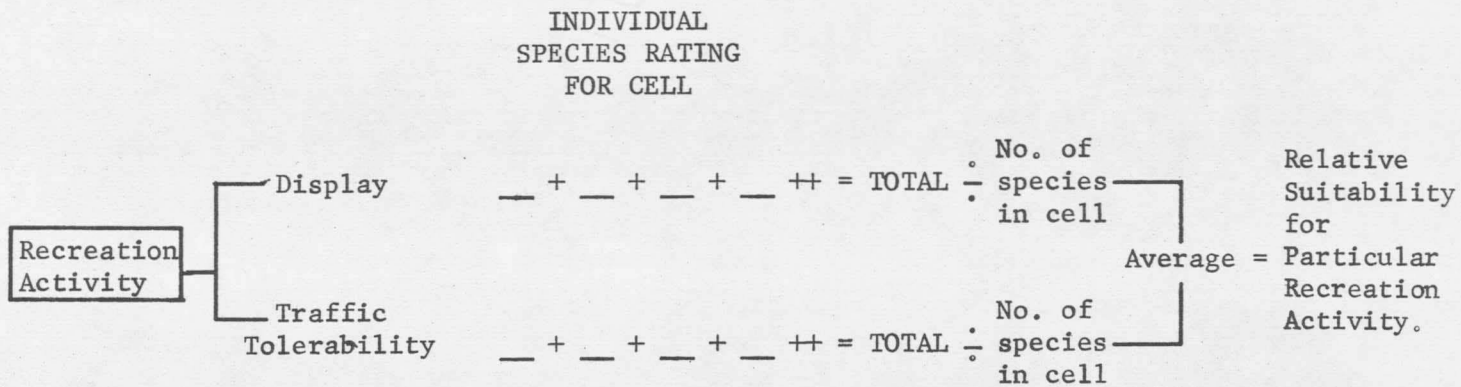


Figure 6. Flow chart for determining relative recreation activity compatibility potential for each cell.

trails and Zone III for picnicking. By selecting indicator species for each zone from the commonly occurring species of that zone a correlation was drawn between characteristics representing the indicator species and the zone's indigenous suitability for a recreational use. The validity of indicator species selection was partially verified with a formula which measured the uniqueness of occurrence of selected species for specific environmental conditions; an assumption was made that each zone represented a different set of environmental conditions. This formula, adapted from a previous study relating the degree of soil podzolization to the composition of ground level flora, Hill (22), was:

$$I = m_1/M_1 - m_2/M_2$$

I - Uniqueness index

m_1 - No. of cells in zone in which species occurs.

M_1 - No. of cells in zone.

m_2 - No. of cells in contrasting zone in which species occurs.

M_2 - No. of cells in contrasting zone.

Computed I values ranged from minus one to plus one. The extremes were indicative of uniform indicator species occurrence in one zone and no occurrence in the contrasting zone. Values of zero indicated equal occurrence in each zone. Indicator species validity was tested

between two single zones and one zone compared with the remaining two zones. For a species to be considered as having occurrence within a cell it was required that it exhibit uniform occurrence throughout that cell. Uniform occurrence best reflected the relationship of a species with its edaphic and physical environment. Indicator species tested showed strong contrasts of presence among zones.

The final step was to develop a system which would select cells within the area which would be compatible with different recreational activities. Determination of cells was based on the three recreational uses corresponding with Zones I, II and III. A computer program was written (Appendix III) that selected cells which contained a specified complement of species. The species complement or input was the declared indicator species for the three recreational activities corresponding with Zones I, II, and III. The data for the program consisted of species presence data in each cell. The output was a list of those cells containing the input species list. The output data was transferred to a study area base map. This map then delineated those areas which were compatible with three recreational activities, and could be used as a basis for a recreation site design plan.

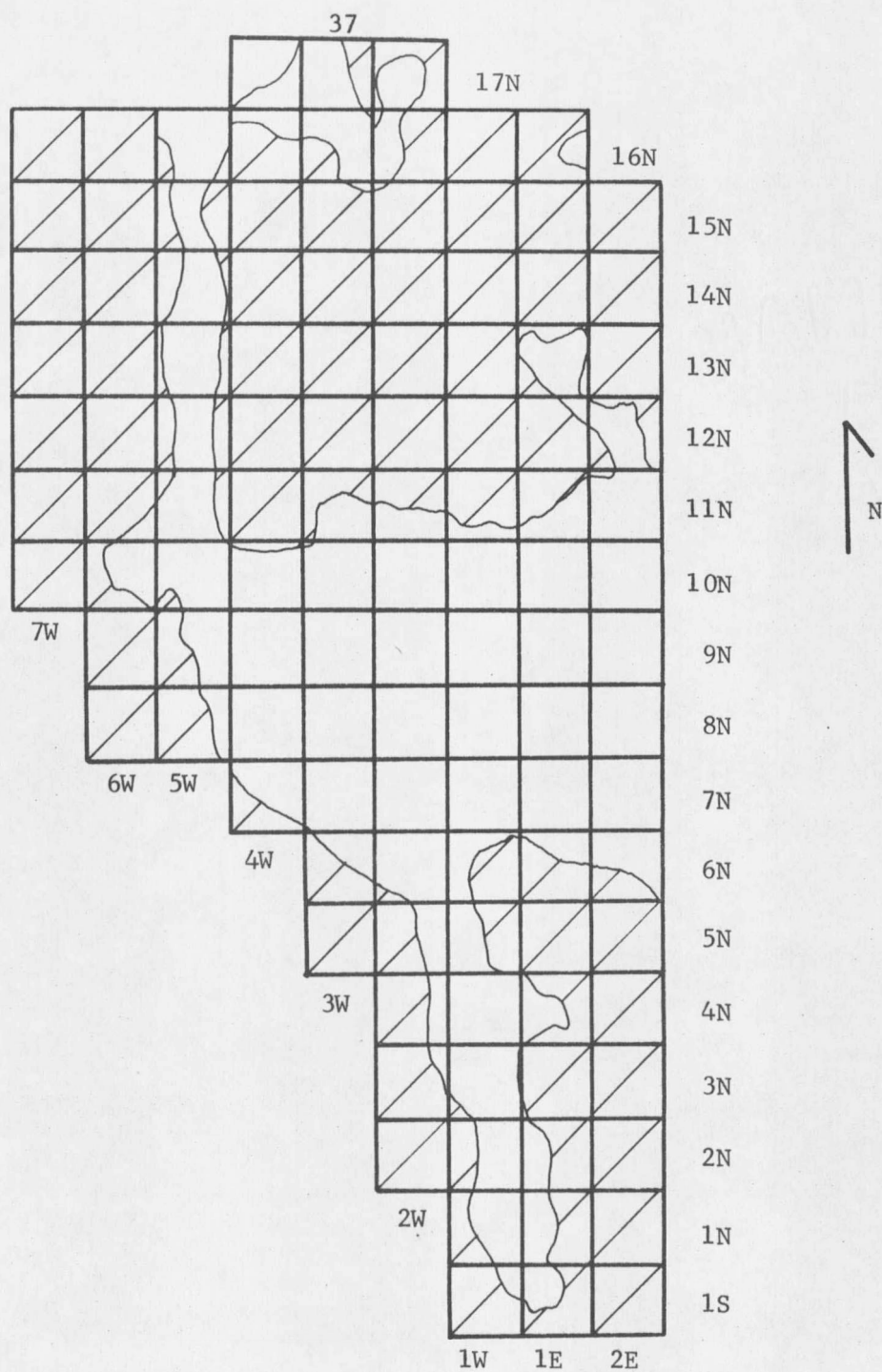


Figure 7. Distribution map of *Arnica cordifolia*. (Scale 1 cm = 50 m)

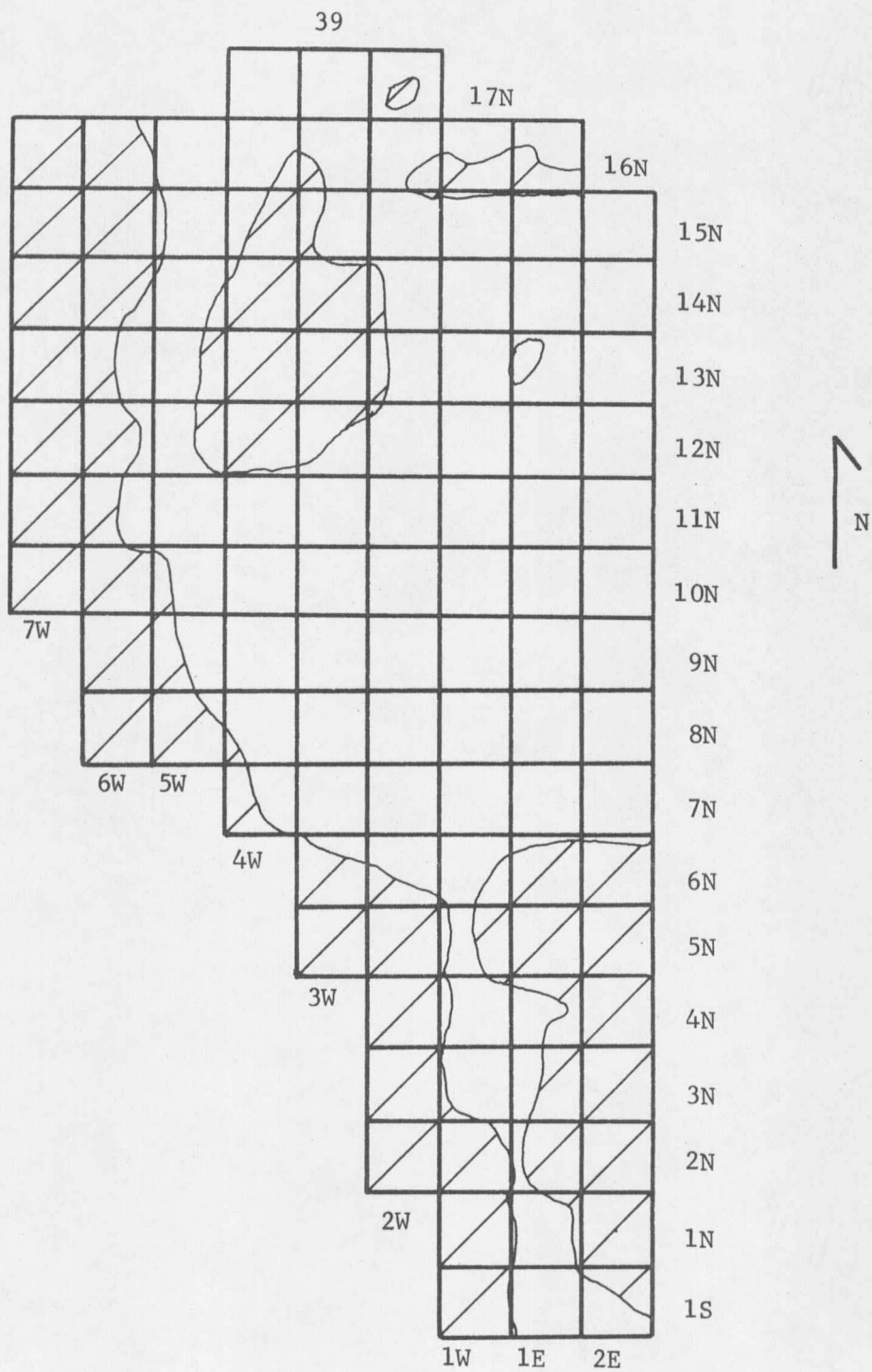


Figure 9. Distribution map of *Vaccinium scoparium*.
(Scale 1 cm = 50 m)

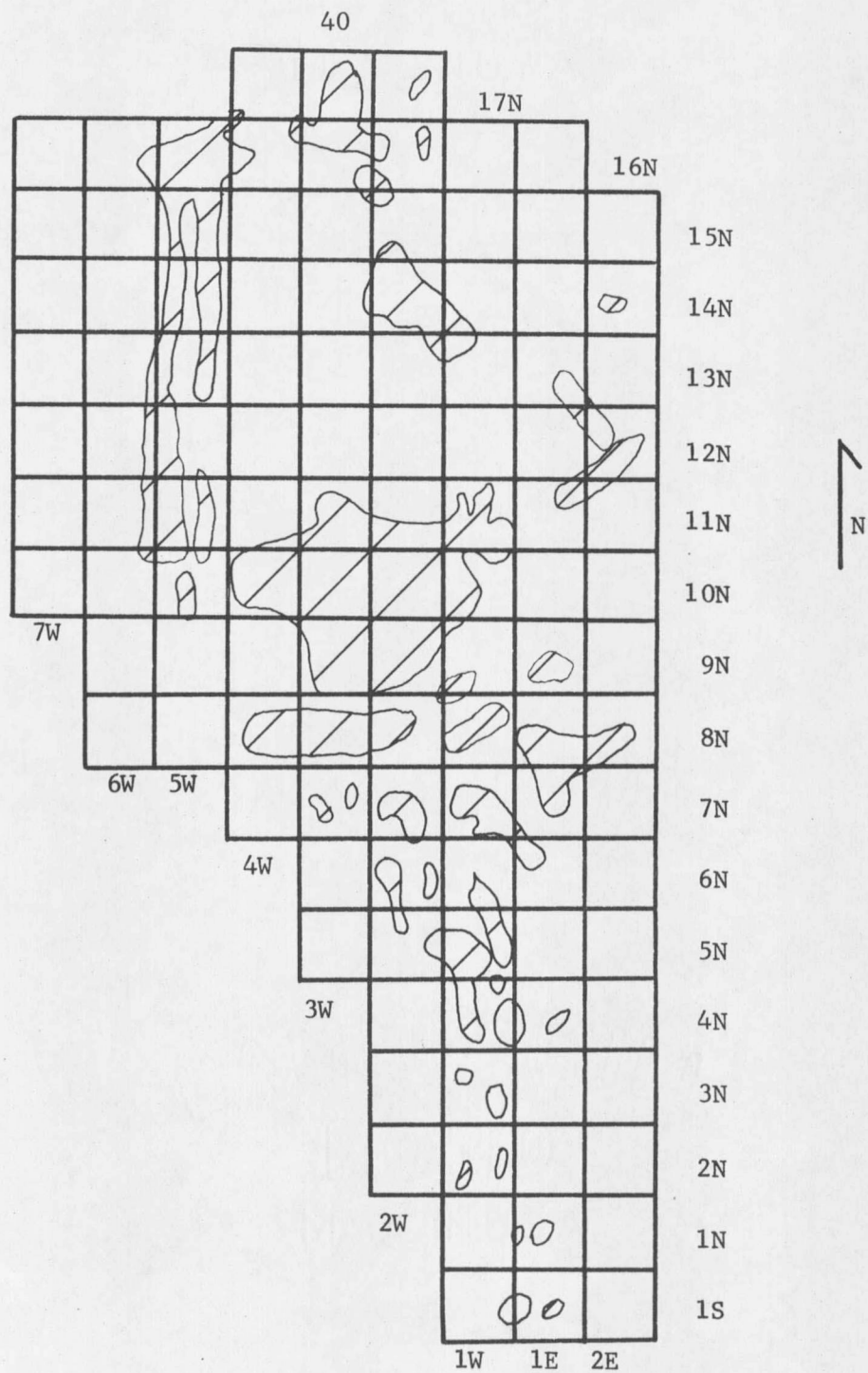


Figure 10. Distribution map of *Rudbeckia occidentalis*.
(Scale 1 cm = 50 m)

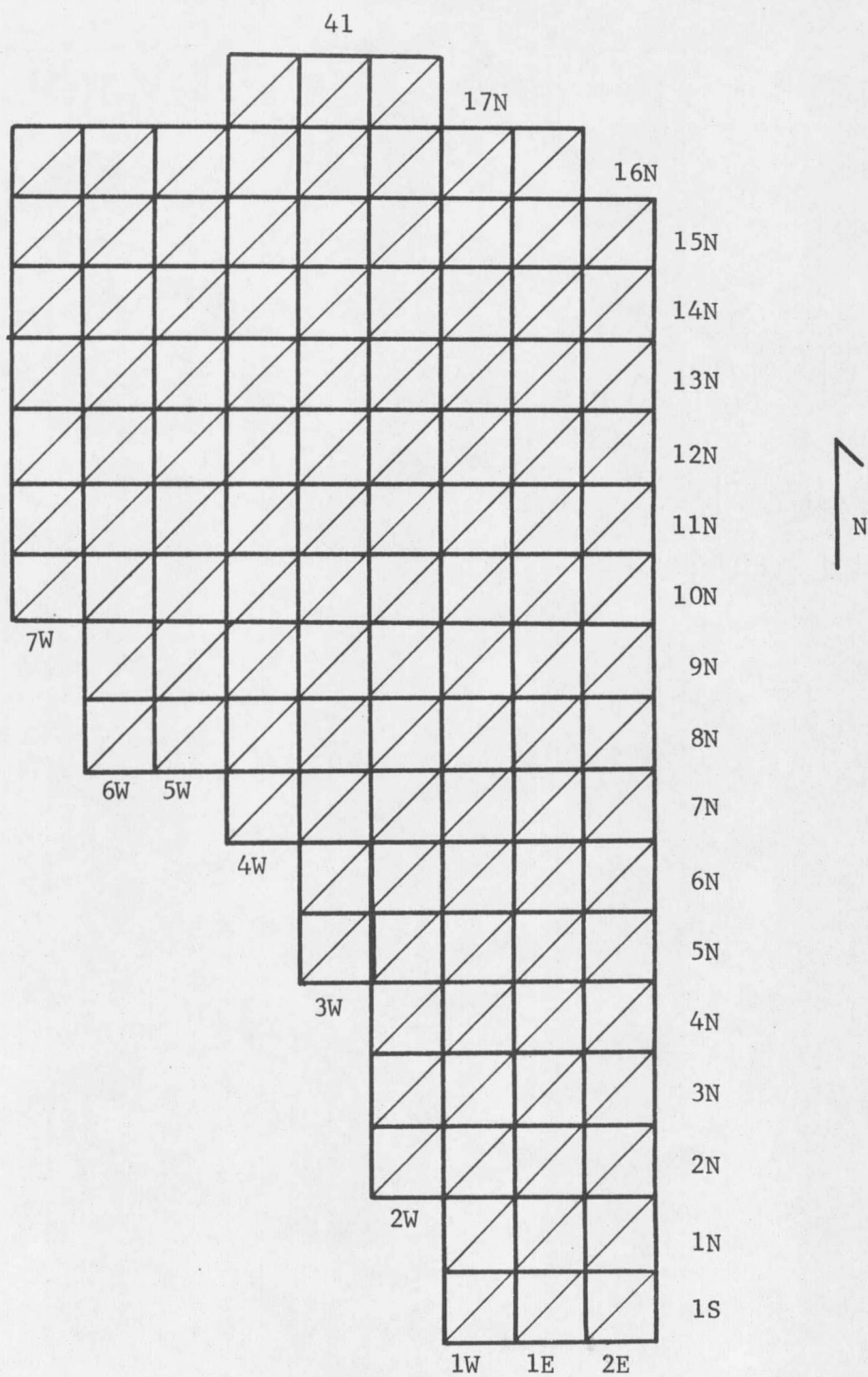


Figure 11. Distribution of *Trifolium* sp. (Scale 1 cm = 50 m)

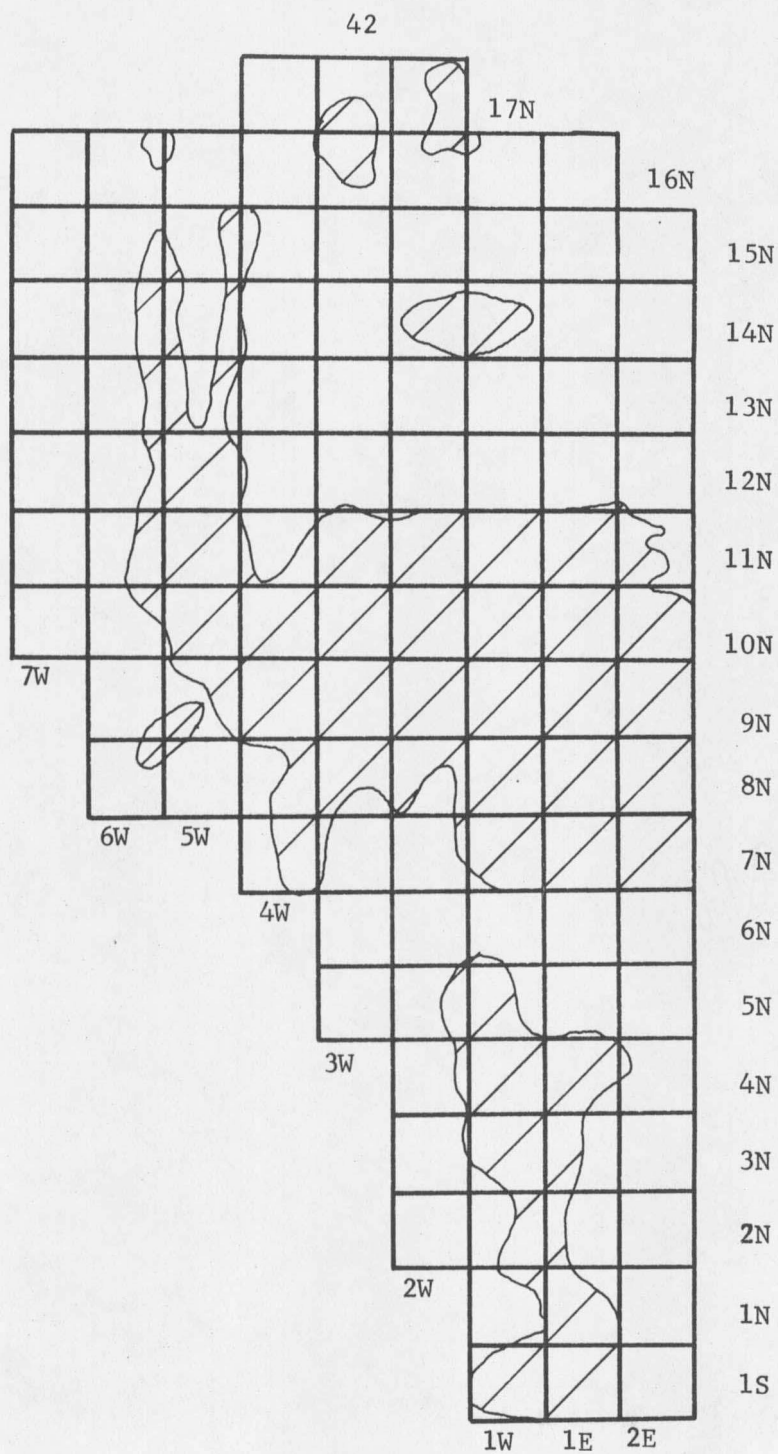


Figure 12. Distribution map of Potentilla gracilis.
(Scale 1 cm = 50 m)

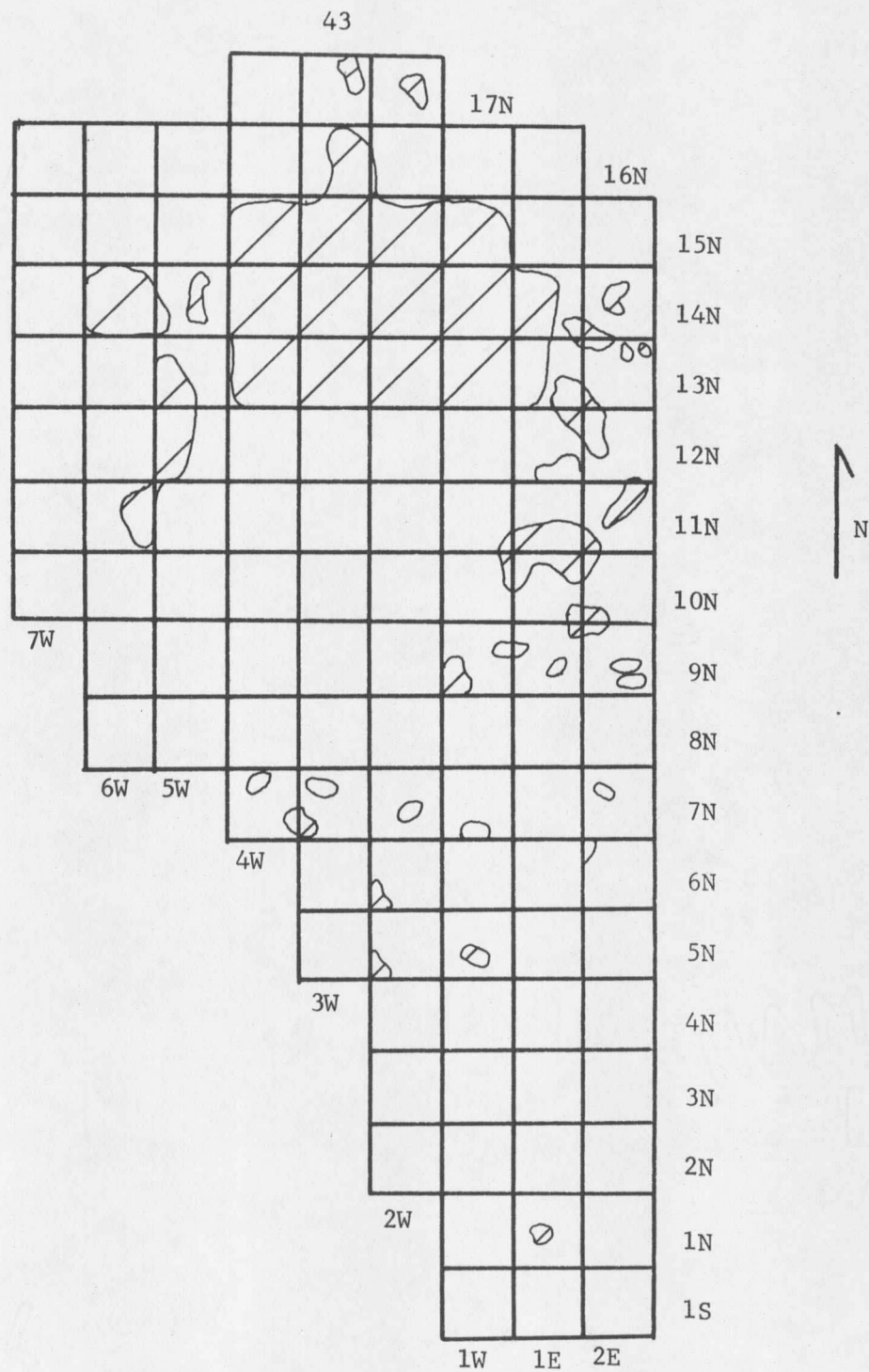


Figure 13. Distribution map of *Geranium richardsonii*.
(Scale 1 cm = 50 m)

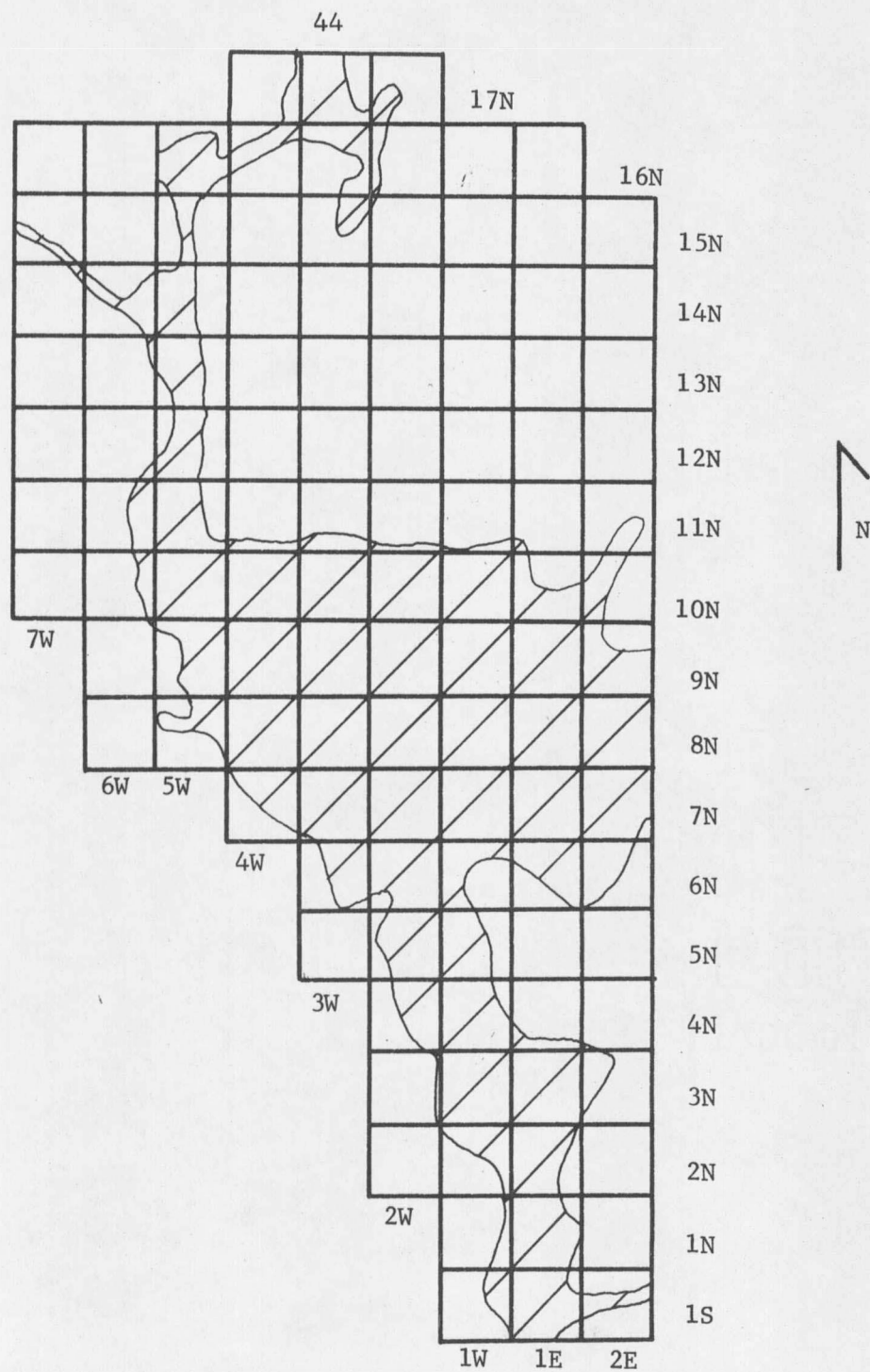


Figure 14. Distribution map of *Poa pratensis*. (Scale 1 cm = 50 m)

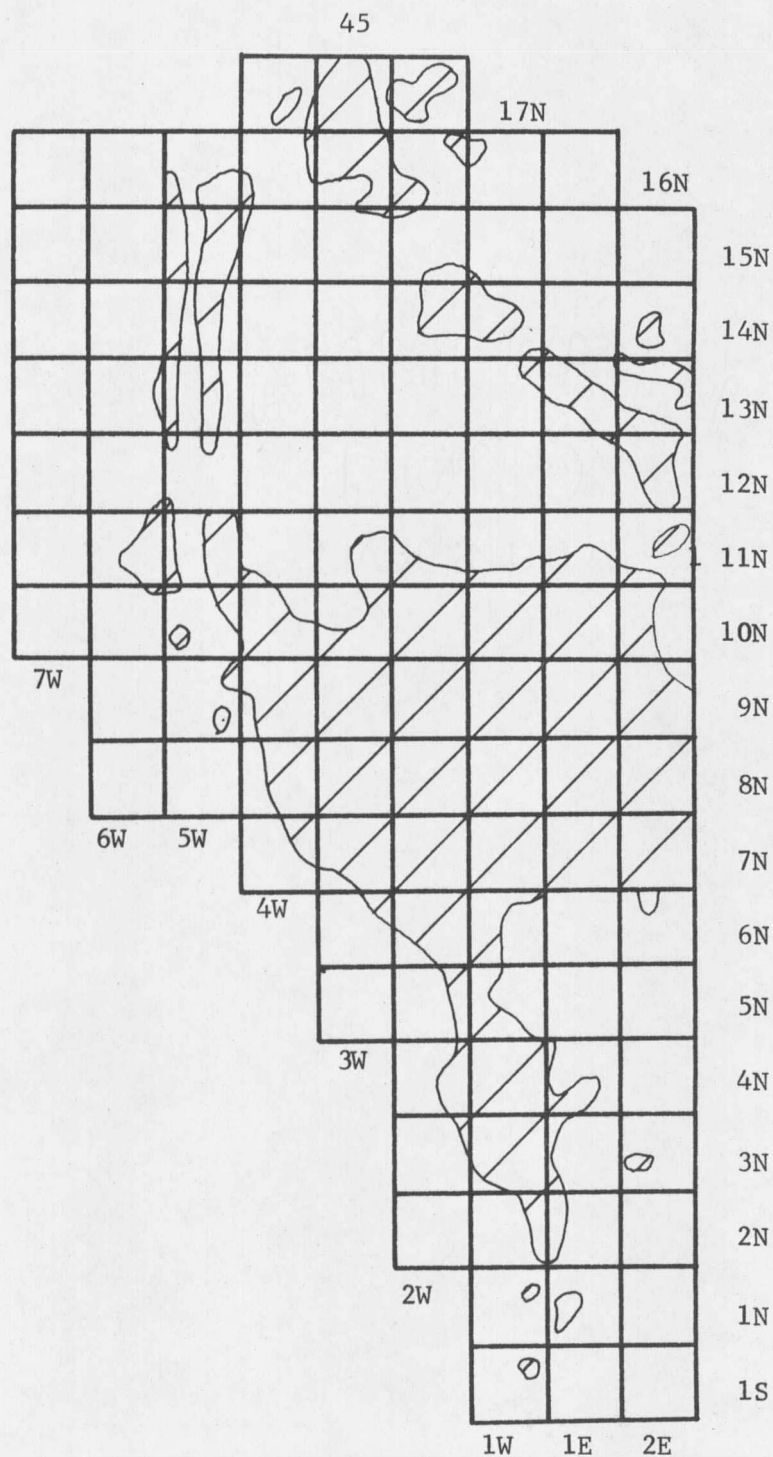


Figure 15. Distribution map of Delphinium occidentale.
(Scale 1 cm = 50 m)

RESULTS AND DISCUSSION

Inventory Discussion

The inventories were conducted at a time of year which coincided with the heavy recreation use season, which validated the correlations of recreation use and inventoried vegetation.

The cursory soil survey conducted was not meant to preclude the necessity of a detailed soil survey as a prerequisite to site planning. It was meant to aid in the establishment of homogeneous areas (zones) and to complement the vegetation inventory as an aid to the understanding of the soils of the area. Soil information was also used to explain the occurrence of certain plant species.

With the varied topography and overstory densities, locating homogeneous ecosystem location with usable aerial dimensions was limited (Figure 4). In the establishment of zones it was beneficial to compose distribution maps for commonly occurring species (Figures 7-15). These composite maps, when transferred to acetate overlays could be singly or plurally projected to identify areas of similar species composition. Overlays were made from species presence data, avoiding the complexities of shading for coverage classes. From the composite comparisons it was evident that a common factor in determining species distributions was light. Examining actual data, it was detected that frequency of occurrence variations existed between areas receiving similar amounts of light, which could be explained by variations in soil texture, aspect, slope and soil reaction.

In establishing zones, six characteristics were examined to validate the assumption of uniform zonal characteristics (Table 1). For three characteristics, percent canopy, number of species per cell and percent clay in soil, it was found that most characteristics were within two standard deviations of the mean for that characteristic in each individual zone (Table 8). Combined with visual assessments of the proposed zones, it was shown that each zone represented an area of homogeneous characteristics and was unique among the three zones.

With respect to zonal speciation, Zone I contained six species which occurred with relatively equal frequency in each cell of the zone. Zone II exhibited twelve species present in all cells but occurring with unequal frequencies. Zone III, similar to Zone II except in percent canopy coverage, contained seven species occurring in all cells but with unequal frequencies of occurrence (Table 9).

The selection of recreation activities for the recreation site was made subjectively by the researcher from a list of the most common outdoor recreation activities which could occur on this site, Jensen (24). To be most effective in providing recreation activities, an effective survey of local and regional trends and needs would be desirable. On this small site the lack of a survey was not as critical as with the planning and development of large multi-opportunity developments. By naming activities, a basis for establishing compatibility relationships between activities and endemic site vegetation was

Table 8. Analysis of biophysical characteristics of zones established within Hyalite Canyon Study Area.

	<u>Percent Canopy</u>		<u>No. of Species</u>		<u>Percent Clay</u>
Zone I					
10N7W	61		9		25
11N7W	51		11		25
12N7W	51	$\bar{X} = 50.3$	14	$\bar{X} = 11.8$	20
13N7W	50	$S = 7.0$	11	$S = 1.9$	20
14N7W	50		12		20
15N7W	39		14		20
Zone II					
13N1W	50		22		33
13N2W	31		20		32
13N3W	44		16		33
14N1E	38	$\bar{X} = 42.1$	19	$\bar{X} = 20.0$	30
15N1E	44	$S = 6.1$	20	$S = 2.1$	35
15N1W	49		19		32
15N2W	41		23		35
15N3W	40		21		32
Zone III					
7N2E	15		19		32
7N1E	12		17		35
7N3W	10		20		35
8N1E	14		19		33
8N1W	10		15		35
8N2W	9	$\bar{X} = 10.9$	11	$\bar{X} = 15.9$	32
8N3W	10	$S = 2.4$	13	$S = 2.9$	32
9N1W	8		17		33
9N2W	6a		17		33
9N3W	7		13		35
10N1W	16a		16		35
10N2W	12		18		35
10N3W	2a		12		30b

a, b = Did not fall within two standard deviations of the mean of characteristic for that zone.

Table 9. Occurrences (O) and frequencies of occurrence (F) data (%) for commonly occurring species within zones of Hyalite Canyon study area.

		SPECIES ¹																							
		ARCO		CARU		LIBO		LUSE		ROWO		VASC													
		O	F	O	F	O	F	O	F	O	F	O	F												
Zone I																									
10N7W		U ²	3	U	15	P		U	6	P ⁴		U	15												
11N7W		U	2	U	9	P		R ³	3	P		U	15												
12N7W		U	2	U	12	P		U	5	P		U	15												
13N7W		U	2	U	8	P		U	8	P		U	15												
14N7W		U	3	U	5	P		U	8	P		U	15												
15N7W		U	4	U	4	P		U	6	P		U	15												
		ACRU		ARCO		BERE		CAGE		CARU		GERI		GEVI		HESU		LUSE		ROWO		SPBE		SYAL	
		O	F	O	F	O	F	O	F	O	F	O	F	O	F	O	F	O	F	O	F	O	F	O	F
Zone II																									
13N1W		P		R	2	P		P		U	5	U	1	U	2	R	3	R	10	P		P		P	
13N2W		P		U	3	P		P		U	7	U	1	U	2	R	4	R	6	P		U	2	P	
13N3W		P		U	3	P		P		R	5	U	2	U	2	R	4	U	5	P		U	2	P	
14N1E		P		U	2	P		P		R	7	U	3	U	1	R	2	R	5	P		R	3	R	3
15N1E		P		U	4	P		R	3	R	6	P		U	1	R	3	R	15	P		P		P	
15N1W		P		U	3	P		P		U	7	U	1	P		R	2	U	5	P		P		P	
15N2W		P		U	4	P		R	2	R	8	R	3	U	1	R	3	U	3	P		R	2	R	3
15N3W		P		U	3	P		P		R	5	U	2	U	3	R	3	U	3	P		P		P	

Table 9. Continued.

	SPECIES									
	DEOC	GEVI	HAFL	MEBU	POGR	POPR	RUOC			
Zone III										
7N2E	U 3	U 3	U 2	R 10	U 2	U 3	P			
7N1E	U 4	U 4	R 5	R 5	U 2	U 5	R 15			
7N3W	R 5	U 1	R 3	P	P	U 6	R 10			
8N1E	R 3	P	U 5	U 2	U 2	U 3	R 5			
8N1W	U 3	P	R 10	U 3	U 2	U 5	U 2			
8N2W	U 2	P	U 6	U 5	U 5	U 11	U 3			
8N3W	U 5	P	U 4	U 4	U 3	U 15	U 2			
9N1W	U 2	P	R 15	U 2	U 10	U 8	R 12			
9N2W	U 3	P	U 2	U 6	U 10	U 12	U 2			
9N3W	R 5	P	U 2	U 7	U 15	U 12	U 1			
10N1W	U 2	P	U 6	U 3	U 5	U 8	R 10			
10N2W	U 2	P	U 5	U 4	U 10	U 12	U 5			
10N3W	R 3	P	U 3	U 5	U 10	U 15	U 3			

1 Species listed by acronyms; listed in Appendix I.

2 U = Uniform

3 R = Restricted

4 P = Present

established. The provision of recreation opportunities should not preclude providing a recreation site which would remain in unspoiled condition with active recreation use. Ultimately the intrinsic qualities of the site should determine the kind and amount of activities designated for a site.

Cell Evaluation Methodologies

Tolerance levels for soil texture and slope were based upon previously established guidelines, Montgomery (34). Tolerance levels for aspect and percent canopy were subjectively set after assessing the nature of a particular activity. Aspect influences the warmth provided by the sun at different times of the day. Early morning warmth of the sun makes easterly aspects more desirable than northern or western aspect for camping. Consequently in evaluating a site for aspect, an eastern exposure was given preference. A south exposure rated between east and north or west. With picnicking, the afternoon sun of southern and western aspects was desirable. A flat exposure was optimal for all activities.

The multiplicative scheme devised to assess sites from the physical resource standpoint provided variability in segregating suitabilities among sites. Suitabilities for the three zones were computed (Table 10) for the three recreation activities camping, picnicking and trails.

The justification for selecting plant display and trampling tolerability categories was based on the importance previous researchers

Table 10. Relative suitabilities of three zones considering biophysical factors for three recreation activities camping, picnicking and trails.

	<u>Recreation Activity</u>	(Slope Factor)	X	(Soil Texture Factor)	X	(Aspect Factor)	X	(Percent Canopy Factor)	=	Resource Suitability Index
Zone I	Camping	3		2		3		3		54
	Picnicking	3		2		2		2		24
	Trails	3		2		2		3		36
Zone II	Camping	2		2		3		3		36
	Picnicking	2		2		3		3		36
	Trails	3		2		3		3		54
Zone III	Camping	3		2		3		1		18
	Picnicking	3		2		3		3		54
	Trails	3		2		3		3		54

placed on vegetations contribution to a quality recreation experience, Hehn (19), Hancock (17), Wagar (44). The obvious contribution of vegetation was the visual impact. Trampling tolerability indirectly contributes; less tolerable species would not withstand trampling, leading to site deterioration. The elimination of vegetation also directly affected the recreation experience through lost visual appeal. The selection of three subcategories for each category was made to balance the impacts of various vegetation and to aid in the assessment of individual species. With display subcategories a minor floral display was compensated by an appealing foliar display and/or a plant form which contributed to recreation activity appreciation. With trampling tolerability, a plant which exhibited an ability to withstand physical trampling but lost its esthetic appeal and/or had no ability to renew itself after trampling, was balanced. These hypothetical situations explained the relative relationships among subcategories within each category.

In assigning values for each species in each subcategory, decisions were made after evaluating the characteristics of the plant as gleaned from floral identification texts, species references in literature and personal assessments. A large dentate leaf rated higher than a grass-like leaf in the foliar display subcategory, for those recreation activities where the visual contribution was deemed significant. This caused values to vary for a single species with different recreation

activities. The large dentate leaf had more appeal in a trails area or natural area than a play area. A middle appeal was scored for camping and picnicking. Similar rationalizations were made for subcategories of floral display and plant form. Decisions on values for the subcategories of trampling tolerability required more speculation. The ideal species was one with a good physical trampling resistance, as found with gramineous species; an ability to maintain a pleasing aesthetic appearance after trampling, again best found in gramineous species; and an ability to renew existence after trampling, as is found with those plants which vegetatively reproduce i.e. rhizominous species.

By predicating value assignments on plant characteristics, category evaluations could be made by anyone with a feeling for vegetative characteristics which lend to visual appeal or trampling tolerability. Value assignments could vary among evaluators or with the same evaluator on subsequent assessments of a species, and if this approach was undertaken by a researcher with different ecological conditions, value assignments would have to be made for species not included in this investigation. Subjective species evaluations were a surrogate to field trampling experiments. The time and complexities involved with experimental evaluation justified subjective species evaluations.

The cellular evaluation methodology evolved to facilitate the employment of the system using field data. With respect to the various

steps involved, the averaging of the two categorical totals was done to allow extreme values in either category to influence the other category. An exceptional trampling tolerability was allowed to balance a low species display contribution in an activity such as camping. By working with only one number per activity, comparisons for each category of each recreation activity were avoided. It was recognized that different activities were compatible with different conditions with respect to the two categories. Play areas, requiring a relatively high trampling tolerability, did not need a high rating in visual display. Trails were compatible with opposite conditions, as only the path of the trail needed consideration for trampling tolerability. This path was seldom found in a vegetated condition in previous studies, Dale (10). The visual display was important to visitors using the trail. For the various recreation activities, relative acceptable situations for display and trampling tolerability were developed (Table 11). These were meant as suggested situations to develop the compatible conditions for each recreation activity; in evaluating a cell and zone, averages of the two categories in each recreation activity were used.

The threshold value chosen gave an average of expected conditions with which to compare the compatibility averages computed for each recreation activity within each cell. The assumption was made that averages above the threshold value were indicative of compatible

Table 11. Relative suitabilities of vegetational conditions for recreation activities.

Recreation Activity	Suitability	Display	Trampling Tolerability
Camping	Optimum	High	High
	Moderate	Low	High
	Minimum	High	Low
		Low	Low
Picnicking	Optimum	High	High
	Moderate	Low	High
	Minimum	High	Low
		Low	Low
Trails	Optimum	High	High
	Moderate	High	Low
	Minimum	Low	Low
		Low	High
Play Areas	Optimum	Low	High
	Moderate	High	High
	Minimum	Low	Low
		High	Low
Natural Areas	Optimum	High	High
	Moderate	High	Low
	Minimum	Low	High
		Low	Low

conditions and averages below the threshold were not. When more than one activity was suggested compatible, the more compatible activity was chosen providing the physical resources suggested compatibility. Physical resource unsuitability could overrule an activity-vegetation compatibility. Vegetation compatibility averages for the three activities camping, picnicking and trails were computed (Table 12). The recommendation for Zone I was clearly camping as each cell exceeded the threshold value for that cell. The averages for picnicking and trails exceeded the threshold value but camping exceeded the threshold value by the greatest margin. With Zones II and III the suitabilities were not as obvious. Nearly all values exceeded the threshold values but the activity suitability for each zone suggested two activities. In Zone II camping and trails had similar averages for each cell, with camping exceeding the threshold value by the greatest spread five times and trails three times. When physical resources were considered (Table 10) trails were differentiated as being most compatible. The zone had moderate limitations for trails in only the soil texture category. Moderate limitations were found for camping with soil texture and slope. Slope was considered more important to campsite placement. In Zone III the suggested activities from the vegetation compatibility standpoint were camping and picnicking. This was partially due to the invasion of Poa pratensis throughout the zone which was considered a good ground cover for both camping and picnicking activities. The

Table 12. Recreation activity compatibility averages and cell threshold values for three zones of Hyalite Canyon Study Area.

Cell compatibility averages				
	Threshold Values	Camping	Picnicking	Trails
Zone I				
10N7W	36.0	44.7	40.2	40.5
11N7W	29.3	37.1	34.5	33.5
12N7W	28.0	36.6	35.4	32.8
13N7W	30.5	38.7	31.2	34.1
14N7W	28.0	33.6	31.1	32.7
15N7W	26.1	31.6	29.8	30.8
Zone II				
13N1W	19.0	21.8	20.8	23.1
13N2W	22.4	28.5	26.2	26.7
13N3W	28.5	32.4	29.8	32.8
14N1E	21.5	26.3	24.5	25.5
15N1E	16.8	21.5	19.0	20.0
15N1W	23.2	29	26.6	27.8
15N2W	25.5	30	29.4	31.1
15N3W	16.4	20.2	15.9	19.7
Zone III				
9N3W	44.3	57.6	57.1	51.5
10N1W	37.0	45.1	45.8	44.0
10N2W	31.1	39.7	39.6	38.9
10N3W	45.1	58.3	58.6	57.5
7N1E	29.6	35.9	33.4	36.4
7N2E	22.3	28.3	26.0	28.3
7N3W	23.2	29.8	28.4	28.4
8N1E	19.8	24.5	23.7	25.0
8N1W	24.5	30.1	29.6	30.7
8N2W	42.7	52.6	53.4	53.2
8N3W	41.8	49.8	50.7	48.8
9N1W	32.5	40.1	39.9	40.5
9N2W	32.0	41.7	41.3	39.7

physical resources pointed to picnicking as the more compatible activity for the zone due to the minimal overstory density of the zone. Both camping and picnicking had moderate limitations with soil texture but according to suggested desirable overstory density levels the zone had severe limitations for camping.

Selection of Indicator Species

In selecting indicator species for each zone which would predict the zone's indicated recreation activity compatibility, the choices were made from those species which exhibited similar occurrences in each cell of the zone. Six indicator species were chosen for Zone I, ten for Zone II and seven for Zone III (Table 13). Species selected exhibited similar occurrences whether it was present, restricted or uniform or a mixture of uniform and restricted occurrence with similar frequencies of occurrence. Four species chosen had dual roles as being indicators for two zones. The important consideration was not the individual species but the group of species.

To verify a species specificity for the conditions of a zone the formula given in the materials and method section was utilized. Results (Table 14) were not easy to interpret as no value was given which established whether the computed value was significant. Comparisons examined with the formula revealed specificities and distribution variations resulting from varied site conditions. The resolution of the comparisons provided indications of whether occurrences of species

Table 13. Indicator species chosen for three zones.

Indicator Species

Zone I

Arnica cordifolia
Calamagrostis rubescens
Linnaea borealis
Lupinus sericeus
Rosa woodsii
Vaccinium scoparium

Zone II

<i>Actea rubra</i>	<i>Trifolium</i> sp.
<i>Arnica cordifolia</i>	<i>Geranium richardsonii</i>
<i>Berberis repens</i>	<i>Geranium viscosissimum</i>
<i>Carex geyeri</i>	<i>Hedysarum sulphurescens</i>
<i>Calamagrostis rubescens</i>	<i>Rosa woodsii</i>

Zone III

<i>Delphinium occidentale</i>	<i>Potentilla gracillis</i>
<i>Geranium viscosissimum</i>	<i>Poa pratensis</i>
<i>Hackelia floribunda</i>	<i>Rudbeckia occidentalis</i>
<i>Melica bulbosa</i>	

Table 14. Results of interzone comparisons of species occurring uniformly within zones of Hyalite Canyon Study Area.

Species Indicator Values						
<u>Species</u>	<u>IVSII</u>	<u>IVSIII</u>	<u>IIVSIII</u>	<u>IVSII&III</u>	<u>IIVSI&III</u>	<u>IIIVSI&II</u>
Arco	.12	1.0	.88	.67	.46	-.93
Luse	.33	.83	.50	.64	.24	-.64
Vasc	.88	1.0	.13	.95	-.19	-.50
Deoc	0	-.69	-.69	-.43	-.47	.69
Gevi	-.71	-.06	.65	-.31	.67	-.34
Pogr	0	-.92	-.92	-.57	-.63	.92
Ruoc	0	-.54	-.54	-.33	-.37	.54
Caru	.63	1.0	.38	.86	.06	-.64
Cami	.25	.50	.25	.40	.09	.36
Popr	.17	.83	-1.0	-.45	-.74	.93
Haf1	0	-.31	-.31	-.43	-.47	.69
Mebu	0	-.77	-.77	-.48	-.53	.77
Geri	-.75	-.08	.67	.33	.43	-.35

were reflecting different environmental conditions. Recognizing that in any ecological community, complex environmental relationships existed which governed the present or absence of a species, an assumption was made that the study site represented normal conditions for this climate and general area. If this assumption was valid then the presence of a species indicated its compatibility with the particular environmental conditions.

An abbreviated table of I values was composed (Table 15) for indicator species of each zone. The absence of values for several indicator species was due to the convention of computing values only for those species which exhibited uniform occurrence in each zone. Linnaea borealis exhibited presence in every cell of Zone I and occurred in only one cell of Zone II and not at all in Zone III. Rosa woodsii was found in one cell of Zone III but was found in all cells of Zones I and II. Actea rubra, Berberis repens, Carex geyeri, Hedysarum sulphurescens occurred with restricted occurrence in the cells of Zone II; occurrences sufficient to warrant inclusion as indicator species but not sufficient to allow computation of an value. Trifolium sp. was ubiquitous wherever light penetrated the canopy. It was included as an indicator species in Zone II because it was important in establishing the suitability of Zone II for recreation use.

Examination of I values of Table 15 revealed high and low values for different comparisons. For all indicator species evaluated at

Table 15. Abbreviated table of selected interzone comparisons for indicator species.

	Zone Comparisons					
	IVSII	IIVSI	IVSIII	IVSII + III	IIVSI + III	IIIVSI + II
Zone I						
Arco	.13		1	.67		
Caru	.63		1	.86		
Hibo						
Luse	.33		.83	.64		
Rowo						
Vasc	.88		1	.95		
Zone II						
Acru						
Arco	.13	.88			.46	
Bere						
Cage						
Caru	.63	.38			.06	
Clov						
Geri	-.75	.67			.43	
Gevi	-.71	.65				
Hesu					.67	
Rowo						
Zone III						
Deoc		-.69	-.69			.69
Gevi		-.06	.65			-.34
Haf1		-.31	-.31			.69
Mebu		-.77	-.77			.77
Pogr		-.92	-.92			.92
Popr		.83	-1			.93
Ruoc		-.54	-.54			.54

least one value exceeded .5 or was less than -.5. Rudbeckia occidentalis which had the lowest I value of those above .5 exhibited restricted or uniform occurrence in 12 of 13 cells of Zone III and was present in the other cell. The species was not present in Zone I and exhibited presence in only three cells of Zone II.

To verify the validity of indicator species as indicators of recreation use compatibility, correlations were run between recreation use suitability averages and values representing the occurrence data of the indicator species of the particular zone. These values were computed from actual inventory data. The occurrence factor for each species was multiplied by the actual frequency of occurrence and then totaled for all species within each cell. The r values were significant as indicated in Figures 16 - 18.

To determine which cells in the study area were compatible with the three recreational uses camping, picnicking and trails, the computer program was used to output those cells in study area which contained the various sets of indicator species. This output (Figure 19) accounted for 62 percent of the cells within the study area and only three cells were indicated as having dual recreational use compatibility. This provided a strong basis for a site planner to develop a site. When intrinsic attributes of this particular area were considered the result was more significant. The computer eliminated cell 14N2E from compatibility. The particular area was unique in that it contained a spring

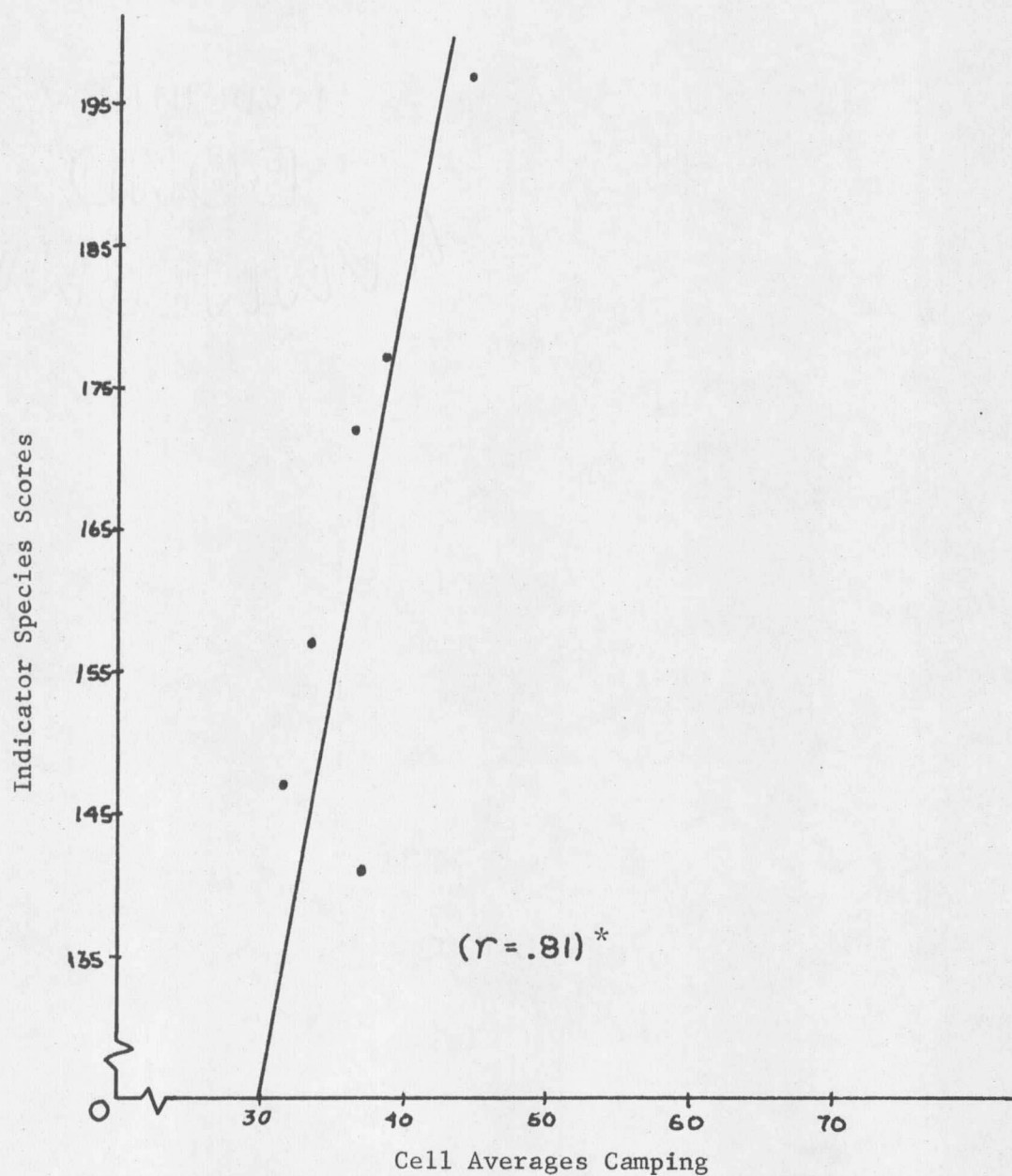


Figure 16. Regression line showing relationship of indicator species score vs cell averages for camping in Zone I.

* r value significant at $p = .05$.

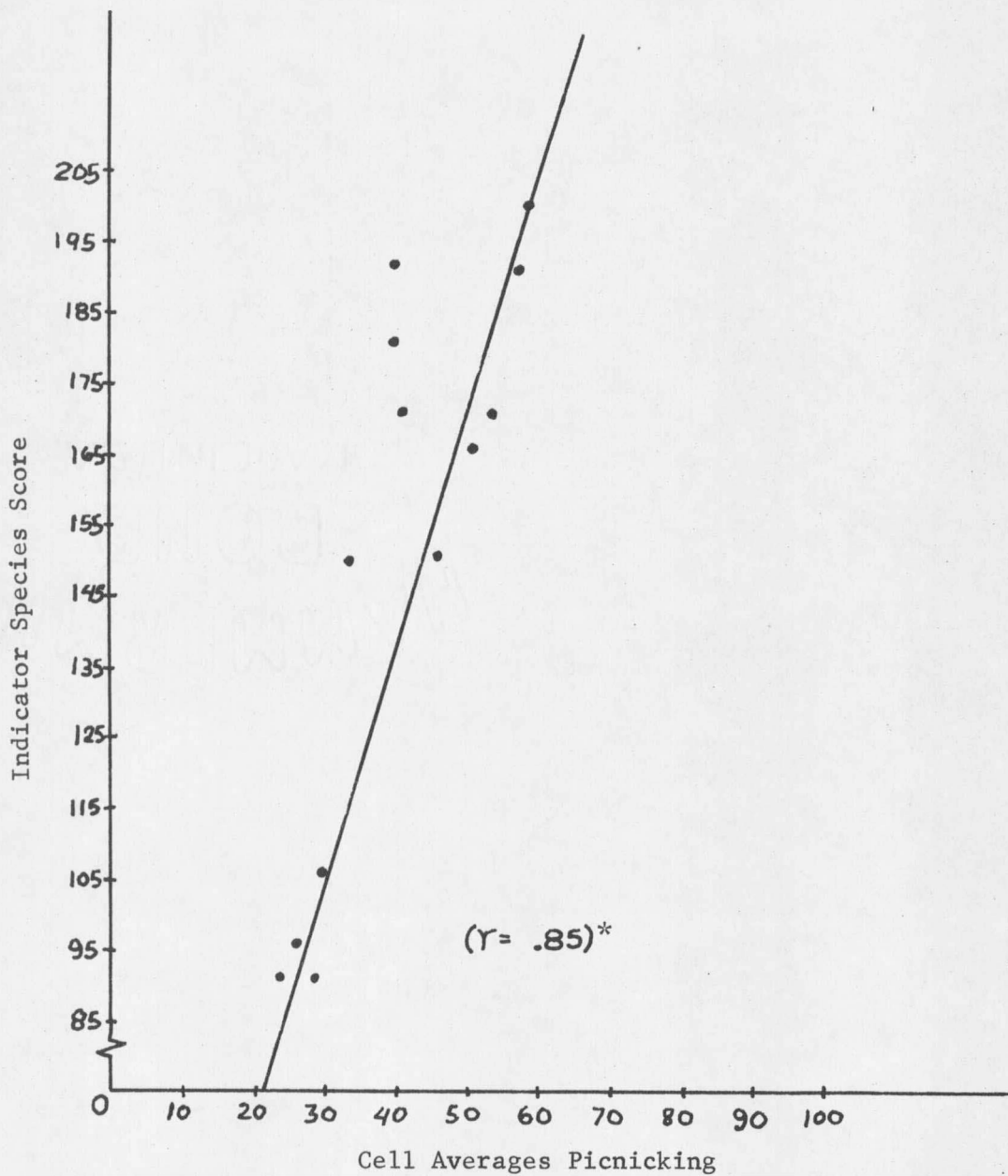


Figure 17. Regression line showing relationship of indicator species score vs cell averages for picnicking in Zone II.

* r value significant at $p = .001$.

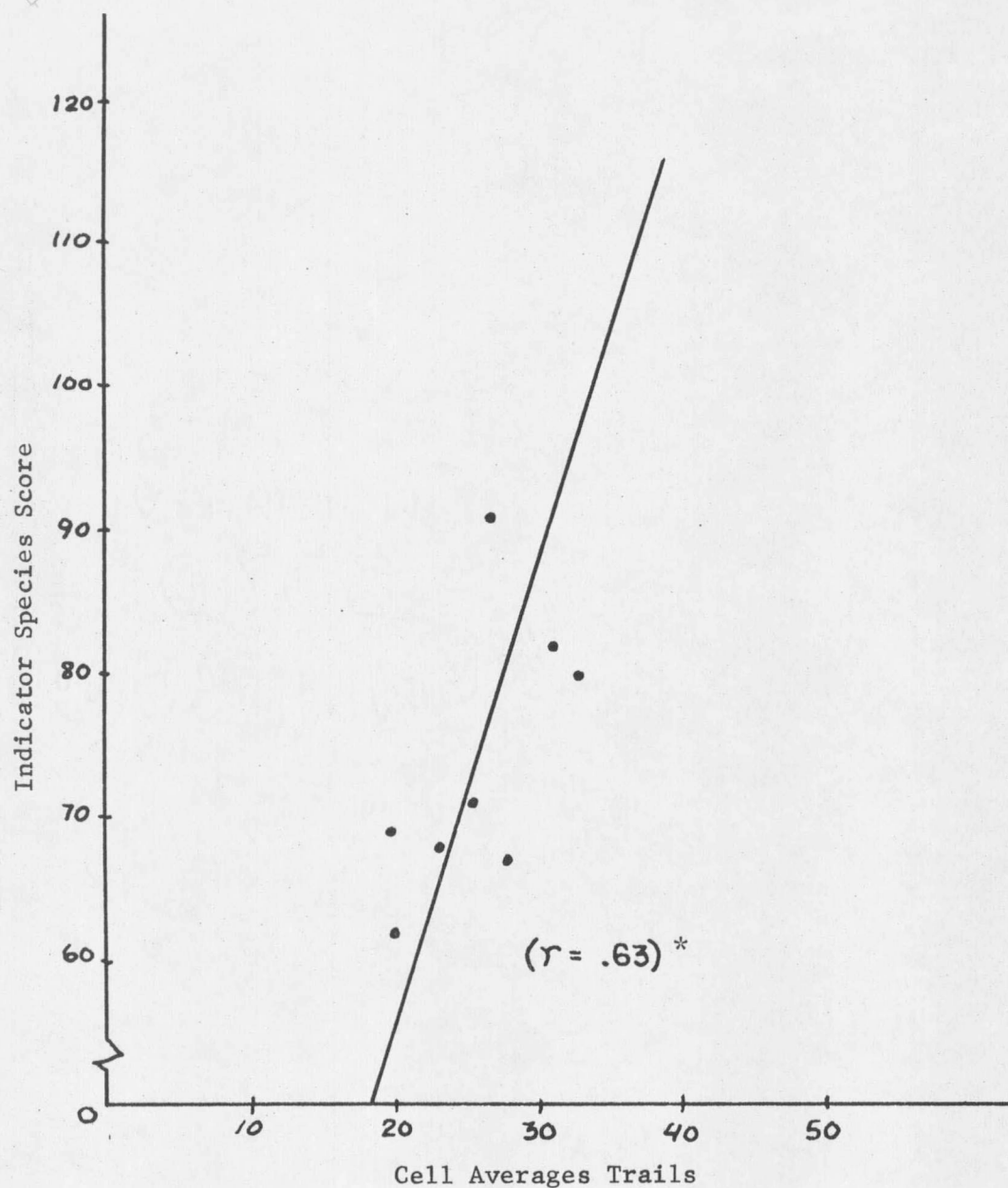


Figure 18. Regression line showing relationship of indicator species score vs cell averages for establishment of trails in Zone III.

* r value significant at $p = .05$.

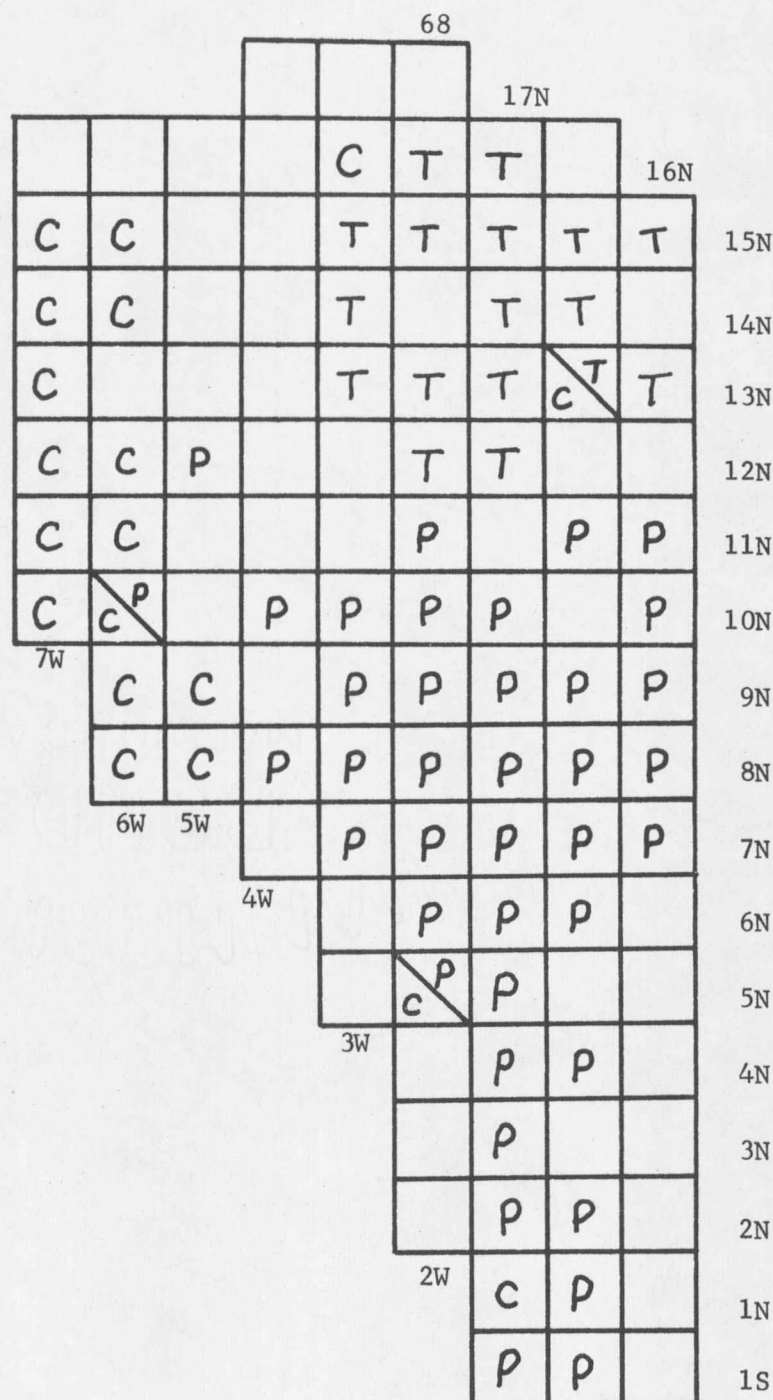


Figure 19. Computer output display indicating which cells of Hyalite Canyon Study Area were compatible with three recreation activities camping (C), picnicking (P) or trails (T). (Scale 1 cm = 50 m)

which flowed continually and it fostered a complex gradient of ecosystems. This attribute warranted exclusion as a use area other than as a natural area. The program also eliminated five heavily disturbed cells - 10N5W, 11N5W, 13N5W, 14N5W and 15N5W. Elimination of other cells within the area was a result of ecotones in which conditions existed that were unfavorable to a particular set of indicator species. Several cells were eliminated on the perimeter of the study area which coincided with the original delineation of potential recreation sites.

The program output was computed from presence-absence data and could be refined to work with occurrence and frequency of occurrence classes.

An additional result of this study was the suggested biophysical resources preferences suggested for the selected indicator species. These preferences, gleaned from zone characteristics are summarized in Table 16.

Application of Research

The practical application of this research was felt to be providing agencies and individuals involved with developing recreation sites with a tool for aiding in the determination of site durability. By rating an expanded list of species for recreational activity compatibility, one could complete a potential site vegetation inventory and then correlate compatible activities and areas within the site. This could be approached several ways. The methodologies developed here could be

Table 16. Suggested biophysical preferences for indicator species.

Species ¹	Soil pH	Soil Texture ²	Aspect	Shade or Sun
Acru	5.5 - 6.5	SCL	West	Shade
Arco	5.0 - 6.5	SiL, SCL	E, W	Shade
Bere	5.5 - 6.5	SCL	W	Shade
Cage	5.5 - 6.5	SCL	W, E	Both
Caru	5.0 - 6.5	SiL, SCL	W, E	Shade
Deoc	5.5 - 6.5	SCL	W	Sun
Geri	5.5 - 6.5	SCL	W, E	Shade
Gevi	5.5 - 6.5	SCL	W, E	Both
Hafl	5.5 - 6.5	SCL	W	Sun
Hesu	5.5 - 6.5	SCL	W	Shade
Libo	5.0 - 5.5	SiL	E	Shade
Luse	5.0 - 5.5	SiL	E	Shade
Mebu	5.5 - 6.5	SCL	W	Sun
Pogr	5.5 - 6.5	SCL	W	Sun
Popr	5.5 - 6.5	SCL	W	Sun
Rowo	5.0 - 6.5	SiL, SCL	E, W	Shade
Ruoc	5.5 - 6.5	SCL	W	Sun
Vasc	5.0 - 5.5	SiL	E	Shade
Clov	5.0 - 5.5	SiL, SCL	E, W	Both

¹ Species acronyms, see Appendix I.

² SCL = Sandy Clay Loam; SiL = Silt Loam.

used as they are and obtain a computer printout of potentially compatible use areas or the methodologies could be altered to suit the site evaluator. The computer program may need refinement to incorporate more data than mere species presence. The inventory procedure may be changed to increase precision. One of the more practical approaches might be for the site evaluator to familiarize himself with those vegetative characteristics which are compatible with the various activities and then rate areas within the site as a visual survey of the site is made. If the subjective species evaluations developed here are valid then one could rate the potential of a site by visually assessing the site and its endemic vegetation.

As an estimate of the time required to vegetatively evaluate a potential recreation area, a person with a good understanding of indicator species might evaluate 40 hectares (100 acres) in approximately two weeks.

It was never intended that the vegetation inventory be a replacement for planning schemes utilizing physical resource inventories. It was meant to be an additional planning tool.

CONCLUSIONS

Research in evaluating the contribution of a vegetation inventory to recreation site planning led to the following conclusions:

- 1) There exists a need for utilization of the vegetation inventory in site planning schemes.
- 2) It was possible to subjectively assess a potential recreation site's compatibility with endemic vegetation by examining the vegetation characteristics.
- 3) Species show preference for specific biophysical resources.
- 4) Indicator species can be used to predict an area's recreation suitability.
- 5) Combined with the vegetation inventory, computer analysis may be used to select compatible recreation use areas within a recreation site.

APPENDIX

APPENDIX I

List of Species and Acronyms

Latin Name	Common Name Shrubs, Forbes and Grasses	Acronym
<i>Achillea millefolium</i>	Yarrow	Acmi
<i>Actea rubra</i>	Baneberry	Acru
<i>Agoseris aurantica</i>	False Dandelion	Agau
<i>Allium brevistylum</i>	Shortsyle onion	Albr
<i>Allium cernuum</i>	Nodding onion	Alce
<i>Amelanchier alnifolia</i>	Serviceberry	Amal
<i>Antennaria racemosa</i>	Pussytoes	Anra
<i>Arctostaphylos uva-ursi</i>	Kinnikinnic	Aruv
<i>Arnica cordifolia</i>	Arnica	Arco
<i>Arnica latifolia</i>	Arnica	Arla
<i>Artemesia tridentata</i>	Sagebrush	Artr
<i>Balsamorhiza sagittata</i>	Arrowleaf Balsamroot	Basa
<i>Berberis repens</i>	Oregon Holly-grape	Bere
<i>Calamagrostis canadensis</i>	Bluejoint	Caca
<i>Calamagrostis rubescens</i>	Pinegrass	Caru
<i>Campanula rotundifolia</i>	Harebell	Caro
<i>Carex geyeri</i>	Elk sedge	Cage
<i>Castilleja miniata</i>	Paintbrush	Cami
<i>Chimaphila umbellata</i>	Prince's Pine	Chum
<i>Cirsium arvense</i>	Thistle	Ciar
<i>Clematis pseudoalpina</i>	Clematis	Clps
<i>Collomia linearis</i>	Collomia	Coli
<i>Corallorhiza maculata</i>	Spotted Coralroot Orchid	Coma
<i>Delphinium nelsoni</i>	Larkspur	Dene
<i>Delphinium occidentale</i>	Tall Larkspur	Deoc
<i>Epilobium angustifolium</i>	Fireweed	Epau
<i>Equisetum arvense</i>	Field Horsetail	Eqar
<i>Erythronium grandiflorum</i>	Glacier Lily	Ergr
<i>Festuca idahoensis</i>	Idaho Fescue	Feid
<i>Fragaria sp.</i>	Wild strawberry	Frag
<i>Galium boreale</i>	Bedstraw	Gabo
<i>Galium triflorum</i>	Bedstraw	Gatr
<i>Gaillardia aristata</i>	Gaillardia	Gaar
<i>Geranium richardsonii</i>	White geranium	Geri
<i>Geranium viscosissimum</i>	Sticky geranium	Gevi
<i>Geum triflorum</i>	Geum	Getr
<i>Hackelia floribunda</i>	Stickseed Forget-me-not	Hafl
<i>Hedysarum sulphurescens</i>	White Sweetvetch	Hesu

Latin Name	Common Name	Acronym
	Shrubs, Forbes and Grasses	
<i>Helianthus nuttallii</i>	Nuttall Sunflower	Henu
<i>Iliamna rivularis</i>	Mountain Hollyhock	Ilri
<i>Iris missouriensis</i>	Wild Iris	Irni
<i>Juniperus communis</i>	Common Juniper	Juco
<i>Linnaea borealis</i>	Twinflower	Libo
<i>Lonicera utahensis</i>	Twinberry Honeysuckle	Lout
<i>Lupinus sericius</i>	Lupine	Luse
<i>Melica bulbosa</i>	Melica Grass	Mebu
<i>Mentha arvensis</i>	Mint	Mear
<i>Mertensia ciliata</i>	Mountain Bluebell	Mece
<i>Perideridia gairdneri</i>	Yampa	Pega
<i>Poa pratensis</i>	Bluegrass	Popr
<i>Polygonum bistortoides</i>	American bistort	Pobi
<i>Potentilla gracilis</i>	Shrubby Cinquefoil	Pogr
<i>Prunella vulgaris</i>	Common selfheal	Pryu
<i>Pterospora andromedea</i>	Pinedrops	Ptan
<i>Ribes montigenum</i>	Gooseberry	Rimo
<i>Rosa woodsii</i>	Woods Rose	Rowo
<i>Rudbeckia occidentalis</i>	Coneflower	Ruoc
<i>Senecio indecorus</i>	Groundsel	Sein
<i>Senecio triangularis</i>	Arrowleaf Groundsel	Setr
<i>Shepherdia canadensis</i>	Buffaloberry	Shca
<i>Smilacina stellata</i>	Solomons seal	Smst
<i>Solidago occidentalis</i>	Goldenrod	Sooc
<i>Spirea betulifolia</i>	Spirea	Spbe
<i>Streptopus amplexifolius</i>	Twisted stalk	Stam
<i>Symphoricarpus albus</i>	Snowberry	Syal
<i>Thalictrum occidentale</i>	Meadowrue	Thoc
<i>Trifolium sp.</i>	Clover	Clov
<i>Vaccinium globulare</i>	Huckleberry	Vagl
<i>Vaccinium scoparium</i>	Whortleberry	Vasc
<i>Zigadenus paniculatus</i>	Death Camus	Zipa

Trees

<i>Abies lasiocarpa</i>	Subalpine Fir	Abla
<i>Picea engelmannii</i>	Englemann Spruce	Pien
<i>Pinus albicaulis</i>	Whitebark Pine	Pial
<i>Pinus contorta</i>	Lodgepole Pine	Pico
<i>Pseudotsuga menziesii</i>	Douglas Fir	Psme
<i>Populus tremuloides</i>	Quaking Aspen	Potr

Appendix II

Vegetation Inventory Checklist #1

Date _____

Cell No. _____

Species	% Coverage by class		
	U	R	P
Geranium v. (Gevi)			
Geranium r. (Geri)			
Polygonum b. (Pobi)			
Hackelia f. (Haf1)			
Helianthus n. (Henu)			
Melica b. (Mebu)			
Senecio i. (Sein)			
Berberis r. (Bere)			
Collomia l. (Coli)			
Clematis sp. (Clps)			
Iris m. (Irmi)			
Shepherdia c. (Shea)			

Trees

Sp. _____

Repro. _____

% Canopt _____

Vigor level _____

Disease _____

Topographic features:

Grass coverage %: _____

Logging indicators:

Appendix II

Vegetation Inventory Checklist #2

Date _____

Species	% Coverage by class		
	U	R	P
Potentilla gracilis (Pogr)			
Vaccinium scoparium (Vasc)			

Cell No. _____

Vegetation Inventory Checklist #3

Date _____

Species	% Coverage by class		
	U	R	P
Delphinium occidentale (Deoc)			
Lupinus sericeus (Luse)			
Arnica sp. (Arco)			
Castilleja miniata (Cami)			
Allium cernuum (Alce)			
Allium brevistylum (Albr)			
Balsamorhiza sagittata (Basa)			

Cell No. _____

Appendix II

Vegetation Inventory Checklist #4

Date _____

Species	% Coverage by class		
	U	R	P
Linnaea borealis (Libo)			
Mertensia ciliata (Meci)			
Rudbeckia occidentalis (Ruoc)			
Rosa woodsii (Rowo)			

Cell No. _____

Vegetation Inventory Checklist #5

Date _____

Species	% Coverage by class		
	U	R	P
Trifolium (Clov)			
Circuum arvense (Ciar)			
Artemesia tridentata (Artr)			
Ribes montigenum (Rimo)			
Thalictrum occidentale (Thoc)			

Cell No. _____

Appendix II

Vegetation Inventory Checklist #6

Date _____

Species	% Coverage by class		
	U	R	P
Symphoricarpus albus (Syal)			
Calamagrostis rubescens (Caru)			
Carex geyeri (Cage)			
Festuca idahoensis (Feid)			
Actea rubra (Acru)			
Spirea betulifolia (Spbe)			
Poa pratensis (Popr)			
Hedysarum Sulphurescens (Hesu)			
Smilacina stellata (Smst)			

Cell No. _____

APPENDIX III

CELL SELECTION PROGRAM

```
1. Integer array (120, 30), Tarray (18), temp, name (120, 2)
2. Integer tname (2), check array (15)
3. Do 1 I = 1, 120
4. Do 1 J = 1, 30
5. 1 array (I, J) = 4H
6. Do 2 I = 1, 120
7. 2 Name (I, 1) = Name (I, 2) = 4H
8. I = 0
9. 5 Read (110, 1000, End = 19) Tname, Tarray
10. If (Tname (1) .eq. Name (I, 1). and. Tname (2) .eq. Name (I, 2)) Go To 12
11. 10 I = I + 1; J = 1
12. Name (I, 1) = Tname (1); Name (I, 2) = Tname (2)
13. 12 Do 15 K = 1, 18
14. If (Tarray (K) .eq. 4H) Go To 18
15. Array (I, J) = Tarray (K)
16. If (J .GE. 30) J = 1; Go To 18
17. 15 J = J + 1
18. 18 Go To 5
19. 19 Numcells = I
20. C Write (106, 103) (Name (I, J), J = 1, 2), (Array (I, K), K = 1, 30), I = 1, Numcells)
21. 100 Do 20 I = 1, 15
22. Read (105, 1001, End = 25) Checkarray (I)
23. 20 Continue
24. 25 If (I .eq. 1) Go To 99
25. Do 50 J = 1, Numcells
26. Do 40 K = 1, I - 1
27. Do 30 L = 1, 30
28. If (Array (J, L) .eq. 4H) Go To 50
29. If (Check array (K) .LT. Array (J, L)) Go To 50
30. If (Check array (K) .EQ. array (J, L)) Go To 40
31. 30 Continue
```

APPENDIX III CONTINUED

CELL SELECTION PROGRAM

- 32. 40 Continue
- 33. Write (108, 1002) Name (J, 1), Name (J, 2)
- 34. 50 Continue
- 35. Go To 100
- 36. 99 Stop
- 37. 1000 Format (A4, A1, 18A4)
- 38. 1001 Format (A4)
- 39. 1002 Format (1H, 2A4)
- 40. 103 Format (120 (1H, A4, A1, X, 25 (A4, X) / , 5 (A4, X) /))

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Eggensperger, Thomas P
Application of the
vegetation inventory to
recreation site planning

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