Biophysical environments of the rough fescue/Idaho fescue (Festuca scabrella/Festuca Idahoensis) habitat type of western Montana
by James Austin Barber

A thesis submitted in partial fulfillment of the requirements of the degree Masters of Science
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Abstract:
Ecosystem patterns (e.g., vegetation) and processes (e.g., succession) are spatially and temporally dynamic. Accordingly, they are best understood through identification of the primary agents responsible for their formation. Hierarchy theory suggests that higher levels of organization in an ecosystem establish constraints in which lower levels of organization develop. Biophysical environments are relatively stable at a given scale of study and establish primary constraints on the types of finer-scale patterns found in an ecosystem. A hierarchical stratification of biophysical environments was used in this study to explain species composition variability within the rough fescue/ Idaho fescue (Festnca scabrella/Festuca Idahoensis) habitat type of western Montana. Canonical correspondence analysis was used to identify species-environment relations and identify environmental variables most important in explaining species variance across sampled plots. Cluster analysis grouped plots into 4 classes based on coarser-scale biophysical environment variables. Analysis of variance and T-tests examined environmental and species composition differences between these classes. Discriminant analysis was used to inspect the correspondence between indirect biophysical environment classifications and direct biophysical environment variables. Results indicate that species variability across plots is a scaled phenomenon in which species distributions are determined by both coarser-scale biophysical environments and finer-scale site variables. Relations between site variables and species composition were significantly improved in this study when sample sites were stratified by appropriate coarser-scale biophysical environment variables. The importance of scaled environmental relations in predicting plant species distributions is emphasized' by this research.

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James Austin Barber

This thesis has been read by each member of the thesis committee and has been found to be satisfactory regarding content, English usage, format, citations, bibliographic style, and consistency, and is ready for submission to the College of Graduate Studies.

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ABSTRACT

Ecosystem patterns (e.g., vegetation) and processes (e.g., succession) are spatially and temporally dynamic. Accordingly, they are best understood through identification of the primary agents responsible for their formation. Hierarchy theory suggests that higher levels of organization in an ecosystem establish constraints in which lower levels of organization develop. Biophysical environments are relatively stable at a given scale of study and establish primary constraints on the types of finer-scale patterns found in an ecosystem. A hierarchical stratification of biophysical environments was used in this study to explain species composition variability within the rough fescue/ Idaho fescue (Festuca scabrella/Festuca Idahoensis) habitat type of western Montana. Canonical correspondence analysis was used to identify species-environment relations and identify environmental variables most important in explaining species variance across sampled plots. Cluster analysis grouped plots into 4 classes based on coarser-scale biophysical environment variables. Analysis of variance and T-tests examined environmental and species composition differences between these classes. Discriminant analysis was used to inspect the correspondence between indirect biophysical environment classifications and direct biophysical environment variables. Results indicate that species variability across plots is a scaled phenomenon in which species distributions are determined by both coarser-scale biophysical environments and finer-scale site variables. Relations between site variables and species composition were significantly improved in this study when sample sites were stratified by appropriate coarser-scale biophysical environment variables. The importance of scaled environmental relations in predicting plant species distributions is emphasized by this research.

OBJECTIVE

The study of ecological systems requires an understanding of ecological patterns and processes at multiple spatial and temporal scales (Bourgeron and Jensen 1994). Ecosystem patterns of importance to management (e.g., vegetation) are spatially and temporally dynamic; consequently, they are best understood through identification of the primary agents responsible for their formation (i.e., biophysical environments and the disturbance agents they constrain) (Levin 1978, Urban et al. 1987).

Vegetation classifications in Montana (Pfister et al. 1979, Meuggler and Stewart 1980) have focused primarily on the use of diagnostic species as environmental integrators without adequate quantification of the environmental variables that constrain their distribution. Environmental variables, when described, are generally treated as accessory characteristics of the plant communities classified and are usually limited to finer-scale variables (e.g., elevation, aspect, slope, and soil properties). Coarser-scale ecosystem components (e.g., landform, lithology) that establish constraints on finer-scale ecosystem patterns (e.g., species composition) are rarely addressed in such classifications.

The primary objective of this research was to examine the relations between coarser-scale, indirect biophysical environment variables, finer-scale site features, and species composition of the rough fescue/Idaho fescue (_Festuca scabrella/Festuca Idahoensis_) habitat type (Meuggler and Stewart 1980) of western Montana. A secondary objective was to detail the hierarchical procedure for classifying ecosystems based on biophysical environment criteria. The specific hypothesis tested in this research was:

H_0: There are _not_ significant species composition differences between biophysical environments of the rough fescue/Idaho fescue habitat type.

H_1: There are significant species composition differences between biophysical environments of the rough fescue/Idaho fescue habitat type.

INTRODUCTION

Vegetation classification in North America has generally concentrated on Clements' view of climax communities (Clements 1916) which assumes that selected assemblages of species indicate the potential for the site in the absence of disturbance (Whittaker 1962). A popular vegetation classification system that embraces this concept is the habitat type system proposed and developed by Daubenmier (1952). In this system, selected species with high fidelity to a particular plant association have been used as diagnostic criteria in the identification of habitat types (Mueller-Dombois and Ellenberg 1974). Many of these species, however, have wide environmental amplitudes which have led to the inclusion of broad site variation in the environments that support a habitat type (Hann 1982). Phases have also been used to further subdivide a habitat type, based on presence of additional diagnostic plant species (Pfister et al. 1977, Meuggler and Stewart 1980). Habitat type classifications are appropriate to the description of biophysical environments on undisturbed sites; however, their usefulness in describing environmental relations on disturbed sites is limited because the diagnostic species used in such classifications may be absent.

Many resource managers use the habitat type classification system to make specific interpretations of resource potentials, limitations, and responses to management activities based on the diagnostic species present on a site. Since many diagnostic species and habitat types occupy wide ranges in environmental gradients (e.g., temperature, moisture, elevation, slope, soil properties), resource interpretations vary within a single habitat type. Further stratification within some habitat types is needed to identify different environments with different management interpretations. Resource managers need detailed information concerning the environments that habitat types occupy to make better and more informed management decisions.

The Clements-based succession model that provides the foundation for habitat type classification systems is inconsistent with current ecological theory regarding succession on many rangelands (Borman and Pyke 1994, Joyce 1993, Friedel 1991, Laycock 1991). Smith (1988) and Laycock (1991) have identified a number of ecologists who have suggested that theories of plant succession which lead to a climatic climax (as suggested in Clements' model) are scientifically inadequate for semi-arid and arid rangeland ecosystems. The ambiguity of establishing climax for most ecosystems is exacerbated by the fact that the climax vegetation for one site may be similar to the species composition of a degraded site which is located on different soil conditions or under different precipitation patterns (Risser 1989). There is not yet general agreement concerning a unifying concept for plant succession; however, theories involving multiple steady states and state-and-transition processes appear to be gaining more acceptance in the scientific literature (Borman and Pyke 1994). Regardless of the theories of plant ecology and community succession used, the examination of differences between plant communities must involve the examination of variables that establish the primary constraints on species found in an ecosystem (Bailey et al. 1994, Bourgeron and Jensen 1994).

Ecological systems are considered complex because they are characterized by strong interactions among components, complex feedback loops, discontinuities, thresholds, and limits (Constanza et al. 1993). These attributes make it difficult to use knowledge of ecosystem behavior at finer-scales to predict behavior at coarser-scales (Jensen et al. 1995). Hierarchy theory (Allen and Starr 1982, O'Neill et al. 1986) suggests that the pattern and process relations of ecosystems are spatially and temporally scaled in such a manner that smaller, finer-scale systems develop within constraints established by the larger, coarser-scale systems in which they are nested. Driving variables at coarser-scales (e.g., lithology, landform) constrain driving variables at finer-scales (e.g., elevation, slope, soil properties) which in turn constrain the types of vegetation that occur on a specific site. For example, coarser-scale driving variables of granitic parent material and glaciated, trough wall landforms constrain finer-scale driving variables such as elevation, slope, and soil properties. Granitic trough walls occur at high elevations with steep slopes, and coarse textured, lithic soils. Vegetation patterns are constrained by finer-scale variables and vegetation types that occupy these sites are commonly limited to whitebark pine (Pinus albicaulis) and sub-alpine fir (Abies lasiocarpa) plant communities. Identification of driving variables at various scales leads to a comprehensive approach to classification based on biophysical environment criteria.

Biophysical environment maps are used to describe ecosystems that behave in a similar manner given their potential ecosystem composition, structure, and function (Bourgeron and Jensen 1994). The ecosystem components used in developing biophysical environment maps commonly include: climate, geology, landform, and soils. Since these components do not display high temporal variability and remain relatively stable following most management activities, biophysical environment maps provide a useful template for interpretation of data that commonly display change following management treatments (e.g. existing vegetation) (Bailey et al. 1994, Bourgeron and Jensen 1994, Jensen et al. 1995).

Biophysical environment maps may be delineated at different spatial scales depending on assessment needs and the types of ecological patterns and processes to be predicted (Jensen et al. 1995). Ecological units (Bailey et al. 1994, ECOMAP 1993, McNab and Avers 1994), land units (Zonnefeld 1989), ecoregions (Omernick 1987), biogeoclimatic ecosystems (Meidinger and Pojar 1991), habitat units (Demarchi 1992), and land systems (Christian and Stewart 1968) are examples of biophysical environment mapping systems that delineate relatively homogeneous environments at different spatial scales based primarily on climatic, geomorphic, and biotic criteria.

Two types of biophysical environment maps are commonly used in ecosystem characterization efforts: those with direct variables and those with indirect variables (Jensen et al. 1995). Direct variables are those found at finer-scales which are presumed to constrain finer-scale patterns of interest (e.g., vegetation) and include: elevation, aspect, slope, and soil properties. Mapping direct biophysical environment variables is both difficult and costly because they require detailed field sampling or modeling to describe (Lessard 1995). Coarser-scale, indirect biophysical environment variables establish constraints on finer-scale, direct variables (ECOMAP 1993) and include: lithologic/surficial material types (ICBEMP 1995), geomorphic landforms, and potential vegetation settings

(Bourgeron et al. 1995). Mapping indirect biophysical environment variables provides resource managers with an inexpensive template to strategize expensive and timely field sampling to ensure that the entire range of environmental gradients for the pattern of interest are adequately quantified.

The National Hierarchical Framework of Ecological Units developed by the USDA, Forest Service, ECOMAP Working Group (ECOMAP 1993) provides a hierarchical system useful to the characterization and description of biophysical environments. The ECOMAP framework suggests methods appropriate to the description of how coarser-scale, indirect biophysical environment variables constrain finer-scale, direct biophysical environment variables. ECOMAP displays how ecosystem patterns (e.g., plant community distribution) and processes (e.g., succession) can be viewed in a hierarchical context. An overview of the National Hierarchical Framework of Ecological Units is provided in Table 1 (ECOMAP 1993).

The primary purpose of the ECOMAP hierarchy is to identify land and water areas at different levels of resolution that have similar capabilities and potentials for management (ECOMAP 1993). Ecological units are identified in this hierarchy based on areas that display similarities in: (1) potential natural communities, (2) soils, (3) hydrologic function, (4) landform and topography, (5) lithology,

Table 1. Generalized Scales Used in Ecological Assessment Efforts and Their Associated Biophysical Environment Units (ECOMAP 1993).

Assessment Scale	Typical Polygon Size (km^2)	Biophysical Units	Differentiating Criteria
Global	>1,000,000	Domain	Broad climate
Continental	100,000-1,000,000	Division	Regional climate
Regional	10,000-100,000	Province	Potential natural vegetation
Subregional	1,000-10,000	Section	Geomorphic province, lithology
Subregional	100-1,000	Subsection	Geomorphic process, surficial material
Landscape	10-100	Landtype Association	Geomorphic landform, local climate
Land Unit	1-10	Landtype	Topography, plant association
Land Unit	0.1-1	Landtype Phase	Soil, slope position, plant association phase

(6) climate, (7) air quality, and (8) natural processes for cycling plant biomass and nutrients (e.g. succession, productivity, fire regimes) (ECOMAP 1993).

The hierarchical scaling procedures used in this study follow those outlined in the ECOMAP framework. Specifically, the effects that coarser-scale biophysical environment variables have on plant species distribution within the rough fescue/Idaho fescue (Festuca scabrella/Festuca Idahoensis) habitat type are described. Data sets are stratified by important coarser-scale, indirect biophysical environment variables (e.g., lithology, landform) to facilitate improved description of the effects that finer-scale, direct biophysical environment variables (e.g., elevation, aspect, slope) have on species distributions. Accounting for the influence that coarser-scale drivers have on species distributions is important if the relations between finer-scale environmental features and species composition are to be understood.

STUDY AREA

The rough fescue/Idaho fescue (Festuca scabrella/ Festuca Idahoensis) habitat type of western Montana (Meuggler and Stewart 1980) represents a grassland plant community with high fidelity of both kinds of fescue along with a variety of annual forbs. Forage production ranges from 400 to over 2,000 lbs/acre depending on range condition class and seasonal weather and is considered one of the most productive upland forage types in western Montana (Meuggler and Stewart 1980). This type occupies a wide range of elevations, precipitation zones, and soil properties.

This study was conducted on both sides of the continental divide in western Montana. The study area was generally limited to mountain environments managed by the USDA Forest Service with a few sites located in Glacier National Park. Several hundred sites were sampled between 1989 and 1993 using consistent sampling procedures as described by the ecology program of the USDA Forest Service, Northern Region (USDA-FS 1988). Sample sites occurred in various landform settings which included: glaciated mountains, colluvial slopes, mass wasted deposits, and fluvial outwash plains. Lithologies and surficial materials sampled included: fine and coarse sediments, meta-sediments, granitics, volcanics, and unconsolidated alluvium and glacial till. Climate regimes of plots in the study area range from warm, dry environments with average annual temperature and precipitation of approximately 6° C and 40 cm (respectively) to cold, wet environments with average annual temperature and precipitation of approximately 0° C and 150 cm (respectively). Elevations range from 1130 to over 2400 meters. The sample sites analyzed occurred on all aspects and generally occupied slopes of less than 30 percent.

METHODS

Plot Level Sampling Procedures

The large amount of data required for statistical analysis in this study required the use of existing data sets collected by the author as well as other soil scientists and ecologists of the USDA, Forest Service, Northern Region. Approximately 400 plots with site and vegetation data collected using ECODATA sampling procedures (USDA-FS 1988) were analyzed in this study. Although plots were sampled by many people (soil scientists, range conservationists, wildlife biologists) for various purposes (ecological inventory, forage values, wildlife habitat), sampling procedures were consistent and followed those outlined in ECODATA (USDA-FS 1988).

A 1/10th acre plot was used in sampling. Site and vegetation data were collected by plot. Site characteristics (e.g. elevation, aspect, slope steepness, slope position, slope shape) and ground cover (Table 2) were described using the General Sampling Method of ECODATA (USDA-FS 1988). Herbaceous and shrub foliar canopy cover and height were recorded based on ocular estimation of canopy cover class (Table 3) using the Plant Composition Sampling Method of ECODATA (USDA-FS 1988).

Table 2. Descriptions of Ground Cover Variables Used in General Site Sampling Procedures (USDA-FS 1988).

Variable	Description
Litter	Organic litter < 1/4 inch diameter
Moss	Live moss on soil surface
Rock	Surface rock > 1/4 inch diameter
Wood	Dead wood > 1/4 inch diameter
Bveg	Basal vegetation
Soil	Bare Soil
Gravel	Surface gravel < 1/4 in. diameter

Table 3. Canopy Cover Classes Used in Plant Composition Sampling Procedures (USDA-FS 1988).

Percent Canopy Cover	Canopy Cover Class
1-3	1
3-5	5
5-15	10
15-25	20
25-35	30
35-45	40
45-55	50
55-65	60
65-75	70
75-85	80
85-95	90
95-100	100

Steps used in analysis of field data (Figure 1) follow those used by Jensen et al. (1995) in development of hierarchical watershed classifications.

STEP 1

Develop disturbance classes based on invader species, surface gravel, and bare soil present on the plots.

STEP 2

Assign biophysical environment variables through ArcInfo Geographic Information System map overlay procedures.

STEP 3

Determine indirect biophysical environment variables responsible for explaining variance in species composition between plots (canonical correspondence analysis).

STEP 4

Develop classifications of plots using significant indirect variables identified in step 3 (cluster analysis).

STEP 5

Determine differences in both indirect and direct variables between classification groups (F-ratios, analysis of variance, T-tests, box plots).

STEP 6

Determine differences in species composition between classification groups (analysis of variance, T-tests, constancy/average cover table).

STEP 7

Test the correspondence between classifications based on indirect vs. direct biophysical environment variables (discriminant analysis).

STEP 8

Identify direct variables responsible for explaining species composition variance in each classification group and describe environmental ordination of species in each classification group (canonical correspondence analysis).

Figure 1. Generalized Description of Steps Used in Analysis of Biophysical Environments in this Study.

The following is a description of analysis steps used in this study:

Step 1: Disturbance Criteria

To minimize species variance due to different successional stages of sampled plots, disturbance classes were developed based on the abundance of invader species, and the percent cover of bare soil, and surface gravel (< 1/4 inch diameter) on the plots. Invader species used in this analysis were species associated with overgrazing in previous rangeland studies (Dyskerius 1949, Meuggler and Stewart 1980) and included: thistle (Cirsium vulgare), spotted knapweed (Centaurea maculosa), dandelion (Taraxacum officinale), Kentucky bluegrass (Poa pratensis), cheat grass (Bromus tectorum), yellow salsify (Tragopogon dubius), and spikemoss (Selaginella densa). Surface gravel and bare soil are not necessarily a result of disturbance but when present in large quantities, may be a result of grazing pressure. The criteria used in assigning plots to disturbance classes for analysis in this study are displayed in Table 4. Only LOW disturbance class plots were used for analysis to improve understanding of the effects that different environmental variables have on species distributions across the study area. Plots in MODERATE and HIGH disturbance classes were excluded from the analysis to minimize the effects of past grazing on the relations presented.

Table 4. Criteria Used in Disturbance Stratification of Sampled Plots.

Disturbance Class	Invader Species Canopy Cover		Bare Soil + Surface Gravel Cover		Bare Soil Cover
HIGH	>20%	or	>50%	or	≥35%
MODERATE	>3% & ≤20%	or	>30% & ≤50%		
LOW	≤3%	and	≤30%		

Step 2: GIS Map Overlay Procedures

Indirect biophysical environment variables were assigned to sampled plot data through map overlay procedures in an ArcInfo Geographic Information System. These variables were developed for western Montana at a 1x1 km resolution in the Columbia River Basin Assessment Project (ICBEMP 1995) and included: subsection group, regional potential natural vegetation, and lithology/surficial material type.

Subsection groups were mapped at the subregional scale in the ECOMAP hierarchy and are characterized by combinations of climate, geomorphic process, and topography (ECOMAP 1993). The 283 subsections developed for the Columbia River Basin were assembled into 39 subsection groups based primarily on landform and surficial geology criteria (ICBEMP 1995). Six subsection groups occurred on plots in this study and are described in Table 5.

Table 5. Description of Subsection Groups That Occurred on Plots Analyzed in This Study.

Subsection Group	Province	Landform	Processes	Lithologies
M33203	Middle Rocky Mtn.	intermontain basins and valleys	fluvial and glacial	sedimentary
M33205	Middle Rocky Mtn.	mountains	glacial, fluvial, colluvial, mass wasting	granite and gneiss
M33206	Middle Rocky Mtn.	mountains	glacial, fluvial, colluvial, mass wasting	granitic and sedimentary
M33207	Middle Rocky Mtn.	mountains	fluvial, colluvial, mass wasting, and frost churning	heterogeneous: igneous and metamorphic
M33208	Middle Rocky Mtn.	mountains	fluvial and colluvial	heterogeneous: igneous, sedimentary and metamorphic
M33303	Northern Rocky Mtn.	mountains	glacial and fluvial	granitic and metasedimentary

A total of 48 regional potential natural vegetation (PNV) types were identified across the Columbia River Basin (CRB) based on topographic modeling of plant association group settings within geoclimatic subsections (Bourgeron et al. 1995). A regional hierarchical classification of western

U.S. vegetation (Bourgeron and Engelking 1994) was used to assign 807 terrestrial plant associations to 4x4 matrices of temperature and moisture within broad physiognomic vegetation classes of forest, shrubland, and herbaceous environments. The 48 regional PNV types were assigned to a 1x1 km base map through use of a 90 meter digital elevation model using elevation, aspect and slope rule sets developed by subsection to facilitate spatial descriptions of such classifications across the CRB (Jensen et al. 1995). Fourteen regional PNV types occurred on plots in this study and are described in Table 6.

Table 6. Regional Potential Natural Vegetation Types that Occurred on Plots Analyzed in this Study.

PNV Type	Description
H23	cool, dry herblands
H33	warm, dry herblands
S13	cold, dry shrublands
S22	cool, moist shrublands
F11	cold, wet forests
F12	cold, moist forests
F13	cold, dry forests
F21	cool, wet forests
F22	cool, moist forests
F23	cool, dry forests
F24	cool, very dry forests
F32	warm, moist forests
F33	warm, dry forests
F43	hot, dry forests

A total of 41 lithology/surficial material types were identified for the Columbia River Basin at a 1x1 km resolution based on USGS State Geology maps (Jensen et al. 1995). Twelve lithology/surficial material types occurred on plots in this study and are described in Table 7.

Table 7. Lithology/Surficial Material Types That Occurred on Plots Analyzed in this Study.

Lithology/ Surficial Material Type	Description
L2	alluvium
L3	argillite and slate
L4	calcareous-alkaline intrusive
L6	calcareous-alkaline volcanoclastic
L7	carbonate
L12	glacial drift
L21	mafic intrusive
L29	meta-siltstone
L31	mixed carbonate and shale
L33	mixed miogeosynclinal
L36	sandstone
L37	shale and mudstone

Climate variables were treated as finer-scale, direct biophysical environment variables in this study and were modeled for the Columbia River Basin using MTCLIM - a mountain microclimate simulation model (Hungerford et al. 1989). Climate data for 1989 were used in this analysis because 1989 was an average year for temperature and moisture in Montana. MTCLIM extrapolates weather data from a point of measurement (weather station) to the site of interest, making corrections for differences in elevation, aspect, and slope between the station and the site. Climate variables used in this analysis are described in Table 8.

Table 8. Climate Variables Used in this Study.

Climate Variable	Description
PRCP	total annual precipitation
PRCPSP	total spring precipitation (Apr,May,Jun)
PRCPSU	total summer precipitation (Jul,Aug,Sep)
PRCPFA	total fall precipitation (Oct,Nov,Dec)
PRCPWN	total winter precipitation (Jan,Feb,Mar)
TAVG	average annual temperature
TMAXJUL	maximum July temperature
TMINJAN	minimum January temperature
SRAD	total annual solar radiation

Step 3: Canonical Correspondence Analysis

Relations between species composition and biophysical environment variables (direct and indirect) for sample plots were established using canonical correspondence analysis (CCA), a multivariate ordination procedure (terBraak 1992). CCA is used in ecological studies to determine the minimal set of variables that best explain the observed variance in species composition of sampled plots (Jensen et al. 1995). CCA also aligns species along ordination axes. Species that tend to occur together on certain plots are placed on one end of the axis; species that occur together on other plots are placed at the opposite end of the axis. Environmental variables are correlated to the ordination axis thus facilitating improved understanding of the species-environment relations across the sample plots.

Canonical correspondence analysis was performed using no species or environmental variable weighting. Forward selection of environmental variables was performed to determine the cumulative variance in species abundance explained by the addition of each new variable.

Step 4: Biophysical Environment Classes

Biophysical environment classifications were developed using the indirect variables that best explained the species composition variance of sampled plots in canonical correspondence analysis (terBraak 1992). A model-based clustering algorithm (Banfield and Raftery 1993) was used to suggest the optimum number of classes present in the data using the MCLUST program of S-PLUS (Statistical Sciences, Inc. 1993). Assignment of plots to individual classes was accomplished using the Ward (1963) hierarchical agglomerative clustering method of MCLUST.

Step 5: Differences in Biophysical Variables

Differences in both direct and indirect biophysical environment variables were determined between biophysical environment classes. Discriminant analysis in SYSTAT (Wilkinson 1989) was used to determine which indirect variables were most significant in assigning class membership to plots. An analysis of variance was performed in SYSTAT to determine if the classes significantly minimized the observed variance in direct variables across plots. T-tests were performed in SYSTAT to determine significant differences in direct variables between classes.

Step 6: Differences in Species Composition

An analysis of variance (ANOVA) in SYSTAT (Wilkinson 1989) was used to determine if indirect biophysical environment classes significantly minimized the observed variance in species composition across plots. T-tests were performed on species determined significant by the ANOVA. A constancy/average cover table (ECADS 1995) was constructed to examine species composition differences between classes.

Step 7: Discriminant Analysis Between Classes

Discriminant analysis in SYSTAT (Wilkinson 1989) was used to test how well direct biophysical environment variables predicted class membership of plots as determined by the classification based on indirect biophysical environment variables. This test was performed to determine if the classifications based on indirect variables could be explained in terms of direct biophysical properties that constrain the finer-scale pattern of species composition.

Step 8: Environmental Ordination Within Classes

A total of four ordination axes were derived within each indirect biophysical environment class to explain relations between species composition and direct biophysical variables using canonical correspondence analysis (terBraak 1992). The significance of these ordinations in explaining the variance of species composition by direct variable criteria was determined for the first canonical ordination axis and all four axes collectively.

RESULTS AND DISCUSSION

Species-Environment Relations Across All Plots

Canonical correspondence analysis (CCA) (terBraak 1992) was performed to determine those direct and indirect variables most responsible for explaining variance in species composition between plots. Only minimally disturbed plots (LOW, n=172) were used in analysis to reduce the amount of species variance attributable to past management activities in the data set (i.e., disturbed community types were excluded from analysis). Several plots with canopy cover less than three percent were inadvertently included in the analysis. These plots should have been omitted on the basis of being affected by past management but probably did not have significant impacts on the statistical results or conclusions. Direct and indirect variables were run separately to inspect the relation that each had on species distributions across the sample sites. Results of the CCA are displayed for indirect variables in Table 9 and direct variables in Table 10.

Table 9. Canonical Correspondence Analysis Output Based on Indirect Biophysical Environment Variables (n=172).

	Axis 1	Axis 2	Axis 3	Axis 4
Eigenvalues	.350	.327	.310	.296
Species-Environment Correlations	.845	.873	.940	.832
Cumulative Percent Variance of Species Data	1.9	3.6	5.3	6.9
Cumulative Percent Variance of Species-Environment Relations	10.5	20.4	29.7	38.6

Table 10. Canonical Correspondence Analysis Output Based on Direct Biophysical Environment Variables (n=172).

	Axis 1	Axis 2	Axis 3	Axis 4
Eigenvalues	.380	.300	.272	.239
Species-Environment Correlations	.836	.822	.826	.821
Cumulative Percent Variance of Species Data	2.0	3.7	5.1	6.4
Cumulative Percent Variance of Species-Environment Relations	11.5	20.7	28.9	36.2

Axis 1 for both indirect and direct variables displayed the strongest environmental gradient within the data set as shown by the high eigenvalues which measure the importance of the axes. The species-environment correlations, which measure the strength of relation between species and environmental variables were relatively high (.845 and .836); however, the percent variance of species data explained by these axes were low (1.9% and 2.0%). The cumulative percent of species variance explained by all four axes was 6.9% for indirect variables and 6.4% for direct variables.

Results of both direct and indirect biophysical environment ordinations were relatively similar indicating that indirect variables were as effective as direct variables in explaining the species composition across sampled plots. The combination of low variance scores and similarity between canonical correspondence analysis runs suggests that there may be some coarser-scale variable relations that inhibit the ability of finer-scale variables to explain species composition variance.

In an attempt to increase the amount of species variance explained by finer-scale, direct biophysical environment variables, plots were clustered based on those indirect biophysical environment variables that best explained species variance in a forward selection procedure of canonical correspondence analysis (Table 11). Twelve indirect variables were found to be significant ($p \leq 0.10$) in explaining species composition variance across all plots. These variables were used in developing classifications of coarser-scale biophysical environments that constrained species distributions at the site (plot) level.

Table 11. Listing of Significant ($p \leq 0.10$) Indirect Biophysical Environment Variables Most Useful in Explaining Species Variance Across Sampled Plots.

Importance Order	Variable	P-Value	Cumulative Variance Explained
1	S13	0.07	0.31
2	M33206	0.01	0.62
3	M33208	0.01	0.86
4	L2	0.01	1.10
5	M33207	0.04	1.32
6	F11	0.01	1.62
7	L3	0.07	1.82
8	L4	0.01	2.00
9	F13	0.01	2.18
10	F24	0.05	2.35
11	F22	0.02	2.66
12	F23	0.02	2.81

Identification of Geoclimatic Settings

Model-based clustering (Banfield and Raftery 1993) in S-PLUS (Statistical Sciences Inc. 1993) indicated that four classes provided optimum separation of plots based on the indirect biophysical environment variables listed in Table 11. Hierarchical clustering (Ward 1963) in the MCLUST program of S-PLUS grouped plots into four classes that represent distinct geoclimatic settings (Figures 2 and 3). Percent composition of indirect variables within each class was also determined (Tables 12-14).

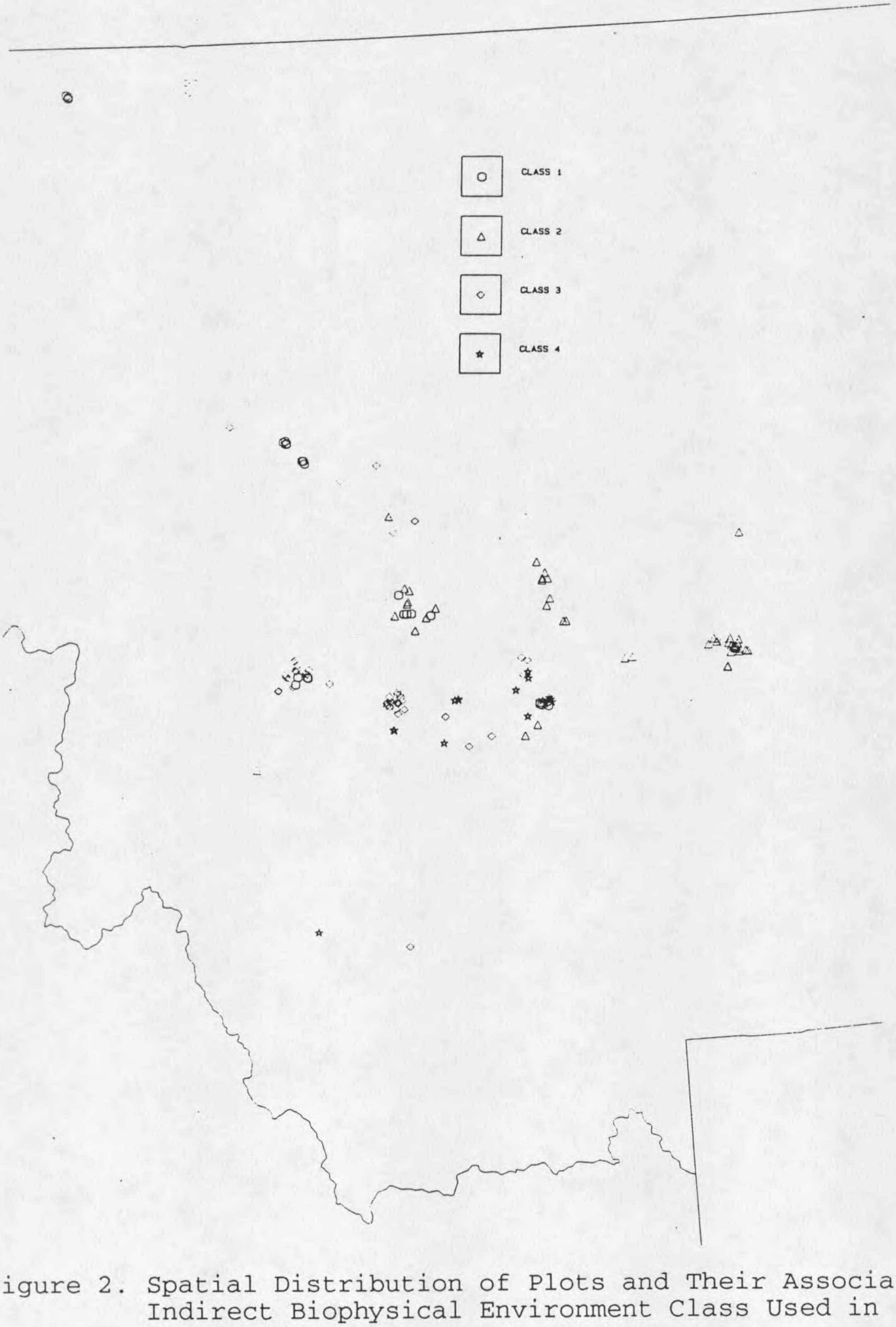

Figure 2. Spatial Distribution of Plots and Their Associated Indirect Biophysical Environment Class Used in this Study.

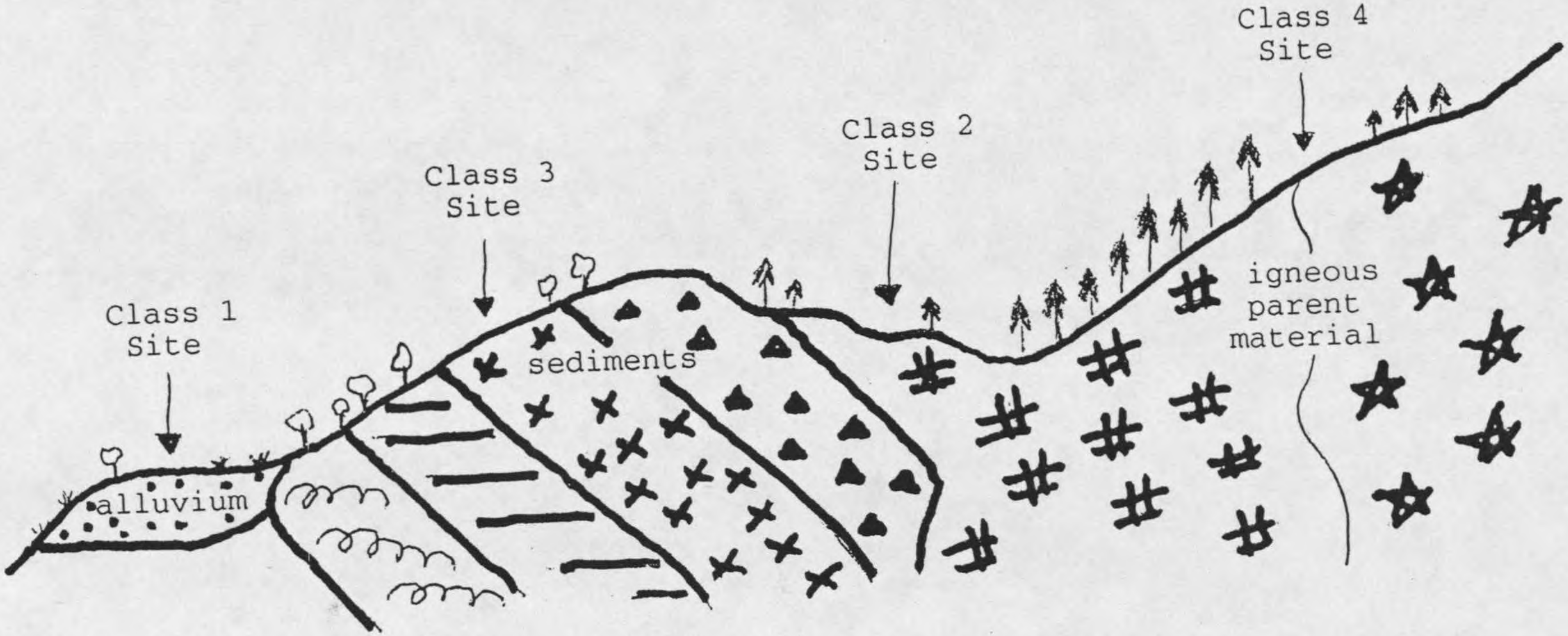

Figure 3. Cross-sectional View of Modal Sites for Plots in Four Biophysical Environment Classes Developed in This Study.

Table 12. Percent Composition of Subsection Groups Within Four Indirect Biophysical Environment Classes.

Subsection Group	Class 1	Class 2	Class 3	Class 4
M33203			1	5
M33205	30	2	76	95
M33206			7	
M33207		2	8	
M33208	17	96	4	
M33303	53		3	

Table 13. Percent Composition of Lithology/Surficial Material Types Within Four Indirect Biophysical Environment Classes.

Lithology/ Surficial Material Type	Class 1	Class 2	Class 3	Class 4
L2	47			
L3		4	1	
L4			13	37
L6	17	4	36	63
L7	3	16	3	
L12		2	1	
L21			3	
L29	3	6	6	
L31	7	20	1	
L33	10	16	10	
L36	3	6	4	
L37	10	27	22	

Table 14. Percent Composition of Regional Potential Natural Vegetation Types Within Four Indirect Biophysical Environment Classes.

PNV Type	Class 1	Class 2	Class 3	Class 4
H23		10	3	
H33			11	
S13		2		
S22			19	
F11			7	
F12		4	1	
F13				100
F21			1	
F22	17	29	6	
F23	67		6	
F24			14	
F32		8		
F33	17	47	19	
F43			13	

To facilitate an improved understanding of each biophysical environment class, a description of a modal site for each setting is as follows:

A typical plot for Class 1, geoclimatic settings, occurs in a valley bottom on a glacial outwash plain of mixed mineralogy. The soil is medium to fine textured with numerous coarse fragments. This plot occurs at 5,300 feet elevation on a 5% slope, with an easterly aspect. The site matures phenologically early in the summer and drys out by the end of July in normal seasons. Adjacent plant communities include Douglas fir (Pseudotsuga menziesii) and mountain big sage (Artemisia tridentata) plant associations.

A typical plot for Class 2, geoclimatic settings, occurs on a colluvial slope of shale lithology. The soil is fine textured with few coarse fragments. This plot occurs at 6,200 feet elevation on a 10% slope, with a northerly aspect. This site maintains adequate soil moisture late into the summer and dries out in mid-August. Adjacent plant communities include Douglas fir (Pseudotsuga menziesii) and subalpine fir (Abies lasiocarpa) plant associations.

A typical plot for Class 3, geoclimatic settings, occurs on rhyolite lithology that has been affected by glaciation and frost churning. Soils are medium textured with numerous angular coarse fragments. This plot occurs at an elevation of 5,900 feet, on a 15% slope, and has a westerly aspect. This site dries out in early August due to the high energy aspect and low water holding capacity of the soil. Adjacent plant communities are Douglas fir (Pseudotsuga menziesii) plant associations.

A typical plot for Class 4, geoclimatic settings, occurs on a glacially scoured slope with areas of glacial deposition. Lithology is volcanoclastic intrusive. Soils are medium textured with numerous coarse fragments. This plot occurs at an elevation of 7,600 feet, on a 20% slope, and has a southerly aspect. Vegetation on this site matures later in the spring due to late snow cover and dries out in late August. Adjacent plant communities are subalpine fir (Abies lasiocarpa) plant associations.

A discriminant analysis (Wilkinson 1989) was performed on the four indirect biophysical environment classes to determine which of the 12 indirect biophysical environment variables were most significant in determining class membership of individual plots. Univariate F-tests in the discriminant analysis (Table 15) suggest that subsection group M33208 (unglaciated, fluvial/colluvial landforms with mixed lithologies) was highly significant in determining the class membership of plots. Regional potential natural

Table 15. Indirect Biophysical Environment Variables Ordered by Significance in Determining Classification Groupings in MCLUST.

Importance Order	Variable	F-Value	P-Value
1	M33208	182.10	0.00
2	F23	54.73	0.00
3	L2	40.45	0.00
4	L4	10.09	0.00
5	F22	6.40	0.00
6	F24	5.25	0.01
7	L7	3.71	0.01
8	M33206	2.43	0.07
9	F11	2.43	0.07
10	M33207	2.03	0.11
11	S13	0.79	0.50
12	L3	0.78	0.51

vegetation type F23 (cool/dry forests), and lithology/ surficial material types L2 (alluvium) and L4 (calcareous-alkaline intrusive) were also important in determining the placement of plots into the four indirect biophysical environment classifications developed.

Comparison of information contained in Tables 12 through 15 facilitated an improved understanding of the different environments indicated by the four indirect biophysical environment classifications developed in this study. For example, subsection group M33208 dominated Class 2 plots and occurred only as an inclusion in other classes. Regional potential natural vegetation type F23 occurred almost exclusively on Class 1 plots and F24 occurred only on Class 3 plots. Lithology/surficial material type L2 occurred only on Class 1 plots, and L4 only on class 3 and 4 plots.

Three multivariate test statistics including Wilk's Lambda, Pillai, and Hotelling-Lawley (Wilkinson 1989) were also performed in the discriminant analysis on all indirect variables (Table 16). All tests revealed highly significant

Table 16. Multivariate Test Statistics on Indirect Biophysical Environment Variables Between Four Indirect Biophysical Environment Classes.

Multivariate Test	F-value	P-value
Wilk's Lambda	33.26	0.00
Pillai	20.12	0.00
Hotelling-Lawley	44.88	0.00

differences (p<0.01) in indirect variables between classes. These results from the univariate and multivariate tests are not surprising because the variables tested were those used to build the indirect biophysical environment classifications.

All direct biophysical environment variables (except aspect) are continuous variables; consequently, differences in these variables between indirect biophysical environment classes were determined through analysis of variance (ANOVA) and T-tests. Differences in direct variables between indirect biophysical environment classes are displayed by boxplots in Appendix A. An ANOVA (Table 17) determined that the four classes significantly reduced the variance in 15 direct biophysical environment variables (p<0.10) studied across the plots. Selected T-test results (Table 18) show differences in mean values of the variables tested between classes. The classes compared are shown in the first two columns followed by the variable tested, mean values for each class, and the calculated T- and P-values. Boxplots (Appendix A) show the median value of the variable examined as a white bar, the 95% confidence interval for the median as a dark box, and the inter-quartile range as a light box. These results indicate that the indirect biophysical environment classes differed with respect to certain direct biophysical environment variables. For example, elevations of Class 4 plots were significantly higher than plots of

Table 17. Effectiveness of Four Indirect Biophysical Environment Classes in Explaining the Variance of Direct Biophysical Environment Variables Across All Sample Plots. Between and Within Degrees of Freedom are 3 and 168 Respectively.

Variable	Between Sum Sqr.	Within Sum Sqr.	Total Sum Sqr.	Between Mean Sqr. Error	Within Mean Sqr. Error	F Value	P Value
Litter	22,692	54,549	77,241	7,564	325	23.30	0.00
TMINJAN	95	270	365	32	2	19.72	0.00
TAVG	93	269	362	31	2	19.26	0.00
Bveg	5,342	16,774	22,117	1,781	100	17.84	0.00
TMAXJUL	132	554	686	44	3	13.31	0.00
SRAD	6,562	27,612	34,175	2,187	164	13.31	0.00
Elevation	27,521,499	36,378,730	63,900,229	9,173,833	811,778	11.30	0.00
Slope	2,921	22,988	25,909	974	137	7.12	0.01
Moss	2,086	18,753	20,840	695	112	6.23	0.01
PRCPSU	216	2,346	2,562	72	14	5.15	0.01
PRCPFA	740	9,849	10,589	247	59	4.21	0.01
Gravel	187	2,715	2,902	62	16	3.87	0.01
Rock	370	5,606	5,976	123	33	3.69	0.01
PRCPWN	475	8,222	8,697	159	49	3.24	0.02
PRCP	348,484	7,482,818	7,831,302	116,161	44,541	2.61	0.05
Water	14	412	427	5	2	1.95	0.12
Wood	6	191	197	2	1	1.81	0.15
Soil	230	10,292	10,522	77	61	1.25	0.29
PRCPSP	5	3,540	3,545	2	21	0.07	0.97

Table 18. Differences in Selected Direct Biophysical Environment Variables Between Four Indirect Biophysical Environment Classes.

Class	Class	Variable Tested	Mean 1	Mean 2	T Value	P Value
1	2	Elevation	5,667	6,304	-2.49	0.02
1	3	Elevation	5,667	6,201	-2.20	0.03
1	4	Elevation	5,667	7,196	-6.47	0.00
2	3	Elevation	6,304	6,201	0.64	0.52
2	4	Elevation	6,304	7,196	-5.84	0.00
3	4	Elevation	6,201	7,196	-7.73	0.00
1	2	Slope	9	12	-0.91	0.37
1	3	Slope	9	17	-3.16	0.01
1	4	Slope	9	22	-3.29	0.01
2	3	Slope	12	17	-2.88	0.01
2	4	Slope	12	22	-2.95	0.01
3	4	Slope	17	22	-1.34	0.19
1	2	TAVG	3.6	2.6	3.37	0.01
1	3	TAVG	3.6	3.2	1.16	0.25
1	4	TAVG	3.6	1.0	8.42	0.00
2	3	TAVG	2.6	3.2	-2.72	0.01
2	4	TAVG	2.6	1.0	7.45	0.00
3	4	TAVG	3.2	1.0	8.98	0.00
1	2	TMAXJUL	26.4	26.1	0.94	0.35
1	3	TMAXJUL	26.4	26.0	1.04	0.30
1	4	TMAXJUL	26.4	23.3	7.00	0.00
2	3	TMAXJUL	26.1	26.0	0.31	0.75
2	4	TMAXJUL	26.1	23.3	8.08	0.00
3	4	TMAXJUL	26.0	23.3	6.55	0.00
1	2	TMINJAN	-9.6	-11.0	4.86	0.00
1	3	TMINJAN	-9.6	-9.9	0.91	0.37
1	4	TMINJAN	-9.6	-11.8	5.95	0.00
2	3	TMINJAN	-11.0	-9.9	-5.26	0.00
2	4	TMINJAN	-11.0	-11.8	2.76	0.01
3	4	TMINJAN	-9.9	-11.8	6.08	0.00

other classes and elevations of Class 1 plots were significantly lower than plots in other classes ($p \leq 0.03$). Slopes were significantly steeper on Class 3 and 4 plots than on Class 1 and 2 plots ($p \leq 0.01$). Annual average temperature, maximum July temperature, and minimum January temperature are significantly lower on Class 4 plots ($p \leq 0.01$) and were generally highest on Class 1 plots ($p \leq 0.37$).

Biophysical environments based on indirect variables are commonly assumed to integrate the effects that direct variables have on constraining finer-scale patterns of ecological relevance (e.g., species composition) (ECOMAP 1993, Jensen et al. 1995). Discriminant analysis in SYSTAT (Wilkinson 1989) was used to test this assumption across the four indirect biophysical environment classes developed in this study. Discriminant functions were derived to test the ability of direct biophysical variables to assign plots into their correct indirect biophysical environment class. Results of this analysis indicated that 63 to 89 percent of the sampled plots could be correctly assigned to their indirect biophysical environment classification based on direct biophysical environment criteria (Tables 19 and 20). These results indicate that classes based on indirect biophysical environment variables provided a reasonable synthesis of the direct variables that influence species distributions in this study.

Table 19. Re-Classification of Plots Based on Direct Biophysical Environment Variables.

Class	Predicted Class 1	Predicted Class 2	Predicted Class 3	Predicted Class 4
1	19	1	6	4
2	4	39	5	3
3	4	8	52	8
4	1	1	0	17

Table 20. Percent of Plots Correctly Assigned to their Indirect Biophysical Environment Class Based on Direct Biophysical Environment Variables.

Class	Total Number of Plots	Percent Correctly Classified
1	30	63
2	51	76
3	72	72
4	19	89

Differences in species composition between classes were determined by analysis of variance (ANOVA), constancy/ average cover tables, and T-tests. An ANOVA (Table 21) determined that the four indirect biophysical environment classes significantly reduced the variance of 28 species ($p<0.05$) across all plots. Table 22 shows the constancy/ average cover of these 28 significant species (with canopy cover $\geq$ 3%) and Table 23 shows T-test results of selected species differences between indirect biophysical environment classes. A constancy/average cover table of all species with $\geq$ 3 % canopy cover for all classes is located in Appendix B.

Table 21. Effectiveness of Four Indirect Biophysical Environment Classes in Explaining Species Abundance Differences Across All Plots. Only Species with P-values less than 0.05 are Displayed in this Table. Between and Within Degrees of Freedom are 3 and 168 Respectively.

Species	Between Sum Sqr.	Within Sum Sqr.	Total Sum Sqr.	Between Mean Sqr. Error	Within Mean Sqr. Error	F Value	P Value
Lupinus sericeus	1,040	6,607	7,647	347	39	8.82	0.000
Koeleria cristata	280	1,869	2,149	93	11	8.40	0.000
Arenaria congesta	239	1,850	2,089	80	11	7.23	0.000
Arnica fulgens	6	56	63	2	0.3	6.39	0.000
Geranium richardsonii	3	29	32	1	0.2	5.86	0.001
Anaphalis margaritacea	3	29	32	1	0.2	5.86	0.001
Pedicularis groenlandica	3	29	32	1	0.2	5.86	0.001
Streptanthella longirostris	3	29	32	1	0.2	5.86	0.001
Carex hoodii	107	1,031	1,138	36	6	5.83	0.001
Danthonia parryi	25	244	269	8	1.5	5.68	0.001
Agropyron smithii	39	388	427	13	2	5.59	0.001
Lupine argenteus	253	2,557	2,810	84	15	5.55	0.001
Festuca scabrella	4,089	46,651	50,740	1,363	278	4.91	0.003
Cerastyum arvense	72	822	894	24	5	4.91	0.003

Table 21 (cont). Effectiveness of Four Indirect Biophysical Environment Classes in Explaining Species Abundance Differences Across All Plots. Only Species with P-values less than 0.05 are Displayed in this Table. Between and Within Degrees of Freedom are 3 and 168 Respectively.

Species	Between Sum Sqr.	Within Sum Sqr.	Total Sum Sqr.	Between Mean Sqr. Error	Within Mean Sqr. Error	F Value	P Value
Antenaria microphylla	255	2,611	2,836	75	16	4.83	0.003
Poa fendleriana	6	72	78	2	0.4	4.28	0.006
Erigeron subtrinervis	28	371	399	9	2	4.21	0.007
Penstemon procerus	56	753	809	19	4	4.16	0.007
Eriogonum umbellatum	81	1,132	1,213	27	7	4.01	0.009
Carex raynoldsii	3	44	47	1	0.3	3.59	0.015
Artemisia ludoviciana	12	198	210	4	1	3.38	0.019
Carex luzulina	10	171	181	3	1	3.30	0.022
Euphorbia esula	49	823	872	16	5	3.30	0.022
Danthonia intermedia	302	5,332	5,635	101	32	3.18	0.026
Carex filifolia	266	5,097	5,363	89	30	2.93	0.035
Gayophytum racemosum	1	15	16	0.3	0.1	2.77	0.043
Lomatium cous	1	15	16	0.3	0.1	2.77	0.043
Antennaria racemosa	2	45	47	0.7	0.3	2.66	0.049

Table 22. Constancy/Average Cover Table for Species Listed in Table 21 (with Canopy Cover $\geq$ 3%) by Four Indirect Biophysical Environment Classes. Values Presented are Constancy, Average Cover When Present, Minimum Cover When Present, and Maximum Cover When Present, Respectively.

Species	Class 1	Class 2	Class 3	Class 4
Lupinus sericeus	33(8)[3-20]	22(8)[3-30]	33(5)[3-20]	58(16)[3-40]
Koeleria cristata	13(7)[3-10]	8(12)[3-30]	17(10)[3-20]	0(0)[0- 0]
Arenaria congesta	10(3)[3- 3]	16(4)[3-10]	24(7)[3-10]	53(8)[3-20]
Arnica fulgens	0(0)[0- 0]	2(3)[3- 3]	0(0)[0- 0]	16(3)[3- 3]
Geranium richardsonii	0(0)[0- 0]	0(0)[0- 0]	0(0)[0- 0]	11(3)[3- 3]
Anaphalis margaritacea	0(0)[0- 0]	0(0)[0- 0]	0(0)[0- 0]	11(3)[3- 3]
Pedicularis groenlandica	0(0)[0- 0]	0(0)[0- 0]	0(0)[0- 0]	11(3)[3- 3]
Streptanthella longirostris	0(0)[0- 0]	0(0)[0- 0]	0(0)[0- 0]	11(3)[3- 3]
Carex hoodii	0(0)[0- 0]	0(0)[0- 0]	4(8)[3-10]	2(12)[3-20]
Danthonia parryi	13(7)[3-10]	0(0)[0- 0]	0(0)[0- 0]	0(0)[0- 0]
Agropyron smithii	0(0)[0- 0]	16(6)[3-10]	0(0)[0- 0]	0(0)[0- 0]
Lupine argenteus	0(0)[0- 0]	24(11)[3-30]	1(10)[10-10]	0(0)[0- 0]
Festuca scabrella	97(22)[3-60]	86(30)[3-70]	82(18)[3-70]	79(20)[3-30]
Cerastium arvense	3(3)[3- 3]	6(3)[3- 3]	17(5)[3-10]	37(5)[3-10]

Table 22 (cont). Constancy/Average Cover Table for Species Listed in Table 21 (with Canopy Cover ≥ 3%) by Four Indirect Biophysical Environment Classes. Values Presented are Constancy, Average Cover When Present, Minimum Cover When Present, and Maximum Cover When Present, Respectively.

Species	Class 1	Class 2	Class 3	Class 4
Antenaria microphylla	33(6)[3-20]	10(3)[3- 3]	38(7)[3-20]	21(5)[3-10]
Poa fendleriana	0(0)[0- 0]	10(3)[3- 3]	0(0)[0- 0]	0(0)[0- 0]
Erigeron subtrinervis	0(0)[0- 0]	12(7)[3-10]	0(0)[0- 0]	0(0)[0- 0]
Penstemon procerus	3(3)[3- 3]	0(0)[0- 0]	21(5)[3-20]	32(3)[3- 3]
Eriogonum umbellatum	33(4)[3-10]	2(3)[3- 3]	26(4)[3-20]	32(5)[3-10]
Carex raynoldsii	0(0)[0- 0]	2(3)[3- 3]	0(0)[0- 0]	11(3)[3- 3]
Artemisia ludoviciana	0(0)[0- 0]	12(4)[3-10]	1(3)[3- 3]	0(0)[0- 0]
Carex luzulina	0(0)[0- 0]	10(4)[3-10]	0(0)[0- 0]	0(0)[0- 0]
Euphorbia esula	7(20)[20-20]	0(0)[0- 0]	0(0)[0- 0]	0(0)[0- 0]
Danthonia intermedia	23(5)[3-10]	16(13)[3-40]	26(5)[3-10]	47(11)[3-40]
Carex filifolia	10(3)[3- 3]	18(4)[3-10]	29(10)[3-30]	16(5)[3-40]
Gayophytum racemosum	0(0)[0- 0]	0(0)[0- 0]	0(0)[0- 0]	5(3)[3- 3]
Lomatium cous	0(0)[0- 0]	0(0)[0- 0]	0(0)[0- 0]	5(3)[3- 3]
Antennaria racemosa	7(3)[3- 3]	0(0)[0- 0]	0(0)[0- 0]	5(3)[3- 3]

Table 23. Differences in Selected Plant Species Abundance Values Between Four Indirect Biophysical Environment Classes.

Class	Class	Species Tested	Mean 1	Mean 2	T Value	P Value
1	2	AGRSMI	0.00	1.04	-2.66	0.01
1	3	AGRSMI	0.00	0.00		
1	4	AGRSMI	0.00	0.00		
2	3	AGRSMI	1.04	0.00	2.66	0.01
2	4	AGRSMI	1.04	0.00	2.66	0.01
3	4	AGRSMI	0.00	0.00		
1	2	ANAMAR	0.00	0.00		
1	3	ANAMAR	0.00	0.00		
1	4	ANAMAR	0.00	0.42	-1.46	0.16
2	3	ANAMAR	0.00	0.00		
2	4	ANAMAR	0.00	0.42	-1.46	0.16
3	4	ANAMAR	0.00	0.42	-1.46	0.16
1	2	ARECON	0.40	0.76	-1.01	0.31
1	3	ARECON	0.40	1.82	-2.89	0.01
1	4	ARECON	0.40	4.47	-2.97	0.01
2	3	ARECON	0.76	1.82	-2.03	0.05
2	4	ARECON	0.76	4.47	-2.69	0.01
3	4	ARECON	1.82	4.47	-1.87	0.08
1	2	CARLUZ	0.00	0.53	-2.05	0.05
2	3	CARLUZ	0.00	0.00		
1	4	CARLUZ	0.00	0.00		
2	3	CARLUZ	0.53	0.00	2.05	0.05
2	4	CARLUZ	0.53	0.00	2.05	0.05
3	4	CARLUZ	0.00	0.00		
1	2	DANPAR	1.00	0.00	1.89	0.07
1	3	DANPAR	1.00	0.00	1.89	0.07

Table 23 (cont). Differences in Selected Plant Species Abundance Values Between Four Indirect Biophysical Environment Classes.

Class	Class	Species Tested	Mean 1	Mean 2	T Value	P Value
1	4	DANPAR	1.00	0.00	1.89	0.07
2	3	DANPAR	0.00	0.00		
2	4	DANPAR	0.00	0.00		
3	4	DANPAR	0.00	0.00		
1	2	ERISUB	0.00	0.88	-2.31	0.02
1	3	ERISUB	0.00	0.00		
1	4	ERISUB	0.00	0.00		
2	3	ERISUB	0.88	0.00	2.31	0.02
2	4	ERISUB	0.88	0.00	2.31	0.02
3	4	ERISUB	0.00	0.00		
1	2	ERIUMB	1.57	0.08	3.13	0.01
1	3	ERIUMB	1.57	1.39	0.30	0.77
1	4	ERIUMB	1.57	2.00	-0.46	0.65
2	3	ERIUMB	0.08	1.39	-3.48	0.01
2	4	ERIUMB	0.08	2.00	-2.33	0.03
3	4	ERIUMB	1.39	2.00	-0.68	0.50
1	2	EUPESU	1.40	0.00	1.44	0.16
1	3	EUPESU	1.40	0.00	1.44	0.16
1	4	EUPESU	1.40	0.00	1.44	0.16
2	3	EUPESU	0.00	0.00		
2	4	EUPESU	0.00	0.00		
3	4	EUPESU	0.00	0.00		
1	2	LUPARG	0.00	2.75	-2.81	0.01
1	3	LUPARG	0.00	0.15	-1.00	0.32
1	4	LUPARG	0.00	0.00		
2	3	LUPARG	2.75	0.15	2.62	0.01

Table 23 (cont). Differences in Selected Plant Species Abundance Values Between Four Indirect Biophysical Environment Classes.

Class	Class	Species Tested	Mean 1	Mean 2	T Value	P Value
2	4	LUPARG	2.75	0.00	2.81	0.01
3	4	LUPARG	0.15	0.00	1.00	0.32
1	2	LUPSER	3.07	1.92	0.88	0.38
1	3	LUPSER	3.07	2.15	0.85	0.40
1	4	LUPSER	3.07	10.00	-2.29	0.03
2	3	LUPSER	1.92	2.15	-0.24	0.81
2	4	LUPSER	1.92	10.00	-2.71	0.01
3	4	LUPSER	2.15	10.00	-2.71	0.01
1	2	POAFEN	0.00	0.39	-2.33	0.02
1	3	POAFEN	0.00	0.00		
1	4	POAFEN	0.00	0.00		
2	3	POAFEN	0.39	0.00	2.33	0.02
2	4	POAFEN	0.39	0.00	2.33	0.02
3	4	POAFEN	0.00	0.00		
1	2	POTENT	0.27	0.00	1.44	0.16
1	3	POTENT	0.27	0.00	1.44	0.16
1	4	POTENT	0.27	0.00	1.44	0.16
2	3	POTENT	0.00	0.00		
2	4	POTENT	0.00	0.00		
3	4	POTENT	0.00	0.00		
1	2	STRLON	0.00	0.00		
1	3	STRLON	0.00	0.00		
1	4	STRLON	0.00	0.42	-1.46	0.16
2	3	STRLON	0.00	0.00		
2	4	STRLON	0.00	0.42	-1.46	0.16
3	4	STRLON	0.00	0.42	-1.46	0.16

Significant differences in species abundance were apparent between the four indirect biophysical environments identified. For example, _Geranium richardsonii_, _Anaphalis margaritacea_, _Pedicularis groenlandica_, and _Streptanthella longirostris_ occurred only on Class 4 plots and appeared to occur together. These species were not very significant across all classes (p=0.16) because of their low constancy (11%) within Class 4 (Table 23). Constancy and average cover of _Lupinus sericeus_ and _Arenaria congesta_ were significantly higher on Class 4 plots than on plots in other classes (p=0.03 and 0.08 respectively).

Danthonia parryi and _Euphorbia esula_ occurred only on Class 1 plots. _Danthonia parryi_ was slightly significant (p=0.07) because it had a constancy of 13 percent but _Euphorbia esula_ was not very significant (p=0.16) because of a low constancy of 7 percent (Table 23). _Euphorbia esula_ had a relatively high canopy cover (20%) when present.

Agropyron smithii, _Lupinus argenteus_, _Poa fendleriana_, _Erigeron subtrinervis_, and _Carex luzulina_ occurred almost exclusively on Class 2 plots. All five of these species had significantly different abundances within Class 2 environments than other class environments ($p \leq 0.05$, Table 23). _Eriogonum umbellatum_ had a significantly lower abundance on Class 2 plots than plots in other classes ($p<0.03$, Table 23).

The only species that showed significant abundance differences between Class 3 environments and other classes is Arenaria congesta. Abundance of this species was higher in Class 3 than Class 1 and 2 plots but lower than Class 4 plots ($p \leq 0.08$, Table 23).

These results indicate that species composition at finer-scales can be explained by coarser-scale indirect biophysical environment variables. Both the analysis of variance and T-tests performed (Tables 21,23) provide evidence to reject the null hypothesis and accept the alternative hypothesis that there are significant species composition differences between biophysical environments of the rough fescue/Idaho fescue (Festuca scabrella/Fesctuca Idahoensis) habitat type. Although the statistics were significant, none of the species mentioned had sufficiently high constancy values to be used as diagnostic species in floristically based classifications of site potential (i.e., habitat types).

Species-Environment Relations Within Geoclimatic Settings

Canonical correspondence analysis (CCA) was performed within each indirect biophysical environment class to determine the amount of species variance explained by direct biophysical environment variables. Results of this analysis are displayed in Tables 24 through 27.

Table 24. Canonical Correspondence Analysis Output for Class 1 Indirect Biophysical Environment Settings (n=30).

	Axis 1	Axis 2	Axis 3	Axis 4
Eigenvalues	.678	.532	.480	.450
Species-Environment Correlations	.987	.988	.971	.987
Cumulative Percent Variance of Species Data	10.9	19.5	27.3	34.6
Cumulative Percent Variance of Species-Environment Relations	12.4	22.1	30.9	39.2

Table 25. Canonical Correspondence Analysis Output for Class 2 Indirect Biophysical Environment Settings (n=51).

	Axis 1	Axis 2	Axis 3	Axis 4
Eigenvalues	.616	.472	.399	.349
Species-Environment Correlations	.903	.961	.929	.900
Cumulative Percent Variance of Species Data	6.6	11.7	15.9	19.7
Cumulative Percent Variance of Species-Environment Relations	13.4	23.7	32.4	40.0

Table 26. Canonical Correspondence Analysis Output for Class 3 Indirect Biophysical Environment Settings (n=72).

	Axis 1	Axis 2	Axis 3	Axis 4
Eigenvalues	.555	.499	.456	.355
Species-Environment Correlations	.902	.929	.912	.915
Cumulative Percent Variance of Species Data	5.2	9.9	14.2	17.5
Cumulative Percent Variance of Species-Environment Relations	11.3	21.4	30.7	37.9

Table 27. Canonical Correspondence Analysis Output for Class 4 Indirect Biophysical Environment Settings (n=19).

	Axis 1	Axis 2	Axis 3	Axis 4
Eigenvalues	.930	.503	.462	.385
Species-Environment Correlations	1.00	1.00	1.00	1.00
Cumulative Percent Variance of Species Data	23.6	36.4	48.1	57.9
Cumulative Percent Variance of Species-Environment Relations	23.7	36.4	48.1	57.9

Forward selection of variables in CCA indicated that direct variables account for 34.6, 19.7, 17.5, and 57.9 percent of species variance for classes 1 through 4, respectively. These values are representative of results commonly obtained using CCA with ecological data sets (terBraak 1992, Jensen et al 1995). These results are also quite an improvement over the 6.9 percent of the species variance explained in the initial CCA run of the entire data set (Table 10). These results suggest that in this study, species-environment relations are a scaled phenomenon and that stratification by coarser-scale, indirect biophysical environment variables is a necessary step when trying to explain species variance based on finer-scale, direct variables. Results of the CCA also indicate that different direct biophysical environment variables are responsible for explaining species variance across the four indirect biophysical environments studied (Table 28).

Table 28. Listing of Direct Variables Most Useful in Explaining Species Composition Variance Within Four Indirect Biophysical Environment Classes Based on a Forward Selection Procedure of Canonical Correspondence Analysis.

Importance Order	Class 1	Class 2	Class 3	Class 4
1	Rock	PRCPSP	PRCPSU	Litter
2	Wood	SRAD	Moss	Slope
3	TAVG	PRCPSU	Slope	PRCPSP
4	Bveg	Southerly	Elevation	Gravel
5	Soil	PRCPFA	Rock	Moss
6	Elevation	Bveg	Northerly	Elevation
7	Water	Rock	PRCPSP	PRCPSU
8	Westerly	Northerly	PRCPWN	PRCP
9	Moss	Slope	Soil	Easterly
10	Northerly	Gravel	TMINJAN	Bveg
11	Slope	Moss	Gravel	Northerly
12	TMAXJUL	Easterly	TMAXJUL	Southerly
13	PRCPSP	Elevation	PRCPFA	TMINJAN

The direct biophysical environment variables most responsible for explaining species variance on Class 1 plots were predominantly ground cover variables. This suggests that disturbance has not been completely eliminated from this class and that variance in species composition is possibly being explained by disturbance affected variables. The direct variables most useful in explaining species variance on Class 2 plots were primarily climatic attributes. Important direct variables on Class 3 plots were primarily site attributes. Forward selection on Class 4 plots produced results from which little or no conclusions concerning environmental gradients could be drawn; possibly due to the small sample size (n=19) in this class.

Interset correlations (terBraak 1992) of direct biophysical environment variables with species scores along the first two canonical ordination axes of canonical correspondence analysis were developed to interpret the species-environment relations within each indirect biophysical environment class (Tables 29-32).

Ordination axis 1 in Class 1 (Table 29) primarily represents a temperature gradient in which _Fragaria_ species, _Vaccinium caespitosum_, and traces of _Pinus contorta_ had moderate ordination scores (168 to 426) and occupied sites with higher annual average temperatures (TAVG, r=.40) and higher minimum January temperatures (TMINJAN, r=.37). Axis 2 does not appear to display an environmental trend and

Table 29. Interset Correlations of Direct Variables and Species Scores Along Canonical Ordination Axes 1 and 2 for Class 1.

Variable	Axis 1 Correlation	Species	Ordination Score	Variable	Axis 2 Correlation	Species	Ordination Score
TAVG	.40	FRAGAR	426	North	.35	ARTTRI	480
TMINJAN	.37	VACCES	426	Moss	.23	ERILAF	248
TMAXJUL	.29	PINCON	340	PRCPFA	.18	DANPAR	71
Gravel	.27	CARGEY	168	Rock	.13	PINCON	67
Soil	.26	LUPSER	61	Litter	.10	STIRIC	51
East	-.14	POTFRU	-57	SRAD	-.23	COLLIN	-65
North	-.15	BESRUB	-60	PRCPWN	-.24	EUPESU	-68
Slope	-.17	PEDCON	-67	Water	-.30	POTARG	-71
Elevation	-.22	ANENUT	-75	Elevation	-.34	AGOGLA	-78
SRAD	-.26	POLBIS	-75	TMINJAN	-.35	TAROFF	-78

Table 30. Interset Correlations or Direct Variables and Species Scores Along Canonical Ordination Axes 1 and 2 for Class 2.

Variable	Axis 1 Correlation	Species	Ordination Score	Variable	Axis 2 Correlation	Species	Ordination Score
PRCPSP	.57	POTARE	775	Bveg	.49	ERIUMB	372
PRCPSU	.44	PHLPRA	661	PRCPSP	.36	LINLEW	372
PRCP	.36	OXYCAM	154	SRAD	.32	CLEHER	318
PRCPFA	.32	MICNIG	110	Slope	.30	BROMAR	289
Wood	.20	TAROFF	87	South	.25	ERISPE	274
West	-.12	ERICOR	-106	Wood	-.08	ASTBOU	-90
Slope	-.15	CARGEY	-110	Rock	-.09	STIRIC	-92
TMAXJUL	-.24	ARTDRA	-207	West	-.11	PEDCON	-107
TMINJAN	-.30	GUTSAR	-207	North	-.18	ANEMUL	-133
TAVG	-.36	ARNDIV	-243	PRCPSU	-.24	DANUNI	-145

Table 31. Interset Correlations of Direct Variables and Species Scores Along Canonical Ordination Axes 1 and 2 for Class 3.

Variable	Axis 1 Correlation	Species	Ordination Score	Variable	Axis 2 Correlation	Species	Ordination Score
North	.38	PHLPRA	332	PRCPSU	.78	PHLPRA	379
PRCPSP	.29	ASTCHI	291	PRCP	.66	PRUVIR	287
Litter	.22	BROMAR	291	PRCPSP	.64	ARCUVA	205
Rock	.21	IRIMIS	291	PRCPFA	.62	AMEALN	172
PRCPSU	.16	ELYCAN	291	PRCPWN	.51	POTFRU	140
West	-.21	ANTANA	-97	Bveg	-.14	IRIMIS	-172
Moss	-.24	KOEMAC	-99	Slope	-.16	MELBUL	-172
Wood	-.30	SENCAN	-117	North	-.22	MERCIL	-172
Gravel	-.30	ASTRAG	-151	Rock	-.26	POAINT	-172
SRAD	-.32	CHRVIS	-151	SRAD	-.48	SYMALB	-172

Table 32. Interset Correlations of Direct Variables and Species Scores Along Canonical Ordination Axes 1 and 2 for Class 4.

Variable	Axis 1 Correlation	Species	Ordination Score	Variable	Axis 2 Correlation	Species	Ordination Score
Litter	.47	DODECA	342	PRCP	.78	CARRAY	270
TAVG	.42	ELYMUS	342	Moss	.76	OXYCAM	270
East	.38	IRIMIS	342	Soil	.76	PEDGRO	270
Water	.38	POLBIS	342	PRCPWN	.74	PHLCAE	270
TMAXJUL	.38	TAROFF	342	PRCPSP	.69	STRLON	270
PRCP	-.29	OXYCAM	-33	Bveg	-.35	AGRCAN	-138
Slope	-.30	OXYSER	-33	East	-.47	FRAVIR	-138
PRCPWN	-.32	PEDGRO	-33	TAVG	-.60	LITRUD	-138
PRCPSU	-.33	PHLCAE	-33	Litter	-.70	POAINT	-138
Elevation	-.37	STRLON	-33	TMAXJUL	-.76	STIOCC	-138

provided very low species ordination scores except where Artemisia tridentata had a high ordination score (480) and occupied sites with northerly aspects (North, r=.35).

Axis 1 on Class 2 plots (Table 30) represents a precipitation and temperature gradient in which Potentilla argenta and Phleum pratensis had high ordination scores (110 to 775) and occupied sites with higher summer (PRCPSU, r=.44) and spring (PRCPSP, r=.57) precipitation. Conversely, Gutierrezia sarothrae and Arnica diversifolia had negative ordination scores (-110 to -243) and occupied sites with higher minimum January temperatures (TMINJAN, r=.30) and higher annual average temperatures (TAVG, r=.36).

Axis 1 on Class 3 plots (Table 31) represents a cool, moist gradient where Phleum pratensis, Aster chilenis, Bromus marginatus, and Iris missouriensis had moderate ordination scores (291 to 332) and occupied sites with higher spring precipitation (PRCPSP, r=.29) and northerly aspects (North, r=.38). Axis 2 represents a strong precipitation gradient where Phleum pratensis, Prunis virginiana, and Arctostaphylos uva-ursi had moderate ordination scores (140 to 379) and occupied sites with higher summer (PRCPSU, r=.78), total annual (PRCP, r=.66), and spring (PRCPSP, r=.64) precipitation.

The ordination axes on Class 4 plots (Table 32) displayed high correlations but obscure environmental gradients. These results could possibly be a function of the small sample size (n=19) of this class and the narrow environmental gradients that occurred within it. The negative end of axis 1 represents a moisture gradient where Pedicularis groenlandica, Phleum caespitosum and Streptanthella longirostris (ordination scores -33) occupied sites with higher elevations (Elevation, r=.37), higher summer precipitation (PRCPSU, r=.33), and higher winter precipitation (PRCPWN, r=.32). On axis 2, Carex raynoldsii, Oxytropis campestris, Pedicularis groenlandica, Phleum caespitosum, and Streptanthella longirostris (ordination score 270) occupied sites with higher total annual (PRCP, r=.78) and winter (PRCPWN, r=.74) precipitation, and higher canopy covers of moss and bare soil (Moss, Soil, r=.76). At the other end of the axis, Lithospermum ruderale, Poa interior, and Stipa occidentalis had low ordination scores (-138) and occupied sites with higher average annual temperatures (TAVG, r=.47), east aspects (East, r=.38), and higher canopy covers of litter (Litter, r=.47).

CONCLUSION

The primary objective of this research was to examine species composition differences between different coarser-scale biophysical environments of the rough fescue/Idaho fescue (Festuca scabrella/Festuca Idahoensis) habitat type (Meuggler and Stewart 1980) of western Montana.

Results of this study suggest that species composition variability is a scaled phenomenon and that stratification of sample plots by coarser-scale, indirect biophysical environment variables facilitates improved understanding of the effects that finer-scale, direct biophysical environment variables have on species occurrence and abundance. This study identified four indirect biophysical environment classes which displayed significant differences in direct biophysical environment variables as well as species composition.

Results of the analysis provide sufficient evidence to reject the null hypothesis and accept the alternative hypothesis that there are significant species composition differences between various coarser-scale, indirect biophysical environments of the rough fescue/Idaho fescue (Festuca scabrella/Festuca Idahoensis) habitat type. Although the statistics of species differences were significant, no species had constancy values high enough within each class to be used as diagnostic species in a floristically based classification of site potential (i.e., habitat types). A more intensive study involving a larger data set covering the entire environmental range of both kinds of fescue along with detailed soil information is required to build a comprehensive biophysical environment classification of these grassland types in western Montana.

This study provided an example of the hierarchical procedure for examining species-environment relations in ecological data sets. The procedure can help resource managers understand complex ecological patterns and processes in terms of the variables that constrain their distributions. Results of this study indicate that the procedure worked for this particular habitat type; however, additional efforts are needed to define the methodology for multi-scaled approaches to all kinds of resource inventories. This hierarchical approach to mapping and understanding ecosystems provides a quantitative procedure useful for wildland management.

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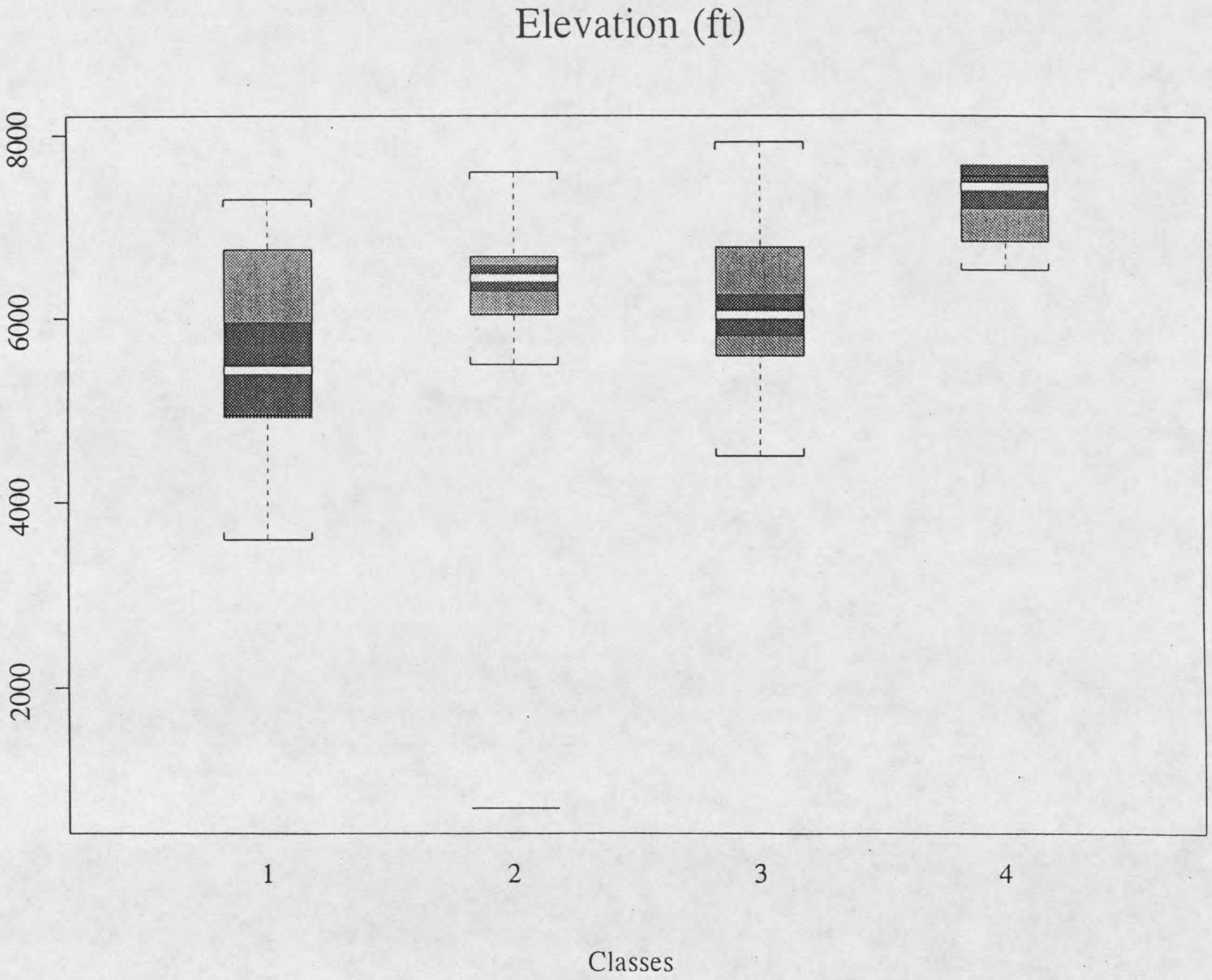
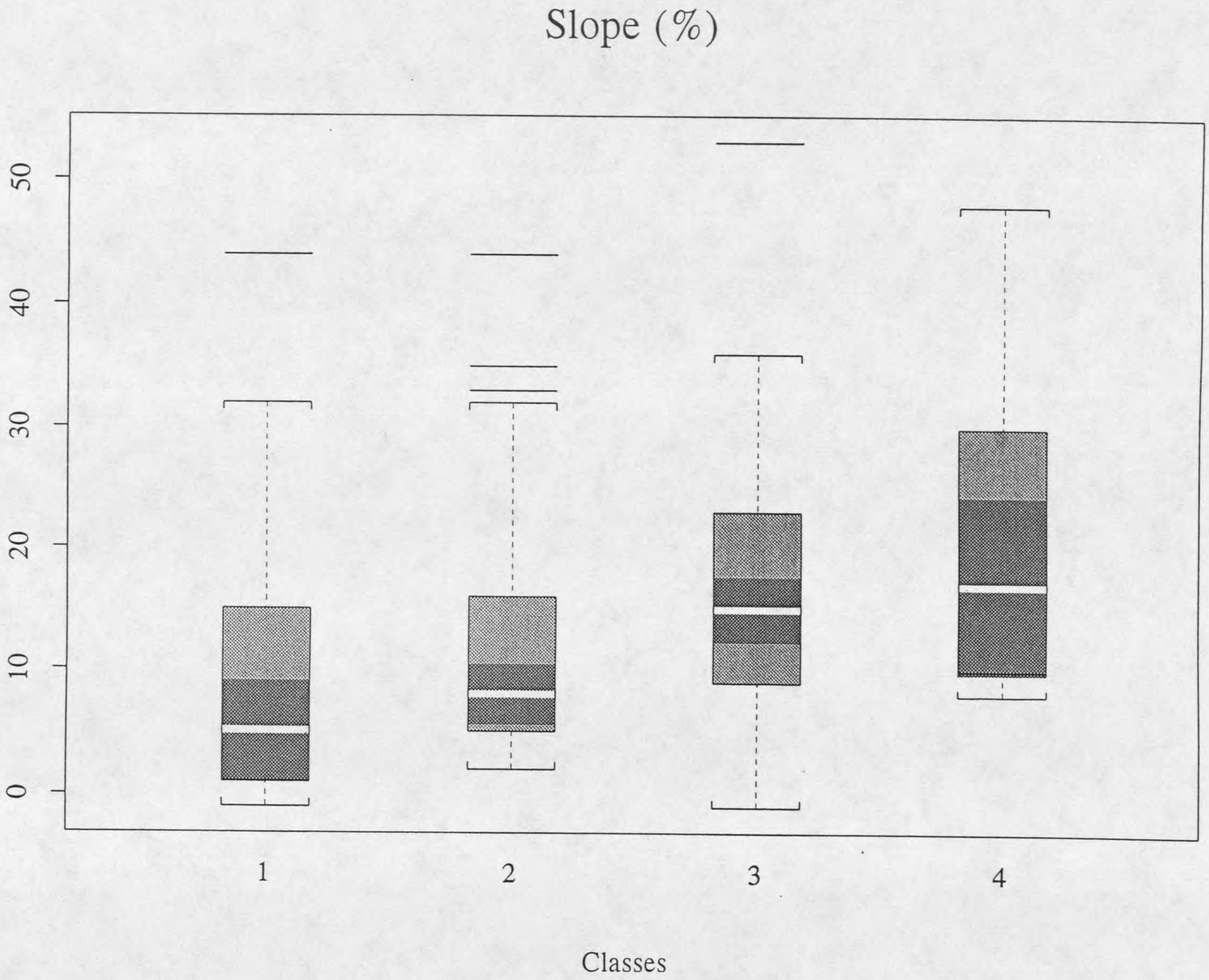
APPENDICES

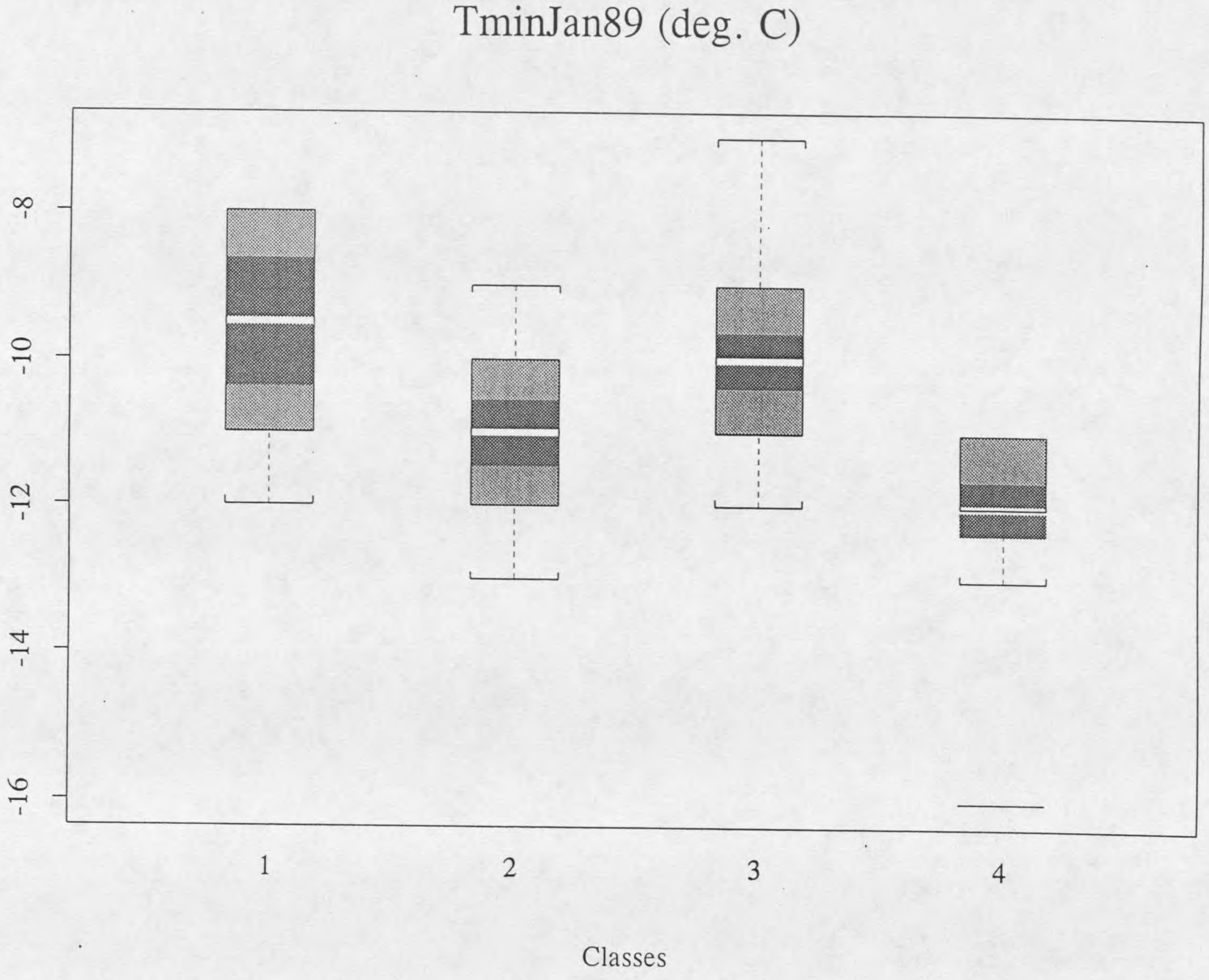
Appendix A:

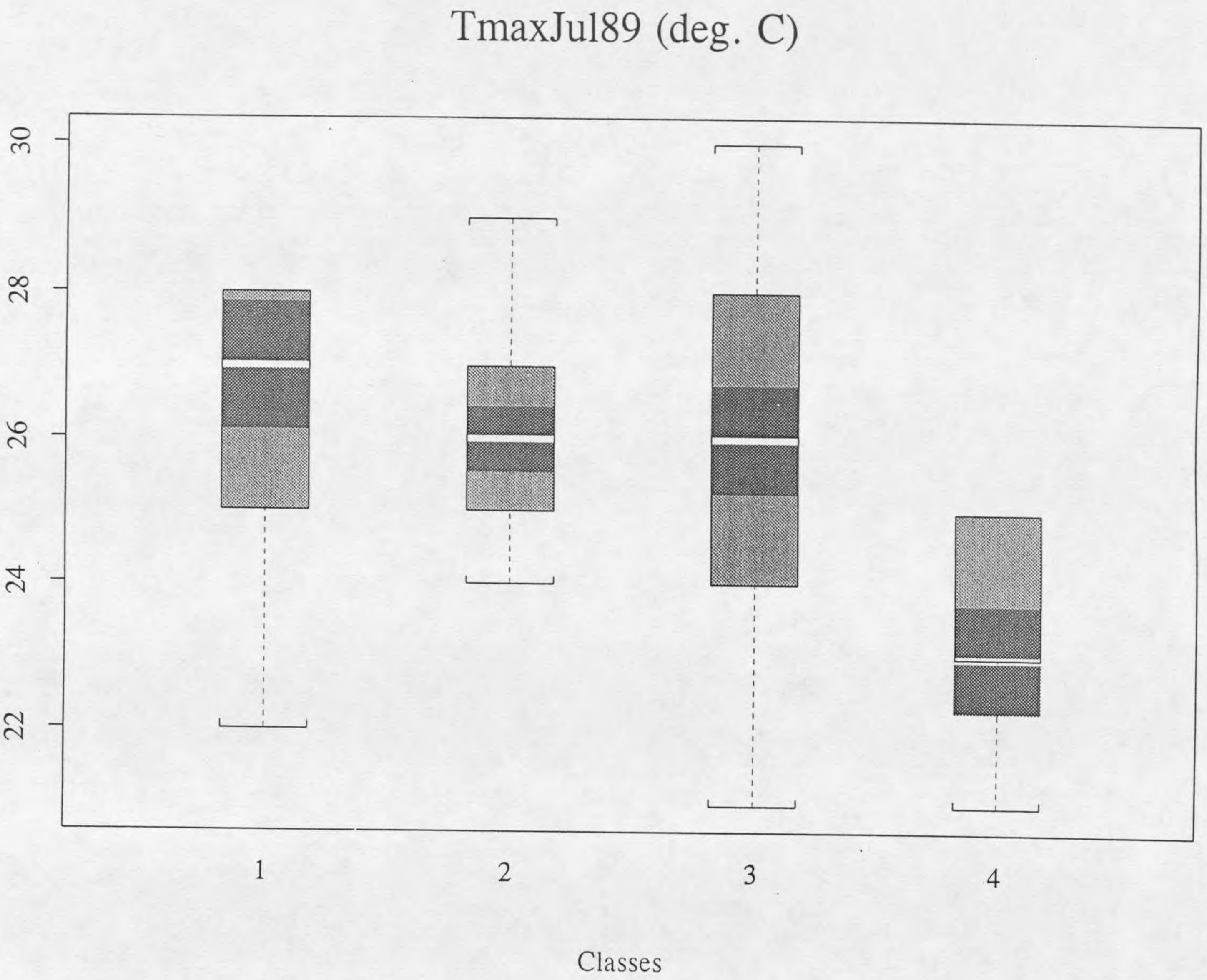
Boxplots of Direct Variables for the Four Indirect Biophysical Environment Classes Identified in This Study



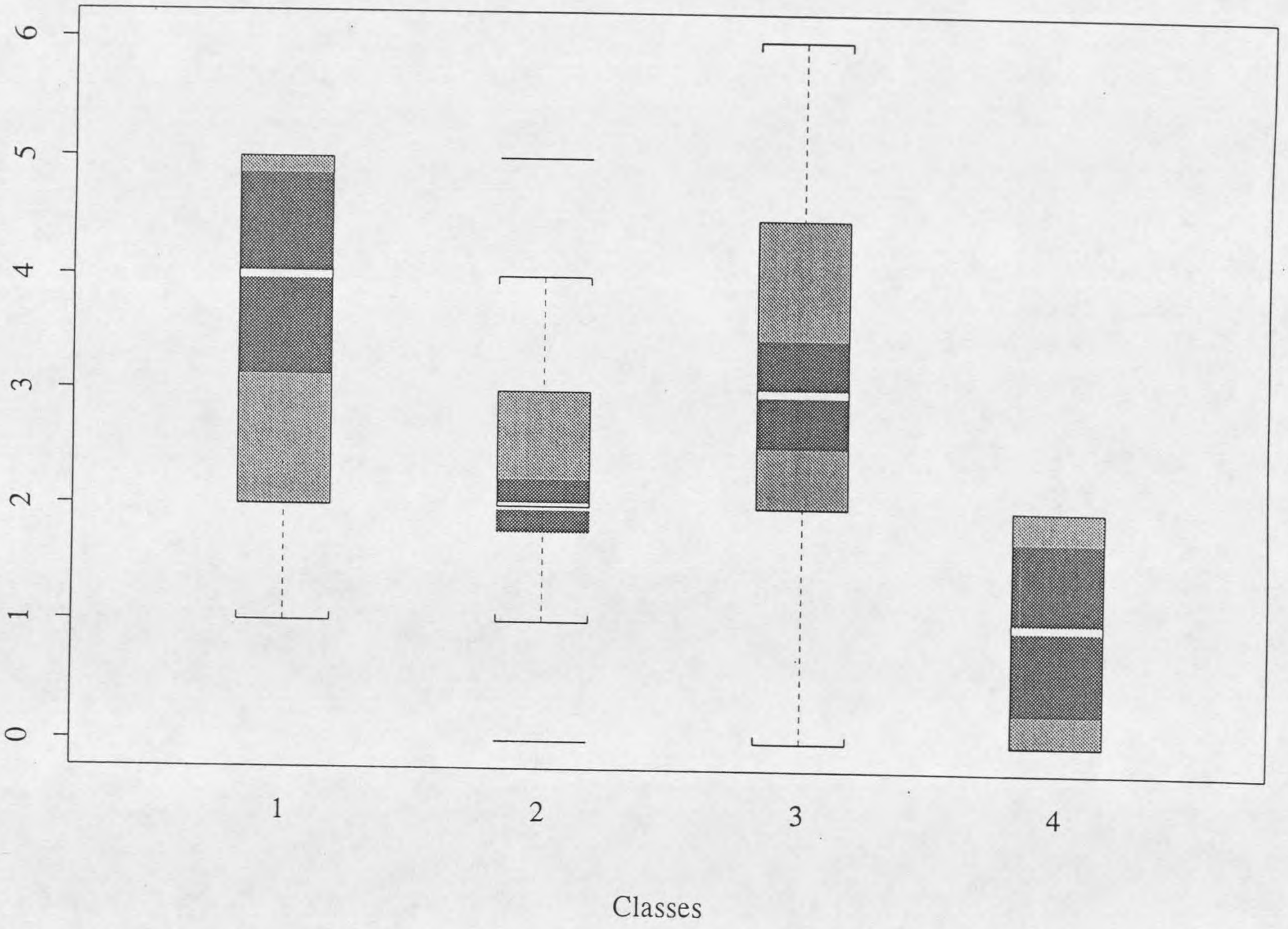
Elevation (ft)
8000
6000
4000
2000
1
2
3
4
Classes

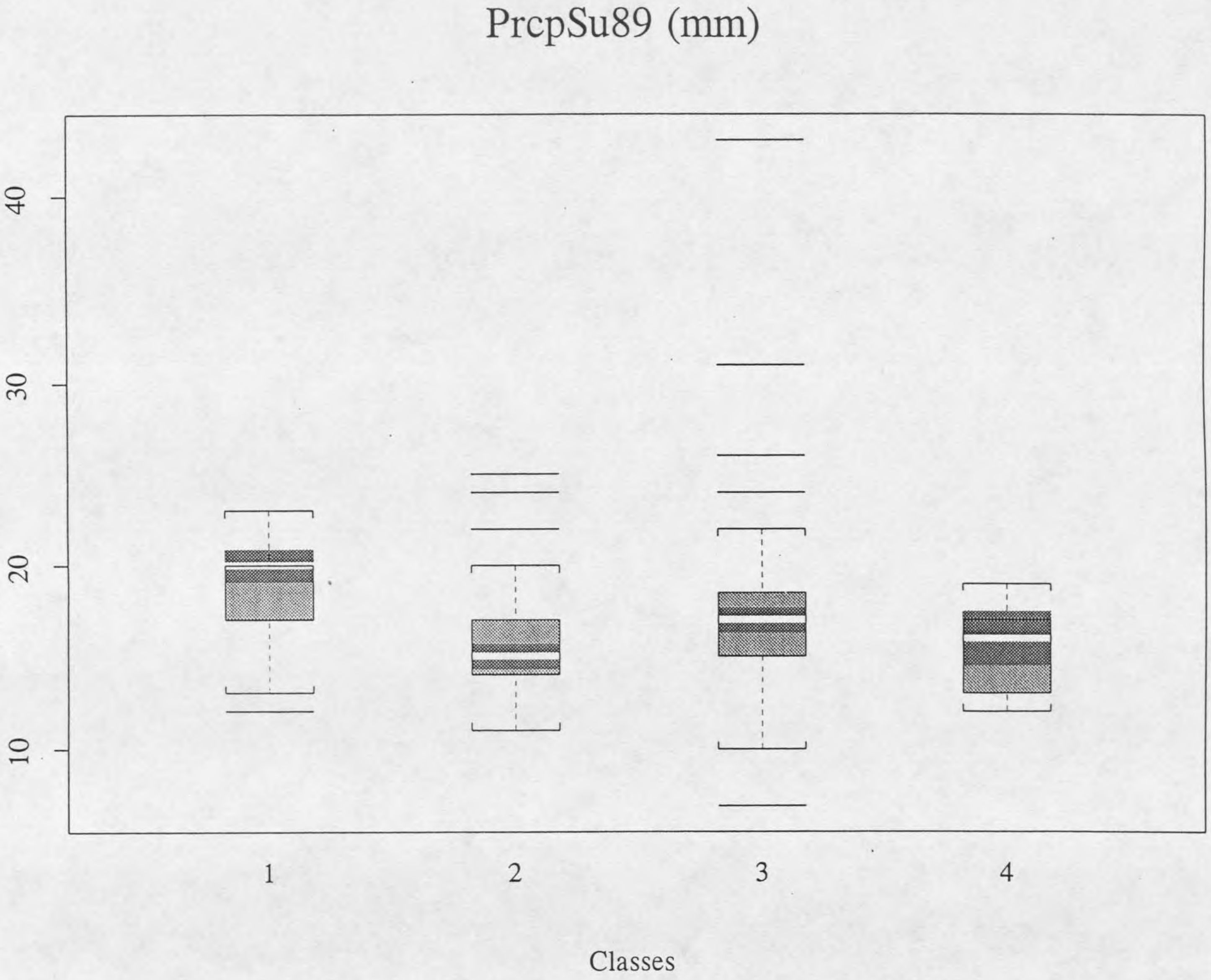

Slope (%)
0
10
20
30
40
50
1
2
3
4
Classes

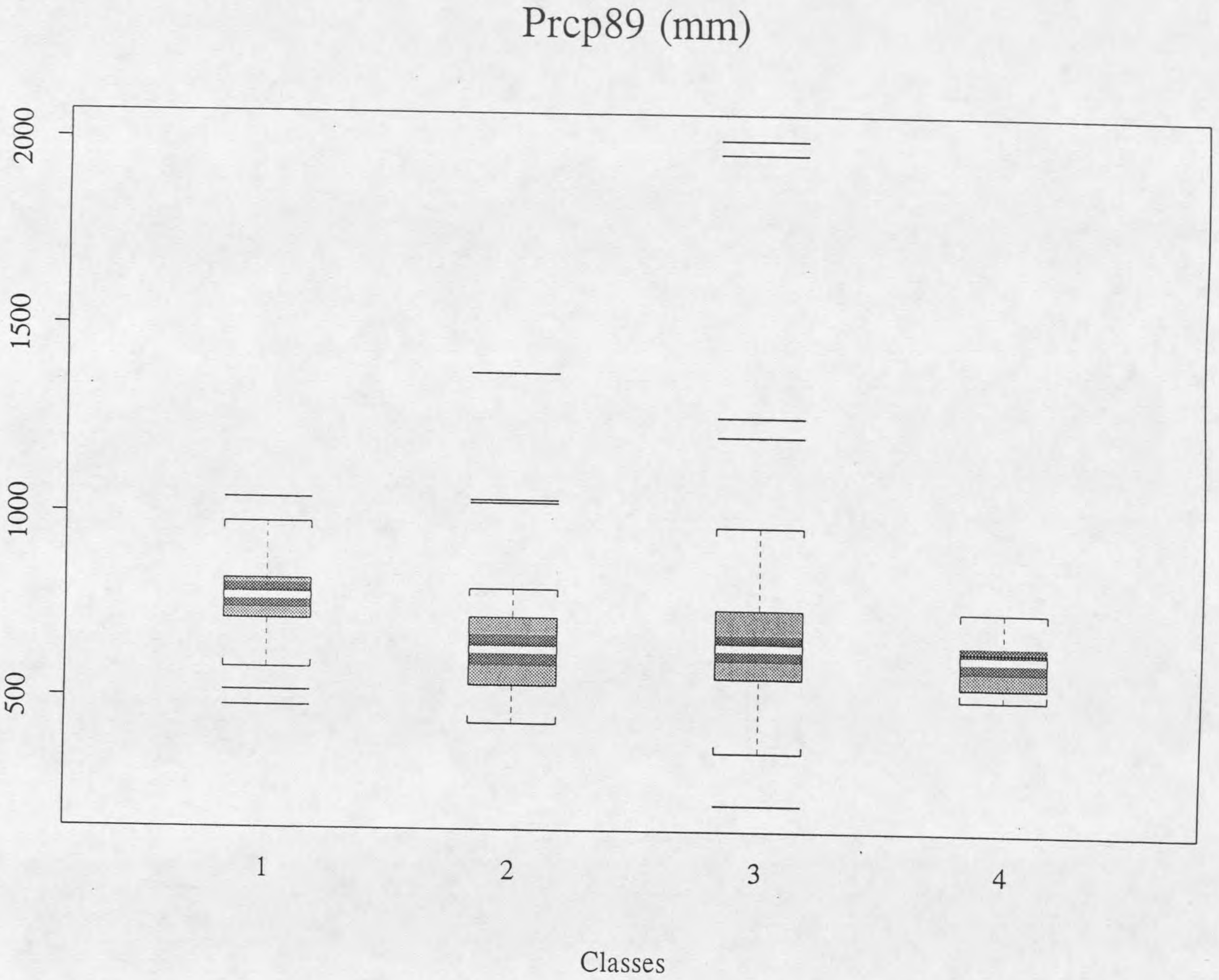

TminJan89 (deg. C)
-8
-10
-12
-14
-16
1
2
3
4
Classes

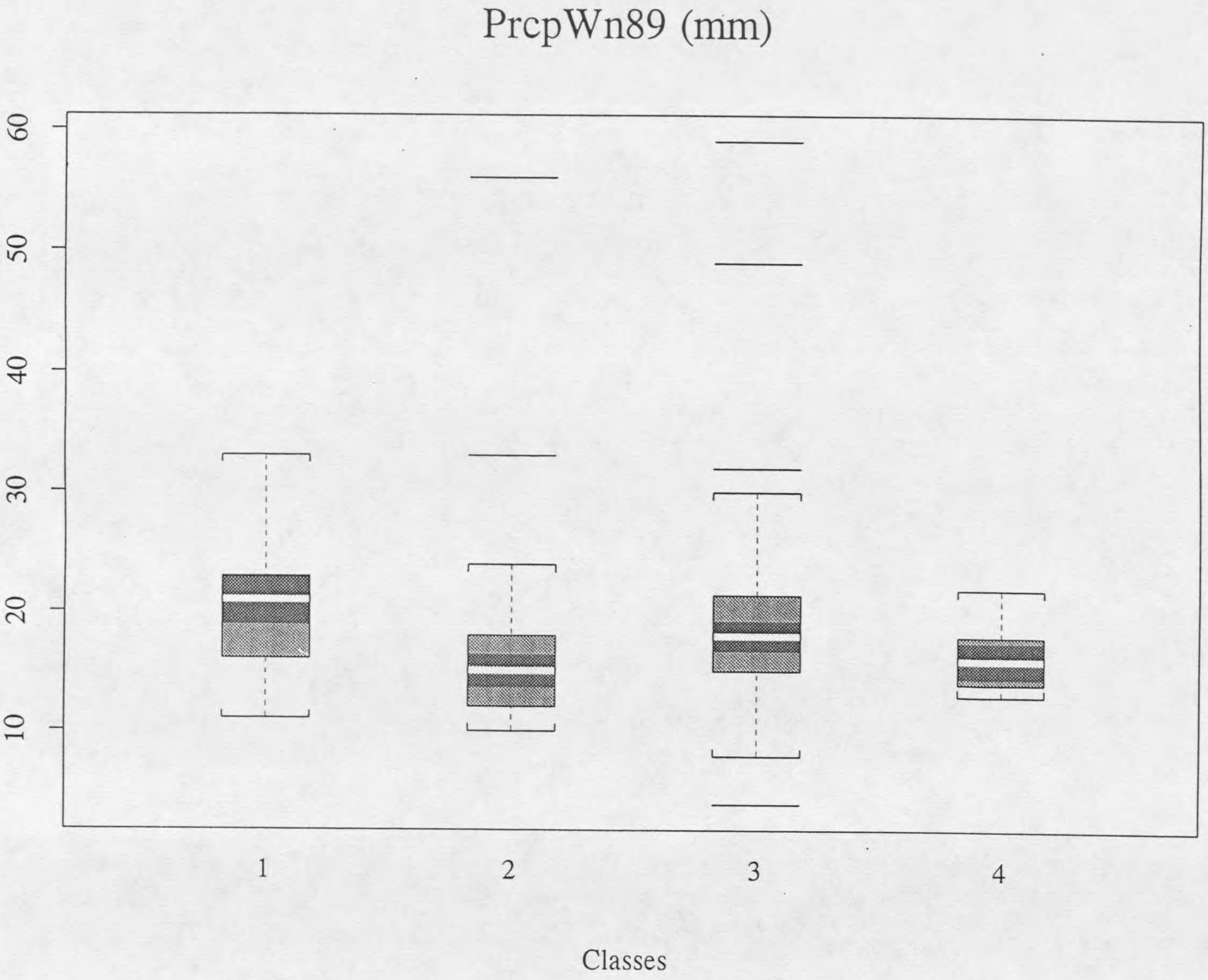

TmaxJul89 (deg. C)
30
28
26
24
22
1
2
3
4
Classes

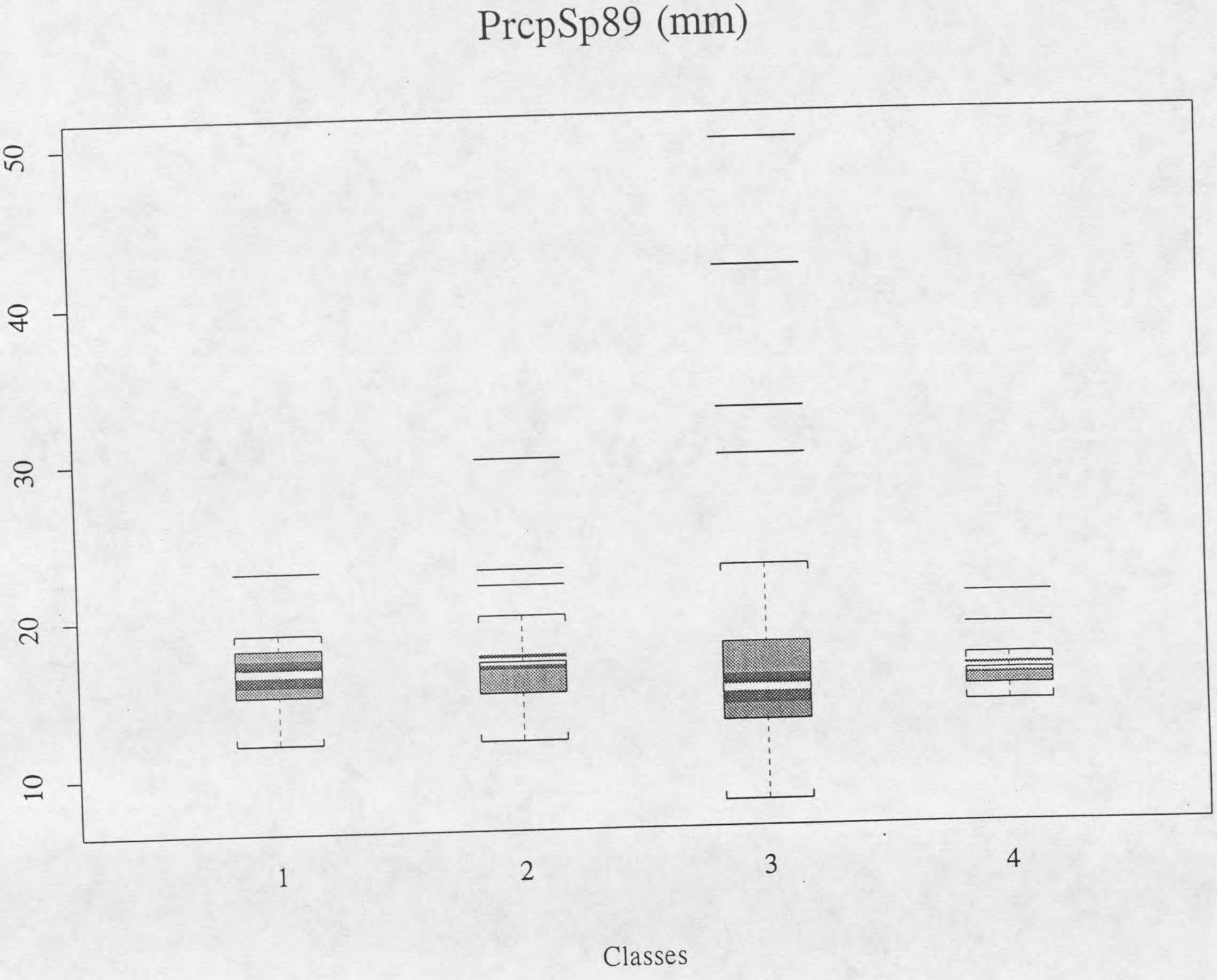
Tavg89 (deg. C)




PrcpSu89 (mm)
40
30
20
10
1
2
3
4
Classes


Prcp89 (mm)
2000
1500
1000
500
1
2
3
4
Classes


PrcpWn89 (mm)
60
50
40
30
20
10
1
2
3
4
Classes


PrcpSp89 (mm)
10
20
30
40
50
1
2
3
4
Classes

Appendix B:

Constancy/Average Cover Table of Species with Canopy Cover ≥ 3% for the Four Indirect Biophysical Environment Classes Identified in This Study

```
                    ***** Cover Constancy Table (Average Abund) *****
                               **  [Minimum - Maximum] Range   **
***********************************************************************************************:
Community Order  *       0000        *       0001        *       0002        *       0003      :
Number of Plots  *     N =   30      *     N =   51      *     N =   72      *     N =   19    :
***********************************************************************************************:

** Species Codes **

***** Trees *****
    PINCON           7 ( 7) [ 3 - 10]    0 ( 0) [ 0 -  0]    1 (10) [10 - 10]    0 ( 0) [ 0 -  0]
    PINFLE           0 ( 0) [ 0 -  0]    0 ( 0) [ 0 -  0]    1 (10) [10 - 10]    0 ( 0) [ 0 -  0]
    PSEMEN           0 ( 0) [ 0 -  0]    4 ( 7) [ 3 - 10]    1 ( 3) [ 3 -  3]    0 ( 0) [ 0 -  0]

***** Shrubs *****
    AMEALN           0 ( 0) [ 0 -  0]    0 ( 0) [ 0 -  0]    4 ( 5) [ 3 - 10]    0 ( 0) [ 0 -  0]
    ARCUVA           7 ( 7) [ 3 - 10]    0 ( 0) [ 0 -  0]    1 ( 3) [ 3 -  3]    0 ( 0) [ 0 -  0]
    ARTFRI           0 ( 0) [ 0 -  0]    8 ( 5) [ 3 - 10]    6 ( 7) [ 3 - 10]    0 ( 0) [ 0 -  0]
    ARTTRI           3 (40) [40 - 40]    0 ( 0) [ 0 -  0]    0 ( 0) [ 0 -  0]    0 ( 0) [ 0 -  0]
    ARTTSV           7 ( 3) [ 3 -  3]    8 ( 5) [ 3 - 10]    3 ( 3) [ 3 -  3]    0 ( 0) [ 0 -  0]
    BERREP           0 ( 0) [ 0 -  0]    0 ( 0) [ 0 -  0]    1 ( 3) [ 3 -  3]    0 ( 0) [ 0 -  0]
    CHRNAU           0 ( 0) [ 0 -  0]    0 ( 0) [ 0 -  0]    1 (10) [10 - 10]    0 ( 0) [ 0 -  0]
    CHRVIS           0 ( 0) [ 0 -  0]    2 (10) [10 - 10]    1 ( 3) [ 3 -  3]    0 ( 0) [ 0 -  0]
    GUTSAR           0 ( 0) [ 0 -  0]    2 ( 3) [ 3 -  3]    0 ( 0) [ 0 -  0]    0 ( 0) [ 0 -  0]
    JUNCOM           0 ( 0) [ 0 -  0]    2 ( 3) [ 3 -  3]    0 ( 0) [ 0 -  0]    0 ( 0) [ 0 -  0]
    JUNHOR           0 ( 0) [ 0 -  0]    2 ( 3) [ 3 -  3]    0 ( 0) [ 0 -  0]    0 ( 0) [ 0 -  0]
    POTFRU           3 ( 3) [ 3 -  3]    0 ( 0) [ 0 -  0]    3 ( 3) [ 3 -  3]    0 ( 0) [ 0 -  0]
    PRUVIR           0 ( 0) [ 0 -  0]    0 ( 0) [ 0 -  0]    1 (10) [10 - 10]    0 ( 0) [ 0 -  0]
    ROSA             3 (10) [10 - 10]    0 ( 0) [ 0 -  0]    1 (20) [20 - 20]    0 ( 0) [ 0 -  0]
    ROSARK           0 ( 0) [ 0 -  0]    0 ( 0) [ 0 -  0]    3 ( 3) [ 3 -  3]    0 ( 0) [ 0 -  0]
    ROSAXX           0 ( 0) [ 0 -  0]    0 ( 0) [ 0 -  0]    3 ( 3) [ 3 -  3]    0 ( 0) [ 0 -  0]
    ROSSAY           0 ( 0) [ 0 -  0]    2 ( 3) [ 3 -  3]    0 ( 0) [ 0 -  0]    0 ( 0) [ 0 -  0]
    ROSWOO           0 ( 0) [ 0 -  0]    4 ( 7) [ 3 - 10]    1 ( 3) [ 3 -  3]    0 ( 0) [ 0 -  0]
    SYMALB           0 ( 0) [ 0 -  0]    0 ( 0) [ 0 -  0]    3 (20) [20 - 20]    0 ( 0) [ 0 -  0]
    TETCAN           0 ( 0) [ 0 -  0]    2 ( 3) [ 3 -  3]    0 ( 0) [ 0 -  0]    0 ( 0) [ 0 -  0]
    VACCES           3 (10) [10 - 10]    0 ( 0) [ 0 -  0]    0 ( 0) [ 0 -  0]    0 ( 0) [ 0 -  0]

***** Grasses *****
    AGRCAN          10 ( 3) [ 3 -  3]    8 ( 3) [ 3 -  3]   11 ( 5) [ 3 - 10]   11 ( 3) [ 3 -  3]
    AGRDAS           0 ( 0) [ 0 -  0]    4 ( 7) [ 3 - 10]    0 ( 0) [ 0 -  0]    0 ( 0) [ 0 -  0]
    AGREXA           0 ( 0) [ 0 -  0]    6 ( 8) [ 3 - 10]    0 ( 0) [ 0 -  0]    0 ( 0) [ 0 -  0]
    AGRHYE           0 ( 0) [ 0 -  0]    0 ( 0) [ 0 -  0]    3 ( 3) [ 3 -  3]    0 ( 0) [ 0 -  0]
    AGRIDA           0 ( 0) [ 0 -  0]    2 ( 3) [ 3 -  3]    0 ( 0) [ 0 -  0]    0 ( 0) [ 0 -  0]
    AGRSMI           0 ( 0) [ 0 -  0]   16 ( 6) [ 3 - 10]    0 ( 0) [ 0 -  0]    0 ( 0) [ 0 -  0]
    AGRSPI           3 ( 3) [ 3 -  3]   22 (17) [ 3 - 60]   42 ( 8) [ 3 - 40]   37 (11) [ 3 - 20]
    AGRTRI           0 ( 0) [ 0 -  0]    4 ( 3) [ 3 -  3]    0 ( 0) [ 0 -  0]    0 ( 0) [ 0 -  0]
    BROCAR           3 ( 3) [ 3 -  3]    0 ( 0) [ 0 -  0]    1 ( 3) [ 3 -  3]    0 ( 0) [ 0 -  0]
    BROMAR           0 ( 0) [ 0 -  0]    4 ( 7) [ 3 - 10]    3 (10) [10 - 10]    0 ( 0) [ 0 -  0]
    BROMUS           0 ( 0) [ 0 -  0]    0 ( 0) [ 0 -  0]    1 ( 3) [ 3 -  3]    0 ( 0) [ 0 -  0]
    BROTEC           0 ( 0) [ 0 -  0]    0 ( 0) [ 0 -  0]    1 ( 3) [ 3 -  3]    0 ( 0) [ 0 -  0]
    CALRUB           3 ( 3) [ 3 -  3]    0 ( 0) [ 0 -  0]    1 ( 3) [ 3 -  3]    0 ( 0) [ 0 -  0]
    CARCON           0 ( 0) [ 0 -  0]    0 ( 0) [ 0 -  0]    1 ( 3) [ 3 -  3]    0 ( 0) [ 0 -  0]
    CARELE           0 ( 0) [ 0 -  0]    4 ( 3) [ 3 -  3]    0 ( 0) [ 0 -  0]    0 ( 0) [ 0 -  0]
    CAREXX           7 ( 7) [ 3 - 10]    2 ( 3) [ 3 -  3]    6 ( 3) [ 3 -  3]   11 (12) [ 3 - 20]
```

CARFIL	10 (3) [3 - 3]	18 (4) [3 - 10]	29 (10) [3 - 30]	16 (15) [3 - 40]
CARGEY	10 (3) [3 - 3]	4 (3) [3 - 3]	13 (9) [3 - 20]	0 (0) [0 - 0]
CARHOO	0 (0) [0 - 0]	0 (0) [0 - 0]	4 (8) [3 - 10]	21 (12) [3 - 20]
CARLUZ	0 (0) [0 - 0]	10 (.4) [3 - 10]	0 (0) [0 - 0]	0 (0) [0 - 0]
CARMIC	0 (0) [0 - 0]	0 (0) [0 - 0]	3 (10) [10 - 10]	0 (0) [0 - 0]
CAROBT	0 (0) [0 - 0]	0 (0) [0 - 0]	3 (3) [3 - 3]	0 (0) [0 - 0]
CARPET	13 (3) [3 - 3]	8 (7) [3 - 10]	7 (6) [3 - 10]	21 (8) [3 - 10]
CARPRA	0 (0) [0 - 0]	2 (3) [3 - 3]	0 (0) [0 - 0]	0 (0) [0 - 0]
CARRAY	0 (0) [0 - 0]	2 (3) [3 - 3]	0 (0) [0 - 0]	11 (3) [3 - 3]
CARRUP	3 (3) [3 - 3]	0 (0) [0 - 0]	0 (0) [0 - 0]	0 (0) [0 - 0]
CARSPE	0 (0) [0 - 0]	0 (0) [0 - 0]	6 (15) [10 - 20]	0 (0) [0 - 0]
CARSTE	0 (0) [0 - 0]	0 (0) [0 - 0]	1 (3) [3 - 3]	0 (0) [0 - 0]
DANCAL	0 (0) [0 - 0]	4 (3) [3 - 3]	0 (0) [0 - 0]	0 (0) [0 - 0]
DANINT	23 (5) [3 - 10]	16 (13) [3 - 40]	26 (5) [3 - 10]	47 (11) [3 - 40]
DANPAR	13 (7) [3 - 10]	0 (0) [0 - 0]	0 (0) [0 - 0]	0 (0) [0 - 0]
DANSPI	0 (0) [0 - 0]	4 (7) [3 - 10]	1 (3) [3 - 3]	0 (0) [0 - 0]
DANTHO	0 (0) [0 - 0]	0 (0) [0 - 0]	1 (3) [3 - 3]	0 (0) [0 - 0]
DANUNI	0 (0) [0 - 0]	4 (25) [10 - 40]	4 (3) [3 - 3]	0 (0) [0 - 0]
DESCES	0 (0) [0 - 0]	0 (0) [0 - 0]	1 (10) [10 - 10]	0 (0) [0 - 0]
ELYCAN	0 (0) [0 - 0]	0 (0) [0 - 0]	3 (20) [20 - 20]	0 (0) [0 - 0]
ELYMUS	0 (0) [0 - 0]	0 (0) [0 - 0]	0 (0) [0 - 0]	5 (3) [3 - 3]
FESIDA	80 (14) [3 - 40]	86 (16) [3 - 60]	93 (16) [3 - 40]	95 (19) [3 - 50]
FESOCC	0 (0) [0 - 0]	0 (0) [0 - 0]	1 (30) [30 - 30]	0 (0) [0 - 0]
FESSCA	97 (22) [3 - 60]	86 (30) [3 - 70]	82 (18) [3 - 70]	79 (20) [3 - 50]
GRASSX	0 (0) [0 - 0]	0 (0) [0 - 0]	0 (0) [0 - 0]	11 (3) [3 - 3]
HELHOO	0 (0) [0 - 0]	2 (10) [10 - 10]	0 (0) [0 - 0]	0 (0) [0 - 0]
JUNBAL	0 (0) [0 - 0]	2 (3) [3 - 3]	0 (0) [0 - 0]	0 (0) [0 - 0]
JUNCUS	0 (0) [0 - 0]	0 (0) [0 - 0]	0 (0) [0 - 0]	5 (80) [80 - 80]
JUNTEN	0 (0) [0 - 0]	2 (3) [3 - 3]	0 (0) [0 - 0]	0 (0) [0 - 0]
KOECRI	13 (7) [3 - 10]	12 (4) [3 - 10]	51 (5) [3 - 10]	53 (5) [3 - 10]
KOEMAC	0 (0) [0 - 0]	0 (0) [0 - 0]	1 (3) [3 - 3]	0 (0) [0 - 0]
KOEPYR	0 (0) [0 - 0]	2 (3) [3 - 3]	0 (0) [0 - 0]	0 (0) [0 - 0]
MELBUL	0 (0) [0 - 0]	0 (0) [0 - 0]	3 (3) [3 - 3]	0 (0) [0 - 0]
PHLPRA	7 (3) [3 - 3]	4 (12) [3 - 20]	8 (13) [3 - 40]	0 (0) [0 - 0]
POA	0 (0) [0 - 0]	2 (20) [20 - 20]	0 (0) [0 - 0]	5 (3) [3 - 3]
POAFEN	0 (0) [0 - 0]	10 (3) [3 - 3]	0 (0) [0 - 0]	0 (0) [0 - 0]
POAINT	0 (0) [0 - 0]	0 (0) [0 - 0]	3 (10) [10 - 10]	11 (3) [3 - 3]
POAPRA	10 (3) [3 - 3]	18 (3) [3 - 3]	25 (3) [3 - 3]	11 (3) [3 - 3]
POASAN	3 (3) [3 - 3]	6 (3) [3 - 3]	11 (6) [3 - 20]	0 (0) [0 - 0]
POASEC	7 (7) [3 - 10]	4 (22) [3 - 40]	1 (3) [3 - 3]	0 (0) [0 - 0]
POAXXX	3 (3) [3 - 3]	2 (10) [10 - 10]	1 (3) [3 - 3]	5 (10) [10 - 10]
STIOCC	0 (0) [0 - 0]	0 (0) [0 - 0]	1 (20) [20 - 20]	0 (0) [0 - 0]
STICOM	0 (0) [0 - 0]	0 (0) [0 - 0]	1 (3) [3 - 3]	0 (0) [0 - 0]
STIOCC	10 (3) [3 - 3]	12 (3) [3 - 3]	21 (4) [3 - 10]	11 (10) [10 - 10]
STIRIC	37 (7) [3 - 20]	8 (12) [3 - 30]	17 (10) [3 - 20]	0 (0) [0 - 0]
STIVIR	0 (0) [0 - 0]	2 (10) [10 - 10]	0 (0) [0 - 0]	0 (0) [0 - 0]
***** Forbs *****				
ACHMIL	20 (5) [3 - 10]	22 (6) [3 - 10]	39 (4) [3 - 10]	37 (4) [3 - 10]
AGOGLA	3 (3) [3 - 3]	8 (3) [3 - 3]	4 (5) [3 - 10]	5 (3) [3 - 3]
ALLCER	0 (0) [0 - 0]	0 (0) [0 - 0]	4 (3) [3 - 3]	5 (3) [3 - 3]

ALLIUM	0 (0) [0 - 0]	0 (0) [0 - 0]	0 (0) [0 - 0]	5 (3) [3 - 3]
ANAMAR	0 (0) [0 - 0]	0 (0) [0 - 0]	0 (0) [0 - 0]	11 (3) [3 - 3]
ANEMON	3 (10) [10 - 10]	0 (0) [0 - 0]	3 (3) [3 - 3]	0 (0) [0 - 0]
ANEMUL	0 (0) [0 - 0]	2 (3) [3 - 3]	3 (7) [3 - 10]	0 (0) [0 - 0]
ANENUT	3 (3) [3 - 3]	0 (0) [0 - 0]	3 (3) [3 - 3]	0 (0) [0 - 0]
ANEPAR	0 (0) [0 - 0]	4 (7) [3 - 10]	0 (0) [0 - 0]	0 (0) [0 - 0]
ANTANA	0 (0) [0 - 0]	4 (3) [3 - 3]	1 (3) [3 - 3]	0 (0) [0 - 0]
ANTMIC	33 (6) [3 - 20]	10 (3) [3 - 3]	38 (7) [3 - 20]	21 (5) [3 - 10]
ANTPAR	0 (0) [0 - 0]	0 (0) [0 - 0]	3 (3) [3 - 3]	0 (0) [0 - 0]
ANTRAC	7 (3) [3 - 3]	0 (0) [0 - 0]	0 (0) [0 - 0]	5 (3) [3 - 3]
ANTROS	0 (0) [0 - 0]	4 (3) [3 - 3]	3 (10) [10 - 10]	0 (0) [0 - 0]
ANTUMB	0 (0) [0 - 0]	0 (0) [0 - 0]	6 (9) [3 - 20]	0 (0) [0 - 0]
ARECON	10 (3) [3 - 3]	16 (4) [3 - 10]	24 (7) [3 - 10]	53 (8) [3 - 20]
ARNDIV	0 (0) [0 - 0]	2 (10) [10 - 10]	0 (0) [0 - 0]	0 (0) [0 - 0]
ARNFUL	0 (0) [0 - 0]	2 (3) [3 - 3]	0 (0) [0 - 0]	16 (3) [3 - 3]
ARNICA	3 (3) [3 - 3]	0 (0) [0 - 0]	0 (0) [0 - 0]	0 (0) [0 - 0]
ARNRYD	0 (0) [0 - 0]	8 (5) [3 - 10]	0 (0) [0 - 0]	0 (0) [0 - 0]
ARNSOR	7 (3) [3 - 3]	8 (3) [3 - 3]	1 (3) [3 - 3]	0 (0) [0 - 0]
ARTDRA	0 (0) [0 - 0]	2 (3) [3 - 3]	0 (0) [0 - 0]	0 (0) [0 - 0]
ARTLUD	0 (0) [0 - 0]	12 (4) [3 - 10]	1 (3) [3 - 3]	0 (0) [0 - 0]
ASTBOU	0 (0) [0 - 0]	2 (3) [3 - 3]	0 (0) [0 - 0]	0 (0) [0 - 0]
ASTCAM	0 (0) [0 - 0]	0 (0) [0 - 0]	1 (3) [3 - 3]	0 (0) [0 - 0]
ASTCHI	0 (0) [0 - 0]	0 (0) [0 - 0]	3 (3) [3 - 3]	0 (0) [0 - 0]
ASTINT	0 (0) [0 - 0]	0 (0) [0 - 0]	3 (3) [3 - 3]	0 (0) [0 - 0]
ASTMIS	0 (0) [0 - 0]	0 (0) [0 - 0]	3 (3) [3 - 3]	0 (0) [0 - 0]
ASTOCC	0 (0) [0 - 0]	0 (0) [0 - 0]	3 (3) [3 - 3]	0 (0) [0 - 0]
ASTRAG	0 (0) [0 - 0]	0 (0) [0 - 0]	1 (3) [3 - 3]	0 (0) [0 - 0]
BALSAG	0 (0) [0 - 0]	2 (3) [3 - 3]	4 (9) [3 - 20]	0 (0) [0 - 0]
BESRUB	3 (3) [3 - 3]	0 (0) [0 - 0]	0 (0) [0 - 0]	5 (3) [3 - 3]
BESWYO	0 (0) [0 - 0]	8 (5) [3 - 10]	3 (12) [3 - 20]	0 (0) [0 - 0]
CAMROT	0 (0) [0 - 0]	6 (3) [3 - 3]	11 (4) [3 - 10]	16 (3) [3 - 3]
CASEXI	0 (0) [0 - 0]	0 (0) [0 - 0]	1 (3) [3 - 3]	0 (0) [0 - 0]
CASLUT	0 (0) [0 - 0]	0 (0) [0 - 0]	3 (3) [3 - 3]	0 (0) [0 - 0]
CENMAC	0 (0) [0 - 0]	0 (0) [0 - 0]	3 (3) [3 - 3]	0 (0) [0 - 0]
CERARV	3 (3) [3 - 3]	6 (3) [3 - 3]	17 (5) [3 - 10]	37 (5) [3 - 10]
CHRVIL	0 (0) [0 - 0]	2 (3) [3 - 3]	3 (7) [3 - 10]	0 (0) [0 - 0]
CIRFOL	0 (0) [0 - 0]	0 (0) [0 - 0]	1 (3) [3 - 3]	0 (0) [0 - 0]
CIRSIU	0 (0) [0 - 0]	0 (0) [0 - 0]	0 (0) [0 - 0]	5 (3) [3 - 3]
CIRVUL	0 (0) [0 - 0]	0 (0) [0 - 0]	3 (3) [3 - 3]	0 (0) [0 - 0]
CLEHIR	0 (0) [0 - 0]	4 (12) [3 - 20]	0 (0) [0 - 0]	0 (0) [0 - 0]
COLLIN	3 (3) [3 - 3]	2 (3) [3 - 3]	0 (0) [0 - 0]	0 (0) [0 - 0]
COMUMB	0 (0) [0 - 0]	0 (0) [0 - 0]	1 (3) [3 - 3]	0 (0) [0 - 0]
CREATR	0 (0) [0 - 0]	0 (0) [0 - 0]	3 (3) [3 - 3]	0 (0) [0 - 0]
CREMOD	0 (0) [0 - 0]	2 (3) [3 - 3]	0 (0) [0 - 0]	0 (0) [0 - 0]
CRENAN	0 (0) [0 - 0]	2 (3) [3 - 3]	0 (0) [0 - 0]	0 (0) [0 - 0]
DELBIC	0 (0) [0 - 0]	6 (3) [3 - 3]	0 (0) [0 - 0]	0 (0) [0 - 0]
DODECA	3 (3) [3 - 3]	0 (0) [0 - 0]	0 (0) [0 - 0]	5 (3) [3 - 3]
DODPUL	0 (0) [0 - 0]	0 (0) [0 - 0]	1 (10) [10 - 10]	0 (0) [0 - 0]
DOUMON	3 (10) [10 - 10]	0 (0) [0 - 0]	0 (0) [0 - 0]	0 (0) [0 - 0]
EPIANG	3 (10) [10 - 10]	2 (3) [3 - 3]	3 (7) [3 - 10]	5 (3) [3 - 3]

ERICOM	0 (0) [0 - 0]	0 (0) [0 - 0]	4 (5) [3 - 10]	0 (0) [0 - 0]
ERICOR	0 (0) [0 - 0]	4 (3) [3 - 3]	0 (0) [0 - 0]	0 (0) [0 - 0]
ERIFLA	7 (3) [3 - 3]	0 (0) [0 - 0]	4 (5) [3 - 10]	0 (0) [0 - 0]
ERIGER	3 (10) [10 - 10]	0 (0) [0 - 0]	0 (0) [0 - 0]	0 (0) [0 - 0]
ERIHUM	0 (0) [0 - 0]	6 (5) [3 - 10]	0 (0) [0 - 0]	0 (0) [0 - 0]
ERIOCH	0 (0) [0 - 0]	2 (3) [3 - 3]	0 (0) [0 - 0]	0 (0) [0 - 0]
ERIOGO	3 (10) [10 - 10]	0 (0) [0 - 0]	0 (0) [0 - 0]	0 (0) [0 - 0]
ERISPE	10 (3) [3 - 3]	6 (9) [3 - 20]	1 (3) [3 - 3]	0 (0) [0 - 0]
ERISUB	0 (0) [0 - 0]	12 (7) [3 - 10]	0 (0) [0 - 0]	0 (0) [0 - 0]
ERIUMB	33 (4) [3 - 10]	2 (3) [3 - 3]	26 (4) [3 - 20]	32 (5) [3 - 10]
EUPESU	7 (20) [20 - 20]	0 (0) [0 - 0]	0 (0) [0 - 0]	0 (0) [0 - 0]
FORBAN	0 (0) [0 - 0]	0 (0) [0 - 0]	1 (3) [3 - 3]	0 (0) [0 - 0]
FORBXX	3 (10) [10 - 10]	0 (0) [0 - 0]	1 (3) [3 - 3]	0 (0) [0 - 0]
FRAGAR	3 (20) [20 - 20]	0 (0) [0 - 0]	0 (0) [0 - 0]	0 (0) [0 - 0]
FRASPE	3 (3) [3 - 3]	8 (13) [3 - 20]	4 (3) [3 - 3]	0 (0) [0 - 0]
FRAVES	0 (0) [0 - 0]	0 (0) [0 - 0]	3 (3) [3 - 3]	5 (3) [3 - 3]
FRAVIR	13 (3) [3 - 3]	8 (5) [3 - 10]	15 (5) [3 - 10]	11 (3) [3 - 3]
FRIPUD	0 (0) [0 - 0]	0 (0) [0 - 0]	1 (3) [3 - 3]	0 (0) [0 - 0]
GAIARI	0 (0) [0 - 0]	10 (6) [3 - 20]	6 (5) [3 - 10]	0 (0) [0 - 0]
GALBOR	10 (8) [3 - 10]	18 (6) [3 - 20]	14 (7) [3 - 20]	16 (8) [3 - 10]
GAYRAC	0 (0) [0 - 0]	0 (0) [0 - 0]	0 (0) [0 - 0]	5 (3) [3 - 3]
GENAFF	0 (0) [0 - 0]	4 (3) [3 - 3]	0 (0) [0 - 0]	0 (0) [0 - 0]
GENCAL	0 (0) [0 - 0]	0 (0) [0 - 0]	3 (3) [3 - 3]	0 (0) [0 - 0]
GERRIC	0 (0) [0 - 0]	0 (0) [0 - 0]	0 (0) [0 - 0]	11 (3) [3 - 3]
GERVIS	27 (8) [3 - 40]	22 (6) [3 - 10]	28 (8) [3 - 20]	26 (10) [3 - 20]
GEUMXX	0 (0) [0 - 0]	0 (0) [0 - 0]	1 (3) [3 - 3]	0 (0) [0 - 0]
GEUTRI	37 (8) [3 - 20]	31 (4) [3 - 10]	36 (5) [3 - 20]	32 (4) [3 - 10]
GNAMIC	3 (10) [10 - 10]	0 (0) [0 - 0]	1 (3) [3 - 3]	0 (0) [0 - 0]
HACFLO	0 (0) [0 - 0]	0 (0) [0 - 0]	1 (3) [3 - 3]	0 (0) [0 - 0]
HELUNI	3 (3) [3 - 3]	0 (0) [0 - 0]	0 (0) [0 - 0]	0 (0) [0 - 0]
HETVIL	0 (0) [0 - 0]	0 (0) [0 - 0]	3 (3) [3 - 3]	0 (0) [0 - 0]
HEUCYL	3 (3) [3 - 3]	0 (0) [0 - 0]	3 (3) [3 - 3]	0 (0) [0 - 0]
HEVCYL	0 (0) [0 - 0]	0 (0) [0 - 0]	1 (3) [3 - 3]	0 (0) [0 - 0]
HIEACI	0 (0) [0 - 0]	0 (0) [0 - 0]	3 (7) [3 - 10]	0 (0) [0 - 0]
HIEALB	3 (3) [3 - 3]	0 (0) [0 - 0]	1 (3) [3 - 3]	0 (0) [0 - 0]
HIEALE	0 (0) [0 - 0]	0 (0) [0 - 0]	6 (11) [3 - 20]	0 (0) [0 - 0]
HIEGRA	0 (0) [0 - 0]	0 (0) [0 - 0]	1 (3) [3 - 3]	0 (0) [0 - 0]
HIERAC	3 (3) [3 - 3]	0 (0) [0 - 0]	3 (3) [3 - 3]	0 (0) [0 - 0]
IRIMIS	0 (0) [0 - 0]	0 (0) [0 - 0]	3 (3) [3 - 3]	5 (10) [10 - 10]
IRISXX	0 (0) [0 - 0]	0 (0) [0 - 0]	3 (3) [3 - 3]	0 (0) [0 - 0]
LINLEW	0 (0) [0 - 0]	2 (3) [3 - 3]	0 (0) [0 - 0]	0 (0) [0 - 0]
LITRUD	3 (10) [10 - 10]	6 (5) [3 - 10]	18 (4) [3 - 10]	11 (3) [3 - 3]
LOMCOU	0 (0) [0 - 0]	0 (0) [0 - 0]	0 (0) [0 - 0]	5 (3) [3 - 3]
LOMMAC	0 (0) [0 - 0]	2 (3) [3 - 3]	0 (0) [0 - 0]	0 (0) [0 - 0]
LOMTRI	0 (0) [0 - 0]	0 (0) [0 - 0]	1 (3) [3 - 3]	0 (0) [0 - 0]
LUPARG	0 (0) [0 - 0]	24 (11) [3 - 30]	1 (10) [10 - 10]	0 (0) [0 - 0]
LUPINU	7 (7) [3 - 10]	0 (0) [0 - 0]	6 (15) [10 - 30]	0 (0) [0 - 0]
LUPNUS	0 (0) [0 - 0]	0 (0) [0 - 0]	3 (7) [3 - 10]	0 (0) [0 - 0]
LUPSER	33 (8) [3 - 20]	22 (8) [3 - 30]	33 (5) [3 - 20]	58 (16) [3 - 40]
LUPWYE	0 (0) [0 - 0]	0 (0) [0 - 0]	1 (10) [10 - 10]	0 (0) [0 - 0]

LYCDRU	0 (0) [0 - 0]	2 (3) [3 - 3]	0 (0) [0 - 0]	0 (0) [0 - 0]
MARVUL	0 (0) [0 - 0]	2 (3) [3 - 3]	0 (0) [0 - 0]	0 (0) [0 - 0]
MERCIL	0 (0) [0 - 0]	0 (0) [0 - 0]	3 (10) [10 - 10]	0 (0) [0 - 0]
MICNIG	0 (0) [0 - 0]	2 (3) [3 - 3]	0 (0) [0 - 0]	0 (0) [0 - 0]
MICNUT	0 (0) [0 - 0]	0 (0) [0 - 0]	1 (3) [3 - 3]	0 (0) [0 - 0]
MUSDIV	0 (0) [0 - 0]	0 (0) [0 - 0]	1 (3) [3 - 3]	0 (0) [0 - 0]
ORTLUT	0 (0) [0 - 0]	2 (3) [3 - 3]	1 (3) [3 - 3]	0 (0) [0 - 0]
ORTTEN	0 (0) [0 - 0]	2 (3) [3 - 3]	4 (9) [3 - 20]	0 (0) [0 - 0]
OXYCAM	0 (0) [0 - 0]	2 (3) [3 - 3]	3 (3) [3 - 3]	11 (3) [3 - 3]
OXYSER	0 (0) [0 - 0]	8 (7) [3 - 10]	0 (0) [0 - 0]	5 (3) [3 - 3]
OXYSPL	0 (0) [0 - 0]	4 (3) [3 - 3]	0 (0) [0 - 0]	0 (0) [0 - 0]
PEDCON	7 (3) [3 - 3]	4 (7) [3 - 10]	0 (0) [0 - 0]	0 (0) [0 - 0]
PEDGRO	0 (0) [0 - 0]	0 (0) [0 - 0]	0 (0) [0 - 0]	11 (3) [3 - 3]
PEDICU	0 (0) [0 - 0]	0 (0) [0 - 0]	1 (3) [3 - 3]	0 (0) [0 - 0]
PEDPAR	0 (0) [0 - 0]	2 (3) [3 - 3]	1 (3) [3 - 3]	0 (0) [0 - 0]
PENCON	17 (3) [3 - 3]	0 (0) [0 - 0]	1 (20) [20 - 20]	0 (0) [0 - 0]
PENPRO	3 (3) [3 - 3]	0 (0) [0 - 0]	21 (5) [3 - 20]	32 (3) [3 - 3]
PENRYD	0 (0) [0 - 0]	0 (0) [0 - 0]	1 (3) [3 - 3]	0 (0) [0 - 0]
PENSTE	3 (3) [3 - 3]	0 (0) [0 - 0]	0 (0) [0 - 0]	5 (3) [3 - 3]
PHLCAE	0 (0) [0 - 0]	0 (0) [0 - 0]	6 (3) [3 - 3]	11 (3) [3 - 3]
PHLHOO	0 (0) [0 - 0]	2 (3) [3 - 3]	1 (10) [10 - 10]	0 (0) [0 - 0]
PHLLON	0 (0) [0 - 0]	0 (0) [0 - 0]	4 (3) [3 - 3]	0 (0) [0 - 0]
PHLOXX	3 (3) [3 - 3]	0 (0) [0 - 0]	0 (0) [0 - 0]	5 (3) [3 - 3]
POLBIS	3 (3) [3 - 3]	4 (3) [3 - 3]	3 (3) [3 - 3]	5 (3) [3 - 3]
POLVIV	0 (0) [0 - 0]	0 (0) [0 - 0]	1 (3) [3 - 3]	0 (0) [0 - 0]
POTANS	0 (0) [0 - 0]	4 (3) [3 - 3]	0 (0) [0 - 0]	0 (0) [0 - 0]
POTARE	0 (0) [0 - 0]	2 (20) [20 - 20]	0 (0) [0 - 0]	0 (0) [0 - 0]
POTARG	7 (3) [3 - 3]	0 (0) [0 - 0]	7 (3) [3 - 3]	0 (0) [0 - 0]
POTBIP	0 (0) [0 - 0]	2 (3) [3 - 3]	0 (0) [0 - 0]	0 (0) [0 - 0]
POTENT	7 (3) [3 - 3]	0 (0) [0 - 0]	0 (0) [0 - 0]	0 (0) [0 - 0]
POTGLA	7 (3) [3 - 3]	2 (3) [3 - 3]	10 (5) [3 - 10]	0 (0) [0 - 0]
POTGRA	13 (3) [3 - 3]	29 (5) [3 - 10]	25 (9) [3 - 20]	32 (5) [3 - 10]
POTREC	0 (0) [0 - 0]	4 (3) [3 - 3]	0 (0) [0 - 0]	0 (0) [0 - 0]
RANUNC	0 (0) [0 - 0]	0 (0) [0 - 0]	0 (0) [0 - 0]	5 (3) [3 - 3]
SAXRHO	0 (0) [0 - 0]	2 (10) [10 - 10]	1 (3) [3 - 3]	0 (0) [0 - 0]
SEDLAN	0 (0) [0 - 0]	2 (3) [3 - 3]	4 (3) [3 - 3]	0 (0) [0 - 0]
SEDSTE	0 (0) [0 - 0]	0 (0) [0 - 0]	1 (3) [3 - 3]	0 (0) [0 - 0]
SEDUM	3 (3) [3 - 3]	0 (0) [0 - 0]	0 (0) [0 - 0]	0 (0) [0 - 0]
SENCAN	0 (0) [0 - 0]	0 (0) [0 - 0]	1 (3) [3 - 3]	0 (0) [0 - 0]
SENECI	0 (0) [0 - 0]	2 (3) [3 - 3]	0 (0) [0 - 0]	11 (12) [3 - 20]
SILSCO	0 (0) [0 - 0]	0 (0) [0 - 0]	1 (3) [3 - 3]	0 (0) [0 - 0]
SOLMIS	10 (11) [3 - 20]	4 (7) [3 - 10]	15 (6) [3 - 10]	0 (0) [0 - 0]
SOLRIG	0 (0) [0 - 0]	2 (3) [3 - 3]	0 (0) [0 - 0]	0 (0) [0 - 0]
STRLON	0 (0) [0 - 0]	0 (0) [0 - 0]	0 (0) [0 - 0]	11 (3) [3 - 3]
TAROFF	3 (3) [3 - 3]	8 (3) [3 - 3]	3 (3) [3 - 3]	5 (3) [3 - 3]
TRILON	0 (0) [0 - 0]	6 (9) [3 - 20]	0 (0) [0 - 0]	0 (0) [0 - 0]
VICAME	0 (0) [0 - 0]	4 (3) [3 - 3]	4 (3) [3 - 3]	0 (0) [0 - 0]
ZIGELE	0 (0) [0 - 0]	4 (7) [3 - 10]	0 (0) [0 - 0]	0 (0) [0 - 0]
ZIGVEN	3 (3) [3 - 3]	8 (3) [3 - 3]	3 (3) [3 - 3]	0 (0) [0 - 0]

```
***** Ferns *****

   LYCANN      0 ( 0) [ 0 -  0]    2 ( 3) [ 3 -  3]    0 ( 0) [ 0 -  0]    0 ( 0) [ 0 -  0]
   LYCOPO      0 ( 0) [ 0 -  0]    0 ( 0) [ 0 -  0]    0 ( 0) [ 0 -  0]    5 (10) [10 - 10]
   MOSSES      3 (30) [30 - 30]    0 ( 0) [ 0 -  0]    0 ( 0) [ 0 -  0]    0 ( 0) [ 0 -  0]
   MOSSXX      0 ( 0) [ 0 -  0]    0 ( 0) [ 0 -  0]   10 ( 7) [ 3 - 10]    0 ( 0) [ 0 -  0]
   SELAGI      0 ( 0) [ 0 -  0]    0 ( 0) [ 0 -  0]    1 (10) [10 - 10]    0 ( 0) [ 0 -  0]
   SELDEN      7 ( 3) [ 3 -  3]   10 ( 3) [ 3 -  3]   14 ( 3) [ 3 -  3]   11 ( 3) [ 3 -  3]

***** Bryophytes *****
   LICHEN      0 ( 0) [ 0 -  0]    0 ( 0) [ 0 -  0]    1 (10) [10 - 10]    0 ( 0) [ 0 -  0]
   MOSS       10 ( 8) [ 3 - 10]    2 ( 3) [ 3 -  3]    3 (10) [10 - 10]   11 ( 3) [ 3 -  3]
   MOSSXX      7 ( 7) [ 3 - 10]    0 ( 0) [ 0 -  0]    6 (19) [ 3 - 60]    0 ( 0) [ 0 -  0]
```