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AN EVALUATION AND COMPARISON OF ALTERNATIVE VEGETATION CLASSIFICATION SYSTEMS ON THE LUBRECHT EXPERIMENTAL FOREST

by

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Abstract

There currently exists no single, operational, standard National Vegetation Classification System (NVCS). A number of agencies and organizations at the federal and state level each have their own system for classifying, inventorying, assessing, mapping, and reporting data, some of which are in conflict. Many disciplines such as landscape ecology, conservation biology, and natural resource management, require the use of a vegetation classification system. The Federal Geographic Data Committee Vegetation Subcommittee (FGDC), the Ecological Society of America (ESA) and the Nature Conservancy (TNC) have recognized the need for a national system and are developing a seven level hierarchical system using physiognomy to define the top five levels and floristics to define the bottom two.

For this study, a classification was developed based on data collected from eight forty-acre grids on the Lubrecht Experimental Forest in northwest Montana in order to evaluate methodology in defining alliances and community associations using classification and ordination techniques. Eight new types were created based on the results of TWINSPAN, cluster analysis, and synthesis tables using floristic data from 67 homogeneous plots. The new types reflect an ecological gradient, primarily moisture and elevation. The taxonomic key for the new types is based on a dominant overstory species and a diagnostic understory species.

Comparison of the new community associations with alternative classification system types, including habitat types, cover types, process-based structure types, and stand structure types, demonstrates possibilities and difficulties in transforming existing data to conform with the proposed NVCS hierarchy.

The questions of including non-homogeneous plots in a classification, and of utilizing an objective, systematic sampling grid, are addressed with respect to the concept of entitation and repeated plots within the same stand by comparing an ecotonal data set to a non-ecotonal data set.

Creation of a classification is shown to be a multifaceted task based on user judgement, statistical validity, comparison with other classifications, and final acceptance of criteria for defining new types.

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My final note of thanks goes to Richard Stineman, who along with Jamestown School Forest Association, provided support throughout my entire forestry education. Thanks also for providing the initial inspiration years ago to devote my life to the natural world.

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Chapter I: Introduction and Problem Statement

The need for vegetation classification systems in the form of inventory, taxonomy, reporting, and mapping has changed dramatically during the past decade (Pfister and Hansen 1993). Landscape ecology patch types (Forman 1995), coarse filter conservation strategies (Christensen et. al. 1996), ecosystem management, and natural resource management planning all require the use of a classified system of vegetation types as well as knowledge of existing vegetative cover by seral stage on the land area to be managed. There currently exists no single, operational, standard National Vegetation Classification System (NVCS) accepted by the federal and state agencies, academic institutions, and non-governmental organizations that use classification systems. The number of existing classification systems is large with broad variation in the systems. One primary difference in systems is between those using existing vegetation and those using potential natural vegetation. Various agencies and organizations inventory, map, analyze, and report vegetation in a variety of ways, sometimes in direct conflict with each other due to different protocols or definitions (FGDC 1997). In the federal government alone, there are thirteen agencies that regularly use various vegetation classification systems. In addition, many classification systems are used in inappropriate ways due to a lack of a better system in a particular region or site.

Previous demand for a single vegetation classification was low and classification approaches were localized to deal with disparate, unconnected activities. Today, pressure to manage resources in a coordinated manner is high. A unified approach would increase our understanding of the ecology of forested systems and management of forested areas at large scales, as well as ease communication among agencies, levels of government, and private landowners. Specific benefits of a unified classification system may include accurate and consistent predictions of timber production, enhanced communication in natural resource professions (Kimmins 1997), a more consistent, science-based effort to preserve global natural diversity through a coarse filter/fine filter approach (Christensen et. al. 1996, Bourgeron et. al. 1989), and more accurate prediction of dynamic ecological processes such as successional productivity and prediction of environmental change (Damman 1998, Personal Communication). Research needs identified at a major 1987 vegetation classification symposium included the need to "coordinate, unify, or standardize concepts and approaches of classification to meet needs of users,", to "develop regional correlations of classifications,", to "improve ecotone identification and mapping techniques"; and to come to an "agreement on desired vegetation classification system " and achieve "increased cooperation and coordination among agencies in classifying vegetation" (Pfister 1989b). There also exists a "profound need for a unified, peer-reviewed" classification system based on standardized nomenclature, terminology, methods, descriptions, and data management (Damman 1998, Personal Communication).

A. Literature Review

1. A National Vegetation Classification System

The proposed NVCS is the culmination of a multi-agency, interdisciplinary effort, established by the Vegetation Subcommittee of the Federal Government Data Committee (FGDC) (FGDC 1997). The current version, based on existing vegetation, is strongly influenced by The Nature Conservancy (TNC) efforts over the past decades (Grossman et. al. 1994). A major difference in alternative systems developed since in the 1970's is the use of either potential natural vegetation or existing vegetation. In 1973, the United Nations Educational, Scientific, and Cultural Organization (UNESCO) developed a potential natural vegetation system for use over broad land areas. Out of this effort, a system developed by Driscoll et. al. (1984) was based on the UNESCO system for application to potential natural vegetation as a site classification tool. A major shortcoming of the UNESCO system was its generality, while the Driscoll et. al. work was limited by its lack of mapping components. In the late 1980's the GAP Analysis Program initiated a national, state-by-state mapping effort using natural and semi-natural existing vegetation described in a publication by Jennings (1993). A wealth of federal natural legislation including the National Forest Management Act of 1976, the National Environmental Policy Act of 1969, and the Endangered Species Act of 1973 hinted at the necessity of a standardized method of classifying vegetation for the nation (Ferenstein 1994). In 1994 the FGDC produced its first draft of an NVCS. A Vegetation Classification Panel in the Ecological Society of American (ESA) was established in 1995 to first review efforts by the FGDC and secondly to develop standards for the floristic-based lower levels of the FGDC hierarchy (Loucks 1996). The 1996 draft of the NVCS was published in the Federal Register for public comment. The 1997 final version received federal approval from Interior Secretary Bruce Babbitt in June of 1997 (FGDC 1997).

The NVCS is designed as a seven-level hierarchical system combining physiognomy and floristics. Floristic systems use total plant species composition in grouping ecosystems, and physiognomic approaches are among the oldest systems based on plant growth form (Mueller-Dombois and Ellenberg 1974). Grossman et al. (1994) promoted the idea of integrating the two systems, although a system combining these two major approaches to classifying an ecosystem is a concept dating back to the previous century (see Warming 1895, English translation 1909). For clarification, the other main approach to ecosystem classification is by site, which is not included in the NVCS; site-based classification have widespread use in the northwestern U. S. including the Biogeoclimatic Ecosystem Classification of British Columbia (Pojar et al. 1987), and habitat typing (Daubenmire 1952, Daubenmire and Daubenmire 1968, Dyrness et al. 1974, Pfister et al. 1977, Mueggler and Stewart 1980, Cooper et al. 1987). For a complete review of major types of ecosystem classification, see Mueller-Dombois and Ellenberg (1974) and Kimmins (1997).

The upper five physiognomic levels are defined in broad terms for large areas of land, while the bottom two, the Alliance and Community Association, will require local floristic specific data. The top five levels have been already defined for broad application across a variety of landscapes in the U. S.; the bottom two require specific floristic data to be collected or collated by more restrictive region in defining the alliance and association. At this point, no standard methodology for translating plot data into alliances and community associations has been adopted although several procedures are discussed by the ESA Vegetation Classification Panel in a working draft report, currently not available for citation, presented at the National ESA Conference in Albuquerque, NM, in 1997.

Interest in translating existing data or using a qualitative rating system on the reliability and robustness of data for defining an association is growing.

2. A Brief History of Classification

Classification is an intuitive, natural, and inherent process (Shimwell 1971) resulting perhaps from an innate desire to explain, understand and predict ourselves and our environment (Kimmins 1997). It is a fundamental, ubiquitous activity (Gauch 1982). The history of vegetation classification follows the history of vegetation science as pioneers in the field attempted to group like assemblages of vegetation to describe and communicate their observations. As Whittaker (1962) observed, "no aspect of synecological science has been the subject of more discussion and argument, or has had a more crucial role in the evolution of ecological science, than the classification of natural communities." Many schools or traditions of vegetation classification have developed in Europe (see Heimburger's 1934 study and reviews by Becking 1957, Whittaker 1962, Shimwell 1971, McIntosh 1978, and Kimmins 1997). American plant ecology was heavily influenced by the ideas of Clements (1936) who recognized stable vegetation units as "associations" controlled by regional climate, causing the "climatic climax," although his ideas were never universally accepted in the U. S. (Whittaker 1962). Gleason (1926) formed his contrasting ideas on the individualistic concept of a plant association, causing a persistent controversy in American literature (review McIntosh 1978). The use of the term "association" is a source of confusion to the present because the association as an abstract type versus the association as an individual community or entity was not distinguished. Both plant ecology concepts were questioned by British plant ecologist Tansley, who along with British plant ecologists and some American ecologists recognized a polyclimax theory and discounted a single climax, a "biotic community" concept, and a "complex organism concept" (Tansley 1935). Although British and American schools of vegetative thought were considered distinct (Whittaker 1962) many of the concepts were held in common; influential American plant ecologist Cowles' ideas (1901, 1899), were influenced by the ideas and works of Warming (1895), another British ecologist. In contrast, drastic differences in schools of thought developed between the American "plant ecologists" and the European "phytosociologists," embodied in the Zurich-Montpellier School of Phytosociology that explained phytosociology as "a science of the flora," delimiting regions based on plant taxa without regard to abundance and ecology (Becking 1957). Classical phytosociology was based on the assumption that vegetation occurred in discrete units called stands, with a clear distinction between them, allowing classification to take place. The "principle exponent" of this school was Braun-Blanquet who developed an extensive system for description of large areas of plant communities by a subjective selection of homogeneous area, called a releve plot (Poore 1955a, Poore 1955b, Moore 1961, Van der Maarel 1975). The Braun-Blanquet approach "accepts a view of the plant community that is intermediate between the super-organism concept and the individualistic or continuum concept" (Kimmins 1997). The advantage of this system is the preexistence of overall structure in terms of alliances, allowing easier classification. A criticism of the Braun-Blanquet approach is that it relies on "the selection of stands which the practitioner judges to be homogeneous" therefore no rigorous test of the resulting classification is possible (Hill et al. 1975). The process of entitation, or recognition of homogeneous stands as discrete entities on the landscape, is the keystone of correct application and use of the Braun-Blanquet system; entitation allows the "subjective without preconceived bias" sampling to take place, and is accepted by the FGDC (1997) as one acceptable method to be used in future plot sampling. Furthermore, Mueller-Dombois and Ellenberg (1974) explain that sampling done as "subjective without preconceived bias" is a generally accepted procedure for data collection to be used in practitioner-judged homogeneity of stands.

Certain evolving American ideas during the era of support of the continuum concept led to criticism of plant association and climatic climax concepts by Whittaker (1951), who promoted the idea of the continuum concept of vegetation defined by Gleason (1926), stating that the vegetation would distribute itself along an environmental gradient. Other work (Curtis and McIntosh 1951, McIntosh 1967) also recognized the presence of an environmental gradient along a continuum of vegetation. Vegetation could be defined as a function of its environment, as well as a vegetative community defined as a function of its collective environment (Major 1951).

Discrete vegetation concepts received support through the work of Daubenmire's (1952) vegetation classification on the basis of recognized near-climax stands. Daubenmire (1966) refuted part of the idea of the continuum concept by demonstrating the discontinuity of a vegetated area while explaining the inherent problems of an objective sample when attempting to construct a syntaxonomy without regarding vegetation as having distinct edges. Studies supporting the continuum viewpoint often including many severely disturbed or seral stands, or disturbed mosaics of vegetation in which the "seral mixtures can provide frequent bridging between otherwise reasonably distinct stable types" (Daubenmire 1966). Arguing that these "intergrades" were the prevailing vegetation ignores "synecologically significant phenomenon of the sharpening of ecotones by competitive elimination" (Daubenmire 1966). Daubenmire's approach can be said to be similar to the Braun-Blanquet approach in many ways, such as the Braun-Blanquet emphasis on the "distinction between the abstract idea of the association and the real plant community that is growing in a real physical environment and which is assigned to a particular abstract class or association" (Kimmins 1997) although Daubenmire's (1952) use of the term association was restricted to late-successional vegetation. Further evidence of Daubenmire's approach's similarity to Braun-Blanquet's approach, or that of the Zurich-Montpelier School of Phytosociology, are apparent in Moravec's (1992) article, such as the treatment of "succession in terms of an alteration of floristically distinguished plant communities." Elements of the Scandinavian school of vegetation, which emphasized ground vegetation, epitomized by Cajander in 1926 (Kimmins 1997), are also evident in Daubenmire's system with the focus on important understory indicator species. Classification of late successional associations (as a basis for habitat (site) classification) has resulted in over 100 monographs throughout the western U. S. (Wellner 1989).

3. Some Different Classifications

Vegetation classification by Daubenmire (1952) was the earliest floristic-based classification specific to the inland northwest (Kimmins 1997). Daubenmire used the term association in his "forest associations" meaning strictly the climax type for the site, rather than the more general use by Braun-Blanquet (1928, Westhoff and van der Maarel 1973). The association is the basic unit of vegetation classification which is also used to define the habitat type; the "climax association" represents the potential vegetative condition if all successional stages were telescoped into one instant at the latest successional stage and the effects of disturbance were removed (Pfister and Arno 1980). Reproductive success and predicted late-successional dominant overstory species are used to define the series level; minimal occurrence of specific diagnostic species in the understory defines the association and in some cases the phase. Daubenmire's conceptual basis for recognizing forest associations was initial recognition of potential climax tree species as the primary dominant potential species, followed by distribution of diagnostic undergrowth vegetation (Daubenmire 1952, 1989). The series is restricted to climax types and is described by primary dominant potential species (Pfister and Arno 1980). Stands are grouped into types called associations, followed by keys written to utilize the diagnostic indicator species (Daubenmire and Daubenmire 1968, Pfister and Arno 1980). Habitat typing was intended to be used as a vegetation-based site classification with one of the objectives being "to present information on successional development, timber productivity potential, and other biological observations of importance to forest land managers" (Pfister et. al. 1977). The habitat types used in this study are after Pfister et. al. (1977) defined for the state of Montana.

The Society of American Foresters (SAF) has been involved in the identification, description, and classification of forest cover types since 1929, when the first description and classification of forest types of the eastern United States appeared as a report in the April 1932 issue of the *Journal of Forestry* (Eyre 1980). Prior to this publication, forest cover types were subject to a variety of nomenclature and definitions based on regional tradition and personal opinion, and could involve site variables, ground vegetation, or other quantitative variables in defining a type. Pioneering work in "forest types" within the Russian and Finnish schools of vegetation classification was done during the early part of the twentieth century by Cajander, Morosov, and Sukachev (Heimburger 1934). As early as 1897 the Russian Gutorovisch followed by Morosov in 1904 first used names for different types of forests for timber management; a "forest-stand type" was defined as all stands having similar site quality (Heimburger 1934). Forest cover types were separated from site based typing approaches to focus on the dominant overstory vegetation of the stand. By 1940, the SAF version of forest cover types was consolidated into a bulletin entitled *Forest Cover Types of the Eastern United States* with a companion Western version published five years later (Eyre 1980). The first comprehensive publication was published in 1950 with the involvement of the Canadian Institute of Forestry as Forest Cover Types of North America; this publication has been updated several times to its present form (Eyre 1980, Wenger 1983). Cover types are recognized on the basis of trees rather than the total forest community. Cover types are used extensively in many management applications as this system is easy to learn and use, but these types are "not geared to ecological management of forest lands" (Wellner 1989). Cover types used in this study are after the SAF types (Eyre 1980) for the western United States.

Conventional stand structure types in various formats have been used for decades to describe successional stages, density, and vertical structure of forest vegetation (Pfister 1997, Personal Communication). The conventional stand structure typing used in this study, involving the existing forest vegetation, was developed for use on the Bald Hills Planning Unit of the Lubrecht Experimental Forest as part of a classroom exercise and includes nineteen types (Pfister 1997, Personal Communication). The typing addresses the overall percent cover of the stand, either open or closed; the size class of the trees in the stand, and the number of layers in a stand to define the stands into one of nineteen separate structural categories, as well as a non-forest category (Pfister 1997, Personal Communication).

Process-based structure typing was developed to address the need for a classification system based on "biologically significant vegetative characteristics" that capture the variation of broad areas of the Inland Northwest, encompassing rugged mountainous topography, contrasting geologic substrates, and a highly variable maritime influence from the Pacific coast (O'Hara et. al. 1996). Process-based structure types are a structural vegetation classification based on stand development processes which operate across stands and landscapes. As stated earlier, vegetation classifications based on physiognomic characteristics represent one of the oldest forms of vegetation classification (Mueller-Dombois and Ellenberg 1974). A review of physiognomic systems leading to the process typing development is found in O'Hara et. al. (1996). Use of such an integrated system can help address the significant role of disturbance in Western forests (Habeck 1987) in developing specific resource management objectives and in predicting and planning for vegetation changes over time (O'Hara et. al. 1996). The process-based structure types used in this study were developed for the Interior

Columbia River Basin project where seven unique types were established and described (O'Hara et. al. 1996).

B. Objectives

The objectives of this study are 1) to develop and test protocol for defining vegetation community associations and alliances for existing vegetation of the LEF by developing a classification based on LEF data , 2) to compare alternative vegetation classification systems as expressed on a real landscape, and 3) to examine the effects of ecotonal plot inclusion on the outcome of a classification compared to using non-ecotonal plot data.

Specifically, objective one involved testing the FGCD definitions of alliance and association by exploring the naming of types by dominance or indicator species, or the possibility of combining the two. In Appendix A, the FGDC hierarchy with examples at each level is listed. Vegetation community associations and alliances were named through analytical analysis techniques and synthesis tables. A key created for the new types allows each plot to be included. A key created for the new types allows each plot to be included in one of the defined new LEF types.

Objective two involves a priori comparison of four types collected in the field with analytically derived types and new developed types for the LEF. Habitat types, cover types, process-based structure types, and conventional stand structure types are compared to the groups derived by TWINSPAN, cluster analysis, and the first approximation types developed from analytical techniques and synthesis tables through a series of confusion tables and a sorted comparison table. Non-ecotonal plot data was used for analysis. The transect data used for mapping can also be used for comparison purposes as part of a complementary study once the new LEF types are mapped.

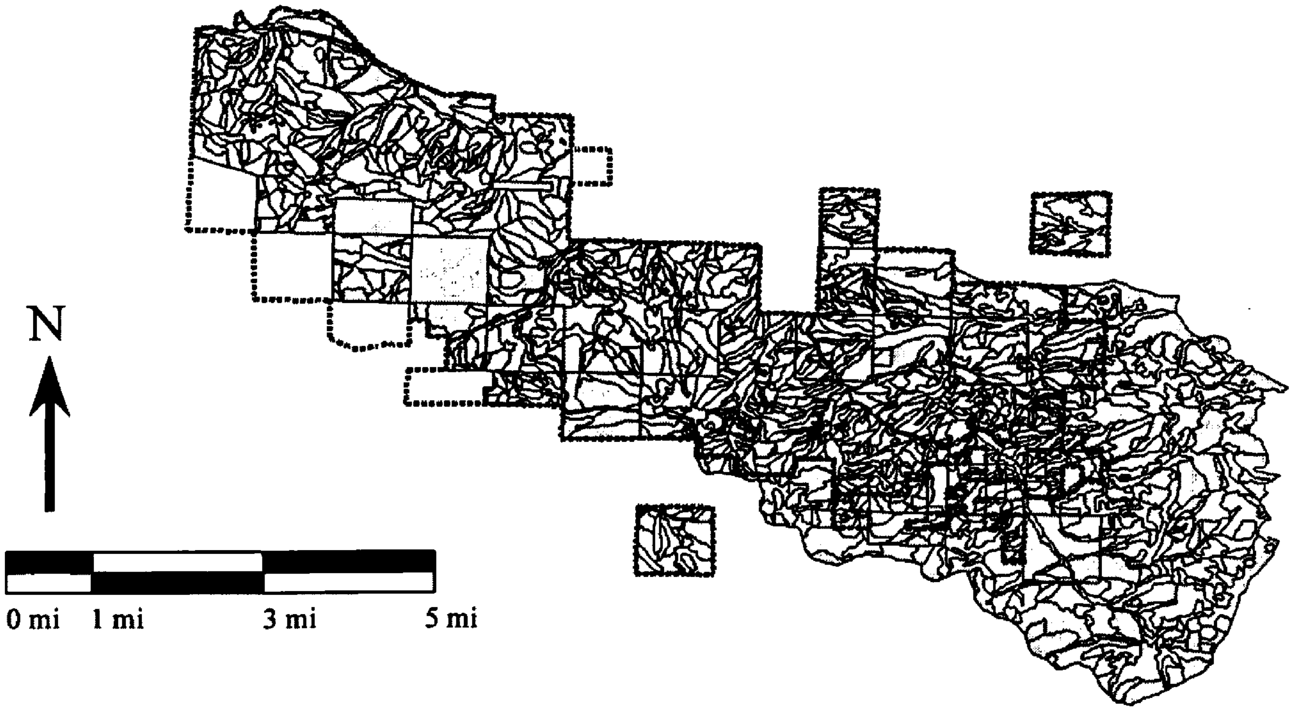
Objective three involves similar analysis and comparison techniques to objectives one and two, using the entire data to observe the changes that occurred in the analysis by the inclusion of ecotonal plots.

Chapter II: Study Area

The study area encompasses the 10,927 ha (28,000 acre) Lubrecht Experimental Forest located in northwestern Montana (46'53'N, 113'27'E) along the Blackfoot River about 53 km (30 miles) east of Missoula, MT (Manasi 1990). Past and present activities on sampled areas include timber harvesting, livestock grazing, hunting, mining, and recreation (Pfister 1983). Main disturbance events include wildfire and clearcutting and other timber harvesting practices. The forest is zoned according to major use as scenic/recreational, demonstration/visual, and integrated resource management with most of the sample sites falling into resource management areas and one in a demonstration area.

This region is part of the Rocky Mountains; in vegetation patterning is affected by a complex set of climatic, physiographic, edaphic, and geologic factors (Habeck 1987). Vegetation is composed mainly of conifers representing a few major vegetation types, which due to elevational gradations, remain fairly constant over broad regions because of the mountainous nature of the terrain (Peet 1988). Forest cover is primarily ponderosa pine (*Pinus ponderosa*), and Douglas-fir (*Pseudotsuga menziesii*) at lower to mid-elevations, with western larch *(Larix occidentalis*) mixed with the Douglas-fir on north and east slopes; dense lodgepole pine *(Pinus contorta*) covers about 10% of the area, mainly resulting from wildfires; and occasional Engelmann spruce (*Picea engelmannii*) and some subalpine fir (*Abies lasiocarpa*) occur at the higher elevations and moist drainages. Quaking aspen (*Populus tremuloides*) is interspersed across the Forest, particularly in disturbed areas. Finally, black cottonwood *(Populus trichocarpa*) occurs in riparian zones and swampy areas along with quaking aspen. Cover types and habitat types have been recorded for the entire forest. Precipitation averages around 18 inches per year changing with elevation, half in the form of snow; elevations range from 3,580 to 6480 feet at the highest peak; and mean annual temperature is 5 C (39 F) (Teuber 1983). Sample sites were located between 3600 and 5240 feet. Soils fall into four orders (alfisols, entisols, inceptisols, and mollisols) with geological substrates of Tertiary sediment, glacial deposits, residuum on ridge crests, granite colluvium, belt, granite and limestone colluvium, alluvium, and lacustrine sediments (Nimlos 1986). Topography ranges from flat riparian zones to steep subalpine areas with all intermediate grades.

Figure 1: Map of Lubrecht Experimental Forest

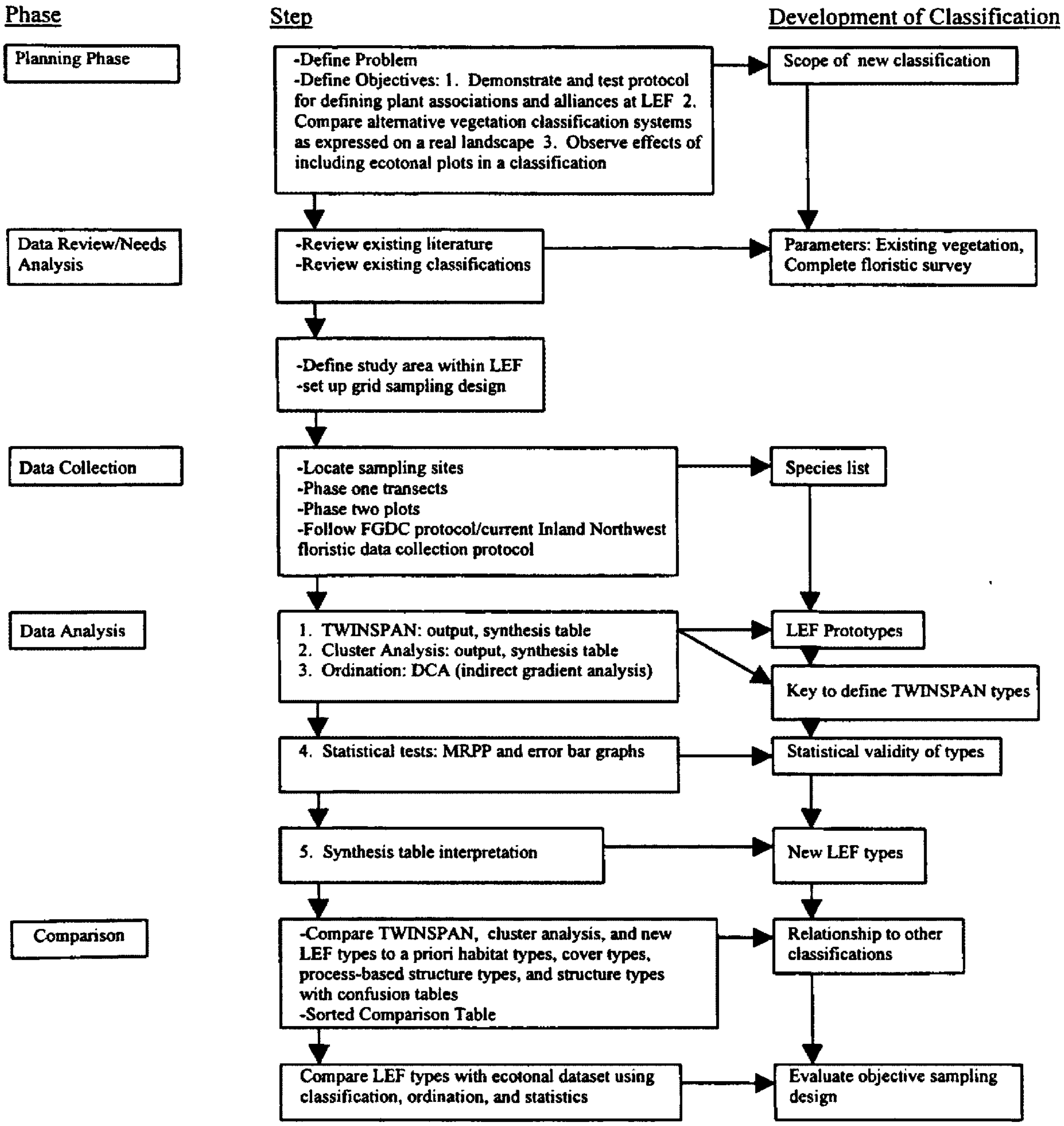


Chapter III: Methods

Figure 2 presents a flow chart of the methodology used in this study, including the phase of the project, the procedure employed, and the development of the classification. The methods chapter details sampling design development, including study area and sites and the actual sample grid employed; the vegetation sampling, including plots, transects, and the taxonomy used; and data analysis. Detailed analysis methodology is reserved for the following chapter, "Developing a Taxonomy."

Vegetation is considered the dependent variable in all analysis after Major (1951). Vegetation can be viewed as a functional equation with the abiotic environment. The equation specifically is modified after the Hans Jenny soil functional equation such that vegetation = f (climate, parent material, topography, biota, time) in which not only the specific properties of vegetation are related to the functional factors, but also the entire plant communities (Major 1951). The dependent variables in this study are therefore climate, parent material, topography, biota, and time, including the ideas of succession and disturbance.

Figure 2: Flow Chart of Methodology



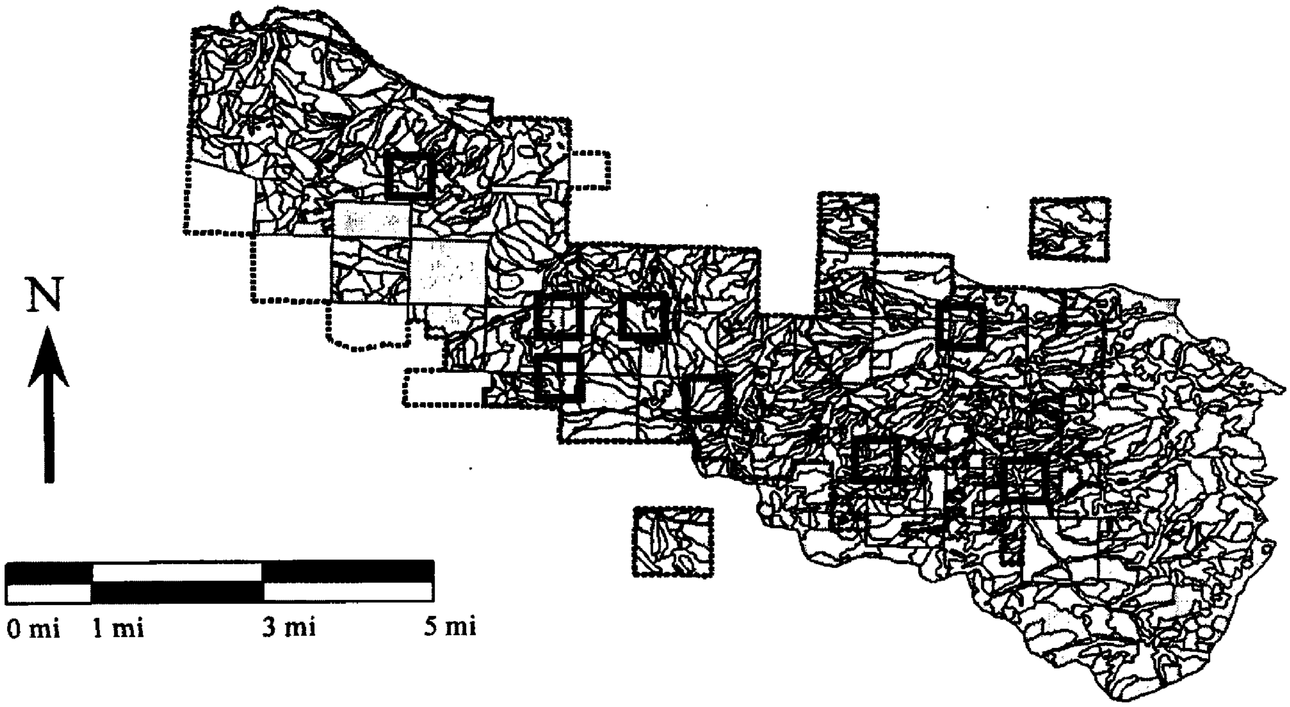
A. Sampling Design Development

The sampling design was set up as a set of forty acre square, fixed systematic grids with four transect lines and sixteen plots, four plots per transect line. A systematic grid, one of the three basic designs often used in forest measurements (Avery and Burkhart 1994), was chosen to be the most objective design possible. Grids were one quarter mile to a side. Appropriate field forms for transects and for plots were developed based on standard plot design, regional convention, NVCS guidelines, and ESA/TNC guidelines (Damman 1998, Personal Communication, FGDC 1997, Avery and Burkhart 1994, Bourgeron and Engelking 1994, TNC/ESRI 1994, Barbour et al. 1987, Arno et al. 1985, Pfister et al. 1977, Mueller-Dombois and Ellenberg 1974, Franklin et al. 1970).

Grids were randomly located across the Lubrecht Experimental Forest with the following restrictions: location at section corners, complete inclusion within the Lubrecht Forest boundary, location at corners where GIS data was available for all four sections, and areas logistically possible to access; Figure 3 shows the locations of the grids across the LEF. Each grid was labeled with the name of some outstanding feature or road name in its vicinity. Compass and pacing determined transect line and plot placement from the section corner with a GIS-based map of the Forest.

Sampling was done in two phases (phase one for transects, phase two for plots) from early July 1997 through the end of September 1997 and included eight plot grids for a total of 32 transect lines and 128 plots, of which 121 were suitable for analysis. Plots were semi-permanently marked by wooden stakes; transect ends were flagged. All plots of over 50% upland forest cover were recorded regardless of location on an obvious ecotone or within plot heterogeneity although vegetative plot data was only taken if 50% constituted an upland forest site. Plots were all photographed for archival purposes.

Figure 3: Map of Lubrecht Experimental Forest Showing Study Sites

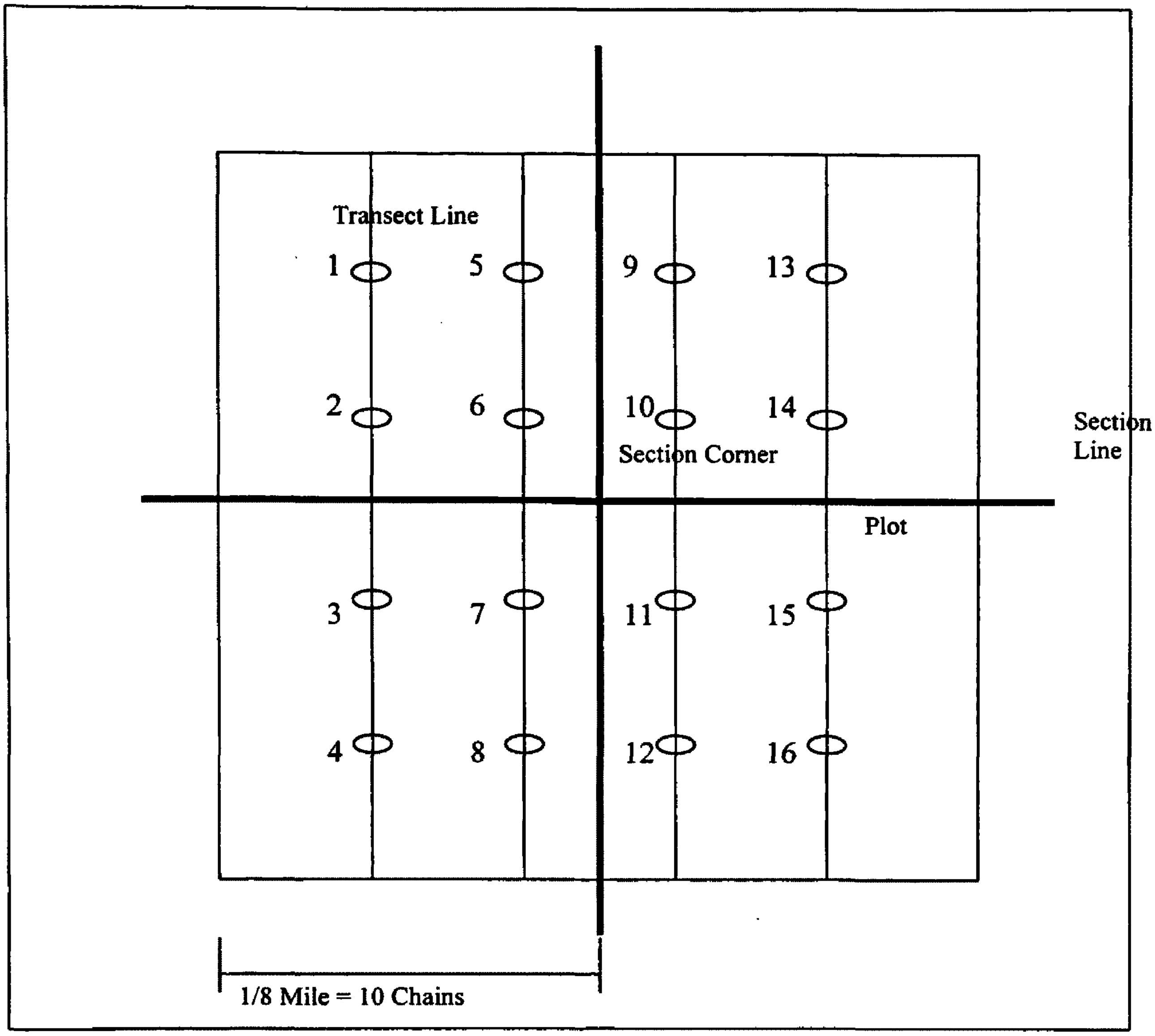


B. Vegetation Sampling

1. Transects

Transects sampled first are referred to as phase one sampling. A sampling grid is illustrated in Figure 4. The four transect lines per gird were located five chains apart, running north to south, each twenty chains long. Total transect length for each forty acre grid was therefore one mile. Future plot locations were marked along the transect lines at a distance of four chains during the first phase of sampling. Habitat type changes and obvious existing vegetation (cover type) changes were recorded while walking the transect lines. Transect line data was taken only for the strict line of the transect with no belt area. Habitat type changes were determined by habitat type taxonomy (Pfister et. al 1977) or in some cases by riparian community type taxonomy (Hansen et al. 1995) while existing vegetation (cover type) was determined by dominant tree overstory (Wenger 1983, Eyre 1980) up to three species in order of dominance. Determination of a change in composition (cover type) or structure (structure type) served as the primary criteria for field recognition of stand boundaries in the process of "entitation" described by Mueller-Dombois and Ellenberg (1974) . Overstory size class, canopy cover by ten percent classes, and structural stage (seedling/sapling, pole, medium, large, or very large) were recorded for each transect segment (based on change in cover type) after Lubrecht inventory procedures (Mogilesky and Wood 1995) ; percent slope and aspect were recorded for each segment of the transect. Process-based structure types (O'Hara et al. 1996, modified from Oliver and Larson 1990) were recorded for each

Figure 4: Sample Grid Design



transect segment. These types include Stand Initiation (SI), Understory Reinitiation (UR), Young Forest Multi-Strata (YF-MS), Old Forest Multi-Strata (OF-MS), Old Forest Single-Stratum (OF-SS), Stem Exclusion - Open Canopy (SE-OC), and Stem Exclusion - Closed Canopy (SE-CC) (O'Hara et al. 1996). Transects were patterned after the concept of gradsects, or gradient-oriented transect sampling, in order to "provide a description of the full range of biotic variability in a region by sampling along the full range of environmental variability" with transect selection for optimization of "information gained in proportion to the time and effort spent during the vegetation survey (TNC/ESRI 1994). Sample sites are deliberately located to minimize travel time, and the method has been statistically shown to capture more information than standard design (Gillison and Brewer 1985).

2. Plots

Plot sampling was done after transect sampling, and will be referred to as phase two sampling. The four plots on each transect line were circular fifth acre plots (52.8 foot radius plots) with tenth acre plots (37.6 foot radius plots) centered within them (Franklin et al. 1970, Spies and Franklin 1991). Plots were located four chains from each other, with the first plot four chains in from the northern grid boundary and the last plot four chains in from the southern grid boundary, at four, eight, twelve, and sixteen chains along each transect.

Site data taken included recorders, date, plot number (by letter of grid and number of plot), and for the larger sized (fifth acre) plot, the percent slope, aspect, topography (bench, flat, convex, concave, or undulating), ecotone or not, unvegetated area (by percent), and successional stage (seedling/sapling, pole, medium, large, very large, field, or other). Aspect data was later converted to a directional code by the eight main directions. Soil type was recorded by coded type from a Lubrecht Soils map (Nimlos 1986). Elevation was taken from the 1995 Walkthrough Inventory Arcview coverage and recorded to the nearest forty feet (Mogilesky and Wood 1995).

Vegetation data for the fifth acre plot included a stand table was taken to record the dbh of every tree greater than one foot high with its center within the plot boundary. Trees were dot tallied by two inch diameter classes by species and totaled on the form. For the tenth acre plot, every species on the plot and its corresponding cover class was recorded as 1 = 0-5%, 2- = 5-10%, 2 = 10-20%, 2+ = 20-25%, 3 = 25 - 50%, 4 = 50 - 75%, 5 = 75 - 95%, and 6 = 95 - 100% (Arno et al. 1985) to provide a complete floristic survey. The codes of Arno et al. (1985) break up classes below 25% cover which accommodates the often smaller percent cover per plot of the type of vegetation in this region; these codes were modified from scales by Pfister et al. (1977) and Daubenmire (1959). This cover class system is readily convertible to these two scales as well as compatible with other commonly used scales including Bourgeron et al. (1992), Mueller-Dombois and Ellenberg (1974), and the simplest Braun-Blanquet scale (1928). Unknown species on the plot were collected at the site and taken for identification. A section for notes accommodated observations on logging history, proximity to roads/skid trails, and possible fire history or other disturbance at the plot and surrounding forests, observations on why a plot was an ecotone (if applicable), as well as any other pertinent observations.

Vertical stratification data included layers on the plot were recorded by dominant tree species (up to three), percent cover, and size class. All those greater than ten percent were recorded. Stratum was recorded in classes by ESA plot standard suggested guidelines (Damman 1998, Personal Communication). Stratum was broken up into ten groups by height and dominant physiognomy, including moss, herbaceous, shrub, and tree. Obvious stratum layers were recorded by species comprising the majority of the stratum and by cover class code as used in the tenth acre plot. The four a priori types included cover type, habitat type, process-based structure type, and structure type and were recorded for the tenth acre plot area. Cover types were named according to specific criteria, after the predominant tree species (by basal area) as the primary type and also including a secondary and even tertiary species when necessary if at least 20% of the total basal area includes the species in the name (Eyre 1980). Habitat types were named by potential climax tree species and understory indicator species and also understory phase where applicable (Pfister et. al. 1977). Seven process-based structure types were named after O'Hara et. al. (1996) by comparison to diagrams and written description. Bald Hills Planning Unit structure types were identified by size class, percent canopy cover, and layering after Pfister (1997, Personal Communication).

Ecotonal plots included any plot that appeared heterogeneous in some way. Ecotonal plot included stand boundaries or edges of existing vegetation, such as a field to a forest, or a forest to a stream transition, as well as a change in composition or structure of the vegetation within the plot boundary. Also, any plot that fell in a disturbed areas, such as a road, an old landing, a parking lot, a structure, or an obvious non-vegetated area was labeled an ecotone.

3. Nomenclature

Naming of plants in the field follows mainly Hitchcock and Cronquist (1973), with occasional assistance from Lackschewitz (1991) and Whitson et. al. (1996). Unknown species on the plot were collected at the site and later identified. Unknowns were recorded by physiognomic type (T = tree, S = shrub or subshrub, G = graminoid, F = forb, and O = other, such as ferns and allies), order of finding, and plot number when necessary.

C. Data Analysis

Vegetative plot data was entered in Microsoft Excel for use in the PC-ORD program. PC-ORD version 3.0 contains software for several classification and ordination techniques, including TWINSPAN (two-way indicator species analysis), cluster analysis, and DCA (detrended correspondence analysis), which were used for the classification and ordination of this data (McCune and Mefford 1997). Data was organized as a primary matrix of species by samples (individual plots) for the whole data set with all plots and for the non-ecotonal plots only. A secondary matrix with environmental variables by plots was also developed for both sets of plots. For the primary matrix, plot data was entered alpha-numerically by grid letter and plot number and species were entered by four letter code using the first two letters of both the generic and specific name. Species were entered alphabetically by physiognomic type, trees followed by shrubs and subshrubs, graminoids, ferns/primitive herbs, and forbs. Values entered per plot per species were the midpoint of the cover class codes recorded for each plot. PC-ORD was used for a power transformation of non-ecotonal data to a presence/absence matrix as well as a midpoint cover class matrix. A total of 170 species were encountered. Species occurring in only a single plot with coverages of only one percent were deleted resulting in 111 species used for analysis in the non-ecotonal dataset and 144 species in the ecotonal dataset. TWINSPAN was run for the two data sets (ecotonal and non-ecotonal) with six divisions and user defined cutoffs based on the cover class code maximum percentages (after Hubbard 1995). Rare species were downweighted. TWINSPAN was also run with default values cutoffs and with the presence/absence matrix using default cutoffs for the non-ecotonal dataset.

Variables included in the second matrix for both data sets were percent slope, elevation in forty-feet increments, ten-percent canopy cover classes, number of layers, unvegetated area percent, topography code, soil type code, and aspect code (as the eight main directional aspects) with the last three variables entered as categorical variables rather than quantitative. In addition, the first four levels of TWINSPAN divisions of plots into groups, cluster analysis aggregation of plots into groups, habitat type codes, cover type codes and primary cover type codes, CRB process type codes, and structural codes were entered as categorical variables.

Table 1 explains the various TWINSPAN input parameters and matrices used in the three different runs. The field cover data columns list the actual percent cover of each species and the code it was recorded under. The matrices used are CCM or cover class midpoint and PA or presence absence with the appropriate values by class listed. The different TWINSPAN parameters refer to the pseudospecies cutoff levels, with UDC for user defined cutoffs, taken from Hubbard (1991) and entered by hand, or DF, or the default values available as an option in the PC-ORD TWINSPAN package. The tabular output refers to the numbers present in the TWINSPAN output table of species by plots, based on the matrix used and the parameter entered.

Table 1: TWINSPAN Input Parameter Values and Matrices

Field Cover Data		**Matrices Used**		**TWINSPAN Parameters**		**Tabular Output**		
Cover	***Code***	***CCM***	***PA***	***UDC***	***DF***	***UDC Code***	***DF Code***	***PA***
0	0	0	0	0	0	0	0	0
1	Trace	1	1	5	2	1	1	1
1-5	1	2.5	1	10	5	1	2	1
5-10	2-	7.5	1	20	10	2	3	1
10-20	2	15	1	30	20	3	4	1
20-25	2+	22.5	1	40		4	5	1
25-50	3	37.5	1	50		4	5	1
50-75	4	67.5	1	60		7	5	1
75-95	5	85	1	75		-	5	1
95-100	6	97.5	1	100		-	5	1

First approximation types for the LEF classification were based on the results of analysis of non-ecotonal plot data only. The analysis on all plots, including all the ecotonal plots, is addressed in Chapter V, "Ecotonal Versus Releve Sampling." MRPP (multi-response permutation procedure) was run for TWINSPAN groups at levels three and four, with the different settings, and for cluster analysis groups using both the cover class midpoint matrix and the presence/absence matrix. MRPP was used as a basic statistical test of separation of the groups. TWINSPAN groups were statistically tested using MRPP (multi-response permutation procedures) in PC-ORD. MRPP is a non-parametric method for testing the hypothesis of no difference between two or more groups of entities, which is used to test multivariate differences among pre-defined groups which must be a priori (McCune and Mefford 1997). MRPP has the advantage of not requiring assumptions such as multivariate normality and homogeneity of variances that are not often met with ecological community data. The R value is the basis of the MRPP test and describes within-group homogeneity with the most similarity within-group agreement expressed as 1 (McCune and Mefford 1997). Determination of the R value is from the test statistic (T), which is the difference between the observed and expected deltas, or the average within-group distance, divided by the square root of the variance in delta; it describes the separation between the groups. Probability of a smaller or equal delta is expressed as P.

To display statistical differences or similarities in possible groups of plots, graphs were created using DCA primary and secondary axes values. Groups were represented as a point (the mean axes values) with standard error bars in two-dimensional space. Error bar graphs were created for TWINSPAN at levels one through four and cluster analysis results. In addition, separate graphs were created for different settings in TWINSPAN at levels three and four including user-defined cutoff values, default values, and default values with the presence/absence matrix. Cluster analysis error bar graphs were created for the cover class midpoint matrix and the presence/absence matrix. Statistical difference was represented by exclusive error bars by group on the graph. Groups with overlapping error bars were considered similar in floristic composition. A synthesis table was also created for the non-ecotonal plot dataset. A summary of these procedures is presented in Table 2. MRPP refers to multi-response permutation procedure, a statistical program to determine similarity among groups; DCA refers to detrended correspondence analysis, an indirect ordination procedure (McCune and Mefford 1997).

Table 2: Summary of Analysis Procedures with Various Parameters

Procedure	**Setting**	**Matrix**	**Data Set**	**Display Figure**
TWINSPAN	User Defined Cutoff	CCM	Non-Ecotonal	
TWINSPAN	Default	CCM	Non-Ecotonal	
TWINSPAN	Default	P/A	Non-Ecotonal	
TWINSPAN	User Defined Cutoff	CCM	All	
Cluster Analysis	Default	CCM	Non-Ecotonal	
Cluster Analysis	Default	P/A	Non-Ecotonal	
Cluster Analysis	Default	CCM	All	
Synthesis Table	Default	CCM	Non-Ecotonal	
MRPP	User Defined Cutoff	CCM	Non-Ecotonal	
MRPP	Default	CCM	Non-Ecotonal	
MRPP	Default	P/A	Non-Ecotonal	
MRPP	Default	CCM	All	
DCA	User Defined Cutoff	CCM	Non-Ecotonal	TWINSPAN Level 3
DCA	User Defined Cutoff	CCM	Non-Ecotonal	TWINSPAN Level 4
DCA	Default	CCM	Non-Ecotonal	TWINSPAN Level 3
DCA	Default	CCM	Non-Ecotonal	TWINSPAN Level 4
DCA	Default	P/A	Non-Ecotonal	TWINSPAN Level 3
DCA	Default	P/A	Non-Ecotonal	TWINSPAN Level 4
DCA	User Defined Cutoff	CCM	All	TWINSPAN Level 3
DCA	User Defined Cutoff	CCM	All	TWINSPAN Level 4
DCA	Default	CCM	Non-Ecotonal	Cluster Analysis
DCA	Default	P/A	Non-Ecotonal	Cluster Analysis
DCA	Default	CCM	All	Cluster Analysis

CCM = Cover Class Midpoint
P/A = Presence Absence

Confusion tables involved derived types shown against a priori types in order to compare the different classification systems on the LEF. A summary of the confusion tables is presented in Table 3. A complete representation of comparison plot by plot was best displayed as a sorted comparison table encompassing the derived TWINSPAN level groups and cluster analysis groups with the a priori habitat types, cover types, process-based structure types, and structure types.

Table 3: Summary of Confusion Tables for a prior Habitat Type, Cover Type, Process-Based Type and Structure Type

Data Set	Derived Type	Setting	Matrix	Table Number
Non-Ecotonal	TWINSPAN Level 3	User Defined Cutoff	CCM	10
Non-Ecotonal	TWINSPAN Level 3	Default	CCM	12
Non-Ecotonal	TWINSPAN Level 3	Default	P/A	13
All	TWINSPAN Level 3	User Defined Cutoff	CCM	20
Non-Ecotonal	TWINSPAN Level 4	User Defined Cutoff	CCM	11
All	TWINSPAN Level 4	User Defined Cutoff	CCM	21
Non-Ecotonal	Cluster Analysis	Default	CCM	14
Non-Ecotonal	Cluster Analysis	Default	P/A	15
All	Cluster Analysis	Default	CCM	22
Non-Ecotonal	New LEF Types	-	-	16
Both	New LEF Types	-	-	24

CCM = Cover Class Midpoint Matrix
P/A = Presence Absence Matrix

Ordination graphs, located in Appendix B, were used to display categorical variables as different symbols in order to show how types sorted out in ordination space (see Cooper et al. 1997). Biplots of environmental variables were superimposed on the data point spread to display the direction of particular environmental data along an ordination axis with the potential result of explaining why certain plots were divided into particular groups (McCune and Mefford 1997, ter Braak and Verdonschot 1995). The longer the biplot line is, the more important that particular variable defining the line is to the arrangement of data points within the ordination. In addition, the direction of the biplot line indicates the direction along which the variable shows the strongest influence in data point spread. The ordination itself arrays all the plot data or the species data in three-dimensional space along three axis by a complex series of iterations involving the floristic composition of the plots. Potential gradients may exist along one or more axis and the amount of variation explained by the axis is given by the eigenvalue as a component of eigenanalysis (Gauch 1982). Eigenvalues were examined for correlations for explanations of distribution in ordinations groups and for distribution of plots across the graphs.

Chapter IV: Developing a Taxonomy

Classification is the assignment of entities into groups, arranging stands into classes, the members of which have in common one or more characteristic, setting them apart from the members of other classes (Greig-Smith 1983). All syntaxonomy and vegetation mapping is based on classification, the grouping of similar objects, to produce defined types. Community ecology customarily puts data into a two-way samples by species data matrix. Although there are "uncountable individual techniques for classification" (Gauch 1982), the main purpose of community classification is to summarize large community data sets with other ancillary purposes of aiding the environmental interpretation of and hypothesis generation about community variation and refining models of community structure (Gauch 1982). Classification of communities involves an interaction between ecologists and communities (Whittaker 1962). Classification has developed as a theory drawing from actual community structure and from the thought pattern of ecologists. Properties of individual techniques in classification to consider when developing a classification include formal or informal, nonhierarchical or hierarchical, quantitative or qualitative data, general or special purpose, divisive or agglomerative, polythetic or monothetic, dual or single, linear or rapidly rising computer requirements, and robustness (Gauch 1982). Important properties to this study include hierarchical or nonhierarchical, in which the levels of divisions or agglomerations of the samples from the data nest within the previous level or not; and divisive or agglomerative, in which the data is either separated starting from the entire set down to the individual plots or works up from the single plots to the entire set (Pielou

1984). Main classification techniques in community ecology draw from these properties; they include table arrangement, nonhierarchical classification, and hierarchical classification. Table arrangement is the earliest classification technique in community ecology epitomized by Braun-Blanquet's work in analyzing plant community data and subsequently used in thousands of studies (van der Maarel 1975). Two-Way Indicator Species ANalysis (TWINSPAN) was developed by Hill (1979) for table arrangement "much along the lines of Braun-Blanquet analysis," the algorithm of which is "sophisticated enough to produce a final product in many cases" (Gauch 1982). TWINSPAN is similar to the Braun-Blanquet table approach in its emphasis on indicator species and production of an arranged matrix.

Ordination is often used in combination with classification and direct gradient analysis by community ecologists with the purposes of description, discussion, understanding, and management of communities (Gauch 1982). Ordination means basically "to put in order" or to put sample and species relationships as faithfully as possible in a low-dimensional space, usually producing a two-dimensional graph showing similar species or samples as clustering together and dissimilar items as far apart in the graph (Gauch 1982). Ecologically speaking, ordination attempts to place each stand in relation to one or more axes in such a way that a statement of its position relative to the axes conveys the maximum information about its composition (Greig-Smith 1983). "Current thinking emphasizes the complimentary use of ordination and classification and recognizes the utility of classification for many practical purposes even when rather arbitrary dissections must be imposed on essentially continuous community variation" (Gauch 1982). Classification was the main focus in developing the taxonomy of the LEF while ordination was used for statistical tests and display in two-dimensional graphs as a complement of the classification techniques. The approach to developing a taxonomy for the LEF was hierarchical and polythetic using TWINSPAN for table arrangement as a hierarchical divisive technique and cluster analysis as a hierarchical agglomerative technique.

No classification or ordination approach is perfect; each is subject to a set of advantages and disadvantages that must be weighed when considering the objectives of the study requiring community ecology description. An ecological classification of plant communities will perhaps "never be achieved with the same degree of perfection found in taxonomic classification; such perfection is not necessary" (Oosting 1956). The resulting taxonomy from an analysis of community data will likely have outliers and anomalies of plots or species which do not fit the gradients or patterns observed in a classification or ordination output. A community should however be characterized with sufficient accuracy to "permit identification at any time," to compare it with other similar communities, and to have an "accurate permanent record of its nature and occurrence" (Oosting 1956).

A. TWINSPAN

TWINSPAN functions as a set of three ordinations to form a tabular representation of community similarity. The three ordinations are the primary ordination (reciprocal averaging), which is divided to obtain an initial, crude dichotomy; the refined ordination, which is derived from the primary ordination through the identification of differential species; and the indicator ordination, which is a simplified ordination based on a few of the most highly preferential species (Hill 1979). In the first ordination, the plots are ordered by the first axis of a reciprocal averaging (RA) ordination, then the plots are divided into two halves at the center of gravity of the ordination (Hill 1979). Another explanation of the first level ordination is that the species that characterize the RA axis extremes are divided into two clusters by breaking the ordination axis near its middle (Gauch 1982). Five "indicator species" are chosen which are used to define two groups of data producing one dichotomy. The data is divided again in the same way so that each newly divided groups is again divided into two, until the number of specified divisions have been reached (Hill 1979, Hill et al. 1975). The final ordination, the indicator species, is only an appendage and not the real basis of the method, but useful for a "succinct characterization of the dichotomy" (Hill 1979). TWINSPAN was used to classify the whole dataset with the intent of removing outlying plots which separated out in the first or second division. Afterwards, I accepted 121 plots of 122 plots for analysis. Using the TWINSPAN divisions, the plots were divided into community associations on the basis of important differential species. Species important in driving the splits that TWINSPAN made were used in naming the types; in many cases the important differential species were those listed in the output as part of the third ordination in the TWINSPAN process.

The final tabular output of TWINSPAN is superficially similar to synthesis tables used extensively by proponents of Daubenmire's habitat typing for the inland northwest (Pfister et al. 1977, Pfister and Arno 1980, Cooper et al. 1987). Advantages of TWINSPAN include the use of original vegetative data in the program, the integrated classification of both samples and species, the production of an arranged data matrix, the deliberate ordering of sample sequences to place most similar samples together along the table, making dendrograms clear, and the minimal computer requirements (Gauch 1982). Disadvantages include the inflexibility of the tabular output, and the potential that no gradient will be clear after analysis and grouping.

In Table 4, the "split level" column refers to the level of TWINSPAN. The "group" column indicates the specific group number for that level TWINSPAN split. These group numbers are coded by two or three numbers with the first number either a three for the third level split or a four for the fourth level split, and the second and third number referring to the specific group running left to right along the TWINSPAN tabular output gradient, starting with one at the left side up to twelve on the right side. The "average distance" column is the calculated average distance between the plots within the group based on floristic composition. The "size" column refers to the number of individual plots within each group. The R value is for the entire set of groups and indicates that the TWINSPAN groups at both levels three and four groups have a high enough value to be more than half similar for the user defined cutoff values, with the greatest R value of 0.84 at level four. This grouping of plots is therefore 84 percent similar. The R value increases with the lower division from a value of 0.64 at level three. The floristic composition of these groups is therefore sufficiently dissimilar from each other to justify considering each a separate type. P values are at or near zero for each data set and each level. R values are low for the default value TWINSPAN run at 0.22 and 0.27 for levels three and four, with no great gain in significance with a lower division level. The lowest R values occur with the presence/absence matrix, at 0.14 and 0.17.

Neither the default value run nor the presence/absence matrix run indicate statistical validity within their respective TWINSPAN groupings. Since the user defined cutoff run is the most statistically valid, this particular TWINSPAN parametric input may be most appropriate for the data collected. The values were designed to accommodate the particular cover class codes used in data collection, and with statistical backing may be most useful in defining types. The lower divisions of TWINPSAN, levels five and six, for which MRPP results are not shown, increase in R value to the point where each group is completely different. However, the number of plots comprising each group is so small as to be statistically insignificant.

Table 4: MRPP Results for TWINSPAN

Split Level	Group	Ave Distance	Size	R	P	T
TWINSPAN, User Defined Cutoff Values						
3				0.63980878	0.00000002	-12.804843
	34	3.7172198	34			
	37	169.03408	13			
	38	0	4			
	36	0	3			
	35	1.0392305	6			
	33	1.0392305	5			
	32	1.0392305	5			
4				0.84325926	0	-15.536326
	46	3.3601617	21			
	45	2.7329295	9			
	410	4.9156632	9			
	38	0	4			
	36	0	3			
	49	0	4			
	48	0	3			
	44	0	3			
	47	0	3			
	41	0	2			
	43	0	2			
	42	0	3			
TWINSPAN, Default Values						
3				0.22036381	0	-18.425689
	35	60.473579	4			
	34	58.234411	21			
	38	50.261682	6			
	36	42.764467	6			
	33	58.984174	9			
	37	44.117442	11			
	32	63.216877	8			
	31	46.241215	2			
4				0.2703262	0	-15.668928
	25	60.473579	4			
	46	70.806416	7			
	411	45.828621	4			
	48	38.790347	4			
	43	60.670988	5			
	45	46.767081	14			
	49	38.817826	5			
	40	44.657276	6			
	47	47.573627	2			
	44	42.002755	4			
	412	51.833869	2			

Table 4, Continued: MRPP Results for TWINSPAN

Split Level	Group	Ave Distance	Size	R	P	T
	42	31.665854	3			
	41	70.759304	5			
	31	46.241215	2			
Presence/Absence Matrix						
3				0.13622243	0	-23.718943
	35	4.6551616	8			
	33	4.9585944	12			
	24	4.3588989	2			
	32	4.0716579	12			
	31	3.887513	15			
	36	4.8028571	10			
	34	4.6017096	8			
4				0.17433709	0	-20.098199
	49	4.8938651	3			
	45	4.7338876	8			
	410	4.2734863	5			
	24	4.3588989	2			
	44	4.3588989	2			
	41	3.8297383	5			
	43	3.836843	10			
	412	4.6288908	4			
	411	4.476319	6			
	42	3.7078499	10			
	46	4.5962391	4			
	47	4.3205246	6			
	48	4.3588989	2			

TWINSPAN groups can be represented by a dendrogram illustrating the hierarchical splits taken directly from the tabular output. Figures 5, 6, and 7 depict the divisive hierarchy of the three TWINSPAN runs of differing parameters. Eigenvalues are given for each level, and are similar among the dendrograms. The number of plots in each division is also given in parentheses. Final splits are shown by bold lines with the plot numbers included. The indicator species from the final level of TWINSPAN ordination are shown for divisions. The numbers next to the boxes at the third level split correlate with the numbers in the first column of Table 5, the Derived TWINSPAN Types. Plots appear to be arranged along a moisture/elevational relationship from left to right in the table based on dominant tree distribution. Plots along the left side include more lodgepole pine (*Pinus contorta*), then western larch (*Larix occidentalis*) and Douglas-fir (*Pseudotsuga menziesii*), with ponderosa pine (*Pinus ponderosa*) concentrated at the right end. All three runs have similar indicator species, although often in different levels or places within the dendrogram. The main differences in the dendrograms is the evenness of number of plots in each split; the presence/absence matrix run (Figure 7) followed by the default value run (Figure 6) allow much more even divisions down the hierarchy. Final divisions split out more readily, at earlier divisions, in the user defined cutoff run (Figure 5). When examining the floristic component of the groups, the clearest environmental gradient from cool/moist, higher elevation to warm/dry, lower elevation is apparent in the user defined cutoff run (Figure 5). The presence/absence matrix run (Figure 7) gives a messier arrangement of plots while the default value run (Figure 6) rearranges lodgepole pine stands to somewhere in the middle of the dendrogram as opposed to the extreme end of the suspected moisture/elevational gradient. The patterns in the dendrograms are more clearly illustrated in the confusion tables to follow.

Figure 5: User Defined Cutoff TWINSPAN Dendrogram

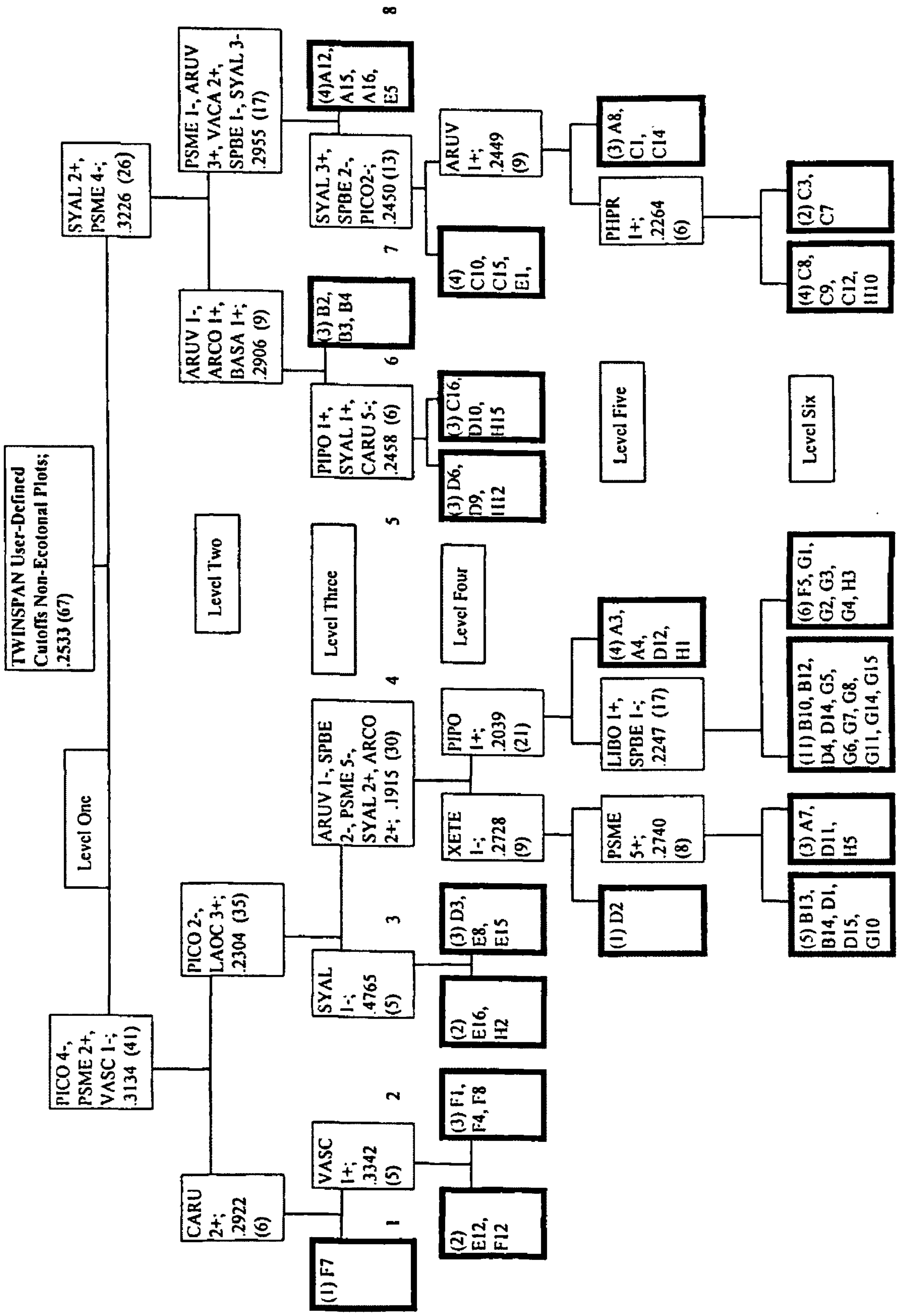


Figure 6: Default Values TWINSPAN Dendrogram

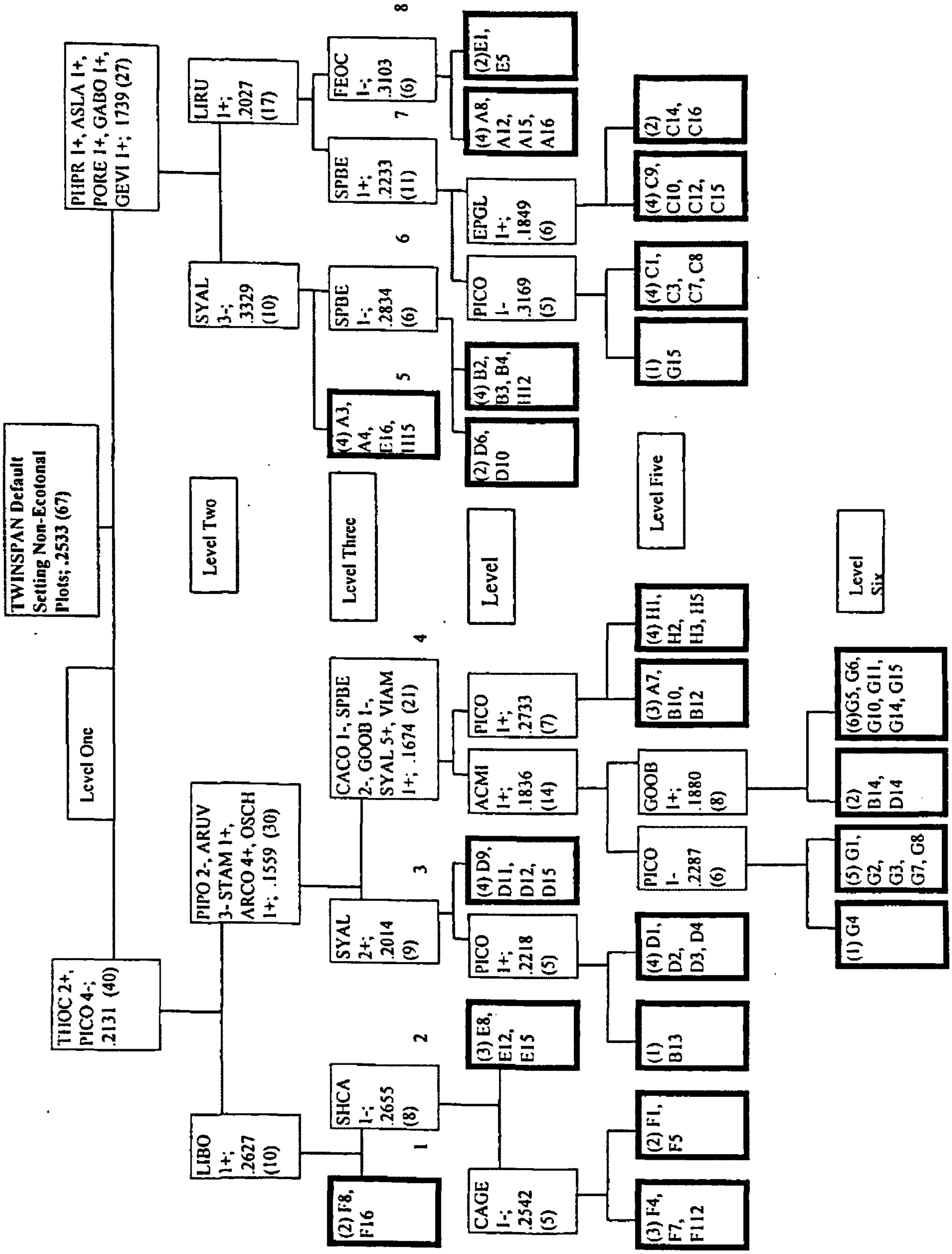
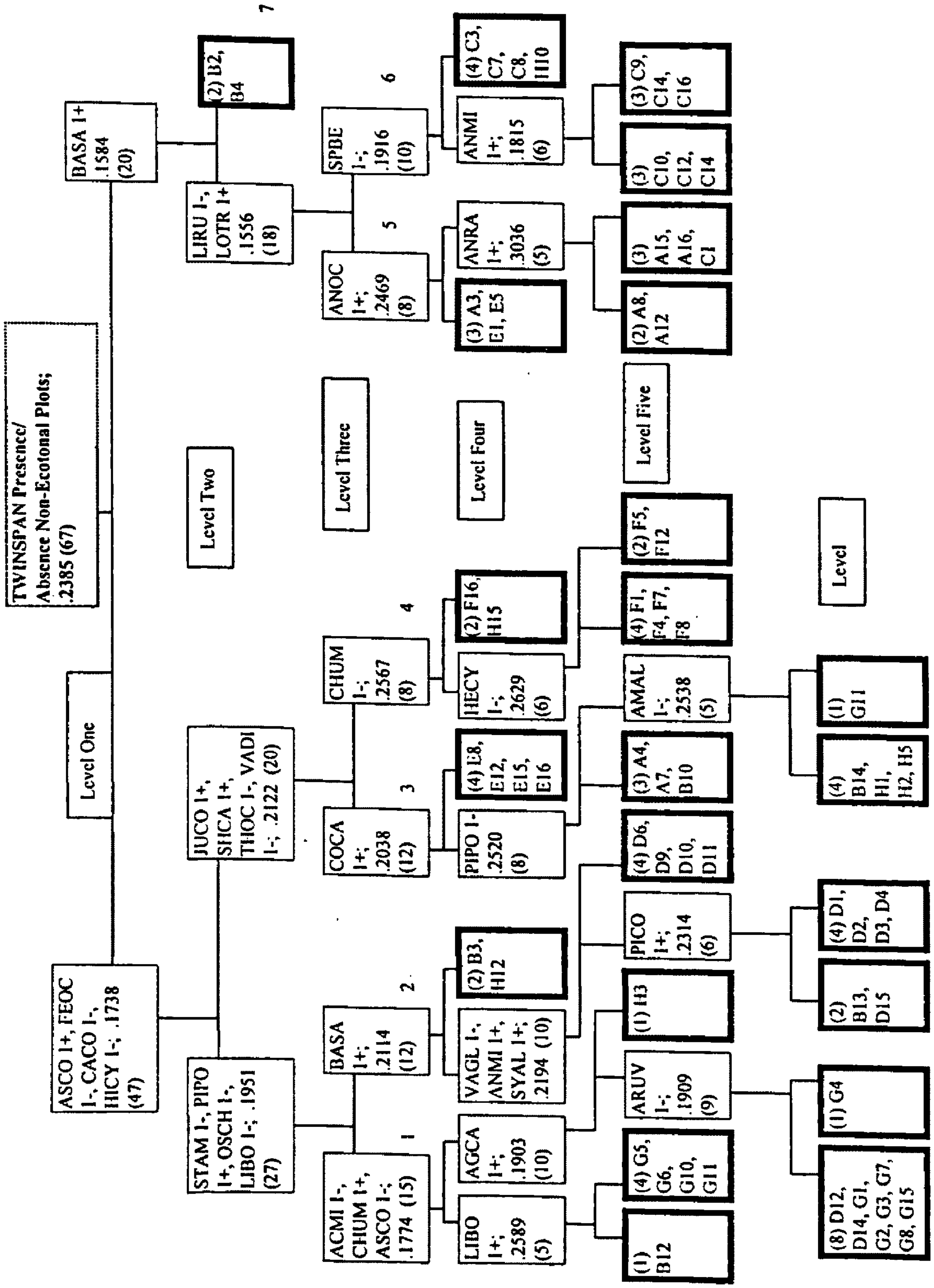


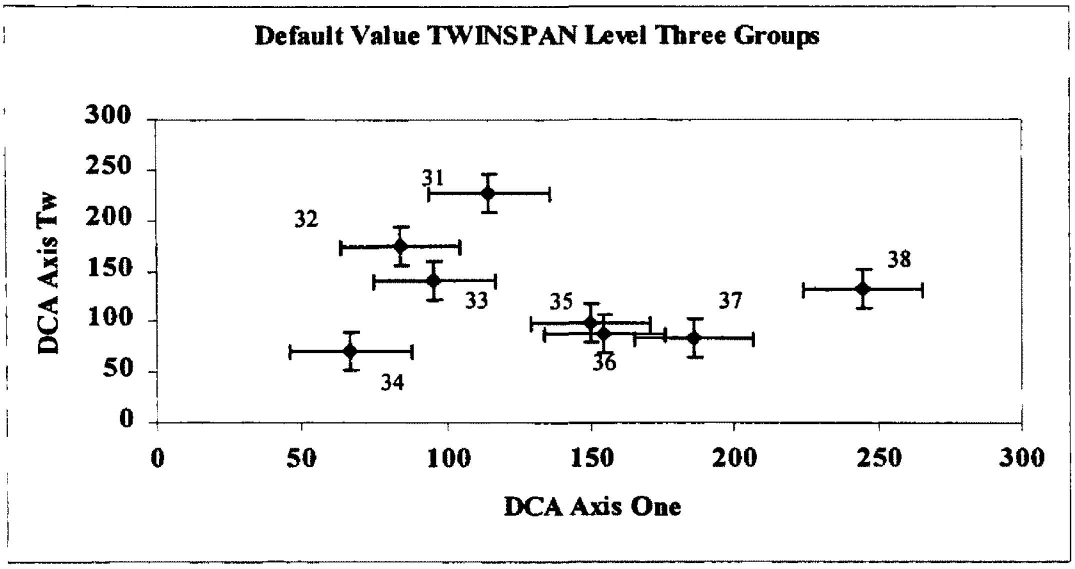
Figure 7: Presence/Absence Matrix TWINSPAN Dendrogram

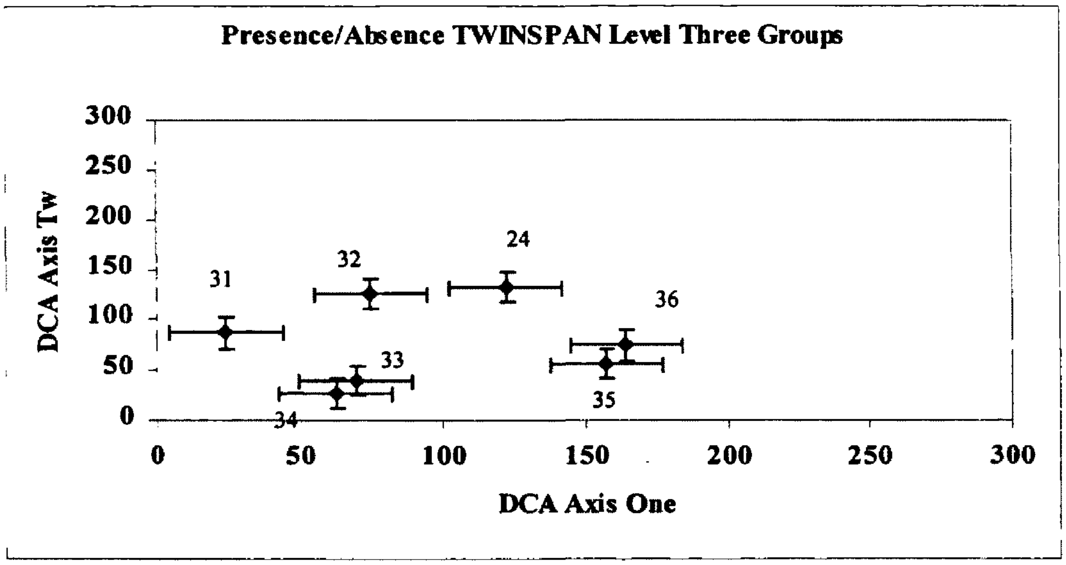


Additional statistical testing of TWINSPAN groups was done in the form of DCA ordination graphs. The purpose of the graphs is simply to condense a cloud of points which all represent a particular categorical type into a single point, with error bars on the point for both axes, rather than draw a circle around the cloud of points. Overlapping error bars, one standard error each, indicate that the groups represented by that mean point may be too similar to be considered a distinct type. Appendix B contains the original DCA ordination graphs with the clouds of plots represented by different colors and symbols for each different grouping. Particular groups are labeled by TWINSPAN level from one to four by the first number and position along the TWINSPAN gradient by the second number, from one on the left to up to twelve on the right by the second and third number. Figure 8 shows the error bar graphs for TWINSPAN level 3 groups for all three runs. Bars represent one standard error in Figures 8 and 9; DCA axes one and two are arbitrary values. All three TWINSPAN runs exhibit several clear, distinct groups with some groups clustered. User defined cutoff and default value runs give the exact same DCA ordination axes and have the same error bar graphs. In comparison with the presence/absence matrix run, the other two graphs, which utilize the percent cover code midpoint matrix, show overlap of three groups in one clump to overlap of two groups each into two clumps. Moving down a level in Figure 9, groups tend to clump even more. The default value and user defined cutoff runs are again the same, both with clumps of two, three, and four groups. The presence/absence run shows even more clumping with only two individual groups at this level, and four clumps of two, two, four, and four groups.

None of the graphs show ideal separation and complete statistical difference. The most independent groups are found in level three for the user defined cutoff and default value runs. Considering the appearance of the error bar graphs, and the results of the MRPP, the most viable source for defining new types from TWINSPAN is the third level user defined cutoff groups.

Figure 8: Error Bar Graphs, TWINSPAN Level Three


Default Value TWINSPAN Level Three Groups


Presence/Absence TWINSPAN Level Three Groups

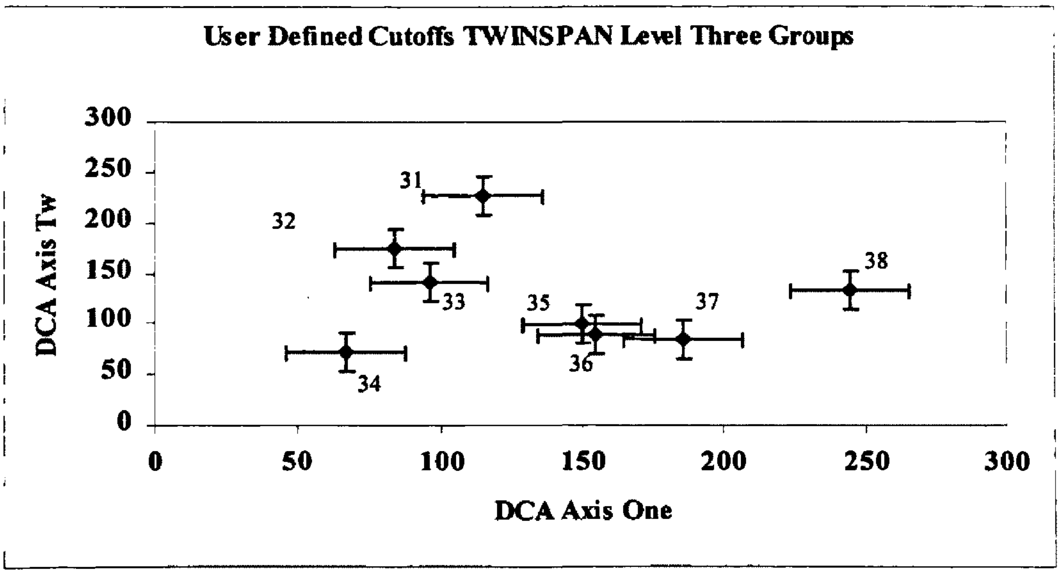
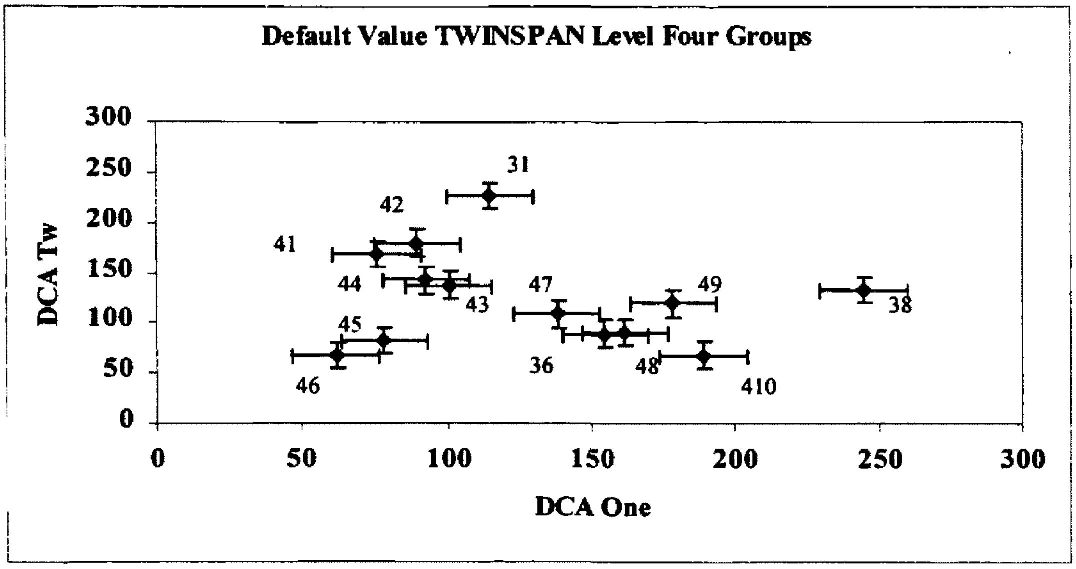
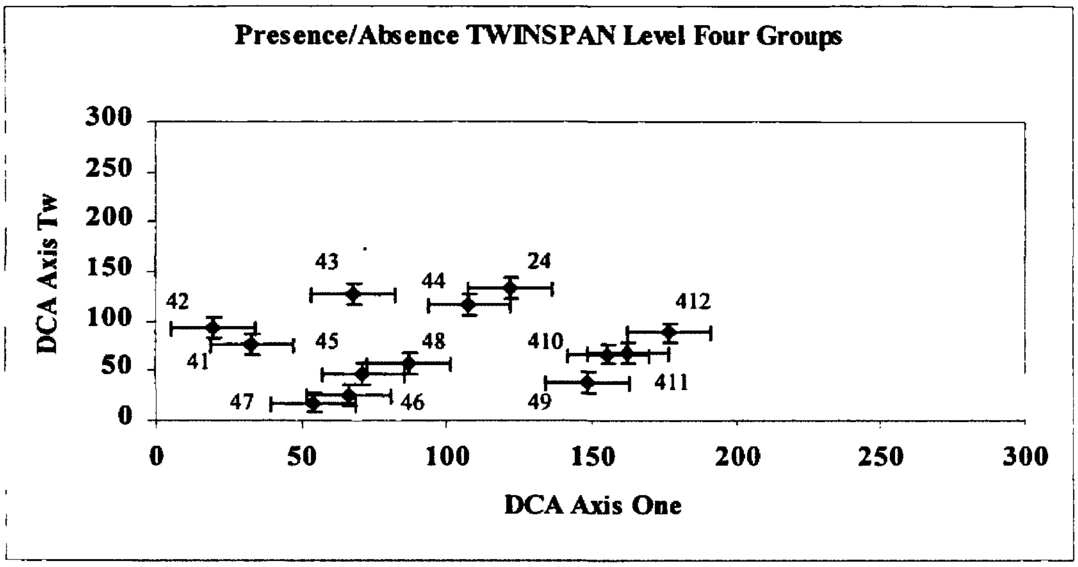
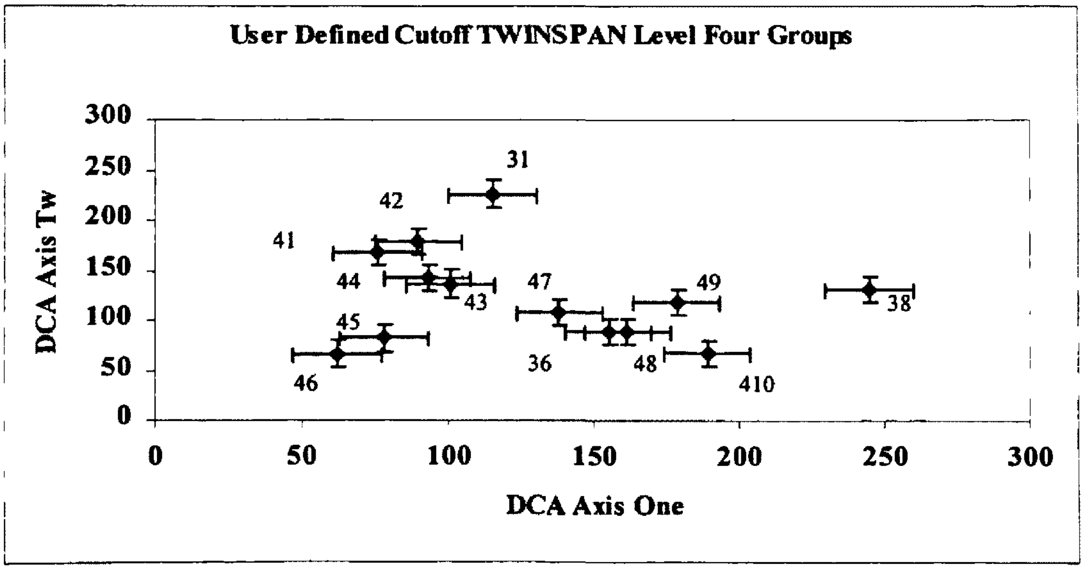

User Defined Cutoffs TWINSPAN Level Three Groups

Figure 9: Error Bar Graphs, TWINSPAN Level Four







The resulting groups or "prototypes" from all three TWINSPAN runs were given alliance and community type names. The alliance name was derived from the most prevalent dominant or most prevalent codominant overstory species for that particular type based on the heaviest overall percent cover of the overstory species in that type. The community type was derived from a selected predominant understory indicator species drawn from the final indicator species ordination in the TWINSPAN program as well as examination of the entire synthesis table or main matrix. All names are presented in a species four letter code similar to habitat type names after Pfister et. al. (1977). A complete species list is located in Appendix C. Table 5 lists the TWINSPAN run prototypes for the third level; fourth level groups were discounted as being not statistically strong enough to justify in naming as types. As expressed through MRPP results and error bar graphs, the user defined cutoff types are the most statistically valid and were used most heavily in determining first approximation types following more analyses. Types are in many cases similar and in a few the same among the runs, including a PIPO/VACA (*Pinus ponderosa/Vaccinium caespitosum*) type for the user defined cutoff and default value runs. The most dissimilar types are found in the presence/absence matrix run which is most likely caused by the equalization of the floristic coverages. Ecologically important species such as Douglas-fir (*Pseudotsuga menziesii*) appeared in virtually every plot, causing most alliances to be named for its presence. Lodgepole pine (*Pinus contorta*) is no longer a factor in naming types, while rarer species such as JUCO (*Juniperus communis*) and BASA (*Balsamorrhiza sagittata*) stand out in driving TWINSPAN splits. Blank spaces in Table 4 indicate groups of one plot that were not large enough to name independently.

Table 5: Derived TWINSPAN Types

TWINSPAN Order (Left to Right)	UDC Types	DF Types	P/A Matrix Types
1		PICO-PSME/ACMI	PSME-LAOC/STAM
2	PICO/VASC	PICO-PSME/VASC	PSME-LAOC-PIPO/HICY
3	PICO-PSME/SYAL	PSME-LAOC/ARUV	PSME-LAOC-PICO/VADI
4	PSME-LAOC/ARCO	LAOC-PSME/STAM	PSME-PICO/JUCO
5	PSME/ARUV	PSME-PIPO/SYAL	PSME-PIPO/LIRU
6	PSME-PIPO/BASA	PSME-PIPO/BASA	PIPO-PSME/LOTR
7	PIPO-PSME/SYAL	PIPO-PSME/SPBE	PIPO-PSME/BASA
8	PIPO/VACA	PIPO/VACA	

UDC = User Defined Cutoffs
DF = Default Values
P/A = Presence/Absence

B. Cluster Analysis

A cluster analysis was done to compare an aggregative program to the divisive TWINSPAN program. The general goal of an agglomerative method of classification is to group similar samples together hierarchically into larger and larger clusters, to basically define groups of items based on their similarities. Although most community ecologists show a "marked preference" for divisive over agglomerative methods (Gauch 1982), no technique is without drawbacks. Agglomerative methods begin by examining small distance between similar samples. In community data, these small distances are more a "reflection of noise than anything else" (Gauch 1982). This "notable disadvantage" is explained further by Pielou (1984) as the chance that a few atypical quadrats in the data set can have a strong effect on the first round of the clustering process, which cause "bad" fusions at the beginning influencing all later fusions.

This analysis used Ward's method with Euclidean distances, also known as "error sum of squares" and developed independently by L. Orloci, (McCune and Mefford 1997). This method is hierarchical, agglomerative, and polythetic, meaning the analysis forms large clusters composed of small clusters, proceeds by joining clusters rather than by dividing clusters, and uses many attributes of the data set to decide the optimum way to combine clusters (McCune and Mefford 1997). Cluster analysis is most useful because it is a simple and quick method. It creates groups which are similar with respect to the data, and which can afterward be compared to a priori grouping (Hengeveld and Hogeweg 1979).

Cluster analysis groups were statistically tested for both the cover class midpoint matrix and the presence/absence matrix using MRPP. R values in both cases (Table 6) were low at 0.30 for the cover class matrix and 0.17 for the presence/absence matrix. The relative lack of robustness of this method is reflected in the lack of statistical validity. The MRPP results also indicate that while the group separation is not statistically supported in the cover class midpoint matrix, the groups are more clearly defined for this matrix. The "group number" column is the value arbitrarily assigned to the particular cluster analysis group by the PC-ORD program.

Table 6: MRPP Results for Cluster Analysis

Group	Ave Distance	Size	R	P	T
Cluster Analysis, Default Values					
			0.3028456	0	-23.639982
1	45.582006	17			
3	53.886747	6			
5	43.918222	10			
13	39.409203	5			
24	53.132231	5			
27	51.651123	6			
28	44.049457	12			
42	70.151896	4			
62	66.657708	2			
Cluster Analysis, Presence/Absence Matrix					
			0.1668887	0	-25.476949
1	4.3586622	6			
4	4.5783602	7			
8	4.5264446	5			
12	4.0896452	13			
16	4.639262	8			
33	3.9198242	15			
38	4.5962391	4			
42	4.3205246	6			
61	4.2327332	3			

Cluster analysis generates dendrograms which are presented in Figures 10 and 11. Distances between agglomerations are arbitrary. The percent chaining is similar in both the cover class midpoint matrix and the presence/absence matrix and is acceptably low. Each cluster analysis group is labeled by the number from Table 6. The major difference apparent in these dendrograms is the later agglomeration in the presence/absence matrix (Figure 11). Aggregations are earlier and clearer in the cover class midpoint matrix. Groups are therefore more easily defined in Figure 10.

Figure 10: Cluster Analysis Dendrogram, Cover Class Midpoint Matrix

Percent chaining = 2.30

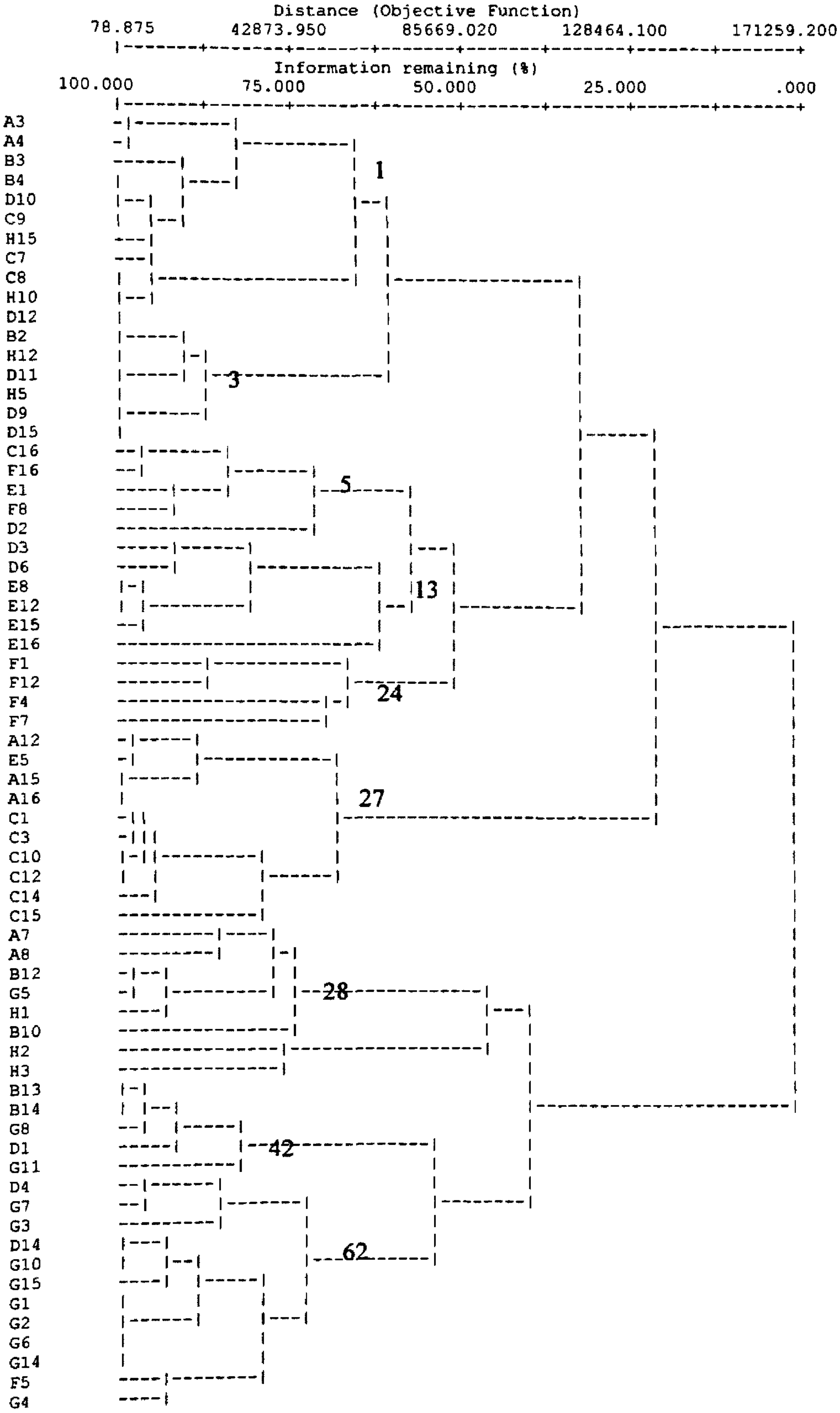
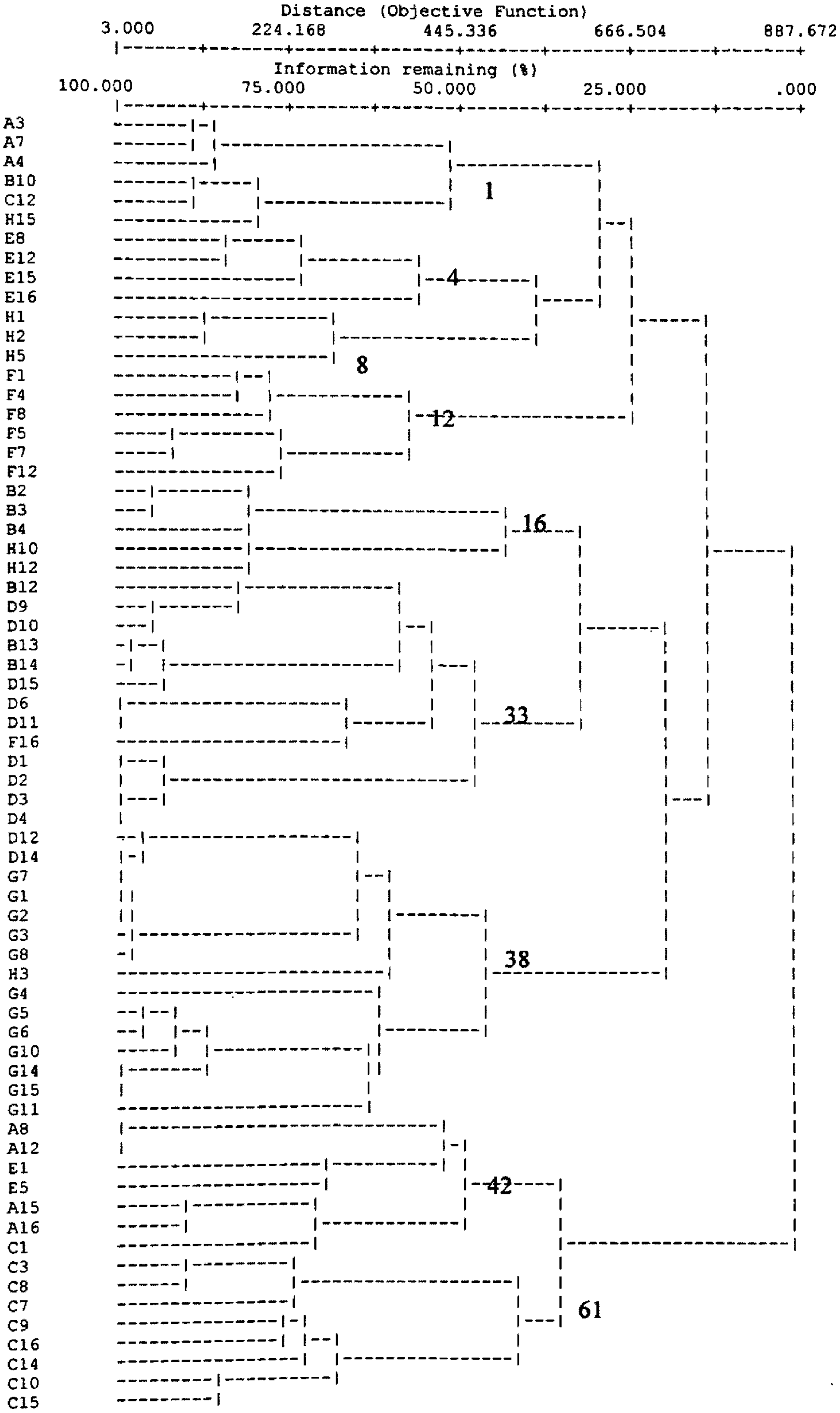


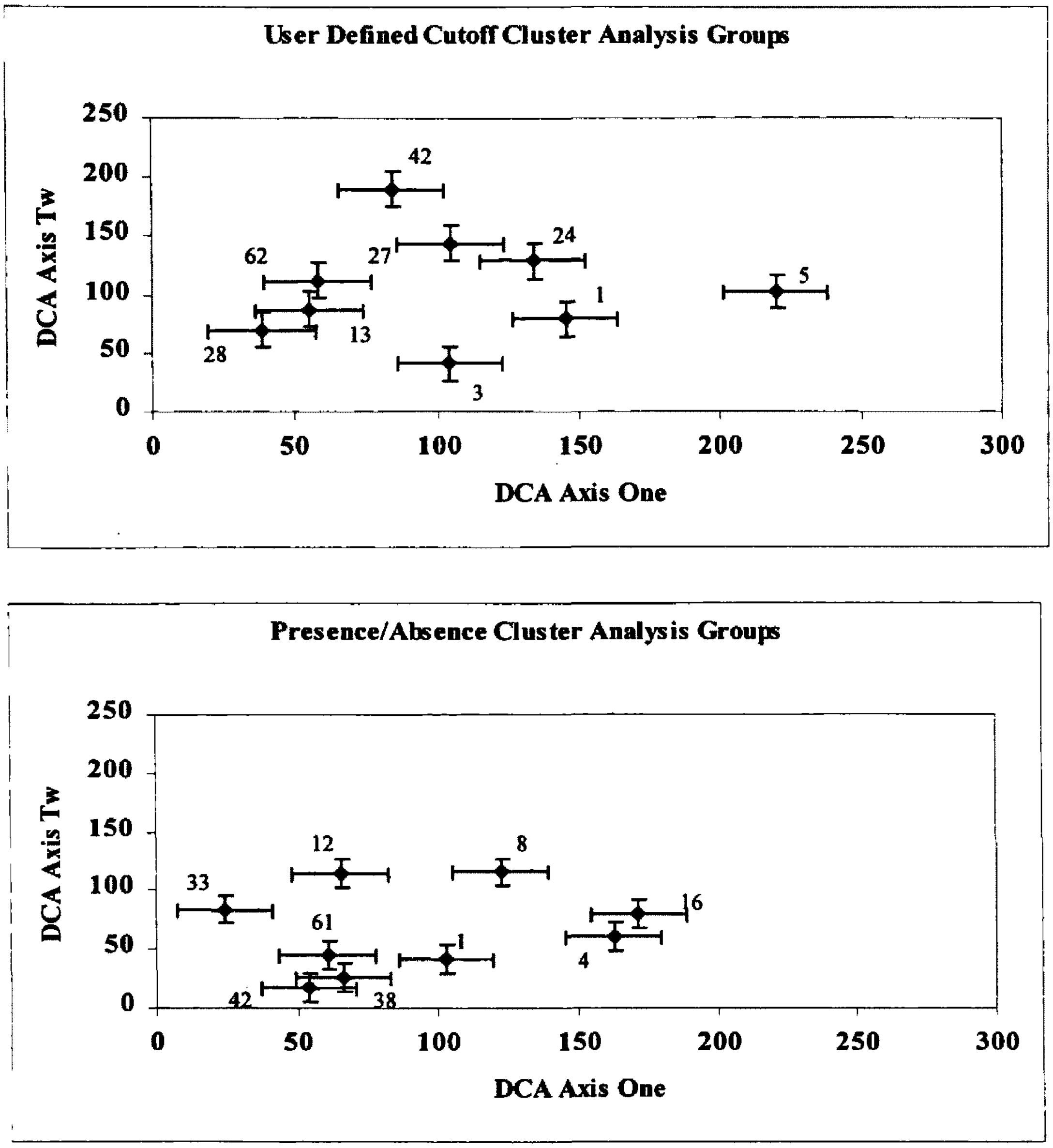
Figure 11: Cluster Analysis Dendrogram, Presence/Absence Matrix

Percent chaining = 2.09



The DCA ordination error bar graphs for cluster analysis show a similar degree of clumping of the groups (Figure 12). Both matrices have six independent groups and one clump of three groups. Groups show a more similar alignment in space than the TWINPSAN runs indicating that the cluster analysis groups are more similar regardless of the matrix used. Determining which cluster analysis matrix, either cover class midpoint or presence/absence, is better for defining types is more arbitrary than with TWINSPAN. Prototypes are presented in Table 7; alliances were again named by prevalent dominant or prevalent codominant overstory species in the group by highest overall percent cover. Associations were named by the use of a synthesis table which was sorted by cluster analysis type and then examined floristically to determine what indicator species were important in causing the clusterings. Plots within each group were examined for composition in naming the types. Types from the cover class midpoint matrix run along a warm/dry, lower elevation to cool/moist, higher elevation gradient while the presence/absence matrix mixes the types more. One type, PICO/VASC (*Pinus contorta/Vaccinium scoparium*) is the same with both matrices.

Figure 12: Error Bar Graphs, Cluster Analysis



Bars represent one standard error

Table 7: Derived Cluster Analysis Types

Cluster Analysis Order (Top to Bottom)	Cover Class Midpoint Matrix Types	Presence/Absence Matrix Types
1	PSME-PIPO/FRVI	PSME-PIPO/ARCO
2	PSME-LAOC/ARCO	PIPO/VACA
3	PIPO/ARUV	PSME/BASA
4	PSME-LAOC/SPBE	PSME/THOC
5	PSME-PIPO/ARUV	PIPO-PSME/PHPR
6	PSME-PICO/LIBO	LAOC-PSME/ARCO
7	LAOC-PSME/VAGL	PICO-PSME/GATR
8	PICO/VASC	PICO/VASC
9	PICO/SYAL	PSME-LAOC/SYAL

C. New Lubrecht Experimental Forest Community Types

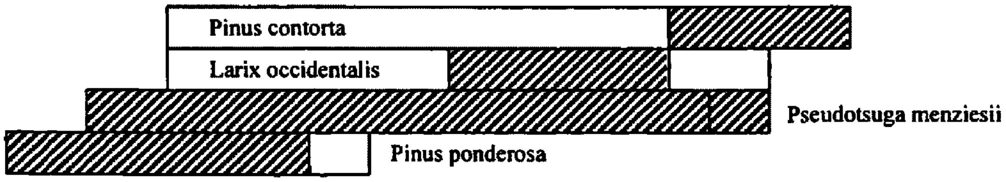
1. Synthesis Tables

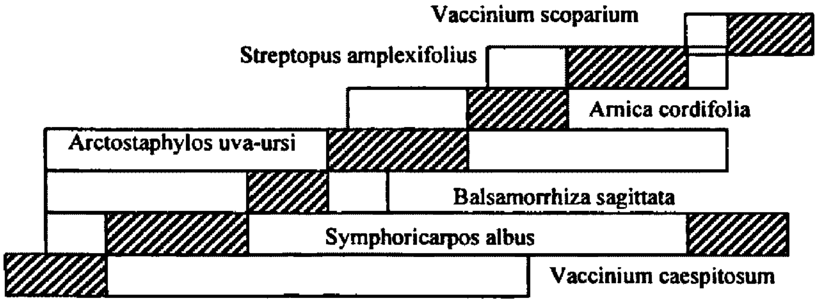
A synthesis table was created for the non-ecotonal dataset to allow flexibility in moving plots along a possible environmental gradient, and is located in Appendix D. A synthesis table is similar to a TWINSPAN table in appearance, with plots across the top of the table arranged in an ecologically significant order, and species along the left side of the table. Plots are found along the top of the table, with species in alphabetical order along the left side of the table. Numbers in the table are the cover class midpoint by species within each plot. By moving the individual plots around based on floristic similarity, a true representation of the distribution of vegetation across the gradient can be developed. Types can be named based on the diagnostic species that are clustered together in the table. A synthesis table is presented to provide an alternate grouping of plots compared to the grouping derived from TWINSPAN and cluster analysis. The basis for selection of plots is based purely on visual tabular analysis in this case rather than statistical tests. Similarity matrices using Sorensen's Index of Similarity (see Pielou 1984 for a discussion of similarity indices) can be calculated to compare each plots similarity to one another, or a group of plots similarity to one another. These similarity matrices provide the basis for testing similarity relationships of plots within types.

Figure 13 is a schematic diagram of the overstory alliance species and the understory indicator species used in naming the types for the first approximation. Overstory species are at the top of the diagram, with understory species below them. The distribution left to right of the species represents a moisture gradient, with the warm/dry types to the left, and the cool/moist types to the right. The relationship of the species to each other across the landscape is visualized by bar lengths representing the ecological amplitude of the species. Additional graphs showing indicator species ecological amplitude based on DCA ordination are found in Appendix E.

Below the bars in Figure 13 are the first approximation alliance and associations. The alliances have many codominants, and each alliance is different. A more accurate way to name the alliances may be to aggregate the dominant species so that the main alliances would be lodgepole pine, Douglas-fir, and ponderosa pine. Within each of these three main alliances would be a moist and a dry phase. The proposed aggregations of alliances are shown below the alliance and association bar.

Figure 13: Schematic Diagram of Overstory Dominance Species and Understory Indicator Species





PIPO	PIPO-PSME	PSME-PIPO	PSME	PSME-LAOC	LAOC-PSME	PICO-PSME	PICO	Alliance
VA CA	SYAL	BA SA	ARUV	AR CO	STAM	SY AL	VA SC	Association

PIPO		PSME			PICO		
DRY	MOIST	DRY	MEDIUM	MOIST	DRY	MOIST	Aggregated Alliances

2. Naming the Types

Types can basically be named from any program output; the "method of analysis or of subsequent data manipulation can completely determine the nature of the conclusions reached" (Daubenmire 1966) because if "two methods of analysis support different conclusions, one must ask whether they are equally valid." The challenge is to define types that consistently reflect the pattern of vegetation readily observable on the landscape. In addition, developing the classification requires thought and consideration by its constructors; "regardless of technique, judgement must be accepted as an essential factor in constructing a useful classification" (Pfister and Arno 1980). For the LEF dataset, a set of new types was named and will be referred to as "first approximation types."

First approximation types as presented in Table 8 reflect a draw on the prototypes from the TWINSPAN user defined cutoff run and default value run at the third level of significance, with consideration of other runs and the cluster analysis runs. In many cases the prototype names had the same alliance (overstory species) while the associations (understory species) were similar and often occurred together in repeatable patterns on the landscape. The alliance names for the final approximation types were based on the dominant overstory species for that particular group, while the association name was based on the TWINSPAN indicator species, or those species most important in driving the splits between groups. Overstory species used to named the alliances were not necessarily important indicator species in TWINSPAN. Plots were assigned to a type after examination of each individual plot's floristic composition. Plots were in some cases moved from one TWINSPAN group to a different, adjacent type to conform with the taxonomic key that was being developed to clearly separate the types.

These particular types are distributed along an environmental gradient, from cool/moist types at the PICO end to warm/dry types at the PIPO end. The gradient is most likely a moisture or elevational gradient. Types along the gradient may represent different successional stages of a potential natural vegetation type.

The NVCS hierarchy has upper divisions dependent on the percent canopy cover and define over 60% as closed canopy, under 60% as open canopy (FGDC 1997). A true representation of types across the landscape in accordance to NVCS standards would include divisions of open and closed forest types. These new LEF types have no particular parameters on amount of canopy cover.

Table 8: First Approximation Types (New LEF Types)

Type Number	Type Name
1	PICO/VASC
2	PICO-PSME/SYAL
3	LAOC-PSME/STAM
4	PSME-LAOC/ARCO
5	PSME/ARUV
6	PSME-PIPO/BASA
7	PIPO-PSME/SYAL
8	PIPO/VACA

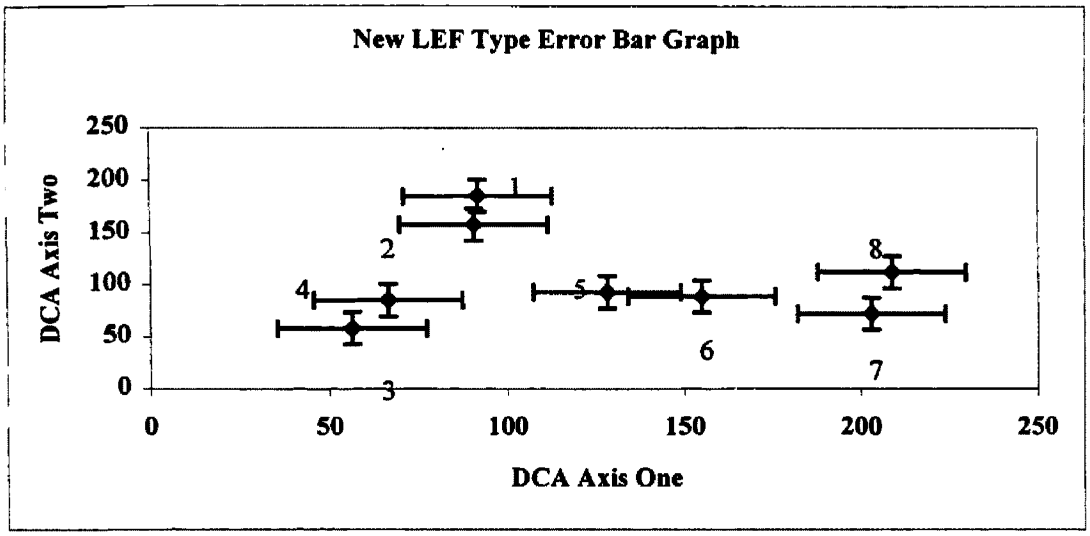
The new LEF types in Table 8 were subject to statistical testing in the form of MRPP, and DCA to create error bar graphs. The new LEF types show a low R value of .22 (Table 9). A number of plots were moved from their TWINSPAN prototype groups to fit into the taxonomic key that was being developed for the new LEF types. Plots were assigned on the basis of specific overstory and understory species, some of which had low coverages, and the remainder of the plot composition may have been dissimilar enough to effect the statistical comparison of within group similarity.

Table 9: MRPP Results for New LEF Types

New Type	Group	Ave Distance	Size	R	P	T
				0.22936311	0	-19.76378
4	1	60.298123	10			
8	2	50.331721	9			
6	3	38.323013	3			
3	4	54.474173	15			
7	5	44.914993	6			
5	6	49.35815	14			
2	7	68.35545	6			
1	8	59.167495	4			

In Figure 14 of the error bar graphs, the new types separate out reasonably well in ordination space. The original DCA ordination graph is located in Appendix E. Mean points with one standard error are labeled with the appropriate new LEF type number. The eight types show a reasonable separation along the first DCA axis and some separation along the second DCA axis. Types one and two having slightly overlapping error bars as do types 5 and 6. As the first DCA axis is more interpretable as a moisture gradient, the overlap of types 5 and 6 is more of a concern than the overlap on the second gradient, which is ambiguous as to what environmental gradient it may represent.

Figure 14: Error Bar Graph for New LEF Types



Bars represent one standard error

3. A Brief Description of the Types

Type 1: PICO/VASC (*Pinus contorta/Vaccinium scoparium*) is a higher elevation, cool/moist type occurring in many cases at a northern exposure, often at slopes of greater than 60 degrees. Topography is often concave or undulating. PICO stands are often dense and spindly examples that have come in after disturbance events across the LEF. In many cases these sites are dark and minimal in understory vegetation. The higher elevation of these sites and/or the dense PICO canopy often limits the presence of PSME, as well as the disturbance history at LEF, but at lower elevations PSME may be a significant component of the overstory. Major associated species include *Vaccinium globulare, Linnaea borealis, Chimaphila umbellata, Calamagrostis rubescens, Spiraea betulifolia,* and in drier sites, *Juniperus communis* and *Arctostaphylos uva-ursi.*

Type 2: PICO-PSME/SYAL (*Pinus contorta-Pseudotsuga menziesii/Symphoricarpos albus*) generally occurs below Type 1 in elevation. Sites are found in patches where fires may have occurred and in areas of windthrow, based on LEF history. Topography is flat to convex. In many cases the PICO is dense and spindly, which is a function of stand density rather than site. Sites are found on a variety of edaphic and hydric conditions including low lying seep areas, which greatly affects the complement of species that can occur on it; however, in most cases SYAL is a common species with a high percent cover. In wetter areas SYAL with still occur, but will be more limited, being displaced by *Spiraea betulifolia.* Major associated species include *Linnaea borealis*, *Berberis repens*, *Calamagrostis rubescens,* and *Arctostaphylos uva-ursi.*

Type 3: LAOC-PSME/STAM (*Larix occidentalis-Pseudotsuga/Streptopus amplexifolius*) occurs in bands of moderate elevation, varying slope, and flat to concave topography. LAOC is at the eastern edge of its range at the LEF and occurs in patches on north facing slopes. The usual association is with PSME with pure LAOC stands rare. Sites are cool and moist and often found along drainages in lower elevations. An associated overstory species is *Picea engelmannii*, particularly in the drainages, indicating some of these are close to riparian sites. Major associated species include *Thalictrum occidentale, Vaccinium globulare, Linnaea borealis, Symphoricarpos albus, Spiraea betulifolia, Arnica cordifolia*, and *Calamagrostis rubescens.* Disturbed sites near roads will have *Trifolium repens.*

Type 4: PSME-LAOC/ARCO (*Pseudotsuga menziesii-Larix occidentalis/Arnica cordifolia*) is similar to type 3 but found in sites of less slope, lower elevations, and is generally moist. Topography is flat to concave and sometimes undulating. PSME are the larger trees in most sites. Sites often have many stems per acre with a closed forest canopy due to fire suppression. Major associated species include *Linnaea borealis, Streptopus amplexifolius, Calamagrostis rubescens, Pyrola secunda* (present due to the amount of shade), *Thalictrum occidentale, Vaccinium globulare* and *Goodyera oblongifolia.*

Type 5: PSME/ARUV (*Pseudotsuga menziesii/Arctostaphylos uva-ursi)* is one of the most common types on the LEF, found at mid-elevations under a variety of edaphic conditions, mainly flat topography, and generally drier than the above types. Large contiguous areas of forest are comprised of this type which can also have LAOC or PIPO mixed in lower proportions and dominant PSME regeneration. Major associated species include *Calamagrostis rubescens, Symphoricarpos albus, Spiraea betulifolia, Arnica cordifolia,* and *Thalictrum occidentale.* Patches of other species including *Linnaea borealis, Vaccinium caespitosum,* and *Vaccinium globulare* can be found interspersed in the understory. Disturbed sites will have *Trifolium repens* and *Taraxacum officinale.*

Type 6: PSME-PIPO/BASA *(Pseudotsuga menziesii-Pinus ponderosa/Balsamorrhiza sagittata*) is a drier site occupying open stands of southern aspect and convex topography. Sites often have large, old growth PIPO trees with smaller PSME generations around them and an open canopy. Major associated species include *Festuca* spp., *Calamagrostis rubescens, Arctostaphylos uva-ursi, Symphoricarpos albus, Spiraea betulifolia,* and *Aster conspicuous.* Disturbed sites will have *Centaurea maculosa, Phleum pratense*, and *Cirsium vulgare.*

Type 7: PIPO-PSME/SYAL (*Pinus ponderosa-Pseudotsuga* *menziesii/Symphoricarpos albus*) is another common type on the LEF, covering wide areas of forest. Sites are dry, flat to convex in topography, with an open canopy. Regeneration on these sites is primarily PSME with older PIPO trees. In some cases, PIPO is regenerating and there is a variety of age classes. Major associated species are similar to Type 6 and include *Festuca* spp., *Calamagrostis rubescens, Arctostaphylos uva-ursi, Spiraea betulifolia,* and in disturbed sites *Phleum pratense, Centaurea maculosa,* and *Poa pratensis.*

Type 8: PIPO/VACA (*Pinus ponderosa/Vaccinium caespitosum*) is a less common type across LEF but invariably appears as a low elevation, dry, open, and flat site comprised mainly of PIPO, VACA, and grasses with a few additional shrubs and forbs. Associated species may include *Symphoricarpos albus, Calamagrostis rubescens, Festuca* spp., *Antennaria neglecta,* and *Arctostaphylos uva-ursi.* Disturbed sites will have *Phleum pratense, Centaurea maculosa,* and *Poa pratensis.*

D. Comparison with Other Taxonomies

In order to compare the derived types with other taxonomies, confusion tables and sorted comparison tables were used. The confusion table is designed to provide a quick overall comparison of a priori types to derived types and is set up with the a priori types along the left column arranged in a particular ecological order, with the derived types across the top in the order of output (Dufrene and Legendre 1997). Tables include habitat types, cover types, process-based structure types, and structure types as the a priori types along the left. Habitat types and cover types are arranged along a moisture/elevational gradient from cool/moist, higher elevation at the top of the table to warm/dry, lower elevation types at the bottom of the table. The process-based structure types and structure types are arranged along what is more or less a disturbance gradient, from the oldest, most mature stand types at the top to the most open, recently disturbed stand types at the bottom. Data is entered on a plot by plot basis with sums by type and by a priori type.

The pattern that is expected in the confusion table is a diagonal line in the case of a divisive classification system such as TWINSPAN, running from the upper left hand corner to the lower right hand corner, particularly for a moisture/elevational gradient. The primary force in shaping the distribution of types is most likely moisture and elevation. Table 10 shows the third level separation of TWINSPAN groups with more groups falling into lower types along the gradient particularly for cover types but with scattered effects for habitat types, process-based structure types and structure types. Table 11 continues this trend at the level four splits. The clearest distinction of types occurs consistently in the cover types. The separation by level is apparent as plots divide into more and more like groups. Habitat types in this case are not as true by plot as is seen in long horizontal strings of numbers along the table, by the fourth level split in Table 10.

Tables 11 and 12 show the results for TWINSPAN level three for the different parameters. Table 11, the default values, show a similar pattern to the user defined cutoffs, while the presence/absence matrix, Table 12, show a more confusing mess of numbers, particularly in the process and structure types. In all cases, the cover types show the most true sorting of types into a priori types. The same progression is repeated in the level four TWINSPAN outputs for the various parameter (see Appendix F for the actual tables).

Table 10: Confusion Table, TWINSPAN Level Three, User Defined Cutoffs

	TWINSPAN Groups, Level Three								
Habitat Types	**C1**	**C2**	**C3**	**C4**	**C5**	**C6**	**C7**	**C8**	**Sum**
PICEA/GATR									0
PSME/LIBO, VAGL			1	11					12
PSME/LIBO, SYAL									0
PSME/VAGL, ARUV	1		1	3	1		1		7
PSME/VAGL, VAGL		4		9					13
PSME/VACA		1	3	6	1	1	6	4	22
PSME/PHMA, CARU									0
PSME/SYAL, CARU				1	3	1	6		11
PSME/CARU, ARUV					1				1
PSME/CARU, CARU						1			1
Sum	1	5	5	30	6	3	13	4	67
Cover Types									
ES									0
LP	1	3							4
LP/WL		2							2
LP/DF			1						1
LP/PP									0
WL/LP				1					1
WL				5					5
WL/DF				5					5
WL/PP							1		1
DF/LP			2		1				3
DF/WL				13					13
DF			1	5	3	2	2		13
DF/WL/PP									0
DF/PP				1	2		2		5
PP/LP							1		1
PP/WL									0
PP/DF					1	1	2		4
PP							5	4	9
NONE									0
Sum	1	5	4	30	7	3	13	4	67

Table 10, Continued: Confusion Table, TWINSPAN Level Three, User Defined Cutoffs

	TWINSPAN Groups, Level Three								
Process Type	**C1**	**C2**	**C3**	**C4**	**C5**	**C6**	**C7**	**C8**	**Sum**
7 - OF, MS				6	2	2	3	1	14
6 - OF, SS									0
5 - SE, CC	1	2	3	16					22
4 - SE, OC				2					2
3 - YF, MS		2	2	4	3	1	1		13
2 - UR		1		2	1		9	3	16
1 - SI									0
Sum	**1**	**5**	**5**	**30**	**6**	**3**	**13**	**4**	**67**
Structure Type									
E - C, M, VL		1		6					7
J - C, S, VL									0
N - O, M, VL			1	3	2		1		7
S - O, S, VL				1					1
D - C, M, L			1	5	1		4	1	12
I - C, S, L									0
M - O, M, L	1	2	2	4	1		2		12
R - O, S, L				2					2
C - C, M, Me				5	2	1	5	3	16
H - C, S, Me									0
L - O, M, Me		2	1	4		2			9
Q - O, S, Me									0
B - C, M, P									0
G - C, S, P									0
K - O, M, P							1		1
P - O, S, P									0
F- C, S, S/S									0
O - O, S, S/S									0
A - NonForest									0
Sum	**1**	**5**	**5**	**30**	**6**	**3**	**13**	**4**	**67**

Table 11: Confusion Table, TWINSPAN Level Four, User Defined Cutoffs

	TWINSPAN Groups, Level Four													
Habitat Types	**C1**	**D1**	**D2**	**D3**	**D4**	**D5**	**D6**	**D7**	**D8**	**C6**	**D9**	**D10**	**C8**	**Sum**
PICEA/GATR														0
PSME/LIBO, VAGL				1		3	8							12
PSME/LIBO, SYAL														0
PSME/VAGL, ARUV	1				1	1	2	1			1			7
PSME/VAGL, VAGL		1	3			3	6							13
PSME/VACA		1		1	2	2	4		1	1	3	3	4	22
PSME/PHMA, CARU														0
PSME/SYAL, CARU							1	2	1	1		6		11
PSME/CARU, ARUV										1				1
PSME/CARU, CARU									1					1
Sum	**1**	**2**	**3**	**2**	**3**	**9**	**21**	**3**	**3**	**3**	**4**	**9**	**4**	**67**
Cover Types														
ES														0
LP	1	1	2											4
LP/WL		1	1											2
LP/DF				1										1
LP/PP														0
WL/LP				1			1							2
WL							5							5
WL/DF						1	4							5
WL/PP												1		1
DF/LP					2			1						3
DF/WL						7	6							13
DF					1	1	4	2	1	2	1	1		13
DF/WL/PP														0
DF/PP							1		2			2		5
PP/LP											1			1
PP/WL														0
PP/DF										1	2	2		5
PP												3	4	7
NONE														0
Sum	**1**	**2**	**3**	**2**	**3**	**9**	**21**	**3**	**3**	**3**	**4**	**9**	**4**	**67**

Table 11, Continued: Confusion Table, TWINSPAN Level Four, User Defined Cutoffs

	TWINSPAN Groups, Level Four													
Process Type	**C1**	**D1**	**D2**	**D3**	**D4**	**D5**	**D6**	**D7**	**D8**	**C6**	**D9**	**D10**	**C8**	**Sum**
7 - OF, MS						2	4	1	1	2	1	2	1	14
6 - OF, SS														0
5 - SE, CC	1	2		1	2	5	11							22
4 - SE, OC							2							2
3 - YF, MS			2	1	1	1	3	2	1	1	1			13
2 - UR			1			1	1		1		2	7	3	16
1 - SI														0
Sum	**1**	**2**	**3**	**2**	**3**	**9**	**21**	**3**	**3**	**3**	**4**	**9**	**4**	**67**
Structure Type														
E - C, M, VL		1				1	5							7
J - C, S, VL														0
N - O, M, VL					1	1	2		2			1		7
S - O, S, VL						1								1
D - C, M, L				1		2	3	1			2	2	1	12
I - C, S, L														0
M - O, M, L	1		2	1	1	1	3	1				2		12
R - O, S, L						1	1							2
C - C, M, Me						2	3	1	1	1	2	3	3	16
H - C, S, Me														0
L - O, M, Me		1	1		1		4			2				9
Q - O, S, Me														0
B - C, M, P														0
G - C, S, P														0
K - O, M, P												1		1
P - O, S, P														0
F- C, S, S/S														0
O - O, S, S/S														0
A - NonForest														0
Sum	**1**	**2**	**3**	**2**	**3**	**9**	**21**	**3**	**3**	**3**	**4**	**9**	**4**	**67**

Table 12: Confusion Table, TWINSPAN Level Three, Default Values

	TWINSPAN Groups, Level Three								
Habitat Types	**C1**	**C2**	**C3**	**C4**	**C5**	**C6**	**C7**	**C8**	**Sum**
PICEA/GATR									0
PSME/LIBO, VAGL			2	10					12
PSME/LIBO, SYAL									0
PSME/VAGL, ARUV	1	1	3	1		1			7
PSME/VAGL, VAGL	1	4	1	7					13
PSME/VACA		3	2	2	3	1	5	6	22
PSME/PHMA, CARU									0
PSME/SYAL, CARU			1	1	1	2	6		11
PSME/CARU, ARUV						1			1
PSME/CARU, CARU						1			1
Sum	**2**	**8**	**9**	**21**	**4**	**6**	**11**	**6**	**67**
Cover Types									
ES									0
LP	1	3							4
LP/WL		2							2
LP/DF					1				1
LP/PP									0
WL/LP		1		1					2
WL				5					5
WL/DF				5					5
WL/PP								1	1
DF/LP		2				1			3
DF/WL			5	8					13
DF	1		4	2	1	4	1		13
DF/WL/PP									0
DF/PP					2		3		5
PP/LP								1	1
PP/WL									0
PP/DF						1	2		3
PP							5	4	9
NONE									0
Sum	**1**	**5**	**4**	**30**	**7**	**3**	**13**	**4**	**67**

Table 12, Continued: Confusion Table, TWINSPAN Level Three, Default Values

	TWINSPAN Groups, Level Three								
	C1	**C2**	**C3**	**C4**	**C5**	**C6**	**C7**	**C8**	**Sum**
Process Type		2	2	3		3	3	1	14
7 - OF, MS									0
6 - OF, SS	1	4	2	12	1		2		22
5 - SE, CC	1				1				2
4 - SE, OC		1	2	2	1	2	5		13
3 - YF, MS		1	3	4	1	1	1	5	16
2 - UR									0
1 - SI	2	8	9	21	4	6	11	6	67
Sum									
Structure Type	1	2	1	2	1				7
E - C, M, VL									0
J - C, S, VL		2	1	2				2	7
N - O, M, VL						1			1
S - O, S, VL		3	1	2	2	1	1	2	12
D - C, M, L									0
I - C, S, L			2	8			1	1	12
M - O, M, L			1			1			2
R - O, S, L		1	2	2	1	3	6	1	16
C - C, M, Me									0
H - C, S, Me	1		1	5			2		9
L - O, M, Me									0
Q - O, S, Me									0
B - C, M, P									0
G - C, S, P							1		1
K - O, M, P									0
P - O, S, P									0
F- C, S, S/S									0
O - O, S, S/S									0
A - NonForest									0
Sum	2	8	9	21	4	6	11	6	67

Table 13: Confusion Table, TWINSPAN Level Three, Presence/Absence Matrix

	TWINSPAN Groups, Level Three							
Habitat Types	**C1**	**C2**	**C3**	**C4**	**C5**	**C6**	**B4**	**Sum**
PICEA/GATR								0
PSME/LIBO, VAGL	8	2	2					12
PSME/LIBO, SYAL								0
PSME/VAGL, ARUV	2	3		2				7
PSME/VAGL, VAGL	4	1	3	5		5		18
PSME/VACA		3	7		7			17
PSME/PHMA, CARU								0
PSME/SYAL, CARU	1	2		1	1	5	1	11
PSME/CARU, ARUV		1						1
PSME/CARU, CARU							1	1
Sum	15	12	12	8	8	10	2	67
Cover Types								
ES								0
LP			1	3				4
LP/WL				2				2
LP/DF			1					1
LP/PP								0
WL/LP			1	1				2
WL	3		2					5
WL/DF	3		2					5
WL/PP					1			1
DF/LP		1	2					3
DF/WL	6	5	2					13
DF	3	5	1	1		1	2	13
DF/WL/PP								0
DF/PP				1	1	3		5
PP/LP					1			1
PP/WL								0
PP/DF		1				2		3
PP					5	4		9
NONE								0
Sum	15	12	12	8	8	10	2	67

	C1	C2	C3	C4	C5	C6	B4	Sum
Process Type	2	5	2	2	1	2		14
7 - OF, MS								0
6 - OF, SS	4		4	6	4		1	19
5 - SE, CC			2					2
4 - SE, OC	4	3	2		1	2	1	13
3 - YF, MS	5	1	2		2	6		16
2 - UR								0
1 - SI	15	9	12	8	8	10	2	64
Sum								
Structure Type	1	1	2		2		1	7
E - C, M, VL								0
J - C, S, VL	1	3		1		2		7
N - O, M, VL			1					1
S - O, S, VL	3	1	1		3	3	1	12
D - C, M, L								0
I - C, S, L	4	2		5		1		12
M - O, M, L	1	1						2
R - O, S, L	5	2	3		3	3		16
C - C, M, Me								0
H - C, S, Me		2	4	2		1		9
L - O, M, Me								0
Q - O, S, Me								0
B - C, M, P								0
G - C, S, P			1					1
K - O, M, P								0
P - O, S, P								0
F- C, S, S/S								0
O - O, S, S/S								0
A - NonForest	15	12	12	8	8	10	2	67
Sum								

Cluster analysis tables show the exact opposite trend that the TWINSPAN tables which is due to the individual methodology of the analyses. Since cluster analysis is aggregative, the groups it formed were along a similar gradient as TWINSPAN but along an opposite direction. The diagonal pattern that is expected, only in reverse, asserts itself most obviously in the cover types (Tables 15 and 16). Habitat types are less true to the groups than cover types. In both cluster analysis runs, cover class midpoint matrix and the presence/absence matrix, process-based structure types and structure types are obscure. Both runs have very similar groupings.

Table 14: Confusion Table, Cluster Analysis, Cover Class Midpoint Matrix

	Cluster Analysis Groups									
Habitat Types	**1**	**3**	**5**	**13**	**24**	**27**	**28**	**42**	**62**	**Sum**
PICEA/GATR										0
PSME/LIBO, VAGL		1		2	1		6		2	12
PSME/LIBO, SYAL										0
PSME/VAGL, ARUV	4				1	1		1		7
PSME/VAGL, VAGL	1	1		2	1		5	3		13
PSME/VACA	4	3	7	1	2	4	1			22
PSME/PHMA, CARU										0
PSME/SYAL, CARU	6	1	3			1				11
PSME/CARU, ARUV	1									1
PSME/CARU, CARU	1									1
Sum	**17**	**6**	**10**	**5**	**5**	**6**	**12**	**4**	**2**	**67**
Cover Types										
ES										0
LP					1			2		3
LP/WL						1		2		3
LP/DF						1				1
LP/PP										0
WL/LP							1		1	2
WL		1		1			2		1	5
WL/DF		4					1			5
WL/PP		1								1
DF/LP						3				3
DF/WL	1			4	1		7			13
DF	10				1	1	1			13
DF/WL/PP										0
DF/PP	4				1					5
PP/LP					1					1
PP/WL										0
PP/DF	2		1							3
PP			9							9
NONE										0
Sum	**17**	**6**	**10**	**5**	**5**	**6**	**12**	**4**	**2**	**67**

Process Type	**1**	**3**	**5**	**13**	**24**	**27**	**28**	**42**	**62**	**Sum**
7 - OF, MS	6	2	1	2	2		1			14
6 - OF, SS										0
5 - SE, CC	3	1		2		4	10	2		22
4 - SE, OC				1			1			2
3 - YF, MS	4	2			3	2		1	1	13
2 - UR	4	1	9					1	1	16
1 - SI										0
Sum	**17**	**6**	**10**	**5**	**5**	**6**	**12**	**4**	**2**	**67**
Structure Type										
E - C, M, VL	2	1			1		2	1		7
J - C, S, VL										0
N - O, M, VL	4				1	1	1			7
S - O, S, VL				1						1
D - C, M, L		2	5	1		1	2		1	12
I - C, S, L										0
M - O, M, L	1	1	1	1	1	2	3	2		12
R - O, S, L		1		1						2
C - C, M, Me	7		4		2		2		1	16
H - C, S, Me										0
L - O, M, Me	2	1		1		2	2	1		9
Q - O, S, Me										0
B - C, M, P										0
G - C, S, P										0
K - O, M, P	1									1
P - O, S, P										0
F- C, S, S/S										0
O - O, S, S/S										0
A - NonForest										0
Sum	**17**	**6**	**10**	**5**	**5**	**6**	**12**	**4**	**2**	**67**

Table 15: Confusion Table, Cluster Analysis, Presence/Absence Matrix

	Cluster Analysis Groups									
Habitat Types	**1**	**4**	**8**	**12**	**16**	**33**	**38**	**42**	**61**	**Sum**
PICEA/GATR										0
PSME/LIBO, VAGL				2		8			2	12
PSME/LIBO, SYAL										0
PSME/VAGL, ARUV			1	3		2		1		7
PSME/VAGL, VAGL				2		5		5	1	13
PSME/VACA	4	6	1	2	5		4			22
PSME/PHMA, CARU										0
PSME/SYAL, CARU	2	1	2	3	3					11
PSME/CARU, ARUV				1						1
PSME/CARU, CARU			1							1
Sum	**6**	**7**	**5**	**13**	**8**	**15**	**4**	**6**	**3**	**67**

Cover Types	**1**	**4**	**8**	**12**	**16**	**33**	**38**	**42**	**61**	**Sum**
ES										0
LP							1	3		4
LP/WL								2		2
LP/DF							1			1
LP/PP										0
WL/LP								1	1	2
WL	1					4				5
WL/DF	1			1		2			1	5
WL/PP		1								1
DF/LP				1			2			3
DF/WL				6		6			1	13
DF	1		4	5		3				13
DF/WL/PP										0
DF/PP	2				3					5
PP/LP		1								1
PP/WL										0
PP/DF			1		2					3
PP	1	5			3					9
NONE										0
Sum	**6**	**7**	**5**	**13**	**8**	**15**	**4**	**6**	**3**	**67**

Process Type	**1**	**4**	**8**	**12**	**16**	**33**	**38**	**42**	**61**	**Sum**
7 - OF, MS	2	3	3	3	2	1				14
6 - OF, SS										0
5 - SE, CC	1			3		10	4	3	1	22
4 - SE, OC						2				2
3 - YF, MS			1	7		1		2	2	13
2 - UR	3	4	1		6	1		1		16
1 - SI										0
Sum	**6**	**7**	**5**	**13**	**8**	**15**	**4**	**6**	**3**	**67**

Structure Type	**1**	**4**	**8**	**12**	**16**	**33**	**38**	**42**	**61**	**Sum**
E - C, M, VL	2			1		3		1		7
J - C, S, VL										0
N - O, M, VL	2			1	2	1	1			7
S - O, S, VL				1						1
D - C, M, L	1	2	1	1	3	3			2	13
I - C, S, L										0
M - O, M, L	1	1	1	1		2	2	4		12
R - O, S, L				2						2
C - C, M, Me		4		5	3	2			1	15
H - C, S, Me										0
L - O, M, Me			2	1		4	1	1		9
Q - O, S, Me										0
B - C, M, P										0
G - C, S, P										0
K - O, M, P			1							1
P - O, S, P										0
F- C, S, S/S										0
O - O, S, S/S										0
A - NonForest										0
Sum	**6**	**7**	**5**	**13**	**8**	**15**	**4**	**6**	**3**	**67**

Table 16 shows the first approximation types for the LEF in the same confusion table design as with the previous analysis type groups. The patterns shown in this table are similar to those found in the TWINSPAN tables for level three, which is expected as the first approximation types utilize the TWINSPAN splits in their determination. Habitat types in this case shown a spread along the different types; the PSME/VACA habitat type appears in every LEF type. LEF types 3 and 5 have a wide assortment of habitat types within them. With this dispersal of habitat types throughout the new LEF types, no clear diagonal sorting pattern is clear. Cover types are the most true to the new LEF types. A

Table 16: Confusion Table, Final Approximation Types (New LEF Types)

	New LEF Types								
Habitat Types	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**Sum**
PICEA/GATR									0
PSME/LIBO, VAGL		1	7	3	1				12
PSME/LIBO, SYAL									0
PSME/VAGL, ARUV	1		1		5				7
PSME/VAGL, VAGL	2	2	5	2	2				13
PSME/VACA	1	3	1	5	1	1	1	9	22
PSME/PHMA, CARU									0
PSME/SYAL, CARU			1		4	1	5		11
PSME/CARU, ARUV					1				1
PSME/CARU, CARU						1			1
Sum	**4**	**6**	**15**	**10**	**14**	**3**	**6**	**9**	67
Cover Types									
ES									0
LP	3	1							4
LP/WL	1	1							2
LP/DF		1							1
LP/PP									0
WL/LP		1		1					2
WL			5						5
WL/DF			3	2					5
WL/PP								1	1
DF/LP		2			1				3
DF/WL			5	5	3				13
DF			2	1	8	2			13
DF/WL/PP									0
DF/PP				1	2		1	1	5
PP/LP								1	1
PP/WL									0
PP/DF						1	2		3
PP							3	6	9
NONE									0
Sum	**4**	**6**	**15**	**10**	**14**	**3**	**6**	**9**	67

Process Type	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**Sum**
7 - OF, MS			1	4	3	2		4	14
6 - OF, SS									0
5 - SE, CC	2	4	10	3	3				22
4 - SE, OC			1	1					2
3 - YF, MS	1	2	2	1	6	1			13
2 - UR	1		1	1	2		6	5	16
1 - SI									0
Sum	**4**	**6**	**15**	**10**	**14**	**3**	**6**	**9**	**67**
Structure Type									
E - C, M, VL				3	1	1		2	7
J - C, S, VL									0
N - O, M, VL			2	1	1		2	1	7
S - O, S, VL						1			1
D - C, M, L	1	2	5	2	2				12
I - C, S, L									0
M - O, M, L	1			2	3		3	3	12
R - O, S, L								2	2
C - C, M, Me	1	4	8	1	2				16
H - C, S, Me									0
L - O, M, Me	1			1	4	1	1	1	9
Q - O, S, Me									0
B - C, M, P									0
G - C, S, P									0
K - O, M, P					1				1
P - O, S, P									0
F- C, S, S/S									0
O - O, S, S/S									0
A - NonForest									0
Sum	**4**	**6**	**15**	**10**	**14**	**3**	**6**	**9**	**67**

clear diagonal is visible across the gradient of cover type, although there are several cases of plots outside of the main pattern. Process-based structure types show no visible pattern and appear as a block across the spectrum of new types. Structure types show a nearly opposite diagonal pattern, which is difficult to discern. Structure types are concentrated again in medium and large classes and are found throughout the various types with no clear sorting into particular ones. Each new LEF types seems to have a number of structure types within it. Since the new LEF types are based on floristic data, correlation with process-based structure types or structure types is likely to be less clear because the various process-based structure types and structure types are not necessarily dependent on the floristic composition of the stands.

By looking at four valid, frequently used classification systems collected a priori in the field in comparison with mathematically derived, objective types, we have the basis of an objective comparison of alternative classification systems. Of particular importance and interest is the hope of transferring existing data in the form of habitat types, cover types, process-based structure types, or structure types, to the hierarchy of the proposed NVCS. Since the proposed NVCS is based on existing vegetation, data that is used to determine types for the NVCS must be readily comparable to an existing vegetation type, regardless of how it was collected. Therefore a fairly true and accurate pattern of relationship between a priori types and objectively determined types must be demonstrated before a type can be converted into the NVCS hierarchy. In the case of these data, cover types exhibit the most true portrayal of the types on the ground, as determined by TWINSPAN and cluster analysis. Of particular interest is the statistically significant TWINSPAN level three classification with user defined cutoff or default values. Habitat types accommodate too wide a variety of successional variation to define the variety of existing vegetation types on the ground. Likewise, the determined final approximation types reflect a broader ecological spectrum across time, disturbance, or space than is included in the habitat types that were determined in the field. Only eleven habitat types to the phase level were found in the field, ten of which were Douglas-fir types, and two of which (including the non-Douglas-fir type) were found only once, on ecotonal plots. Process-based structure types, with only seven to choose from, are even more restrictive and not readily converted to existing vegetation types at the scale we are dealing with in this study. Structure types at this point in the development of LEF forests reflect some of the past history and the overabundance of medium sized trees on the forest, and are not a good indicator of existing vegetation. A particular classification system alone may simple not be adequate to describe all aspects of vegetation present across a landscape, particularly across broad scales. A combination of available vegetation systems that work together in a complementary way may be a solution to a single system involving either potential natural vegetation or existing vegetation, to avoid forcing types into a hierarchy. An example of an integration of systems is an Ecological Diversity Matrix developed by the Boise-Cascade Company which display a number of systems, how they correlate, where they are applicable, along with site factors, wildlife, disease potential, fire potential, and other factors present on a particular landscape. Developed of such a matrix for any landscape, such as the LEF and surrounding region, provides a wealth of tools for decision making due to the ease in comparing systems.

A final way of comparing systems to assess ease in translation of data is a sorted comparison table, keyed by new LEF type in Table 17. New types can be readily compared to groups in the three runs of TWINSPAN, in the two runs of cluster analysis, and to the a priori types collected in the field, on a plot by plot basis. In terms of comparison with analysis groups, new types are similar to TWINSPAN groups for user defined cutoffs (UDC) and for default values (DF). Presence/absence matrix (P/A) TWINSPAN groups are similar to new types, but the new types in many cases have more than one presence/absence matrix TWINSPAN groups within them. Cluster analysis types show some fidelity to the new types, but not as strongly, with several cluster analysis groups within a single new type, or new types mixed within various cluster analysis groups. Presence/absence cluster analysis shows a greater fidelity to the new types. Obviously we would expect good correlation in TWINSPAN types, particularly user defined cutoff and default value runs, with the new types because these results were used heavily in determining the types, although all analysis types were given some consideration in determining the particular understory species to be used in naming the types and thus serving as indicator species for this classification. In terms of a priori type comparison, habitat types show a definite relationship to the new types, particularly in terms of moisture; drier habitat types correlate with drier types and vice versa, though the habitat type alliances are more restrictive than the new types because they only include Douglas-fir (*Pseudotsuga menziesii*) types. Indicator species used in the systems assist in maintaining the fidelity of new types to habitat types as several of the species are the same or quite similar ecologically. Examples include perfect correlation with PIPO/VACA new types and PSME/VACA habitat types, and close correlation with LAOC-PSME/STAM new types and PSME/LIBO,VAGL or PSME/VAGL,VAGL habitat types. Process-based structure types are quite limited and do not show a strong fidelity to particular new types, because the stage of development of vegetation is not necessarily related to the composition and subsequently the type given it in this system of classification. Any conclusion to relation of process-based structure types to new types could only be very general and not very informative. Structure types show certain patterns with medium and smaller sized classes found most frequently in moister types such as LAOC-PSME/STAM, and larger sized classes in drier types, such as PIPO/VACA. Some more widespread types such as PSME/ARUV have a large number of different structure types within them.

Table 17: Table of Classification Systems, Sorted by New LEF Types

TWINSPAN				**Cluster**		**New LEF Types**	**A Priori Types**			
Plot	**UDC-3**	**DF-3**	**PA-3**	**CCM**	**P/A**		**Cov Type**	**Hab Type**	**Proc**	**Struc**
E12	C2	C2	C3	27	38	PICO/VASC	LP	PSME/VACA	5	D
F1	C2	C2	C4	42	42	PICO/VASC	LP/WL	PSME/VAGL,VAGL	2	M
F7	C1	C2	C4	42	42	PICO/VASC	LP	PSME/VAGL,ARUV	5	C
F8	C2	C1	C4	24	42	PICO/VASC	LP	PSME/VAGL,VAGL	3	L
E8	C3	C2	C3	27	38	PICO-PSME/SYAL	DF/LP	PSME/VACA	5	D
E15	C3	C2	C3	27	38	PICO-PSME/SYAL	DF/LP	PSME/VACA	5	C
E16	C3	C5	C3	27	38	PICO-PSME/SYAL	LP/DF	PSME/VACA	5	C
F4	C2	C2	C4	42	42	PICO-PSME/SYAL	LP	PSME/VAGL,VAGL	3	D
F12	C2	C2	C4	42	42	PICO-PSME/SYAL	LP/WL	PSME/VAGL,VAGL	5	C
H2	C3	C4	C3	62	61	PICO-PSME/SYAL	WL/LP	PSME/LIBO,VAGL	3	C
B10	C4	C4	C3	3	1	LAOC-PSME/STAM	WL	PSME/VACA	5	C
B12	C4	C4	C1	3	12	LAOC-PSME/STAM	WL/DF	PSME/SYAL,CARU	3	C
D14	C4	C4	C1	28	33	LAOC-PSME/STAM	DF	PSME/VAGL,ARUV	5	D
G1	C4	C4	C1	28	33	LAOC-PSME/STAM	WL	PSME/LIBO,VAGL	5	D
G3	C4	C4	C1	28	33	LAOC-PSME/STAM	WL	PSME/LIBO,VAGL	5	C
G4	C4	C4	C1	28	33	LAOC-PSME/STAM	DF/WL	PSME/LIBO,VAGL	5	C
G5	C4	C4	C1	3	33	LAOC-PSME/STAM	WL/DF	PSME/VAGL,VAGL	7	N
G6	C4	C4	C1	28	33	LAOC-PSME/STAM	DF/WL	PSME/VAGL,VAGL	5	D
G8	C4	C4	C1	13	33	LAOC-PSME/STAM	DF/WL	PSME/LIBO,VAGL	5	C
G10	C4	C4	C1	28	33	LAOC-PSME/STAM	DF/WL	PSME/LIBO,VAGL	5	D
G11	C4	C4	C3	13	33	LAOC-PSME/STAM	WL	PSME/VAGL,VAGL	4	N
G14	C4	C4	C1	28	33	LAOC-PSME/STAM	DF	PSME/VAGL,VAGL	5	D
G15	C4	C4	C1	28	33	LAOC-PSME/STAM	DF/WL	PSME/VAGL,VAGL	5	C
H1	C4	C4	C3	3	61	LAOC-PSME/STAM	WL/DF	PSME/LIBO,VAGL	3	C
H3	C4	C4	C1	62	33	LAOC-PSME/STAM	WL	PSME/LIBO,VAGL	2	C
A3	C4	C5	C5	1	1	PSME-LAOC/ARCO	DF/PP	PSME/VACA	7	N
A4	C4	C5	C3	1	1	PSME-LAOC/ARCO	DF	PSME/VACA	7	E
A7	C4	C4	C3	3	1	PSME-LAOC/ARCO	WL/DF	PSME/VACA	2	D
B13	C4	C3	C2	13	12	PSME-LAOC/ARCO	DF/WL	PSME/VACA	7	E
B14	C4	C4	C3	13	12	PSME-LAOC/ARCO	DF/WL	PSME/VAGL,VAGL	5	M
D2	C4	C3	C2	24	12	PSME-LAOC/ARCO	DF/WL	PSME/LIBO,VAGL	3	L
D4	C4	C3	C2	28	12	PSME-LAOC/ARCO	DF/WL	PSME/VACA	7	E
F5	C4	C2	C4	28	42	PSME-LAOC/ARCO	WL/LP	PSME/VAGL,VAGL	5	C
G2	C4	C4	C1	28	33	PSME-LAOC/ARCO	WL/DF	PSME/LIBO,VAGL	5	D
G7	C4	C4	C1	28	33	PSME-LAOC/ARCO	DF/WL	PSME/LIBO,VAGL	4	M
C16	C5	C7	C6	24	16	PSME/ARUV	DF/PP	PSME/VACA	7	M
D1	C4	C3	C2	13	12	PSME/ARUV	DF/WL	PSME/LIBO,VAGL	7	E
D3	C3	C3	C2	27	12	PSME/ARUV	DF	PSME/VAGL,ARUV	3	D
D6	C5	C6	C2	27	12	PSME/ARUV	DF/LP	PSME/SYAL,CARU	3	L
D9	C5	C3	C2	1	12	PSME/ARUV	DF	PSME/SYAL,CARU	3	L

Table 17, Continued: Table of Classification Systems, Sorted by New LEF Types

TWINSPAN				Cluster		New LEF Types	A Priori Types			
Plot	UDC-3	DF-3	PA-3	CCM	P/A		Cov Type	Hab Type	Proc	Struc
D10	C5	C6	C2	1	12	PSME/ARUV	DF	PSME/CARU,ARUV	3	M
D11	C4	C3	C2	1	12	PSME/ARUV	DF	PSME/VAGL,ARUV	5	C
D12	C4	C3	C1	1	33	PSME/ARUV	DF	PSME/VAGL,ARUV	3	D
D15	C4	C3	C2	1	12	PSME/ARUV	DF/WL	PSME/VAGL,VAGL	5	L
F16	C7	C1	C4	24	12	PSME/ARUV	DF	PSME/VAGL,ARUV	3	L
H5	C4	C4	C3	1	61	PSME/ARUV	DF/WL	PSME/VAGL,VAGL	5	C
H10	C7	C7	C6	1	8	PSME/ARUV	DF	PSME/SYAL,CARU	2	K
H12	C5	C6	C2	1	8	PSME/ARUV	DF	PSME/VAGL,ARUV	7	M
H15	C5	C5	C4	1	1	PSME/ARUV	DF/PP	PSME/SYAL,CARU	2	N
B2	C6	C6	B4	1	8	PSME-PIPO/BASA	DF	PSME/CARU,CARU	7	S
B3	C6	C6	C2	1	8	PSME-PIPO/BASA	PP/DF	PSME/VACA	7	E
B4	C6	C6	B4	1	8	PSME-PIPO/BASA	DF	PSME/SYAL,CARU	3	L
C1	C7	C7	C5	5	4	PIPO-PSME/SYAL	PP	PSME/SYAL,CARU	2	N
C3	C7	C7	C6	5	16	PIPO-PSME/SYAL	PP/DF	PSME/SYAL,CARU	2	M
C7	C7	C7	C6	1	16	PIPO-PSME/SYAL	DF/PP	PSME/SYAL,CARU	2	L
C8	C7	C7	C6	1	16	PIPO-PSME/SYAL	PP/DF	PSME/SYAL,CARU	2	N
C12	C7	C7	C6	5	1	PIPO-PSME/SYAL	PP	PSME/SYAL,CARU	2	M
C15	C7	C7	C6	5	16	PIPO-PSME/SYAL	PP	PSME/VACA	2	M
A8	C7	C8	C5	3	4	PIPO/VACA	WL/PP	PSME/VACA	7	E
A12	C8	C8	C5	5	4	PIPO/VACA	PP	PSME/VACA	2	R
A15	C8	C8	C5	5	4	PIPO/VACA	PP	PSME/VACA	2	R
A16	C8	C8	C5	5	4	PIPO/VACA	PP	PSME/VACA	2	M
C9	C7	C7	C6	1	16	PIPO/VACA	DF/PP	PSME/VACA	7	M
C10	C7	C7	C6	5	16	PIPO/VACA	PP	PSME/VACA	2	L
C14	C7	C7	C6	5	16	PIPO/VACA	PP	PSME/VACA	2	M
E1	C7	C8	C5	24	4	PIPO/VACA	PP/LP	PSME/VACA	7	E
E5	C8	C8	C5	5	4	PIPO/VACA	PP	PSME/VACA	7	N

UDC = User Defined Cutoff
DF = Default Value
P/A = Presence/Absence Matrix
Cluster = Cluster Analysis

Cov Typ = Cover Type
Hab Typ = Habitat Type
Proc = Process Type
Struc = Structure Type

A final step in the classification of new LEF types was to create a taxonomic key, shown in Table 18. The groupings led to the creation of the key, which in turn completes the creation of a LEF taxonomy. This key is applicable to the areas that were covered in the data collection phase, and can be applied specifically to plots that were determined to be ecotonal in the field and thus were not included in this initial analysis. The key can also be tested at other placed in the LEF or nearby forested lands to determine the repeatability of types over the landscape, and the need for inclusion of more types. The key is dichotomous and was developed by examining the new types on a plot by plot basis and observing the percentages of indicator species were in each plot. Focus was first on the dominant overstory vegetation, then refined to the understory indicator species.

This comparison of a priori habitat types, cover types, process-based structure types, and structure types to the analysis groupings and the first approximation types addresses the second study objective, comparison of alternative classification systems on the LEF.

Table 18: Taxonomic Key to New Lubrecht Experimental Forest Types

1. PICO cover >20%..2
1. PICO cover <20%..3

    2. PSME cover < 20%, VASC present............................PICO/VASC
    2. PSME cover > 20%, ARUV present............................PICO-PSME/ARUV

3. LAOC cover >20%..4
3. LAOC cover < 20%..5

    4. PSME cover < 20%, STAM present............................LAOC-PSME/STAM
    4. PSME cover > 20%, ARCO present and > ARUV cover....PSME-LAOC/ARCO

5. PSME the dominant tree, >20% cover, ARUV present............PSME/ARUV
5. PIPO cover > 20%..6

    6. PSME cover > PIPO cover, BASA present......................PSME-PIPO/BASA
    6. PIPO cover > PSME cover...7

7. SYAL present, VACA absent..PIPO-PSME/SYAL
7. VACA present..PIPO/VACA

Chapter V: Ecotonal Versus Releve Sampling

Ecotones have also been defined as an "intermediate habitat" (Barbour et al. 1987) or "an abrupt or relatively rapid change in an environmental complex-gradient" (Gauch 1982). The question of the appropriateness of sampling ecotones is a continual point of contention in any school of vegetative thought. Historically in vegetation science, there has been wide recognition and discussion that there are discontinuities between communities although the boundaries of communities have received little critical study, perhaps due to the attitude that boundary areas are lacking in scientific interest or worth described by Whittaker (1962). Current attitudes have allowed more interest in areas of transition particularly when considering environmental factors controlling a gradation. Van der Maarel (1990) stressed that ecotones are of great interest ecologically and are deserving of more attention in research. Recent work has shown that environmental factors controlling tree species distribution at ecotones are not symmetrical (Stohlgren and Bachand 1997). Ecotones have merit in that they often represent the physiological or competitive distribution limit of a species and can define a species local distribution. Justification for the use of ecotones in a classification system can be found in the observation that "confining measurements of forest characteristics and environmental factors to homogeneous units may not represent species-environment relationships that dominate complex landscapes, exaggerating the distances between clusters in an ordination diagram (Stohlgren and Bachand 1997). Although ecotones have been "largely neglected" in plant ecology as more research has focused on the community itself (Kent and Coker 1992), often an ecotone is found to be more species-rich than either of the communities it separates, and suggestions that the ecotone could be recognized as a community itself have been proposed (TNC/ESRI 1994). When considering the role of disturbance in landscapes, Noss (1987) feels that disturbance regimes "often do not operate and cannot be kept track of at the scale of the single community-type" which "underscores the need to consider spatial units above the homogeneous community type." The "bottom line message is that the world is considerably less tidy than we thought" (Christensen 1988).

Recommended procedures by the ESA (1997) include stand sampling without regard to successional status or disturbance history but a requirement of uniform conditions in the stand. Sampling done as "subjective without preconceived bias," within recognized "entities," is accepted as a legitimate procedure for data collection (Mueller-Dombois and Ellenberg 1974) and used as the general justification for practitioner-judged homogeneity of stands; in addition, sampling done as "objective, according to chance" is also listed as acceptable. The authors explain that subjective sampling without preconceived bias has lead to "the most rapid advancements in science" because of its flexibility in terms of entitation, or stand recognition, by the user. Continuing, they describe objective sampling as sometimes necessary where "vegetative patterns are nondistinct or unclear to the investigator" or when probability statistics are to be used. Again, statistical testing of subjectively collected data is difficult (Hill et al. 1975) although statistical tests of subjective systems exist, such as the Kulczynski technique described in Whittaker (1962). A problem in subjective sampling is entitation; the Braun-Blanquet system has received criticism because of the often ambiguous area around a stand (van der Maarel 1975). Whittaker (1962) specifies a number of cases of indistinction of associations in classification attempts and stated that when samples are taken by "unprejudiced means," a large proportion of them may be "mixed, atypical, or transitional." Oosting (1956) describes ecotones or "transition zones" as sometimes wide, sometimes relatively narrow, but rarely a sharp demarcation from one community of any size to another. Daubenmire (1966) presents a contrasting view by stating that

> it seems hardly debatable that the earth's *flora* presents a continuum, with the plant life of one area blending with imperceptibly with that of contiguous areas" but "in order to reach the conclusion that *vegetation* likewise is fundamentally a continuum, lacking nodes, it seems necessary to adopt methods that either (i) employ heterogeneous samples rather than samples based on rigorous ecological stratification, or (ii) ignore the important dynamics in determining the discreteness of vegetation types.

A point to consider is that for landscape analysis, all of the land needs to be classified rather than just the homogeneous spots. A systematic sampling design (as employed in this study) may be problematic by inclusions of disturbed sites, non-homogeneous plots, and plots straddling obvious stand-boundary ecotones. This potential problem was investigated by field notation of "ecotonal" versus "non-ecotonal" on each plot. This allowed stratification of the data base for analysis of non-ecotonal plots as homogeneous plots considered representative of a relatively homogeneous stand (the traditional phytosociological basis for vegetation classification of stands) and independent analysis of all plots.

The entire data set including the ecotonal plots was analyzed similarly to the non-ecotonal dataset with only the user defined cutoff parameters in TWINSPAN and only the cover class midpoint matrix for TWINSPAN and cluster analysis (see Table 2). The results from the statistical test using MRPP (Table 19) show a strong similarity to the non-ecotonal dataset results for levels three and four with user defined cutoffs, with the same R values at 0.64 for level three and 0.83 for level four. Comparing back to the non-ecotonal dataset results from Table 4, the values for both data sets are almost identical, with non-ecotonal values of 0.64 for level 3 and 0.84 for level four. Again, groups become more distinct the further down the TWINPAN division, though the number of plots at each level decreases enough to make the groups questionable. The cluster analysis MRPP R value is low at 0.27 and comparable to the non-ecotonal result of 0.30 for the cover class matrix midpoint.

Table 19: MRPP Results, All Plots TWINSPAN and Cluster Analysis

Split Level	Group	Ave Distance	Size	R	P	T
TWINSPAN						
3				0.64607003	0	-30.771147
	35	266.16938	21			
	32	2.1705273	39			
	33	229.61005	36			
	36	0	3			
	34	382.95422	10			
	31	5.6928688	11			
4				0.83398919	0	-23.675754
	420	0.92570075	17			
	44	1.5572416	14			
	43	1.31103	25			
	45	298.21235	22			
	49	0	4			
	46	33.383435	11			
	36	0	3			
	47	56.573425	9			
	48	0	4			
	41	3.9333333	6			
	42	0.84852814	5			
Cluster Analysis				0.25731651	0	-41.157449
	1	48.02714	16			
	2	50.530253	28			
	3	43.153933	25			
	7	57.962839	12			
	19	61.57986	8			
	20	40.700168	11			
	49	58.074094	13			
	65	77.696525	2			
	84	56.50647	6			

Figure 15 shows a TWINSPAN dendrogram for the all plots data set. The dendrogram is larger than the previous one due to the greater number of plots, 121 instead of the non-ecotonal 67. Generally, the arrangement of plots follows the expected moisture/elevational gradient from cool/moist, higher to warm/dry, lower, although there is a scattering of lodgepole pine away from its expected position on the extreme left of the diagram, a pattern that is more clearly shown in the confusion tables to follow. Splits are often uneven, leaving eleven plots in one final group and one in another. Plots which split out early to the extreme right of the diagram include nonforest sites and very disturbed, weedy sites.

In the cluster analysis dendrogram (Figure 16) plot separation is also sometimes uneven though the aggregative nature of the program allows more even inclusion into groups. The upper aggregations of plots may be suspect due to the diverse nature of the lower plots as discussed earlier (Pielou 1984).

Figure 15: TWINSPAN Dendrogram, All Plots Data Set

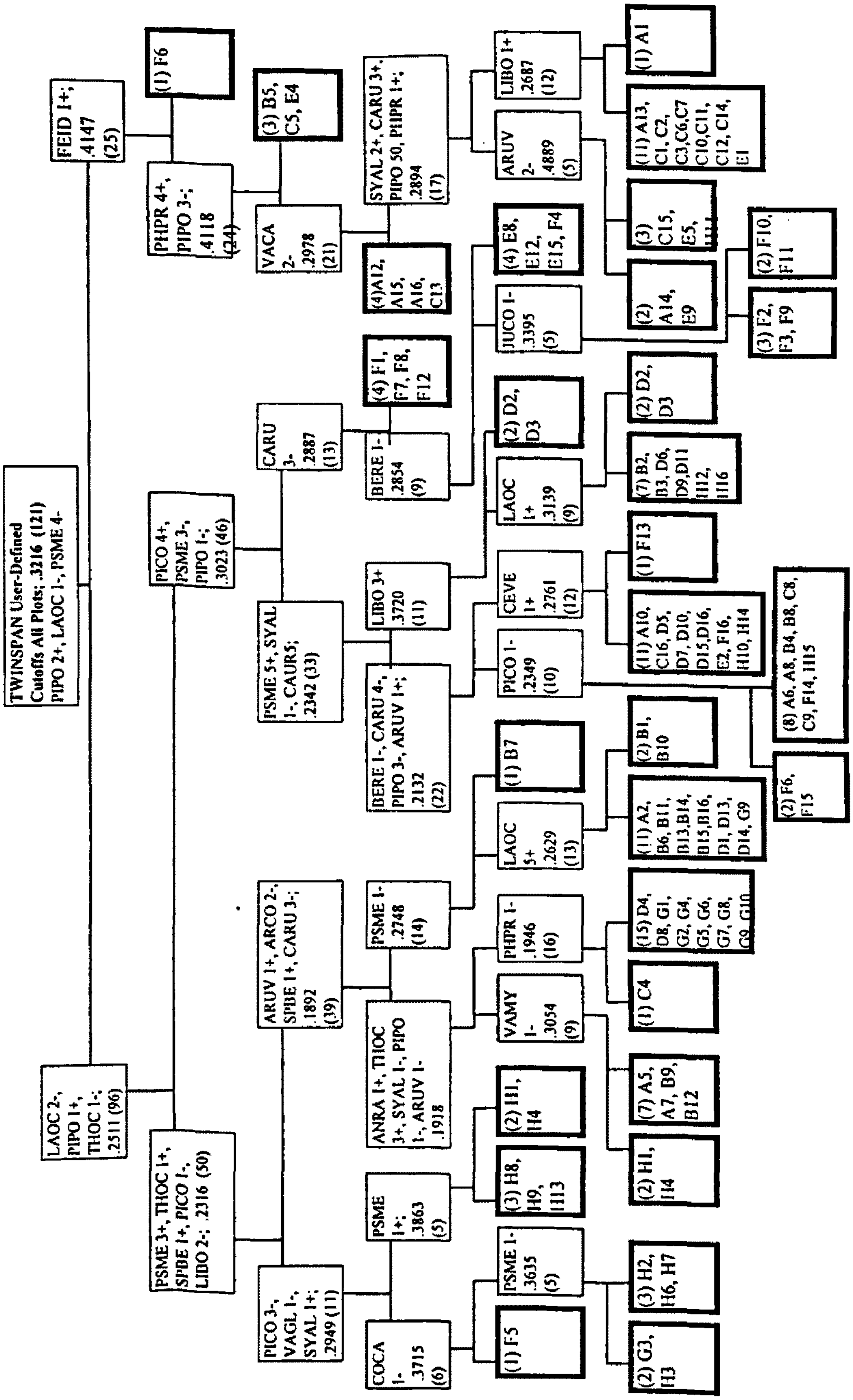


Figure 16: Cluster Analysis Dendrogram, All Plots Data Set

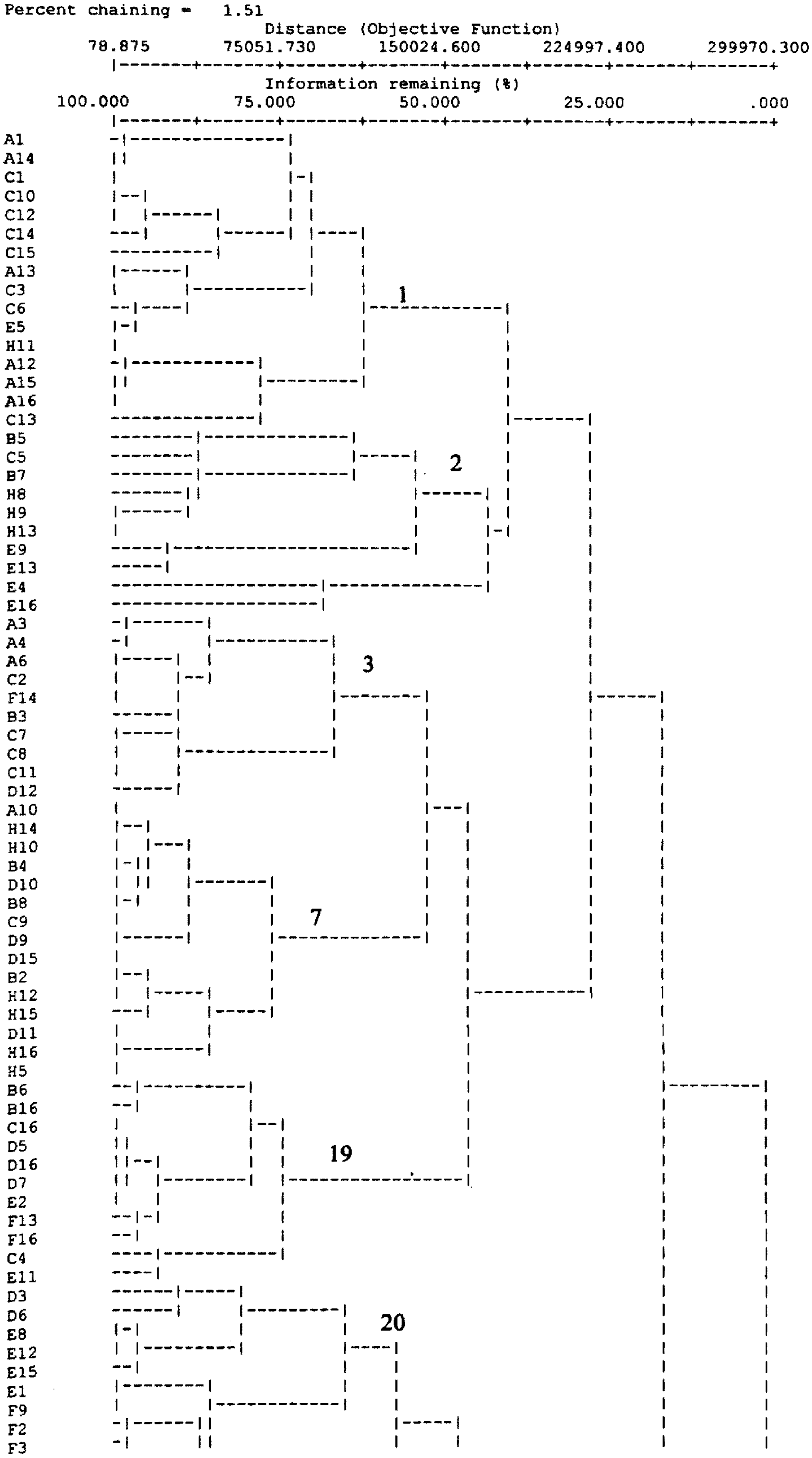
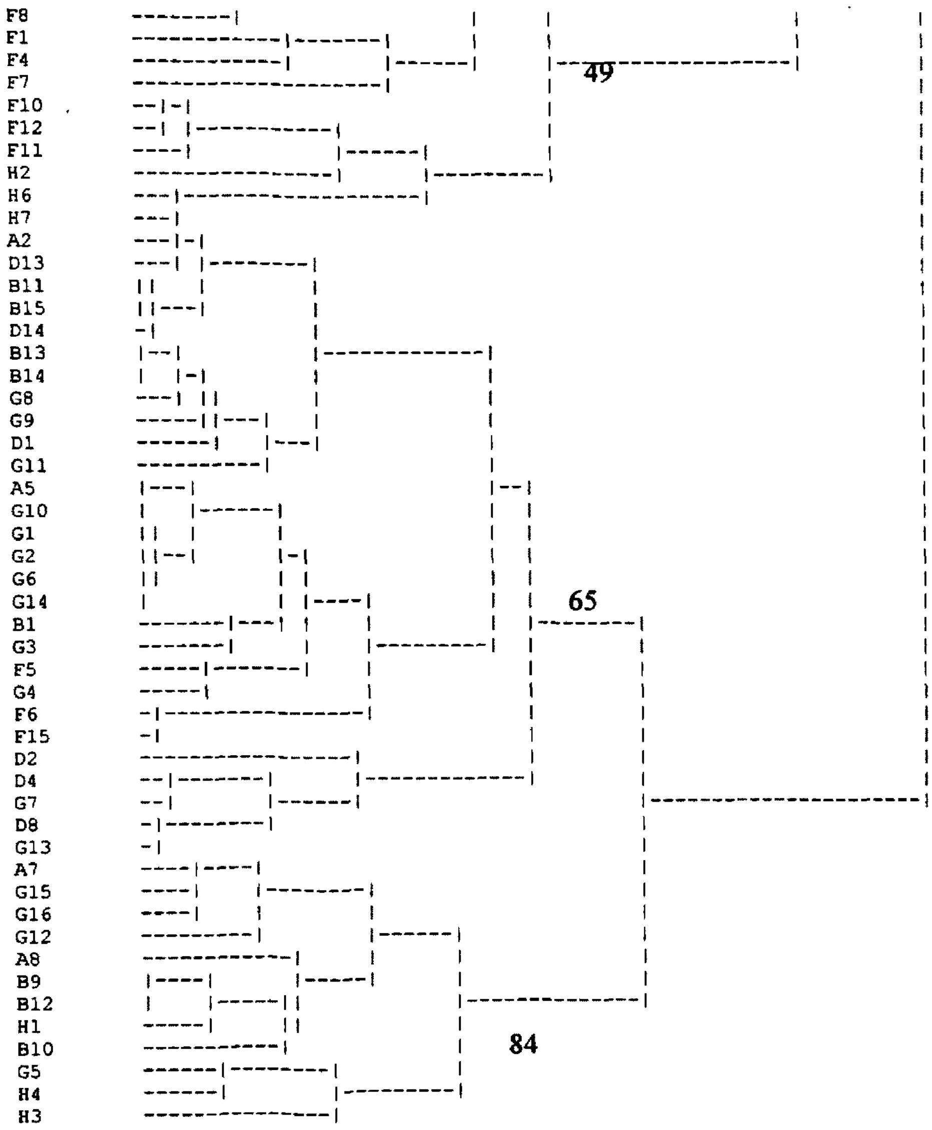


Figure 16, Continued: Cluster Analysis Dendrogram, All Plots Data Set



Error bar graphs in Figure 17 show a clear separation of TWINSPAN level three groups, with no overlap of error bars, each representing one standard error. Level four includes many groups with some overlapping clumps of two, and the cluster analysis graph only shows one overlapping clump. The use of a larger data set probably helps the separation into more significant groups earlier in TWINSPAN and in cluster analysis. The floristic component of this data set is larger with weedy species, non-natives, and riparian species which also help to define groups more readily. Referring back to the non-ecotonal data set error bars in Figure 8, the ecotonal dataset shows clearer separation of TWINSPAN groups, with fewer groups at level three. Two groups separated out, one at level two with only one plot, and one at level three as a non-forested type (see Figure 15). Level four in Figure 17 introduces a larger number of groups which frequently overlap as compared to level four in Figure 9. Cluster analysis groups in Figure 17 show clear separation except for two; compared to Figure 12 the number of groups is the same but the overlap of error bars is less.

Confusion tables for TWINSPAN levels three and four are presented in Tables 20 and 21. By level three the cover types show in addition to the expected diagonal line an offshoot of mainly lodgepole pine types. The habitat types, process-based structure types, and structure types become obscure and scatter into many groups in level three, a trend which is carried further in level four (Table 21). Cluster analysis (Table 22) in this case is obscure in all four classifications with no obvious patterns appearing in the table.

Figure 17: Error Bar Graphs, All Plots Data Set

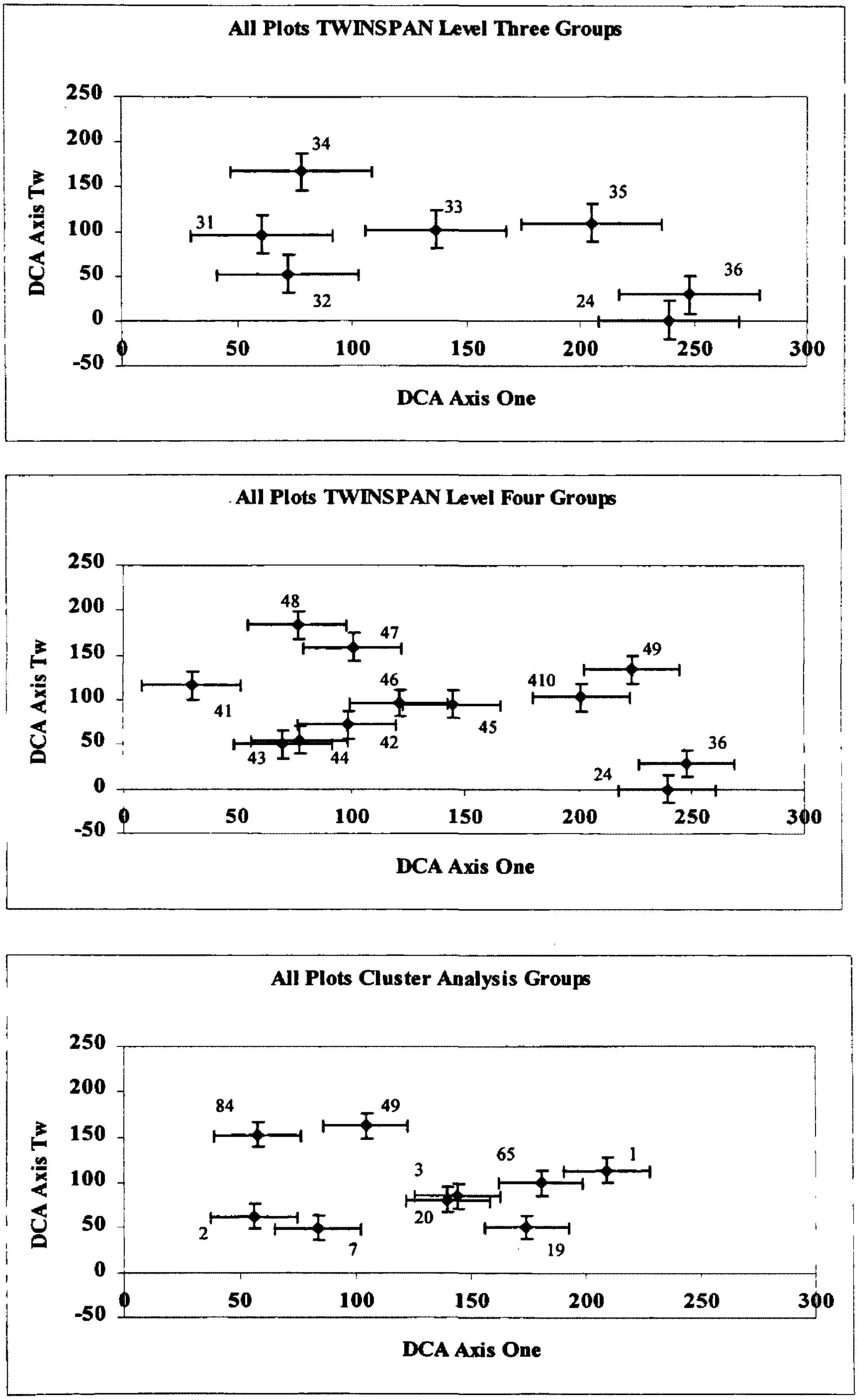


Table 20: Confusion Table, All Plots TWINSPAN Level Three

	TWINSPAN Groups, Level Three							
Habitat Types	**C1**	**C2**	**C3**	**C4**	**C5**	**C6**	**B4**	**Sum**
PICEA/GATR						1		1
PSME/LIBO, VAGL	6	12	1					19
PSME/LIBO, SYAL				2				2
PSME/VAGL, ARUV		3	6	1				10
PSME/VAGL, VAGL	4	12	1	4				21
PSME/VACA		9	9	3	12	1		34
PSME/PHMA, CARU		1						1
PSME/SYAL, CARU	1	2	13		7	1	1	25
PSME/CARU, ARUV			4		1			5
PSME/CARU, CARU			2		1			3
Sum	**11**	**39**	**36**	**10**	**21**	**3**	**1**	**121**
Cover Types								
ES						1		1
LP	1			6				7
LP/WL				2				2
LP/DF			1					1
LP/PP			1					1
WL/LP	3							3
WL	6	5	1					12
WL/DF	1	7						8
WL/PP			1					1
DF/LP			1	2				3
DF/WL		14	2					16
DF		11	19				1	31
DF/WL/PP			1					1
DF/PP		1	5		3			9
PP/LP			1		1			2
PP/WL		1						1
PP/DF			2		2			4
PP			1		15			16
NONE						2		2
Sum	**11**	**39**	**36**	**10**	**21**	**3**	**1**	**121**

Process Type	**C1**	**C2**	**C3**	**C4**	**C5**	**C6**	**B4**	**Sum**
7 - OF, MS		10	14	1	3			28
6 - OF, SS								0
5 - SE, CC	2	13	4	6				25
4 - SE, OC	3	6	3		2		1	15
3 - YF, MS	3	7	10	2				22
2 - UR	3	3	5	1	16	1		29
1 - SI						2		2
Sum	**11**	**39**	**36**	**10**	**21**	**3**	**1**	**121**
Structure Type								
E - C, M, VL	2	1	3		1			7
J - C, S, VL								0
N - O, M, VL	1	4	4	3	3	1		16
S - O, S, VL		2						2
D - C, M, L	1	3	2	1	7			14
I - C, S, L					1			1
M - O, M, L	2	6	6	2	2			18
R - O, S, L		2	1					3
C - C, M, Me	1	7	6	3				17
H - C, S, Me								0
L - O, M, Me	3	8	11	1	4	1		28
Q - O, S, Me		5	1		1		1	8
B - C, M, P		1						1
G - C, S, P								0
K - O, M, P	1		1		1			3
P - O, S, P								0
F- C, S, S/S								0
O - O, S, S/S			1					1
A - NonForest					1	1		2
Sum	**11**	**39**	**36**	**10**	**21**	**3**	**1**	**121**

Table 21: Confusion Table, All Plots TWINSPAN Level Four

	TWINSPAN Groups, Level Four												
Habitat Types	**D1**	**D2**	**D3**	**D4**	**D5**	**D6**	**D7**	**D8**	**D9**	**D10**	**C6**	**B4**	**Sum**
PICEA/GATR											1		1
PSME/LIBO, VAGL	4	2	10	2		1							19
PSME/LIBO, SYAL							2						2
PSME/VAGL, ARUV			1	2	3	3		1					10
PSME/VAGL, VAGL	2	2	6	6	1	1	3						21
PSME/VACA			6	3	6	3	3		4	8	1		34
PSME/PHMA, CARU			1										1
PSME/SYAL, CARU		1	1	1	8	2	3			7	1	1	25
PSME/CARU, ARUV					4					1			5
PSME/CARU, CARU						2				1			3
Sum	**6**	**5**	**25**	**14**	**22**	**12**	**11**	**1**	**4**	**17**	**3**	**1**	**121**
Cover Types													
ES												1	1
LP	1						4	2					7
LP/WL								2					2
LP/DF						1							1
LP/PP							1						1
WL/LP	2	1											3
WL	3	3	3	2	1								12
WL/DF		1	4	3									8
WL/PP					1								1
DF/LP						1	2						3
DF/WL			10	4	1	1							16
DF			7	4	12	7						1	31
DF/WL/PP					1								1
DF/PP			1		5					3			9
PP/LP													0
PP/WL				1						1			2
PP/DF					1	1	1			2			5
PP							1		4	11			16
NONE												2	2
Sum	**6**	**5**	**25**	**14**	**22**	**11**	**9**	**4**	**4**	**17**	**0**	**4**	**121**

Table 21, Continued: Confusion Table, All Plots TWINSPAN Level Four

	TWINSPAN Groups, Level Four												
Process Type	**D1**	**D2**	**D3**	**D4**	**D5**	**D6**	**D7**	**D8**	**D9**	**D10**	**C6**	**B4**	**Sum**
7 - OF, MS			5	5	8	3	4			3			28
6 - OF, SS													0
5 - SE, CC	2		10	3	2	2	4	2					25
4 - SE, OC	1	2	4	2	3					2		1	15
3 - YF, MS	1	2	4	3	6	4	1	1					22
2 - UR	2	1	2	1	3	2		1	4	12	1		29
1 - SI											2		2
Sum	**6**	**5**	**25**	**14**	**22**	**11**	**9**	**4**	**4**	**17**	**3**	**1**	**121**
Structure Type													
E - C, M, VL	1	1		1	2	1				1			7
J - C, S, VL													0
N - O, M, VL	1		4			3	3	1		3	1		16
S - O, S, VL				2									2
D - C, M, L		1	1	2	1	1		1	1	6			14
I - C, S, L										1			1
M - O, M, L	1	1	3	3	4	1	1	2		2			18
R - O, S, L			1	1	1								3
C - C, M, Me	1		6	1	5	1	3						17
H - C, S, Me													0
L - O, M, Me	2	1	7	1	7	4	1		3	1	1		28
Q - O, S, Me			3	2			1			1		1	8
B - C, M, P				1									1
G - C, S, P													0
K - O, M, P		1			1					1			3
P - O, S, P													0
F- C, S, S/S													0
O - O, S, S/S					1								1
A - NonForest										1	1		2
Sum	**6**	**5**	**25**	**14**	**22**	**11**	**9**	**4**	**4**	**17**	**3**	**1**	**121**

Table 22: Confusion Table, All Plots Cluster Analysis

	Cluster Analysis Groups									
Habitat Types	**1**	**2**	**3**	**7**	**19**	**20**	**49**	**65**	**84**	**Sum**
PICEA/GATR	1									1
PSME/LIBO, VAGL		9	4	4	1		1			19
PSME/LIBO, SYAL									2	2
PSME/VAGL, ARUV		2	1	1	2	1	3			10
PSME/VAGL, VAGL		6	3	4	1	3	1		3	21
PSME/VACA	8	6	7	2	2	5	2	2		34
PSME/PHMA, CARU					1					1
PSME/SYAL, CARU	6	3	7	1	2	2	4			25
PSME/CARU, ARUV		2	1				2			5
PSME/CARU, CARU			2						1	3
Sum	**15**	**28**	**25**	**12**	**9**	**11**	**13**	**2**	**6**	**121**
Cover Types										
ES	1									1
LP		1			1		2		3	7
LP/WL						1			1	2
LP/DF						1				1
LP/PP							1			1
WL/LP		1		1	1					3
WL	1	3	2	3	2	1				12
WL/DF		3	1	3		1				8
WL/PP		1								1
DF/LP					1	1		1		3
DF/WL		8	2	3		1	1		1	16
DF	1	7	10	2	4	1	4	1	1	31
DF/WL/PP							1			1
DF/PP	2	2	4				1			9
PP/LP						1	1			2
PP/WL			1							1
PP/DF	1		2			1				4
PP	8	2	3			1	2			16
NONE	1					1				2
Sum	**15**	**28**	**25**	**12**	**9**	**11**	**13**	**2**	**6**	**121**

Process Type	**1**	**2**	**3**	**7**	**19**	**20**	**49**	**65**	**84**	**Sum**
7 - OF, MS	1	8	7	2	2	2	4	1	1	28
6 - OF, SS										0
5 - SE, CC		10	3	2	2	4	1	1	2	25
4 - SE, OC	3	3	3	2	2		2			15
3 - YF, MS		4	6	4	1	2	4		1	22
2 - UR	10	3	6	2	2	2	2		2	29
1 - SI	1					1				2
Sum	**15**	**28**	**25**	**12**	**9**	**11**	**13**	**2**	**6**	**121**
Structure Type										
E - C, M, VL		3	2			2				7
J - C, S, VL										0
N - O, M, VL	1	4	3	1	1	1	4		1	16
S - O, S, VL	1		1							2
D - C, M, L		7	2	2	2	1				14
I - C, S, L							1			1
M - O, M, L	2	5	5	1		2	1	1	1	18
R - O, S, L	3									3
C - C, M, Me		6	3	3		2	1	1	1	17
H - C, S, Me										0
L - O, M, Me	3	3	6	4	3	2	4		3	28
Q - O, S, Me	3				3					6
B - C, M, P				1						1
G - C, S, P										0
K - O, M, P	1		2							3
P - O, S, P			1				1			2
F- C, S, S/S										0
O - O, S, S/S	1									1
A - NonForest						1	1			2
Sum	**15**	**28**	**25**	**12**	**9**	**11**	**13**	**2**	**6**	**121**

As a final comparison, a table with plot by plot data is given in Table 23. Plots can be compared to their position in Figures 15 and 16. The new types for non-ecotonal plots are included in this table. Based on the fidelity of TWINSPAN types and cluster analysis types from the non-ecotonal data set, those ecotonal plots in the same TWINSPAN groups at level three or the same cluster analysis group as non-ecotonal plots of a certain new type may possibly sort out to be in the same new type. Keying out the plots using Table 18 may provide insight as to how well ecotonal plots fit into the newly developed classification, or if the inclusion of the plots would require the development and naming of additional types, including weedy or invasive types.

Table 23: Table of Classification Systems with All Plots

Plot #	Ecotone	Lv3	Lv4	Cluster	New Types	Cov Type	Hab Type	Proc	Struc
A1	1	C5	D10	1		DF/PP	PSME/VACA	2	K
A2	1	C2	D4	3		DF	PSME/VACA	4	L
A3	2	C2	D3	3	PSME-LAOC/ARCO	DF/PP	PSME/VACA	7	N
A4	2	C2	D3	2	PSME-LAOC/ARCO	DF	PSME/VACA	7	E
A5	1	C2	D3	3		DF	PSME/VACA	3	L
A6	1	C3	D5	7		DF	PSME/VACA	3	L
A7	2	C2	D3	7	PSME-LAOC/ARCO	WL/DF	PSME/VACA	2	D
A8	2	C3	D5	2	PIPO/VACA	WL/PP	PSME/VACA	7	E
A10	1	C3	D5	3		DF	PSME/VACA	3	L
A12	2	C5	D9	1	PIPO/VACA	PP	PSME/VACA	2	R
A13	1	C5	D10	1		PP	PSME/VACA	4	S
A14	1	C5	D10	1		PP	PSME/VACA	2	R
A15	2	C5	D9	1	PIPO/VACA	PP	PSME/VACA	2	R
A16	2	C5	D9	2	PIPO/VACA	PP	PSME/VACA	2	M
B1	1	C2	D4	7		WL/DF	PSME/VAGL,VAGL	7	B
B2	2	C3	D6	3	PSME-PIPO/BASA	DF	PSME/CARU,CARU	7	S
B3	2	C3	D6	3	PSME-PIPO/BASA	PP/DF	PSME/VACA	7	E
B4	2	C3	D5	19	PSME-PIPO/BASA	DF	PSME/SYAL,CARU	3	L
B5	1	C6	C6	20		NONE	PSME/VACA	1	A
B6	1	C2	D4	19		DF	PSME/VAGL,ARUV	7	Q
B7	1	C2	D4	3		PP/WL	PSME/SYAL,CARU	7	M
B8	1	C3	D5	7		DF/WL	PSME/SYAL,CARU	7	L
B9	1	C2	D3	1		WL	PSME/VACA	7	L
B10	2	C2	D4	2	LAOC-PSME/STAM	WL	PSME/VACA	5	C
B11	1	C2	D4	7		WL/DF	PSME/VAGL,ARUV	3	L
B12	2	C2	D3	2	LAOC-PSME/STAM	WL/DF	PSME/SYAL,CARU	3	C
B13	2	C2	D4	2	PSME-LAOC/ARCO	DF/WL	PSME/VACA	7	E
B14	2	C2	D4	2	PSME-LAOC/ARCO	DF/WL	PSME/VAGL,VAGL	5	M
B15	1	C2	D4	20		WL/DF	PSME/VAGL,VAGL	3	N
B16	1	C2	D4	3		DF	PSME/VAGL,VAGL	3	D
C1	2	C5	D10	1	PIPO-PSME/SYAL	PP	PSME/SYAL,CARU	2	N
C2	1	C5	D10	1		DF/PP	PSME/SYAL,CARU	2	Q
C3	2	C5	D10	20	PIPO-PSME/SYAL	PP/DF	PSME/SYAL,CARU	2	M
C4	1	C2	D3	19		DF	PSME/PHMA,CARU	4	Q
C5	1	C6	C6	1		NONE	PSME/SYAL,CARU	1	O
C6	1	C5	D10	3		PP	PSME/SYAL,CARU	2	N
C7	2	C5	D10	3	PIPO-PSME/SYAL	DF/PP	PSME/SYAL,CARU	2	L
C8	2	C3	D5	3	PIPO-PSME/SYAL	PP/DF	PSME/SYAL,CARU	2	N
C9	2	C3	D5	2	PIPO/VACA	DF/PP	PSME/VACA	7	M
C10	2	C5	D10	3	PIPO/VACA	PP	PSME/VACA	2	L
C11	1	C5	D10	1		PP/DF	PSME/SYAL,CARU	4	L
C12	2	C5	D10	1	PIPO-PSME/SYAL	PP	PSME/SYAL,CARU	2	M
C13	1	C5	D9	1		PP	PSME/VACA	2	L
C14	2	C5	D10	1	PIPO/VACA	PP	PSME/VACA	2	M
C15	2	C5	D10	20	PIPO-PSME/SYAL	PP	PSME/VACA	2	M

Table 23, Continued: Table of Classification Systems with All Plots

Plot #	Ecotone	Lv3	Lv4	Cluster	New Types	Cov Type	Hab Type	Proc	Struc
C16	2	C3	D5	3	PSME/ARUV	DF/PP	PSME/VACA	7	M
D1	2	C2	D4	3	PSME/ARUV	DF/WL	PSME/LIBO,VAGL	7	E
D2	2	C3	D6	49	PSME-LAOC/ARCO	DF/WL	PSME/LIBO,VAGL	3	L
D3	2	C3	D6	2	PSME/ARUV	DF	PSME/VAGL,ARUV	3	D
D4	2	C2	D3	20	PSME-LAOC/ARCO	DF/WL	PSME/VACA	7	E
D5	1	C3	D5	49		DF/PP	PSME/VAGL,ARUV	7	N
D6	2	C3	D6	20	PSME/ARUV	DF/LP	PSME/SYAL,CARU	3	L
D7	1	C3	D5	2		DF	PSME/CARU,ARUV	4	L
D8	1	C2	D3	3		DF	PSME/LIBO,VAGL	3	M
D9	2	C3	D6	49	PSME/ARUV	DF	PSME/SYAL,CARU	3	L
D10	2	C3	D5	3	PSME/ARUV	DF	PSME/CARU,ARUV	3	M
D11	2	C3	D6	3	PSME/ARUV	DF	PSME/VAGL,ARUV	5	C
D12	2	C2	D3	2	PSME/ARUV	DF	PSME/VAGL,ARUV	3	D
D13	1	C2	D4	2		DF	PSME/VAGL,VAGL	2	L
D14	2	C2	D4	3	LAOC-PSME/STAM	DF/WL	PSME/VAGL,VAGL	5	D
D15	2	C3	D5	20	PSME/ARUV	DF	PSME/VAGL,ARUV	5	L
D16	1	C3	D5	2		DF	PSME/CARU,ARUV	7	N
E1	2	C5	D10	20	PIPO/VACA	PP/LP	PSME/VACA	7	E
E2	1	C3	D5	65		DF	PSME/VACA	7	M
E4	1	C6	C6	1		ES	PICEA/GATR	2	Q
E5	2	C5	D10	49	PIPO/VACA	PP	PSME/VACA	7	N
E8	2	C4	D7	19	PICO-PSME/SYAL	DF/LP	PSME/VACA	5	D
E9	1	C5	D10	49		PP	PSME/CARU,ARUV	2	Q
E11	1	C3	D6	49		DF	PSME/VACA	2	I
E12	2	C4	D7	19	PICO/VASC	LP	PSME/VACA	5	D
E13	1	B4	B4	49		DF	PSME/SYAL,CARU	4	A
E15	2	C4	D7	65	PICO-PSME/SYAL	DF/LP	PSME/VACA	5	C
E16	2	C3	D6	20	PICO-PSME/SYAL	LP/DF	PSME/VACA	5	C
F1	2	C4	D8	84	PICO/VASC	LP/WL	PSME/VAGL,VAGL	2	M
F2	1	C3	D7	49		LP/PP	PSME/SYAL,CARU	7	N
F3	1	C3	D7	49		PP/LP	PSME/SYAL,CARU	7	N
F4	2	C4	D7	2	PICO-PSME/SYAL	LP	PSME/VAGL,VAGL	3	D
F5	2	C1	D1	2	PSME-LAOC/ARCO	WL/LP	PSME/VAGL,VAGL	5	C
F6	1	C3	D5	49		DF/WL/PP	PSME/CARU,ARUV	4	M
F7	2	C4	D8	49	PICO/VASC	LP	PSME/VAGL,ARUV	5	C
F8	2	C4	D8	49	PICO/VASC	LP	PSME/VAGL,VAGL	3	L
F9	1	C3	D7	2		PP	PSME/SYAL,CARU	7	N
F10	1	C4	D7	84		LP	PSME/LIBO,SYAL	5	L
F11	1	C4	D7	84		LP	PSME/LIBO,SYAL	7	L
F12	2	C4	D8	20	PICO-PSME/SYAL	LP/WL	PSME/VAGL,VAGL	5	C
F13	1	C3	D5	3		DF	PSME/SYAL,CARU	3	L
F14	1	C3	D5	2		DF/PP	PSME/SYAL,CARU	7	N
F15	1	C3	D5	20		WL	PSME/VAGL,VAGL	5	D
F16	2	C3	D5	49	PSME/ARUV	DF	PSME/VAGL,ARUV	3	L
G1	2	C2	D3	2	LAOC-PSME/STAM	WL	PSME/LIBO,VAGL	5	D
G2	2	C2	D3	2	PSME-LAOC/ARCO	WL/DF	PSME/LIBO,VAGL	5	D
G3	2	C1	D1	2	LAOC-PSME/STAM	WL	PSME/LIBO,VAGL	5	C
G4	2	C2	D3	7	LAOC-PSME/STAM	DF/WL	PSME/LIBO,VAGL	5	C

Table 23, Continued: Table of Classification Systems with All Plots

Plot #	Ecotone	Lv3	Lv4	Cluster	New Types	Cov Type	Hab Type	Proc	Struc
G6	2	C2	D3	2	LAOC-PSME/STAM	WL/DF	PSME/VAGL,VAGL	7	N
G6	2	C2	D3	2	LAOC-PSME/STAM	DF/WL	PSME/VAGL,VAGL	5	D
G7	2	C2	D3	2	PSME-LAOC/ARCO	DF/WL	PSME/LIBO,VAGL	4	M
G8	2	C2	D3	2	LAOC-PSME/STAM	DF/WL	PSME/LIBO,VAGL	5	C
G9	1	C2	D4	7		WL	PSME/LIBO,VAGL	4	L
G10	2	C2	D3	2	LAOC-PSME/STAM	DF/WL	PSME/LIBO,VAGL	5	D
G11	2	C2	D3	7	LAOC-PSME/STAM	WL	PSME/VAGL,VAGL	4	N
G12	1	C2	D3	2		DF/WL	PSME/LIBO,VAGL	4	M
G13	1	C2	D3	7		DF/WL	PSME/LIBO,VAGL	2	M
G14	2	C2	D3	7	LAOC-PSME/STAM	DF	PSME/VAGL,VAGL	5	D
G15	2	C2	D3	2	LAOC-PSME/STAM	DF/WL	PSME/VAGL,VAGL	5	C
G16	1	C2	D3	3		DF	PSME/LIBO,VAGL	5	C
H1	2	C1	D2	7	LAOC-PSME/STAM	WL/DF	PSME/LIBO,VAGL	3	C
H2	2	C1	D1	7	PICO-PSME/SYAL	WL/LP	PSME/LIBO,VAGL	3	C
H3	2	C1	D1	3	LAOC-PSME/STAM	WL	PSME/LIBO,VAGL	2	C
H4	1	C1	D2	84		WL	PSME/LIBO,VAGL	3	L
H5	2	C2	D3	84	PSME/ARUV	DF/WL	PSME/VAGL,VAGL	5	C
H6	1	C1	D1	19		LP	PSME/VAGL,VAGL	2	L
H7	1	C1	D1	19		WL	PSME/LIBO,VAGL	4	L
H8	1	C1	D2	19		WL/LP	PSME/VAGL,VAGL	2	Q
H9	1	C1	D2	1		WL	PSME/SYAL,CARU	4	Q
H10	2	C3	D5	3	PSME/ARUV	DF	PSME/SYAL,CARU	2	K
H11	1	C5	D10	19		PP	PSME/CARU,CARU	7	N
H12	2	C3	D6	3	PSME/ARUV	DF	PSME/VAGL,ARUV	7	M
H13	1	C1	D2	3		WL	PSME/VAGL,VAGL	4	Q
H14	1	C3	D5	3		DF	PSME/SYAL,CARU	4	K
H15	2	C3	D5	84	PSME/ARUV	DF/PP	PSME/SYAL,CARU	2	N
H16	1	C3	D6	2		DF	PSME/CARU,CARU	2	L
Ecotone: 1 = yes, 2 = no									

This table was sorted by new LEF types and determine how well the plots stayed within a TWINSPAN type and how many were moved to accommodate the creation of a workable key. Table 24 illustrates the movement of plots from new types in the non-ecotonal dataset. The TWINSPAN groups are listed on the left; these represent the user defined cutoff parameter, which the types were most strongly developed from. The new LEF types are listed across the top by number (refer to Table 7). If TWINSPAN were used exclusively to define types, each group on the left correspond exactly with each new

LEF type across the type, as in C1 corresponding with new type number 1, C2 corresponding with new type number 2, and so forth. Three plots were moved from the second TWINSPAN group (C2), five from the third group, twenty from the fourth group, and seven from the seventh group, for a total of 35 plots moved. The ecotonal dataset has fewer TWINSPAN groups and shows a less clear diagonal pattern across the new LEF types, which is expected because these groups were not used to determine the new LEF types. The lodgepole pine new LEF types (numbers one and two) sort out somewhere in the middle of the ecotonal TWINSPAN gradient. The ecotonal dataset includes 54 additional plots that were not assigned a new type and are not reflected in this table.

Table 24: Confusion Table of New Types Versus Both Datasets

Non-Ecotonal Dataset

	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**Sum**
C1	1								1
C2	3	2							5
C3		4			1				5
C4			15	10	5				30
C5					6				6
C6						3			3
C7					2		6	5	13
C8								4	4
Sum	4	6	15	10	14	3	6	9	67

Ecotonal Dataset

	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**Sum**
C1		1	3	1					5
C2			12	8	3				23
C3		1		1	11	3	1	2	19
C4	4	4							8
C5							5	7	12
C6									0
B4									0
Sum	4	6	15	10	14	3	6	9	67

A major cause of the alteration of the patterns of cover type and the increased obscuring of the other types is the introduction of ecological noise. Ecological noise involves data such as unusual species or cover types assemblages at a small scale, or a plot level, that can obscure the true pattern across the landscape the investigator is attempting to uncover. Noise will distort analysis results but is an indication of certain processes operating with the ecological unit of study. Inclusion of ecotonal plots obviously introduces a good deal of noise, with heavily disturbed sites, open landing or slash pile areas, roadsides, riparian sites, and any other heterogeneous area included in the floristic analysis. An eigenvalue represents the amount of environmental variation explained by a particular axes (McCune and Mefford 1997). Table 25 gives the actual eigenvalues by axis for non-ecotonal and all plots datasets. The values are very similar for both datasets which is somewhat unexpected given the inclusion of so much potential obscuring noise in the all plots dataset. Eigenvalue of above .3 are considered ecologically significant (Gauch 1982) so only the first axes in either data set used to develop theories or generate hypotheses about. As discussed earlier, the first axis likely represents the moisture/elevational gradient. The other two may represent a disturbance gradient but do not offer strong support for theoretical consideration.

Table 25: Comparison of Eigenvalues

	Non-Ecotonal	**All**
Axis 1	0.31088	0.30701
Axis 2	0.21436	0.20979
Axis 3	0.10133	0.12798

VI. Vegetation Mapping and Taxonomy Relationships

Phase one of this study provided a data base to investigate application of syntaxonomy to vegetation and site mapping. It also provided the opportunity to gain experience in the application of a priori classification systems before using them during plot data collection. Only a brief discussion will be presented in this thesis for two reasons: 1). the taxonomy portion became the primary focus of effort for this thesis, and 2). the new Alliances and Community Associations cannot be used in the comparison without revisiting all of the transects.

Entitation is the process of recognition of discrete, homogeneous clumps of vegetation on the landscape, or recognition of the "entity" of the stand (Mueller-Dombois and Ellenberg 1974). Entitation is a necessary process to recognize a homogeneous stand (entity) prior to establishing a representative "releve" plot in the Braun-Blanquet (1928) system. Entitation was also critical in recognizing unique near-climax stands and then establishing a representative plot during Daubenmire's initial vegetation classification (1952) in the inland west. Phase one sampling, the transect lines, provided the means to practice entitation across the sampling unit. Vegetation changes in composition, size, density and layering were all recorded as existing vegetation changes, and site changes were recognized by using the habitat typing key (Pfister et. al. 1977).

The use of transect lines and plots provides a means to compare the transect segmentation with the independent, objective plot sampling. Maps were constructed for each forty-acre unit using the detailed record of changes along each transect; at each change, a mark was made on the paper map which could be connected to corresponding type changes in the adjacent transect line, until all the changes in type were connected as polygons representative of stands on the landscape. Maps showing habitat types, cover types, and structure type polygons are located in Appendix G. These variables were also recorded at each plot independently and can eventually be compared to the stands indicated by the polygons on the maps to see how well they correlate. Several plots may be located in a single stand, as the plots were not true releve plots. (Releve plots are taken in only one representative place in the stand to avoid repetitive measurements, which can affect the results of a classification.) The inclusion of many plots within the same stand, composed of the same vegetation, may also affect the final type names and the plots included in each one, from the TWINSPAN and cluster analysis results.

The spatial analysis of mapping and taxonomic relationships should be continued as a separate complementary project to this thesis as agreed upon by thesis writer and project director. The hand drawn maps should be digitized in a GIS environment, in order to overlay the stand polygons with the entire LEF database already available in Arc/Info. A comparison should also be made with stand polygons delineated independently as part of the 1995 LEF inventory (Mogilesky and Wood 1995). Additional field data collection and considerable analysis will be required for the comparison of plots to transect-derived polygons and aerial photo derived polygons. This would provide an excellent opportunity for another MS thesis focusing on the application of plot-based taxonomy to spatial representation of "stand," "patches," and "ecotones" on the landscape.

Chapter VII: Discussion

Creating a taxonomy can at first be a challenging task when formulating the steps of the process, including the data collection, the analysis techniques, the statistical validation, and the final naming of types for the taxonomy. Addressing the objectives of the study provided a logical framework for the development of the taxonomy and the comparison of alternative classification systems, once past the major stumbling block of finding an objective method of data collection.

Sampling Design

Designing an objective and efficient sampling design in order to create a taxonomy for the LEF was accomplished by reviewing literature and regional protocol in setting up a plot, plus some creative innovation in the systematic grid with transects. Observations while collecting data indicated that the natural patterns of vegetation were adequately covered by the systematic design, and that large clumps were not overlooked, which could have been assessed with a species-area curve. The plots that fell in non-ecotonal areas could not be considered releve plots because instead of being a single, representative plot in a homogenous area of a stand (Braun-Blanquet 1928), they often were multiple representative plots in the same stand. A bias that may have arose is the unequal plot to stand ratios. Another possible source of variation during data collection includes phenological variation which from July to October in the understory forbs.

TWINSPAN

In creating the new taxonomic classification (the first objective) the methods chosen were widely used and readily available. TWINSPAN is a proven robust, widely accepted program for classification purposes (Hill et al. 1975, Jensen 1990, Dollar et al. 1992, van Groenewoud 1992, Babcock and Ely 1994, Padgett and Crow 1994, Bernard and Seischab 1995, Dunwiddie et al. 1996, Dufrene and Legendre 1997). The correlation of non-ecotonal plots to cover types was positive. There was also good distribution along the suspected moisture/ elevational gradient in the TWINSPAN runs, particularly the user defined cutoff and the default values.

Species Weighting

Using different parameters to weight species abundance in the TWINSPAN program can have significant effects on the distribution of plots in final division, but upper divisions remain similar. User defined cutoff runs in both MRPP and the DCA error bar graphs provided the highest statistical significance suggesting that careful consideration of input values in TWINSPAN can be useful in creating a taxonomy based on data collection techniques, particularly if the developer of the taxonomy was involved in the data collection and knows the methodology well. Default values also provided similar results to the user defined cutoff. Using an entirely different weighting, the presence/absence matrix, produces different results and affects the statistical significance of the groups that are created. Cover class codes are completely equalized in an effort to uncover the species that are truly important in driving the groupings in the program. TWINSPAN's dependence on pseudospecies cut levels (abundance weighting) and series of iterative ordinations cause the most disparity between the results when using the different matrices. Presence/absence may be a good idea in defining only Community Associations, but not necessarily the Alliances when they are defined by dominance overstory. Tree species such as Douglas-fir (*Pseudotsuga menziesii*) were "present" in virtually every plot, along with species such as snowberry (*Symphoricarpos albus*), pinegrass (*Calamagrostis rubescens*), spiraea (*Spiraea betulifolia*), creeping Oregon grape (*Berberis repens*), kinnickinnick (*Arctostaphylos uva-ursi*), western meadow rue (*Thalictrum occidentale*), and pussy-toes (*Antennaria* spp.) but the importance of these particular species across the LEF was overlooked because of the abundance of them in the presence/absence analysis. Instead, some of the rarer or more obscure species ended up being important in defining groups, which is not necessarily a true representation of the ecology of the LEF.

TWINSPAN Levels

With such a small data set, lower divisions of TWINSPAN, while interesting to consider, were of no significance statistically. The upper level were increasingly more statistically important, but belayed considerably less ecological information as they were more general. A compromise was made in selecting the third level of TWINSPAN prototypes as the initial foundation for defining the types.

Cluster Analysis

Cluster analysis, as an alternative acceptable method of classifying plots (Damman 1998, Personal Communication), produced somewhat similar results to

TWINSPAN in the similar clumps in ordination. Given the less significant distribution of means and standards errors, TWINSPAN groups were superior to cluster analysis groups as a primary classification technique. Groupings between the two matrices (CCM versus PA) did not differ as much as with different TWINSPAN runs, probably because of the process of cluster analysis. Plot composition in terms of presence or absence on a plot by plot basis is more easily compared than in an entire dataset of plots.

Synthesis Tables

Synthesis tables were produced from TWINSPAN output and used to clearly define the cluster analysis prototypes. This allowed visual tabular analysis of the individual plot-by-plot floristic composition of each type, once the table was sorted by cluster analysis group. Tabular analysis remains an essential component of vegetation taxonomy (Pfister and Arno 1980, Grossman 1998, Personal Communication) because quantitative analyses alone do not produce an operational taxonomy. Using synthesis tables was necessary in developing a workable key to identify the new LEF types. A large number of the stands were moved from their pure TWINSPAN analysis groups to accommodate the separation of types as abstract taxonomic entities. This is part of the judgement process in developing an operation vegetation taxonomy (Pfister and Arno 1980, Grossman 1998, Personal Communication).

Further analysis was planned in the form of SIMREL, a program developed by Roberts (1987) to test within and among group similarity of types, but was not accomplished because software was not available at this time.

Defining Types

The definition of first approximation types was a difficult process which ended up combining dominant overstory species with indicator understory species to name the Alliances and Associations. The Alliances named by the analysis procedures splits had many codominant species and aggregation into larger, single-species alliances may be possible. Aggregation of the lower Association or type units remains a problem in that individual plots may be aggregated upward through the proposed hierarchy, but named types might not be easily or effectively aggregated. The associations in this case are part of a dominance alliance but use floristics, specifically diagnostic species, to be defined. The Alliance/Association complex is therefore a hybrid of dominance and floristics. The official description in the FGDC (1997) hierarchy is that:

> Alliances represent an aggregation of Associations and are characterized by one or a group of diagnostic species, which, as a rule, occur in the dominant or uppermost stratum of the vegetation. The finest floristic unit of the classification standard is the Association which is characterized by the diagnostic species that occur in all strata (overstory and understory) of the vegetation. The diagnostic species used to determine both the Alliance and Association are primarily the dominant species. When data indicate that additional diagnostic species (including differential, indicator, or character species) provide a better characterization of ecological patterns, they are used in addition to the dominant species to classify these floristic units.

Understory Species

Naming associations by understory dominant species is difficult as almost every plot had snowberry or pinegrass in it, so indicator species were used. In Appendix E, the ecological amplitudes of the dominant overstory species and the understory indicator species for the first approximation types are shown from the DCA ordinations. Each species has a particular distribution and separation from other species somewhere within the ordination cloud along the first axis, and in some cases, a separation along the second axis. Another way of examining this dataset would be to test understory distribution along an environmental gradient independent of the overstory, by doing the set of analyses described for only understory species. In many cases the assemblages of understory vegetation may be dynamic and independent of the affects or the composition of the overstory. A particularly strong division along the second axis is between lodgepole pine dominated plots, which sort out near the top of the left side of the ordination diagram, and Western larch dominated plots, which sort out near the bottom. Since the eigenvalue on this axis is so low, theories on why this sorting took place are limited, although with a larger data set this relationship may be clarified and explored. Some problems with the DCA ordination arrangement, or any other analytical technique such as TWINSPAN, may be overcome by the rearrangement of plots in the synthesis table. The true diagnostic species may be better reflected, and placed along the environmental gradient in a more appropriate location. For example, the location of VACA (*Vaccinium caespitosum*) at the extreme dry end of the TWINSPAN runs and first approximation types is at odds with its placement in other taxonomies (see Pfister et. al. 1977). The use of pseudospecies for weighting in TWINSPAN may give inordinate weight to certain diagnostic species which may not be appropriate in naming associations. Figure 13, compared to similar figures found in Pfister et. al. (1977), is set up the same way, along an environmental gradient from left to right, or from warm/dry to cool/moist. The position of the overstory species is similar in this study compared to their position in the Pfister et. al. (1977) diagrams. The understory indicator species are not similar and in some cases are in very different positions. In addition, SYAL (*Symphoricarpos albus*) is used as an indicator twice. The small area and small size of the dataset may influence the choice of indicator species; the Pfister et. al. (1977) diagram is based on a wider region and a larger dataset.

Comparing Classifications

Comparison of different classification systems is a natural step in evaluating their effectiveness. Objective two involved comparison of habitat types, cover types, process-based structure types, and structure types to new types derived independently in PC-ORD. All classifications are subject to their advantages and to their shortcomings, and any given classification may not always be appropriate for a particular landscape or a particular kind of study. As stated by Kimmins (1997), "there can be no single 'best' classification that will serve all purposes under all circumstances, although there will nearly always be a best method for a specific application." Habitat types in the database are restricted to a single series. The results from this study illustrate that the same successional stages, overstory types, and understory dominants occur in several habitat types, precluding attempts to work backwards with this classification to assign new alliances and community associations proposed to fit the FGDC system of existing vegetation types.

Cover types are easy to define and detect from remote sensing. Cover types were the most true to the analysis groups, most likely because analysis groups were all based on existing vegetation, and dominance was a major criterion for the Alliances. Cover types might legitimately be translated into the proposed FGDC system at the Alliance level with subdivisions to define Associations based on knowledge of the understory component of the stands.

Process-based structure types are useful for the purpose of understanding stand development dynamics. This set of data deals with small areas and individual stands, while process-based structure types may be better used in explaining large scale patterns across the landscape, at a different scale of diversity; they are too restrictive in translating well to existing vegetation types.

Structure types reflect information on the successional or stand development history of a stand or a larger land region. The appearance of the structure types in the confusion tables is generally blocky and repeats itself in several different tables. The LEF is overwhelmingly composed of medium sized timber, which affects the distribution of structure types among groups. Naturally, many different groups will have medium sized categories in them. Given time, we can expect a pattern of certain regeneration species in certain sites subject to particular environmental conditions, such as Douglas-fir (*Pseudotsuga menziesii*) coming in beneath ponderosa pine (*Pinus ponderosa*), western larch (*Larix occidentalis*) coming in gaps or open areas, or lodgepole pine (*Pinus contorta*) filling in exclusively in upper elevation areas of windthrow. At this point in the development of LEF forests, the past management history is reflected more strongly than natural ecological patterns of disturbance. The variables defining conventional stand structure types are related to process-based structure types but can be examined independently on forested lands. The interrelationships between processes of forest stand development and structural variables are currently being explored by O'Hara and graduate students at the University of Montana. Structure typing by either method should recognize the unique ecological interpretations of the architecture of forested vegetation. A community structure change could mean a change in species abundance.

Ecotonal Plots

The very design of the study from sampling onward brings up the question of the effects of ecotonal sampling on a classification, the third objective. The classification developed from the non-ecotonal plots, following accepted and recommend protocol, can potentially ignore interesting ecological processes happening on the landscape. The possibility of using ecotones in a classification systems is illustrated by the statistical validity of the third level TWINSPAN splits in MRPP and in the DCA error bar graphs. In addition, eigenvalues from a DCA ordination were comparable to those of the non-ecotonal data set run. Ecotonal vegetation assemblages in some cases divided out as their own type. If the taxonomy that was developed had included ecotonal plots, Associations based on unusual overstory compositions such as Western larch - ponderosa pine (*Larix occidentalis-Pinus ponderosa*) or ponderosa pine – lodgepole pine (*Pinus ponderosa-Pinus contorta*) with invasive or weedy main understory indicator species such as timothy (*Phleum pratense*) or Kentucky bluegrass (*Poa pratensis*) would have appeared in addition to stable upland forest Community Associations. This variety of types may reflect more of the true composition of the vegetation on the areas where data was collected.

Determination of an ecotone, or a homogeneous plot, was entirely based on individual field judgement in this study. Homogeneous areas were identified as such within the boundaries of a fifth acre plot. Ecotones were named on the basis of structure and composition of the existing vegetation, and also on the presence of disturbance or areas lacking vegetation, which may explain why so many of the plots were labeled as ecotone. Disturbance plots were basically non-homogeneous plots that reflected a fine-grained reflection of disturbance history. Ecotones could also be named by a change in indicator species, indicating a change in potential natural vegetation, or a habitat type ecotone, although such ecotones were not recognized in the course of this study's field work.

Results from analysis of the entire dataset including ecotones reveals that distribution in TWINSPAN may be altered by factors which skew the smooth distribution along a clear environmental gradient. The presence of lodgepole pine dominated plots in TWINSPAN-derived groups near the center of the TWINSPAN table is in contrast to the placement of lodgepole pine dominated plots in the non-ecotonal dataset. Known or suspected gradients do not necessarily explain the pattern of species due to confounding environmental factors, past disturbance events, or unknown preferences (Allen and Peet 1990, Hill 1990, Stohlgren and Bachand 1997). Based on observations in the field, lodgepole pine stands occurred in distinctive locations, with some in higher elevations on steep slopes, comprised of thick stands of thin trees, with little Douglas-fir undergrowth, while others were located in lower elevations, in flatter areas interspersed with more

Douglas-fir and at larger sizes of a more even spacing. The plots in the second lodgepole pine locations all were recorded as ecotones, and not used in the new LEF type development. In this way, subjective plot selection may ignore several legitimate existing vegetation types. The floristic complement of the non-ecotonal plots is less which may be an explanation for the closer distribution of mean and standard error entities, although the non-ecotonal plot set is statistically valid.

Ecotones in particular are subject to a unique set of environmental conditions and may be important constituents of monitoring environmental change (Stohlgren and Bachand 1997) which is a suggested use of an NVCS (Damman 1998, Personal Communication). Environmental variables appear to drive the plot distribution in the all plots data set more than in the non-ecotonal dataset during ordination. In future classifications, I recommend inclusion of a greater number of environmental variables and disturbance or land use history quantified variables to examine the effects of a wide set of site conditions on plot distribution in ordination space, in order to reveal stronger relationships along axes and reasons behind the particular classification of plots. Recognition of ecotones represents the reality of vegetation communities across a land area. Slope and elevation are strongly influential in the distribution of types in ordinations as seen in Appendix H . Generally, higher slopes and elevations were associated with lodgepole pine, larch, then Douglas-fir associations. The environmental gradient that types are found along is of great interest in predicting vegetation change over time. By understanding the influences on vegetation, implications of management action can be better understood. The amount, type, composition, and distribution of the vegetation is dependent on the site factors. Interpretation of the LEF types can reveal which types are seral stages, or what environmental factors are driving the typal differentiation.

Comparing the non-ecotonal dataset to the ecotonal dataset reveals that inclusion of ecotonal plots adds noise to the analysis. Statistical results from MRPP are similar, and the error bar graphs show even better separation of groups in the ecotonal dataset than in the non-ecotonal dataset. However, comparing the placement of plots into the new LEF types reveals that the ecotonal dataset doesn't fit as well, which is somewhat expected as the new LEF types are derived from the other data set. The complement of floristics in the ecotonal dataset is different, causing an alteration of the distribution of plots along the TWINSPAN or DCA ordination axes. Ecotonal plots, particularly those straddling obvious stand boundaries, obviously will add noise. Creating a working taxonomy using ecotonal plots in the dataset is possible using the methods in this study, but consideration must be given to the potential gradient alteration when attempting to name and describe types. A working taxonomic key with ecotonal plots included may include site or environmental factor key items in addition to pure floristics. Exploration into this method is limited as is literature at this point. Future sampling should include a clear definition of what an ecotone is, such as the difference between disturbance boundary plots and non-homogeneous plots.

New Type Representations

The new LEF types and their description are obviously only a limited sample of vegetation types on the LEF. They represent only the eight forty-acre units that were covered by the data collection. Subsequent surveys of land areas around these units will undoubtedly reveal more types, particularly at higher elevations or around riparian areas. This first approximation taxonomy and database remains open ended for inclusion of more types following similar methodology. A larger dataset covering more areas would likely follow the same pattern along a moisture/elevation gradient in TWINSPAN and cluster analysis. Some of the first approximation types may represent different seral types within the same environment. Almost every plot had Douglas-fir on it, causing the entire data set to be with the Douglas-fir series for habitat typing. In many cases, the plots dominated with ponderosa pine, larch, or lodgepole pine may eventually become dominated with Douglas-fir.

Chapter VIII: Summary and Conclusions

"Classification is the prerequisite of all conceptual thought" (Gilmour 1951). Such a grandiose statement, although referring specifically to vegetation science, is used here to emphasize the importance of creating a flexible, dynamic vegetation classification system that will allow consideration of the vegetated landscape as a true, living entity instead of a dry, categorical sheet of names. Vegetated areas offer resources to meet vital needs of human societies and are therefore frequently subject to management regimes. With a classification system in place, land managers have the basis of decision-making for a variety of natural resources on their landscape and the ability to communicate with other land managers effectively, allowing cohesive land management over large vegetated areas. Choosing the "best system of classification is one of the biggest problems facing land managers" because of the "sheer number of systems available" (Bailey et. al. 1978). A standard National Vegetation Classification would be an ideal system to be applied over wide areas as the emphasis on management shifts to larger landscape scales. Difficulties arise in creating a system, implementing the system, and revising and monitoring the system.

A test of the proposed NVCS yields result throughout this study indicating that a standard system could be applied to many areas if the system was flexible enough to accommodate a range of vegetation and vegetation change over time; modifications of the methodology would be necessary to accommodate different physiognomic regions. A small, single season test may be limited in projecting solid conclusions, but this study remains a starting point for addition studies focusing on testing the system of data collection and creation of new types.

Naming the types can be accomplished in a variety of ways. The number of different analysis packages capable of processing complex ecological data is large and continues to grow with technological advances and innovations in thinking about vegetative communities. Recommendation of a single, correct system of naming types is beyond the scope of this study. Demonstrated methodology includes producing a taxonomy using standard data collection protocol recommended by the developers of the NVCS. Once past the interpretation of the results of the programs, in this case TWINSPAN and cluster analysis, naming the types is a partially mechanical process based on the results of statistically significant groupings from the programs and a partially judgmental process based in interpreting the floristic complement of the groups for significant indicator species. Care must be taken in developing future types to avoid renaming extant types. Development of a methodology for continual inclusion of types as they are determined and named on the landscape is recommended.

Translation of data already collected in various classification systems must be approached with caution. The interest in translation existing data is strong based on economic and temporal concerns; obviously using data that has already been collected would be easier than recollecting data on the large land areas across the country. The system used to collect the data must be examined very carefully to see if an adequate bridge can be made from one system into another, or from the previously classified data system directly into the NVCS. In some cases there may be adequate data on the original data sheets to assist the translation, but in some cases the system used may be far to general or simply inappropriate for use within a single hierarchical, physiognomic and floristic-based system such as the NVCS. From this study, only cover types can be recommended for translation.

The age old controversy of method of data collection is not entirely resolved by this study. The results from the non-ecotonal data set yield a set of types which are representative of the current forests of the LEF. The results from the entire data set include several potential types based on disturbance, weedy, or non-native vegetation which is also part of the current vegetation at the LEF. A question arises as to how much of a land area must be covered by a certain complement of vegetation in order for it to be considered a type. As this study included only a small data set, no recommendations on amount of cover can be made. A type should be repeatable though unless it represents a unique ecological situation, in which case environmental variables may have to be considered when deciding to include a type in a final classification. Some possible disturbance types, or ecotonal types, occupy significant land areas and may be deserving of a unique type name. Based on the statistical results of the analysis, ecotonal sampling may be a viable opportunity in developing future classifications, including a NVCS. Perhaps ecotonal plot data may be useful in creating a classification based on the true compliment of existing vegetation across a landscape, particularly for landscape analysis. Noise in one area of investigation may be representative of some important ecological processes significant in understanding the complex complement of vegetation. Future ecotonal studies will require a precise definition of "ecotonal" than used in this study, as well as clarification of what is meant by a stand "entity" relative to both mapping and sampling.

The natural world is a far more complex place than can be adequately explored in short term studies. The attempt to classify that which is found in the natural world is an intimidating task, particularly when considering the number of systems already developed for particular classification tasks or particular ecosystems. Often, the "'best' classification is generally a compromise between the need for simplicity and the need for sufficient detail to make the classification effective" (Kimmins 1997). Patterns and processes across larger scales, spatial and temporal, are just beginning to be uncovered, while management decisions are being made today that effect the dynamics of the ecosystem. Further study as to the feasibility of an NVCS that is acceptable across the vastly variable vegetated land of the U.S. is recommended in expanding this type of study to other ecosystems and to larger temporal and spatial scales.

Related to the expansion of studies, there are many areas of land that are part of what can be considered an ecotone that can be sampled along with non-ecotonal areas. Broad ecotones hold a large amount of ecological information, and may provide insight as to environmental variables responsible for vegetation change over a land area; narrow ecotones my be valuable for discovering thresholds of environmental difference or understanding historical disturbance. Further study into collecting data that includes ecotones is recommended. Study results indicate that a classification can be created from data included non-homogeneous plots and that unique disturbance types, weedy vegetation types, or invasive species types can be included in such a classification. While these ecotonal areas may represent seral vegetation or areas of disturbance, they are still a part of the complement of existing vegetation on the ground. Disturbance and succession are natural processes, and some consideration of them within a classification system could be an interesting path of study.

Development of a NVCS with a standard methodology of data collection, type naming, and adding types to the hierarchy is confounded by a number of problems and concerns. The quality of data entered into a classification is of concern as the classification is only as good as the data it is derived from. The NVCS developers recommend that only "usable and reliable data" be entered while stressing that the quality of data must be carefully controlled (FGDC 1997). A high quality classification is desired as it improves information on the status and patterns of the vegetation of a region, and is more acceptable to a wider audience. Existing data and classifications must be carefully considered before translation into an NVCS takes place; in many cases within this study, the other classification systems types are not translatable to NVCS, although the database in individual plots may be useful for new analysis. Further study involving translation of other systems is recommended (O'Hara et al. 1996). Adoption of standard methodology for new data development and Community Association assignment should ensure that the system is "continuously revisable and allows user reconstruction of defined community elements" (Damman 1998, Personal Communication). Vegetation classification as a science cannot be stagnant and immutable. Widespread acceptance of an NVCS will only occur if the system is in fact applicable to a variety of land areas encompassing many management systems.

A single standard classification system may not be the only solution to the need for a national classification system. Within the currently politically charged arena of NVCS development, the thought of throwing out systems currently in use has been suggested, in order to start over with a completely new hierarchical system. Although this concept has some appeal, the elimination of existing classification systems is not necessarily economically or scientifically desirable. As stated by Kimmins,

> Classification is not a static, once-and-for-all activity, and present-day classifications will undoubtedly evolve to meet the future needs of forestry. However, it should be noted that where the initial classification involves a comprehensive, ecosystematic approach, it should be possible to adapt the basic classification for changing needs, eliminating the need for costly reclassification.

Two points to separate out when considering the utility of the NVCS are that multiple class systems have strong value for a variety of purposes related to classification work, and that data from one system for use in other systems also has high value. The NVCS hierarchy may not be the ideal solution to a single, standard system, as at the present time the definitions and protocol for defining alliances and associations, plus guidelines for effective aggregation into higher levels, is unclear. A single hierarchy may not be "truly integrative" and rather "single purpose" while multiple hierarchies for multiple purposes could provide "greater understanding, utility, and flexibility" (Pfister 1998, Personal Communication). Integration of various systems may be the solution for providing a system that is dynamic and flexible enough to be acceptable to the wide variety of landowners and agencies needing a vegetation classification system. An example is an ecosystem matrix concept developed by the Boise-Cascade company which combines several systems, including wide scale geological types, habitat types, cover types, structure types, as well as associated wildlife forage, disease and insect susceptibility, and other systems into an easily referenced and read document.

Related to the concept of an integrated system is temporal concerns. To ensure that a NVCS is more than a static vegetation classification without use over time (Pojar et al. 1987) we need not simply classify and catalog plant communities, but could also establish the habitat and ecological relationships among vegetation types, so that the classification could be used to predict productivity, successional patterns, and other site properties (Damman 1998, Personal Communication). Another benefit of an NVCS based on existing vegetation is the application for wildlife habitat assessment and management decision guidelines. Continued application of a potential natural vegetation system may hold problems over time, because as Kuchler observed (1964) a potential natural vegetation systems must bear a date if it is to be meaningful given the changes in vegetation successional pathways due to perhaps disturbance events. The value of a classification improves if it aids in the interpretation of habitat and ecological relationships and predicts the properties of a site, and can be used in place of a site based system (Bourgeron and Engelking 1994). Further exploration into classifications including all constituents of the vegetation including ecotones in a land region is a necessary step in defining the factors that drive the ecology of vegetation and predicting anything beyond a simple classification.

Based on the results of this study, a classification can be created using NVCS protocol. The use of the proposed NVCS over the entire United States is a possibility if certain standard procedures are adopted, including the naming of Alliances and Associations. The current mixture of dominance and indicator species criteria is still ambiguous and needs to be clarified if standardization is expected. Some form of a standard system will be increasingly necessary as land areas continue to see an increase in resource use as the population increases and as management practices shift to larger scales. Ideally, the proposed NVCS could be applied to any scale and any type of ecosystem. The implications of adopting a standard system that is acceptable across the scales of management involve more than simply enhanced communication; an integrated, flexible, dynamic system can serve as the cohesive bond between various pieces of legislation and agencies with goals at odds with one another. Vegetated areas in the U.S. and potentially other countries, acknowledging that political boundaries rarely follow ecosystems, after time may finally be managed in accordance with a defined, legally mandated procedure, instead of haphazard individualistic decisions made to cover a small parcel of land under the current lack of organized direction in management decisions on federal, state, and private lands. Somewhere in the distant haze beyond egos and personal agendas lies the distinct possibility of the NVCS.

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Appendices

Appendix A: NVCS Hierarchy (FGDC 1997)

The hierarchy nests itself as follows:

- A. Division
  - B. Order

- 1. Physiognomic Class
  - 2. Physiognomic Subclass
    - 3. Physiognomic Group
      - 4. Subgroup

(Physiognomic Levels) 5. Formation

(Floristic Levels) 6. Alliance

7. Community Association

The top two levels are general categories:

A. Division: separates Earth cover into either vegetated or non-vegetated categories. **(Vegetated (>1% vegetation cover)**

B. Order: Generally defined by dominant life form (tree, shrub, dwarf shrub, herbaceous, or non-vascular). **(Tree Dominated)**

The seven levels are defined as follows:

The top five are physiognomic **(example in bold)**:

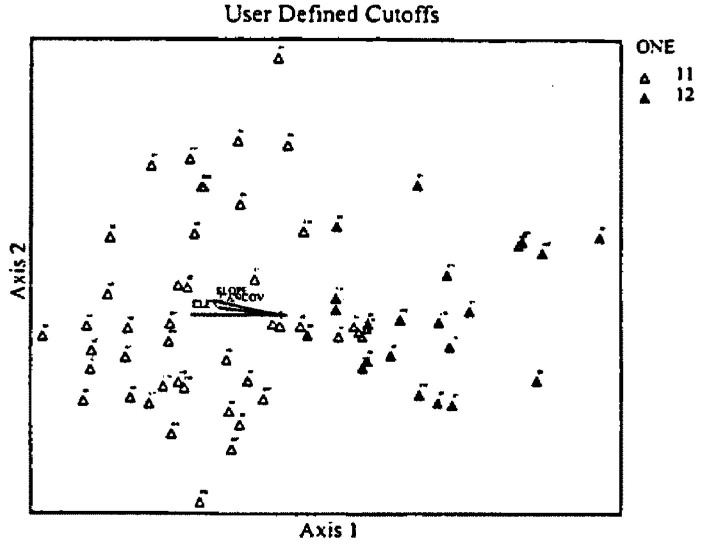
1. Physiognomic Class: life form and relative cover. **(Closed Tree Canopy, >60% cover)**
2. predominant leaf phenology of woody plants/leaf type and periodicy of herbaceous plants. **(Evergreen Closed Tree Canopy (>75% of total tree cover))**
3. combination of climate, leaf morphology, and leaf phenology. **(Temperate or subpolar needle-leaved evergreen closed tree canopy)**
4. separation of Natural/Semi-Natural from Planted/Cultivated Types **(Natural/Semi-natural))**
5. ecological groupings of vegetation units with broadly defined environmental and additional physiognomic factors. **(Rounded-crowned temperate or subpolar needle-leaved evergreen closed tree canopy)**

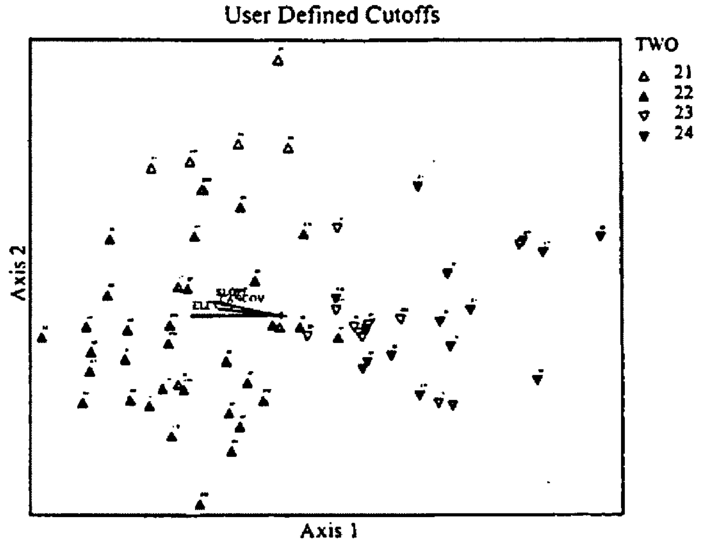
The bottom two floristic:

6. an aggregation of community associations characterized by a diagnostic species (or group) occurring in dominant or uppermost stratum of the vegetation. **(ponderosa pine)**
7. the basic floristic unit characterized by diagnostic species that occur in the overstory and understory of the vegetation. **(ponderosa pine/snowberry)**

Appendix B: DCA Ordination Graphs

Figure B - 1: User Defined Cutoff Graphs for TWINSPAN Levels One and Two





The legend for each graph gives the symbols assigned arbitrarily to each group. Biplot scores are shown radiating from the center of the ordination. In the user defined cutoff graphs (which are identical to default value graphs) and presence/absence graphs, slope, elevation, and canopy cover are significant along axis one. For the all plots graphs, only elevation is significant, also along axis one.

Figure B - 2: User Defined Cutoff Graphs for TWINSPAN Levels Three and Four

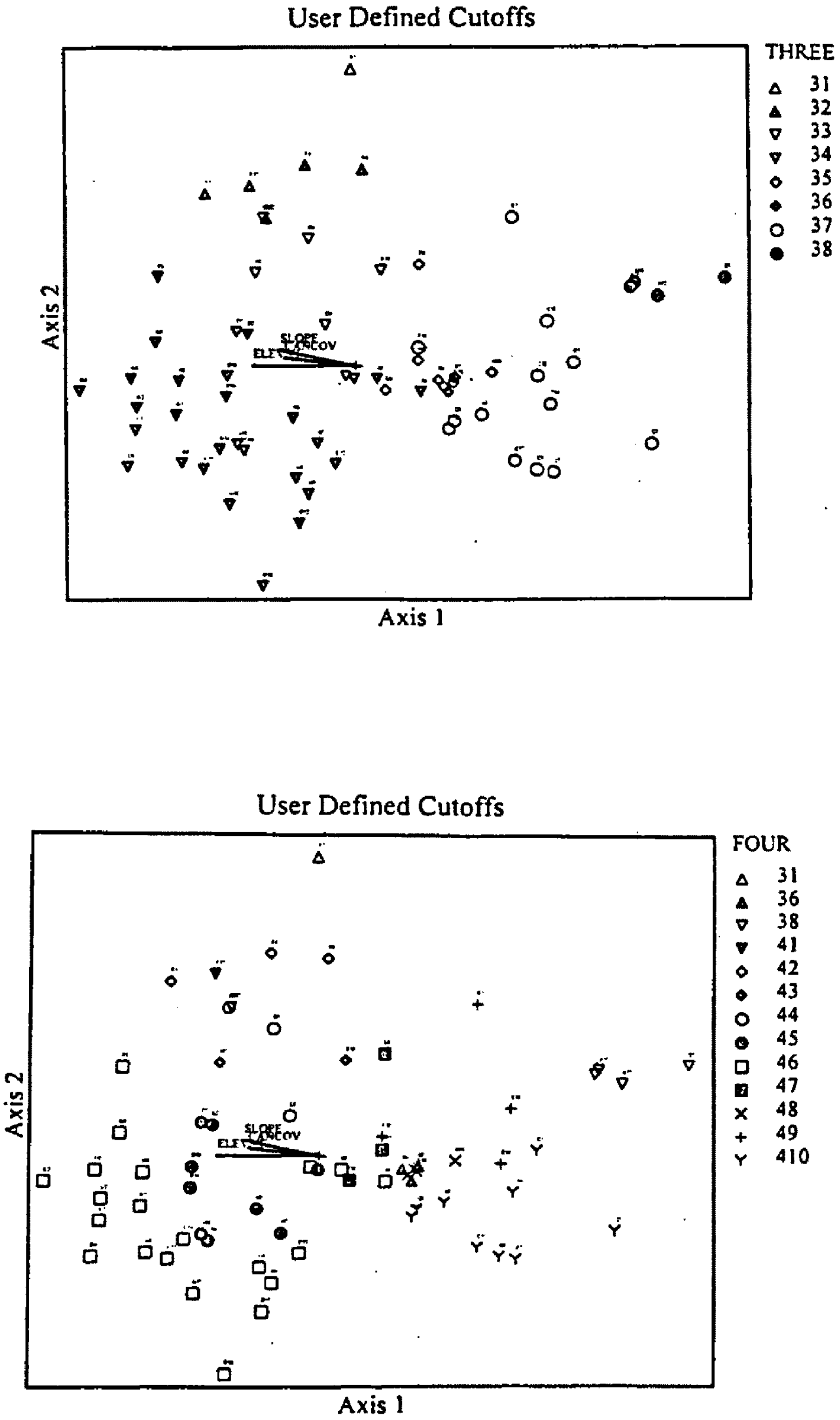
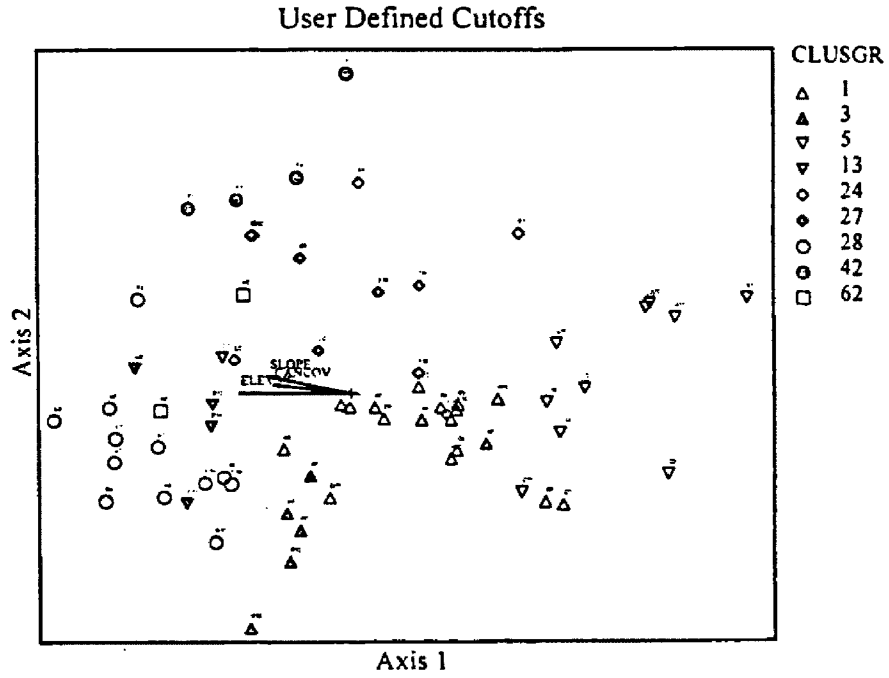


Figure B - 3: User Defined Cutoff Graphs for Cluster Analysis and Habitat Types



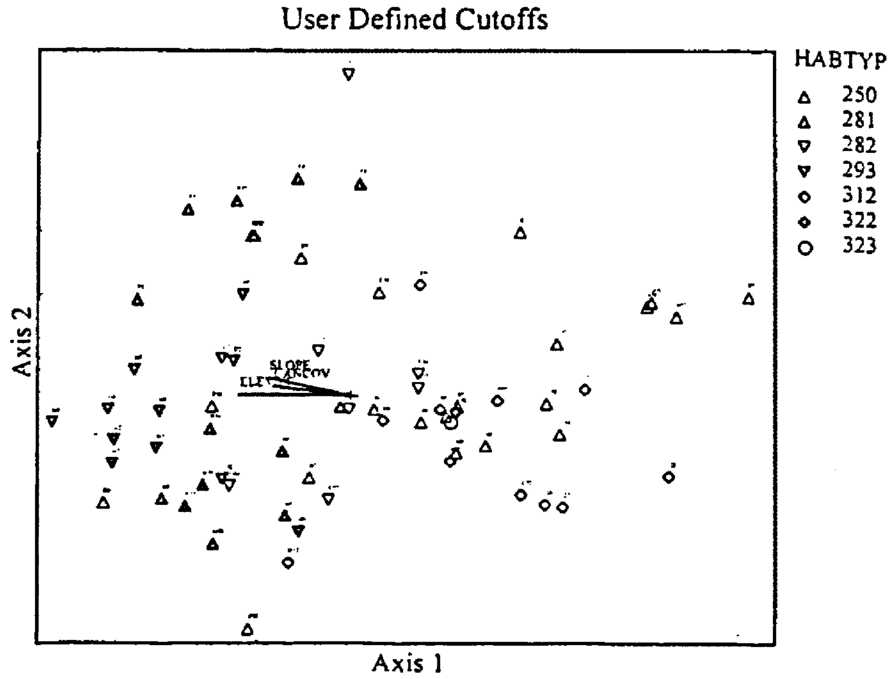
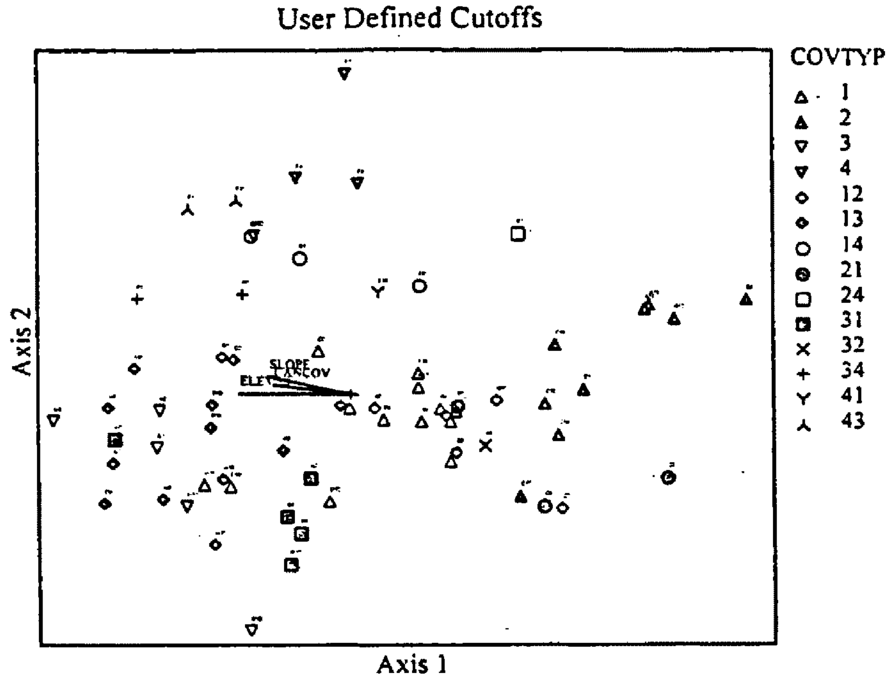


Figure B - 4: User Defined Cutoff Graphs for Cover Types and Process-based structure types



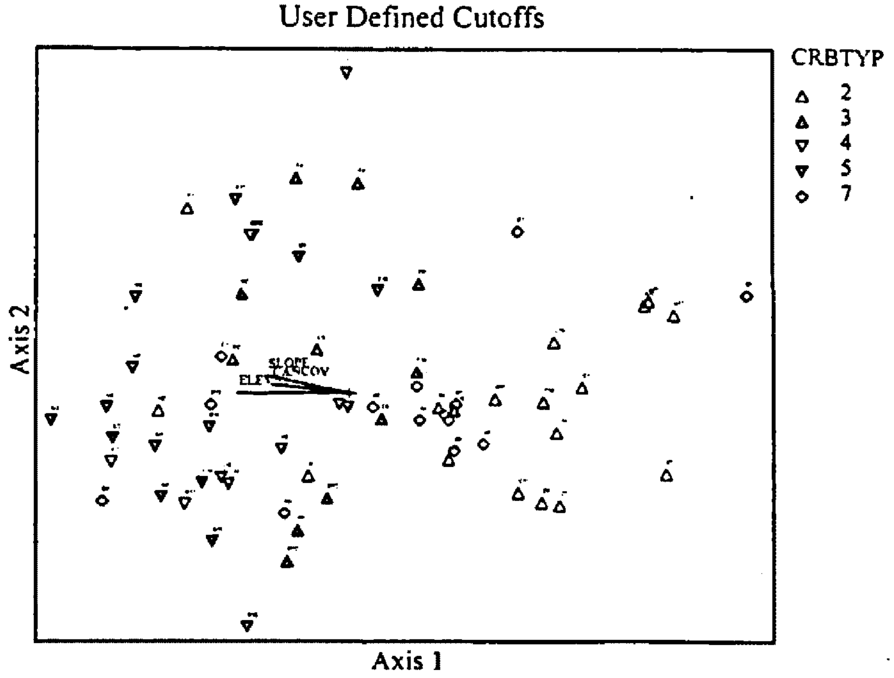
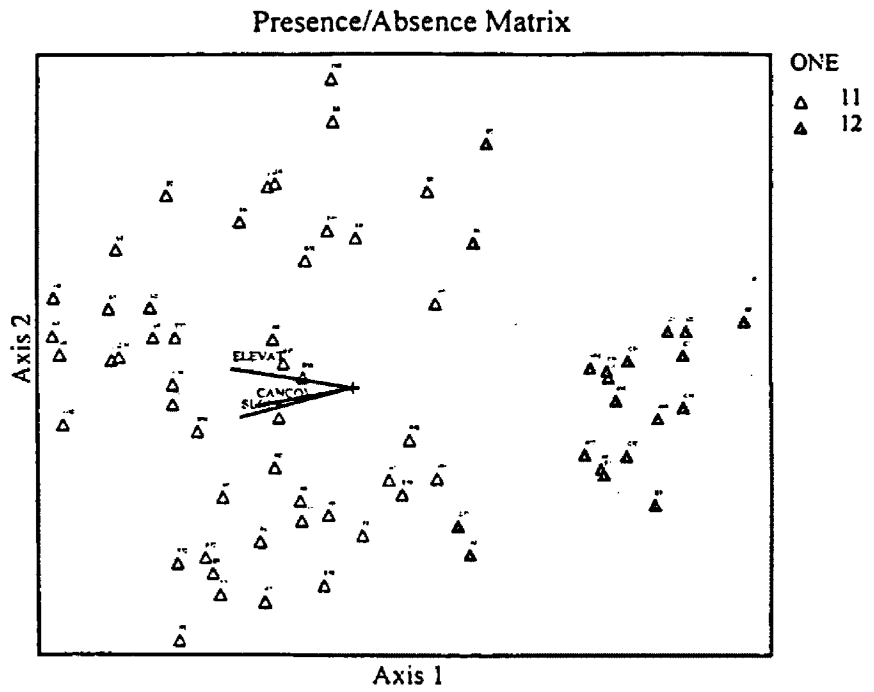


Figure B - 5: Presence/Absence Graphs for TWINSPAN Levels One and Two



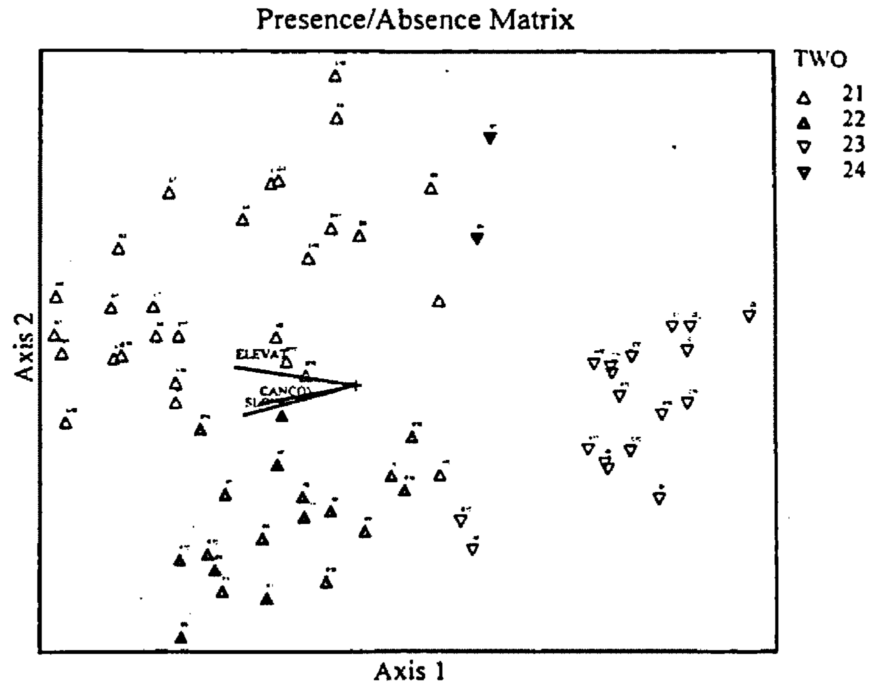


Figure B - 6: Presence/Absence Graphs for TWINSPAN Levels Three and Four

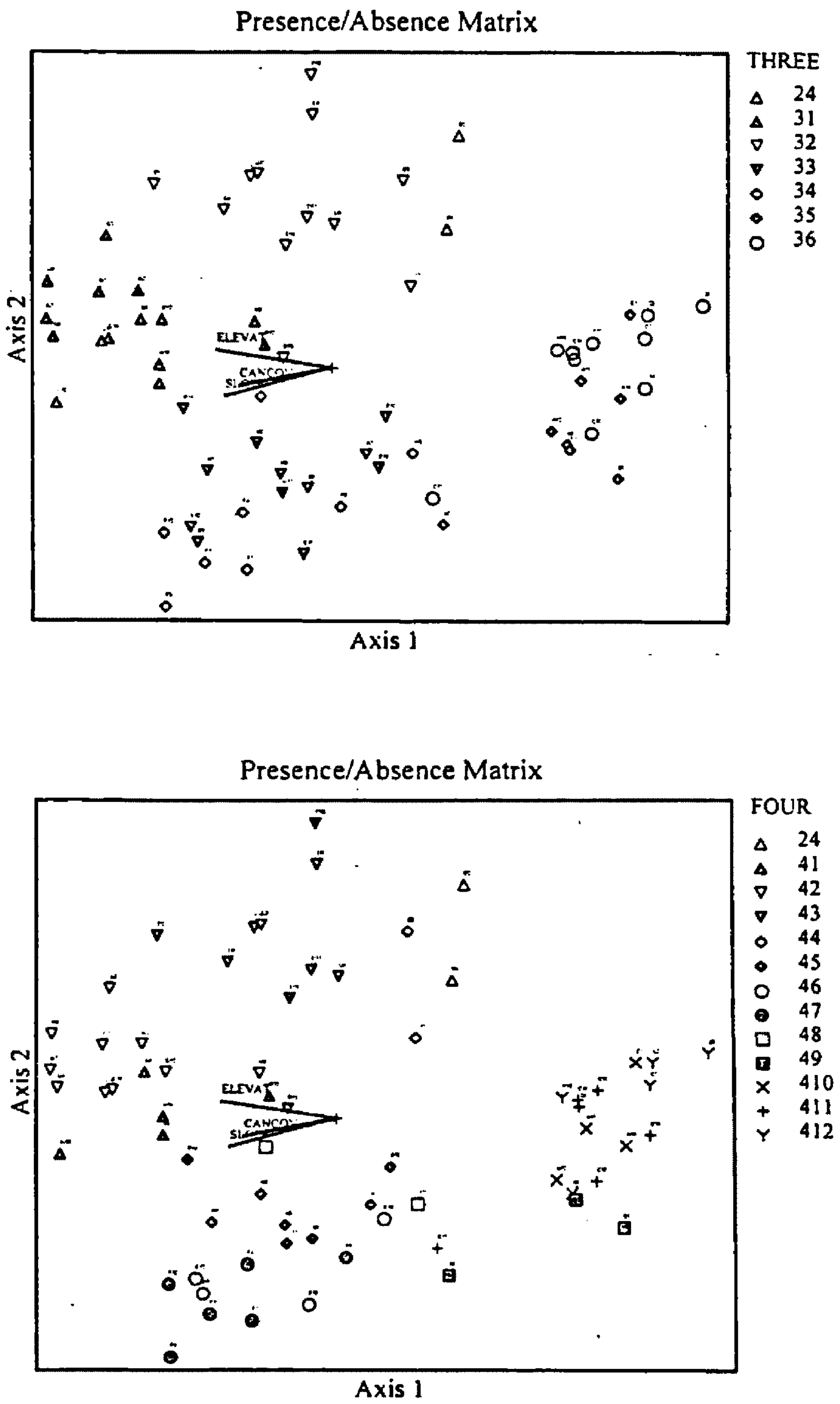
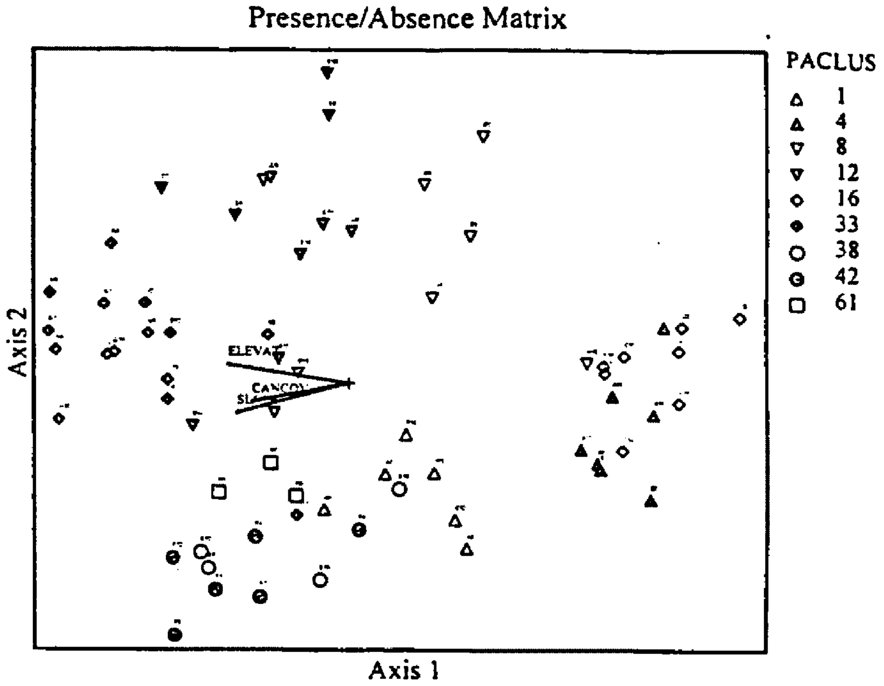


Figure B - 7: Presence/Absence Graphs for Cluster Analysis and Habitat Types



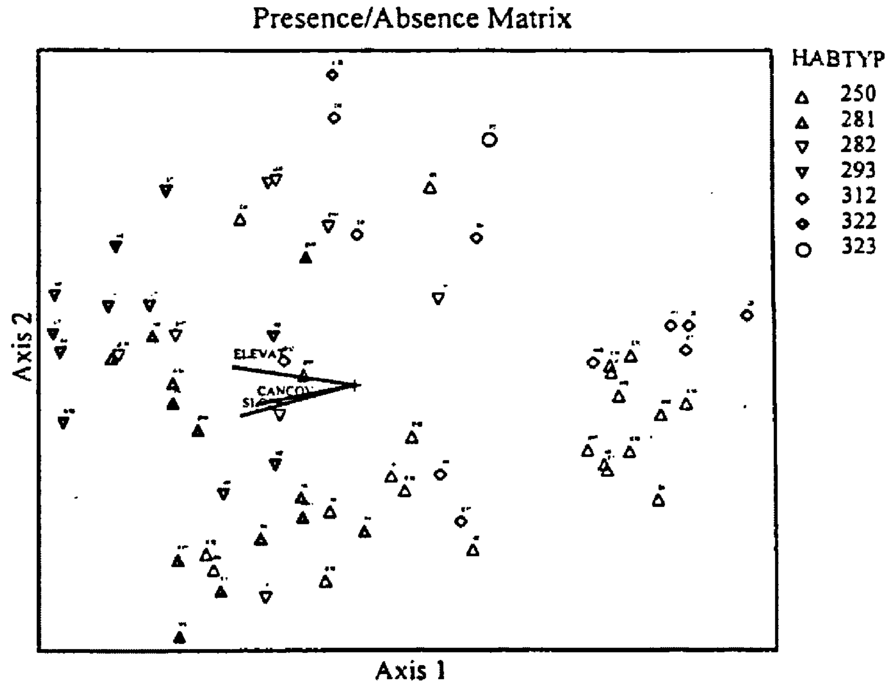
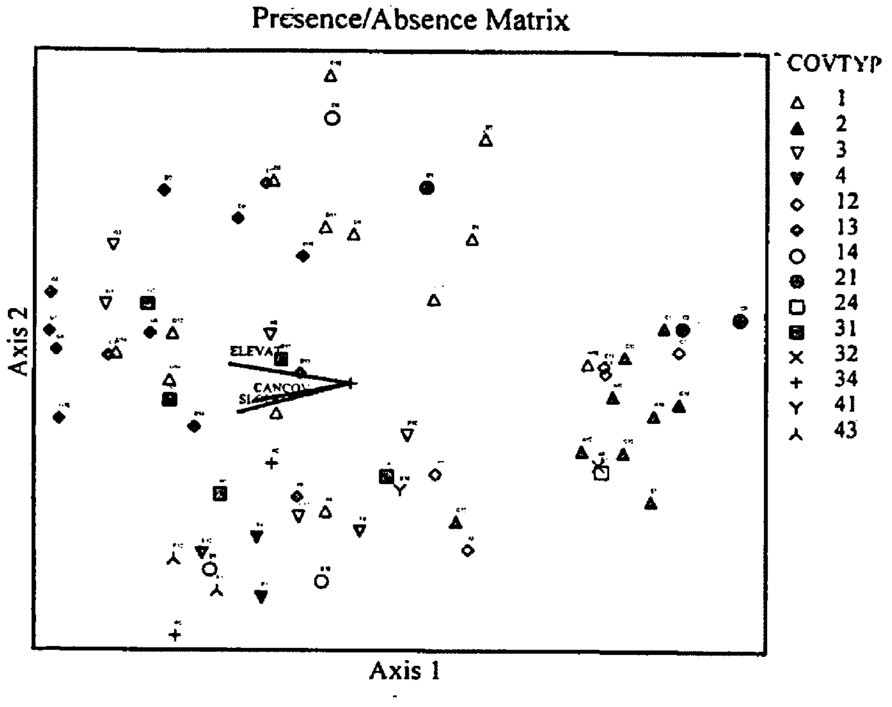


Figure B - 8: Presence/Absence Graphs for Cover Types and Process-based structure types



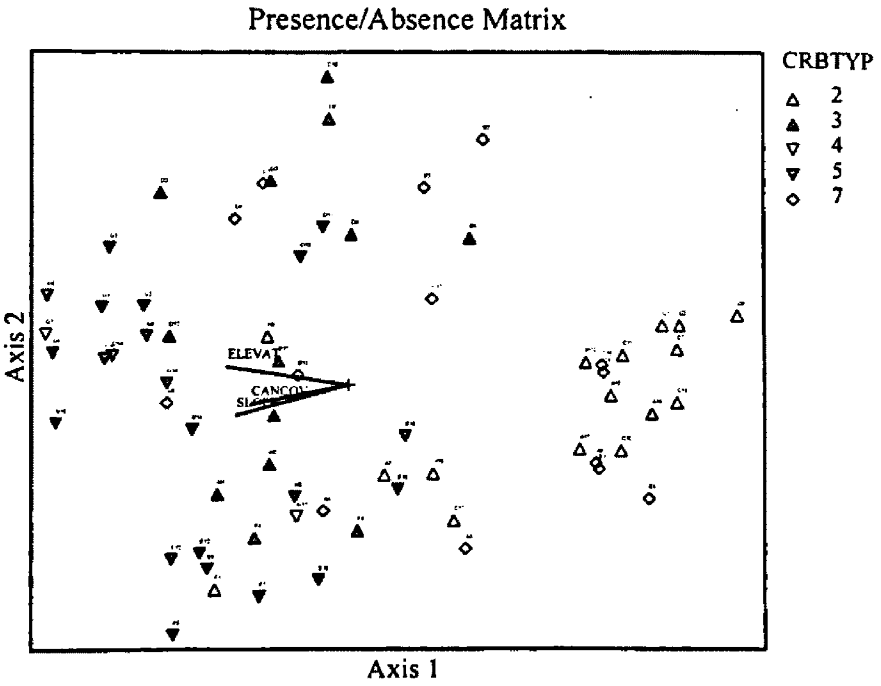


Figure B - 9: All Plots Graphs for TWINSPAN Levels Three and Four

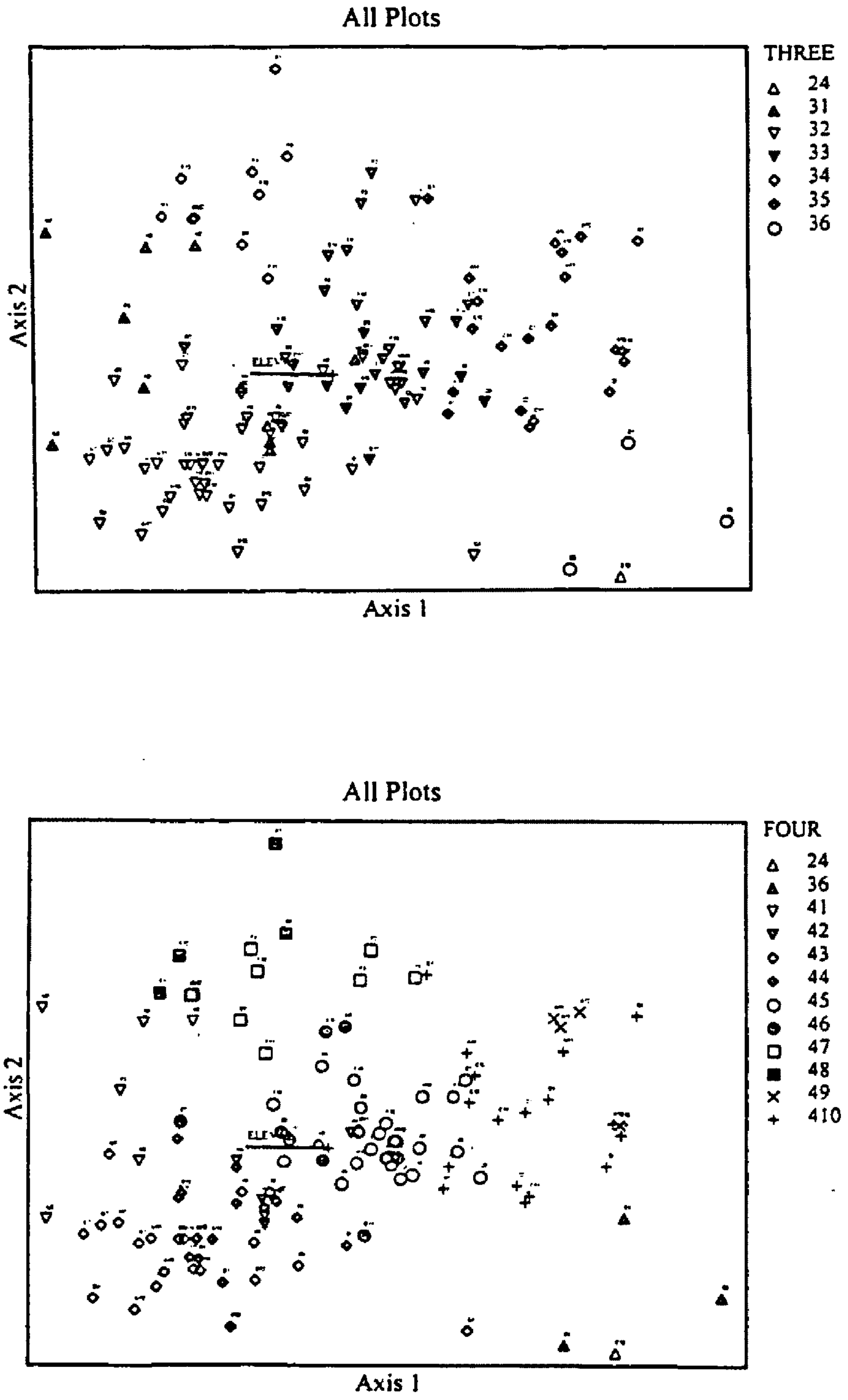
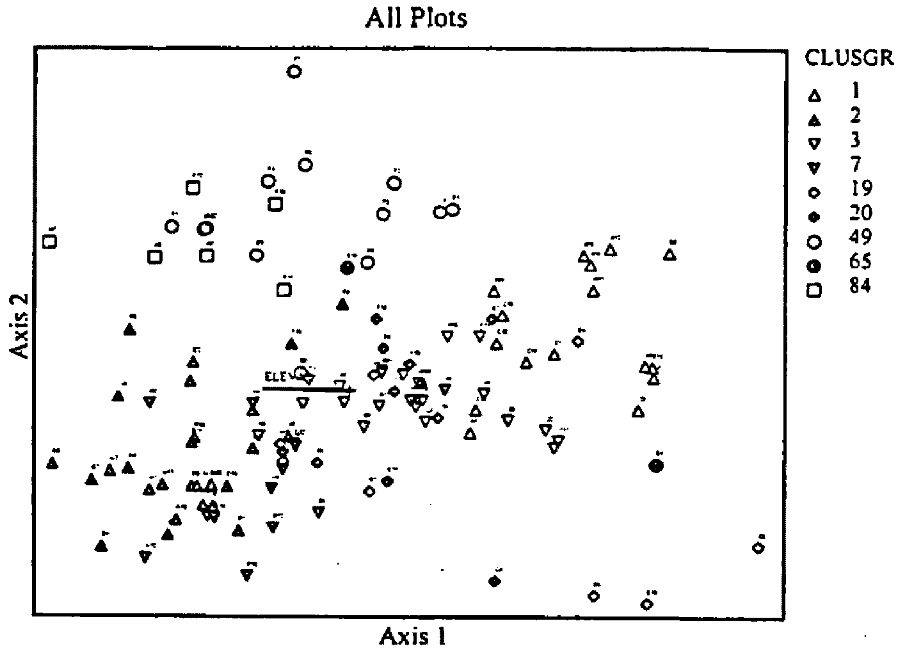


Figure B - 10: All Plots Graphs for Cluster Analysis and Habitat Types



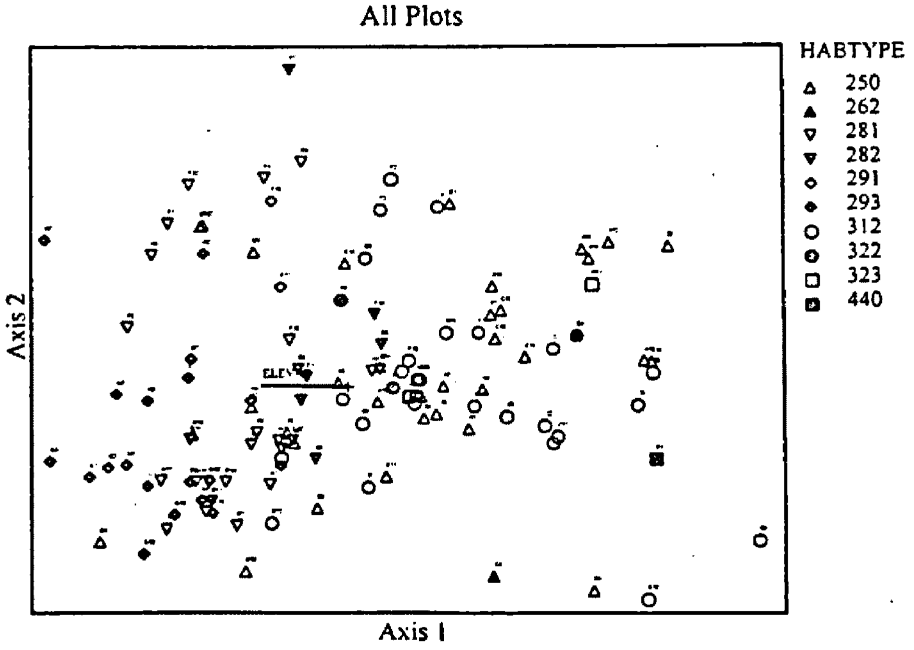


Figure B -11: All Plots Graphs for Cover Types and Process-based structure types

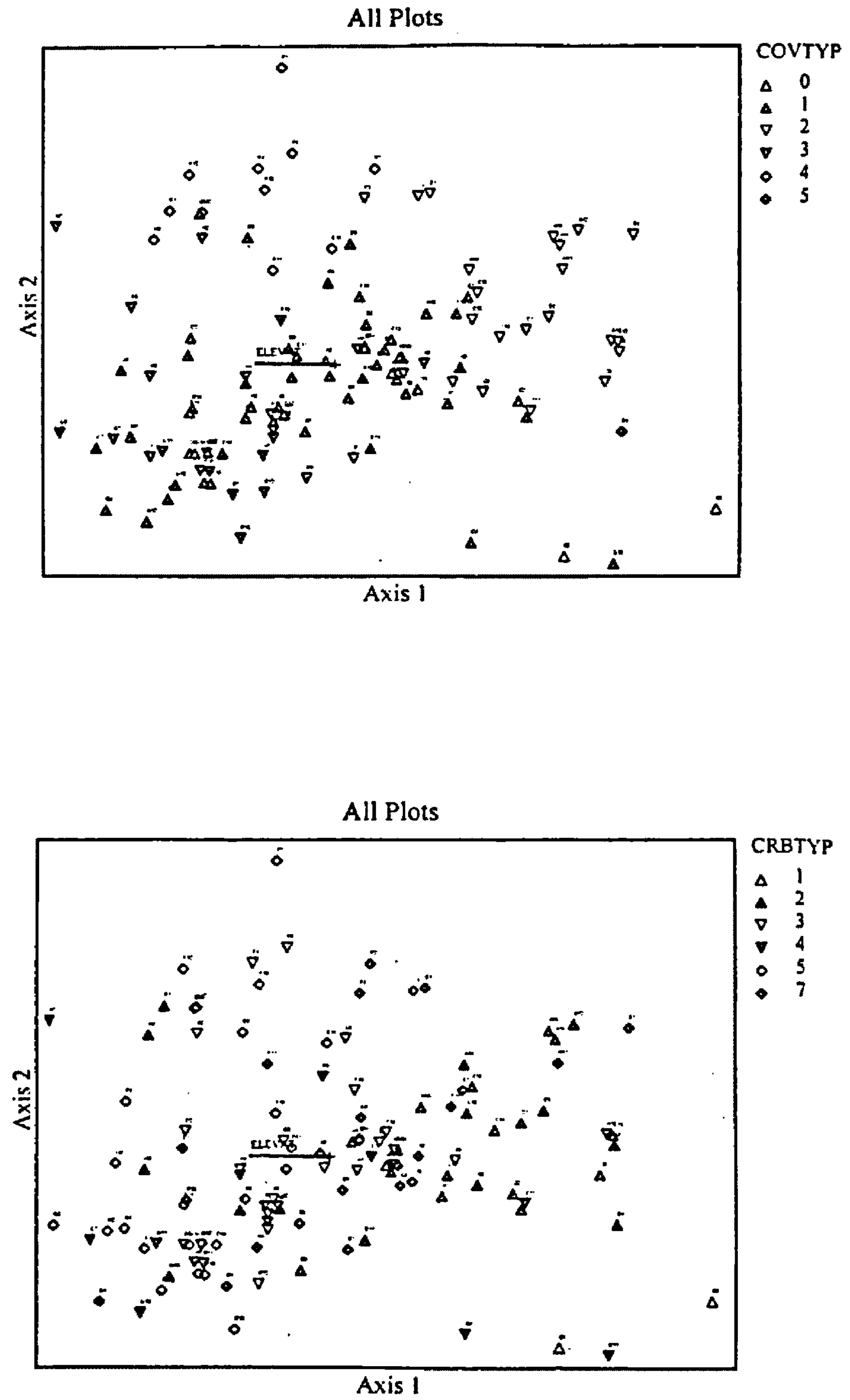
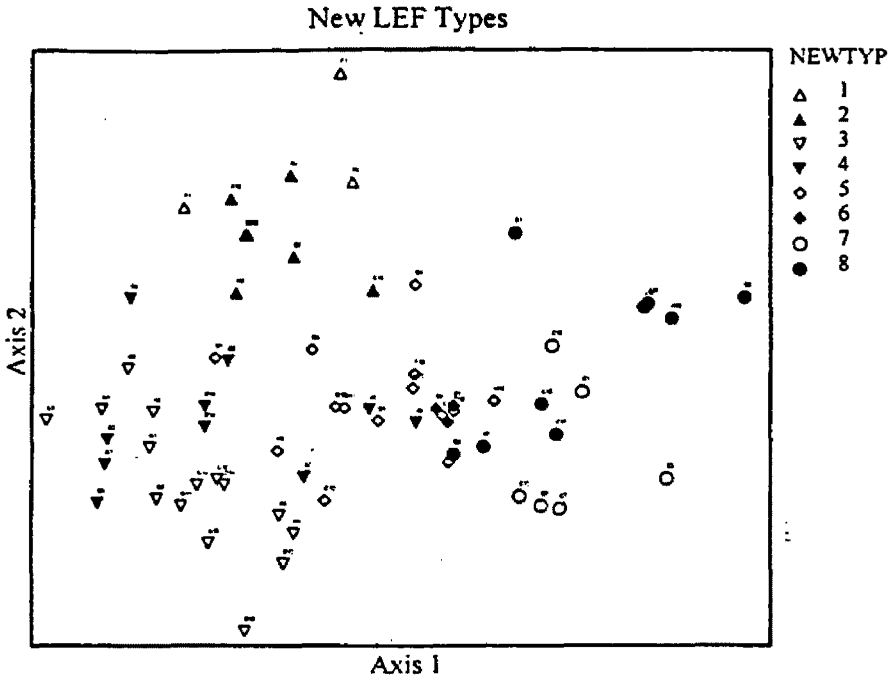


Figure B - 12: New LEF Types Ordination



Appendix C: Species list for LEF

Table C -1: Species List

Number	Type	Code	Name	Family	Common
1	T	JUSC	Juniperus scopularum	Cupressaceae	Rocky Mountain juniper
2	T	LAOC	Larix occidentalis	Pinaceae	western larch
3	T	PICO	Pinus contorta	Pinaceae	lodgepole pine
4	T	PIEN	Picea engelmannii	Pinaceae	Engelmann spruce
5	T	PIPO	Pinus ponderosa	Pinaceae	ponderosa pine
6	T	POTR	Populus tremuloides	Salicaceae	quaking aspen
7	T	POTR2	Populus trichocarpa	Salicaceae	black cottonwood
8	T	PSME	Pseudotsuga menziesii	Pinaceae	Douglas-fir
9	S/SS	ACGL	Acer glabrum	Aceraceae	Rocky Mountain maple
10	S/SS	ALSI	Alnus sinuata	Betulaceae	Sitka alder
11	S/SS	AMAL	Amelanchier alnifolium	Rosaceae	serviceberry
12	S/SS	ARUV	Arctostaphylos uva-ursi	Ericaceae	kinnickinnick
13	S/SS	BERE	Berberis repens	Berberidaceae	creeping Oregon grape
14	S/SS	CEVE	Ceanothus velutinus	Rhamnaceae	ceanothus
15	S/SS	CHUM	Chimaphila umbellata	Ericaceae	pipsissewa
16	S/SS	COCA	Cornus canadensis	Cornaceae	bunchberry dogwood
17	S/SS	COST	Cornus stolonifera	Cornaceae	silky dogwood
18	S/SS	HODI	Holodiscus discolor	Rosaceae	ocean spray
19	S/SS	JUCO	Juniperus communis	Cupressaceae	common juniper
20	S/SS	LIBO	Linnaea borealis	Ericaceae	twinflower
21	S/SS	LOUT	Lonicera utahensis	Ericaceae	red twinberry
22	S/SS	MEFE	Menziesia ferruginea	Ericaceae	menziesia
23	S/SS	PRVI	Prunus virginiana	Rosaceae	chokecherry
24	S/SS	PTAN	Pterosporum andromeda	Ericaceae	pinedrops
25	S/SS	PYAS	Pyrola asarifolia	Ericaceae	pink pyrola
26	S/SS	PYMI	Pyrola minor	Ericaceae	lesser pyrola
27	S/SS	PYSE	Pyrola secunda	Ericaceae	sidebells pyrola
28	S/SS	RIHU	Ribes hudsonianum	Grossulariaceae	western black currant
29	S/SS	ROAC	Rosa acicularis	Rosaceae	prickly rose
30	S/SS	RUPA	Rubus parviflorus	Rosaceae	thimbleberry
31	S/SS	SASC	Salix scouleriana	Salicaceae	Scouler's willow
32	S/SS	SHCA	Sheperdia canadensis	Ericaceae	buffaloberry
33	S/SS	SPBE	Spiraea betulifolia	Rosaceae	white spiraea
34	S/SS	SYAL	Symphorocarpus albus	Caprifoliaceae	snowberry
35	S/SS	VACA	Vaccinium caespitosum	Ericaceae	dwarf huckleberry
36	S/SS	VAGL	Vaccinium globulare	Ericaceae	blue huckleberry
37	S/SS	VAMY	Vaccinium myrtillus	Ericaceae	low blueberry
38	S/SS	VASC	Vaccinium scoparium	Ericaceae	grouse whortleberry
39	G	AGCA	Agropyron canium	Poaceae	bearded wheatgrass
40	G	AGIN	Agropyron intermedium	Poaceae	intermediate wheatgrass
41	G	AGSP	Agropyron spicatum	Poaceae	bluebunch wheatgrass
42	G	AGTE	Agrostis tenuis	Poaceae	common bentgrass
43	G	BRIN	Bromus inermis	Poaceae	smooth brome
44	G	CACA	Calamagrostis canadensis	Poaceae	bluejoint reedgrass
45	G	CACO	Carex concinnoides	Cyperaceae	concinnoides sedge
46	G	CADO	Carex douglasii	Cyperaceae	Douglas's sedge
47	G	CAGE	Carex geyeri	Cyperaceae	elk sedge
48	G	CAMI	Carex microptera	Cyperaceae	small-winged sedge
49	G	CARO	Carex rossii	Cyperaceae	Ross's sedge
50	G	CARU	Calamagrostis rubescens	Poaceae	pinegrass
51	G	DISA	Digitaria sanguinalis	Poaceae	hairy crabgrass
52	G	FEID	Festuca idahoensis	Poaceae	Idaho fescue
53	G	FEOC	Festuca occidentalis	Poaceae	western fescue
54	G	FESC	Festuca scabrella	Poaceae	rough fescue

Table C -1, Continued: Species List

Number	**Type**	**Code**	**Name**	**Family**	**Common**
55	G	HOJU	Hordeum jubatum	Poaceae	foxtail barley
56	G	PHPR	Phleum pratense	Poaceae	timothy
57	G	POAN	Poa annua	Poaceae	annual bluegrass
58	G	POCO	Poa compressa	Poaceae	Canada bluegrass
59	G	POPA	Poa palustris	Poaceae	fowl bluegrass
60	G	POPR	Poa pratensis	Poaceae	Kentucky blugrass
61	G	POSA	Poa sandbergii	Poaceae	Sandberg's bluegrass
62	G	STCO	Stipa comata	Poaceae	needle and thread
63	G	STRI	Stipa richardsonii	Poaceae	Richardson's needlegrass
64	F/PH	DRAU	Dryopteris austriaca	Polypodiaceae	mountain wood fern
65	F/PH	EQAR	Equisetum arvense	Equisetaceae	common horsetail
66	F/PH	EQSP	Equisetum spp.	Equisetaceae	horsetail
67	F/PH	GYDR	Gymnocarpium dryopteris	Polypodiaceae	oak fern
68	F	ACMI	Achillea millefolium	Asteraceae	yarrow
69	F	ACRU	Actaea rubra	Ranunculaceae	baneberry
70	F	AGAU	Agoseris aurantiaca	Asteraceae	orange agoseris
71	F	ALCE	Allium cernuum	Liliaceae	nodding onion
72	F	ANMA	Anaphalis margaritacea	Asteraceae	pearly everlasting
73	F	ANMI	Antennaria microphylla	Asteraceae	rose pussytoes
74	F	ANNE	Antennaria neglecta	Asteraceae	field pussytoes
75	F	ANOC	Anemone occidentalis	Ranunculaceae	western pasqueflower
76	F	ANRA	Antennaria racemosa	Asteraceae	woods pussytoes
77	F	ANUM	Antennaria umbrinella	Asteraceae	umber pussytoes
78	F	APAN	Apocynum androsaemifolium	Apocynaceae	creeping dogbane
79	F	ARCO	Arnica cordifolia	Asteraceae	heartleaf arnica
80	F	ARHO	Arabis holboellii	Brassicaceae	Holboell's rockcress
81	F	ARRU	Arenaria rubella	Caryophyllaceae	red sandwort
82	F	ASCA	Asarum caudatum	Aristilochiaceae	wild ginger
83	F	ASCO	Aster conspicuous	Asteraceae	showy aster
84	F	ASLA	Aster laevis	Asteraceae	smooth blue aster
85	F	ASMI	Astragalus miser	Fabaceae	weedy milkvetch
86	F	BAOR	Barbarea orthoceras	Brassicaceae	American wintercress
87	F	BASA	Balsamorhiza sagittata	Asteraceae	arrowleaf balsamroot
88	F	CAAP	Calochortus apiculatis	Liliaceae	sego lily
89	F	CALU	Castelleja lutescens	Scrophulariaceae	indian paintbrush
90	F	CAOL	Cardamine oligosperma	Brassicaceae	small western bittercress
91	F	CAQU	Camassia quamash	Liliaceae	camas
92	F	CARO2	Campanula rotundifolia	Campanulaceae	Scotch harebell
93	F	CEAR	Cerastium arvense	Caryophyllaceae	field chickweed
94	F	CEMA	Centaurea maculosa	Asteraceae	spotted knapweed
95	F	CIAR	Cirsium arvense	Asteraceae	Canada thistle
96	F	CISC	Cirsium scariosum	Asteraceae	elk thistle
97	F	CIVU	Cirsium vulgare	Asteraceae	bull thistle
98	F	CLCO	Clematis columbiana	Ranunculaceae	Columbia virgin's bower
99	F	COMA	Corallorhiza maculata	Orchidaceae	spotted coral root
100	F	COPA	Collinsia parviflora	Scrophulariaceae	blue-eyed Mary
101	F	CYMO	Cyprepedium montanum	Orchidaceae	mountain lady's slipper
102	F	EPAN	Epilobium angustifolim	Onagraceae	fireweed
103	F	EPGL	Epilobium glandulosum	Onagraceae	common fireweed
104	F	EPWA	Epilobium watsonii	Onagraceae	Watson's fireweed
105	F	ERAC	Erigeron acris	Asteraceae	bitter fleabane
106	F	ERDI	Erigeron divergens	Asteraceae	spreading fleabane
107	F	FIAR	Filago arvense	Asteraceae	field filago
108	F	FRVI	Fragaria virginiana	Rosaceae	strawberry
109	F	GAAR	Gaillardia aristata	Asteraceae	blanket flower
110	F	GABO	Gallium boreale	Rubiaceae	northern bedstraw

Table C - 1, Continued: Species List

Number	**Type**	**Code**	**Name**	**Family**	**Common**
111	F	GATR	Gallium triflorum	Rubiaceae	sweetscented bedstraw
112	F	GEMA	Geum macrophyllum	Rosaceae	large-leaved avens
113	F	GETR	Geum triflorium	Rosaceae	prairie smoke
114	F	GEVI	Geranium viscosissimum	Geraniaceae	sticky wild geranium
115	F	GOOB	Goodyera oblongifolia	Orchidaceae	westerns rattlesnake plantain
116	F	HADI	Habenaria dilatata	Orchidaceae	white bog orchid
117	F	HECY	Heuchera cylindrica	Saxifragaceae	roundleaf alumroot
118	F	HELA	Heracleum lanatum	Apiaceae	cow parsnip
119	F	HIAL	Hieracium albiflorum	Asteraceae	white-flowered hawkweed
120	F	HICY	Hieracium cynoglossiocles	Asteraceae	hounds-tongue hawkweed
121	F	LEVI	Lepidium virginicum	Brassicaceae	Virginia pepper weed
122	F	LIRU	Lithospermum ruderale	Boraginaceae	wayside gromwell
123	F	LISE	Linanthus septentrionalis	Polemoniaceae	northern linanthus
124	F	LOTR	Lomatium tritematum	Apiaceae	nine-leaf lomatium
125	F	LUAR	Lupinus argenteus	Fabaceae	silvery lupine
126	F	LYAL	Lychnis albus	Caryophyllaceae	white campion
127	F	LYCI	Lysimachia ciliata	Ranunculaceae	fringed loosestrife
128	F	MAMA	Matricaria matricarioides	Asteraceae	pineapple-weed
129	F	MEAL	Melilotis alba	Fabaceae	white sweet clover
130	F	MEAR	Mentha arvense	Lamiaceae	wild mint
131	F	MEOF	Melilotis officinalis	Fabaceae	yellow sweet clover
132	F	MIBR	Mitella breweri	Saxifragaceae	Brewer's mitrewort
133	F	MIGR	Microsteris gracilis	Polemoniaceae	pink microsteris
134	F	MOPE	Montia perfoliata	Portulaceae	miner's lettuce
135	F	OSCH	Osmorhiza chilensis	Apiaceae	mountain sweet-cicely
136	F	PEAL	Penstemon albertinus	Scrophulariaceae	Albert's penstemon
137	F	PEBR	Pedicularis bracteosa	Scrophulariaceae	bracted lousewort
138	F	PEPR	Penstemon procerus	Scrophulariaceae	small-flowered penstemon
139	F	PERA	Pedicularis racemosa	Scrophulariaceae	sickled lousewort
140	F	PEWI	Penstemon wilcoxii	Scrophulariaceae	Wilcox's penstemon
141	F	PLMA	Plantago major	Plantaginaceae	common plantain
142	F	POAC	Polygonum achoreum	Polygonaceae	knotweed
143	F	POGL	Potentilla glandulosa	Rosaceae	sticky cinquefoil
144	F	POKE	Polygonum kelloggii	Polygonaceae	Kellogg's knotweed
145	F	PORE	Potentilla recta	Rosaceae	sulphur cinquefoil
146	F	POSA2	Polygonum sawatchense	Polygonaceae	sawatch knotweed
147	F	PRVU	Prunella vulgaris	Lamiaceae	self-heal
148	F	RAPO	Ranunculus populago	Ranunculaceae	mountain buttercup
149	F	RUAC	Rumex acetosella	Polygonaceae	sheep sorrel
150	F	RUUN	Ranunculus uncinatus	Ranunculaceae	little buttercup
151	F	SELA	Sedum lanceolatum	Crassulaceae	lance-leaved stonecrop
152	F	SIAN	Silene antirrhina	Caryophyllaceae	sleepy catchfly
153	F	SIME	Silene menziesii	Caryophyllaceae	Menzies's silene
154	F	SMST	Smilacina stellata	Liliaceae	starry false Solomon's seal
155	F	SOMI	Solidago missouriensis	Asteraceae	Missouri goldenrod
156	F	STAM	Streptopus amplexifolius	Liliaceae	twisted-stalk
157	F	TAOF	Taraxacum officinale	Asteraceae	common dandelion
158	F	TAVU	Tanacetum vulgare	Asteraceae	tansy
159	F	THOC	Thalictrum occidentale	Ranunculaceae	western meadow rue
160	F	TRDU	Trifolium dubium	Fabaceae	least hop clover
161	F	TRDU2	Tragopogon dubius	Asteraceae	yellow salsify
162	F	TRRE	Trifolium repens	Fabaceae	white clover
163	F	URDI	Urtica dioica	Urticaceae	stinging nettle
164	F	VADI	Valeriana dioica	Valerianaceae	Sitka valerian
165	F	VETH	Verbascum thapsis	Scrophulariaceae	common mullein
166	F	VEVI	Veratrum viride	Liliaceae	western false hellebore
167	F	VEWO	Veronica wormskjodii	Scrophulariaceae	alpine speedwell

Table C - 1, Continued: Species List

Number	**Type**	**Code**	**Name**	**Family**	**Common**
168	F	VICA	Viola canadensis	Violaceae	Canada violet
169	F	VIAM	Vicia americana	Fabaceae	American vetch
170	F	XETE	Xerophyllum tenax	Liliaceae	beargrass

T = Tree
S/SS = Sub/Subshrub
F/PH = Fern/Primitive Herb
G = Graminoid
F = Forb

Appendix D: Synthesis Table

Figure D - 1: Synthesis Table for Non-Ecotonal Plots Arranged by New LEF Type

	1	1	1	1	2	2	2	2	2	2	3	3	3	3	3	3	3	3	3	3	3	3	3	3
	E12	F1	F7	F8	E8	E15	E16	F4	F12	H2	B10	B12	D14	G1	G3	G4	G5	G6	G8	G10	G11	G14	G15	H1
ACGL	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0
ACMI	0	0	0	3	0	1	1	0	0	0	3	1	1	0	0	0	7.5	1	0	1	7.5	1	1	1
AGCA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AGIN	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AGSP	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
AGTE	0	0	0	0	0	0	0	1	0	3	0	3	0	0	0	0	0	0	0	0	0	0	0	3
ALCE	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0
AMAL	1	0	1	0	3	1	1	0	0	3	38	0	15	3	1	3	0	3	0	3	0	0	1	1
ANMA	0	0	1	1	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ANMI	0	1	0	3	0	1	1	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ANNE	0	1	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ANOC	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ANRA	1	1	0	1	3	1	1	3	0	1	3	3	3	7.5	1	3	7.5	7.5	7.5	7.5	7.5	7.5	1	1
APAN	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ARCO	1	7.5	3	3	1	3	3	1	0	23	0	0	7.5	15	15	38	15	15	23	0	7.5	23	15	15
ARUV	0	15	63	23	1	7.5	7.5	15	7.5	1	1	1	7.5	3	1	0	3	1	3	0	0	1	1	0
ASCO	0	0	1	7.5	1	1	1	7.5	7.5	1	0	0	0	0	0	0	3	1	0	0	1	3	0	1
ASLA	0	0	1	1	0	1	0	1	1	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0
ASMI	0	0	0	0	0	0	0	0	0	0	0	0	7.5	0	0	0	1	0	0	1	1	0	0	0
BASA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BERE	0	3	1	3	0	1	1	3	7.5	1	1	1	3	1	1	0	7.5	0	3	7.5	15	7.5	23	7.5
BRIN	0	0	0	0	1	0	1	0	0	0	1	1	0	0	0	0	1	0	0	0	0	1	0	0
CAAP	0	0	0	0	0	0	0	0	0	1	0	0	0	1	1	0	0	0	1	0	0	0	0	0
CACO	0	0	0	0	0	0	0	3	0	0	0	0	3	3	1	1	0	1	1	1	0	3	3	0
CAGE	0	0	3	3	1	1	0	3	3	0	1	0	3	0	0	0	0	1	0	0	1	0	0	3
CAQU	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CARO2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CARU	38	15	7.5	15	38	38	63	23	38	38	15	38	23	38	23	15	63	38	23	38	15	38	15	38
CEMA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CEVE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CHUM	0	3	1	1	0	1	0	1	3	1	1	0	3	1	7.5	7.5	0	0	7.5	0	1	1	3	1
CIAR	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CIVU	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CLCO	0	0	0	0	1	1	1	0	0	0	1	1	0	0	0	0	0	1	0	1	0	0	0	1
COCA	1	23	0	0	3	1	7.5	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
COMA	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
COPA	1	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
CYMO	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0
DISA	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
EPAN	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
EPGL	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
FEOC	0	0	0	0	1	0	0	0	0	0	1	1	7.5	3	1	1	7.5	15	1	3	3	7.5	3	0
FRVI	1	1	0	1	1	3	1	0	1	1	1	1	7.5	3	0	1	3	1	3	0	3	3	1	1
GABO	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	3	0	0	1
GATR	1	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1
GETR	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
GEVI	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
GOOB	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	3	1	1	1	1	1	1	1	0
HADI	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
HECY	0	1	1	1	1	1	1	1	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0
HIAL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
HICY	0	0	0	1	0	0	1	1	0	0	0	1	0	1	0	1	0	1	1	0	0	1	1	0
JUCO	0	15	3	3	0	0	0	38	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
JUSC	0	0	1	3	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LAOC	15	38	3	0	1	3	0	3	38	15	63	38	38	38	63	38	38	38	38	38	38	38	38	38
LIBO	15	3	15	0	15	38	38	15	15	38	0	0	7.5	15	15	7.5	3	1	23	3	3	1	1	15
LIRU	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LOTR	0	0	0	0	0	0	0	0	0	1	1	1	0	0	0	0	0	0	0	0	1	1	0	0
LOUT	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7.5	0	0	1	0	0	0	0	0
LUAR	0	0	1	1	0	0	1	0	0	1	0	0	0	3	0	0	0	0	0	0	0	0	0	0
MEFE	0	0	0	0	3	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Figure D - 1, Continued: Synthesis Table for Non-Ecotonal Plots Arranged by New LEF Type

	1	1	1	1	2	2	2	2	2	2	3	3	3	3	3	3	3	3	3	3	3	3	3	3
	E12	**F1**	**F7**	**F8**	**E8**	**E15**	**E16**	**F4**	**F12**	**H2**	**B10**	**B12**	**D14**	**G1**	**G3**	**G4**	**G5**	**G6**	**G8**	**G10**	**G11**	**G14**	**G15**	**H1**
OSCH	0	1	0	0	0	0	0	0	0	1	1	1	1	1	0	0	0	0	1	3	0	1	1	1
PEAL	1	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PEBR	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
PEPR	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PERA	0	0	0	0	0	0	1	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	1
PEWI	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PHPR	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PICO	38	38	63	38	38	38	15	38	62	63	0	0	0	0	0	1	0	0	0	0	0	0	0	1
PIEN	0	0	0	0	0	3	38	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PIPO	0	0	3	3	0	0	0	3	0	0	1	0	3	0	0	0	0	0	0	0	0	0	0	0
POCO	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
POGL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
POPR	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PORE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
PRVI	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PRVU	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
PSME	15	15	7.5	15	38	38	15	38	3	3	38	38	38	38	15	38	38	38	38	38	38	38	38	38
PTAN	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
PYAS	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0
PYSE	0	1	0	0	3	0	0	0	1	1	0	0	1	0	0	1	0	0	0	1	0	1	3	0
RIHU	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ROAC	1	3	1	1	1	1	1	1	0	1	1	0	3	15	7.5	7.5	0	1	1	3	1	1	0	1
RUAC	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
RUPA	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
SASC	0	0	0	0	0	0	0	3	0	0	0	0	1	0	0	3	0	0	0	0	0	0	0	0
SELA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SHCA	0	15	1	1	0	0	0	3	15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SIME	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SMST	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1
SOMI	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SPBE	1	7.5	7.5	15	3	7.5	1	23	15	1	7.5	7.5	23	3	3	3	15	7.5	38	15	38	3	3	1
STAM	1	0	0	0	3	1	1	1	0	1	1	1	1	1	1	1	1	1	3	1	1	1	1	1
STCO	0	0	0	1	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	1	1	1	0
STRI	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	3	15	0	0	0
SYAL	1	3	0	0	0	0	15	1	0	38	38	38	15	3	0	1	38	3	0	3	23	15	23	63
TAOF	0	0	0	0	0	0	1	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0
THOC	1	0	0	0	0	0	3	0	1	1	3	15	3	23	15	1	15	23	0	7.5	23	7.5	15	3
TRDU	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
TRRE	0	0	0	0	0	0	7.5	0	0	7.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
VACA	1	0	0	0	3	1	15	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0
VADI	1	0	0	1	1	1	1	0	0	0	1	1	0	0	0	0	0	0	0	0	1	0	0	0
VAGL	3	7.5	3	7.5	0	15	0	3	3	15	0	0	3	15	23	0	3	15	15	3	38	15	3	1
VAMY	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
VASC	1	23	23	7.5	1	0	0	38	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
VETH	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
VEVI	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	2
VIAM	0	1	0	1	0	1	1	1	0	3	1	0	0	0	0	0	0	0	0	0	0	0	0	0
VICA	1	1	0	1	1	1	1	1	0	1	0	0	0	0	0	1	1	0	0	1	1	0	1	1
XETE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0

Figure D - 1, Continued: Synthesis Table for Non-Ecotonal Plots Arranged by New LEF Type

	3	4	4	4	4	4	4	4	4	4	4	5	5	5	5	5	5	5	5	5	5	5	5	5
	H3	A3	A4	A7	B13	B14	D2	D4	F5	G2	G7	C16	D1	D3	D6	D9	D10	D11	D12	D15	F16	H5	H10	H12
ACGL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	7.5	0	0	0
ACMI	0	1	0	1	1	1	1	0	0	0	0	3	1	1	1	3	7.5	1	0	3	1	1	1	3
AGCA	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0
AGIN	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AGSP	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AGTE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
ALCE	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
AMAL	1	0	1	1	1	7.5	3	1	1	1	3	1	0	3	1	3	1	1	3	3	1	1	1	1
ANMA	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ANMI	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	0	0	1	0	0	0
ANNE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
ANOC	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
ANRA	3	0	0	0	3	1	7.5	7.5	0	3	7.5	3	3	3	3	7.5	3	3	3	7.5	0	1	1	1
APAN	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	7.5	3	0	0	0	0	0
ARCO	38	15	7.5	15	7.5	7.5	0	7.5	23	23	23	3	0	3	0	0	0	0	0	0	0	3	0	3
ARUV	0	1	3	15	7.5	15	7.5	3	0	1	3	15	15	23	15	7.5	15	7.5	7.5	7.5	7.5	3	3	15
ASCO	0	0	15	3	0	0	0	0	1	0	0	0	0	0	0	3	0	0	0	0	3	3	0	0
ASLA	0	1	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	1	1	1
ASMI	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BASA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
BERE	1	7.5	7.5	7.5	3	3	0	0	3	1	1	1	1	0	1	1	1	7.5	3	3	15	1	3	1
BRIN	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	3	1	0	0	0	0	1	0	0
CAAP	1	0	0	0	0	0	1	1	0	0	0	1	1	1	1	1	0	0	0	1	0	1	0	1
CACO	0	0	1	0	0	0	3	7.5	0	3	1	0	7.5	3	1	0	3	1	3	0	0	0	0	0
CAGE	1	1	3	15	3	3	3	0	0	0	1	3	15	0	3	0	0	7.5	1	1	3	1	3	1
CAQU	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
CARO2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
CARU	38	38	23	15	15	15	15	23	15	23	38	23	7.5	38	63	63	38	38	38	38	15	38	38	63
CEMA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0
CEVE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0
CHUM	1	0	1	1	0	1	1	1	3	0	1	0	1	0	0	0	0	0	3	0	0	1	0	0
CIAR	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CIVU	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
CLCO	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0
COCA	0	0	0	0	0	0	0	0	15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
COMA	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1
COPA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CYMO	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
DISA	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
EPAN	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
EPGL	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0
FEOC	7.5	1	1	1	3	0	1	15	0	1	1	15	1	15	0	1	1	0	1	0	0	0	0	1
FRVI	3	1	1	1	1	1	3	1	1	1	3	1	3	3	1	3	7.5	3	7.5	1	1	3	1	1
GABO	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
GATR	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
GETR	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
GEVI	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
GOOB	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0
HADI	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
HECY	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	7.5	1	1	1
HIAL	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	1	0	0
HICY	1	0	0	0	1	0	1	1	0	1	0	0	1	0	1	1	1	1	0	0	0	0	1	1
JUCO	0	0	0	0	0	0	0	0	7.5	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0
JUSC	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LAOC	63	15	15	38	38	38	7.5	38	38	38	38	0	38	7.5	3	3	0	1	3	7.5	3	15	0	0
LIBO	38	23	15	15	1	1	15	3	15	15	15	0	3	0	0	0	0	3	3	0	0	0	0	0
LIRU	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LOTR	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	3	1
LOUT	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LUAR	3	0	0	0	0	0	0	0	0	7.5	0	0	0	0	0	1	0	0	0	0	1	3	1	0
MEFE	0	0	0	0	0	0	0	0	23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
OSCH	1	1	1	1	0	1	0	0	1	1	1	0	0	0	0	0	0	0	1	0	0	1	0	1
PEAL	0	0	0	0	1	0	0	0	0	0	0	1	1	0	0	0	0	1	0	0	0	0	1	1
PEBR	0	0	0	0	0	0	0	0	0	0	0	0	1	3	0	0	0	0	0	0	0	0	0	0
PEPR	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0

Figure D - 1, Continued: Synthesis Table for Non-Ecotonal Plots Arranged by New LEF Type

	3	4	4	4	4	4	4	4	4	4	4	5	5	5	5	5	5	5	5	5	5	5	5	5
	H3	A3	A4	A7	B13	B14	D2	D4	F5	G2	G7	C16	D1	D3	D6	D9	D10	D11	D12	D15	F16	H5	H10	H12
PERA	1	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	1
PEWI	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	1	0	1	1	0	0	0
PHPR	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0
PICO	23	1	3	0	0	0	23	1	23	0	0	0	23	38	38	0	0	1	7.5	0	15	1	7.5	3
PIEN	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PIPO	0	38	38	7.5	0	0	23	3	3	0	0	15	7.5	7.5	15	0	23	7.5	7.5	3	15	0	1	3
POCO	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
POGL	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
POPR	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
PORE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PRVI	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7.5	0	0	0
PRVU	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
PSME	15	38	38	63	38	38	63	38	38	38	38	38	38	63	38	38	38	63	38	38	38	63	38	63
PTAN	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PYAS	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PYSE	1	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0
RIHU	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ROAC	0	3	1	1	1	1	0	0	3	3	0	1	0	0	0	0	0	0	1	1	0	0	0	0
RUAC	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
RUPA	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SASC	0	0	0	0	1	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
SELA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	1	0	0	0	1
SHCA	0	0	1	0	1	0	0	0	3	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
SIME	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SMST	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0
SOMI	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0
SPBE	0	0	0	0	38	38	15	0	3	3	15	15	38	7.5	3	15	3	15	0	23	23	1	0	0
STAM	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	1	1
STCO	1	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	1
STRI	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SYAL	38	7.5	23	38	0	3	0	1	0	3	7.5	7.5	0	0	3	3	0	3	38	0	15	7.5	23	1
TAOF	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	1	1	1
THOC	7.5	15	7.5	7.5	3	7.5	15	38	0	15	38	0	15	15	1	3	7.5	3	15	1	0	7.5	1	1
TRDU	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TRRE	3	0	0	1	0	0	0	1	0	0	0	3	0	7.5	0	0	0	0	0	0	0	0	1	0
VACA	0	3	3	1	3	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
VADI	0	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0
VAGL	23	0	0	0	7.5	7.5	38	38	7.5	15	38	0	15	7.5	0	0	0	15	15	3	1	15	0	1
VAMY	0	7.5	23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
VASC	0	0	0	0	0	0	0	0	7.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
VETH	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
VEVI	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
VIAM	3	3	0	1	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	3	0	0
VICA	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1
XETE	0	0	0	0	0	0	15	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0

Figure D - 1, Continued: Synthesis Table for Non-Ecotonal Plots Arranged by New LEF Type

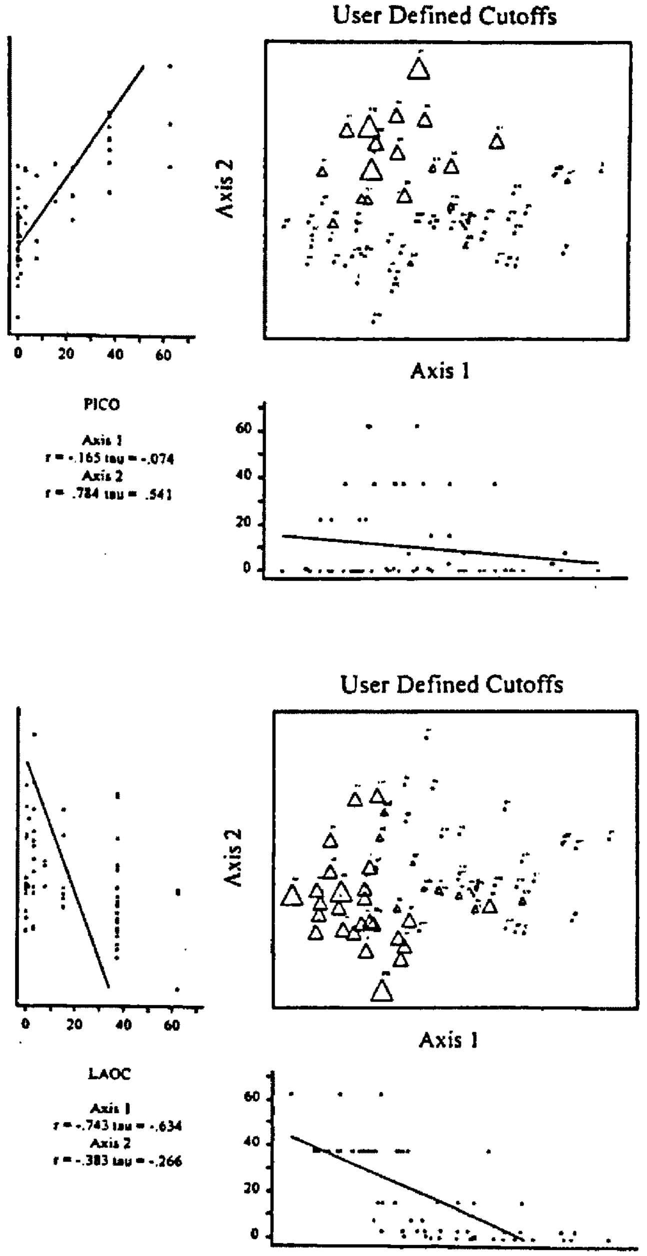
	5	6	6	7	7	7	7	7	7	8	8	8	8	8	8	8	8	8
	H15	B3	B4	C1	C3	C7	C8	C12	C15	A8	A12	A15	A16	C9	C10	C14	E1	E5
ACGL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ACMI	1	3	3	0	1	1	3	1	1	1	1	1	1	1	1	1	1	1
AGCA	0	0	0	0	0	0	3	0	1	0	0	0	0	0	0	0	0	0
AGIN	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0
AGSP	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AGTE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ALCE	0	0	1	0	0	1	0	0	1	0	0	0	0	1	0	0	0	0
AMAL	1	1	0	0	0	0	1	1	1	0	0	1	1	1	1	0	0	0
ANMA	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
ANMI	1	0	0	3	3	7.5	3	0	0	0	1	1	1	1	0	1	3	7.5
ANNE	0	0	3	1	0	1	1	0	0	1	1	1	1	0	0	1	1	0
ANOC	0	0	0	1	1	0	1	0	0	1	1	1	1	0	0	0	0	0
ANRA	0	3	1	1	1	1	0	1	1	0	0	1	1	1	3	0	0	0
APAN	0	0	0	3	0	0	0	0	1	0	0	0	0	1	1	1	1	0
ARCO	3	15	15	3	1	1	0	1	0	0	0	1	0	1	0	1	3	0
ARUV	1	1	3	7.5	0	0	0	0	3	15	23	23	38	1	3	15	7.5	7.5
ASCO	15	0	0	0	0	3	0	1	1	3	1	0	0	0	0	0	0	3
ASLA	0	0	0	3	3	3	3	1	1	3	1	0	0	1	1	1	1	0
ASMI	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BASA	0	15	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BERE	7.5	1	15	3	1	3	7.5	1	1	15	7.5	3	1	1	1	1	1	3
BRIN	0	0	0	0	0	1	0	0	1	0	1	0	0	0	0	0	0	0
CAAP	0	1	1	0	3	3	1	0	1	1	0	0	0	1	0	0	0	0
CACO	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
CAGE	0	3	3	3	1	3	3	3	0	3	1	1	0	0	1	3	0	0
CAQU	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
CARO2	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	1	1	0
CARU	63	38	38	38	15	38	38	38	38	38	23	38	23	38	38	23	23	15
CEMA	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	7.5
CEVE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CHUM	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CIAR	0	0	0	0	1	0	0	0	0	0	0	1	1	0	0	0	0	0
CIVU	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0
CLCO	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
COCA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
COMA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
COPA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CYMO	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
DISA	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
EPAN	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
EPGL	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1
FEOC	0	1	0	3	1	3	1	0	1	1	1	1	3	1	0	1	0	0
FRVI	1	0	3	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1
GABO	0	0	0	7.5	3	1	1	1	1	1	3	1	1	3	1	1	1	1
GATR	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
GETR	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0
GEVI	0	0	0	0	0	1	0	1	1	1	1	1	1	1	1	1	0	1
GOOB	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
HADI	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
HECY	0	1	1	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0
HIAL	0	0	1	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0
HICY	0	1	3	1	0	1	1	0	0	0	0	0	0	1	0	1	1	1
JUCO	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
JUSC	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LAOC	0	1	3	0	0	0	0	3	3	38	3	0	3	15	0	15	0	0
LIBO	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
LIRU	1	0	1	0	0	0	0	0	0	3	1	1	1	0	0	0	1	3
LOTR	3	0	0	0	1	3	3	1	1	0	0	0	0	3	1	1	0	0
LOUT	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LUAR	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MEFE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
OSCH	1	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0
PEAL	0	0	1	1	3	1	3	0	1	0	0	1	1	0	1	1	3	1
PEBR	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PEPR	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0

Figure D - 1, Continued: Synthesis Table for Non-Ecotonal Plots Arranged by New LEF Type

	5	6	6	7	7	7	7	7	7	8	8	8	8	8	8	8	8	8
	H15	B3	B4	C1	C3	C7	C8	C12	C15	A8	A12	A15	A16	C9	C10	C14	E1	E5
PERA	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PEWI	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PHPR	0	0	0	3	15	23	1	0	1	0	1	0	1	1	3	1	0	0
PICO	0	0	0	0	0	0	0	0	0	0	7.5	3	3	0	0	0	38	0
PIEN	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PIPO	23	38	23	23	38	15	23	38	63	38	63	38	38	23	38	38	38	63
POCO	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3
POGL	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	1	1
POPR	0	0	0	3	1	0	1	0	1	0	0	1	0	1	0	0	0	3
PORE	0	0	0	1	1	1	1	0	1	0	0	1	1	1	1	1	0	0
PRVI	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PRVU	0	0	0	1	0	1	0	0	0	0	0	1	1	0	0	0	0	0
PSME	38	63	38	7.5	7.5	23	38	15	15	38	1	1	1	38	15	3	23	3
PTAN	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
PYAS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PYSE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
RIHU	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ROAC	0	0	1	3	1	1	1	1	3	1	1	1	3	1	1	1	1	3
RUAC	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	1
RUPA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SASC	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SELA	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SHCA	0	0	0	0	0	0	0	0	0	1	1	0	1	1	0	0	1	0
SIME	0	0	0	0	1	1	1	1	0	1	0	0	0	1	0	0	1	0
SMST	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SOMI	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1
SPBE	1	0	0	0	0	0	0	7.5	38	0	0	0	0	7.5	23	7.5	7.5	0
STAM	1	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0
STCO	3	0	0	0	3	0	3	1	1	0	0	0	0	1	3	3	0	0
STRI	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	1	0	0
SYAL	7.5	1	3	15	23	38	38	38	3	38	15	7.5	15	15	15	38	3	3
TAOF	1	0	0	0	1	1	0	0	0	0	0	0	0	1	1	1	0	0
THOC	0	0	1	0	1	1	0	7.5	1	3	0	1	0	3	0	0	0	0
TRDU	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0
TRRE	0	0	0	7.5	0	3	3	0	3	0	0	1	0	1	1	7.5	0	0
VACA	0	1	0	0	0	0	0	0	1	23	23	23	23	1	1	3	7.5	3
VADI	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	1	0
VAGL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
VAMY	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
VASC	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
VETH	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
VEVI	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
VIAM	1	0	0	0	0	0	0	1	3	0	0	0	0	3	3	7.5	0	1
VICA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1
XETE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

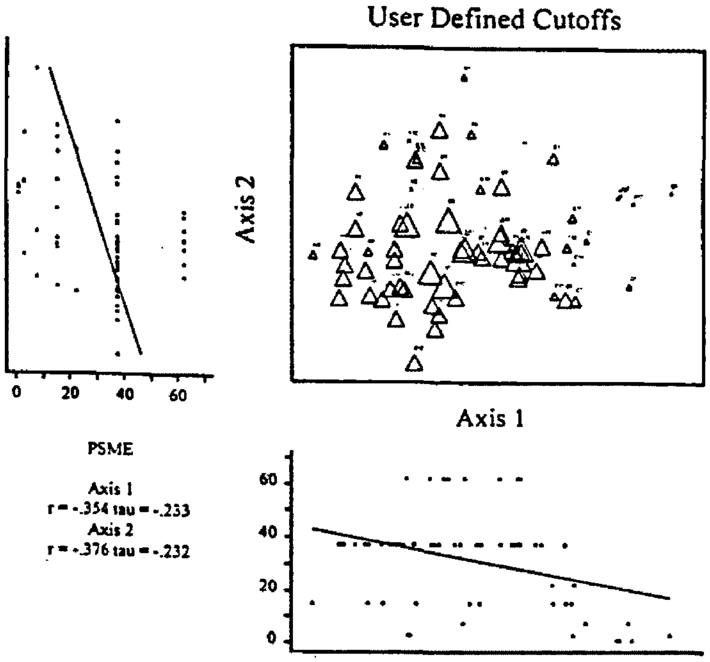
Appendix E: Dominant Overstory Species and Understory Indicator Species DCA Ordination Ecological Amplitude Graphs

Figure E - 1: Overstory Graphs for *Pinus contorta* and *Larix occidentalis*



Relative importance of the species in the ordination is indicated by the size of the triangles in the main graph; regression along the first and second axes is given in the other two graphs for each species. The species is indicated in four letter code.

Figure E - 2: Overstory Graphs for *Pseudotsuga menziesii* and *Pinus ponderosa*



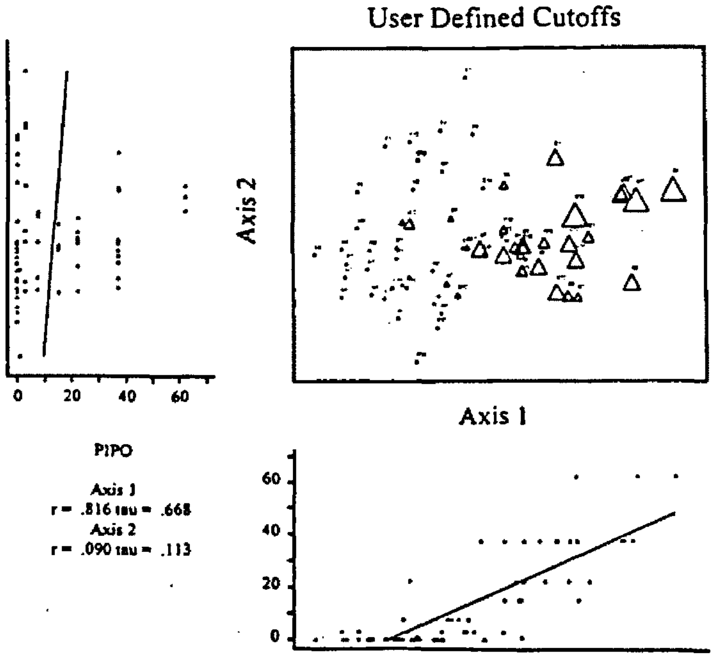


Figure E - 3: Understory Graphs for *Vaccinium scoparium* and *Symphoricarpos albus*

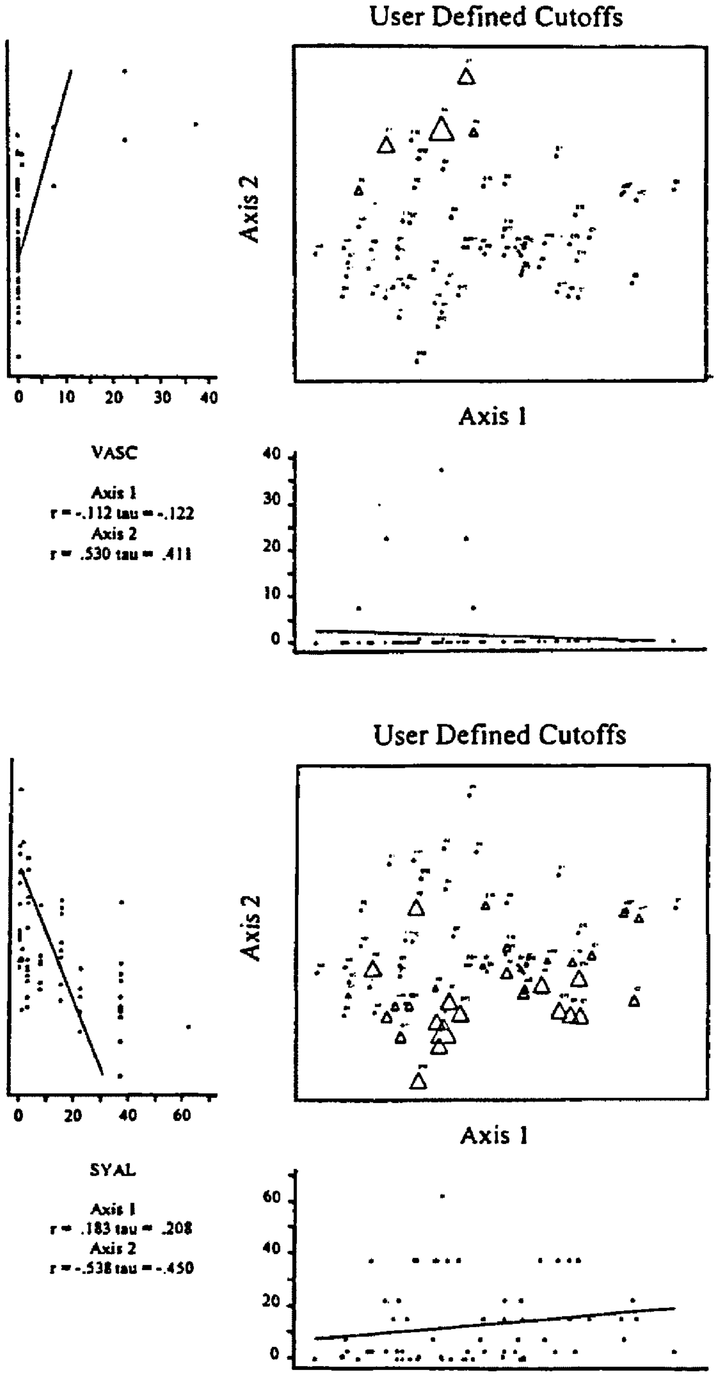
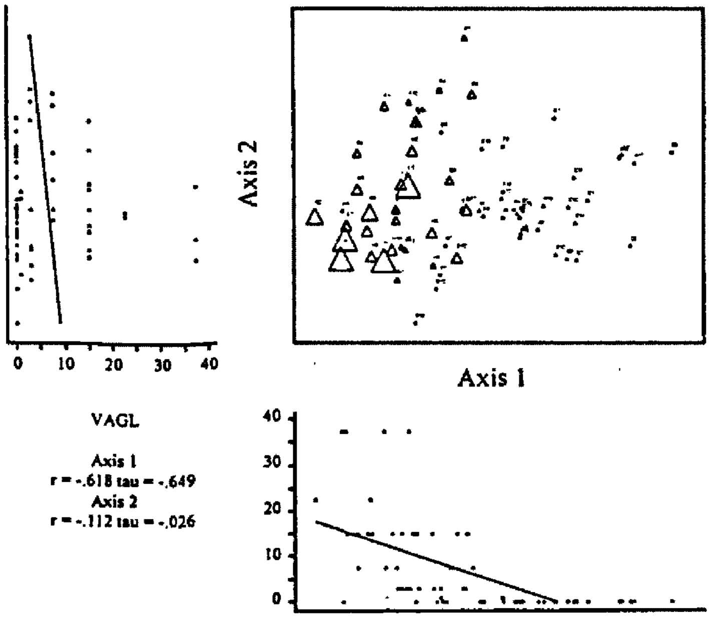


Figure E - 4: Understory Graphs for *Vaccinium globulare* and *Streptopus amplexifolius*

User Defined Cutoffs



User Defined Cutoffs

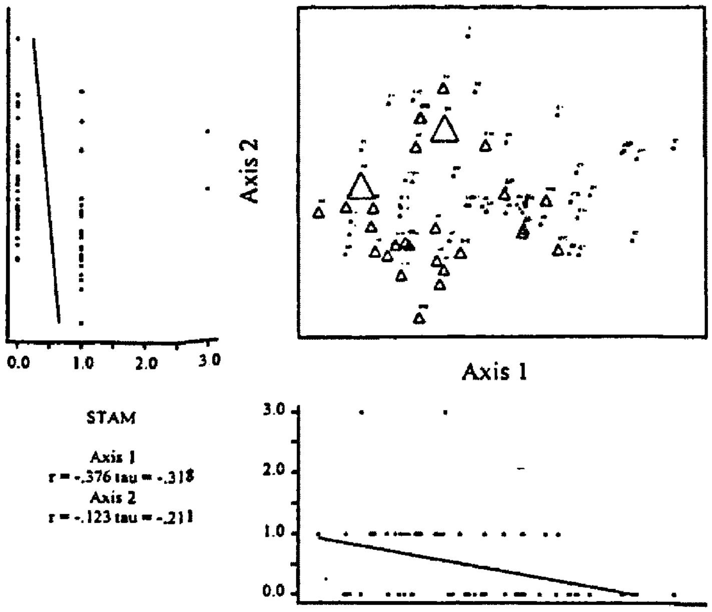
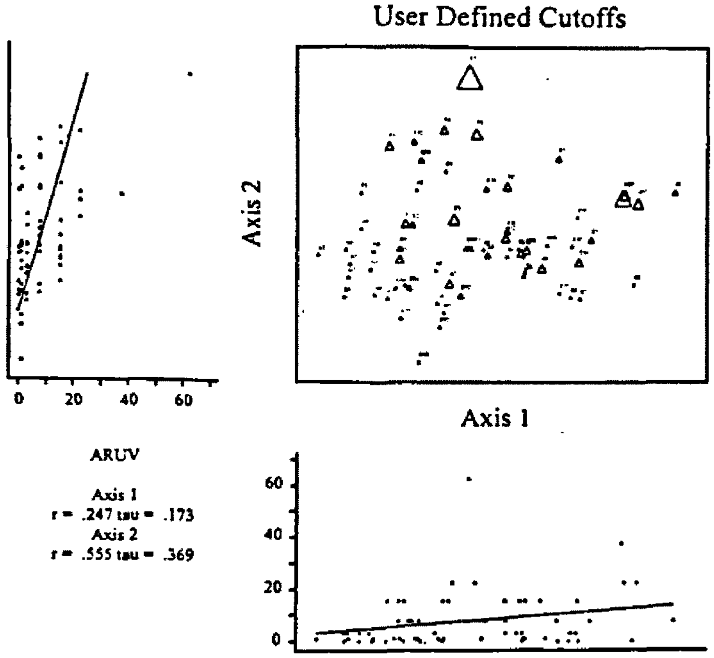


Figure E - 5: Understory Graphs for *Arctostaphylos uva-ursi* and *Balsamorrhiza sagittata*



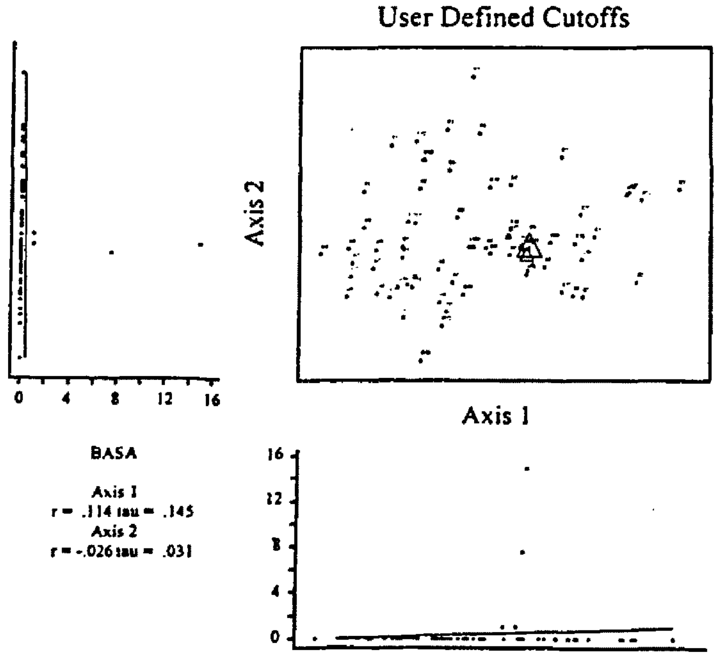
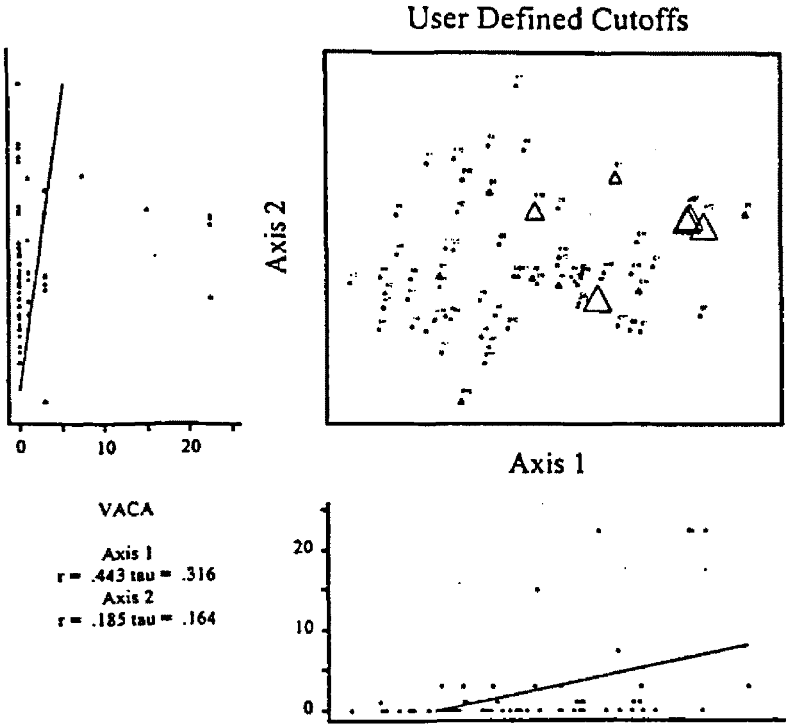


Figure E - 6: Understory Graph for *Vaccinium caespitosum*



Appendix F: Additional Confusion Tables

Table F - 1: Confusion Table, Default Values TWINSPAN Level 4

	TWINSPAN Groups, Level Four														
Habitat Types	**C1**	**D1**	**D2**	**D3**	**D4**	**D5**	**D6**	**C5**	**D7**	**D8**	**D9**	**D10**	**D11**	**D12**	**Sum**
PICEA/GATR															0
PSME/LIBO, VAGL				2		7	3								12
PSME/LIBO, SYAL															0
PSME/VAGL, ARUV	1	1		1	2	1				1					7
PSME/VAGL, VAGL	1	4			1	6	1								13
PSME/VACA			3	2			2	3		1		5	4	2	22
PSME/PHMA, CARU															0
PSME/SYAL, CARU					1		1	1	1	1	5	1			11
PSME/CARU, ARUV									1						1
PSME/CARU, CARU										1					1
Sum	2	5	3	5	4	14	7	4	2	4	5	6	4	2	67
Cover Types															
ES															0
LP	1	2	1												4
LP/WL		2													2
LP/DF								1							1
LP/PP															0
WL/LP		1					1								2
WL						3	2								5
WL/DF						2	3								5
WL/PP													1		1
DF/LP			2						1						3
DF/WL				4	1	7	1								13
DF	1			1	3	2		1	1	3	1				13
DF/WL/PP															0
DF/PP								2			1	2			5
PP/LP														1	1
PP/WL															0
PP/DF										1	2				3
PP											1	4	3	1	9
NONE															0
Sum	2	5	3	5	4	14	7	4	2	4	5	6	4	2	67

Table F - 1, Continued: Confusion Table, Default Values TWINSPAN Level 4

	TWINSPAN Groups, Level Four														
Process Type	**C1**	**D1**	**D2**	**D3**	**D4**	**D5**	**D6**	**C5**	**D7**	**D8**	**D9**	**D10**	**D11**	**D12**	**Sum**
7 - OF, MS			2	1	1	2	1		1	2	2	1	1		14
6 - OF, SS															0
5 - SE, CC	1	4		2		10	2	1			1	1			22
4 - SE, OC	1							1							2
3 - YF, MS		1		2			2	1	1	1	1	4			13
2 - UR			1		3	2	2	1		1	1		3	2	16
1 - SI															0
Sum	**2**	**5**	**3**	**5**	**4**	**14**	**7**	**4**	**2**	**4**	**5**	**6**	**4**	**2**	**67**
Structure Type															
E - C, M, VL	1	2		1		1	1	1							7
J - C, S, VL															0
N - O, M, VL			2	1		2							2		7
S - O, S, VL									1						1
D - C, M, L		3			1		2	2		1		1		2	12
I - C, S, L															0
M - O, M, L				2		4	4				1		1		12
R - O, S, L					1				1						2
C - C, M, Me			1		2	2		1		3	1	5	1		16
H - C, S, Me															0
L - O, M, Me	1			1		5					2				9
Q - O, S, Me															0
B - C, M, P															0
G - C, S, P															0
K - O, M, P											1				1
P - O, S, P															0
F- C, S, S/S															0
O - O, S, S/S															0
A - NonForest															0
Sum	2	5	3	5	4	14	7	4	2	4	5	6	4	2	67

Table F - 2: Confusion Table, TWINSPAN P/A Level 4

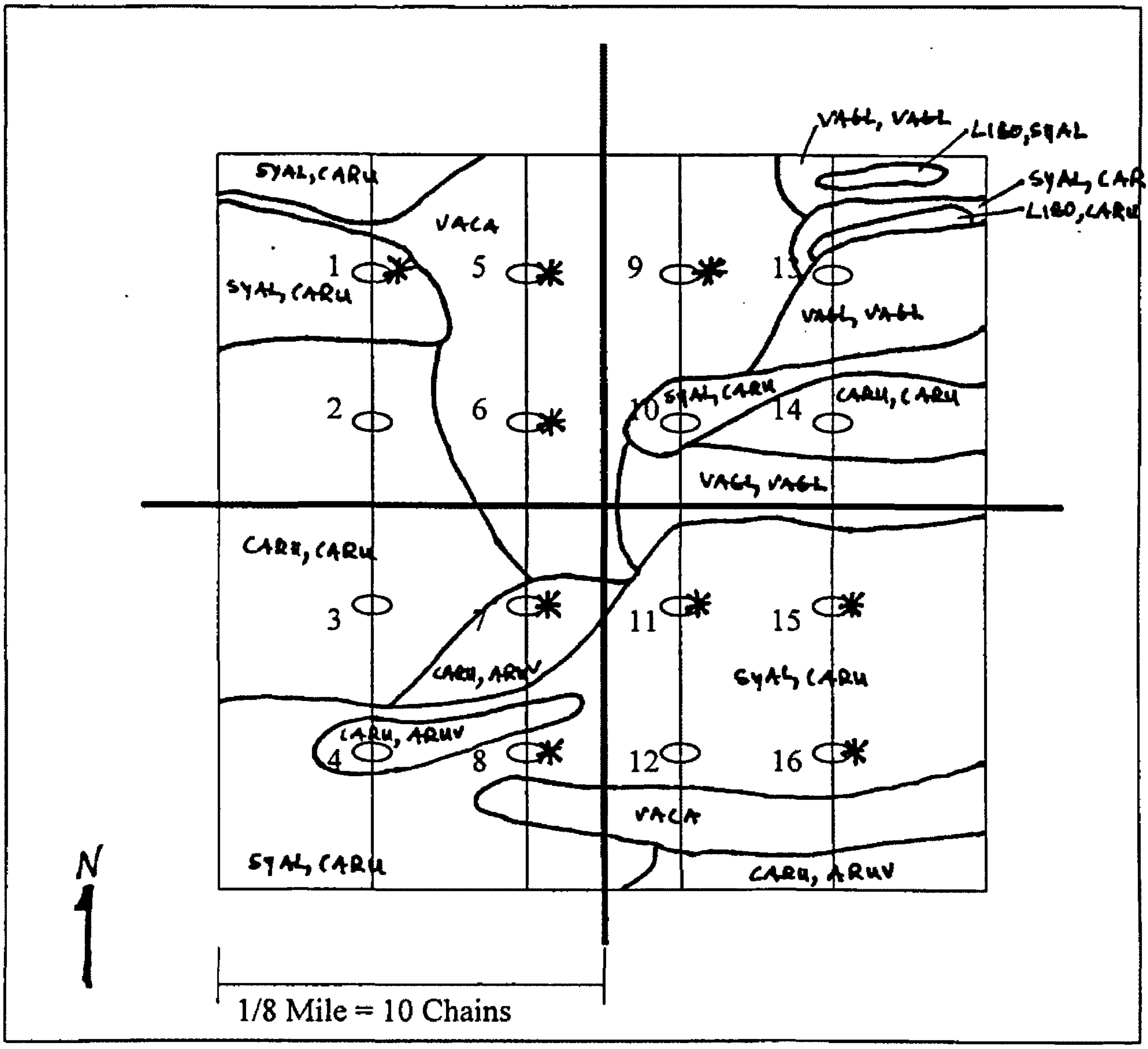
	TWINSPAN Groups, Level Four													
Habitat Types	**D1**	**D2**	**D3**	**D4**	**D5**	**D6**	**D7**	**D8**	**D9**	**D10**	**D11**	**D12**	**B4**	**Sum**
PICEA/GATR														0
PSME/LIBO, VAGL	1	7	2		2									12
PSME/LIBO, SYAL														0
PSME/VAGL, ARUV		2	2	1			1	1						7
PSME/VAGL, VAGL	3	1	1		3		5							13
PSME/VACA			2	1	3	4			3	4	5			22
PSME/PHMA, CARU														0
PSME/SYAL, CARU	1		2					1		1	1	4	1	11
PSME/CARU, ARUV			1											1
PSME/CARU, CARU													1	1
Sum	**5**	**10**	**10**	**2**	**8**	**4**	**6**	**2**	**3**	**5**	**6**	**4**	**2**	**67**
Cover Types														
ES														0
LP						1	3							4
LP/WL							2							2
LP/DF						1								1
LP/PP														0
WL/LP					1		1							2
WL		3			2									5
WL/DF	2	1			2									5
WL/PP										1				1
DF/LP			1			2								3
DF/WL	2	4	5		2									13
DF	1	2	4	1	1			1				1	2	13
DF/WL/PP														0
DF/PP								1	1		2	1		5
PP/LP									1					1
PP/WL														0
PP/DF				1								2		3
PP									1	4	4			9
NONE														0
Sum	**5**	**10**	**10**	**2**	**8**	**4**	**6**	**2**	**3**	**5**	**6**	**4**	**2**	**67**

Table F - 2, Continued: Confusion Table, TWINSPAN P/A Level 4

Process Type	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10	D11	D12	B4	Sum
7 - OF, MS		2	4	1	2		1	1	1		1	1		14
6 - OF, SS														0
5 - SE, CC		4	2	1	1	3	5	1	1	3			1	22
4 - SE, OC					2									2
3 - YF, MS	4		3		2					1		2	1	13
2 - UR	1	4	1		1	1			1	1	5	1		16
1 - SI														0
Sum	**5**	**10**	**10**	**2**	**8**	**4**	**6**	**2**	**3**	**5**	**6**	**4**	**2**	**67**
Structure Type														
E - C, M, VL		1			1	1			1	1			1	6
J - C, S, VL														0
N - O, M, VL		1	3								2			6
S - O, S, VL					1									1
D - C, M, L		3	1	1	1					3	2	1	1	13
I - C, S, L														0
M - O, M, L	2	2	2				4	1			1			12
R - O, S, L	1		1											2
C - C, M, Me	2	3	2		3				2	1	1	2		16
H - C, S, Me														0
L - O, M, Me			1	1	1	3	2					1		9
Q - O, S, Me														0
B - C, M, P														0
G - C, S, P														0
K - O, M, P					1									1
P - O, S, P														0
F- C, S, S/S														0
O - O, S, S/S								1						1
A - NonForest														0
Sum	**5**	**10**	**10**	**2**	**8**	**4**	**6**	**2**	**3**	**5**	**6**	**4**	**2**	**67**

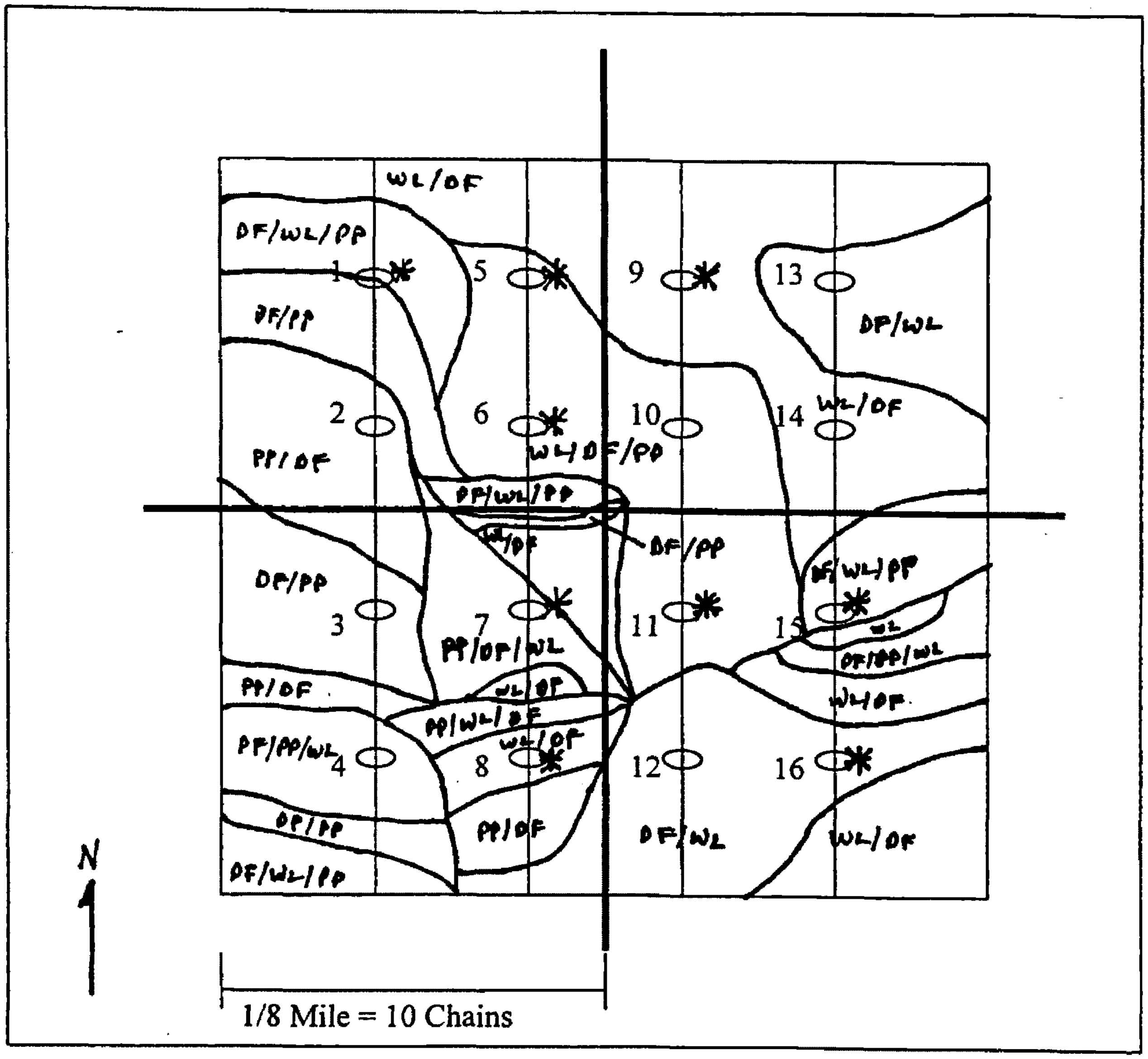
Appendix G: Maps

Figure G - 1: Habitat Type Map for Section B



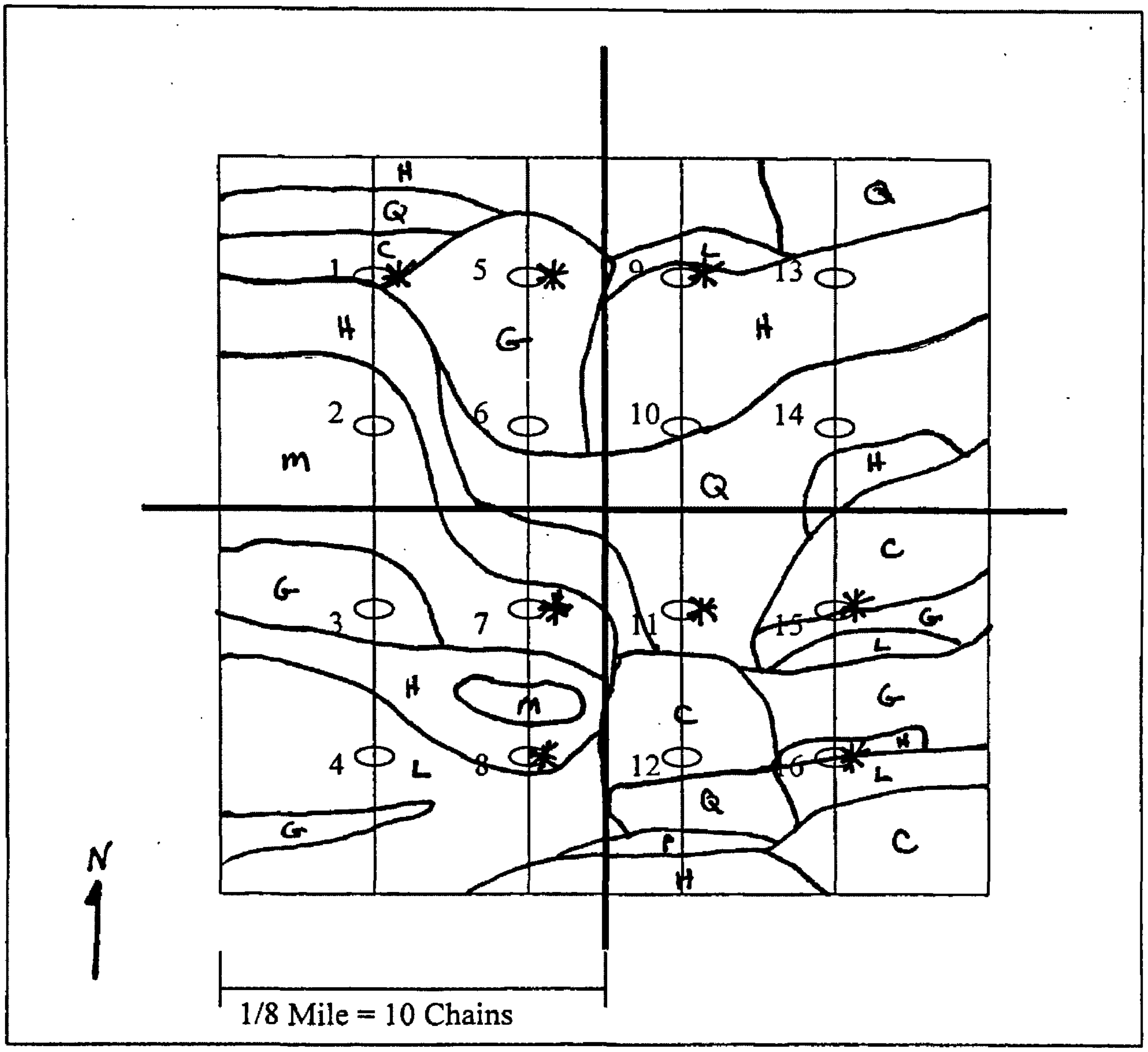
* = Ecotonal Plot

Figure G - 2: Cover Type Map for Section B



* = Ecotonal Plot

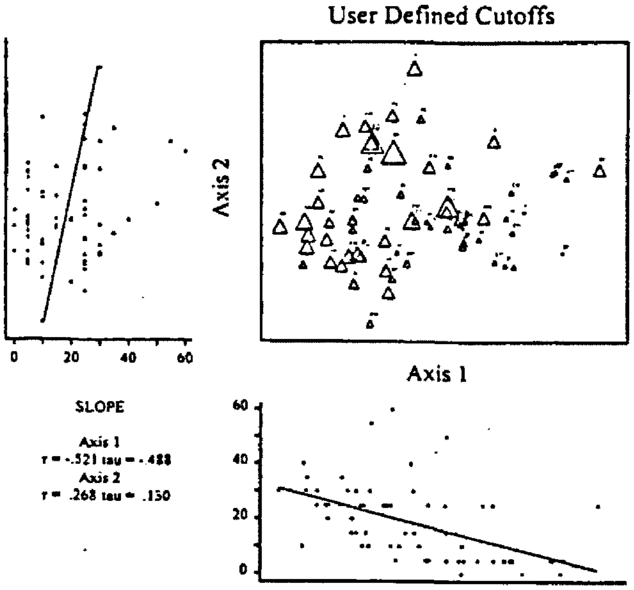
Figure G - 3: Structure Type Map for Section B

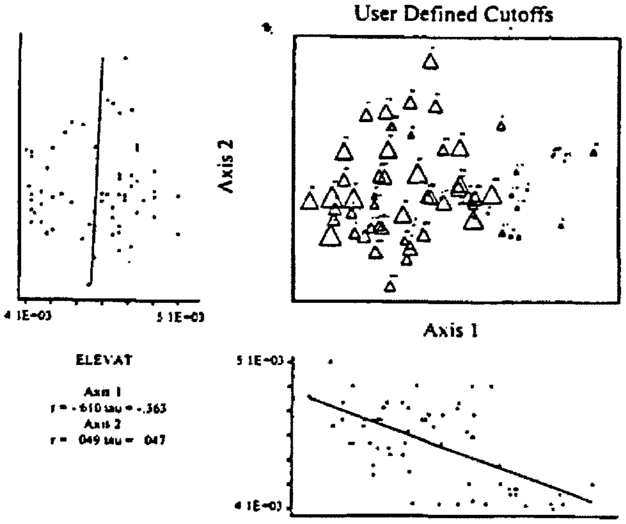


* = Ecotonal Plot

Appendix H: Environmental Variable Graphs

Figure H - 1: Slope and Elevation Graphs





Relative importance of the environmental variable in the distribution of plots is shown by size of the triangle in the main graph. Regression of slop or elevation is shown is the other two graphs. Plots are indicated by the triangles. Environmental variables are not included in DCA ordination.