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Discriminant function for old forest classification of mesic types in the northern Rocky Mountains

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DISCRIMINANT FUNCTION FOR OLD FOREST CLASSIFICATION OF MESIC TYPES IN THE NORTHERN ROCKY MOUNTAINS

by

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Public land managers are obligated by law to provide for a diversity of plant and animal communities. The old forest or "old-growth" has been identified as an important stage to maintain. For managers to inventory and manage old forest structures they need to be able to distinguish it from younger stages of forest development. This thesis uses discriminant analysis to help determine diagnostic structural characteristics of old forests for many cover types associated with mesic habitat types in northern Idaho and western Montana.

The key variables for classifying old forests were the number of cohorts, the combination of small and large tree canopy cover, and basal area over 21 inches (53 cm) dbh.

The role of disturbances, especially fire, in the development and maintenance of old forests is of vital importance. That is why the number of cohorts was the most powerful variable in the discriminant funtion.

This research found that discriminant analysis is an effective tool for classifying old forest stands. It does not have the limitations of using minimum criteria.

PREFACE

I want to acknowledge the U.S. Forest Service, Northern Region and Lolo National Forest for providing the data, equipment, some funds and support for this study to be accomplished.

The completion of this project has taken the support and patience of a number of people to which I would like to thank. First to my family, Shirley, Sarah, and Bethany for giving up many nights and weekends with their husband and dad. Next To Dr. Kevin O'Hara for taking on a nontraditional student who kept having work and family needs compete with this thesis. Thanks for helping to keep me going Kevin! I also wish to thank Dr. Wendel Hann for helping me select a meaningful project. I want to thank my committee, Drs. Ray Callaway, Bob Pfister and Hal Salwasser for their efforts to help make this project come together. Lastly, two folks that provided assistance along the way, Dr. Hans Zuuring and Penny Latham.

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INTRODUCTION

Public land management agencies, such as USDA Forest Service, USDI Bureau of Land Management, Bureau of Indian Affairs, National Park Service and others have the responsibility for managing millions of acres of forested land in the northern Rocky Mountains. Part of these agencies' missions is to provide for the maintenance of biological diversity. For example the Forest Service is to assure the "diversity of plant and animal communities..." in accordance with the National Forest Management Act. The Code of Federal Regulations (36 CFR 219) includes the goal "to manage habitats to maintain viable populations of native and desired non-native species...". These public agencies are also required to implement the Endangered Species Act in cooperation with the U.S. Fish and Wildlife Service.

Agencies accomplish these goals primarily through the maintenance of adequate habitat for species that prefer or need various habitat conditions in their life cycles. Some of these relationships are known, but many are unknown. The approach of providing adequate habitat to support known and unknown species is the concept of the coarse filter (Hunter 1990). The old-growth structures have been identified as a component of the forested landscape that is often scarce because of past land uses, primarily logging. As a result old-growth has become a much discussed topic in both the scientific and social literature (Thomas and others 1988).

Old-growth in the northern Rockies has not been extensively studied and what has been done has been mostly in the ponderosa pine forest cover type and drier end of the western larch cover type. The Northern Region of the Forest Service developed a set of definitions for all the cover types occurring there.

This study is focused on the more mesic habitat types (Pfister and others 1977, Cooper and others 1987). It will look at the most common cover types within this environment, Douglas-fir (Pseudostuga menziesii), western larch (Larix occidentalis), grand fir (Abies grandis), Engelmann spruce (Picea engelmannii), subalpine fir (Abies lasiocarpa) and western white pine (Pinus monticola).

LITERATURE REVIEW

Over the past 15-20 years, old-growth forests have been recognized as a community that support species which prefer and sometimes depend upon its existence to maintain their populations (McClelland and others 1979, Thomas and others 1979). Much of the research and knowledge about the uniqueness of old-growth has come out of the Douglas-fir region of western Oregon and Washington (Franklin and others 1981, Spies and Franklin 1988, Ruggierio and others 1991). Transferring much of what has been learned in these coastal forests is not appropriate for the northern Rocky Mountains because of the differing climatic conditions, species compositions, and disturbance regimes (Green and others 1992). However, there are also a number of principles and concepts that are transferrable and pertinent to the northern Rocky Mountains. Research done in the northern Rockies on the dynamics of vegetation, particularly in relationship to the role of fire, (Fischer and Bradley 1987, Arno and others 1985, Habeck 1990, Smith and Fischer in preparation) helps us understand the ecology of the old-growth stage and its relationship to other stages of forest development.

Habeck in 1988 discussed the question "What is Old-growth?" in a paper on northern region old-growth forests. He identifies the difficulty of "... a single definition being successfully applied to the wide range of ecogeographic subunits making up the northern Rockies." Pfister (1987) found that when desired levels of individual characteristics of old-growth are used in combination, very few stands qualify. Similar results have been reported in western Oregon and Washington where a high percentage of stands fulfill individual criteria, but a much lower number can fulfill all the criteria (Franklin and Spies 1991b).

This information reflects the high amount of heterogeneity in this stage of forest development that results from a combination of disturbance history, variations in species composition, establishment, site productivity, and others. It also highlights the pitfalls of using minimum criteria for several characteristics. However, use of only one characteristic like age or diameter, which has relatively strong correlations with the old-growth condition, also have enough error associated with them to be inadequate by themselves (Moir 1992, Spies and Franklin 1988).

The term "old-growth" has been used relatively loosely in the literature for decades. Foresters generally used it to connote stands that were well past the age of culmination of mean annual increment and which had little or no net wood production (Franklin and Spies 1991b, Hunter 1989, 1990);

wildlife biologists often used it to describe stand conditions that had characteristics beneficial to certain species of animals associated with or dependent on large decadent trees, snags, canopy layering (Bull 1978, McClelland and others 1979, Miller 1978); sometimes the term has been associated with individual old decadent trees; old-growth has also been called the last stage of succession (Miller 1978, Fischer and Bradley 1987, Thomas and others 1979), which has led to equating climax to old-growth.

More recently, attempts have been made to define it in broader ecological terms of composition, structure, and/or function (Franklin and others 1981, Spies and Franklin 1988, Bingham and Sawyer 1991). Hayward (1991) presented the argument that population dynamics of the trees may be used to define the old-growth stage based on the work of other researchers. Oliver and Larson (1990) presented the idea of true old-growth as the result of autogenic processes and the resulting forest is entirely comprised of trees that have grown from beneath the original overstory. They also recognized "transition old-growth" in forests that have relic long-lived seral species. They indicate structural conditions often associated with other definitions of old-growth can result from multi-cohort stands, mixed species single cohort stands in the stem exclusion, and stand reinitiation phases depending on the multitude of factors (allogenic processes such as fire, wind, insects, etc., species composition, tree initiation variations, etc.) that can influence stand development (Oliver and Larson 1990).

Kaufman and others (1992) discuss old-growth characteristics as independent of forest community development because of perturbations, such as fire, insects, disease, climatic, etc., that can affect the trajectory of stand development. They indicate that seral stands can acquire old-growth characteristics and then lose them (e.g. aspen). Moir (1992) discusses the idea of "a post-old-growth structure" where mortality of the old tree component dies out and is not replaced and the structure resembles earlier stages of forest succession. The resemblance does not mean that the next stage of development will be similar.

Franklin and Spies (1991b) purport a generic definition of old-growth forests, applicable to most temperate and subalpine forests: "Old-growth forests are later stages in forest development that are often compositionally and always structurally distinct from earlier successional stages." Franklin and Spies (1991b) then describe structural, compositional, and functional relationships generally associated with old-growth: Structurally, a wide within-stand range of tree sizes and spacing; trees that are large for the particular species and site combination; decadence is often evident in larger and older trees; multiple canopy layers are generally present; total organic matter accumulations are high relative to other developmental stages. Compositionally, there is usually an increase in the number of tree species, particularly shade tolerants, in old-growth. They indicate all climax forests qualify as old-growth, though most old-growth forests are not climax. Functionally, old-growth is characterized by slow growth of the dominant trees and stable biomass accumulations over long periods; respiration reduces net annual additions to live organic matter to low amounts relative to earlier stages. Franklin and Spies (1991b) also indicate the age at which forests become old-growth varies widely with forest type or species, site conditions and stand history.

Hunter (1990) considered 5 age criteria: 1) Is it near climax? 2) Is net annual growth close to zero? 3) Is the forest significantly older than the average interval between natural disturbances severe enough to lead to succession? 4) Have the dominant trees reached the average life expectancy for that species for that type of site? 5) Has the forest's current annual growth rate declined below the life-time average? He also examined two disturbance criteria: 6) Has the forest been extensively or intensively cut? 7) Has the forest ever been converted by people to another type of ecosystem? He goes on to express the very restrictive nature of criteria 1 and 6 and then chooses the term old rather than old-growth for the rest of his book, reasoning old can use the other 5 criteria for age.

In addition to the ecological values associated with old-growth, there are strong social values associated with this stage of forest development. People have expressed these values by referring to them as "ancient forests", "primeval", "virgin", "cathedral", and other similar terms, which evoke strong feelings associated with old-growth (Hunter 1990). Franklin and Spies (1991b) assert not all virgin or primeval forests are old-growth. Therefore, for both ecological and social reasons, the management of old-growth is important to public land managers.

The importance of the old-growth issue means that public land managers need to know how much and where they have old-growth. They need to understand the dynamics of old-growth development and maintenance, within a stand and across the landscape. These are prerequisites to deciding how to manage it and plan for its eventual replacement. However, before they inventory it, they must first define it.

In 1989, all the regions of the Forest Service were directed by the Chief to develop definitions for their various forest types. They were guided by a generic definition provided by the Washington Office, "... ecosystems distinguished by old trees and related structural attributes" (Robertson 1989).

The Northern Region developed definitions for three subregions, (northern Idaho, western Montana and eastern Montana), by habitat group and forest type using their existing timber inventory records system (Green and others 1992). A committee of professionals selected data, from each National Forest within a zone, based on age (greater than 100 years), dbh (greater than 9 inches or 23 cm), habitat type, cover type and no evidence of past logging. They developed old-growth types based on groupings of similar habitat types and cover types associated with those habitat types and then arrayed the plot characteristics. Based upon their professional judgement and experience, they established minimum criteria for age, and number of trees per acre by dbh for each habitat type group and cover type combination.

The Northern Region published the committee's results in a desk reference for agency managers use (Appendix E). The Regional Ecologist has expressed the desire to have the definitions tested for the northern Rockies.

Forest structure dynamics has been classified into stages called stand initiation, stem exclusion, understory reinitiation and old-growth (Oliver 1981, Oliver and Larson

1990). These stages are the "typical" development for a single cohort stand operating with autogenic or within-stand types of disturbances. They go on to describe how forests develop when added allogenic disturbances occur, (e.g. mixed-severity fire, insect, disease or weather-induced disturbances). These disturbances can produce multi-cohort stands with more complicated structure and composition.

O'Hara and others (1996) described several additional stages. They split stem exclusion into open versus closed condition. They changed "old-growth" into old forest multi-strata and old forest single-strata and added a young forest multi-strata. The disuse of old-growth attempts to get away from the "baggage" of the multiple definitions it has in the scientific and general public communities, while more effectively describing the stage of forest development from a scientific standpoint.

The "single" versus "multi" strata approach recognizes the existence of two very different conditions of the old forest stage. The single strata condition is often associated with the ponderosa pine forest type, fire group 4, or the drier western larch type that occurs in the broad valley bottoms that typically had a fairly frequent light to moderate severity fires (Fischer and Bradley, 1987). Fire suppression this century has turned many of the old forest single strata stands into multi-strata stands.

The multi-strata condition reflects the environments that had longer fire return intervals, fire groups 9 and 11 and the fires ranged from mixed severity to stand replacement (Fischer and Bradley 1987). This multi-strata condition is the focus of this study.

The mesic habitat types for this study are in fire groups nine and eleven in Montana (Fischer and Bradley, 1987) and fire groups five, seven, and eight in northern Idaho (Smith and Fischer in press). They have relatively long stand replacement fire return intervals 80-250+ years, but may experience fires as frequent as 20 years or as long as 450 years apart as reported by Zack and Morgan (unpublished) review of fire research in these mesic types. However their work reported the average stand replacement return interval to be 203 years in the interior Couer d'Alene basin and 138 years adjacent to Rathdrum prairie. They also estimated one to three mixed severity or nonlethal fires during the interval between the stand replacement fires.

One study in this habitat type group had mixed severity fires occur as frequently as every 30 years in the Swan Valley of Montana (Freedman and Habeck 1985). This kind of disturbance pattern leads to stands of multiple cohorts, which may or may not include intolerant species in the younger cohorts depending on the severity of the fire, seed sources, etc. The frequency and severity of these non-stand-replacing fires can have a substantial influence on the composition and structure associated with the development of these forest stands (Habeck 1970, Antos and Habeck 1981, Fischer and Bradley 1987, Oliver and Larson 1990).

In addition to fire as a disturbance agent, there are numerous insects and diseases that can substantially or subtly alter stand development, such as mountain pine beetle, Douglas-fir beetles, root rots, and the introduced white pine blister rust (Hagle and others 1989, Hagle and Byler 1993).

All these agents create the possibility for new cohorts to become established, grow, and respond to the changing competitive conditions that result. This leads to relatively complex stand age and composition structures (Oliver and Larson 1990).

The review above illustrates the abundance of qualitative description and definitition that has been applied to old-growth. While there has been fewer efforts to quantitatively describe and classify old-growth (Spies and Franklin 1991, Bingham and Sawywer 1991, Robertson 1992, Green and others 1992). The use of discriminant analysis has been used in a number of these studies to achieve the quantification of old-growth classification and description.

Thomas and others (1988) point out the importance of developing old growth definitions that are specific for all forest types.

Discriminant analysis assumes that the objects can be correctly classified initially and then the resulting discriminant function can be used to assign unknown observations to the proper group (Lachenbrch 1975). It can also be used to identify or describe attributes other than the ones used to assign them to groups (Klecka 1980). Discriminant analysis provides an objective method to evaluate the usefulness of a wide range of attributes, individually and collectively for the process of identification.

STUDY OBJECTIVES

The primary purpose of the study was to determine what *quantitative* ecological characteristics (structural, functional, compositional) are most effective in discriminating between the qualitative forest classes of Old Forest multi-strata (OFMS - old-growth) and all other stages (NonOFMS).

Mesic habitat types in the lower Clark Fork zone (Appendix A.), which very closely approximates the M333 province of Bailey's ecoregions (Bailey and others 1994) as modified by McNab and Avers (1994), were investigated for the following forest cover types· western larch, Douglas-fir, grand fir, Engelmann spruce, western white pine or subalpine fir.

Discriminant analysis can be used for either classification purposes or descriptive purposes (Klecka 1980). This study took advantage of both of these aspects of the technique.

The following are secondary objectives of the study:

a) Compare the results of the best discriminant model with the minimum criteria definition developed by Green and others (1992) for the Northern Region of the Forest Service and with other generic definitions that have been asserted.

b) Develop a methodology for refining old-growth (OFMS) definitions that may be applicable to the other old-growth types throughout the Northern Region.

The ecological characteristics available for use are limited to those collected for ECODATA exams for the Northern Region of the U.S. Forest Service (Jensen and others 1992). This was done for two reasons: first, there is an existing database in place from which to draw upon and secondly, it is the database that is being used for analyzing data by O'Hara and others (1996) for the Interior Columbia River Basin Project, of which this is a part.

METHODOLOGY

The methodology and analysis described below is loosely patterned after the studies conducted by Spies and Franklin (1991) in western Oregon and Washington, Bingham and Sawyer (1991) in northern California, and Robertson in Colorado (1992). These investigators sampled stands and assigned them to three age-classes labeled, young, mature and old-growth. Then they conducted stepwise discriminant analyses to identify ecological variables that provided the best multi-variate for distinguishing between these age-classes. The present study only has two age-groupings, Old Forest multi-strata (OFMS = old-growth) versus a group that includes stem exclusion, understory reinitiation and young forest multi-strata, (NonOFMS). A separate study is examining the differentiation of these structural classes. This study will use discriminant analysis with the author selecting the variables rather than in a stepwise fashion.

The data to be analyzed in this study are from the Northern Region ECODATA database. There are several sources of variation using this data set; multiple variations in the plot configuration; long periods of time over which the data has been collected; many different crews collecting the data; many different types of data could be collected. To minimize this variation the screening process below will be used.

1) The exam has been completed since 1988.

2) The stand habitat type falls into habitat type groups four, five and seven (Appendix A.) defined for the "lower Clark Fork" zone of the Northern Region (Applegate and others unpublished). The habitat types (Pfister and others 1977, Cooper and others 1987) include the western redcedar, western hemlock series and the mesic types of the grand fir and subalpine fir series. It represents a combination of the groups identified by Green and others (1992) for northern Idaho old-growth and for western Montana old-growth. The modification was made in recognition of the artificial (ecologically) nature of the state lines as a boundary.

3) The sample ECODATA plots had to have a minimum of: General Form (GF), which has the plot identification number, general site data, (such as slope, aspect, elevation, habitat type), and summary vegetation data; Tree Data (TD), which has detailed information about the trees on the plot i.e. species, diameter at breast height (dbh), height, damage agent, age etc.; Location Linkage (LL) which has the location information i.e. aerial photo it is located on, latitude and longitude, etc. A Down Wood (DW) was desirable, but not required. It has data from line

transects taken on the plot for duff depth, woody debris by size classes and decay classes, etc. (Jensen and others 1992)

4) The stands exist within Lolo N.F., Flathead N.F., Kootenai N.F., Idaho Panhandle N.F. and the Clearwater N.F.

5) The sampling must have included the recording of dead trees if present.

6) The stands exist within the Province M333: Northern Rocky Mountain Forest - Steppe - Coniferous Forest - Alpine Meadow (McNab and Avers 1994).

7) The Cover Type (Eyre 1980) had to be one of the following: western redcedar, western hemlock, western larch, Douglas-fir, grand fir, Engelmann spruce, western white pine or subalpine fir.

8) Stands with evidence of significant logging will be dropped to avoid the variation this treatment might induce.

9) Plots without tree age data were dropped, or that did not have ages from a variety of size classes.

The ECODATA (Jensen and others 1992) plot is normally a tenth-acre (0.04 ha) fixed plot. A variable plot sampling of certain tree components (live and dead) greater than five inches (12.7 cm) dbh is sometimes used. Snags are a component of forests that are generally few in number compared to the live trees and therefore are not sampled very well by a system designed to sample live trees. Therefore many of the plots used a combination of the tenth-acre (0.04 ha) macroplot and a small BAF variable plot (5 or 10) to sample the dead trees greater than five inches. The less than 5 inch (12.5 cm) tree components are sampled on a fixed plot. The fixed plot can vary in size from the tenth-acre macroplot to some fraction of that macroplot. In the data set used for this analysis it varied from the full macroplot, to one-tenth of the tenth acre (or 1/100th ac or .004 ha). On one set of the plots the variable plot sampling technique using a Basal Area Factor (BAF) was used in conjunction with a fixed hundreth-acre plot for the understory trees. Appendix C. displays all the plots and their respective plot sizes for sampling. The variety of sample plot configurations introduce an element of variation that is undesirable but had to be tolerated.

Tree age was recorded as the actual age. It was usually collected on one tree per diameter class, however not always.

The habitat type is sampled using the tenth-acre (0.04 ha) macroplot (Pfister and others 1977 and Cooper and others 1987). The coarse woody debris was sampled with a set of fuel transects (from 4 to 10 per macroplot) (Brown 1974).

After the plots were screened to identify which could be used for the study they were separated into two groups:

a test set and an independent validation set. There were 58 plots in the non-old forest multi-strata (NonOFMS) set. Thirty-eight were assigned to the test set and 20 to the validation set. The old forest multi-strata (OFMS) only had a total of 26 plots available 10 were put in the validation set and 16 in the test set.

Old-growth is a stage of forest development typically characterized by a relatively high degree of heterogeneity within a stand. The northern Rocky Mountains have a high degree of variation in environment because of changes in slope, aspect, elevation, soil type and changes in microclimate. Robertson (1992), in his analysis of spruce-fir and lodgepole pine old-growth in Colorado discusses the importance of trying to reduce this heterogeneity when analyzing old-growth forests. In the northern Rocky Mountains, groups of similar habitat types have been used to stratify the sites and reduce environmental variation within sample groups.

The environmental variation has been reduced for this study by using the old-growth types which are a combination of habitat type groups and cover type developed for the Northern Region (Green and others 1992). The old growth type number is four for both western Montana and north Idaho zones of the region. The old growth types include the more mesic habitat types of the grand fir, alpine fir and western redcedar series. The forest types included are western larch, Douglas-fir, grand fir, subalpine fir, or redcedar in western Montana whereas north Idaho separates redcedar into its own group and includes western white pine. Table 4. displays the two types and the old growth characteristics.

This study ignored state line boundaries and used the M333 province (McNab and Avers 1994) as a geographic area of relatively uniform climate and thus potential vegetation. Western redcedar and western hemlock were excluded from the cover types, as they behave considerably different from the other cover types, given their extreme shade tolerance, thin bark and the role of fire in their development is much reduced. The western white pine type was included in the analysis as in the north Idaho definition. The only significant difference, in the criteria, between these definitions is the age break, 150 years for Idaho and 180 for Montana. This was based on the generally higher potential productivity in northern Idaho than in western Montana and therefore a longer period of time was needed to achieve the other characteristics.

The data was divided into 2 groups: Old Forest multi-strata (OFMS) and Non Old Forest multi-strata (NonOFMS). It has been recognized by other authors (Spies and Franklin 1991, Kaufman and others 1992) that this is an artificial division of a continuous system. However, it is needed to describe and define these classes for the purposes of inventory and management.

To use discriminant analysis the data must be assigned to groups a priori. The separation between NonOFMS and OFMS was taken from the age definition in Green and others (1992) for western Montana (180 years). The category it would have been in if the north Idaho age break (150 years) had been the criterion used was also recorded. Age was chosen because it is strongly correlated with the characteristics of old-growth (Franklin and other 1981).

I did not want to use any other minimum criteria, such as minimum dbh of a certain size, as it would preclude the use of that variable in the discriminant analysis. The use of additional criteria would have resulted in the pitfalls identified by Pfister (1987) and Spies and Franklin (1991), associated with multiple minimums. In making the decision to only use age in defining the two classes, it was recognized that there would likely be misclassification errors (Thomas and others 1988), that would not be real errors based on the professional evaluation of the stand attributes and the assignment to one of the classes.
The use of a single inflexible criterion when classifying a continuum will cause some degree of error identification (McNicoll 1994). This method of placing stands into groups was considered necessary because existing data were used and

the sites were not visited to allow the qualitative assignment to groups. Given this situation, the plots were reviewed and evaluated after the final discriminant modeling runs were made to assess the affects of using the age criteria only.

The age selected by Green and others (1992) approximates the time when long-lived seral species of this old-growth type (western larch, Douglas-fir, western white pine) show signs of declining condition such as stem rots, dead or broken tops and other characteristics of "old-age". Older age also permits a greater likelihood that the set of agents, i.e. fire, insects, disease, competition or the combination of several or all of them, facilitate the development of additional cohorts. The age of the stand was determined by examining the age of the oldest cohort evident in the stand.

Many of the variables analyzed (basal areas, trees/acre, etc.) are taken from the summary tables generated by the TREE program in ECOPAC (Jensen and others 1992). Some were extracted directly from the ECODATA database or manipulated with PRESENT (1985) software macros (basal area of top damaged trees, stem defect, cover of trees by size class, etc.). The number of cohorts was determined by reviewing the age data summarized by the TREE output (Live Mean Age Table). The following rules were used as guidelines for assigning a cohort:

a) To assign a cohort to the intolerant category there had to be one of the following species present: western larch, ponderosa pine, lodgepole pine, Douglas-fir or western white pine.

b) In reviewing the different ages, intolerants were generally assigned to a separate cohort if there was more than 30 years age difference. Sometimes there was a progression of ages that appeared to be part of the same cohort and a second cohort would not be identified even if the 30 year span was exceeded.

c) Ages of the tolerant species between intolerant cohorts were ignored if the intolerants were closer than 80-100 years.

d) When spans longer than 80-100 years occurred or there was only one or no intolerant cohort present, I looked for "waves" of ages in the tolerant species. These "waves" could be 50-60 years wide. Western redcedar could have even longer "waves" because of its ability to continue to establish itself in very low light conditions.

Given the continuous nature of forest development and the myriad of forces operating that cause it to follow different pathways, I did not expect to develop a discriminant function that would separate stands perfectly.

I expected some stands would have a combination of characteristics that would cause them to be classified OFMS or NonOFMS incorrectly according to the age.

CALCULATIONS AND ANALYSIS

To differentiate OFMS from NonOFMS, my dependent variables, the list of independent variables (Table 1) were developed. The list was based on a review of the literature and my own experience indicating variables that might serve as ecologically meaningful in separating old forests from younger stages of forest development (Spies and Franklin 1991, Bingham and Sawyer 1991, Popp and others 1992).

The median and quartiles for each of the interval data variables were calculated and displayed in box plots using the SYSTAT software (Wilkinson 1989) statistical package (Appendix B.). The boxplots were reviewed to identify the independent variables that appeared to be different enough to warrant testing in a discriminant function.

Using boxplots (Appendix B.), means, and standard deviations (Appendix D.), the variables in Table 3. were identified as worth testing in the discriminant analysis. The variables were selected by comparing the alignment of the quartiles visually and identifying the variables that had less than approximately 50% overlap.

There were five parameters reviewed for each run to assess the performance of the discriminant function: Wilks Lamba, which is an inverse multivariate measure of group differences ranging from 0 to 1 (Klecka 1980); Canonical Correlation, which is a measure of association that summarizes the degree of relatedness between the groups and the discriminant function (Klecka 1980); Correct Classification Rate, which is the percentage of the time the data is assigned to the correct group; the Probability associated with the overall function, which indicates the likelihood there is statistical significance; the F-statistic which is a test of group differences, and is compared to standardized tables.

The resulting discriminant model was validated against the independent set of stands randomly selected.

Table 1. Variables Considered in Discriminant Analyses

OVERSTORY (> 5 in dbh)	
BA_TOT	Total basal area
TPA_GT5	Tree density - trees per acre
BA_TOT21	Basal Area trees > 21" dbh
BA_21_N	BA_TOT21 divided by BA_TOT
BA_GT19	Basal Area trees > 19" dbh
BA_GT17	Basal Area trees > 17" dbh
BA_GT15	Basal Area trees > 15" dbh
BA_TOL21	Basal Area of tolerant trees > 21"
BA_INT21	Basal Area of intolerants > 21" dbh
DBH_GT5	Tree dbh mean
CVDBH	Tree dbh Coefficient of Variation
BA_INTOL	Intolerants basal area
BA_TOL	Shade tolerant basal area
CVHT	Height Coefficient of Variation
BA_TOP	Top damaged trees BA, all species
BA_STEM	Stem defect BA, all species
DECAY	Sum of BA_TOP AND BA_STEM
DECAY_N	DECAY divided by BA_TOT
COHO_INT	# of cohorts, intolerants
COHO_TOT	# of cohorts, total
COHO_SUM	Sum of COHO_INT and COHO_TOT

TREE COVER BY SIZE CLASS	
COV_SEED	Cover of seedlings (%)
COV_SAP	Cover of saplings (%)
COV_POLE	Cover of poles (%)
COV_MED	Cover of medium (%)
COV_LG	Cover of large (%)
COV_VLG	Cover of very large (%)
COV_TOT	Cover of all size classes (%)
YOUNG	Sum of COV_SEED and COV_SAP
YOUNGX	Product of
BIG	Sum of cover of large and v.large trees
YOBIG	Sum of YOUNG and BIG
YOBIGX	Product of YOUNG+1 and BIG+1
YOBMRATO	YOBIG divided by COV_MED+1
YOBXMRAT	YOBIGX divided by COV_MED+1
UNDERSTORY	
TPA_LT5	Total seed/sapling density < 5" dbh
MOSS_COV	Moss cover (%)
FORB_COV	Herbaceous cover (%)
S_TOT	Shrub cover (%) - all heights
FERN_COV	Fern cover (%)
DEAD COMPONENTS	
TPA_DTOT	Total # of snags/ac
DED_GT10	Total # of snags/ac > 10"
DED_GT18	Total # of snags/ac > 18"
BA_DTOT	Total dead basal are
BA_DTOL	Basal area of dead tolerant species
BA_DINT	Basal area of dead intolerant species
SNAG_DBH	Average dbh of snags
SNAG_CON	Average condition class of snags
DUFF_LIT	Duff and litter thickness
TOT_1000	Total tonnage > 3" diameter material
ROT_1000	Tonnage of rotten > 3" dia. material
SND_1000	Tonnage of sound > 3" dia. material
TOT_WOOD	Total tonnage of material > 1/4"

RESULTS AND DISCUSSION

CLASSIFICATION RESULTS

Comparison of Model Runs

Initial runs tested used structural variables that were indicative of an old forest such as top damage, stem damage, the basal area of trees greater than 21 inches (53 cm), average dbh of snags, average dbh of live trees greater than five inches, and combinations of these variables. The resulting function from run 15 gave a fairly good classification rate, 81.5% (Table 2).

Following the intial runs two groups of variables were tested. The first group relates to the number of strata, or the canopy structure, of the stand. They are the variables related to canopy cover by size classes, the tree cover by size class variables in Table 1. Several combinations of size classes showed good potential from the box plots. Run 23A illustrates the strongest of these variables, the sum of the seedling/sapling trees with the large trees (YOBIG). Table 2 shows the improvement of the canonical correlation and Wilks Lambda values. The partial F-value was the largest for a variable to that point in the analysis.

The second group of variables tested related to the number of cohorts in a stand. I counted the number of shade intolerant cohorts (COHO_INT), the total number of cohorts

(COHO_TOT) and the sum of the two variables (COHO_SUM) in Table 3. All three variables proved to be powerful discriminators with the sum of the intolerant cohorts and the total number of cohorts (COHO_SUM) being the most powerful of all the variables tested.

Table 2. Discriminant Analysis Evaluation Parameters.

Run No.	Wilk's Lambda	Canon Correl.	Correct Classif.	F-Stat	Variable Used
15a	.641	.599	81.5%	6.85	Decay_N Snag_DBH DBH_GT5 BA_Tot21
23a	.546	.674	85.0%	7.98	Decay_N Snag_DBH BA_Tot21 YoBig
26	.384	.785	92.6%	12.55	Decay_N Snag_DBH DBH_GT5 BA_Tot21 YoBig CohoSum
35	.404	.772	96.3%	14.15	Snag_DBH DBH_GT5 BA_Tot21 YoBig CohoSum
36	.419	.762	94.4%	16.96	DBH_GT5 BA_Tot21 YoBig CohoSum
37	.423	.760	94.4%	22.78	BA_Tot21 YoBig CohoSum

The discriminant function that appeared to provide the best overall performance, based on the parameters above, was run 35 (Table 2), which had 96% correct classification rate. Run 35 was tested without the variables SNAG_DBH and DBH_GT5 and retained a 94% classification rate. This discriminant model, number 37, was identified as the most desirable for classification purposes (Figure 1.), since it achieves a high classification rate with only three variables (COHO_SUM, YOBIG, BA_TOT21), making it more efficient. The resulting discriminant function is:

$$f = -44.68 + .737(Coho\_Sum) + .405(YoBig) + .379(BA\_Tot21)$$

Where f denotes the discriminant scores for each case and the variable name represents the value for that case. If the value is greater than zero then it is assigned to old forest multi-strata and if less than zero it is non-old forest multi-strata.

Group Assignment (ROWS) by predicted (COLUMNS)

FREQUENCIES

	NonOFMS	OFMS	TOTAL
NonOFMS	36	2	38
OFMS	1	15	16
TOTAL	37	17	54

Figure 1. Classification of Structural Classes from plots used to build Discriminant Model.
Overall classification success rate: 94.4%

Figure 2 illustrates the array of the classified plots and their relative position to each other. The graph illustrates the continuous nature of the stands.

The final model was run on the independent data set with the resulting classification rate of 90% in Figure 3.

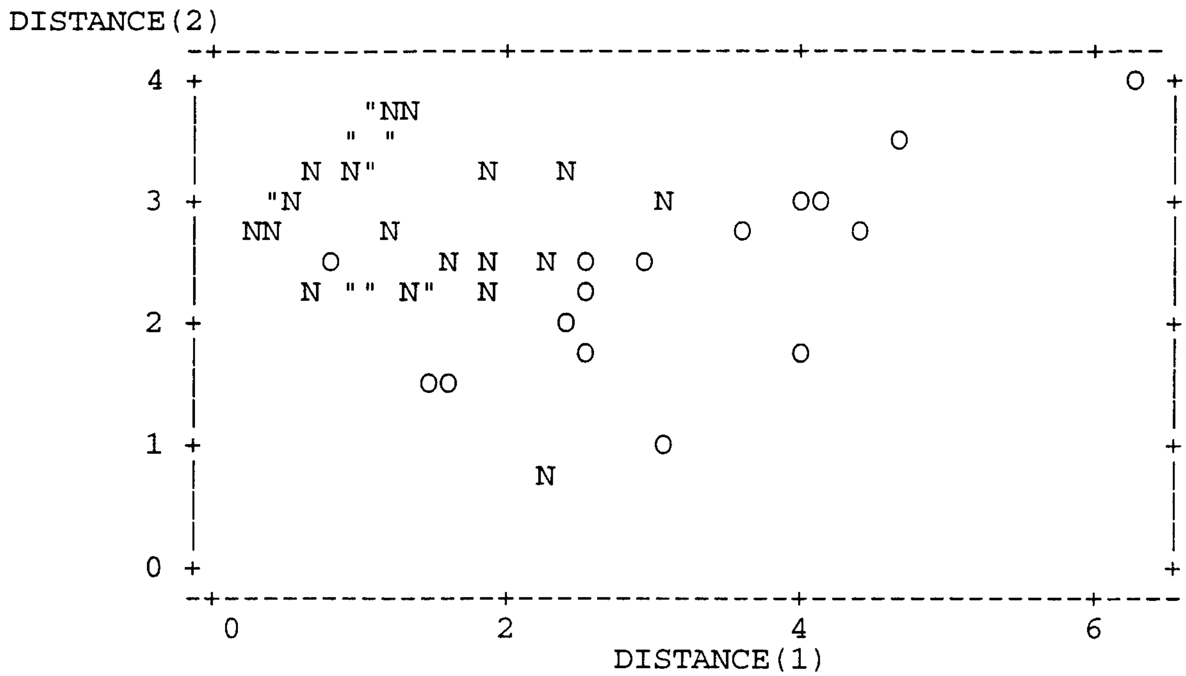

Figure 2. Array of Classified Plots.
N=NonOFMS O=OFMS " = more than one plot at the location

Group Assignment (ROWS) by predicted (COLUMNS)

FREQUENCIES

	NonOFMS	OFMS	TOTAL
NonOFMS	19	1	20
OFMS	2	8	10
TOTAL	21	9	30

Figure 3. Classification of Structural Classes from Independent Data Set.
Overall classification success rate: 90%

Table 3. Variables Tested in Discriminant Runs.

OVERSTORY (> 5 in dbh)	
BA_TOT	Total basal area
BA_TOT21	Basal Area trees > 21" dbh
BA_21_N	BA_TOT21 divided by BA_TOT
BA_GT19	Basal Area trees > 19" dbh
BA_GT17	Basal Area trees > 17" dbh
BA_GT15	Basal Area trees > 15" dbh
BA_TOL21	Basal Area of tolerant trees > 21"
BA_INT21	Basal Area of intolerants > 21" dbh
DBH_GT5	Tree dbh mean
BA_TOP	Top damaged trees BA, all species
BA_STEM	Stem defect BA, all species
DECAY	Sum of BA_TOP AND BA_STEM
DECAY_N	DECAY divided by BA_TOT
COHO_INT	# of cohorts, intolerant species
COHO_TOT	# of cohorts, total
COHO_SUM	Sum of COHO_INT and COHO_TOT
TREE COVER BY SIZE CLASS	
YOUNG	Sum of COV_SEED and COV_SAP
YOUNGX	Product of
BIG	Sum of cover of large and v.large trees
YOBIG	Sum of YOUNG and BIG
YOBIGX	Product of YOUNG+1 and BIG+1
YOBMRATO	YOBIG divided by COV_MED+1
YOBXMRAT	YOBIGX divided by COV_MED+1
DEAD COMPONENTS	
SNAG_DBH	Average dbh of snags

Model Errors

Review of the misclassified plots, including the three from the test set (used to develop the model) and the three from the independent data set, indicates three types of errors:

a) Errors associated with the use of the western Montana age criterion of 180 years (Table 4). There were two of the six plots in this category. The age of the oldest cohorts were 168 and 170 years, which means they would be considered old-growth using the Northern Region's, north Idaho age criterion of 150 years. However one of the two plots were located in Montana. Both of the plots had higher than average basal area for trees greater than 21 inches (53 cm). Both plots were very near the average for canopy cover in the small and large size classes. For the cohort variable, they were near the average for NonOFMS stands. Therefore, these model "errors" are actually correctly classified and the mismatch can be attributed to the labeling methodology. It was recognized in the design of the study some of these apparent errors would be created, as discussed in the methods section.

Table 4. Northern Region Old-growth Characteristics

OG TYPE	MIN AGE*	MIN TPA*	DBH VARIA	% DEAD TOP	DWOOD	DECAY	CANOPY LAYERS	SNAGS	STATE
4	180	10>21"	H	9	H	9	MLT	15	W.MT
4	150	10>21"	M	0-28	M	1-4	SNGL/-MLT	1-3	ID
	* - required criteria								

b) Errors associated with the labeling of OFMS by using age alone as a criterion. Two of the errors were similar to a) above except in the other direction. On these plots the age criterion was easily exceeded (312 and 305 years), however the amount of large trees was quite low (20 (1.9 square meters) and 24 square feet (2.2 square meters) of basal area/ac. compared to 124 square feet (11.5 square meters) average for OFMS). The number of cohorts was less (4 versus an average of 5.8) for both plots and one was considerably low in the canopy cover by size class variable, the other was above the average. Evaluation of the data revealed them to both have remnant survivors from fairly severe fires and one was in the stem exclusion phase, while the other was in the understory reinitiation phase. Therefore, these are more "apparent" errors and the model accurately classified them when more than age was considered.

c) The final two errors, after reviewing the plot data are true errors in classification. The data supported the original labels, though they are in the "gray zone" of assigning continuous phenomena into discrete classes. Their attributes are such that they overlap with the other class. This is evident when the probabilities associated with the assignment to a class are examined in Table 5. It reveals these two plots do not have a high likelihood of belonging to either group.

The review of these "apparent errors" indicates the discriminant model performs better than the indicated classification rate. The results are congruent with the prediction of such errors by using only age as the variable for creating the categories.

Table 5. Discriminant Analysis Probabilities of Group Membership

	DIST(1)	DIST(2)	PROB(1)	PROB(2)	GROUP	PREDICT
CASE 73	1.422	1.306	0.460	0.540	NonOFMS	OFMS
CASE 80	1.529	1.786	0.605	0.395	OFMS	NonOFMS

DESCRIPTIVE RESULTS

Processes

The sum of intolerant and total number of cohorts variable (COHO_SUM), reflects the nature of the development of forests in the northern Rockies as a result of fire modifying the population dynamics in the stands. Generally, the longer a stand develops without a stand replacing fire the more cohorts can be expected to have developed as a result of mixed severity fires, insect outbreaks, or disease. Often these stands can be viewed as having progressed through two or more cycles of cohort establishment, depending on the severity of the fire. They may exhibit the characteristics of stand initiation, stem exclusion or understory reinitiation, while retaining trees of the surviving cohort which affect the survival, growth, and development of the new cohort, examples of multi-cohort stands (Oliver and Larson 1990).

Usually, the mixed severity fire disproportionately reduces the fire intolerant species (i.e. grand fir, spruce, hemlock, cedar, lodgepole). Many of these trees are shade tolerant resulting in significant shifts in species composition in the surviving stand. The amount of mortality in the overstory and the resulting amount of growing space available influences the species composition and subsequent growth and structure of the stand. All these factors contribute to the high degree of variation in what people commonly refer to as old-growth in the northern Rockies.

The number of cohorts proved to be the most significant variable, whether looking at shade intolerant cohorts or at the total number of cohorts. Only 3 of the 26 OFMS stands did not have multiple cohorts of intolerant species. As mentioned above this indicates the important role of allogenic disturbances in the development of old forests in the northern Rockies, be it fire, insect outbreaks, weather or a combination of all of them.

Dead Components

The results of this study indicated snag abundance sorted by size class was a relatively poor variable for separating old forest multi-strata (OFMS) from non-old forest multi-strata (NonOFMS), based on the boxplots, means, and standard deviations (Appendix B). This is in contrast to Spies and Franklin (1991) study on the west coast that found snag numbers and downed logs to be significant variables for discrimination.

There are a couple of possible explanations for this difference between the west coast and northern rocky mountain old forests. First, given the frequency of mixed severity fires in these stands many of the snags may be periodically lost (and created) during these events. However past inventories done on the Lolo N.F. (Lolo N.F. unpublished, Missoula, MT) have shown greater numbers of larger snags in the older stands. Therefore, the second possible explanation has some merit: the occurrence of snags on an acre is relatively low compared to live trees, therefore the tenth-acre plot (used most frequently to sample snags in the study) in combination with only one plot per stand may have resulted in variation from sampling too great to detect any differences that may occur between the populations.

The average snag diameter (SNAG_DBH) variable had a partial-F value indicating it had some differentiating ability and that the OFMS condition has larger snags on the average than the NonOFMS stands.

The down wood sampling is more reliable than the snags, since there were multiple transects taken on the plot. Unfortunately only 13 of the 16 OFMS plots and 23 of the 38 NonOFMS plots were sampled and therefore were not used in the discriminant analysis. However examination of the boxplots indicated little promise for its use. The duff/litter depth, and the large (> 3 inch (7.6 cm) diameter) woody debris variables all had overlapping values between the OFMS and NonOFMS stands (Figure 4). The mixed severity fires periodically would tend to reduce the accumulation of organic matter that Spies and Franklin (1991) noted. It is important to recognize that Spies and Franklin chose stands in their sampling scheme that had no evidence of intermediate fires. In the northern Rockies it is hard to find such a stand. Fischer and Bradley's (1987) work summarized numerous fire and fuel loading studies and the down wood and duff depth data do not show any clearly discernible trend with stand age, as evidenced by the data reported for fire group 11. Bingham and Sawyer's (1991) work in northern California in old-growth Douglas-fir/hardwoods, which received significant effects from low to moderate intensity fires, reported that the dead wood components have little to moderate discriminating ability because of the between and within stand variation.

Harmon and others (1986) report that decay rates, environment, disturbance history and topography affect the accumulation and distribution of coarse woody debris. They often come in waves as a result of a disturbance. They can also disappear in waves (a "double burn" event). These factors interact and influence stand development regardless of age and help explain why these features can be similar regardless of stage of development.

```
     BOX PLOT OF VARIABLE: ROT_1000    , N =    36
        GROUPED BY VARIABLE:     STAGE
    0.00                                                          63.46
MINIMUM                                                         MAXIMUM

    ----+------
  -+(  +    ) +--------------   *                                 0        NONOFMS
    ----+------
     +-----------
  --+     )     +---                                      0       0        OFMS
     +-----------
       BOX PLOT OF VARIABLE: TOT_1000    , N =    36
        GROUPED BY VARIABLE:     STAGE
    2.24                                                         104 53
MINIMUM                                                         MAXIMUM

  -----+------
  + (  +    ) +---------               *                                   NONOFMS
  -----+------
     -+-------
  (--++  )    +---           *                                     0        OFMS
     -+-------

       BOX PLOT OF VARIABLE: SND_1000    , N =    36
        GROUPED BY VARIABLE:     STAGE
    0.00                                                         104.53
MINIMUM                                                         MAXIMUM

  -+--
  (+)+----    *                                                            NONOFMS
  -+--
   -+---
  (++ )+        *                                                  0        OFMS
   -+---

       BOX PLOT OF VARIABLE: TOT_WOOD    , N =    36
        GROUPED BY VARIABLE:     STAGE
    3.50                                                         106.32
MINIMUM                                                         MAXIMUM

      ----+------
  ---+(  +    ) +--------               *                                  NONOFMS
      ----+------
        -+------
   -(--++  )   +---           *                                   0        OFMS
        -+------

       BOX PLOT OF VARIABLE: DUFF_LIT    , N =    36
        GROUPED BY VARIABLE:     STAGE
    0.00                                                           6.16
MINIMUM                                                         MAXIMUM

             -------+---------
  -----------+ (     +     )   +----------------------          *          NONOFMS
             -------+---------
               ----+-----------
             (-+    +        )   +----------                               OFMS
               ----+-----------
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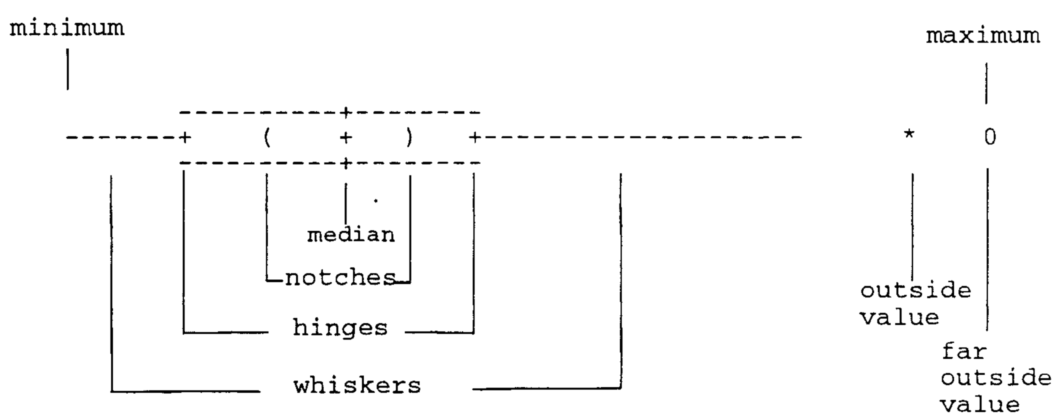

Figure 4. Boxplots of Organic Matter Variables. (Tons/acre)

Overstory

The overstory variables have been grouped into density, dimension, decadence and cohort variables for the following discussion.

Canopy Structure

The arrangement of canopy cover into various layers, proved to be important. The YOBIG variable, the significant layers are the seedling and saplings combined with the large and very large size classes. These indicate trees becoming established and competing in response to available growing space provided by a disturbance of intermediate severity or the opening up of the canopy from autogenic processes.

Density

Review and analysis of the data indicates that large trees are important variables in classifying and describing old forests multi-strata. The basal area of trees greater than 21 inches (53 cm) was the best density/size variable for discrimination, however using basal area greater than 19 inches (48 cm) had very similar discriminatory power. This indicates the continuous nature of this characteristic. The evaluation of the greater than 17 inch (43 cm) and greater than 15 inch (38 cm) diameter classes showed considerable drops in discriminatory power thus validating the use of 21 inches (53 cm) as a reasonable break to use. This confirms that old forests have relatively large trees, although there were a few stands that were classified as old forests that had zero basal area in this category. Conversely there are some stands that can achieve a large size and not be very old. This is observed in some of the plots having quite large trees for their age, plot FS011607912E018 had 106 square feet (9.8 square meters) of BA greater than 21" (53 cm) dbh with 130 year old trees.

Dimension

The examination of the coefficient of variation of height and diameter of the trees in the two groups showed no discriminating power. This was expected because the non-old forest multi-strata (NonOFMS) class included many young multi-strata (YFMS) stands and understory reinitiation stands that have high variation in diameters and height. Spies and Franklin (1991) identify variation of diameters as important however their study did not include multi cohort stands, thus removing the type of variation that YFMS stands can introduce.

Decadence

The amount of decay occurring in the old forest multi-strata stands (OFMS) was generally more abundant than the non-old forest multi-strata (NonOFMS) stands, however the variability within the two populations sampled makes it less valuable as a criterion for differentiation. There are many processes that can initiate decay in trees, (weather, fire, etc.) and these can operate on young stands as well as old, thus its lower reliability for differentiation. However the generality that OFMS will tend to have more decadence is borne out by the boxplots Appendix B.

Comparison with Generic Definitions

The literature has many generic different descriptions, criteria and definitions outlined for old-growth (Thomas and others 1988, Hunter 1989, Franklin and Spies 1991b, Moir 1992). Many of these have a lot of similarity. Comparisons of the results of this study to the most commonly used characteristics in the literature indicate the following:

1) **Age** - Are the dominant trees close to their average life expectancy or are they significantly older than the average time interval between natural disturbances?

Lethal or stand replacement average fire return intervals of these mesic types in various studies have been: 119, 138, 150, 197, 203 and 216 years with the range being from 18-452 years (Zack and Morgan unpublished). In this study the youngest cohort classified as OFMS was 167 years. Therefore the stands are sometimes older and sometimes younger than the average lethal fire return interval. But they are considerably older than the intermediate fire return intervals, which are generally 100 years or less (Zack and Morgan unpublished).

The most common species in this oldest cohort, Douglas-fir, western larch, and western white pine can be quite long lived (maximum of 500-700 years old). Their average life expectancy is determined by the next stand replacement fire or insect or disease outbreak and consequently is much shorter than the maximum. Therefore the old forests from this classification are generally greater than the average time interval between stand replacement fires but are considerably less than their potential life expectancy.

2) **Growth Rate** - Is net annual growth close to zero and are biomass accumulations stable over long periods?

This was not measured directly in this study. The oldest cohorts were well past the age when stands are expected to have culminated mean annual growth. However the stands have numerous cohorts, many of which include shade intolerant species that require substantial amounts of light and growing space to thrive and compete, which indicates periods of growth that would have been substantially positive. They likely have had and may have again (after an intermediate disturbance) a period of time when the annual increment is positive for several decades before the site is again fully occupied and mortality again offsets growth. This fluctuating pattern of growth does not fit the image the growth rate descriptor above portrays of a stand that exhibits little change in growth over long periods.

These intermediate disturbances also cause similar fluctuations in total biomass. Duff and woody debris are consumed in a fire, or may increase with a windstorm that blows down part of the stand. Therefore total biomass fluctuates also.

3) **Decadence** - Is there evidence of decay in the stand?

This study indicates there usually is but younger classes can have as much and occasionally more, though the general rule is applicable.

4) **Climax** - Is the species composition of old-growth relatively stable; an increase in the number of species, particularly tolerant species compared to earlier stages of development? An analysis looking specifically at how composition varied was not done. However, attempts to use variables that grouped tolerant and intolerant species had no value in the analysis. Only 15% of the OFMS stands were tolerant species cover types wheras 32% of the NonOFMS stands were tolerant species which indicates little

relationship to climax or even dominance by tolerant species.

It is difficult to assess "relatively stable". How long a time period does this encompass? What percentage of a stand's history is involved? Except for the stand initiation period, stands are relatively stable in composition throughout their development unless some allogenic disturbance occurs. If processes are autogenic then any change in composition, if it does occur, must be measured gradually over decades. These OFMS stands are likely "relatively stable" until the next disturbance.

5) **Structure** - The canopy layering by size class is more complex on old forest multi-strata (OFMS) than non-old forest multi-strata (NonOFMS). The variation in dbh and height was not a significant variable. This is due to the variability in young forest multi-strata stands. Stand initiation and stem exclusion are much more uniform (Latham unpublished).

None of the generic definitions discuss intermediate severity disturbances having a role defining old-growth. The discussion always relates to gap processes from individual tree mortality. Oliver and Larson (1990) note that multi-cohort stands have structural attributes like old-growth but are created by these intermediate disturbances.

The use of definitions of old-growth that exclude intermediate disturbances and/or use multiple minimum criteria will indicate only small amounts of old-growth in the Northern Rocky Mountains. If these kinds of definitions are used then the results of this study are unrelated to old-growth because almost all of the old forest stands have evidence of intermediate disturbances in their development. However the results of this study indicate there is a recognizable structural class in the northern Rocky Mountains called old forest multi-strata (which may or may not also meet the socially defined term old-growth). It is distinct, and a component of current landscapes which is structurally complex with relatively old, relatively big trees.

Comparison with Northern Region Definition

When the discriminant analysis results are compared to the Northern Region old-growth definitions (Green and others 1992), the same conclusions are reached as Pfister (1987) and Franklin and Spies (1991b). Namely, a combination of minimum criteria result in excluding stands that are really old growth except they don't meet one or more of the minimums. It is less of a problem for the northern region than the other studies since they only had two criteria to meet, a minimum age and minimum number of trees per acre greater than 21 inches dbh (53 cm). In addition, Green and others (1992) indicate that assignment to old growth should not be based strictly on the numbers because there is so much variation in old-growth stand structures.

The discriminant analysis confirms the use of 21 inches dbh (53 cm) as a reasonable value, however there were cases that did not have any trees greater than 21 inches (53 cm) that were old forest multi-strata based on the other criteria and create errors of omission if the dbh is used as a minimum. The results demonstrate that a minimum age criterion will result in some old forest multi-strata stands not being identified as such thus creating errors of omission when classifying.

The use of discriminant analysis avoids the problem of minimums, since it uses the combination of the model variables to make the assignment to a class. One variable can be very low but the other variables compensate, allowing it to be assigned to the class even though it did not meet the minimum criteria. The user has the added benefit of reviewing the euclidean distance or probability the plot has of being assigned to a class. Probabilities that are very close together are an indication of a stand that is on the edge of the two classes, thereby helping the user to see the continuous nature of forest conditions (Appendix E). This feature accomplishes the stated desire of Green and others (1992) that strict number minimums should not be applied.

The other descriptive variables (Table 4.) identified by Green and others (1992) are generally applicable, but have a great deal of variation which makes them less reliable as distinguishing characteristics, which is what they concluded.

Data Limitations

There are several shortcomings in the data used in this study and suggestions for improvement of similar work in the future to be noted.

1) The stands had only one plot in it chosen to be representative of the stand. This precludes the opportunity to examine and describe the within stand variation, especially attributes that have a clumpy distribution.

2) The plots were collected over the span of 5 years and by different crews with other objectives in mind. Therefore, the potential for inconsistencies being introduced exist. Point three below highlights one of these.

3) Snags were sampled with different methods. Some of the plots used the tenth-acre macro plot, which is

too small to adequately sample a population with the low density and variable distribution generally found with snags. Some of the plots used two different basal area factors (BAF), one for live trees and a smaller one (usually a five) for the snags. The existence of only one plot per stand combines to make the sampling of this attribute decidedly lacking.

4) The lack of dead biomass information on all the plots precluded a complete evaluation of its role in classifying old forests.

5) A nested plot sampling design would have improved the usefulness of the data, as Spies and Franklin (1991) and Bingham and Sawyer (1991) used.

6) More complete age sampling would be desirable. Some of the plots had less than desired amounts of age data. The age sampling should attempt to identify all potential age cohorts.

7) Collection and documentation of disturbance history data and the likely agents of change would be helpful in more completely documenting our understanding of old forest dynamics.

8) Collection of enough plots in the various cover types to examine whether there are differences between the types that were grouped in this study.

9) Possibly the most important suggestion would be to use one or more people knowledgable of the O'Hara and others (1996) system to make assignments to the classes in the field, based on their evaluation. This would permit the use of oldest cohort age as a variable in the discriminant analysis, which could not be because it was used to create the initial groups. I would expect it to be a significant variable in a discriminant analysis since it was chosen as the best single variable to make assignments to groups. Therefore it would be desirable to have it included in the discriminant analysis.

CONCLUSIONS

I identified three ecological characteristics, besides age, that were most effective in quantitatively separating old forest multi-strata (OFMS) from non-old forest multi-strata (NonOFMS) stands: a) the sum of the shade intolerant cohorts and the total number of cohorts for the stand (COHO_SUM), b) the sum of the canopy cover of small and large trees, c) the basal area of trees greater than 21 inches (53 cm).

The results indicate the use of discriminant analysis for an ecogeographic region in this study was successful as a tool for identifying old forest multi-strata stands. No problems were identified that would prevent it from being applied to other old forest types within the northern Rocky Mountains. Its application for classification of structural class and description of old forests is warranted.

The results also indicate the Northern Region's current definition for old growth type 4 (Green and others, 1992) has some errors of omission because of the dual criteria of minimum age and minimum trees per acre greater than 21 inches (53 cm). Therefore the Northern Region should consider revising their current definitions using this methodolgy.

Lastly, the role of non-stand replacing disturbances, as a process, in the development of structure and composition of old forests in the northern Rocky Mountains is vital to understanding its creation and maintenance and needs to be recognized for the management implications of this forest community.

MANAGEMENT IMPLICATIONS

Discriminant analysis for refinement of old forest (Old-growth) definitions, in place of minimum criteria, offers opportunities to reduce the errors of omission that are otherwise common with minimum criteria (Pfister 1987, Franklin and Spies 1991b). The result would be an improved inventory of old forests.

With a better understanding of the role of disturbances in creating and maintaining OFMS, managers can better plan how to maintain it as part of the landscape in the short and long term. The role of light to moderate severity fires in conjunction with other agents of change within these forest types is crucial to the future maintenance and development of this ecosystem and thus the health of the whole landscape. Old-growth is not something that should have a line placed around it and preserved and protected for the long term (Agee 1991). It is a dynamic system that exists in a dynamic landscape and will need to be managed in that context.

I believe it is important that managers start testing different ways of facilitating the development of old forests so future generations can learn from our attempts as to what worked and what did not work. The understanding of how old forest multi-strata (OFMS) stands are created and maintained will allow managers to identify stands that are in the stem exclusion, understory reinitiation or young multi-strata forest classes that can be managed so they develop into OFMS. I believe this can be accomplished in the matter of a few to several decades in the northern Rocky Mountains.

Given the dynamic nature of forest development in the northern Rocky Mountains, it is important to recognize the multiple pathways and processes by which the changes are accomplished. Oliver and Larson (1990) describe these pathways and the influence each layer has on the other through competition for resources and the various ways the subsequent stand may develop. It behooves managers to provide for treatment prescriptions that will facilitate the development of OFMS from a variety of paths rather than focusing on a set of attributes that it must have; we must not get tunnel vision.

One of the reasons the term "old-growth" has so many variations in its definition is that the perspective of the describer has caused them to focus on one portion of it, as illustrated by the story of the five blind men holding on to different parts of the elephant and then describing the animal based on that part. In the situation of the OFMS or old-growth we are not describing a single organism, but an ecosystem that may have more or less of a particular part.

Is an elephant without a tail no longer an elephant? Is an old forest multi-strata stand with relatively few snags or relatively small amounts of coarse woody debris still OFMS? I believe the answer is yes. However, we need to recognize that there are OFMS stands that represent the other end of the spectrum as well, having an abundance of these attributes. Therefore, managers need to provide for the full breadth of this spectrum.

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APPENDIX A. Habitat Type Groups.

HABITAT GROUP 4 - MODERATELY WARM and MOIST

These are warm and moist habitats occurring along the lower slopes and valley bottoms. The group is highly diverse and nearly all the conifer species in the area can occurr on these types. Understory vegetation may be dominated by a wide variety of species.,

Fire free interval is wide from 50 years on the drier types to over 200 years on the more moist types characterizes these types. Typical fires are minor ground fires that create a mosaic within the stand. On the other extreme with drying, a complete stand replacement fire will occur. Many times this is the result of a fire burning from an adjacent and drier type.

Fire exclusion on these sites has changed them very little except to reduce the number of acres in early succession types. Many species do well on these sites and may thrive for centuries without disturbance. Thuja plicata is the most notable example.

Habitat Types comprising Habitat Group 4

HABITAT TYPE	PHASE	CODE	FIRE GROUP MT	FIRE GROUP ID
Abies grandis/ Asarum caudatum		516		7
	Asarum caudatum	517		7
	Menziesia ferruginea	518		7
	Taxus brevifolia	519		7
Abies grandis/ Clintonia uniflora		520	11	7
	Clintonia uniflora	521	11	7
	Aralia nudicaulis	522	11	
	Physocarpus malvaceus	524	11	7
	Menziesia ferruginea	525	11	7
	Taxus brevifolia	526	11	7
Abies grandis/ Senecio trangularis		529		7

HABITAT GROUP 5 - MODERATELY COOL and MOIST

These are moderately cool and moist sites. They contain many species, including Thuja plicata, western Tsuga heterophylla, Pseudotsuga menziesii, Picea engelmannii, Abies grandis, Pinus contorta, Tsuga mertensiana, Larix occidentalis and Pinus monticola. Very high basal areas can be achieved on these types.

Fire frequency can be low due to the maritime influence on these sites. Fire severity can be highly variable due the most common moist conditions, but is severe during periods of drought. Fire free intervals range from 50 to greater than 200 years (Fischer, 1987). Many species do well on these sites and may thrive for centuries without disturbance. Thuja plicata is the most notable example.

Habitat Types comprising Habitat Group 5

HABITAT TYPE	PHASE	CODE	FIRE GROUP MT	FIRE GROUP ID
Thuja plicata/ Clinonia uniflora		530	11	
	Clinonia uniflora	531	11	8
	Aralia nudicaulis	532	11	
	Menziesia ferruginea	533	11	8
	Xerophyllum tenax	534	11	8
	Taxus brevifolia	535	11	8
Thuja plicata/ Asarum caudatum		545	11	
	Asarum caudatum	546	11	8
	Menziesia ferruginea	547	11	8
	Taxus brevifolia	548	11	8
Thuja plicata/ Gymnocarpium dryopteris		555	11	8
Tsuga heterophylla/ Gymnocarpium dryopteris		565	11	8

Tsuga heterophylla/ Clintonia unifolia		570	11	
	Clintonia unifolia	571	11	8
	Aralia nudicaulis	572	11	8
	Xerophyllum tenax	573	11	8
	Menziesia ferruginea	574	11	8
Tsuga heterophylla/ Asarum caudatum				
		575	11	
	Aralia nudicaulis	576	11	8
	Menziesia ferruginea	577	11	8
	Asarum caudatum	578	11	8

HABITAT GROUP 7 - COOL and MOIST

These types are characterized by cool and moist site conditions. Species diversity can be high with Larix occidentalis, Pseudotsuga menziesii, Pinus monticola, Picea Engelmannii, Pinus contorta, Abies lasiocarpa and Abies grandis. Other sites are dominated by Pinus contorta after stand replacement burns. These sites are probably too cool for Tsuga heterophylla and Thuja plicata.

Fire history information is scarce. Fire intervals are estimated at greater than 120 years for most sites (Fischer, 1987).

HABITAT TYPE	PHASE	CODE	FIRE GROUP	
			MT	ID
Picea/Clintonia uniflora		420	9	
	Vaccinium caespitosum	421	9	
	Clintonia uniflora	422	9	
Picea/ Linnaea borealis		470	7	

Tsuga heterophylla/ Menziesia ferruginea		579		
Abies lasiocarpa/ Clintonia uniflora		620	9	
	Clintonia uniflora	621	9	5
	Aralia nudicaulis	622	9	
	Vaccinium caespitosum	623	9	
	Xerophyllum tenax	624	9	5
	Menziesia ferruginea	625	9	5
Abies lasiocarpa/ Linnaea borealis		660	9	
	Linnaea borealis	661	9	
	Xerophyllum tenax	662	9	
Abies lasiocarpa/ Menziesia ferruginea		670	9	
	Coptis occidentalis	671		5
	Luzula hitchcockii	672		5
	Xerophylum tenax	673		5
	Vaccinium scoparium	674		5
Tsuga mertensiana/ Menziesia ferruginea		680	9	
	Luzula hitchcockii	681		5
	Xerophylum tenax	682		5
Tsuga mertensiana/ Clintonia uniflora		685		
	Menziesia ferruginea	686		5
	Xerophylum tenax	687		5
Abies lasiocarpa/ Vaccinium scoparium		730		3
	Thalictrum occidentale	733		3
Abies lasiocarpa/ Alnus sinuata		740		
Abies lasiocarpa/ Luzula hitchcockii				
	Menziesia ferruginea	832	10	

The following Habitat Type groups are from Green and others (1992) which were used in conjuction with cover types and age and size criteria to define an old-growth type. Old-growth type 4 in north Idaho includes the following habitat type groups, when Douglas-fir, grand fir, western larch, subalpine fir, western white pine or western hemlock cover types occur on them:

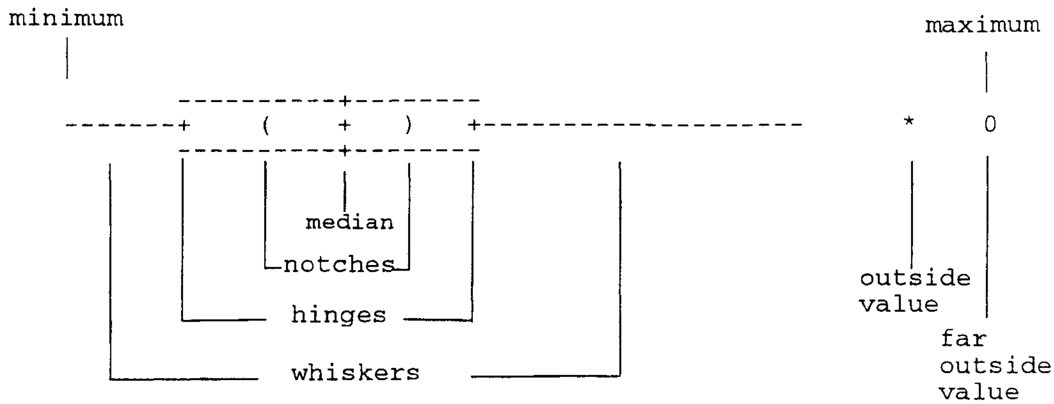
Habitat Type Group	Alpha Code	Numeric Code
C	ABGR/SETR	529
	ABGR/ASCA	516
	ABGR/ASCA-MEFE	518
	ABGR/ASCA-ASCA	517
	ABGR/CLUN	520
	ABGR/CLUN-MEFE	525
	ABGR/CLUN-PHMA	524
	ABGR/CLUN-CLUN	521
C1	ABGR/ASCA-TABR	519
	ABGR/CLUN-TABR	526
D	ABGR/LIBO	590
	ABGR/LIBO-XETE	510
	ABGR/LIBO-COOC	511
	ABGR/LIBO-VAGL	512
	ABGR/CLUN-XETE	523
E	ABGR/PHMA	506
	ABGR/PHMA-COOC	507
	ABGR/PHMA-PHMA	508
	ABGR/SPEBE	505
F	THPL/OPHO	550
	THPL/ATFI	540
	THPL/ATFI-ADPE	541
	THPL/ATFI-ATFI	542
	THPL/ADPE	560
G	THPL/GYDR	555
	THPL/ASCA	545
	THPL/ASCA-MEFE	547
	THPL/ASCA-ASCA	546
	THPL/CLUN	530
	THPL/CLUN-MEFE	533
	THPL/CLUN-CLUN	531
	THPL/CLUN-XETE	534
	TSHE/GYDR	565
	TSHE/ASCA	575
	TSHE/ASCA-ARNU	576
	TSHE/ASCA-MEFE	577
	TSHE/ASCA-ASCA	578

	TSHE/CLUN	570
	TSHE/CLUN-ARNU	572
	TSHE/CLUN-MEFE	574
	TSHE/CLUN-CLUN	571
	TSHE/CLUN-XETE	573
G1	THPL/ASCA-TABR	548
	THPL/CLUN-TABR	535
H	ABLA/STAM	635
	ABLA/STAM-MEFE	636
	ABLA/STAM-LICA	637
	ABLA/CACA	650
	ABLA/CACA-LEGL	655
	ABLA/CACA-VACA	654
	ABLA/CACA-LICA	652
	ABLA/CACA-CACA	651
	TSME/STAM	675
	TSME/STAMLUHI	676
	TSME/STAM-LUHI	677
I	ABLA/CLUN	620
	ABLA/CLUN-MEFE	625
	ABLA/CLUN-XETE	624
	ABLA/CLUN-CLUN	621
	ABLA/MEFE	670
	ABLA/MEFE-LUHI	672
	ABLA/MEFE-VASC	674
	ABLA/MEFE-COOC	671
	ABLA/MEFE-XETE	673
	TSME/CLUN	685
	TSME/CLUN-MEFE	686
	TSME/CLUN-XETE	687
	TSME/MEFE	680
	TSME/MEFE-LUHI	681
	TSME/MEFE	579

The following habitat type groups are for western Montana old-growth type 4, when Douglas-fir, grand fir, subalpine fir, western larch or western redcedar cover types occur on them:

Habitat Type Group	Alpha Code	Numeric Code
D	AGBR/CLUN	520
	ABGR/CLUN-CLUN	521
	ABGR/CLUN-ARNU	522
	ABGR/CLUN-XETE	523
	THPL/CLUN	530
	THPL/CLUN-CLUN	531
	THPL/CLUN-MEFE	532
	TSHE/CLUN	570
	TSHE/CLUN-CLUN	571
	TSHE/CLUN-ARNU	572
E	PICEA/VACA	420
	ABLA/CLUN	620
	ABLA/CLUN-CLUN	621
	ABLA/CLUN-ARNU	622
	ABLA/CLUN-VACA	623
	ABLA/CLUN-XETE	624
	ABLA/CLUN-MEFE	625
	ABLA/LIBO	660
	ABLA/LIBO-LIBO	661
	ABLA/LIBO-XETE	662
	ABLA/MEFE	670
	TSME/MEFE	680
	ABLA/LUHI-MEFE	832
F	PICEA/EQAR	410
	PICEA/GATR	440
	PICEA/SMST	480
	THPL/OPHO	550
	ABLA/OPHO	610
	ABLA/GATR	630
	ABLA/GATR-GATR	631
	ABLA/GATR-CACA	632
	ABLA/CACA	650
	ABLA/CACA-CACA	651
	ABLA/CACA-GATR	653
	ABLA/CACA-VACA	654

APPENDIX B. Boxplots of the Variables



Median of the values is marked with a + sign. It splits the data in half. Hinges split the data in half once more, creating quartiles. Whiskers denote the adjacent outermost values. The * represents the nonadjacent outside values and the 0 indicates the far outside values. The i in the middle of 'minimum' and 'maximum' mark the extreme values of the scale. Notches characterized by () are simultaneous conficence intervals around the median. If the intervals of the two boxes do not overlap, you can be confident at the 95% level that the two population medians are different (Wilkinson 1989).

```
     BOX PLOT OF VARIABLE:  TPA_GT5    , N =     54
            GROUPED BY VARIABLE:    STAGE
    44 80                                                        1107.20
 MINIMUM                                                        MAXIMUM

              -------+---
     ------+     ( +  )---------------              0         0        NONOFMS
              -------+---
           ----+-
        --+ ( ++)--    *                                                OFMS
           ----+-

          BOX PLOT OF VARIABLE:  TPA_LT5     , N =     54
           GROUPED BY VARIABLE:    STAGE
    0.00                                                        11100.00
 MINIMUM                                                        MAXIMUM

    +--
    + +---   **     0                                             0        NONOFMS
    +--
    -+----
    (+ ) +-----                                                            OFMS
    -+----

          BOX PLOT OF VARIABLE: TPA_DTOT     , N =     54
           GROUPED BY VARIABLE:    STAGE
    0.00                                                         360.00
 MINIMUM                                                        MAXIMUM

    ------+------
    +  (  +  )  +-------                                          0        NONOFMS
    ------+------
    -----+-------
    (     +     ) +---------                                               OFMS
    -----+-------
```

```
     BOX PLOT OF VARIABLE: DED_GT10     , N =     54
      GROUPED BY VARIABLE:     STAGE
  0.00                                                      120.00
MINIMUM                                                    MAXIMUM

   ------+------------------
   (     +      )          +-----------------------------------      NONOFMS
   ------+------------------
   ---------+----------
   +(        +        )  +---------------                            OFMS
   ---------+----------

     BOX PLOT OF VARIABLE: DED_GT18     , N =     54
      GROUPED BY VARIABLE:     STAGE
  0.00                                                       82.10
MINIMUM                                                    MAXIMUM

   +------
   +     +-------     **       *      0                     0        NONOFMS
   +------
   +------
   +)    +                         0                                 OFMS
   +------
     BOX PLOT OF VARIABLE: BA_INTOL     , N =     54
      GROUPED BY VARIABLE:     STAGE
  0.00                                                      360.00
MINIMUM                                                    MAXIMUM

          ----------+--------
   -------+     (    +   )    +--------------------          * *     NONOFMS
          ----------+--------
                    --------+------
   ----------------+  (     +      )---------------                  OFMS
                    --------+------

     BOX PLOT OF VARIABLE:   BA_TOL     , N =     54
      GROUPED BY VARIABLE:     STAGE
  0.00                                                      300.30
MINIMUM                                                    MAXIMUM

         --------+----------
   ------+  (    +      )     +-------------------------             NONOFMS
         --------+----------
        ---+----------------
   -(---+  +          )        +------                        *      OFMS
        ---+----------------

     BOX PLOT OF VARIABLE: BA_TOL21     , N =     54
      GROUPED BY VARIABLE:     STAGE
  0.00                                                      267.00
MINIMUM                                                    MAXIMUM

   +
   +0 00  0 0                   0                                    NONOFMS
   +
   +---------------------------------
   +            )                   +--------------------------      OFMS
   +---------------------------------

     BOX PLOT OF VARIABLE: BA_INT21     , N =     54
      GROUPED BY VARIABLE:     STAGE
  0.00                                                      176.20
MINIMUM                                                    MAXIMUM

   +-
   ++    **    0         0   0  0       0                   0        NONOFMS
   +-
        ------+----------------------
   (----+     +          )          +----------------                OFMS
        ------+----------------------
```

```
        BOX PLOT OF VARIABLE: SNAG_DBH     , N =     41
         GROUPED BY VARIABLE:     STAGE
   0.00                                                         27 76
MINIMUM                                                       MAXIMUM

                    -+-----------
  --------------(--++    )       +--------------          *     *       NONOFMS
                    -+-----------
                      --------+-------
              ------+  (      +       )------------------               OFMS
                      --------+-------
              BOX PLOT OF VARIABLE:  BA_DTOT    , N =     52
         GROUPED BY VARIABLE:     STAGE
   0.00                                                         387.20
MINIMUM                                                       MAXIMUM

  --+----------
  ( +    )       +--------                    *            0            NONOFMS
  --+----------
  --+----
  ( +   )+-------        *                                              OFMS
  --+----

        BOX PLOT OF VARIABLE:  BA_DTOL     , N =     54
         GROUPED BY VARIABLE:     STAGE
   0.00                                                         240.10
MINIMUM                                                       MAXIMUM

  +---
  + )+-----     *    *   0  0      0                   .        0       NONOFMS
  +---
  +---
  +)  +-             *                                                  OFMS
  +---

        BOX PLOT OF VARIABLE:  BA_DINT     , N =     54
         GROUPED BY VARIABLE:     STAGE
   0 00                                                         297.00
MINIMUM                                                       MAXIMUM

  +-------
  + )     +----------                                           0       NONOFMS
  +-------
  -+-----
  ++   ) +--------                                                      OFMS
  -+-----

        BOX PLOT OF VARIABLE: SNAG_CON     , N =     54
         GROUPED BY VARIABLE:     STAGE
   0.00                                                           5.00
MINIMUM                                                       MAXIMUM

  -----------+------------------------
  +(         +         )           +------------------------            NONOFMS
  -----------+------------------------
  +-----------------------------------------------
  +                 )                            +                      OFMS
  +-----------------------------------------------

        BOX PLOT OF VARIABLE: ROT_1000     , N =     36
         GROUPED BY VARIABLE:     STAGE
   0.00                                                          63.46
MINIMUM                                                       MAXIMUM

   ----+------
  -+(  +   ) +--------------   *                                0       NONOFMS
   ----+------
    +-----------
  --+     )      +---                                    0      0       OFMS
    +-----------
```

```
      BOX PLOT OF VARIABLE: TOT_1000     , N =     36
        GROUPED BY VARIABLE:     STAGE
   2.24                                                           104.53
MINIMUM                                                          MAXIMUM

   -----+------
   + (  +    ) +---------                    *                             NONOFMS
   -----+------
      -+-------
   (--++  )    +---              *                       0         OFMS
      -+-------


       BOX PLOT OF VARIABLE: SND_1000     , N =     36
        GROUPED BY VARIABLE:     STAGE
   0.00                                                           104.53
MINIMUM                                                          MAXIMUM

   -+--
   (+)+----    *                                                           NONOFMS
   -+--
    -+---
   (++ )+        *                                       0         OFMS
    -+---


       BOX PLOT OF VARIABLE: TOT_WOOD     , N =     36
        GROUPED BY VARIABLE:     STAGE
   3.50                                                           106.32
MINIMUM                                                          MAXIMUM

      ----+------
   ---+(  +    ) +--------                    *                            NONOFMS
      ----+------
        -+------
    -(--++  )  +---              *                      0          OFMS
        -+------


       BOX PLOT OF VARIABLE: DUFF_LIT     , N =     36
        GROUPED BY VARIABLE:     STAGE
   0.00                                                             6.16
MINIMUM                                                          MAXIMUM

             -------+---------
   -----------+ (     +     )   +---------------------         *           NONOFMS
             -------+---------
               ----+-----------
             (-+    +        )   +----------                               OFMS
               ----+-----------


       BOX PLOT OF VARIABLE:     S_TOT     , N =     54
        GROUPED BY VARIABLE:     STAGE
   0.00                                                            90.00
MINIMUM                                                          MAXIMUM

        --------------+-------------
   -----+       (        +       )       +---------------------------      NONOFMS
        --------------+-------------
        ----------+-------
    ----+    (       +       )----------                           *       OFMS
        ----------+-------
```

```
       BOX PLOT OF VARIABLE: FORB_COV    , N =    54
        GROUPED BY VARIABLE:    STAGE
    1.00                                                       60.00
MINIMUM                                                     MAXIMUM

           ----------+----------
   --------+    (    +    )    +------------------------------        NONOFMS
           ----------+----------
           ----------+--------------
   --------(         +         )    +---------------                  OFMS
           ----------+--------------


       BOX PLOT OF VARIABLE: MOSS_COV    , N =    54
        GROUPED BY VARIABLE:    STAGE
    0.00                                                       70.00
MINIMUM                                                     MAXIMUM

   -+------
   (+ )  +---------       *        0                                  NONOFMS
   -+------
    ---+-------
   (+  +   )  +-------------                                 0        OFMS
    ---+-------


       BOX PLOT OF VARIABLE: FERN_COV    , N =    54
        GROUPED BY VARIABLE:    STAGE
    0.00                                                       60.00
MINIMUM                                                     MAXIMUM

   +
   + *      0                                                 0       NONOFMS
   +
   +
   +        0                                                         OFMS
   +


       BOX PLOT OF VARIABLE:  COV_TOT    , N =    54
        GROUPED BY VARIABLE:    STAGE
   20.00                                                       98.00
MINIMUM                                                     MAXIMUM

                            --------+-----------
   -------------------------+  (    +    )      +-------------        NONOFMS
                            --------+-----------
                            ------------+--------------
                 -----------+(          +          )   +------        OFMS
                            ------------+--------------


       BOX PLOT OF VARIABLE:  COV_SAP    , N =    54
        GROUPED BY VARIABLE:    STAGE
    0 00                                                       60.00
MINIMUM                                                     MAXIMUM

     -------+----------
   --+ (    +   )     +--------------------                   *       NONOFMS
     -------+----------
            ----------+----------
     -------+ (       +      )  +------------------------------       OFMS
            ----------+----------


       BOX PLOT OF VARIABLE: COV_SEED    , N =    54
        GROUPED BY VARIABLE:    STAGE
    0.00                                                       30 00
MINIMUM                                                     MAXIMUM

    ----+-------------
   (+   +   )         +                                       *       NONOFMS
    ----+-------------
        --------------+
    ----+       (     +----)---------------                   *       OFMS
        --------------+
```

```
       BOX PLOT OF VARIABLE: COV_POLE    , N =    54
        GROUPED BY VARIABLE:    STAGE
    0.00                                                        70.00
MINIMUM                                                       MAXIMUM

          ---------+--------
   -------+    (    +   )   +---------                    *         NONOFMS
          ---------+--------
              -----+-----------
    --------(-+    +     )    +---------------------      *         OFMS
              -----+-----------


       BOX PLOT OF VARIABLE:  COV_MED    , N =    54
        GROUPED BY VARIABLE:    STAGE
    3.00                                                        80.00
MINIMUM                                                       MAXIMUM

               --------------+--------
   ------------+         (     +     ) +-----------------------         NONOFMS
               --------------+--------
               --------+---
   ------------+  (    +  +)----------                                  OFMS
               --------+---


     BOX PLOT OF VARIABLE:   COV_LG    , N =    54
        GROUPED BY VARIABLE:    STAGE
    0.00                                                        60.00
MINIMUM                                                       MAXIMUM

   +
   + 0      0         0         0                                   NONOFMS
   +
        ----+----------
   ---(-+   +    )    +--------------------         *         *     OFMS
        ----+----------


       BOX PLOT OF VARIABLE:  COV_VLG    , N =    54
        GROUPED BY VARIABLE:    STAGE
    0.00                                                        10.00
MINIMUM                                                       MAXIMUM

   +
   +                                                                NONOFMS
   +
   +
   +                                                        0       OFMS
   +


       BOX PLOT OF VARIABLE: COV_WOOD    , N =    54
        GROUPED BY VARIABLE:    STAGE
    0.00                                                        30.00
MINIMUM                                                       MAXIMUM

                      +--------------------
   -------------(-----+    )              +--------------------     NONOFMS
                      +--------------------
                      +--------------------
        ------(-------+      )            +--------------------     OFMS
                      +--------------------


       BOX PLOT OF VARIABLE: MOSS_LIC    , N =    54
        GROUPED BY VARIABLE:    STAGE
    0.00                                                        70.00
MINIMUM                                                       MAXIMUM

    +------
   (+ )   +---------       *        0                0       0      NONOFMS
    +------
   -+----------------
   ++     )        +--------                                 *      OFMS
   -+----------------
```

```
      BOX PLOT OF VARIABLE:     DUFF    , N =    54
       GROUPED BY VARIABLE:    STAGE
   -1.00                                                               6.20
 MINIMUM                                                            MAXIMUM

                     --------+----
           ---------+     (  +  )+--------------       *     * *         NONOFMS
                     --------+----
                        ----+---------
            -----------(    +    )   +---------                          OFMS
                        ----+---------

      BOX PLOT OF VARIABLE:   YOUNG     , N =    54
       GROUPED BY VARIABLE:    STAGE
    1.00                                                              81.00
 MINIMUM                                                            MAXIMUM

     -----+-------------
  ---+(    +     )        +-------------------------                     NONOFMS
     -----+-------------
          -------------+--------
         -+     (          +        )------------------------------      OFMS
          -------------+--------

      BOX PLOT OF VARIABLE:  YOUNGX     , N =    54
       GROUPED BY VARIABLE:    STAGE
    1.00                                                            1281.00
 MINIMUM                                                            MAXIMUM

  -+---
  (+) +------    *     *                                                 NONOFMS
  -+---
   -----+--------
  (+    +    )  +-----------                 *              0            OFMS
   -----+--------

      BOX PLOT OF VARIABLE:   YOBIG     , N =    54
       GROUPED BY VARIABLE:    STAGE
    1.00                                                             101.00
 MINIMUM                                                            MAXIMUM

      ---+----------
  ----(  +  )      +-----------       *                                  NONOFMS
      ---+---------
                ------------+-------------
       ----------+(           +          )   +------------------         OFMS
                ------------+-------------

      BOX PLOT OF VARIABLE:     BIG     , N =    54
       GROUPED BY VARIABLE:    STAGE
    0.00                                                              60 00
 MINIMUM                                                            MAXIMUM

  +
  + 0      0         0         0                                         NONOFMS
  +
       ----+---------------
  -(---+    +       )       +-------------------------         *         OFMS
       ----+---------------

      BOX PLOT OF VARIABLE: YOBMRATO    , N =    54
       GROUPED BY VARIABLE:    STAGE
    0.02                                                              10.25
 MINIMUM                                                            MAXIMUM

  -+--
  ++)+-----        0             0                          0            NONOFMS
  -+--
     -------+-------
   --+(      +     ) +-------------------           *   *                OFMS
     -------+-------
```

```
        BOX PLOT OF VARIABLE:   YOBIGX     , N =    54
         GROUPED BY VARIABLE:    STAGE
    2.00                                                           2562.00
 MINIMUM                                                           MAXIMUM

   +
   +*    0 0    0                                                           NONOFMS
   +
     -------+------
   --+ (    +     )-                    *         *       0         OFMS
     -------+------
```

```
        BOX PLOT OF VARIABLE: YOBXMRAT     , N =    54
         GROUPED BY VARIABLE:    STAGE
    0.04                                                            156.55
 MINIMUM                                                           MAXIMUM

   +
   +000 0                                                                   NONOFMS
   +
   ------+-----------------
   +     +        )        +---------------------------------       OFMS
   ------+-----------------
```

```
        BOX PLOT OF VARIABLE:   BA_GT19     , N =    54
         GROUPED BY VARIABLE:    STAGE
    0.00                                                           305.90
 MINIMUM                                                           MAXIMUM

   +------
   +)    +----------       *        0        0                          1.000
   +------
          --------------+-------------
     -----+    (         +          ) +-----------------------          2 000
          --------------+-------------
```

```
        BOX PLOT OF VARIABLE:   BA_GT17     , N =    54
         GROUPED BY VARIABLE:    STAGE
    0.00                                                           439.10
 MINIMUM                                                           MAXIMUM

   ---+------
   +( +  )  +--------------     *                                      1.000
   ---+------
        ---------+------------
    ----+(       +          )   +------------------------------        2.000
        ---------+------------
```

```
        BOX PLOT OF VARIABLE: COHO_INT     , N =    54
         GROUPED BY VARIABLE:    STAGE
    0.00                                                             5.00
 MINIMUM                                                           MAXIMUM

             +
   0         +          0                                              1.000
             +
                        +------------
   *                (   +  )       +------------          *            2.000
                        +------------
```

```
        BOX PLOT OF VARIABLE: COHO_TOT     , N =    54
         GROUPED BY VARIABLE:    STAGE
    1.00                                                             5.00
 MINIMUM                                                           MAXIMUM

                +
   0            +            0                                         1.000
                +
                      --------+---------------
                ------(+      +       )      +---------------          2.000
                      --------+---------------
```

```
        BOX PLOT OF VARIABLE:  BA_21_N    , N =    54
          GROUPED BY VARIABLE:    STAGE
    0 00                                                      1.00
MINIMUM                                                     MAXIMUM

   +------
   +     +---------           *    0   0        0          0        1.000
   +------
              --------------+---------
   ------------+     (        +        )------                      2.000
              --------------+---------

        BOX PLOT OF VARIABLE:  BA_TOT     , N =    54
          GROUPED BY VARIABLE:    STAGE
   40.00                                                    555.80
MINIMUM                                                     MAXIMUM

          ----------+--------
   --------+     (    +    )  +-------------------                  1.000
          ----------+--------
               -----+----------
      ---------(+    +    )    +-----------------                   2.000
               -----+----------

        BOX PLOT OF VARIABLE: BA_TOT21    , N =    54
          GROUPED BY VARIABLE:    STAGE
    0.00                                                    305 90
MINIMUM                                                     MAXIMUM

   +---
   +  +-----    *    *      0 0              0                      1 000
   +---
        -------------+-------------
   -----+  (         +          ) +---------------------------     2.000
        -------------+-------------

        BOX PLOT OF VARIABLE: COHO_SUM    , N =    54
          GROUPED BY VARIABLE:    STAGE
    2.00                                                      10.00
MINIMUM                                                     MAXIMUM

   ------+--------
   + (   +   )   +-------                                           1.000
   ------+--------
                 -------+---------------
               ( +      +        )      +-----------------------    2.000
                 -------+---------------

        BOX PLOT OF VARIABLE:  BA_GT15    , N =    54
          GROUPED BY VARIABLE:    STAGE
    0.00                                                    439 10
MINIMUM                                                     MAXIMUM

    ------+--------
   -+  (  +   )   +-----------              *                       1.000
    ------+--------
           -------+------------------
    ----(--+      +          )      +-------------------------      2.000
           -------+------------------

        BOX PLOT OF VARIABLE:  BA_TOP     , N =    54
          GROUPED BY VARIABLE:    STAGE
    0 00                                                      80.00
MINIMUM                                                     MAXIMUM

   +
   +    00  0      0      0    0                           0        1.000
   +
   --+----------
   + +    )    +---------------                                     2 000
   --+----------
```

```
       BOX PLOT OF VARIABLE:  BA_STEM    , N =    54
        GROUPED BY VARIABLE:    STAGE
    0.00                                                      91.74
MINIMUM                                                    MAXIMUM

   +
   +    0            0  0   0             0                        1.000
   +

   +-------------------
   +      )         +------------------                  *         2.000
   +-------------------

       BOX PLOT OF VARIABLE:    DECAY    , N =    54
        GROUPED BY VARIABLE:    STAGE
    0.00                                                     107.50
MINIMUM                                                    MAXIMUM

   +----
   +   +----  *     *  0                     0          0          1.000
   +----
    --------+-------------
   (+       +        )   +-----------                              2.000
    --------+-------------

       BOX PLOT OF VARIABLE:  DECAY_N    , N =    54
        GROUPED BY VARIABLE:    STAGE
    0.00                                                      80.00
MINIMUM                                                    MAXIMUM

   +
   +    00  0      0        0   0                            0     1.000
   +
   --+----------
   + +    )    +---------------                                    2.000
   --+----------

       BOX PLOT OF VARIABLE:  DBH_GT5    , N =    54
        GROUPED BY VARIABLE:    STAGE
    7.35                                                      25.16
MINIMUM                                                    MAXIMUM

          ------+-----
   -------+  (  +  ) +--------------                         0     1.000
          ------+-----
                -----+-----------
    ----------(-+    +     )    +-------                           2.000
                -----+-----------

       BOX PLOT OF VARIABLE:     CVHT    , N =    54
        GROUPED BY VARIABLE:    STAGE
    0.05                                                       0.66
MINIMUM                                                    MAXIMUM

                      -----------+--------
          ------------+     (    +    )  +--------------------     1.000
                      -----------+--------
                 -------+-----------
   --------------(      +       )   +----------------------        2.000
                 -------+-----------

       BOX PLOT OF VARIABLE:    CVDBH    , N =    54
        GROUPED BY VARIABLE:    STAGE
    0.13                                                       0.78
MINIMUM                                                    MAXIMUM

                      ---------+-------
        --------------+    (   +   ) +----------------             1.000
                      ---------+-------
                  -------+----------------
   -------------(-+      +         )      +--------------------    2.000
                  -------+----------------
```

Appendix C. Plot sample Sizes

PLOT ID	*MACROPLOT	*SUBPLOT	*BAF	
FS0104029261032	0.100	0.25	0	
FS0104029261034	0.100	0.25	0	10
FS0104049261041	0.100	0.25	0	
FS0104049261043	0.100	0.25	0	
FS0104049261044	0.100	0.25	0	5
FS0104049261045	0.100	0.25	0	
FS0104049261050	0.100	0.25	0	
FS0104079261037	0.100	0.25	0	40
FS0104089361002	0.100	1.00	0	
FS0104089361008	0.100	0.50	0	
FS0104089361010	0.100	1.00	0	5
FS0104089361012	0.100	1.00	0	
FS0105019261002	0.100	0.25	0	
FS0105019261003	0.100	0.25	0	
FS0105019261024	0.100	0.25	0	
FS0105019261025	0.100	0.25	0	
FS0105019261026	0.100	0.25	0	5
FS0105019361004	0.100	1.00	0	5
FS0105019361005	0.100	0.25	0	5
FS0105019361007	0.100	1.00	0	5
FS0105019361008	0.100	1.00	0	5
FS0105019361012	0.100	1.00	0	5
FS0105019361013	0.100	1.00	0	5
FS0105039261004	0.100	0.25	0	10
FS0105039261018	0.100	0.25	0	
FS0105039261019	0.100	0.25	0	
FS0105039261021	0.100	0.25	0	
FS0105059261027	0.100	0.25	0	5
FS0105069261028	0.100	0.25	0	
FS0105069261051	0.100	0.25	0	
FS01100191BD033	0.100	1.00	0	
FS01100191BD034	0.100	1.00	0	
FS0110019271050	0.100	0.25	0	
FS0110019271053	0.100	0.25	0	
FS0110019271055	0.100	0.25	0	
FS0110019271056	0.100	0.25	0	
FS0110019371301	0.100	1.00	0	5
FS0110019371302	0.100	1.00	0	5
FS0110019371307	0.100	1.00	0	5
FS0110019371309	0.100	0.25	0	5
FS0110019371312	0.100	1.00	0	5
FS0110019371324	0.100	1.00	0	
FS0110019371331	0.100	1.00	0	5
FS0110019371336	0.100	1.00	0	5
FS0110019371337	0.100	1.00	0	
FS0110019371338	0.100	1.00	0	5
FS0110019371340	0.100	1.00	0	5
FS0110019371342	0.100	0.50	0	
FS0110069271057	0.100	0.25	0	
FS0114019271077	0.100	0.25	0	
FS0114029271093	0.100	0.25	0	
FS0114029271095	0.100	0.25	0	

FS0114029271098	0.100	0.25	0	
FS0114029271101	0.100	0.13	0	
FS01140491BD029	0.100	0.25	0	
FS0114069271090	0.100	0.25	0	
FS0114069271091	0.100	0.25	0	
FS01140793DC004	0.010	1.00	20	
FS01140793DC015	0.010	1.00	10	
FS01140793DC019	0.010	1.00	40	
FS01140793DC020	0.010	1.00	40	
FS01140793DC021	0.010	1.00	40	
FS01140793DC022	0.010	1.00	20	
FS01140793DC023	0.010	1.00	40	
FS01140793DC045	0.010	1.00	20	
FS01140793DC047	0.010	1.00	40	
FS01140793DC051	0.010	1.00	20	
FS01140793DC054	0.010	1.00	40	
FS01140793DC055	0.010	1.00	40	
FS01140793DC062	0.010	1.00	40	
FS01140793DC063	0.010	1.00	40	
FS01140793DC064	0.010	1.00	20	
FS01140793DC072	0.010	1.00	20	
FS01140793DC076	0.010	1.00	40	
FS01140793DC088	0.010	1.00	40	5
FS01140793DC089	0.010	1.00	40	5
FS01140793DC095	0.010	1.00	40	5
FS01140793DC099	0.010	1.00	40	5
FS01140793DC101	0.010	1.00	40	
FS011604911E003	0.100	1.00	0	
FS011604911E004	0.100	1.00	0	
FS011604911E006	0.100	1.00	0	
FS011604912E001	0.025	1.00	0	
FS011604912E004	0.100	1.00	0	
FS011604912E006	0.050	1.00	0	
FS011604914E001	0.100	1.00	0	
FS011604914E003	0.050	1.00	0	
FS0116059271002	0.100	0.25	0	
FS0116069271013	0.100	0.25	0	
FS011607911E014	0.100	1.00	0	
FS011607911E016	0.100	1.00	0	
FS011607911E018	0.100	1.00	0	
FS011607911E020	0.050	1.00	0	
FS011607911E021	0.100	0.50	0	
FS011607911E023	0.100	1.00	0	
FS011607911E032	0.100	1.00	0	
FS011607911E035	0.050	1.00	0	
FS011607911E038	0.100	1.00	0	
FS011607911E041	0.100	1.00	0	
FS011607911E043	0.100	1.00	0	
FS011607912E018	0.100	1.00	0	
FS011607914E010	0.100	1.00	0	
FS011607914E012	0.100	1.00	0	
FS011607914E015	0.050	1.00	0	
FS011607914E022	0.100	1.00	0	
FS011607914E024	0.100	1.00	0	
FS011607914E026	0.100	1.00	0	
FS011607914E027	0.100	1.00	0	

FS011607914E028	0.100	1.00	0
FS011607914E030	0.100	0.50	0

* Macroplot = the fixed plot size in acres; Subplot = the fraction of the macroplot sampled for trees less than 5 in. (12.7 cm); BAF = basal area factor used to sample the live trees is in the first column and the baf used to sample dead trees (snags)

Appendix D. Statistics for Discriminant Run Variables.

THE FOLLOWING RESULTS ARE FOR:
SSMT2$ = NONOFMS

TOTAL OBSERVATIONS: 58

	TPA_GT5	TPA_LT5	TPA_DTOT	DED_GT10	DED_GT18
N OF CASES	58	58	58	58	58
MINIMUM	44.800	0.000	0.000	0.000	0.000
MAXIMUM	1107.200	11100.000	360.000	120.000	82.100
MEAN	305.257	757.586	58.086	26.641	7.888
STANDARD DEV	196.967	1668.331	64.666	31.834	15.666

	BA_TOL21	BA_INT21	SNAG_DBH	BA_DTOT	BA_DTOL
N OF CASES	58	58	58	58	58
MINIMUM	0.000	0.000	0.000	0.000	0.000
MAXIMUM	130.000	176.200	27.763	387.200	240.100
MEAN	7.616	13.621	8.730	46.890	22.362
STANDARD DEV	20.596	33.131	6.892	69.624	44.001

	BA_DINT	SNAG_CON	BA_TOP	BA_STEM	DUFF_LIT
N OF CASES	58	58	58	58	37
MINIMUM	0.000	0.000	0.000	0.000	0.000
MAXIMUM	297.000	5.000	80.000	65.520	6.160
MEAN	24.533	1.429	4.114	7.161	2.374
STANDARD DEV	43.966	1.610	12.885	14.867	1.428

	DBH_GT5	TOL_GT5	BA_TOT21	BA_GT19	BA_GT17
N OF CASES	58	58	58	58	58
MINIMUM	2.530	0.000	0.000	0.000	0.000
MAXIMUM	25.155	100.060	224.400	224.400	224.000
MEAN	11.660	45.812	21.236	30.400	50.698
STANDARD DEV	3.377	32.431	43.124	47.298	56.353

	COHO_INT	COHO_TOT	COV_TOT	COV_SEED	COV_SAP
N OF CASES	58	58	58	58	58
MINIMUM	0.000	1.000	20.000	0.000	0.000
MAXIMUM	3.000	4.000	98.000	30.000	60.000
MEAN	1.224	1.966	64.845	4.431	14.552
STANDARD DEV	0.594	0.748	17.296	5.058	13.057

	COV_POLE	COV_MED	COV_LG	COV_VLG	COV_WOOD
N OF CASES	58	58	58	58	58
MINIMUM	0.000	3.000	0.000	0.000	0.000
MAXIMUM	70.000	80.000	30.000	20.000	30.000
MEAN	20.534	37.172	2.690	0.345	12.793
STANDARD DEV	13.874	15.769	7.042	2.626	8.271

	YOBIG	COHO_SUM	VALID	STAGE
N OF CASES	58	58	58	58
MINIMUM	0.000	1.000	0.000	1.000
MAXIMUM	63.000	6.000	1.000	1.000
MEAN	22.017	3.121	0.655	1.000
STANDARD DEV	16.344	1.186	0.479	0.000

THE FOLLOWING RESULTS ARE FOR:
SSMT2$ = OFMS

TOTAL OBSERVATIONS: 26

	TPA_GT5	TPA_LT5	TPA_DTOT	DED_GT10	DED_GT18
N OF CASES	26	26	26	26	26
MINIMUM	130.000	40.000	0.000	0.000	0.000
MAXIMUM	560.000	3400.000	135.600	80.000	44.400
MEAN	250.531	801.538	44.231	25.204	6.165
STANDARD DEV	95.411	772.630	36.804	24.137	10.201

	BA_TOL21	BA_INT21	SNAG_DBH	BA_DTOT	BA_DTOL
N OF CASES	26	26	26	26	26
MINIMUM	0.000	0.000	0.000	0.000	0.000
MAXIMUM	267.000	297.000	24.722	136.500	79.400
MEAN	57.688	66.638	11.996	37.331	12.642
STANDARD DEV	83.525	82.114	6.363	36.302	20.937

	BA_DINT	SNAG_CON	BA_TOP	BA_STEM	DUFF_LIT
N OF CASES	26	26	26	26	23
MINIMUM	0.000	0.000	0.000	0.000	1.390
MAXIMUM	143.500	4.000	56.210	91.740	4.880
MEAN	25.042	1.127	12.420	18.532	2.579
STANDARD DEV	35.602	1.651	15.385	27.211	1.007

	DBH_GT5	TOL_GT5	BA_TOT21	BA_GT19	BA_GT17
N OF CASES	26	26	26	26	26
MINIMUM	8.014	0.000	0.000	5.000	20.000
MAXIMUM	19.706	100.482	309.100	415.700	439.100
MEAN	14.120	37.508	124.327	141.558	167.177
STANDARD DEV	3.176	28.982	104.485	115.321	128.346

	COHO_INT	COHO_TOT	COV_TOT	COV_SEED	COV_SAP
N OF CASES	26	26	26	26	26
MINIMUM	0.000	2.000	40.000	1.000	3.000
MAXIMUM	5.000	5.000	98.000	30.000	60.000
MEAN	2.423	3.423	74.077	8.577	21.769
STANDARD DEV	1.206	0.857	17.013	8.198	13.411

	COV_POLE	COV_MED	COV_LG	COV_VLG	COV_WOOD
N OF CASES	26	26	26	26	26
MINIMUM	3.000	3.000	0.000	0.000	3.000
MAXIMUM	70.000	70.000	60.000	20.000	30.000
MEAN	27.423	32.038	13.038	2.692	12.615
STANDARD DEV	16.919	16.274	15.629	6.038	8.980

	YOBIG	COHO_SUM	VALID	STAGE
N OF CASES	26	26	26	26
MINIMUM	11.000	3.000	0.000	2.000
MAXIMUM	100.000	10.000	1.000	2.000
MEAN	46.077	5.846	0.615	2.000
STANDARD DEV	24.884	1.826	0.496	0.000

APPENDIX E. Discriminant Analysis Group Membership, Probabilities and Euclidean Distances

	FACTOR	DIST(1)	DIST(2)	PROB(1)	PROB(2)	GROUP	PREDICT	PREDICT$
CASE 1	-0.243	0.926	2.156	0.869	0.131	1.000	1.000	N
CASE 2	-0 044	1.340	2.143	0.802	0.198	1.000	1.000	N
CASE 3	-1.302	0.902	3 151	0.990	0.010	1.000	1.000	N
CASE 4	-1.713	0.996	3.489	0.996	0 004	1.000	1.000	N
CASE 5	-0.035	1.428	2.188	0.798	0.202	1.000	1.000	N
CASE 6	-1.852	1.172	3.640	0.997	0.003	1.000	1.000	N
CASE 7	3.482	5.719	4.217	0.001	0.999	2.000	2.000	O
CASE 8	-1.474	0.995	3.312	0.993	0.007	1.000	1.000	N
CASE 9	-0.965	1.538	3.128	0.976	0.024	1.000	1.000	N
CASE 10	0.544	2.652	2.622	0.480	0.520	2.000	2.000	O
CASE 11	3.041	4.337	2.470	0.002	0.998	2.000	2.000	O
CASE 12	0.997	2.407	1.831	0.228	0.772	2 000	2.000	O
CASE 13	-1.080	1 031	3.010	0.982	0.018	1.000	1.000	N
CASE 14	-0.630	1 237	2.696	0 946	0.054	1.000	1.000	N
CASE 15	-0.779	1.921	3.190	0.962	0.038	1.000	1 000	N
CASE 16	-0.383	0 671	2.224	0.904	0 096	1.000	1.000	N
CASE 17	1.484	2.316	0.692	0 080	0 920	1.000	2.000	O
CASE 18	-1.266	0.730	3.077	0.989	0.011	1.000	1.000	N
CASE 19	0.327	2.239	2.437	0.614	0 386	1 000	1.000	N
CASE 20	-0.725	0.311	2.512	0 957	0.043	1.000	1.000	N
CASE 21	0.155	1.818	2.259	0.710	0.290	1.000	1 000	N
CASE 22	1.849	2.600	0.213	0.034	0.966	2.000	2.000	O
CASE 23	-0.988	0.388	2.772	0.977	0.023	1.000	1.000	N
CASE 24	1.511	2.894	1.832	0 075	0.925.	2.000	2.000	O
CASE 25	0.681	1.627	1.342	0.396	0 604	2.000	2 000	O
CASE 26	2.089	3.654	2.330	0.019	0.981	2.000	2.000	O
CASE 27	1.498	2.320	0.654	0.077	0.923	1.000	2.000	O
CASE 28	2.195	3.404	1.768	0.014	0.986	2.000	2.000	O
CASE 29	-1 852	1.172	3.640	0.997	0 003	1.000	1 000	N
CASE 30	3.008	4 399	2.610	0.002	0 998	2.000	2.000	O
CASE 31	2.657	4.917	3.661	0.005	0 995	2.000	2.000	O
CASE 32	0.372	2.243	2.395	0 587	0.413	1.000	1.000	N
CASE 33	0.123	1.511	2.058	0.726	0.274	1.000	1 000	N
CASE 34	0 419	1.515	1 661	0.558	0.442	1.000	1 000	M
CASE 35	-0.307	0 968	2 247	0 887	0 113	1 000	1.000	N
CASE 36	2.216	3 086	0 980	0.014	0.986	2.000	2.000	O
CASE 37	0.794	2 567	2.274	0.330	0.670	2.000	2.000	O
CASE 38	0 872	2.516	2.126	0.288	0 712	2.000	2 000	O
CASE 39	2.680	4.659	3.288	0.004	0.996	2.000	2.000	O
CASE 40	-1.285	2.862	4.149	0.989	0.011	1.000	1.000	N
CASE 41	-1.127	0.449	2.905	0.984	0.016	1.000	1.000	N
CASE 42	-1.852	1.172	3.640	0.997	0.003	1.000	1.000	N
CASE 43	-0 706	1.817	3.070	0.955	0.045	1.000	1.000	N
CASE 44	-0 789	0.749	2.664	0.963	0.037	1.000	1.000	N
CASE 45	-0.183	1.039	2.138	0.852	0.148	1.000	1.000	N
CASE 46	-0.174	1.559	2.425	0.849	0.151	1.000	1.000	N
CASE 47	-1.713	0.996	3.489	0.996	0.004	1.000	1.000	N
CASE 48	-1.932	1.310	3.741	0 998	0.002	1 000	1.000	N
CASE 49	-0.988	0.388	2.772	0.977	0.023	1.000	1 000	N
CASE 50	-1.167	0.518	2 950	0.985	0 015	1.000	1.000	N
CASE 51	1.057	2 878	2 355	0.203	0.797	2 000	2.000	O
CASE 52	-1.127	0.449	2.905	0.984	0.016	1.000	1.000	N
CASE 53	-0 508	0 805	2.402	0.928	0.072	2.000	1 000	N
CASE 54	-1.127	0.449	2.905	0.984	0.016	1.000	1.000	N
CASE 55	-1 326	0.872	3 161	0 990	0.010	1.000	1.000	N
CASE 56	-1.733	1.015	3.508	0 996	0.004	1 000	1.000	N
CASE 57	-1.315	1.202	3.259	0 990	0.010	1.000	1 000	N
CASE 58	-1.733	1.015	3.508	0.996	0.004	1.000	1.000	N
CASE 59	-1.713	0.996	3.489	0.996	0 004	1.000	1.000	N
CASE 60	-1 315	1.202	3.259	0.990	0.010	1.000	1 000	N
CASE 61	-1.673	0.967	3.452	0.996	0.004	1.000	1.000	N
CASE 62	-1.100	1.083	3.045	0.983	0.017	1.000	1.000	N
CASE 63	-1 335	1.169	3.263	0.990	0.010	1.000	1 000	N
CASE 64	-1.266	0.730	3.077	0 989	0.011	1.000	1 000	N
CASE 65	-1.713	0.996	3.489	0.996	0.004	1 000	1.000	N
CASE 66	1 802	3.585	2.524	0.038	0.962	2.000	2.000	O
CASE 67	2 053	3.960	2.817	0.020	0.980	2.000	2 000	O
CASE 68	-0.590	1.242	2.661	0.941	0.059	1.000	1.000	N
CASE 69	3.215	4 043	1.661	0 001	0 999	2 000	2 000	O
CASE 70	0.556	1.474	1 398	0.473	0 527	2 000	2.000	O
CASE 71	5.288	6.256	3.891	0.000	1.000	2.000	2.000	O
CASE 72	1.281	2.494	1.535	0.127	0.873	2.000	2.000	O
CASE 73	0.575	1.422	1.306	0.460	0.540	1.000	2.000	O
CASE 74	-0.133	2.443	3.034	0.835	0.165	1.000	1.000	N
CASE 75	0.490	2.149	2.174	0.514	0.486	2.000	1.000	N

CASE 76	0.679	3 016	2.874	0.397	0.603	1.000	2.000	O
CASE 77	-0.391	1.760	2 763	0.906	0.094	1.000	1.000	N
CASE 78	2.293	4.087	2 785	0.011	0.989	2.000	2.000	O
CASE 79	-0.168	1.252	2.232	0.846	0.154	1.000	1.000	N
CASE 80	0.342	1.529	1.786	0.605	0.395	2.000	1.000	N
CASE 81	-1.673	0.967	3.452	0.996	0.004	1.000	1.000	N
CASE 82	0.281	1.814	2.109	0.641	0.359	1.000	1.000	N
CASE 83	-0.928	0.462	2.729	0.974	0.026	1.000	1.000	N
CASE 84	-0.183	1.039	2.138	0.852	0.148	1.000	1.000	N