REGION 6

INTERIM OLD GROWTH DEFINITION

FOR

DOUGLAS-FIR SERIES
GRAND FIR/WHITE FIR SERIES
INTERIOR DOUGLAS FIR SERIES
LODGEPOLE PINE SERIES
PACIFIC SILVER FIR SERIES
PONDEROSA PINE SERIES
PORT-ORFORD-CEDAR AND TANOAK (REDWOOD) SERIES
SUBALPINE FIR SERIES
WESTERN HEMLOCK SERIES

June 1993

PREFACE

The following is a brief history of the process used to produce these new "Interim" Old-Growth Definitions for use in Region 6.

In October 1989, the Chief of the Forest Service directed all Regional Foresters to develop ecologically based old-growth definitions for the major forest cover types as defined in Forest Cover Types of the United States and Canada, Society of American Foresters, F.H. Eyre, Editor, 1980. (See Table 1 for listing of major cover types applicable to the Pacific Northwest Region.) The definitions were to be based upon the following generic definition/description:

Purpose and Scope

The following describes the ecologically important structural features of old-growth ecosystems. Measurable criteria for these attributes will be established in more specific definitions for forest types, habitat types, plant associations, or groupings of them. The intent of the generic definition is to guide design of specific definitions and new inventories that include measurement of specific attributes. Although old-growth ecosystems may be distinguished functionally as well as structurally, this definition is restricted primarily to stand-level structural features which are readily measured in forest inventory.

Definition

Old-growth forests are ecosystems distinguished by old trees and related structural attributes. Old growth encompasses the later stages of stand development that typically differ from earlier stages in a variety of characteristics which may include tree size, accumulations of large dead woody material, number of canopy layers, species composition, and ecosystem function.

Description

The age at which old growth develops and the specific structural attributes that characterize old growth will vary widely according to forest type, climate, site conditions, and disturbance regime. For example, old growth in fire-dependent forest types may not differ from younger forests in the number of canopy layers or accumulation of down woody material. However, old growth is typically distinguished from younger growth by several of the following attributes:

1. Large trees for species and site.
2. Wide variation in tree sizes and spacing.
3. Accumulations of large-size dead standing and fallen trees that are high relative to earlier stages.

4. Decadence in the form of broken or deformed tops or bole and root decay.
5. Multiple canopy layers.
6. Canopy gaps and understory patchiness.

Compositionally, old growth encompasses both older forests dominated by early seral species, such as fire-dependent species, and forests in later successional stages dominated by shade tolerant species. Rates of change in composition and structure are slow, relative to younger forests. Different stages or classes of old growth will be recognizable in many forest types.

Sporadic, low to moderate severity disturbances are an integral part of the internal dynamics of many old-growth ecosystems. Canopy openings resulting from the death of overstory trees often give rise to patches of small trees, shrubs, and herbs in the understory.

Old growth is not necessarily "virgin" or "primeval." Old growth could develop following human disturbances.

The structure and function of an old-growth ecosystem will be influenced by its stand size and landscape position and context.

Where cover types overlapped into adjoining Regions, coordination between Regions was required to assure that differences in definitions were due to biological differences between areas and not just due to process.

In January 1990, the Regional Forester formed five teams to develop the definitions for the major types in Region 6. These teams ranged from 4-6 people in size and contained at least one Ecologist, Silviculturist, and Wildlife Biologist. All members were selected with consideration of their knowledge and experience in the types they were asked to define. These teams functioned under guidelines from a Regional Old-Growth Core Team composed of several Regional Specialists, plus a PNW Station Research Ecologist, an Environmental Group Representative, and an Industry Representative.

These teams primarily utilized the Ecologist Plot Data Base since it was the best available source of this type of information and this was supplemented with other appropriate data, where available. Time did not permit the collection of additional field data. The teams rapidly came to the conclusion that data was insufficient to develop definitions for individual National Forests, so in <u>most</u> instances the definitions are Regional in scope. Where sufficient data supported meaningful differences, some definitions were further refined by broad productivity classes. The Ecologists from Region 1 and Region 6 agreed that conditions on the Colville National Forest more closely resembled those in Region 1, so the Colville National Forest will use those definitions developed by Region 1 for the North Idaho Zone.

The available vegetation data base (Ecologist Plot Data Base) was collected and stratified based upon "Potential Vegetation Series," rather than the existing vegetation as described by the "Forest Cover Types." <u>Therefore, definitions</u>

for old growth in the Pacific Northwest Region are based upon Vegetation Series rather than Forest Cover Types. At different points in time and in different areas, more than one existing vegetation cover type may exist in a particular potential vegetation series. The vegetation series based old-growth definitions may be cross-referenced to the appropriate SAF Cover Type as follows:

Vegetation Series	SAF Cover Type(s)
Douglas-fir	229
Grand fir - white fir	211,213
Interior Douglas-fir	210
Lodgepole (Climax)	218
Pacific silver fir	226
Ponderosa pine	237
Port-Orford-cedar	231
Tanoak (redwood)	234,232
Subalpine fir	206
Western hemlock	224

Over the 2 year period of time when the definitions were being developed, Deputy Regional Forester/Regional Forester John Lowe met with his "Old-Growth Advisory Group" (a large group of Congressional Staff, Environmental, Industry, State, and other Federal Agency Representatives) to keep them informed of progress on both the old-growth inventory and the old-growth definitions. In January 1992, the entire set of "Draft" old-growth definitions was sent out for review and comment, both internally and externally, to the "advisory group" as well. The few comments received were forwarded to the appropriate teams for consideration in preparing their final product.

In December 1992, the final "Interim" old-growth definitions were sent to the Region 6 Forest Supervisors so they could begin using them. Due to the bulk of these copies of the definitions, the printing was limited to primarily a quantity needed to initially supply the Forests. An abbreviated version of these definitions, that does not contain all of the detail, graphs, charts, tables, etc., developed by the teams as they went through their process, was to be printed for much wider distribution, including interested publics. This document is the "condensed version."

The definitions are written to provide "minimum" attributes of ecological old growth as directed by the Washington Office. A summary table is provided at the front of each definition for easy reference, but the user is cautioned to read the entire text for a better understanding of its use. Some attributes are not required to be present to meet the definition. Basically, the minimum diameter, number of large trees per acre, and age are the only fully required attributes, since in some cases past stand history (fire, salvage, etc.) could effect other attributes, such as snag or down logs. In other words, an area could still be qualified to meet the definition of old growth even if it did not have quite enough snags or down logs, but still met the age and number of large tree requirements.

These definitions are labelled as "Interim" due to the recognition of the limited data base from which they have been developed. Individual attributes are expected to change as more data is accumulated and analyzed.

TABLE 1
SAF Forest Cover Types

NAME	CODE #
Mountain hemlock	205
Engelmann spruce - subalpline fir	206
Interior Douglas-fir	210
White fir	211
Grand fir	213
Lodgepole pine	218
Sitka spruce	223
Western hemlock	224
Western hemlock - Sitka spruce	225
Coastal true fir - hemlock	226
Western redcedar - western hemlock	227
Western redcedar	228
Pacific Douglas-fir	229
Douglas-fir - western hemlock	230
Port-Orford-cedar	231
Redwood	232
Douglas-fir - tanoak - Pacific madrona	234
Ponderosa pine	237

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STANDARD SUMMARY OF OLD GROWTH CHARACTERISTICS

Vegetative Series Douglas-fir

SAF Cover Type(s) 229

Applicable Area (Region/Sub-region,etc) Region 6 (Westside)

Site Productivity Designation High (Sites 1,2,3)

Live Trees						Dead Trees			
Main Canopy			Variation in Tree Diameter	Tree Decadence	Tree Canopy Layers	Standing		Down	
DBH*	TPA*	AGE*	(Yes or No)	TPA	Number	DBH	TPA	Diameter	Pieces
37" (94cm)	8 (20tph)	190	Yes	No	2	13" (33cm)	1 (3tph)	24" (61cm)	4 (10/ha)

*Required minimums

(Metric Equivalents in Parenthesis)

Vegetative Series Douglas-fir

SAF Cover Type(s) 229

Applicable Area (Region/Sub-region,etc) Region 6 (Westside)

Site Productivity Designation Medium (Site 4)

Live Trees						Dead Trees			
Main Canopy			Variation in Tree Diameter	Tree Decadence	Tree Canopy Layers	Standing		Down	
DBH*	TPA*	AGE*	(Yes or No)	TPA	Number	DBH	TPA	Diameter	Pieces
34" (86cm)	9 (22tph)	205	Yes	Yes	2	15" (38cm)	1 (3tph)	24" (61cm)	4 (10/ha)

*Required minimums

(Metric Equivalents in Parenthesis)

STANDARD SUMMARY OF OLD GROWTH CHARACTERISTICS

Vegetative Series Douglas-fir　　SAF Cover Type(s) 229

Applicable Area (Region/Sub-region,etc) Region 6 (Westside)　　Site Productivity Designation Low (Site 5)

Live Trees						Dead Trees			
Main Canopy			Variation in Tree Diameter	Tree Decadence	Tree Canopy Layers	Standing		Down	
DBH*	TPA*	AGE*	(Yes or No)	TPA	Number	DBH	TPA	Diameter	Pieces
24" (61cm)	10 (25tph)	200	Yes	Yes	2	17" (43cm)	1 (3 tph)	24" (61cm)	4 (10/ha)

*Required minimums

(Metric Equivalents in Parenthesis)

Vegetative Series ____________　　SAF Cover Type(s) ____________

Applicable Area (Region/Sub-region,etc) ____________　　Site Productivity Designation ____________

Live Trees						Dead Trees			
Main Canopy			Variation in Tree Diameter	Tree Decadence	Tree Canopy Layers	Standing		Down	
DBH*	TPA*	AGE*	(Yes or No)	TPA	Number	DBH	TPA	Diameter	Pieces

*Required minimums

(Metric Equivalents in Parenthesis)

INTRODUCTION

A series of 23 articles on old-growth forests of the United States and parts of Canada was published in the Natural Areas Journal [Volume 8, nos. 1 & 3; vol. 9, no. 1; and vol. 11, no. 1) between 1988-1991. Most of these articles describe old-growth characteristics of forests from various geographic areas. Some characteristics stand alone for a particular area, some differ numerically, but there are a number of characteristics which are similar for all areas.

The existence of large (diameter and height), old trees is the most common feature described, followed by the presence of snags and coarse woody debris on the ground. Almost every article used 150 years or older as a lower age limit. Structural complexity was nearly always described and included terms or descriptors like gaps, fragmented communities, spatial heterogeneity, and multi-layered canopies. Other characteristics described include large numbers of stems that can endure shade, and a rich species diversity, including epiphytes and mosses.

In the western Cascades and Coast Ranges of the Pacific Northwest old-growth forests are a continuum of ecosystems that vary in space and time, a result of a unique set of environmental circumstances (Franklin and Spies 1984, Spies and Franklin 1988). Compared to many other old-growth forest ecosystems in the Unites States, the ones in the Pacific Northwest are particularly long-lived, some over 1000 years. Much more is known about the structure than the function of old-growth forests, and much more is known about the above-ground system than the below-ground system. Species composition varies among community types and relatively few of these species are found only in old-growth forests. Some species of mosses and epiphytic lichens do find their optimum habitat in old growth. The spotted owl (Strix occidentalis) and the red tree vole (Clethrionomys occidentalis) are thought to be obligate old-growth species.

Though old-growth forests tend to be very productive, productivity can vary considerably. Soil characteristics and long-term climatic conditions may account for some of this variation.
The old-growth forests in the western Cascades are structurally very diverse, but there are certain similar characteristics. In the forests where trees are particularly large and tall, there is a diverse habitat gradient from the top of the tree to the bottom. Shade-tolerant trees tend to increase with time and there is generally a large component of coarse woody debris in the form of snags or wood on the ground.

Disturbances have played an important role in the development of old-growth forests. Depending on where you are in the region, disturbances have run the gamut of large, catastrophic upheavals like fire to more smaller-scaled upheavals like wind, insect outbreaks, and ground fires. Disturbances continue to play a role in the development and distribution of old-growth forests, but many of these disturbances are human caused like clear-cuts and fire.

The mature and climax seral stages of conifer forests in the Pacific Northwest have received a lot of attention due to the rapid harvest of the forests and the possible extinction of the spotted owl, a federally endangered species.

Climax old-growth stands of the Douglas-fir (Pseudotsuga menziesii) series have not specifically been defined in western Oregon and western Washington. The Old Growth Definition Task Group (1986), discussed old-growth Douglas-fir on sites where it is dominant, however, in most cases they were referring to conifer forests where western hemlock (Tsuga heterophylla), and Pacific silver fir (Abies amabillis) are the climax species. Sites defined in this analysis will discuss the occurrence of Douglas-fir, and its associates specifically where Douglas-fir occurs as the climax species. Information used to develop this analysis was derived from over twenty years of ecology plots from the USFS Region Six Ecology program.

The objective of this paper is to use the variables collected on the ecology plots in the Douglas-fir series in the Western Oregon Siskiyou and Cascade mountains and Western Washington Cascades, to track and describe stand development over time. This analysis will define old-growth climax Douglas-fir, and use the data to describe the characteristics of an old-growth stand of climax Douglas-fir.

Literature Review of the Douglas-fir Series

Douglas-fir (Pseudotsuga menziesii) is the dominant tree of the forests of western Oregon, western Washington and northwestern California. Though it is dominant, Western hemlock (Tsuga heterophylla) or Pacific Silver fir (Abies amabilis) is usually climax (Means, 1980). Douglas-fir is more commonly a seral species across this geographic range, however there are identified locales where it is the climax species. These climax forests range from British Columbia (Krajina, 1965) and the Olympic peninsula southward through the Washington Cascades (Franklin et. al, 1980), Oregon Cascades and eastern slope of the Oregon Coast Range to the Siskiyou and Klamath Mountain Provinces of southwest Oregon and northwest California (Cole 1977, Juday 1976, Waring 1969). Incense cedar (Calocedrus decurrens) and sugar pine (Pinus lambertiana) are commonly associated in the southern portion of the range. In the Siskiyou Mountain Province approximately 20% of the acreage is climax or co-climax Douglas-fir (Atzet and Wheeler, 1984). Much of the Douglas-fir found in the Klamath Mountains region is part of a mixed-evergreen formation (Franklin and Dryness, 1990).

Climax Douglas-fir forests are consistently found on the more xeric sites in the coniferous ecosystems of western Oregon and Washington. These are sites with low soil moisture availability, shallow soils, southern and western aspects and lower elevations. Low soil moisture availability is more critical to their occurrence than is high air temperature (Waring and Cleary, 1967). In southwest Oregon, climax Douglas-fir stands occur on the hottest, driest coniferous forest environments (Atzet and McCrimmon, 1990).

Soils are derived from a variety of parent materials: ranging from glacial origin in British Columbia, metamorphosed sedimentary material in the Cascades to igneous rocks and formations of volcanic origin in the southern Cascades (Burns and Honkala, 1990). The convex land forms characteristic of most dry sites have soils kept young by erosion (Means, 1980). As one proceeds southward across it's range, climax Douglas-fir forests occurs at higher elevations (Burns and Honkala, 1990).

Though climax Douglas-fir often grows in pure stands, common associates are: incense cedar, sugar pine, knobcone pine (Pinus attenuata), jeffery pine (Pinus jefferyi) and ponderosa pine (Pinus ponderosa), and on the Olympic peninsula, lodgepole pine (Pinus contorta), (Henderson, et. al, 1989). Often hardwoods are present, such as madrone (Arbutus menziesii), tanoak (Lithocarpus densiflorus), and Oregon oak (Quercus garrayana). Common shrub species are wedgeleaf ceanothus (Ceanothus cuneatus), whiteleaf manzanita (Arctostahpylos viscida), and poison oak (Rhus diversiloba).

Climax Douglas-fir stands are usually initiated by a combination of catastrophic fires that leave very few live remnants of the former stand and lower intensity fires that only partially burn a portion of the stand and canopy (Means, 1990). This fire history has developed even-aged, even-sized stands, as well as structurally diverse stands of nearly pure Douglas-fir (Burke, 1979). The mean interval between fires on dry sites of the western Oregon Cascades is 103 years. There has been at least one non-catastrophic fire since initiation of the oldest cohort present in these stands (Means, 1980).

Stand composition of the dry Douglas-fir forests of the Western Oregon Cascades is characterized by large numbers of small overtopped trees in the reproductive size classes with an exponential decline in stem density into the larger size classes which have few individuals (Means, 1980). This is caused by slow restocking of the site following destruction of the previous stand, regeneration occurring during several distinct periods in the history of the stand, and widely differing tree growth rates. Due to the abundance of younger age classes, the stands may often be viewed as immature stages of primary succession, when this is the normal development (Means, 1980). Numerous size and age classes can be present due to the growing conditions of the site and fire history. Douglas-fir climax stands tend to have uneven-aged size distribution and structures in contrast to the often even-aged size distribution and structure of Douglas-fir on more mesic sites.

Douglas-fir has a broad range in the Pacific Northwest and the species exhibits a great deal of genetic differentiation. Much of this variation is strongly associated with topographic features. Evidence exists for " aspect races " in variety menziesii. Seedlings grown from seed collected on more xeric southern aspects grow slower, set buds earlier, and form larger roots in relation to shoots, than seedlings grown from seeds collected on adjacent north facing slopes. This topoclinal variation in response to micro-environmental heterogeneity is consistent with the distinctly different climax Douglas-fir stands and adjacent stands where Douglas-fir is seral (Burns and Honkala, 1990).

Climax Douglas-fir plant communities provide important landscape definition and diversity to the forested plant communities of western Oregon, western Washington and northwestern California. It is important to recognize that distinct ecological differences exist between climax Douglas-fir communities and the more mesic adjacent seral Douglas-fir plant communities.

MATERIALS AND METHODS

AREA DESCRIPTION AND DATA COLLECTION

The data used in these analyses were collected from Region Six ecology plots over the past twenty years. Data collection procedures are outlined in the Regional Resource Inventory Handbook and Field Instructions for Vegetative Resource Surveys. These data were collected systematically and in a relatively consistent manner. Stands selected were in a stable condition and were measured for productivity, snags and down woody material. These data were analyzed using the SAS statistical software package.

The data set for the Douglas-fir series included plots from the Olympic, Mt. Baker-Snoqualmie, Willamette, Umpqua, Siskiyou, and Rogue River National Forests. Plots occurred across a variety of parent rock types, elevations, slopes, aspects, and terrain. A subset of plots were used to analyze the dead and down material. Data was only available from the Willamette, Rogue River, Siskiyou, and Umpqua National Forests.

Stand age was determined for each plot based on the oldest cohort of trees where there were at least ten per acre. The ecology plot variables were plotted against stand age. Quadratic mean diameter was used rather than diameter at breast height (dbh) because it weighs more heavily toward larger trees which are of greater importance for determination of old growth. All trees greater than five inches dbh were included in these analyses. The number of canopy layers was estimated by looking for thirty to fifty foot differences in height between age groups especially when groups included different species. The variables used in the analysis were live trees per acre (TPA), live tree quadratic mean diameter (QMD), live tree basal area (BA), the standard deviation of live tree dbh (STD), snags per acre (SNAGTPA), snag basal area (SNAGBA), and down woody material on the plots was also analyzed (DD). The standard deviation of dbh was shown by Spies (1991) to be an important variable.

In order to minimize variation, the data set was stratified . Stratifications by geographic area, plant association group, and site class were all examined with the latter having the least variation. All plots were distributed into three categories: high site (sites 1-3), medium site (site 4), and low site site (site 5).
Each category was examined separately for each of the variables.

CHANGES OVER TIME

Nonlinear regression using least square techniques was used to fit a curve to the plots of each variable by stand age. This program (NLIN) estimated an inflection point where each variable reached a plateau. For example trees per acre generally starts high and decreases rapidly until it reaches an approximate equilibrium (reverse J-shaped curve). Old growth is perceived as an age class or condition that is relatively stable compared to younger age classes. Rates of change are slow. Transition into old growth is gradual and differs for each variable and is represented by the plateau region in each graph (Figures 1-12). By examining the age at which the inflection point occurred for each variable, an approximate initial age for old growth was established.

OLD GROWTH DETERMINATION

The average initial age obtained in the NLIN analyses was used in discriminant analysis to break the data into two groups--old growth and young growth. The analysis examined all variables simultaneously and reported on the percentage of correctly classified plots in each group. Several iterations were run, changing the age at which old growth occurred until the best grouping of plots was achieved.

DATA DESCRIPTION

Once a list of old growth plots was established, simple statistics were run to describe those plots providing means and standard deviations of each variable. Data for dominant trees were analyzed using site tree data from each old growth plot. Minimums were defined as one standard deviation less than the mean.

The following plant associations were represented in the old growth plots:

HIGH SITES

PLANT ASSOCIATION	ACRONYM
SITE CLASS 1	
Douglas-fir-Lithocarpus densiflora-Pinus lambertina	PSME/LIDE3/PILA
Douglas-fir/Berberis nervosa/Polystichum munitum	PSME/BENE/POMU
Douglas-fir/Holodiscus discolor-Berberis nervosa	PSME/HODI-BENE

PLANT ASSOCIATION	ACRONYM
SITE CLASS 2	
Douglas-fir-Abies concolor/Holodiscus discolor	PSME-ABCO/HODI
Douglas-fir/Berberis nervosa/Polystichum munitum	PSME/BENE/POMU
Douglas-fir-Lithocarpus densiflora	PSME-LIDE3
Douglas-fir-Lithocarpus densiflora/Gaultheria shallon	PSME-LIDE3/GASH
Douglas-fir-Lithocarpus densiflora/Rhus diversiloba	PSME-LIDE3/RHDI
Douglas-fir-Tsuga heterophylla/Gaultheria shallon	PSME-TSHE/GASH
Douglas-fir-Tsuga heterophylla/Berberis nervosa	PSME-TSHE/BENE
Douglas-fir/Holodiscus discolor-Whipplea modesta	PSME/HODI-WHMO
SITE CLASS 3	
Douglas-fir/Holodiscus discolor-Rosa gymnocarpa	PSME/HODI-ROGY
Douglas-fir-Abies concolor/Holodiscus discolor	PSME-ABCO/HODI
Douglas-fir/Berberis nervosa	PSME/BENE
Douglas-fir-Abies concolor-Pinus ponderosa	PSME-ABCO-PIPO
Douglas-fir/Rhus diversiloba-Berberis piperiana	PSME/RHDI-BEPI
Douglas-fir/Rhus diversiloba-Cynoglossum grande	PSME/RHDI-CYGR
Douglas-fir/Berberis nervosa-Polystichum munitum	PSME/BENE-POMU
Douglas-fir-Pinus ponderosa	PSME/PIPO
Douglas-fir-Abies concolor	PSME-ABCO
Douglas-fir-Lithocarpus densiflora/Rhus diversiloba	PSME-LIDE3/RHDI
Douglas-fir-Lithocarpus densiflora/Quercus chrysolepis	PSME-LIDE3/QUCH
Douglas-fir-Lithocarpus densiflora/Gaultheria shallon	PSME-LIDE3/GASH
Douglas-fir-Pinus lambertina-Lithocarpus densiflora	PSME-PILA-LIDE3
Douglas-fir-Abies concolor/Berberis nervosa	PSME-ABCO/BENE
Douglas-fir/Rhododendron macrophyllum	PSME/RHMA
Douglas-fir-Lithocarpus densiflora	PSME-LIDE3
Douglas-fir/Gaultheria shallon-Polystichum munitum	PSME/GASH-POMU
Douglas-fir/Rhus diversiloba-Pteridium aquilinum	PSME/RHDI-PTAQ
Douglas-fir/Holodiscus discolor-Berberis nervosa	PSME/HODI-BENE
Douglas-fir-Tsuga heterophylla/Gaultheria shallon	PSME-TSHE/GASH
Douglas-fir/Holodiscus discolor-Grass	PSME/HODI-GRASS
Douglas-fir/Holodiscus discolor-Whipplea modesta	PSME/HODI-WHMO
Douglas-fir-Tsuga heterophylla/Berberis nervosa	PSME-TSHE-BENE

MEDIUM SITES

PLANT ASSOCIATION	ACRONYM
SITE CLASS 4	
Douglas-fir/Gaultheria shallon	PSME/GASH
Douglas-fir-Abies concolor/Holodiscus discolor	PSME-ABCO/HODI
Douglas-fir/Berberis nervosa	PSME/BENE
Douglas-fir/Rhus diversiloba-Berberis piperiana	PSME/RHDI-BEPI
Douglas-fir-Abies amabilis/Vaccinium membranaceum	PSME-ABMA/VAME
Douglas-fir/Rhus diversiloba-Cynoglossum grande	PSME/RHDI-CYGR
Douglas-fir/Rhus diversiloba	PSME/RHDI
Douglas-fir-Abies concolor-Pinus ponderosa	PSME-ABCO-PIPO
Douglas-fir/Depauperate	PSME/DEPAUPERATE
Douglas-fir-Abies concolor	PSME-ABCO
Douglas-fir-Lithocarpus densiflora/Rhus diversiloba	PSME-LIDE3/RHDI
Douglas-fir/Depauperate	PSME/DEPAUPERATE
Douglas-fir-Lithocarpus densiflora-Pinus lambertina	PSME-LIDE3-PILA
Douglas-fir-Lithocarpus densiflora/Gaultheria shallon	PSME-LIDE3/GASH
Douglas-fir/Rhododendron macrophyllum	PSME/RHMA
Douglas-fir/Quercus sadleriana	PSME/QUSA
Douglas-fir-Lithocarpus densiflora/Quercus chrysolepis	PSME-LIDE3-QUCH
Douglas-fir-Pinus jefferyi	PSME-PIJE
Douglas-fir-Abies concolor/Berberis nervosa	PSME-ABCO/BENE
Douglas-fir/Gaultheria shallon-Polystichum munitum	PSME/GASH-POMU
Douglas-fir/Rhus diversiloba-Pteridium aquilinum	PSME/RHDI-PTAQ
Douglas-fir/Holodiscus discolor/Grass	PSME/HODI/GRASS
Douglas-fir/Tsuga heterophylla/Berberis nervosa	PSME/TSHE-BENE
Douglas-fir/Holodiscus discolor/Whipplea modesta	PSME/HODI/WHMO
Douglas-fir/Holodiscus-Berberis nervosa	PSME/HODI-BENE

LOW SITES

PLANT ASSOCIATION	ACRONYM
SITE CLASS 5 OR LOWER	
Douglas-fir/Gaultheria shallon	PSME/GASH
Douglas-fir/Arctostaphylos urva-ursa	PSME/ARUV
Douglas-fir/Holodidcus discolor-Rosa gymnocarpa	PSME/HODI-ROGY
Douglas-fir/Berberis nervosa	PSME/BENE
Douglas-fir/Berberis nervosa-Polystichum munitum	PSME/BENE-POMU
Douglas-fir/Rhus diversiloba-Berberis piperiana	PSME/RHDI-BEPI
Douglas-fir/Rhus diversiloba	PSME/RHDI
Douglas-fir-Lithocarpus densiflora/Rhus diversiloba	PSME-LIDE3/RHDI
Douglas-fir-Pinus jefferyi	PSME-PIJE
Douglas-fir-Tsuga heterophylla/Gaultheria shallon	PSME-TSHE/GASH

RESULTS

STAND CHANGES OVER TIME

High Site - The sampled stands ranged from 50 years to 650 years old. Total plots for the high site consisted of 3 Site I plots, 13 Site II plots, and 74 Site III plots for a total of 90 plots. There are few site I and II plots as would be expected when dealing with stands that have tendencies toward the xeric condition. The total number of trees per acre over 5 in. (12.7 cm) dbh starts at about 400 (988 trees per hectare) and decreases with time to an approximate stand age of 148 years where it stabilizes and plateaus at 139 trees per acre (343 trees per hectare) (Fig. 1). Quadratic mean diameter begins at about 10 in. (25.4 cm) and increases through stand age 274, stabilizing at 21.6 in. (54.9 cm) and 200 years stand age (Fig. 1). Basal area showed no significant change over time and ranged from 110 to 420 sq.ft. (10.2 to 39.0 sq m) (Fig. 2). Standard deviation of dbh increased with time (Fig. 2). Live tree data was highly variable, and snag tree data was even more variable. The majority of the data showed snag trees per acre ranging between 0 and 50 (0 and 124 trees per hectare). A small portion of the plots had snags up to 200 trees per acre (494 trees per hectare) (Fig. 3). The quadratic mean diameter for snags increased over time from 8 in. to 23.4 in. (20.3 to 59.4 cm) where it stabilized at a stand age of 206 (Fig. 3). The snag basal area was highly variable, and ranged from 0 to 150 sq ft (0 to 13.9 sq m). No significant trends could be detected (Fig. 4).

Medium Site - The sampled stand ages ranged from 90 years to 650 years old with 68 plots all occurring in Site IV. The live trees per acre data was highly variable. The range was from 30 to 450 trees per acre (74 to 1112 trees per hectare) (Fig. 5). The quadratic mean diameter was also quite variable and did not change over time. The data ranged from 8 in. to 27 in. (20.3 to 68.6 cm) dbh. (Fig. 5). Live tree basal area showed no significant trends, and ranged from 135 sq ft to 325 sq ft (12.5 sq m to 30.2 sq m) of basal area (Fig.6). The standard deviation of the dbh began at 4 in. (10.2 cm) and showed an increase over time (Fig 6). The data from the medium site has the highest variability. Snag trees per acre, quadratic mean diameter, and basal area showed no significant trends over time (Fig. 7 and 8).

Low Site - The sampled stands ranged in age from 60 to 380 years old and the total number of plots was 26. All of the plots were in Site V or lower. The live trees per acre ranged from 125 to 575 (309 to 1421 trees per hectare), and through stand age 280 years and stabilizes at 195 trees per acre (482 trees per hectare) (Fig. 9). The quadratic mean diameter had no significant trend over time. The range for the quadratic mean diameter for low sites is from 5 in. to 20 in. (12.7 cm to 50.8 cm) dbh (Fig. 9). No significant trends appeared in the basal area for live trees (Fig. 10). The standard deviation of dbh for low sites increased over time (Fig. 10). The snag trees per unit area decreased and showed a definite inverse j-shaped curve (Fig. 11). The snag quadratic mean was highly variable on the low sites and showed no change over time. The snag quadratic mean ranged from 8 snags per acre to 37 snags per acre (19 snags per hectare to 91 snags per hectare) (Fig. 11). No significant trend or change over time could be detected in the snag basal area data for low sites. The range of the snag basal area data was from 1 to 110 sq ft (.1 to 10.2 sq m) of basal area (Fig. 12).

Comparison of site classes

Approximate ages at which stability occurred are identified in Table 1. More of the variables from plots for the high site reached stability. Data from the medium site was highly variable and inconclusive. Low site plots seemed to have less variability than the medium sites. Possible reasons for these differences in variability between sites could be the result of stand histories (past activities such as fire, logging, and firewood cutting) or widely ranging geographical locations of the plots.

OLD GROWTH CHARACTERISTICS

High site

The average dbh for all trees greater than 5 in. (12.7 cm) on the high site was 30.4 in. (77.2 cm) with a standard deviation of 15.8 in. (40.1 cm). The mean height was 155.9 ft (47.5 m) with a standard deviation of 39.9 ft (12.2 m). The means for the dominant trees and the variables in the discriminant analysis can be found in Table 3.

There were 15 species present in the plots which included both hardwoods and conifers with a total of 1720 observations. The four major species that occurred on the high sites were madrone (n=74), sugar pine (n=88), ponderosa pine (n=93), and Douglas-fir (n=1326). All of the madrone occurred in the lower dbh classes. Large numbers of Douglas-fir occurred in the lower dbh classes as well as the higher dbh classes (Table 4, Fig. 13). Trees distributed in this manner will create several canopy layers. The Douglas-fir and the ponderosa pine had more trees in the taller height classes than the madrone or the sugar pine (Table 4, Fig. 14). Beyond age class 300 Douglas-fir had more older trees than the sugar pine or the ponderosa pine (Table 4, Fig.15). No age information was available for the madrone.

The largest Douglas-fir in the sample was 73.0 in. (185.4 cm) dbh, while the largest sugar pine was 70.5 in. (179.1 cm) dbh, and the largest ponderosa pine was 65.4 in. (166.1 cm) dbh. The largest madrone was 25 in. (63.5 cm) dbh. The tallest species was a 273 ft (83.2 m) Douglas-fir, the tallest sugar pine was 211 ft (64.3 m) , and the tallest ponderosa pine was 253 ft (77.1 m). No height data were recorded for madrone, but madrone is characteristically shorter, and generally found below the conifer canopy level.

OLD GROWTH CHARACTERISTICS

Medium site

The average dbh for all trees greater than 5 in. (12.7 cm) dbh on the medium site was 25.1 in. (63.8 cm) with a standard deviation of 14.9 in. (37.9 cm). The mean height was 129.2 ft (39.4 m) with a standard deviation of 32 ft (9.8 m). The means for the dominant trees and the variables in the discriminant analysis can be found in Table 3.

There were 16 species present which included both hardwoods and conifers. The four major species that occurred on the medium sites were madrone (n=101), sugar pine (n=113), ponderosa pine (n=154), and Douglas-fir (n=890). All of the madrone occurred in dbh classes under 30 in. (76.2 cm) except for one tree that was over 70 in. (177.8 cm) in diameter. There were more sugar pine in the larger dbh classes than ponderosa pine, but the ponderosa pine and Douglas-fir were more evenly distributed throughout the range of dbh classes (Table 5, Fig. 16). Douglas-fir had more trees in the taller height classes followed by ponderosa pine and then sugar pine (Table 5, Fig. 17). Douglas-fir was well represented throughout the range of all age classes as was ponderosa pine except ponderosa pine had no representation in age class 400 and above. Sugar pine was also well represented in all age classes. Ponderosa pine had more trees represented at age class 250 and sugar pine had more trees represented at age class 150 (Table 5, Fig. 18). There were no age data for madrone.

The largest Douglas-fir was 60.6 in. (153.9 cm) in dbh, and the largest sugar pine was 60.2 in. (152.9 cm) dbh. One large madrone tree reached 72.5 in. (184.2 cm) in dbh, and the largest ponderosa pine was 59.8 in. (151.9 cm) in diameter. Tree heights ranged from 218 ft (66.5 m) for ponderosa pine, to 209 ft (63.7 m) for sugar pine, and 208 ft (63.4 m) for Douglas-fir. There were no height data for madrone.

OLD GROWTH CHARACTERISTICS

Low site

The average dbh for all trees greater than 5 in. (12.7 cm) dbh on the low site was 16.3 in. (41.4 cm) with a standard deviation of 10.0 in. (25.4 cm). The mean height was 63 ft (19.2 m) with a standard deviation of 33 ft (10.1 m). The means for the dominant trees and the variables in the discriminant analysis can be found in Table 3.

There were 14 species present in the plots which included both hardwoods and conifers with a total of 558 observations. Four major species occurring on the low site were madrone (n=26), ponderosa pine (n=49), lodgepole pine (n=46), and Douglas-fir (n=379). All of the madrone occurred in the lower dbh classes. Most of the ponderosa pine occurred in the 30 in. (76.2 cm) dbh class and below, while Douglas-fir occurred in all of the dbh classes. All of the madrone and lodgepole were under 15 in. (38.1 cm) in dbh with the exception of 2 trees. Large numbers of Douglas-fir are in the lower dbh classes with lodgepole and madrone (Table 6, Fig. 19). Ponderosa pine had more of its trees in the taller height classes with the Douglas-fir occurring with it. Douglas-fir occurred throughout the range of height classes. Lodgepole pine occurred in the shorter height classes. There were no height data for madrone. Douglas-fir, lodgepole pine, and madrone form a separate canopy layer under a Douglas-fir and ponderosa pine overstory (Table 6, Fig. 20). The ponderosa pine occurs in three age classes. Douglas-fir is represented in all the age classes, and lodgepole pine occurs in three age classes. The predominant age class for all three species is age 250. There were no age data for madrone (Table 6, Fig. 21).

The largest Douglas-fir in the sample was 60.5 in. (153.7 cm) in dbh while the largest ponderosa pine was 42 in. (106.7 cm) in dbh. The largest madrone was 22.9 in. (58.2 cm) dbh, and the largest lodgepole pine was 20.8 inches in dbh. Tree heights on the low site ranged from 146 ft (44.5 m) for ponderosa pine to 145 ft (44.2 m) for Douglas-fir, and 61 ft (18.6 m) for lodgepole pine.

DISCUSSION

There was little or no difference in the variables describing dominant old growth. The number of trees per acre varied only by one (three per hectare) as site quality decreased. Dominant tree age indicated old growth was attained at about 200 years although there appeared to be a lot of variability in the data. Dominant tree dbh may be slightly smaller on low sites than on high sites (Table 3).

Tree species diversity was quite high on all the sites, and as the site become more xeric lodgepole appeared to replace sugar pine as one of the major components of the stand. Hardwoods were also a major component on all sites.

In designation of old growth stands it is important to note that these definitions are based primarily on stand structure which not only include the live tree data, but also the snags and dead and down material. The average number of snags per unit area for this evaluation was remarkably high. The quadratic mean diameter for live green trees, the snag quadratic mean diameter, trees per unit area, and age (Table 3) agree with PNW 447 (Old-Growth Definition Task Group 1986) which recommends 8 trees per acre (20 per hectare), 32 in. (81.3 cm) in dbh at 200 years. The dead and down information for this analysis was incomplete because data was only collected in the southern portion of Region 6. The Old-Growth Definition Task Group standard for dead and down is more reliable for this analysis: 4 pieces per acre (10 pieces per hectare) greater than or equal to 24 in. (61.0 cm) diameter and greater than 50 ft (15.2 m) long.

CONCLUSION

The minimum values for variables defining old growth climax Douglas-fir in this analysis are as follows: Dominant trees per acre ranged from 8 to 10 (20 to 25 per hectare) and the average for all site classes was 9 (22 per hectare). Dominant dbh ranged from 24 in. (61.0 cm) to 37 in. (94.0 cm) and the average for all site classes was 34 in. (86.4 cm). Old growth stand age ranged from 190 to 205 and the average for all site classes was 198. The number of canopy layers is two. Average dbh of the main canopy was 25 in. (63.5 cm) and average trees per acre of the main canopy was 174 (430 per hectare). Snag trees per acre ranged from 26 to 46 (64 tO 114 per hectare) and the average for all sites was 37 (91 per hectare). Snag quadratic mean diameter ranged from 21 to 23 in. (53.3 to 58.4 cm) in diameter and the average for all sites was 22 in. (55.9 cm). The above information is displayed in Table 7.

Old Growth stands may be developed through management. Leaving large standing trees and dead and down material during stand manipulation may further promote transition of stands to an old growth condition.

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REGION 6

INTERIM OLD GROWTH DEFINITION

FOR

GRAND FIR/WHITE FIR SERIES

June 1992

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STANDARD SUMMARY OF OLD GROWTH CHARACTERISTICS

Vegetative Series White fir/Grand fir SAF Cover Type(s) 211 & 213

Applicable Area (Region/Sub-region,etc) Region6 (Central Oregon) Site Productivity Designation Low & Medium

Live Trees						Dead Trees			
Main Canopy			Variation in Tree Diameter	Tree Decadence	Tree Canopy Layers	Standing		Down	
DBH*	TPA*	AGE*	(Yes or No)	TPA	Number	DBH	TPA	Diameter	Pieces
21" (53cm)	10 (25tph)	150	Yes	Yes	2	14" (36cm)	1 (2.5tph)	12" (30cm)	5 (13/ha)

*Required minimums

(Metric Equivalents in Parenthesis)

Vegetative Series White fir/Grand fir SAF Cover Type(s) 211 & 213

Applicable Area (Region/Sub-region,etc) Region 6 (Central Oregon) Site Productivity Designation High

Live Trees						Dead Trees			
Main Canopy			Variation in Tree Diameter	Tree Decadence	Tree Canopy Layers	Standing		Down	
DBH*	TPA*	AGE*	(Yes or No)	TPA	Number	DBH	TPA	Diameter	Pieces
21" (53cm)	15 (38tph)	150	Yes	Yes	2	14" (36cm)	1 (2.5tph)	12" (30cm)	5 (13/ha)

*Required minimums

(Metric Equivalents in Parenthesis)

STANDARD SUMMARY OF OLD GROWTH CHARACTERISTICS

Vegetative Series White fir/Grand fir   SAF Cover Type(s) 211 & 213

Applicable Area (Region/Sub-region,etc) Region 6 (Blue Mountains)   Site Productivity Designation Low & Medium

Live Trees						Dead Trees			
Main Canopy			Variation in Tree Diameter	Tree Decadence	Tree Canopy Layers	Standing		Down	
DBH*	TPA*	AGE*	(Yes or No)	TPA	Number	DBH	TPA	Diameter	Pieces
21" (53cm)	10 (25tph)	150	Yes	Yes	2	14" (36cm)	1 (2.5tph)	12" (30cm)	5 (13/ha)

*Required minimums

(Metric Equivalents in Parenthesis)

Vegetative Series White fir/Grand fir   SAF Cover Type(s) 211 & 213

Applicable Area (Region/Sub-region,etc) Region6 (Blue Mountains)   Site Productivity Designation High

Live Trees						Dead Trees			
Main Canopy			Variation in Tree Diameter	Tree Decadence	Tree Canopy Layers	Standing		Down	
DBH*	TPA*	AGE*	(Yes or No)	TPA	Number	DBH	TPA	Diameter	Pieces
21" (53cm)	20 (50tph)	150	Yes	Yes	2	14" (36cm)	1 (2.5tph)	12" (30cm)	5 (13/ha)

*Required minimums

(Metric Equivalents in Parenthesis)

WHITE/GRAND FIR OLD-GROWTH DEFINITION
on
NATIONAL FOREST LANDS
in
EASTERN OREGON and WASHINGTON

INTRODUCTION

Ecological data from a number of eastside Region 6 Forest have been summarized to develop the following definition (Appendix A;Figures A - E). These data have come from plots sampled by the Region-6 Ecology group from their classification effort over the last 25 years. These data sets are the best descriptive information available for this activity because they were collected in a consistent manner in carefully selected stable stands and latter verified (Appendix C; Tables 3,5 & Plant Association Tables for Oregon Forests).

The data used to develop the definition is from stands with little or no disturbance. Stands had to be stable and only a minor amount of disturbance was allowed. The initial cut within the data selected only those stands in at least mid seral condition and 150 years of age. Therefore, the definition is meant to be applied to stands similar to those from which it was developed such that: age is at least 150 years and any minor disturbance has not significantly altered the old growth character of the stand under consideration. Consequently, all plots were carefully analyzed and if the data indicated significant disturbance those data were not used, even though some of the criteria used to describe old growth appeared to be represented.

The definition presented is based upon characteristics of **vegetation** only and does not consider other aspects of the old growth issue (e.g. wildlife habitat characteristics; and social considerations). The non-vegetation attributes are considered outside the scope of this initial definition effort.

OLD GROWTH ATTRIBUTES

Six attributes are used to define old growth white fir/grand fir. These six characteristics have been extracted from the available literature as the best attributes of "old growthness". Presentation over the past year or so of these characteristics to various natural resource professionals has served as an informal validation process and have resulted in these six attributes being adopted by most of the National Forests in eastern Oregon. These attributes represent a per acre (0.4ha) basis and include:

1. Number of large trees;
2. Number of snags;
3. Amount of down woody material;
4. Number of tree canopy layers;
5. Native shrub/herb component (layers);
6. Size of gaps/openings;

These six attributes should apply to all sites throughout the range of climax white/grand fir climax forests. The actual values within these categories were developed from data collected on National Forest Lands in eastern Oregon and eastern Washington.
The following conditions are proposed for the determination of old growth on white/grand fir sites. In these true fir ecosystems, we have tried to present values indicative of climatic climax stands that are continuing to be expressed with fire suppression.

WORKING GROUPS

The white fir/grand fir series offer a wide range of growing conditions and stand performance making a singular definition for this series nearly impossible. The 406 ecological plots have growth information (cubic feet/acre/year) associated with each of the described plant associations. This relative measurment of growth (Growth Basal Area [GBA]), considered as a "index" only, serves as a good discriminator for delienating three levels of productivity (Table 1). The three recognized levels of productivity are:

a) low productivity - < 40 cubic feet/year (2.8 cubic meters/year)
b) moderate productivity - 50 to 80 cubic feet/year (3.5 to 5.6 cubic meters/year)
c) high productivity - > 100 cubic feet/acre/year (7.0 cubic meters/year)

Trees per acre > 21" dbh (> 53cm) were summarized for each of the three identified productivity groups. It was determined that the low and moderate productivity groups could be combined since the range of trees/acre were generally close and overlapped in either the "minimally acceptable, typical range or highest value" categories. This would leave then two working groups -- a low-moderate group and a high group. There are 12 described plant associations comprising the low productivity group, while an additional 12 different plant associations make up the moderate group. These 24 plant associations serve as the bases for establishing the trees/acre numbers used in the definition. The high productivity group represents 15 described plant associations. The only place in the definition where these working groups are displayed is in **number and size of trees/acre** attribute. The remaining six attributes do not require the use of the two productivity groups to define those attributes.

OLD GROWTH GRAND/WHITE FIR SITE CHARACTERISTICS

1. **NUMBER OF LARGE TREES.**

--- Blue Mountains (OR) and Eastern Washington---

LOW - MODERATE SITE (Figures B & C)

	Minimally Acceptable		Typical Range		Highest Value	
	TPA	BA (ft^2/ac)	TPA	BA (ft^2/ac)	TPA	BA (ft^2/ac)
	10	24	20-45	48-108	50+	120
TPha		(25)	(50-113)		(125)	
m^2/ha		(5.5)	(11-25)		(28)	

HIGH SITE[1] (Figures B & C)

	Minimally Acceptable		Typical Range		Highest Value	
	TPA	BA (ft^2/ac)	TPA	BA (ft^2/ac)	TPA	BA (ft^2/ac)
	20	48	30-50	72-120	60+	144
TPha	(50/ha)		(75-125/ha)		(150/ha)	
m^2/ha	(11)		(17-28)		(33)	

---Central Oregon---

LOW-MODERATE SITE[1] (Figures D & E)

	Minimally Acceptable		Typical Range		Highest Value	
	TPA	BA (ft^2/ac)	TPA	BA (ft^2/ac)	TPA	BA (ft^2/ac)
	10	24	15-50	36-120	55+	132
TPha	(25/ha)		(38-125/ha)		(138/ha)	
m^2/ha	(5.5)		(8-28)		(30)	

HIGH SITE[1] (Figures D & E)

	Minimally Acceptable		Typical Range		Highest Value	
	TPA	BA (ft^2/ac)	TPA	BA (ft^2/ac)	TPA	BA (ft^2/ac)
	15	36	25-50	60-120	60+	144
TPha	(38/ha)		(63-125/ha)		(150/ha)	
m^2/ha	(8)		(14-28)		(33)	

[1] -See Appendix A for a list of plant associations by site productivity class.

Discussion: The Region 6 Ecology Program plot data shows a distinct stratification by site productivity within the large tree attribute. Ranges have therefore been expressed for both low-moderate and high productivity groups. (Appendix C; Plant Association Tables & Tables 1,3). Unlike the ponderosa pine data set, condition class and level of seral development, is not easily characterized for most true fir dominated sites. Factors such as pathogens, fire occurrance, history of site disturbance, and the highly variable species composition will tend to mask seral stage development. For this reason, a single large tree category of 21+ (53cm) inches has been used in this criterion.

The data from central Oregon has also been presented separately from that of the Blue Mountains and eastern Washington. Again, this was done to reflect the obvious differences in stand characteristics of these areas (Figures B - E).

There were obvious differences in stand characteristics between Washington and Oregon. The data used from Washington had few trees over 26 inches (66cm+) in diameter (Table 3) while Oregon data had a significant number of stands with the larger trees exceeding 33 inches at dbh (> 84cm). Consequently, it was decided to present Oregon data separately from that of Washington and to use only one size class (≥ 21" dbh [53cm]).

Available data and the experience of a number of professional ecologists and silviculturists were used to select the age and size criteria. Ecologists and silviculturists, working in eastside stands, generally support the idea that old growth structural characteristics, both vertical and horizontal, begin to be expressed at about 150 years in age. The rational for tree size is compatable with the Regional Guide for the Pacific Northwest Region (1984).

2. NUMBER OF SNAGS, (14"+ dbh [36cm])

Minimally Acceptable	Typical Range	Highest Value
1 (2.5/ha)	2 - 12 (5 - 30/ha)	20+ (50/ha)

Discussion: Insects, root and stem pathogens, and fire are the principle agents resulting in snags in true fir dominated stands. Smaller snags (5-14 inches dbh [13 - 36cm]) will also be common. In comparison with ponderosa pine old growth, mortality in fir stands will tend to be more variable in stem numbers and occur in distinct groups of trees. A sample of timber stand examinations and ecology program plots taken in 117 existing, unmanaged pine dominated associated and fir dominated associated stands on the Winema, Fremont, Deschutes, and Wenatchee National Forests was used in developing the values for this criterion. The data indicate a distinct gradient, with snag numbers increasing from southern Oregon northward into Washington (Appendix B; B1- B4). Broken stems can be included in snag counts, but six feet (1.8m) in height should be considered a practical minimum size.

3. **DOWN, WOODY MATERIAL.**

NUMBER OF PIECES

Minimally Acceptable	Typical Range	Highest Value
5 (13/ha)	20 - 50 (50 - 125/ha)	50+ (125/ha)

Discussion: This attribute is measured by the number of pieces/acre (0.4ha) of large (at least 12 inches diameter [30cm] on the large end) of woody ground material. Data for estimation of this attribute came from ecology plots from the Wenatchee National Forest (Table 4) that included any piece ≥ five feet (1.53m) in length as a log and with a butt diameter of 12 inches (31cm), however, most logs are well over 5 feet (1.53m) in length. Of 41 samples used in the analysis 37, contained at least ten logs/acre (25/ha) at least 12" in diameter (31cm) at the large end. The maximum number of logs for any one plot in the data was over 200 pieces/acre (500/ha).

This attribute is a function of site productivity, age, and the relative degree of advanced old age present in a given stand. Grand fir/white fir stands, tend to have a high incidence of pathogens. This results in very large numbers of down logs in most stands (Table 4).

Recent fire in late to very late seral stands, especially very late climatic climac conditions, will exhibit large volumes of down material, while mid to late seral stands (mature to very old trees) will have less accumulation of down material.

The numbers above were derived from eastern Washington data and do not reflect the extreme variability in log quantities possible in these stands across east of Cascades Region 6. Generally, observations of ecologists and silviculturists in central Oregon, indicates that the log numbers in those stands would be at the lower end of the range.

4. **NUMBER OF TREE LAYERS (seedlings, saplings and/or poles).**

Minimally Acceptable	Typical Range	Highest Value
1	2 - 3	(complex of layers)

Discussion: Commonly, regeneration in fir dominated stands will be continuous, rather than distinct waves associated with ponderosa pine. This is a function of the complex species composition, presence of relatively shade tolerant species, and the ability of germinants to establish in comparatively thick amounts of organic material and ground debris. This means that old growth fir stands will always contain at least a single understory tree layer. Often the seedling/sapling/pole component will be complex with almost a "diffused" visual appearance when viewing the stand on the oblique. Openings and gaps resulting from insect or disease centers will tend to contain a heavy shrub
and conifer seedling component. Supporting data are Region 6 Ecological plots and professional observations (See Plant Association Tables).

5. SHRUB AND HERBACEOUS COMPONENT.

Percent Canopy Cover
Shrubs and Herbs

Minimally Acceptable	Typical Range	Highest Value
0	10 - 50	100+

Discussion: The above indicated range of percent canopy cover is a reflection of the 406 Ecological plots extracted from eight data sources covering all of eastside Region 6. These numbers are further referenced in the various published plant association guides covering the eastside forests.

Mid seral and older stands of white fir/grand fir offer a wide array of native shrubs and herbs. These naturally diverse ecosystems will support varying amounts of shrubs/herbs generally as a function of frequency of wildfire and coniferous canopy closure, e.g., a recent (last five years) underburn may reduce shrub cover to nearly zero percent canopy cover while similar conditions may also be expressed due to dense coniferous canopies "shadeing out" shrubs and reduce herbaceous cover markedly. However, wildfire and various root rot epicenters may also kill enough of the overstory trees which will then result in a number of shrubs and herbs to increase to levels approaching, and often exceeding, 100% canopy closure (See Plant Association Tables).

6. SIZE OF GAPS AND OPENINGS.

Natural gaps up to 1/2 acre (0.2ha)

Discussion: Ecology data, and the professional judgement of ecologists and silviculturalists all support the existence of natural gaps in white fir/grand fir forests. Natural openings in white fir/grand fir forests are generally more obvious than openings found in ponderosa pine forest. True fir forests generally support considerably more trees/acre than ponderosa pine forests. Natural openings tend to exhibit not only abundant seedlings and saplings but with the creation of the opening in the overstory canopy trees a noticeable increase in shrubs and herbs exhibiting a different size and age class compared to adjacent closed canopy conditions are apparent. Additionally, the shape of openings in true fir old growth tend to be oblong to circular in general outline due to the growth pattern of the various root rots. It is also quite common to find standing dead coniferous in the interior of the openings. Openings created by wildfire will have more of a polyhederal shape and often support less trees and shrubs/herbs since the fire will kill generally all three vegetational lifeforms, if burned of sufficient intensity. Fire created gaps will be more common in downslope associations where ponderosa pine is more abundant, while root rots are generally the causative agent in the creation of openings at higher elevations.

Stand Size and Shape

STAND SIZE

Minimally Acceptable	Typical Range	Highest Value
60 (25ha)	80 - 120 (32 - 49ha)	120 (49ha+)

Discussion: There is very little information or data available addressing a viable stand size considered necessary to support old growth climax white fir/grand fir forests. Much has been written on forest fragmentation and island biogeography (Harris, 1984); however, being a relative new concept, definitive research on ecological processes regarding this and other important factors are only promised. Therefore, a number of professional natural resource practitioneers and research scientist from western states were contacted (Table 2) and asked to comment on the stand size required to maintain old growth vegetation processes (integrity of old growth). Responses ranged from 1/2 to in excess of 1000 acres (0.2 - 405ha). A number of eastside ecologists working in California, Oregon and Washington suggest that to maintain internal integrity of old growth white/grand fir stands require larger acerages than for the more naturally open old growth forests such as ponderosa pine. They maintained that to provide for viable populations exhibiting a reasonable genetic variability smaller acreages were adequate but larger acreage would provide some degree of protection against localized loss due to root rots, insects or wildfire. Other scientist offered a 2 plus dominant tree height distance in from the edge (200 - 350 feet [61 - 107m]) as reasonable to protect internal stand integrity against changes in microsite due to changes in wind, snow and precipitation patterns.

Individuals who suggested smaller stand sizes for old growth often referred to other than vegetative ecological process criteria. For example, some vertebrates and small mammals would not require large acreages. Also, trees will often grow similarly whether in a 10 acre or 100 acre stand (4 - 41ha). Conversely, those who suggest large acreages tended to think more in terms of maintaining landscape process to allow for interaction across large areas--suggesting that extensive tracts of original fire climax forests may require many acres to encompass the variability within that landscape.

The stand size necessary to maintain ecological integrity is also quite dependent on the nature of the vegetation surrounding the proposed stand. Is it clearcut? Is it mature forest? Generally, old growth stands surrounded by very young managed stands should be larger in order to maintain the internal integrity of the old growth patch. On the other hand an old growth stand surrounded by mature forest may not need to be as large. Franklin, et.al., 1986 in their interim old growth definition for westside Douglas-fir originally used 80 acres (32ha) as a minimum. They dropped this size criterion later, however, conceding that minimum acreages for viable old growth stands depend upon the nature of the surrounding stand conditions and management objectives.

The degree and arrangement of various successional stages found within a given old growth set-aside is of great ecological importance. Identified "stands" within an old growth area should support vegetation representing mid, late, and very late (decadent) conditions. This mosiac of seral conditions will mimic historic stands, in part, and provide for increased bio-diversity. Maintenance of old growth conditions over time will require that these areas be managed for old growth objectives. These identified cells within the larger old growth unit must be mappable and should normally range in size from 5 to 20 acres (2 - 8ha). Recognizing desired species mix and major vegetation reaction to treatment, the manager will be able to feature given "islands" that will provide pathways from one seral condition to the next, e.g., allow late seral stands to develop into either very late or "decadent" conditions by not treating the tree/shrub/herb component and allow for stand closure. However, it should not be the intent of the manager that old growth set asides always feature only very late or decadent stands, but rather allow for maximum stand diversity reflecting a variety of conditions associated with mature to old stable stands arranged on the landscape for maximum expression of stand interaction.

Shape of the desired stand is also a consideration. Long narrow stands can have poor internal integrity because of the high proportion of the "edge" in relation to the actual stand size and the shorter distance from the stand edge to the center. A shape approaching a square or circle in general outline is deemed desirable since this shape tends to maximize internal stand integrity.

USE OF THE DEFINITION

Forest stands within the white/grand fir series are characterized by a complex species mix, range of site productivity, age, and condition classes. For this reason, judgement must be used in the application of this definition. The threshold, or minimum acceptable standard, for a stand to qualify as old growth will often be a primary management concern. While all of the criteria are important, the large tree component, and presence of the adequate snag and down woody material will most often be limiting factors. The question then becomes: "Can a stand which is missing one or more of the six attributes still qualify as old growth within the scope of this definition"? This answer is a definite yes. However, a relatively strict interpretation of these criteria is intended. Stands in the mid to late seral stages (mature to stands exhibiting very old trees previoulsy referred to as very late climatic climax) have only marginally developed to the old growth character which is visualized by many resource management professionals. This means that a relatively more rigorous screening against the criteria should be used, in comparasion with those stands in a more late to decadent development stage.

A large proportion of stands to be evaluated against the old growth criteria will not be in a totally undisturbed condition. Some minor tree removals have been made in the form of salvage of short term (9-10 years) mortality, snag removal, or high-grading of valuable large individual trees. This means that some judgement must be used in evaluating "old growthness" under these conditions. A minor amount of site disturbance can be tolerated. There is a threshold of stand disturbance, however, where common natural resource sense dictates that the old growth character of a given area has been lost or greatly comprised.

TABLE 1

PLANT ASSOCIATIONS USED IN THE ANALYSIS PROCESS TO DETERMINE CHARACTERISTICS OF OLD GROWTH WHITE FIR/GRAND FIR ECOSYSTEMS

Plant associations are listed as either low, moderate or high productivity sites:

LOW SITES (12 ASSOCIATIONS) < 40 FT^3/ACRE/YEAR
(< 2.8 CUBIC METERS/HA/YEAR)

Grand fir/pinemat manzanita
Grand fir/grouse huckleberry
Grand fir/birchleaf spirea/ wheelers' bluegrass
Grand fir/mt. snowberry
Grand fir/pinegrass-residual
Grand fir/elk sedge-residual
Grand fir/pinegrass-residual
Grand fir/elk sedge-ash
Grand fir/pinegrass-lupine
Mixed conifer/snowbrush-squaw carpet
White fir-ponderosa pine/ manzanita-Or. grape
White fir-ponderosa pine-sugar pine/manzanita

MODERATE SITES (12 ASSOCIATIONS) 50 - 80 FT^3/ACRE/YEAR
(3.5 - 5.6 CUBIC METERS/HA/YEAR)

Grand fir/heartleaf arnica
Grand fir/bracken fern
Grand fir/common snowberry
Grand fir/snowberry
Grand fir twinflower
Grand fir/big huckelbery
Grand fir/side-flowered mitrewort
Mixed conifer/snowbrush-bearberry
White fir-ponderosa pine-incense cedar/serviceberry
White fir-ponderosa pine/ snowberry/tuber starwort
White fir/snowberry/ strawberry
White fir-ponderosa pine-aspen/long-stolon sedge

HIGH SITES (15 ASSOCIATIONS) > 100 FT^3/ACRE/YEAR
(> 7 CUBIC METERS/HA/YEAR)

Grand fir/vanillaleaf
Grand fir/bigleaf maple
Grand fir/bigleaf maple/queencup beadlily
Grand fir/bigleaf maple/ prince's pine
Grand fir/Cas. Oregon grape-big huckelberry
Grand fir/Rocky Mt. maple
Grand fir/columbia brome
Grand fir-englemann spruce/ big huckelberry

HIGH SITES (15 ASSOCIATIONS) Continued

Grand fir/Pacific yew/
queencup beadlily

Grand fir/Cascade Oregon grape

Grand fir/Cascade Oregon grape/
elk sedge

White fir/chinquapin-Oregon
boxwood-prince's pine/
long-stolon sedge

White fir/chinquapin-Oregon
boxwood-prince's pine

White fir-ponderosa pine-
western white pine/
sticky currant

REGION 6

INTERIM OLD GROWTH DEFINITION

FOR

INTERIOR DOUGLAS-FIR SERIES

June 1992

Prepared by:

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STANDARD SUMMARY OF OLD GROWTH CHARACTERISTICS

Vegetative Series Douglas-fir SAF Cover Type(s) 210

Applicable Area (Region/Sub-region,etc) Region 6 (Eastside) Site Productivity Designation All

Live Trees						Dead Trees			
Main Canopy			Variation in Tree Diameter	Tree Decadence	Tree Canopy Layers	Standing		Down	
DBH*	TPA*	AGE*	(Yes or No)	TPA	Number	DBH	TPA	Diameter	Pieces
21" (53cm)	8 (20tph)	150	Yes	2 (5tph)	1	12" (30cm)	1 (2.5tph)	12" (30cm)	2 (5tph)

*Required minimums

(Metric Equivalents in Parenthesis)

Vegetative Series ______ SAF Cover Type(s) ______

Applicable Area (Region/Sub-region,etc) ______ Site Productivity Designation ______

Live Trees						Dead Trees			
Main Canopy			Variation in Tree Diameter	Tree Decadence	Tree Canopy Layers	Standing		Down	
DBH*	TPA*	AGE*	(Yes or No)	TPA	Number	DBH	TPA	Diameter	Pieces

*Required minimums

(Metric Equivalents in Parenthesis)

DOUGLAS-FIR (INTERIOR) OLD-GROWTH DEFINITION
on
NATIONAL FOREST LANDS
in
EASTERN WASHINGTON and OREGON

INTRODUCTION

The Douglas-fir old-growth definition applies to part of Society of American Foresters (SAF) Forest Type 210, Interior Douglas-fir. For "old-growth" definitions in Region 6 of the USDA Forest Service, SAF Type 210 applies only to stands east of the Cascade Mountain Crest potentially dominated at climax by Douglas-fir. This is commonly termed the "Douglas-Fir Series" in many plant association guides. The Douglas-fir Series as used herein, includes only those plant communities where Douglas-fir is the indicated climatic climax tree species and stands are capable of forming open to closed forest canopies (with 30% or more canopy cover). Douglas-fir may be the indicated climax species at lower elevations in eastern Washington, but site conditions are too harsh to allow establishment of a continuous tree canopy that will fully exclude regeneration by ponderosa pine. This definition does not apply to such woodland sites even though individual trees may attain considerable age and size. Such sites are better considered as variants of the Ponderosa Pine Series for the purpose of old-growth definitions.

Most Douglas-fir Series sites support one or more other conifers, such as lodgepole pine, western larch, and ponderosa pine in all but climax conditions. These species are often important components of old-growth stands and may even be stand dominants. Very shade tolerant and competitive species, such as western hemlock, mountain hemlock, western redcedar, silver fir, grand fir/white fir, subalpine fir, and Engelmann spruce are not considered part of the Douglas-fir Series because these other species form the indicated climax when with Douglas-fir. These latter species are not part of this definition.

Ecology data from Region 6 Forests east of the Cascade Mountain Crest have been summarized to develop the definition. These data are from plots taken by the Region 6 Ecology group in their plant community classification work over the last 25 years. These data are the best currently available in the Region but have the following limitations when used for old-growth definitions:

1. Old-growth is a stand level characteristic, not an individual tree attribute. Our data are from samples of individual trees concentrating on dominants or co-dominants (those meeting site index criteria). Little or no data were taken on the rest of the trees in the stand.

Old-growth stands are more than just an aggregation of selected individual tree attributes.

2. Many plots lack quantitative information on snags, logs, tree decadence, and canopy structure that are important characteristics of old-growth forests.

3. All the data sets are not in the same format or contain the same types of information. Some data sets contain individual tree measurements, while others have plot summaries by species. Similar data may have been taken in different ways, so direct comparison between data sets is not wholly satisfactory. Dead tree information is limited to eastern Washington ecology plots and even there the Okanogan data were collected differently than the Colville and Wenatchee National Forest data; therefore, are not readily amenable to pooled quantitative analysis.

In spite of the above limitations the data are judged to be of sufficient quality and quantity to establish minimum values for essential old-growth attributes until more applicable data become available.

Currently, available Timber Inventory data were examined, but lacked necessary structural information to allow their use.

Available data, literature, and work in Region 1; and the experience of ecologists, biologists, and silviculturists were used to select the age and size criteria.

The rationale for tree size gives consideration to the needs of species, such as the pileated woodpecker that require trees 20 inches (50 cm) or greater in diameter to nest (Thomas, 1979). Cavity excavating birds, such as the pileated woodpecker also play an important role in the life cycle of other birds and mammals (Thomas, 1979) that are important components of old-growth forest ecosystems. Snags and logs, less than 12 inches (30 cm) diameter, are used by fewer species than those larger than 12 inches (30 cm) Large diameter snags can substitute for small diameter snags, but small snags cannot replace the ecologic role of large snags (Thomas, 1979).

"Old-growth" as defined herein is not synonymous with "pristine" or pre-European settlement stand conditions. Alteration of fire patterns and livestock grazing are just some of the landscape-level changes attendant with settlement of eastern Washington and Oregon since the early 1800's. Structural characteristics, both vertical and horizontal, require time to develop. Data analysis indicates that in the Douglas-fir Series 150 to 200 years are necessary on most sites for trees to reach 20-inch (50 cm), or larger.diameters. Such time also allows for the establishment of most plants that will be in old-growth stands with attendant ecological linkages between and among species. Such linkages and structures may form earlier, but 150 years or more appear necessary on most sites for canopy structures, tree diameters, snags, logs, shrub, and herb compositions to develop and/or stabilize, compared to younger stands.

Data are from ecology plots in stands with little recent disturbance from man's activities or natural fires. All stands had to be successionally stable with mid to late seral conditions. Initial plot selection was based on a screening procedure that required eight or more trees to the acre that were 150 years old or more, and 21 inches or greater in diameter at breast height. (These are the criteria used in the Northern Idaho draft old-growth matrix dated October 11, 1990.) Examination of our Douglas-fir Series data indicates these values are reasonable.

These size and age criteria are not reasonably applied to lodgepole pine dominated forests. Lodgepole pine as a species is characterized by a physiologically shorter life span; and mature trees are generally smaller in diameter than Douglas-fir, ponderosa pine, or western larch. Lodgepole pine dominated stands in the Douglas-fir Series in northern Idaho and western Montana are considered to approximate old-growth conditions when they are 120 years old and 13 inches in diameter. Data on lodgepole pine from eastern Washington reveal little relationship between tree diameter and age across a wide range of sites. Lodgepole pine may be a component in old-growth stands in the Douglas-fir Series, but only rarely will be a major stand component in meeting the minimum old-growth criteria.

The definition is based upon the characteristics of the <u>vegetation</u> and does not fully consider other aspects of the old-growth issue (e.g., wildlife and social considerations). The nonvegetation attributes are considered beyond the scope of this initial effort.

<u>OLD-GROWTH ATTRIBUTES</u>

The following minimum attributes are used to define old-growth stands in the Douglas-fir Series. (These attributes are from National USDA Forest Service direction in a letter dated December 4, 1990, under the signature of David G. Unger.)

<u>Attributes.</u>	MINIMUM
1. Live trees in main canopy:	
-DBH (inches)	21 (53 cm)
-trees per acre	8 (20 tph)
-age (years)	150
2. Variation in tree diameters (yes or no)	YES
3. Dead trees (12+ inches (30 cm) diameter):	
-standing trees per acre (number)	1 (0)* (2.5 tph)
-down pieces per acre (number)	2 (0)* (5 tph)
4. Tree decadence (spike or deformed tops, bole or root decay):	
-trees per acre	2

5. Number of tree canopies	1
Additional criteria	
6. Canopy crown cover	30%

* See following discussion on dead tree criteria.

Dead tree information is from eastern Washington ecology plot data from the Colville and Wenatchee National Forests, and may not reflect the variation in snag and log quantities across Region 6. Snags and logs are a function of site productivity, age, stand history (fires, insects, disease, etc.), and the relative degree of decadence of each stand. Broken stems may be included in snag counts, but 6 feet (1.8 m) is a practical minimum height. Small diameter snags (4-12" dbh or 10-30 cm) are often common even in relatively young stands. Logs (down woody material) are measured by the number of pieces/acre 12+ inches (30 cm) diameter (on the large end). Snags and logs are transitory compared to other old-growth attributes and change within a stand as they decay, snags fall, or other trees die; therefore, some "old-growth" stands may currently lack a significant dead tree component. Snags and logs are relatively easy to create through management if live trees of sufficient size and quantity are present.

Quantitative information on tree decadence is lacking. Estimates in the definition are based on field notes and personal observations.

Douglas-fir is moderate in shade tolerance; consequently, old-growth stands usually contain at least a single understory tree layer with Douglas-fir as the primary species in the tree regeneration layer. Openings and gaps resulting from insect or disease centers usually have better development of the shrub and conifer seedling component. Such openings may allow for limited regeneration of less shade tolerant species, such as ponderosa pine, western larch, or lodgepole pine.

Natural gaps, up to one acre in size, are often a characteristic of old-growth stands. Natural openings commonly contain abundant seedlings and saplings with a concomitant increase in shrubs and herbs with a different size and age class compared to adjacent closed canopy stands. Often natural openings are due to root rots. Root rot openings tend to be oblong to circular. Standing dead conifers are common in the interior of such openings. Openings created by wildfire are typically polyhedral, and snags and logs (if any) are charred.

The Douglas-fir Series includes a number of plant associations that are quite different from one another. These associations describe relatively undisturbed mid-seral to climatic climax stands under fire suppression policies. Prior to active fire suppression, wildfires had a significant influence on stand development and composition.

Fire suppression has altered the character of stands in habitats that support a sparse shrub, grass, or herb dominated undergrowth. Prior to fire control sites occupied by plant communities which contain pinegrass, elk sedge, beargrass, huckleberries, or bitterbrush types were subject to periodic underburns on a 5- to 30-year interval between fires. (A list of plant associations is given in the Appendix.) These relatively low intensity fires kept stands open and species composition favored fire tolerant species such as ponderosa pine, western larch, and Douglas-fir. More intense stand replacing fires tended to favor lodgepole pine. With fire suppression, the more competitive and shade-tolerant Douglas-fir increases in proportion in the stands. Stand structures change from relatively open single to two-storied stands to denser multi-layered stands. The periodic natural underburns kept logs and other woody materials on the forest floor at relatively low levels. Under fire suppression, woody materials, canopy levels, and densities increase. Western larch, ponderosa pine, and lodgepole pine are unable to replace themselves in competition with Douglas-fir; therefore, the proportion of snags of those species may decline in the future. Different species form snags and logs with different structure, decay, and chemical compositions, so snag and log-dependent biota may change in composition and amount as the species of snags and logs change. Following several decades of fire control, these drier sites develop stand structures and conditions similar to those in the moister habitats within the Douglas-fir Series. When this occurs most stands burn with much greater intensity.

Underburns were generally less frequent and thus less important in stand development on habitats that support a relatively dense shrub layer under the conifer canopy. Many stands were so dense that a common fire pattern was of occasional intense fires on a 200- to 400-year return interval. Current stand development under fire control on dense shrub sites does not appear markedly different than that prior to European settlement. Plant communities representative of these types of natural fires and related habitats contain ninebark, snowberry, twinflower, huckleberry, or pachistima in the understory. (See Appendix.)

Little information or data are available on minimum stand size to support old-growth forests. Much has been written on forest fragmentation and Island Biogeography (i.e., Harris, 1984), but little definitive research on ecological processes, regarding this and other important factors, has been done. Stand size necessary to maintain ecological integrity is highly dependent on the nature of the vegetation surrounding the proposed stand. Generally, old-growth stands surrounded by young plantations or clearcuts should be larger in size to maintain the internal ecological integrity of the old-growth stand; conversely, an old-growth stand surrounded by mature forest may not need to be as large. Franklin, et.al., 1986, first used 80 acres as a minimum. They later dropped size criteria concluding that minimum acreages for viable old-growth stands depend upon the nature of surrounding stands and management objectives.

Shape of the desired stand is also a consideration, especially if stands are relatively small. Long narrow stands may have poor internal integrity because of the higher amount of "edge" proportional to stand size, and the shorter distance from the stand edge to the center.

USE OF THE DEFINITION

Forest stands within the Douglas-fir Series are characterized by a complex species mix, range of site productivity, age, and condition classes; therefore, judgement must be used in the application of this definition. The threshold, or minimum acceptable standard, for a stand to qualify as old-growth is often a primary management concern. While all the criteria are important, the large tree component and stand structure are essential. As discussed before, snags and logs are largely a function of the live tree component. A relatively strict interpretation of the live tree criteria is intended, while more flexibility is accorded the dead tree component.

A large proportion of stands to be evaluated against the old-growth criteria will not be in an undisturbed condition. Some tree or snag removals may have occurred. Professional judgement must be used in evaluating "old-growthness" under these conditions. Some site disturbance can be tolerated, but the structural and ecological integrity of the stand must remain.

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APPENDIX

Plant Associations with a 5- to 30-Year Fire Return Interval:

Douglas-fir/pinegrass (PSME/CARU)
Douglas-fir/dwarf huckleberry (PSME/VACA)
Douglas-fir/huckleberry (PSME/VACCI)
Douglas-fir/bearberry (PSME/ARUV)
Douglas-fir/bearberry-bitterbrush (PSME/ARUV-PUTR)
Douglas-fir/pinegrass-elk sedge (PSME/CARU-CAGE)

Plant Associations with a 200- to 400-Year Fire Return Interval:

Douglas-fir/ninebark (PSME/PHMA)
Douglas-fir/ninebark-twinflower (PSME/PHMA-LIBOL)
Douglas-fir/common snowberry (PSME/SYAL)
Douglas-fir/common snowberry/elk sedge (PSME/SYAL/CAGE)
Douglas-fir/pachistima (PSME/PAMY)
Douglas-fir/big huckleberry (PSME/VAME)

REGION 6

INTERIM OLD GROWTH DEFINITION

FOR

LODGEPOLE PINE SERIES

June 1992

Prepared by:
Bill Hopkins   Deschutes NF

STANDARD SUMMARY OF OLD GROWTH CHARACTERISTICS

Vegetative Series Lodgepole pine (Sierra)

SAF Cover Type(s) 218

Applicable Area (Region/Sub-region,etc) Region 6 (Central & SE Oregon)

Site Productivity Designation All

Live Trees						Dead Trees			
Main Canopy			Variation in Tree Diameter	Tree Decadence	Tree Canopy Layers	Standing		Down	
DBH*	TPA*	AGE*	(Yes or No)	TPA	Number	DBH	TPA	Diameter	Pieces
12" (30cm)	60 (150tph)	120	Yes	No Data	1	12" (30cm)	5 (13tph)	–	0

*Required minimums

(Metric Equivalents in Parenthesis)

Vegetative Series________________

SAF Cover Type(s)________________

Applicable Area (Region/Sub-region,etc)________________

Site Productivity Designation________________

Live Trees						Dead Trees			
Main Canopy			Variation in Tree Diameter	Tree Decadence	Tree Canopy Layers	Standing		Down	
DBH*	TPA*	AGE*	(Yes or No)	TPA	Number	DBH	TPA	Diameter	Pieces

*Required minimums

(Metric Equivalents in Parenthesis)

LODGEPOLE PINE OLD-GROWTH DEFINITION
for
NATIONAL FOREST LANDS
in
EASTERN OREGON

INTRODUCTION

Three varieties of lodgepole pine occur in Oregon: Pinus contorta var. contorta, coastal form known as shore pine; Pinus contorta var. murrayana, found throughout central and south-central Oregon southward into the Sierra Nevada, known as Sierra lodgepole pine; and Pinus contorta var. latifolia, found in northeast Oregon and then eastward into the Rockies, known as Rocky Mountain lodgepole pine. This definition deals expressily with Pinus contorta var. murrayana, the Sierra lodgepole pine which is considered to be mostly non-serotinious and has been described in climax stands covering roughly 500,000 acres (202,347ha) in central and south-central Oregon (Kovalchik 1987, Hopkins A & B 1979, and Volland 1988).

Ecological data from the Winema, Deschutes and Fremont National Forest have been summarized to develop the following definition (Appendix A; Table 1). These data have come from plots taken by the Region 6 Ecology group in their classification effort over the last 25 years (Appendix A; Tables 2-7). These data sets are the best descriptive information for this activity because they were collected in a consistent manner in carefully selected stable stands and later verified.

The definition presented is based upon the characteristics of the **vegetation** only and does not consider other aspects of the old growth issue (e.g., wildlife habitat characteristics and social considerations). Non-vegetative attributes are considered outside the scope of this initial definition effort.

OLD GROWTH ATTRIBUTES

Six attributes are used to define old growth lodgepole pine. These six characteristics have been extracted from the available literature as the best attributes of "old growthness" and are identical to those used for draft Region 6 eastside definitions dealing with ponderosa pine and white fir-grand fir series old growth definitions (Hopkins, Simon, Schafer and Lillybridge, A & B 1992). Presentation and defense of these six attributes over the last several years to a variety of natural resource professionals has served as an informal validation process and have resulted in these six attributes being adopted by most of the National Forest in Oregon. These attributes are referenced on a per acre basis (0.2ha) and include:

1. Number of large trees;
2. Number of snags;
3. Number/size of large down woody material;
4. Number of tree canopy layers in addition to large overstory;
5. Native shrub/herb/grass canopy coverage
6. Size of gaps or openings

These six attributes should apply to all sites throughout the range of climax Sierra lodgepole pine forests found in Oregon. Actual values within these categories were developed from data collected on National Forest lands. In these described lodgepole pine ecosystems, an attempt to present values indicative of climatic climax stands that are continuing to be expressed with fire suppression is intended.

HISTORIC PERSPECTIVE

The Sierra lodgepole pine forests observed today in Oregon are considered, by this author, to be a biological anomaly since these forest were never allowed to grow into the contigious structured forests characterisitic of the range of Sierra lodgepole pine we now find throughout central and south-central Oregon (Leiberg, 1899, Langille, Plummer, Dodwell et.al., 1903). It has been estimated that fire frequency in climax lodgepole pine forests would range between 20 to 30 years. These pre-european forests settings would best be characterized as vast stands of variously aged and sized lodgepole pine trees with average stem size being probably two - four inches (5 - 10cm) at ground level. Fire near the base of the thin-barked species would result in death to the majority of trees (Munger, 1908 historic photos with narrative). With the advent of aggressive fire suppression around 1905 to 1910, stands of lodgepole pine where allowed to grow into diameters that we now take for granted. In addition to the trees growing into larger diameters, native shrubs and herbs also captured this opportunity to express canopies never displayed across the range of the Sierra lodgepole pine forests found in Oregon. The impacts of fire can also be judged by soil profile descriptions. The Mazama soils (approximately 5600 years old) that commonly occurs throughout the area, exhibit no body wood that would be the result of large stems dying and falling to the ground that would then undergo decay and subsequent incoroporation into the soil. Only recently (in the last 50 to 60 years) large dead trees are found and all are still, essentially, on top of the soil in various states of decay where fire has been excluded. Therefore, sites that today support climax Sierra lodgepole pine with diameters of 10 - 14 inches (25 - 36cm) dbh dominant trees, would have had, historically a "rough" clumpy appearance of small patches of two - four inches (5 - 10cm) diameter trees at ground level with some larger six - eight inches (15 - 20cm) dbh trees widely scattered across the stand. These clumpy patches would be puncuated with variously sized, extremely dense "dog-hair" patches of seedlings/saplings. Native shrub cover was low and a majority of the sites supported fragile-appearing western needlegrass (Stipa occidentalis). In addition to the above scenario, some sites would also exhibit stems ranging from four - seven inches (10 - 18cm) that had been killed by fire and had fallen to form jack-straw ground covering.

SIERRA LODGEPOLE PINE STAND DYNAMICS

Due to the rather short-lived nature of Sierra lodgepole pine (oldest tree measured from vegetative plots was 226 years at dbh but oldest stand age average approximated only 170 years old at dbh) (Appendix A; Table 1); lodgepole pine forest will present a unique challenge regarding managers ability to select a given stand and maintain those conditions for any reasonable period of time. As lodgepole pine forest approach maturity and assume old growth characteristics, a number of natural forest pathogens and pests often become serious problems. The greatest threat to lodgepole pine forests appears to be mountian pine beetle (Dendroctonus monticolae). Mountain pine beetle attach mature lodgepole pine forest when growth has slowed due to advanced age and, generally, overstocking due to the loss of fire consuming seedlings, saplings and pole-sized trees. Consequently, old growth Sierra lodgepole pine forests occur between ages 120 - 150 years. Management of these forest with the expressed desire to maintain old growth characteristics with only a 30 year span before endemic pests/pathogens become serious problems presents a unique challenge.

----------OLD GROWTH SIERRA LODGEPOLE PINE CHARACTERISTICS-------------

1. NUMBER OF LARGE (> 12 INCHES [30CM] DBH) OVERSTORY TREES/ACRE. (Figure A)

Minimally Acceptable		Typical Range		Highest Value	
TPA (TPha)	BA[1] (m^2/ha)	TPA (TPha)	BA[1] (m^2/ha)	TPA (TPha)	BA[1] (m^2/ha)
60 (150)	47 (11)	120-150 (300-375)	95-119 (22-27)	160+ (400+)	126 (29)

1/ = All Basal Area (BA) recorded in ft^2/acre

Discussion: Out of 187 vegetation plots only 24 plots exhibited stands 120 years old and only three plots out of the 24 plots supported stands greater than 170 years in age (Appendix A; Figure A and Tables 8 - 18). Dominant overstory stems ranged from 12 - 17 inches (30-43cm) diameter breast high (dbh) with the average dominants approaching 14 inches (36cm) dbh. Therefore, it appears that "old growthness" in lodgepole pine forest are first expressed when stands approach 120 years in age and can be maintained for an average of, at least, 30 additional years until either mountain pine beetles or a wildfire incident kills the majority of the dominate trees in either a local or a more extensive area. In future years if lodgepole pine forests in Oregon can be silviculturally treated to provide adequate spacing, this will provide for tree vigor making the stands more resistant to mountain pine beetle attack, it is then possible to assume some stand average age may approach 170 - 200 years.

2. NUMBER OF SNAGS/ACRE (0.2Ha).

Five snags > 12 inches/acre (30cm/0.2Ha)

Discussion: Fire and mountain pine beetle are considered the main causal factors resulting in the development of snags in Sierra lodgepole pine forests. Stand exam data collected from various ranger districts from National Forest in Oregon serve as the basis for these numbers (Appendix A; Table 8 with Narrative; Tables 16 - 18).

3. **DOWN, WOODY MATERIAL.**

This attribute is a measure of the number of eight foot pieces per acre (2.5m/0.2Ha) of large (at least 10 inches [25cm] diameter on the large end) woody ground debris. For example, a down log which is 24 feet (7.3m) in length represents three pieces.

NUMBER OF PIECES

Minimally Acceptable	Typical Range	Highest Value
0 1/	12 -20 (30 - 50/ha)	25+ (63+/ha)

Discussion: This attribute is a function of site productivity, age and the relative degree of advanced maturity (decadence) for each stand. Since the advent of fire suppression during the first part of this century, many of the stands have now developed into large diameter mature live trees. However, many stands also exhibit considerable down dead being a reflection of past stand history. Stands that were 50 - 60 years old around the turn of the century experienced protection and were allowed to mature over the following 60 - 80 years only to be attack by various pest/pathogens. This has resulted in some stands exhibiting an increased amount of large dead tree-fall in recent years and tends to be associated more with higher elevation stands that historically reflected a fire frequency at longer return intervals than lower elevation drier-tending stands (Table 8 with Narrative; Tables 16 - 18).

1/ A given acre (0.2ha), or even a stand, may exhibit little to no coarse woody debris or snags for a period of time. Judging only one place at a given point in time is not recommended. Attributes such as snags and woody debris may be at a zero (0) on one or more acres that are being appraised. Accordingly, these attributes must be judged as a function of dominate tree average size and seral condition. The potential of the site to produce these attributes in a reasonable period of time is essential. Both snags and coarse woody debris may be created on site from green trees if sufficient number and size of trees are present.

4. **NUMBER OF TREE LAYERS (Seedlings, Saplings and Poles).**

Minimally Acceptable	Typical Range	Highest Value
0	1-2	(3)

Discussion: Commonly Sierra lodgepole pine stands regenerate a few trees each year. Favorable conditions will often result in hundreds, even thousands, of seedlings to establish in a given year (Appendix A, Tables 2 - 7). This variation is often apparent when comparing the poorly drained soils which are often seasonally (spring) wet lodgepole pine sites to the better drained hotter sites which is the more common and widespread forest condition. Vegetation data summary demonstrate these findings (Appendix A, Table 1).

5. SHRUB AND HERBACEOUS COMPONENT.

Old growth Sierra lodgepole pine forest will often support a layer of native shrub(s) in association with a variety of grasses, sedges and forbs. The criterion is measured by the total percent vegetative canopy. This non-tree component is an important element in both the vertical and horizontal structural diversity in these stands.

Percent Canopy Cover
Shrubs and Herbs

Minimally Acceptable	Typical Range	Highest Value
Shrubs-- (Trace)	2 - 10	(30+)
Herbs-- (Trace)	1 - 10	(20+)
Grasses/Sedges-- (Trace)	1 - 20	(20+)

Discussion: Principle data sources for this attribute are the Ecology Program plots. This is further refelected by published Plant Association Guides, and information extracted from timber stand examination and forest inventory plots (Appendix A; Tables 2 - 7).

6. SIZE OF GAPS AND OPENINGS.

Natural gaps up to 1/2 acre (0.2ha) in size

Discussion: Ecological data, and the professional judgement of ecologists and silviculturlists all agree that natural gaps in lodgepole pine forests can occur. It is important here to separate two conditions: 1) vast areas of recently killed stands due to mountain pine beetle; and 2) current very late climatic climax stands that have not experienced epidemic beetle attack. In the first example literally thousands of acres of the larger dominant trees were destroyed creating vast openings that would have similar affects of a large wildfire. However, mature to very mature "decadent" stands, although not typical of pre-european conditions, reflect occassional dead tree(s) in small pockets being the products of beetle attack and these pockets can approach up to 1/2 acres (0.2ha) in size.

STAND SIZE AND SHAPE

Minimally Acceptable	Typical Range	Highest Value
10 (25ha)	40 - 100 (99 - 247ha)	100+ (247+ha)

Discussion: There exists very little data or information addressing a viable stand size considered biologically necessary to support old growth Sierra lodgepole pine forests. Much has been written on forest fragmentation and island biogeography (Harris, 1984); however, being a relative new concept, definitive research on ecological processes regarding this and other important factors are only promised. The above numbers reflect a "best guess" based on previous discussions with a number of experienced natural resource managers; similar conclusions are reflected here that was developed in the ponderosa pine old growth definition effort. Here, as was the case for interior stands of ponderosa pine, a square or circular shape will better maximize the interior of a given area from asssumed negative influences associated with treated lands adjacent to an old growth area.

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REGION 6

INTERIM OLD GROWTH DEFINITION

FOR

PACIFIC SILVER FIR SERIES

June 1992

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STANDARD SUMMARY OF OLD GROWTH CHARACTERISTICS

Vegetative Series Pacific Silver Fir SAF Cover Type(s) 226

Applicable Area (Region/Sub-region,etc) Region 6 Site Productivity Designation Site 5

Live Trees						Dead Trees			
Main Canopy			Variation in Tree Diameter	Tree Decadence	Tree Canopy Layers	Standing		Down	
DBH*	TPA*	AGE*	(Yes or No)	TPA	Number	DBH	TPA	Diameter	Pieces
22 in. (56cm)	9 (22tph)	260	Yes	Yes	2	22 in. (56cm)	1 (2tph)	24 (61cm)	4 (10tph)

*Required minimums

(Metric Equivalents in Parenthesis)

Vegetative Series Pacific Silver Fir SAF Cover Type(s) 226

Applicable Area (Region/Sub-region,etc) Region 6 (Western) Site Productivity Designation Site 6

Live Trees						Dead Trees			
Main Canopy			Variation in Tree Diameter	Tree Decadence	Tree Canopy Layers	Standing		Down	
DBH*	TPA*	AGE*	(Yes or No)	TPA	Number	DBH	TPA	Diameter	Pieces
22 in. (56cm)	1 (2tph)	360	Yes	Yes	2	22 in. (56cm)	12 (30tph)	24 (61cm)	4 (10tph)

*Required minimums

(Metric Equivalents in Parenthesis)

STANDARD SUMMARY OF OLD GROWTH CHARACTERISTICS

Vegetative Series Pacific Silver Fir   SAF Cover Type(s) 226

Applicable Area (Region/Sub-region,etc) Region 6 (Western)   Site Productivity Designation Sites 2 & 3

Live Trees						Dead Trees			
Main Canopy			Variation in Tree Diameter	Tree Decadence	Tree Canopy Layers	Standing		Down	
DBH*	TPA*	AGE*	(Yes or No)	TPA	Number	DBH	TPA	Diameter	Pieces
26 in. (66cm)	6 (15tph)	180	Yes	Yes	2	22 in. (56cm)	6 (15tph)	24 (61cm)	4 (10tph)

*Required minimums

(Metric Equivalents in Parenthesis)

Vegetative Series Pacific Silver Fir   SAF Cover Type(s) 226

Applicable Area (Region/Sub-region,etc) Region 6 (Western)   Site Productivity Designation Site 4

Live Trees						Dead Trees			
Main Canopy			Variation in Tree Diameter	Tree Decadence	Tree Canopy Layers	Standing		Down	
DBH*	TPA*	AGE*	(Yes or No)	TPA	Number	DBH	TPA	Diameter	Pieces
25 in. (64cm)	7 (17tph)	200	Yes	Yes	2	22 in. (56cm)	4 (10tph)	24 (61cm)	4 (10tph)

*Required minimums

(Metric Equivalents in Parenthesis)

INTRODUCTION

A series of 23 articles on old-growth forests of the United States and parts of Canada was published in the Natural Areas Journal (Volume 8, nos. 1 & 3; vol. 9, no. 1; and vol. 11, no. 1) between 1988-1991. Most of these articles describe old-growth characteristics of forests from various geographic areas. Some characteristics stand alone for a particular area, some differ numerically, but there are a number of characteristics which are similar for all areas.

The existence of large (diameter and height), old trees is the most common feature described, followed by the presence of snags and coarse woody debris on the ground. Almost every article used 150 years or older as a lower age limit. Structural complexity was nearly always described and included terms or descriptors like gaps, fragmented communities, spatial heterogeneity, and multi-layered canopies. Other characteristics described include large numbers of stems that can endure shade, and a rich species diversity, including epiphytes and mosses.

In the western Cascades and Coast Ranges of the Pacific Northwest old-growth forests are a continuum of ecosystems that vary in space and time, a result of a unique set of environmental circumstances (Franklin and Spies 1984, Spies and Franklin 1988). Compared to many other old-growth forest ecosystems in the United States, the ones in the Pacific Northwest are particularly long-lived, some over 1000 years. Much more is known about the structure than the function of old-growth forests, and much more is known about the above-ground system than the below-ground system. Species composition varies among community types and relatively few of these species are found only in old-growth forests. Some species of mosses and epiphytic lichens do find their optimum habitat in old-growth. The spotted owl (*Strix occidentalis*) and the red tree vole (*Clethrionomys occidentalis*) are thought to be obligate old-growth species.

Though old-growth forests tend to be very productive, productivity can vary considerably. Soil characteristics and long-term climatic conditions may account for some of this variation.

The old-growth forests in the Pacific Northwest are structurally very diverse, but there are certain similar characteristics. In the forests where trees are particularly large and tall, there is a diverse habitat gradient from the top of the tree to the bottom. Shade tolerant trees tend to increase with time and there is generally a large component of coarse woody debris in the form of snags or wood on the ground.

Disturbances have played an important role in the development of old-growth forests. Depending on where you are in the region, disturbances have run the gamut of large catastrophic upheavals like fire to smaller-scaled upheavals like wind, insect outbreaks, and ground fires. Disturbances continue to play a role in the development and distribution of old-growth forests, but many of these disturbances are human caused, like clear-cuts and fire.
The mature and climax seral stages of conifer forests in the Pacific Northwest have received a lot of attention lately because of harvest rates and possible

extinction of the northern spotted owl and other endangered species. Efforts to describe the composition and structure of these forests have been interim and have used a broad approach, lumping together forest types over a broad geographical range (Franklin et al. 1986). The Forest Service ecology program in Region 6 has been collecting data on mature stands of dominate conifer types, based on series, for over 20 years.

The objective of this paper is to use the variables collected on ecology plots in the Pacific silver fir (Abies amabilis) series: (1) to detect trends in forest stand changes over time, and (2) to define and describe the characteristics of old growth stands.

LITERATURE REVIEW

The range of the Pacific silver fir series is from the southeastern edge of Alaska (55 degrees N. latitude) south along the coast and islands of British Columbia, except the Queen Charlotte Islands, and in the Cascades through Western Washington to Southern Oregon (43 degrees N. latitude). It is also found locally in the Olympic Mountains, sporadically in the Coast Ranges of Washington and northern Oregon, on the eastside of the Cascades on portions of the Wenatchee and Mount Hood National Forests, and in the Klamath Mountains of Northwestern California (Burns and Honkala 1990; Fowells 1965). The elevational range of the Series is from sea level to 1000 feet (305 m) in Alaska, 3300 feet to 4900 feet (1000 to 1500 m) in Oregon and Washington, and from 5600 feet (1700 m) to 7000 feet (2135 m) in California (Franklin and Dryness 1973; Griffin and Critchfield 1972; Viereck and Little 1972).

The environment of the Pacific silver fir series is humid to super-humid with moderate temperatures, short growing seasons, and a late summer dry period. Deep winter snowpacks from 3 to 10 feet (90 to 305 cm) are common (Fowells 1965; Brockway et al. 1983; and Hemstrom et al. 1982).

A complex of soil forming processes leads toward podzolization, and organic matter accumulations are from 1.2 to 2.8 inches (3 to 7 cm) thick except in northern Washington where accumulations can reach up to 11.8 inches (30 cm). In Oregon podzolization is less strongly expressed and soils are more shallow and rocky (Franklin et al. 1990). Pacific silver fir grows on soils developed from nearly every type of parent material found in the Northwest (Burns and Honkala 1990).

Pacific silver fir is seldom found growing in pure stands in the juvenile stage. It usually exists as advance regeneration under less shade tolerant species. Mature stands are usually a mixture of species with western hemlock (Tsuga heterophylla), western redcedar (Thuja plicata), Alaska yellow cedar (Chamaecyparis nootkatensis), mountain hemlock (Tsuga mertensiana), and subalpine fir (Abies laisocarpa) being the most common. In the oldest stage a species mixture may still exist with Pacific silver fir in approximate equal proportions with western hemlock (Tsuga heterophylla) (Burns and Honkala 1990; Dimock 1958; Fowells 1965). It is the most abundant true fir on the westside of the Pacific Northwest Cascade mountains, and forms extensive pure stands in many localities (Harlow, W. M. and Harrar, E. S. 1968).

Less common associated tree species include grand fir (Abies grandis), noble fir (Abies procera), western larch (Larix occidentalis), Engelmann spruce (Picea engelmannii), Sitka spruce (Picea sitchensis), lodgepole pine (Pinus contorta), western white pine (Pinus monticola), Douglas-fir (Pseudotsuga menziesii), red alder (Alnus rubra), and western black cottonwood (Populus trichocarpa) (Packee et al. 1981). The major shrub species are ovalleaf whortleberry (Vaccinium ovalifolium), big whortleberry (Vaccinium membranaceum), Oregon wintergreen (Gaultheria ovatifolia), snow dewberry (Rubus nivalis), rusty menziesia (Menziesia ferruginea), Arizona mountainash (Sorbus dumosa), vine maple (Acer circinatum), sitka alder (Alnus sinuata), common juniper (Juniperus communis), mapleleaf currant (Ribes acerifolium), western mountain ash (Sorbus occidentalis), myrtle pachistima (Pachistima myrsinites), bearberry (Arctostaphylos uva-ursi), and bush cinquefoil (Potentilla fruticosa) (Dimock 1958).

Individual trees attain maximum heights of about 200 feet (61 m) and diameters are known to be over 6 feet (1.8 m). The largest specimen on record is said to be 245 feet (74.7 m) in height and 8.4 feet (2.6 m) in diameter breast height (dbh). The species frequently reaches 180 to 200 feet (55 to 61 m) tall and more than 2 feet (60 cm) in diameter in climax stands (Burns and Honkala 1990; Dimock 1958; Fowells 1965). Packee et al. (1981) states that Pacific silver fir is one of the most shade tolerant trees of the Pacific Northwest with Pacific yew (Taxus brevifolia) being the only species more tolerant.

Sucessional patterns, according to Franklin et al. (1973), indicate the major climax species throughout the series is Pacific silver fir. He points out that Pacific silver fir is usually last to invade the site. On the Gifford Pinchot National Forest, Brockway (1983) points out long-term stable vegetation exists for the Pacific silver fir series when at least 10% of the cover is Pacific silver fir. This criterion separates the Pacific silver fir series from other adjacent series. Packee et al. (1981) describes the sucessional development of a climax stand within the series. After crown closure, understory development is completely eliminated by shade, causing a very open forest floor which can last as long as 200 years. Eventually, the overstory abrades, promoting the development of shrubs and advanced regeneration which takes place after one to three hundred years. Individual trees die and advance regeneration slowly grows upward creating a multi-aged forest with a major component of Pacific silver fir. This condition is self-perpetuating barring a major disturbance.

MATERIALS AND METHODS

AREA DESCRIPTION AND DATA COLLECTION

The data used in these analyses were collected from Region 6 ecology plots over the last 20 years. Data collection procedures are detailed in the Regional Resource Inventory Handbook and Field Instructions for Vegetative Resource Surveys. These data were collected fairly consistently in stable forest stands and analyzed using the SAS statistical software package.

The data set for the silver fir series was comprised of plots on the Olympic, Mt. Baker-Snoqualmie, Gifford Pinchot, Mt. Hood, Willamette, Umpqua, and Rogue

River National Forests. Plots occurred across a variety of parent rock types, elevations, slopes, aspects, and terrain.

In order to minimize variation, the data set was stratified. Stratifications by geographic area, plant association group, and site class were all examined with the latter being the most successful. Site class variables were determined using Hoyer and Herman, 1989. There were no Site Class 1 plots. Site Classes 2 and 3 were combined to make an adequate sample size. Site Classes 4, 5, and 6 were examined separately.

Stand age was determined for each plot based on the oldest cohort of trees where at least 10 per acre (25 trees per hectare) were present. The variables used in the analyses were live trees per acre (TPA), live tree quadratic mean diameter (QMD), live tree basal area (BA), the standard deviation of live tree dbh (STD) (Spies and Franklin, in press), snags per acre (SNAGTPA), snag quadratic mean diameter (SNAGQMD), and snag basal area (SNAGBA). All trees greater than 5 inches (12.7 cm) dbh were included. Down woody material was not analyzed because of small sample size (n = 11 plots over all site classes).

STAND CHANGES OVER TIME

Nonlinear regression using least squares techniques was used to fit a curve to the plots of each variable by stand age. This program (NLIN) estimated an inflection point where each variable reached a plateau. For example, trees per acre generally starts high and decreases rapidly until it reaches an approximate equilibrium (reverse J-shaped curve). Old growth is perceived as an age class or condition that is relatively stable compared to younger age classes. Rates of change are slow. Transition into old growth is gradual and differs for each variable and is represented by the flat, plateau region in each graph. By examining the age at which the inflection point occurred for each variable, an approximate initial age for old growth was established.

OLD GROWTH DETERMINATION

This initial age was used in discriminant analyses to break the data into two groups--old growth and young growth. The analysis examined all variables simultaneously and reported on the percentage of correctly classified plots in each group. Several iterations were run, changing the age at which old growth started until the best grouping of plots was achieved.

DATA DESCRIPTION

Once a list of old growth plots was established, simple statistics were run to describe those plots providing means and standard deviations of each variable. Data for dominant trees were analyzed using site tree data from each old growth plot. Minimums were defined as one standard deviation less than the mean. Minimum snag DBH was averaged over all site classes. The plant associations represented in each site class are shown in Table 1.

Table 1. Plant associations represented in old growth plots.

Site classes 2 and 3	
Silver fir/Alaska huckleberry/Queencup beadlily	ABAM/VAAL/CLUN
Silver fir/Swordfern	ABAM/POMU
Silver fir/Alaska huckleberry/Coolwart foamflower	ABAM/VAAL/TIUN
Silver fir/Alaska huckleberry/Oregon oxalis	ABAM/VAAL/OXOR
Silver fir/Swordfern-Oregon oxalis	ABAM/POMU-OXOR
Site class 4	
Silver fir/Alaska huckleberry/Beadruby	ABAM/VAAL/MADI2
Silver fir/Thin-leaf huckleberry-Alaska huckleberry	ABAM/VAME-VAAL
Silver fir/Devil's club-Alaska huckleberry	ABAM/OPHO-VAAL
Silver fir/Alaska huckleberry-Dwarf Oregongrape	ABAM/VAAL-BENE
Silver fir/Lycopus	ABAM/LYAM
Silver fir/Alaska huckleberry/Queencup beadlily	ABAM/VAAL/CLUN
Silver fir/Alaska huckleberry/Coolwart foamflower	ABAM/VAAL/TIUN
Silver fir/Thin-leaf huckleberry/Queencup beadlily	ABAM/VAME/CLUN
Silver fir/Alaska huckleberry-California hazel	ABAM/VAAL-COCA
Silver fir/Beargrass	ABAM/XETE
Silver fir/Salal/Oregon oxalis	ABAM/GASH/OXOR
Silver fir/Alaska huckleberry/Oregon oxalis	ABAM/VAAL/OXOR
Silver fir/Swordfern-Oregon oxalis	ABAM/POMU-OXOR
Silver fir/Vanilla leaf-Coolwart foamflower	ABAM/ACTR-TIUN
Silver fir/Thin leaf huckleberry-Whitebark raspberry	ABAM/VAME-RULA
Silver fir-Western hemlock/Queencup beadlily	ABAM-TSHE/CLUN
Silver fir/Vine maple/Coolwart foamflower	ABAM/ACCI/TITR
Site class 5	
Silver fir/Thin leaf huckleberry/Sitka valerian	ABAM/VAME/VASI
Silver fir/Alaska huckleberry/Queencup beadlily	ABAM/VAAL/CLUN
Silver fir/Alaska huckleberry/Coolwart foamflower	ABAM/VAAL/TIUN
Silver fir/Thin leaf huckleberry	ABAM/VAME
Silver fir/Coolwart foamflower-Rosy twistedstalk	ABAM/TIUN-STRO
Silver fir/Dry herb	ABAM/DRY HERB
Silver fir/Alaska huckleberry/Coolwart foamflower	ABAM/VAAL/TIUN
Silver fir/Coolwart foamflower	ABAM/TIUN
Silver fir/Oregon oxalis	ABAM/OXOR
Silver fir/Devil's club	ABAM/OPHO
Silver fir/Rhododendron-Salal	ABAM/RHMA-GASH
Silver fir/Alaska huckleberry/Avalanche fawnlily	ABAM/VAAL/ERMO
Silver fir/Thin leaf huckleberry-Whitebark raspberry	ABAM/VAME-RULA
Silver fir/Vine maple/Coolwart foamflower	ABAM/ACCI/TITR
Site class 6	
Silver fir/Alaska huckleberry/Queencup beadlily	ABAM/VAAL/CLUN
Silver fir/Alaska huckleberry	ABAM/VAAL
Silver fir/Alaska huckleberry/Beadruby	ABAM/VAAL/MADI2
Silver fir/Rhododendron/Beargrass	ABAM/RHMA/XETE
Silver fir/Lycopus	ABAM/LYAM
Silver fir/Oregon oxalis	ABAM/OXOR
Silver fir/Alaska huckleberry-Cascara	ABAM/VAAL-RHAL
Silver fir/Thin leaf huckleberry-Whitebark raspberry	ABAM/VAME-RULA
Silver fir/Rhododendron-Alaska huckleberry	ABAM/RHMA-VAAL

RESULTS

STAND CHANGES OVER TIME

<u>Site Classes 2 and 3</u> - The stand ages sampled were between 25 and 350 years old, with 41 plots.

Total number of trees per acre starts high and drops over time until the stand is about 180 years old and supports approximately 170 trees per acre (420 trees per hectare) (Fig. 1) Quadratic mean diameter increased and appears to level off at 24.8 inches (63.0 cm) at 330 years stand age (Fig. 2). Basal area continued to increase over the range of stand ages examined and exceeded 500 square feet per acre (115 sq m/ha) at 350 years (Fig. 3). Standard deviation of dbh also continued to increase until 320 years and plateaued at 13.7 inches (34.8 cm) (Fig. 4). Both the quadratic mean diameter and standard deviation of dbh may actually continue to increase since the plateau indicated by nonlinear regression starts at the end of the range of stand ages sampled and may be an artifact.

Snag data was more variable than live tree data. Snags per acre is about 150 (370 snags per hectare) in 100-year-old stands and decreases through stand age 350 to about 25 snags per acre (62 snags per hectare) (Fig. 5). Snag basal area and quadratic mean diameter were high variable and showed no trends with stand age (Fig. 6 and 7).

<u>Site Class 4</u> - The stand ages sampled were between 100 and 800 years, with 52 plots.

Total trees per acre is approximately 600 at stand age 100 (1481 trees per hectare) and decreases to 138 trees per acre (341 trees per hectare) by stand age 340 years and older (Fig. 8). QMD increases until stand age 390 years and stabilizes at 23.0 inches (58.4 cm) (Fig. 9) producing a stand of fewer larger trees. Basal area shows no significant trend (Fig. 10). Standard deviation of dbh increased over the range of data, indicating an influx of younger cohorts under an aging overstory (Fig. 11).

Snag trees per acre showed no changes over time and remained constant at 32 trees per acre (79 trees per hectare) (Fig. 12). Snag quadratic mean diameter increased through stand age 517 years and stabilized at 27.9 inches (70.9 cm) (Fig. 13). Snag basal area was highly variable (Fig. 14).

<u>Site Class 5</u>

The stand ages in this sample ranged from 75 to 725 years and included 55 plots. Live trees per acre stabilized at stand age 302 years and 173 TPA (427 trees per hectare) (Fig. 15). Quadratic mean diameter increased until stand age 272 years and stabilized at 21.0 inches dbh (53.3 cm) (Fig. 16). Basal area was highly variable, but appeared to stabilize at 125 years (Fig. 17). Standard deviation of dbh increased through stand age 455 years, stabilizing at 12.0 inches (30.5 cm) (Fig. 18).
Snag trees per acre decreased through stand age 434 years, stabilizing at 36 TPA (89 trees per hectare) (Fig. 19). Snag QMD showed no significant trends

although it appeared to be slightly higher in the older stands (Fig. 20). Snag basal area was highly variable with no significant trends (Fig. 21).

Site Class 6

Stand ages in this sample ranged from 100 years to 800 years and included 42 plots. Live trees per acre decreased from over 600 TPA (1481 trees per hectare) to 169 TPA (417 trees per hectare), stabilizing at 253 years stand age (Fig. 22). Neither basal area nor quadratic mean diameter showed significant change over time (Fig. 23 and 24). Standard deviation of dbh stabilized at stand age 502 years and 12.9 inches (32.8 cm) (Fig. 25).

Number of snags per acre decreased over the range of stand ages examined, reaching 28 TPA (69 trees per hectare) by 800 years (Fig. 26). Snag QMD showed no significant changes over time (Fig. 27). Basal area increased and stabilized at stand age 431 years with 122 square feet (28 sq m) (Fig. 28).

Comparison of Site Classes

Table 2 summarizes the ages at which stability occurs for each variable. The snag variables, quadratic mean diameter, and basal area were highly variable and few trends could be identified. A possible explanation for this is that snag development is dependent on stand history; i.e., the nature and severity of past disturbance, rather than stand age. The number of snags per acre appears to increase as site class decreases. The standard deviation of dbh appears to be the variable that requires the longest time to stabilize. This suggests a steady increase of younger age classes, along with aging trees, making the range of dbh quite high. This would enhance the structural diversity of the stands.

OLD GROWTH DETERMINATION

When discriminant analyses were used to group data, all variables were considered equally and an unbiased estimate was made of which plots belong to old growth and which do not. Any method that assumes a specific age represents old growth then proceeds to describe stands of that age, whether it is 200 years or 500 years, allows bias into the procedure, making it less objective.

Site Classes 2 and 3

A division between young and old growth at stand age 180 years resulted in a classification that was 100 percent correct for both age groups. Stand age was highly significant, and standard deviation and live tree quadratic mean diameter were significant variables in this analysis (Table 3). The average R-squared for the analysis was 0.157.

Site Class 4

Discriminant analysis produced 100 percent correct classification of young growth and 97.4 percent correct classification of old growth when the groups were separated at 200 years old. The one incorrectly classified plot was greater than 200 years old but more closely exhibited traits of younger stands. Five variables were highly significant in this analysis: live trees per acre, live tree quadratic mean diameter, snag quadratic mean diameter, standard deviation of dbh, and stand age. Number of snag trees per acre was significant (Table 3). The average R-squared was 0.244.

Site Class 5

Discriminant analysis produced 100 percent correct young stand classification and 89 percent correct old growth classification when old growth was separated at 260 years. The three misclassified plots were over 260 years old but exhibited traits of young stands. Three variables were highly significant: live tree quadratic mean diameter, standard deviation of dbh, and stand age. Live trees per acre, snag trees per acre, and snag quadratic mean diameter were significant (Table 3). Average R-squared for this analysis is 0.273.

Site Class 6

Young growth and old growth had 95 percent and 92 percent correct classifications, respectively, when old growth was 360 years old or older. One plot older than 360 years exhibited young stand characteristics and one plot younger than 360 years exhibited old growth characteristics. Standard deviation of dbh and stand age were highly significant; and live tree quadratic mean diameter, snag trees per acre, and snag quadratic mean diameter are significant (Table 2). Average R-squared was 0.221.

Table 2. Stand age at which stability is reached for various stand attributes.

Site Class	2 & 3	4	5	6
		Age		
Trees per acre	180	340	302	253
Quadratic mean diameter	330	390	272	*
Basal area	INC	*	*	*
Standard dev. of dbh	INC	INC	455	502
Snags per acre	350	*	434	800
Snag QMD	*	517	*	*
Snag basal area	*	*	*	431

* = No significant trends.
INC = Continued to increase through the range of stand ages sampled.

Table 3. F-values and significance levels of variables used in discriminant analyses to determine young and old growth plots.

Variable	F-Value	Significance Level
Site Classes 2 and 3		
Trees per acre	2.367	0.133
Basal area	1.997	0.167
Quadratic mean diameter	5.678	0.023
Snag trees per acre	3.226	0.082
Snag basal area	0.175	0.679
Snag quadratic mean diameter	2.833	0.102
Standard deviation dbh	7.069	0.012
Stand age	58.107	0.001
Site Class 4		
Trees per acre	25.699	0.001
Basal area	2.530	0.119
Quadratic mean diameter	20.426	0.001
Snag trees per acre	9.821	0.003
Snag basal area	0.920	0.342
Snag quadratic mean diameter	15.407	0.001
Standard deviation dbh	26.697	0.001
Stand age	32.924	0.001
Site Class 5		
Trees per acre	7.150	0.011
Basal area	0.422	0.520
Quadratic mean diameter	13.944	0.001
Snag trees per acre	5.222	0.028
Snag basal area	1.165	0.287
Snag quadratic mean diameter	7.237	0.010
Standard deviation dbh	14.718	0.001
Stand age	41.570	0.001
Site Class 6		
Trees per acre	3.784	0.061
Basal area	0.935	0.341
Quadratic mean diameter	7.723	0.009
Snag trees per acre	8.732	0.006
Snag basal area	2.964	0.095
Snag quadratic mean diameter	6.862	0.013
Standard deviation dbh	17.716	0.001
Stand age	49.158	0.001

Table 4. Means and standard deviations of discriminant variables in young and old growth groups, and minimum values for dominant trees in old growth stands.

Variable	Young Growth	Old Growth
Site Classes 2 and 3		
Trees per acre	235 (107)	171 (91)
Basal area (sq ft)	339 (96)	409 (199)
Quadratic mean diameter (in)	17.1 (4.7)	21.8 (5.3)
Snag trees per acre	60 (42)	32 (25)
Snag basal area (sq ft)	79 (62)	69 (64)
Snag quadratic mean diameter (in)	15.6 (7.3)	20.9 (10.0)
Standard deviation dbh (in)	7.4 (4.3)	12.0 (4.1)
Dominant TPA (minimum)		6
Dominant DBH (minimum inches)		26
Old growth stand age (minimum years)		180
Number of plots	27	8
Site Class 4		
Trees per acre	344 (183)	153 (67)
Basal area (sq ft)	286 (114)	345 (100)
Quadratic mean diameter (in)	13.2 (4.4)	21.4 (5.3)
Snag trees per acre	91 (127)	27 (16)
Snag basal area (sq ft)	70 (77)	92 (63)
Snag quadratic mean diameter (in)	13.4 (6.1)	25.6 (9.1)
Standard deviation dbh (in)	4.9 (2.6)	12.9 (4.7)
Dominant TPA (minimum)		7
Dominant DBH (minimum inches)		25
Old growth stand age (minimum years)		200
Number of plots	10	38
Site Class 5		
Trees per acre	272 (102)	182 (104)
Basal area (sq ft)	344 (93)	361 (67)
Quadratic mean diameter (in)	15.8 (3.2)	20.1 (3.9)
Snag trees per acre	77 (48)	45 (40)
Snag basal area (sq ft)	73 (40)	89 (46)
Snag quadratic mean diameter (in)	14.8 (5.7)	20.5 (6.9)
Standard deviation dbh (in)	6.9 (2.7)	10.7 (3.2)
Dominant TPA (minimum)		9
Dominant DBH (minimum inches)		22
Old growth stand age (minimum years)		260
Number of plots	14	28

Site Class 6

Trees per acre	248 (149)	164 (60)
Basal area (sq ft)	359 (94)	396 (126)
Quadratic mean diameter (in)	17.6 (4.3)	21.7 (4.2)
Snag trees per acre	54 (29)	29 (14)
Snag basal area (sq ft)	82 (44)	132 (123)
Snag quadratic mean diameter (in)	18.4 (8.3)	26.1 (8.3)
Standard deviation dbh (in)	7.9 (3.4)	13.1 (3.6)
Dominant TPA (minimum)		0
Dominant DBH (minimum inches)		22
Old growth stand age (minimum years)		360
Number of plots	21	13

DISCUSSION

DESIGNATION OF OLD GROWTH STANDS

Before a stand can be designated as old growth using this definition, the live tree variables should be attained, particularly standard deviation of dbh. Though snags and dead and down material are important to ecosystem processes, efforts to describe them were difficult. They are the result of the past history of the stand. The average number of snags per acre was found to be significantly higher than the minimum suggested by the Old Growth Definition Task Group. The number of snags observed in the higher site stands may under represent what was there earlier since they result, at least partially, from mortality in intermediate and suppressed trees. They have probably long since decayed. The quadratic mean is about the same as the suggested snag diameter minimum (20 inches). Because we had inadequate dead and down information, it is recommended to use the Task Group standard: logs greater than or equal to 15 tons per acre, including 4 pieces per acre greater than or equal to 24 inches diameter and greater than 50 feet long. Since dead and down is often derived from snags, and we show more snags, the Task Group standard may be low.

STAND DEVELOPMENT

The estimate of number of years to reach old growth is based on natural stand development, including such agents as wind, fire, insects, diseases, and natural weather patterns. Inital stocking of these stands after natural disturbances vary with weather, cone crop, etc. Some of these, particularly fire, have been altered by humans and may result in different amounts of time to reach old growth. Management to develop old-growth-like stands in shorter periods of time may have to mimic natural disturbances. Thinning, underburning, and perhaps underplanting with tolerants may reduce the time required to achieve old growth characteristics. Leaving old growth structure during harvest can speed the development process.

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REGION 6

INTERIM OLD GROWTH DEFINITION

FOR

PONDEROSA PINE SERIES

June 1992

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STANDARD SUMMARY OF OLD GROWTH CHARACTERISTICS

Vegetative Series Ponderosa Pine SAF Cover Type(s) 237

Applicable Area (Region/Sub-region,etc) Region 6 (Eastside) Site Productivity Designation Low

	Live Trees					Dead Trees			
	Main Canopy		Variation in Tree Diameter	Tree Decadence	Tree Canopy Layers	Standing		Down	
DBH*	TPA*	AGE*	(Yes or No)	TPA	Number	DBH	TPA	Diameter	Pieces
21" (53cm)	10 (25tph)	150	Yes	--	1	14" (36cm)	3 (7.5tph)	--	0
1/ 31" (79cm)	2 (5tph)	200	Yes	Yes	1	Same	Same	Same	Same

*Required minimums 1/ Very late seral (decadent) conditions (Metric Equivalents in Parenthesis)

Vegetative Series Ponderosa Pine SAF Cover Type(s) 237

Applicable Area (Region/Sub-region,etc) Region 6 (Eastside) Site Productivity Designation Med - High

	Live Trees					Dead Trees			
	Main Canopy		Variation in Tree Diameter	Tree Decadence	Tree Canopy Layers	Standing		Down	
DBH*	TPA*	AGE*	(Yes or No)	TPA	Number	DBH	TPA	Diameter	Pieces
21" (53cm)	13 (33tph)	150	Yes	--	1	14" (36cm)	3 (7.5tph)	--	0
1/ 31" (79cm)	3 (8tph)	200	Yes	Yes	1	Same	Same	Same	Same

*Required minimums 1/ Very late seral (decadent) conditions (Metric Equivalents in Parenthesis)

PONDEROSA PINE OLD-GROWTH DEFINITION
for
NATIONAL FORESTS LANDS
in
EASTERN OREGON and WASHINGTON

INTRODUCTION

Ecological data from a number of east-side R-6 Forests have been summarized to develop the following definition (Appendix A; Figures A-C). These data have come from plots sampled by the R-6 Ecology group from their classification effort over the last 25 years. These data sets are the best descriptive information available for this activity because the data was collected in a consistent manner in carefully selected stable stands and latter verified.

The definition presented is based upon the characteristics of the vegetation only and does not consider other aspects of the old growth issue (e.g. wildlife habitat characteristics and social considerations). Non-vegetation attributes are considered outside the scope of this initial definition effort.

OLD GROWTH ATTRIBUTES

Six attributes are used to define old growth ponderosa pine. These six characteristics have been extracted from the available literature as the best attributes of "old growthness". Presentation of these characteristics to a variety of natural resource professionals over the past several years has served as an informal validation process and have resulted in these six attributes being adopted by most of the National Forests in eastern Oregon. These attributes represent a per acre basis (0.4ha):

1. Number of large trees;
2. Number of snags;
3. Amount of down woody material;
4. Number of tree canopy layers;
5. Native shrub/herb component (layers);
6. Amount and size of gaps/openings;

These six attributes should apply to all sites throughout the range of climax ponderosa pine forests located east of the Cascades in Oregon and Washington. The actual values within these categories were developed from data collected on National Forest Lands in eastern Oregon and, to a lesser extent, eastern Washington. In Washington especially, there are areas of ponderosa pine climax, commonly below the elevation of National

Forest System Lands, that have not been included in the data set.
The following conditions are proposed for the determination of old growth on ponderosa pine sites. In ponderosa pine ecosystems, we have tried to present values indicative of climatic climax stands that are continuing to be expressed with fire suppression.

WORKING GROUPS

Due to recognized variations in site potential exhibited by climax ponderosa pine stands, the data presented for numbers of large trees has been stratified into two productivity classes (Figure B). These two classes include a "low" working group comprised of nine described plant associations and a moderate-high group characterized by fourteen plant associations (Table 1).

The low site productivity working group has the following attributes:

1. Most sites fall within the transition zone between forest and non-forest environments;
2. support vegetation indicative of xeric conditions such as western juniper, big sagebrush, bluebunch wheatgrass, mountain mahogany and bitterbrush; and
3. have lower tree productivity.

The moderate-high working group exhibits the following the following attributes:

1. The stands within this group are found in contiguous forest settings that have higher available moisture (than the low working group);

2. support vegetation typical of higher precipitation zones; and
3. are more productive-supporting higher numbers of trees with faster growth rates.

OLD GROWTH PONDEROSA PINE SITE CHARACTERISTICS

1. NUMBER OF LARGE TREES.(See Figure C also)

LOW SITE

Minimally Acceptable		Typical Range		Highest Value	
TPA*	BA** ft^2/ac	TPA	BA ft^2/ac	TPA	BA ft^2/ac
10[1] (25/ha)	24(5.5 m^2/ha)	15-25(30-63/ha)	36-60(8.3-13.8 m^2/ha)	30+(75/ha)	72+(16.6 m^2/ha)
2(5/ha)	11(2.5 m^2/ha)	3-5 (8-13/ha)	16-26 (3.7-6.0 m^2/ha)	6+(15/ha)	32+(7.4 m^2/ha)

MOD-HIGH SITE

Minimally Acceptable		Typical Range		Highest Value	
TPA*	BA** ft^2/ac	TPA	BA ft^2/ac	TPA	BA ft^2/ac
13[1] (33/ha)	31(7.1 m^2/ha)	18-40(45-100/ha)	43-96(10-22 m^2/ha)	45+(113/ha)	110+(25.3 m^2/ha)
3(8/ha)	13(3.0 m^2/ha)	5-7(13-18/ha)	26-37(6.0-8.5 m^2/ha)	8+(20/ha)	40+(9.2 m^2/ha)

1-Mid to late seral conditions where dominant trees are greater than 21" dbh, and at least 150 years in age.

2-Late to very late (decadent) seral conditions where dominant trees are greater than 31" dbh and at least 200 years in age.

*TPA=Trees per acre

**BA=Basal Area

Discussion: Within each of the working groups two major tree size class categories are recognized. They generally represent two stand condition and/or developmental categories. Stands that have tree dominants greater than 21 inches (53cm) are considered to be mid-late seral and define one class. The larger size class supports dominant trees greater than 31 inches (79cm) and is considered to represent late to very late (often decadent) stand conditions. These recognized seral conditions are a function of stand history (e.g. past cutting, wildfire, insects, time of development etc.). Stands in which tree ages exceeded 150 years were considered the youngest that might potentially reflect the inception of old growth conditions.

Available data and the experience of a number of professional ecologists and silviculturists were used to select the age and size criteria. This information indicates that trees growing in low site potential "transition zones" can reach 18-20+ inches (46 - 51cm) in diameter in approximately 150 years. Ecologists and silviculturists, working in east-side stands, generally support the idea that old growth structural characteristics, both vertical and horizontal, begin to be expressed at about 150 years of age.

2. **NUMBER OF SNAGS.**

Three snags > 14" (36cm) dbh per acre (7.5/ha) and/or 10% of stand with spire tops.

Discussion: Fire, insects and root pathogens are considered to be the main causal factors resulting in the development of snags in ponderosa pine forests. Munger (1917) indicated that fires killed about three percent of the 30 plus trees (over 12" dbh [30cm]) in the "Yellow Pine" country. Munger further indicated that insects killed about one tree per acre and that root pathogens also added to the snags in a stand. Trees killed by insects and root pathogens may tend to be more clumped than trees killed by fire. The overall effect of these causal agents is estimated to be three snags/acre although any one acre may be devoid of snags. Spire tops, although less common today, were quite common in the historic stands at the turn of the century. Munger (1917) indicated that 10-15% of the "yellow pine" trees had spire tops.

3. **DOWN, WOODY MATERIAL.**

This attribute is measured by the number of eight foot pieces (2.45m) per acre of large (at least 12 inch diameter [30cm] on the large end) woody ground debris. For example, a down log which is 24 feet (7.3m) in length represents three pieces.

NUMBER OF PIECES

Minimally Acceptable	Typical Range	Highest Value
0	3-6 (8-15/ha)	10 (25/ha)

Discussion: This attribute is a function of site productivity, age, and the relative degree of decadence of each stand. Late to very late seral stands (especially decadent ones), without the evidence of recent fire will exhibit large volumes of down material, while mid to late seral stands (mature to overmature) will tend toward the lower end of the range.

There is little current definitive information available from any of the data sources for down woody material under eastside conditions. Historic records from Leiberg (1899), Langille, Plummer, Dodwell et.al (1903), and Munger (1917) indicate that large woody material was essentially absent in the stands of the day. Evidence today indicates the loss of large woody material with even a low intensity prescribed underburn.

4. NUMBER OF TREE LAYERS (seedlings, saplings and/or poles).

Minimally Acceptable	Typical Range	Highest Value
0	1-2 (2.5-5/ha)	2+ (5+/ha)

Discussion: Commonly ponderosa pine regenerates in "episodes". Favorable conditions will allow for a wave of regeneration in some stands. This is particularly true in the mod-high site stands. In the low site stands regeneration may occur as scattered smaller individuals rather than in distinguishable clumps. Where scattered individuals occur, it is sometimes difficult to identify a true "layer" of smaller size-class individuals. Munger (1917) apparently had stands that displayed both an obvious layer of smaller individuals and stands with just a few scattered smaller trees. (Appendix B; Association Tables).

5. **SHRUB AND HERBACEOUS COMPONENT.**

Old growth ponderosa pine stands will often support a layer of native shrubs, in association with a variety of grasses, sedges and forbs. The criterion is measured by the total percent vegetative canopy. This non-tree component is an important element in both the horizonital and vertical structural diversity in these stands.

% Canopy Cover
Shrubs and Herbs

Minimally Acceptable	Typical Range	Highest Value
0	20-40 (20-40/ha)	80+ (80+/ha)

Discussion: Principle sources for this attribute are from the Ecology Program plots. This is further reflected by published Plant Association Guides, and information extracted from timber stand examination and forest inventory plots.

6. **NUMBER AND SIZE OF GAPS AND OPENINGS.**

Natural gaps of at least 1/2 acre (0.2ha)

Discussion: Ecology data, and the professional judgement of ecologists and silviculturists all support the existence of natural gaps in ponderosa pine forests. In low productivity areas these gaps are often difficult to distinguish. In the mod-high sites gaps do occur as more obvious openings in a more or less contiguous canopy. Loss of trees due to fire, insects and disease as well as windthrow result in the creation of the gaps. Munger's (1917) data indicate the loss of about two trees per acre (5/ha) to fire and insects.

Stand Size and Shape

STAND SIZE

Minimally Acceptable	Typical Range	Highest Value
	ACRES	
10 (4ha)	40-100 (16-40ha)	100+ (40+ ha)

Discussion: Very little information or data exists addressing a viable stand size considered necessary to support old growth climax ponderosa pine forests. Much has been written on forest fragmentation and island biogeography (Harris, 1984); however, being a relative new concept, definitive research on ecological processes regarding this and other important factors are only promised. A number of professional natural resource practitioneers and research scientists from the western states were contacted (Table 2) and asked to comment on the stand size required to maintain old growth vegetation processes (integrity of old growth). Responses ranged from 1/2 to in excess of 1000 acres (0.2 to 405ha). A number of eastside ecologists working in California, Oregon and Washington where vast stands exists suggested the 40 to 100+ acre size (16 to 41ha). They maintained that to provide for viable populations exhibiting a reasonable genetic variability smaller acreages were adequate but larger acreage would provide some degree of protection against localized loss due to root rots, insects or wildfire. Other scientists offered a two plus dominant tree height distance in from the edge (200 - 350 feet [61 to 177m]) as reasonable to protect internal stand integrity against changes in microsite due to changes in wind, snow and precipitation patterns.

Individuals who suggested smaller stand sizes for old growth often referred to other than ecological process criteria. For example, some vertebrates and small mammals would not require large acreages. Also, trees will often grow similarly whether in a 10 acre (4.0ha) or 100 acre (41ha) stand. Conversely, those who suggested large acreages tended to think more in terms of maintaining landscape process to allow for interaction across larger areas--suggesting that broad open forests may require many acres to encompass the variability within the landscape.

The stand size necessary to maintain ecological integrity is also quite dependent on the nature of the vegetation surrounding the proposed stand. Is it clearcut? Is it mature forest? Generally, old growth stands surrounded by very young managed stands should be larger in order to maintain the internal integrity of the old growth patch. On the other hand an old growth stand surrounded by mature forest may not need to be as large.

The degree and arrangement of various successional stages found within a given old growth set-aside is of great ecologically importance. Identified "stands" within an old growth area should support vegetation representing mid, late, and very late (here referred to as very late climatic climax [commonly called decadent by some workers]) conditions. This mosiac of seral conditions will mimic historic stands, in part, and provide for increased bio-diversity in addition to providing the old growth manager with the opportunity to manage the entire old growth tract for long periods of time. These identified cells must be mappable and should range in size from 5 - 20 acres (2 to 8ha). Recognizing desired species mix and major vegetation reaction to treatment, the manager will be able to feature given "islands" that will provide pathways from one seral condition to the next, e.g., allow late seral stands to develop into either very late or decadent conditions by not treating the tree/shrub/herb component and allow for stand closure. However, it should not be the intent of the manager that old growth set-asides always feature only very late or decadent stands, but rather allow for maximum stand diversity reflecting a variety of conditions associated with mature to old stable stands arranged on the landscape for maximum expression of stand interaction.

Shape of the desired stand is also a consideration. Old growth stands occurring along and in the transition zone of forest edge often are long and rather narrow. These natural stands are not capable of being enlarged either in length or width due to fairly, precise growing/soil conditions characteristic of these sites. These "hotdog" shaped islands of climax ponderosa pine will be viewed as desirable and will range from five - ten acres adjacent to typical shrub/steppe vegetation. This is in contrast to stands not of the tension edge which offer much larger contiguous forested acres. In this later case, a shape approaching a square or circle in general outline is deemed desirable since this shape tends to maximize internal stand integrity.

USE OF THE DEFINITION

Forest stands characterized by these six criteria, two site productivity groups, and two condition classes will represent a broad range of site-specific conditions. For this reason, judgement must be used in their application. The threshold, or minimum acceptable standard, for a given stand to qualify as old-growth will often be a primary management concern. While all of the criteria are important, the large tree component, amount of down woody material, and vertical canopy development will most often be limiting factors. The question then becomes; can a stand which is missing one or more of the attributes still qualify as old-growth within the scope of this definition? The answer is affirmative. However, a relatively strict interpretation of these criteria is intended. Stands in the mid-to-late seral stages (80-150 years in age) have only marginally developed to the old-growth character which is visualized by many resource management professionals. This means that a relatively more rigorous screening against the criteria should be used, in comparison with those stands in the late to decadent development stage. Sites in the more xeric conditions of the low productivity tension zone between the forest and non-forest environment may occasionally exhibit an old-growth character, while not meeting the criterion for minimum size of dominant trees. In these situations, physical features such as crown form, bark texture and color of the largest trees can serve as a proxy for the strict tree size limits shown in attribute number 1.

TABLE 1

PLANT ASSOCIATIONS USED IN THE ANALYSIS PROCESS TO DETERMINE CHARACTERISTICS OF OLD GROWTH PONDEROSA PINE ECOSYSTEMS.

Plant associations are listed as either low or mod-high productivity sites--(Hall 1973, Hopkins 1979 a, 1979 b, Hopkins and Kovalchik 1983, Volland 1985, Johnson and Simon 1987, Williams and Lillybridge 1983, 1988).

LOW SITES (9)

- Ponderosa pine/bluebunch wheatgrass
- Ponderosa pine/birchleaf spirea
- Ponderosa pine/mountain mahogany
- Ponderosa pine/big sagebrush
- Ponderosa pine/big sagebrush/wheeler's bluegrass
- Ponderosa pine/bitterbrush-big sagebrush
- Ponderosa pine/bitterbrush-big sagebrush/fescue
- Ponderosa pine/fescue
- Ponderosa pine/bluebunch-wheatgrass

MOD-HIGH SITES (14)

- Ponderosa pine/bitterbrush-snowbrush
- Ponderosa pine/bitterbrush/fescue
- Ponderosa pine/bitterbrush-Ross' sedge
- Ponderosa pine/bitterbrush-elk sedge
- Ponderosa pine/bitterbrush-manzanita
- Ponderosa pine/bitterbrush-manzanita/fescue
- Ponderosa pine/manzanita-snowbrush
- Ponderosa pine/common snowberry
- Ponderosa pine/elk sedge
- Ponderosa pine/pine grass
- Ponderosa pine/aspen/Wheeler's bluegrass
- Ponderosa pine/mule's ears
- Ponderosa pine/bitterbrush/bluebunch wheatgrass

TABLE 2

<u>Individuals Consulted Regarding Stand Size and Shape Criteria</u>

STEVE ARNO, Research Scientist,

PHIL AUNE, Program Director, Pacific Southwest Forest and Range Experiment Sta., Redding, CA

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ERNEST COLLARD, Forest Silviculturist, Region 6, US Forest Service, Wallowa-Whitman National Forest.

REX CRAWFORD, Ecologist, Washington Natural Heritage Program.

DICK DEZELLEM, Forest Silviculturist, Region 6, US Forest Service, Winema National Forest.

DAVID DIAZ, Regional Ecologist, Region 5, US Forest Service

WENDELL HANN, Regional Ecologist, Region 1, US Forest Service

FRED HALL, Ecologist, Region 6, US Forest Service

CHARLIE JOHNSON, Area Ecologist, Region 6, US Forest Service, Wallowa-Whitman, Umatilla, and Ochoco National Forests

WALT KNAPP, Regional Silviculturist, Region 6, US Forest Service.

JOHN NESBITT, Regional Fuels Specialist, Region 6, US Forest Service.

DON POTTER, Zone Ecologist, Region 5, US Forest Service

SYDNEY SMITH, Zone Ecologist, Region 5, US Forest Service

ART TIEDEMANN, Research Plant Ecologist, US Forest Service, Pacific Northwest Forest and Range Experiment Sta., La Grande, OR.

CLINT WILLIAMS, Area Ecologist, Region 6, US Forest Service, Okanogan, Wenatchee and Colville National Forests.

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REGION 6

INTERIM OLD GROWTH DEFINITION

FOR

PORT-ORFORD-CEDAR and TANOAK (REDWOOD) SERIES

June 1992

Prepared by:

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Tom Atzet	Siskiyou NF
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STANDARD SUMMARY OF OLD GROWTH CHARACTERISTICS

Vegetative Series Port-Orford-cedar SAF Cover Type(s) 231

Applicable Area (Region/Sub-region,etc) Region 6 (SW Oregon) Site Productivity Designation All

Live Trees						Dead Trees			
Main Canopy			Variation in Tree Diameter	Tree Decadence	Tree Canopy Layers	Standing		Down	
DBH*	TPA*	AGE*	(Yes or No)	TPA	Number	DBH	TPA	Diameter	Pieces
32" (80cm)	16 (40tph)	240	Yes	No data	2	14" (36cm)	6 (15tph)	13" (33cm)	27 (68/ha)

*Required minimums

(Metric Equivalents in Parenthesis)

Vegetative Series ______________ SAF Cover Type(s) ______________

Applicable Area (Region/Sub-region,etc) ______________ Site Productivity Designation ______________

Live Trees						Dead Trees			
Main Canopy			Variation in Tree Diameter	Tree Decadence	Tree Canopy Layers	Standing		Down	
DBH*	TPA*	AGE*	(Yes or No)	TPA	Number	DBH	TPA	Diameter	Pieces

*Required minimums

(Metric Equivalents in Parenthesis)

STANDARD SUMMARY OF OLD GROWTH CHARACTERISTICS

Vegetative Series Tanoak (Redwood) SAF Cover Type(s) 234 & 232

Applicable Area (Region/Sub-region,etc) Region 6 (SW Oregon) Site Productivity Designation All

Live Trees						Dead Trees			
Main Canopy			Variation in Tree Diameter	Tree Decadence	Tree Canopy Layers	Standing		Down	
DBH*	TPA*	AGE*	(Yes or No)	TPA	Number	DBH	TPA	Diameter	Pieces
32" (80cm)	8 (20tph)	240	Yes	No Data	2	32" (80cm)	3 (7.5tph)	13" (33cm)	20 (50/ha)

*Required minimums

(Metric Equivalents in Parenthesis)

Vegetative Series ________ SAF Cover Type(s) ________

Applicable Area (Region/Sub-region,etc) ________ Site Productivity Designation ________

Live Trees						Dead Trees			
Main Canopy			Variation in Tree Diameter	Tree Decadence	Tree Canopy Layers	Standing		Down	
DBH*	TPA*	AGE*	(Yes or No)	TPA	Number	DBH	TPA	Diameter	Pieces

*Required minimums

(Metric Equivalents in Parenthesis)

INTRODUCTION

Background.

Old-growth definitions for broad regional vegetation classes obscure important local differences in stand characteristics. Current definitions for West-side Douglas-fir old-growth, for example, combine 1000 year old north coast stands associated with western redcedar with much younger south coast stands associated with coast redwood. Descriptive statistics for stands with such wide regional variation have limited local application. Identifying and managing old-growth characteristics at the forest scale requires higher resolution. Describing old-growth by series and plant association groups will provide more detailed and locally applicable information.

Objectives.

This report defines and displays the structure of old-growth stands of the Port-Orford-cedar Series, the Tanoak Series, and stands of coast redwood, a special case of the Tanoak Series, as part of the Pacific Northwest Region's effort to refine existing old-growth definitions.

Tables describing old-growth characteristics, narratives for each series, descriptions of each attribute, analytical methods, instruction on how to apply the definitions, information on stand dynamics, and suggestions to help managers prescribe for maintenance and production of old-growth character are presented.

TPA, TBA, STPA, STBA, QMD, SQMD, PPA, and down log information were summarized directly from five point clusters (similar to the 10 point clusters used in Region Six timber inventories). Age and canopy layers were estimated.

Tree age. Breast height age is estimated (rather than actually counted) when the increment bit is too short to reach the tree center or the center was missed. With a 16 inch bit, 85% of the trees 100 years old or less were directly counted; 15% were estimated. Approximately 40% of trees between one and two hundred years old were actually counted; slightly less than 15% of trees over 200 years were measured. The older the tree, the bigger the diameter, and the greater the potential for error in estimating age.

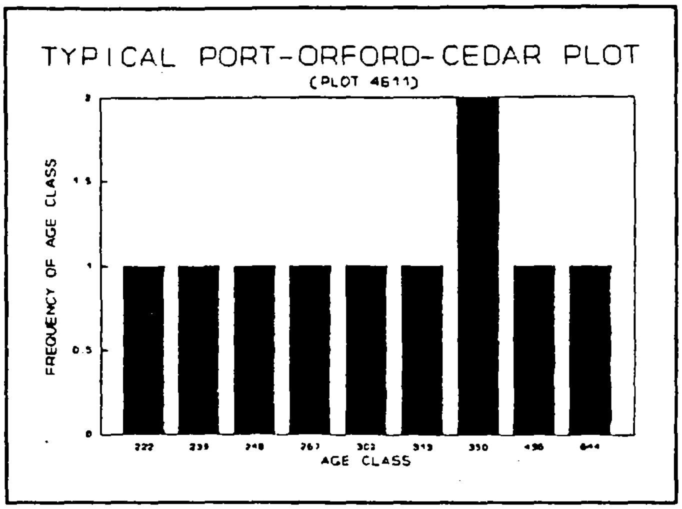

Figure 1 Variation in stand age.

Stand age. Most stands were all-aged, lacking a dominant age class; thus, determining age was somewhat subjective (Figure 1.). We tried using regression coefficients from diameter/age analysis to calculate ages of trees that were not bored, but had their diameter measured. The correlation was weak (r=0.60) and the process, although objective, only seemed to add more variability to the age class distribution. Instead, the maximum age, the minimum age, and age were estimated by examining the age by species listings for each plot (particularly if it were the dominant layer). Maximum age was usually the oldest canopy layer in the stand. Where it was the dominant layer, maximum age and stand age were the same. If there was a younger layer and of uniform age, relative to the oldest layer, it was chosen as the stand age, particularly if there were only 2 or 3 older trees per acre. Minimum age was the youngest discernable layer in the overstory canopy. Four individuals independently used this process to age five different stands. The estimates of stand ages were consistent among observers.

Canopy Layers. Numbers of canopy layers were not measured directly. They were estimated by examining the species by age listings plot by plot. We assumed there were layers, or at least more canopy complexity, when age group differences were over 50 years, particularly when groups were composed of different species. For example, a stand with two Douglas-fir components aged 150 and 200, would be recorded as having two canopy layers (Figure 1.). A stand with Douglas-fir and Port-Orford-cedar components aged 200 and 150 respectively, would almost certainly have two layers and would be recorded as such. About 40 trees were measured per plot, usually over 20% were aged.

Data description. Once a list of old-growth plots was established, descriptive statistics and frequency histograms were run.

Bivariate plotting. Bivariate plotting of the old-growth plots was used to further examine the relationship between the variables. Scatter diagrams and correlations were also produced.

RESULTS AND DISCUSSION

<u>Port-Orford-cedar SAF Cover Type 231</u>.

Plant associations. Five plant association groups (PAG) and seven plant associations were represented by 26 old-growth plots of the 41 plot data set. They are listed in order of increasing site productivity.

Table 1. Port-Orford-cedar plant associations, their group and code.

Plant Association	Plant Association Group	Code
Port-Orford-cedar/Silktassel	Port-Orford-cedar/Oak	CTS1
White fir-POC/Depauperate	White fir SWO, Coastal	CWC6
Tanoak-POC	Tanoak Conifer	HTCO
POC/Salal	POC/Shrub	CTH1
POC/Dwarf Oregongrape/twinflower	POC/Shrub	CHT1
POC/Dwarf Oregongrape/vanillaleaf	POC/Shrub	CHT1
Western Hemlock-POC	W. Hemlock/Swordfern/Oxalis	CHF1

Plant associations in the POC/Oak PAG do not produce closed canopied stands, are compositionally different, and do not develop the structural attributes of "normal" stands. Thus, CTS1 plots were eliminated from the analysis. If the need arises, associations on ultrabasic sites should be analyzed separately. Old-growth descriptions are based on plots combined from other PAGs.

Variables in order of decreasing discrimination between young-growth and old-growth are given below. Age and number of canopy layers were significant discriminators; other variables contribute to overall discrimination but their contribution is non-significant.

Since defining old-growth is an age dependent process, it is not surprising that age is an important discriminator between young-growth and old-growth. Stand age is the most discriminating of the variable set. The cutpoint between young-growth and old-growth is 240 years. The average age of old-growth stands is 355 years with a standard deviation of 85 years. The youngest old-growth stand in the data set is 120 years old. The oldest stand is 720 years old. The average minimum age is 180 years with a standard deviation of 50 years. The average maximum age is 456 years with a standard deviation of 132 years.

A cutpoint of 240 years results in the most efficient classification of plots into either old-growth or young-growth (93%). Decreasing the cutpoint to 220 and 200 resulted in a 90 and 88 percent classification respectively. Increasing the cutpoint also resulted in a less efficient classification.

Empirically, stands 270 years old or older are likely to constitute approximately 84% of the population of old-growth stands. Stands greater than 185 years old would included approximately 97% of the old-growth stands. Therefore, its a good bet that many, if not all, stands over 200 years old have old-growth characteristics.

Canopy layers. The number of canopy layers is about two thirds less effective as a discriminator as age, and is poorly correlated with age (r=.37). The average number of canopy layers in old-growth is four with a standard deviation of 1.3. The fewest layers found in old-growth stands (all characteristics combined classify the stand as old-growth) is two. The greatest number of layers found is six.

Eighty four percent of the old-growth stands have more than two canopy layers. Thus, two layers are considered characteristic of old-growth stands. Stands have an average of 2.5 species in the overstory layer, with a range of 1 to 4 layers. Less than five percent of the plots have only one species in the overstory layer. The most common overstory species are Douglas-fir, Port-Orford-cedar, sugar pine, white fir, incense-cedar, ponderosa pine, and western hemlock.

Total Basal Area. Basal area ranged from 256 ft^2/ac to 545 ft^2/ac. Old-growth stands average 383 ft^2/ac with a standard deviation of 76 ft^2. Approximately 84% of the plots have greater than 300 ft^2/ac. Since slightly less than half of the young-growth plots can have greater than 300ft^2/ac (i.e. basal area overlaps), total stand basal area is not an effective discriminator.

Quadratic Mean Diameter. Quadratic mean diameter of a stand is not a significant discriminator between young and old-growth. The range of mean diameters between the groups overlaps. Average old-growth QMD is 24.9 inches with a standard deviation of 5.8 in. Young growth stands averages 19.8 in with a standard deviation of 9.3 in. The smallest old-growth stand QMD in the data set was 14 in; the largest tree was 35 inches (variation in diameter may be used for discrimination, but was not studied).

Tanoak SAF Cover Type 234 and coast redwood SAF Cover Type 232.

Plant associations. Five plant association groups (PAG) and nineteen plant associations were represented by 85 old growth plots of the 188 plot data set.

Table 4. Tanoak plant associations, their group and code.

Plant Association	Plant Association Group	Code
Tanoak-coast redwood	Tanoak Conifer	HTCO
T/Evergreen Huckleberry-Salal	T/Evergreen Huckleberry	HST1
T/Evergreen Huckleberry	T/Evergreen Huckleberry	HST1
T-California Laurel	T/Evergreen Huckleberry	HST1
T/Pacific Rhododendron	T/Evergreen Huckleberry	HST1
T/Pac. Rho.-Evergreen Huckleberry	T/Evergreen Huckleberry	HST1
T/Pac. Rho.-Salal	T/Rhododendron	HTS2
T/Salal	T/Rhododendron	HTS2
T/Port-Orford-cedar	Tanoak Conifer	HTCO
T/Salal-Pacific Rhododendron	T/Rhododendron	HTS2
T/Salal-Dwarf Oregongrape	T/Rhododendron	HTS2
T-Vine Maple	T/Oregongrape	HTS3
T-White fir-Vine Maple	T/Oregongrape	HTS3
T-White fir	T/Oregongrape	HTS3
T/Dwarf Oregongrape	T/Oregongrape	HTS3
T/Dwarf Oregongrape/Poison oak	T/Canyon Live Oak	HTH1
T-Canyon live oak	T/Canyon Live Oak	HTH1
T-CLO/Dwarf Oregongrape	T/Canyon Live Oak	HTH1
T/Poison oak-Hairy honeysuckle	T/Canyon Live Oak	HTH1

Plots on ultrabasic rock types, such as serpentinite, peridotite, and dunite, were not used in the analysis. They produce open grown stands which are compositionally different, and do not develop the structural attributes of normal closed canopy stands. Old-growth descriptions are based on plots combined from other PAGs and more common rock types.

Variables in order of decreasing discrimination between young-growth and old-growth are given below. Age is by far the most significant discriminator. Other variables may contribute to overall discrimination but their contribution is non-significant. If age were eliminated from the analysis, variables correlated with age would become discriminatory. Numbers of canopy layers ($r = 0.622$ with age) is an example.

As with Port-Orford-cedar, age is the most important discriminator between young-growth and old-growth. The cutpoint separating young-growth from old-growth is 240 years and correctly classifies 95.2% of all plots in the data set (canopy layers, QMD, TBA, TPA, STPA, STBA, SQMD, as well as age were used in the discriminant analysis). No other age cutpoint was as efficient.

Empirically, stands 260 years old or older are likely to constitute approximately 84% (or greater, because the distribution is skewed to the right) of the population of old-growth stands. Stands greater than 200 years old would included approximately 97% of the old-growth stands. Therefore, it is a good bet that stands over 200 years old have old-growth characteristics.

Canopy layers. The number of canopy layers is less than one tenth as effective as a discriminator as age, and is poorly correlated with age (r=.52). The average number of canopy layers is three, with a standard deviation of 1. The figures for coast redwood are the same. The fewest layers found in tanoak stands (all characteristics combined classify the stand as old-growth) is one. The greatest number of layers found is five. Only 4.8 percent of the old-growth tanoak stands have one canopy layer in the overstory (or approximately 95% have 2 or more layers).

Snag Quadratic Mean Diameter. The stand quadratic mean diameter of snags is 22.6 inches with a standard deviation of 14.2 in and a range from zero (no snags) to 59 in. As in the Port-Orford-cedar Series, the size of snags is not an indication of old-growth conditions. Coast redwood stand average SQMD is 21.0 in with a standard deviation of 18 inches.

Trees Per Acre. Old-growth stands averaged 140 t/ac with a standard deviation of 78 and a range between 42 and 367 t/ac. Trees per acre is not a significant discriminator. Coast redwood stands averaged 130 t/ac with a standard deviation of 39 t/ac. The number of trees per acre is not a good discriminator between young and old-growth.

Snag Total Basal Area. Total basal area of snags ranged from 0 to 136 ft^2/ac. The average old-growth stand had 27 ft^2/ac with a standard deviation of 27 ft^2/ac.

Snag Trees Per Acre. Snag trees per acre is the least discriminating of the variables analyzed, and the most variable. Old-growth stands average 13 snag trees per acre with a standard deviation of 23 t/ac. The range is from 0 to 178 t/ac.

Quadratic Mean Diameter. Average old-growth QMD is 21.7 in with a standard deviation of 6.1 in. The maximum stand average is 38.8; the minimum stand average is 11.8 in. The average coast redwood old-growth stand QMD is 25 in. with a standard deviation of 9 in, well within the range of tanoak stands.

CONCLUSIONS

General.

Its not surprising that age is an important factor. The term old-growth is used to denote older stands with certain structural, compositional, and functional characteristics related to later seral stages, old stands. The problem is to find when the transition from young to old takes place and how to discriminate between them. Age and age related variables separate the stages well. The greater the number of stand variables that meet the minimum criteria, the greater the probability the stand functions as old growth.

Developing old-growth stands

Natural stand development. Our analysis suggests under conditions experienced in the past 300 years, developing old-growth would take about 240 years on the average Port-Orford-cedar or tanoak site. This estimate is assuming that processes initiated by natural physical agents of change such as fire, wind, extremes in weather cycles, erosion, and slides and natural biotic agents such as insects, other animals, fungi, and bacteria operate the same today as they did the last two to three hundred years (not a good assumption). Natural fires, for example, have altered stand structure, composition, and the rates of many processes. Underburned stands show an increase in stand diameter, a change in absolute and relative composition, an increase in the number of snags and downed woody materials, an increase in diameter growth rate, an increase in decay rates, a reduction in the number of trees per acre, and the mixing of early and later seral plants and animals. Generally these agents increase the rate of change toward old-growth character and increase biological diversity.

Areas more intensely burned (usually less than 20 percent of the area under a natural fire regime in tanoak and Port-Orford-cedar sites is intensely burned) provide contrasting early seral character juxtaposed randomly across the landscape. However, even after the most intense natural burns, many species, structures, and processes are present and remain functional although process rates and relative abundance of structures have changed.

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REGION 6

INTERIM OLD GROWTH DEFINITION

FOR

SUBALPINE FIR SERIES

June 1992

Prepared by:

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STANDARD SUMMARY OF OLD GROWTH CHARACTERISTICS

Vegetative Series Subalpine fir

SAF Cover Type(s) 206

Applicable Area (Region/Sub-region,etc) Region 6 (Eastside)

Site Productivity Designation High

Live Trees						Dead Trees			
Main Canopy			Variation in Tree Diameter	Tree Decadence	Tree Canopy Layers	Standing		Down	
DBH*	TPA*	AGE*	(Yes or No)	TPA	Number	DBH	TPA	Diameter	Pieces
21" (53cm)	10 (25tph)	150	Yes	4 (10tph)	2	12" (30cm)	2 (5tph)	12" (30cm)	4 (10tph)

*Required minimums

(Metric Equivalents in Parenthesis)

Vegetative Series Subalpine fir

SAF Cover Type(s) 206

Applicable Area (Region/Sub-region,etc) Region 6

Site Productivity Designation Low

Live Trees						Dead Trees			
Main Canopy			Variation in Tree Diameter	Tree Decadence	Tree Canopy Layers	Standing		Down	
DBH*	TPA*	AGE*	(Yes or No)	TPA	Number	DBH	TPA	Diameter	Pieces
13" (33cm)	10 (25tph)	150	Yes	2 (5tph)	1	10" (25cm)	2 (5 tph)	10" (25cm)	4 (10tph)

*Required minimums

(Metric Equivalents in Parenthesis)

SUBALPINE FIR OLD-GROWTH DEFINITION
on
NATIONAL FOREST LANDS
in
EASTERN WASHINGTON and OREGON

INTRODUCTION

The subalpine fir old-growth definition applies to part of Society of American Foresters' (SAF) Forest Type 206, Engelmann spruce-subalpine fir. For "old-growth" definitions in Region 6 of the USDA Forest Service, SAF Type 206 applies only to stands east of the Cascade Mountain Crest that will be dominated at climax by either subalpine fir and/or Engelmann spruce. This is commonly termed the "Subalpine Fir Series" in many plant association guides. The Subalpine Fir Series, as used herein, includes plant communities capable of forming closed forest canopies where subalpine fir or Engelmann spruce are the indicated climatic climax tree species. At upper timberline subalpine fir may be the indicated climax species, but site conditions are too harsh to allow establishment of a continuous tree canopy. This definition does not apply to upper treeline conditions with a discontinuous canopy.

The definition is based upon the characteristics of the **vegetation** only, and does not fully consider other aspects of the old-growth issue (e.g. wildlife habitat characteristics and social considerations). The non-vegetation attributes are considered beyond the scope of this initial effort. "Old-growth," as defined herein, is not synonymous with "pristine" or pre-European settlement stand conditions. Alteration of fire patterns and livestock grazing are just some of the landscape-level changes attendant with settlement of eastern Washington and Oregon since the early 1800's.

Subalpine Fir Series sites generally support one or more other conifers, such as Engelmann spruce, lodgepole pine, western larch, western white pine, whitebark pine, Douglas-fir, grand fir, white fir, and minor amounts of ponderosa pine in all but climax conditions. These species are often important components in old-growth stands and may even be stand dominants. Very shade tolerant and competitive species such as western hemlock, mountain hemlock, western redcedar, and silver fir are not considered part of the Subalpine Fir Series because these other species form the indicated climax when with subalpine fir. Grand fir/white fir may or may not be the indicated climax species when found with subalpine fir/Engelmann spruce, depending on site characteristics, such as elevation.

Ecology data from Region 6 Forests east of the Cascade Mountain Crest have been summarized to develop the definition. These data are from plots taken by the Region 6 ecology group in their plant community classification work over the last 25 years. These data are the best currently available in the Region, but have the following limitations when used for old-growth definitions:

1. Old-growth is a stand level characteristic, not an individual tree attribute. Our data are from samples of individual trees concentrating on dominants or co-dominants (those meeting site index criteria). Little or no data were taken on the rest of the trees in the stand. Old-growth stands are more than just an aggregation of selected individual tree attributes.

2. Many plots lack quantitative information on snags, logs, tree decadence, and canopy structure that are important characteristics of old-growth forests.

3. All the data sets are not in the same format nor contain the same types of information. Some data sets contain individual tree measurements, while others have plot summaries by species. Similar data may have been taken in different ways, so direct comparison between data sets is not wholly satisfactory. Dead tree information is limited to eastern Washington ecology plots and even there the Okanogan data were collected differently than the Colville and Wenatchee National Forest data and as such are not readily amenable to pooled quantitative analysis.

In spite of the above limitations the data are judged to be of sufficient quality and quantity to establish minimum values for essential old-growth attributes until more applicable data becomes available.

Currently available Timber Inventory data were examined, but lacked necessary structural information to allow their use.

Available data, literature, work in Region 1; and the experience of ecologists, biologists, and silviculturists were used to select the age and size criteria.

The Subalpine Fir Series covers considerable variation in conditions for forest growth and development. For the purposes of old-growth definitions it is divided into two main categories based on the growth rate of subalpine fir. These are aggregations of plant associations that are similar in growth rates of subalpine fir. Sites with moderate to high growth potential are termed "high." Sites that were lower in tree growth potential are labeled as "low." (See Appendix for a list of the applicable plant associations.)

Data are from ecology plots in stands with little recent disturbance from man's activities or natural fires. All stands had to be successionally stable with mid to late seral conditions. Few Subalpine Fir Series stands in eastern Washington and Oregon are older than 250 years. Most stands burn, blowdown, or are attacked by insects and disease before then. Individual trees of relatively fire or disease resistant species such as western larch may reach 500+ years of age but these have survived one or more fires.

Old-growth structural characteristics, both vertical and horizontal, require time to develop. Our data and experience suggest that approximately 150 years are needed for the establishment of most plants that will be in old-growth stands with attendant ecological linkages between and among species. Such linkages and structures may form earlier, but 150 years or more appear necessary on most sites for canopy structures, tree diameters, snags, logs, and shrub and herb compositions to develop and/or stabilize compared to younger stands. Data analysis indicates that sites in the high group require 150- to 200-years for trees to reach 20 inches or larger diameters. Trees on the low productive sites rarely grow fast enough to reach 20 inches (50 cm) in diameter.

The rationale for tree size gives consideration to the needs of species, such as the pileated woodpecker that require trees 20 inches (50 cm) or greater in diameter to nest (Thomas, 1979). Snags and logs less than 12 inches (18 cm) diameter are used by fewer species than those larger than 12 inches (18 cm). Large diameter snags can substitute for small diameter snags, but small snags cannot replace the ecologic role of large snags (Thomas, 1979). Small diameter snags and logs are often common in young stands and thinned plantations.

These considerations are not applicable to the low productivity sites. These sites tend to be harsh and cold with short growing seasons. Additionally, the above size and age criteria are not reasonably applied to lodgepole pine dominated forests. Lodgepole pine as a species is characterized by a physiologically shorter life span, and mature trees are generally smaller in diameter than associated conifers. Lodgepole pine dominated stands in the Subalpine Fir Series, in northern Idaho and western Montana, are considered to approximate old-growth conditions when they are 120 years old and 13 inches in diameter. Data on lodgepole pine from eastern Washington reveal little relationship between tree diameter and age across a wide range of sites. Lodgepole pine may be a component in old-growth stands in the more productive portion of the Subalpine Fir Series, but rarely will be a major stand component in meeting the minimum old-growth criteria. It is a very important component of old-growth stands on the low productive habitats in the Subalpine Fir Series.

OLD-GROWTH ATTRIBUTES

The following minimum attributes are used to define old-growth stands in the Subalpine Fir Series. (These attributes are from National USDA Forest Service direction, in a memo dated December 4, 1990, under the signature of David G. Unger.)

"HIGH" PRODUCTIVITY SITES"

Attributes	MINIMUM
1. Live trees in main canopy:	
-DBH (inches)	21 (53 cm)
-trees per acre	10 (25 +ph)
-age (years)	150
2. Variation in tree diameters (yes or no)	YES
3. Dead trees: (12+ inches (30 cm) diameter)	
-standing trees per acre (number)	2 (0)* (5 tph)
-down pieces per acre	4 (0)*(10 tph)
4. Tree decadence (spike or deformed tops, bole, or root decay):	
-trees per acre	4 (10 tph)
5. Number of tree canopies	2
Additional criteria	
6. Canopy crown cover	30%

"LOW" PRODUCTIVITY SITES

Attributes	MINIMUM
1. Live trees in main canopy:	
-DBH (inches)	13 (33 cm)
-trees per acre	10 (25tph)
-age (years)	150 (120)**
2. Variation in tree diameters (yes or no)	YES
3. Dead trees: (10+ inches (25 cm) diameter)	

-standing trees per acre (number)	2 (0)* (5 tph)
-down pieces per acre	4 (0)*(10 tph)
4. Tree decadence (spike or deformed tops, bole or root decay):	
-trees per acre	2 (5 tph)
5. Number of tree canopies	1
Additional criteria	
6. Canopy crown cover	30%

* See following for a discussion on dead tree criteria.
** Lodgepole pine dominated stands.

The dead tree information is from eastern Washington ecology plot data from the Colville and Wenatchee National Forests and may not reflect the variation in snag and log quantities across Region 6. Snags and logs are a function of site productivity, age, stand history (fires, insects, disease, etc.), and the relative degree of decadence of each stand. Broken stems may be included in snag counts, but 6 feet (1.8m) is a practical minimum height. Small diameter snags (4-12" dbh) (or 10-30 cm) are often common, even in relatively young stands. Logs (down woody material) are measured by the number of pieces/acre 12+ inches (30 cm) diameter (on the large end). Snags and logs are transitory compared to other old growth attributes, and change within a stand as they decay, snags fall, or other trees die; therefore, some "old-growth" stands may lack a significant dead tree component. Snags and logs are relatively easy to create through management if live trees of sufficient size and quantity are present.

Quantitative information on tree decadence is lacking. Estimates in the definition are based on field notes and personal observations.

The Subalpine Fir Series encompasses a wide range of potential plant communities (plant associations). In these ecosystems, emphasis is on characteristics indicative of mid-seral, late succession to climatic climax stands under fire suppression policies. Prior to active fire suppression, wildfires had a significant influence on stand development and composition.

Fire suppression has altered the character of stands in drier habitats within subalpine fir climax sites. These drier sites support a grass, low shrub, or herb dominated undergrowth; and include plant communities dominated by pinegrass, huckleberry, grouse huckleberry, tall huckleberry, and dwarf bramble. (See Appendix.) Many sites in these communities were subject to periodic underburns on a 10- to 40-year interval between fires.

Such relatively low intensity fires kept stand structures open and favored fire tolerant seral species such as western larch, western white pine, and Douglas-fir. Fire sensitive species, such as subalpine fir and Engelmann spruce, were normally minor stand components. Intense stand replacing fires often led to dominance for the first 100 years or so by lodgepole pine.

With fire suppression, fire sensitive, but more competitive and shade-tolerant subalpine fir and Engelmann spruce have increased in proportion in the stands; Consequently, stand structures have changed from relatively open, single- to two-storied stands, to denser multi-layered stands. Periodic underburns also, kept logs and other woody materials on the forest floor at relatively low levels. As the relatively large, open grown, fire tolerant species die; they form large snags and logs. Western larch, western white pine, and Douglas-fir are unable to replace themselves in competition with subalpine fir and Engelmann spruce, so the large snag component may decline in such stands in the future. With fire suppression, down woody materials, and snag densities increase, but snags and logs are often smaller in average size. The different tree species form snags and logs with much different structure, decay, and chemical compositions so snag and log dependent biota may also change. Following several decades of fire control these drier sites in the Subalpine Fir Series develop stand structures and conditions similar to those in the moister habitats within the series. When this occurs most stands burn with much greater intensity.

Underburns were much less important in stand development on more moist or colder habitats within the Subalpine Fir Series because most stands were commonly so dense that the typical fire pattern was one of occasional intense fires on a 200- to 400-year return interval. Current stand development under fire control on moist sites does not appear markedly different thatn that prior to European settlement. Plant communities, representative of these types of natural fires and related habitats contain twinflower, rhododendren, huckleberry, beargrass, and queenscup. (See Appendix for list of associations.)

Subalpine fir and Engelmann spruce are able to regenerate in deep shade and comparatively heavy amounts of duff, litter, and accumulated organic material; consequently, old-growth stands normally contain at least a single understory tree layer composed mainly of subalpine fir or Engelmann spruce. Regeneration often appears continuous, rather than forming distinct groups of age (size) classes, but some stands also exhibit distinct age (size) classes. Openings and gaps, resulting from insect or disease centers, usually have better development of the shrub and conifer seedling component. These openings may allow for limited regeneration of species such as Douglas-fir, western white pine, lodgepole pine, or even western larch.

Natural gaps up to 1 acre (2.5 ha) in size are often a characteristic of old-growth stands. Natural openings commonly contain abundant seedlings and saplings with a concomitant increase in shrubs and herbs with a different size and age class, compared to adjacent closed canopy stands. Often, natural openings are due to root rots. Root rot openings tend to be oblong to circular. Standing dead conifers are common in the interior of such openings. Openings created by wildfire are typically polyhedral and snags and logs (if any) are charred.

Little information or data are available on minimum stand size to support old-growth forests. Much has been written on forest fragmentation and Island Biogeography (i.e. Harris, 1984); but little definitive research on ecological processes regarding this and other important factors has been done. Stand size, necessary to maintain ecological integrity, is highly dependent on the nature of the vegetation surrounding the proposed stand. Generally, old-growth stands surrounded by young plantations or clearcuts, should be larger in size to maintain the internal ecological integrity of the old-growth stand; conversely, an old-growth stand surrounded by mature forest may not need to be as large. Franklin, et.al., 1986, first used 80 acres as a minimum. They later dropped size criteria, concluding that minimum acreages for viable old-growth stands depend upon the nature of surrounding stand conditions and management objectives.

Shape of the desired stand is also a consideration, especially if stands are relatively small. Long narrow stands may have poor internal integrity because of the higher amount of "edge" proportional to stand size and the shorter distance from the stand edge to the center.

USE OF THE DEFINITION

Forest stands within the Subalpine Fir Series are characterized by a complex species mix, range of site productivity, age, and condition classes; therefore, judgement must be used in the application of this definition. The threshold, or minimum acceptable standard for a stand to qualify as old-growth, is often a primary management concern. While all the criteria are important, the large tree component and stand structure are essential. As discussed before, snags and logs are largely a function of the live tree component. A relatively strict interpretation of the live tree criteria is intended, while more flexibility is accorded the dead tree component.

A large proportion of stands to be evaluated against the old-growth criteria will not be in an undisturbed condition. Some tree or snag removals may have occurred. Professional judgement must be used in evaluating "old-growthness" under these conditions. Some site disturbance can be tolerated, but the structural and ecological integrity of the stand must remain.

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APPENDIX

Plant Associations with High Growth Potential:

Subalpine fir/queencup beadlily (ABLA2/CLUN)
Subalpine fir/bunchberry dogwood (ABLA2/COCA)
Subalpine fir/twinflower (ABLA2/LIBOL)
Subalpine fir/pachistima (ABLA2/PAMY)
Subalpine fir/false bugbane (ABLA2/TRCA3)
Subalpine fir/dwarf huckleberry (ABLA2/VACA)
Subalpine fir/huckleberry (ABLA2/VACCI)
Subalpine fir/big huckleberry (ABLA2/VAME)
Subalpine fir/low huckleberry (ABLA2/VAMY)
Engelmann spruce/horsetail (PIEN/EQUIS)

Plant Associations with Low Growth Potential:

Subalpine fir/pinegrass (ABLA2/CARU)
Subalpine fir/smooth woodrush (ABLA2/LUHI)
Subalpine fir/red mountainheath (ABLA2/PHEM)
Subalpine fir/Cascade azalea (ABLA2/RHAL)
Subalpine fir/Cascade azalea-beargrass (ABLA2/RHAL-XETE)
Subalpine fir/grouse huckleberry (ABLA2/VASC)
Subalpine fir/grouse huckleberry/pinegrass (ABLA2/VASC/CARU)
Subalpine fir/beargrass (ABLA2/XETE)
Subalpine fir/broadleaf arnica-elk sedge (ABLA2/ARLA-CAGE)

Plant Associations with a 10- to 40-Year Fire Return Interval:

Subalpine fir/pinegrass (ABLA2/CARU)
Subalpine fir/dwarf bramble (ABLA2/RULA)
Subalpine fir/dwarf huckleberry (ABLA2/VACA)
Subalpine fir/huckleberry (ABLA2/VACCI)
Subalpine fir/grouse huckleberry/pinegrass (ABLA2/VASC/CARU)

Plant Assocations with a 200- to 400-Year Fire Return Interval:

Subalpine fir/twinflower (ABLA2/LIBOL)
Subalpine fir/bunchberry dogwood (ABLA2/COCA)
Subalpine fir/queenscup beadlily (ABLA2/CLUN)
Subalpine fir/false bugbane (ABLA2/TRCA3)
Subalpine fir/Cascade azalea (ABLA2/RHAL)
Subalpine fir/rusty menziesia (ABLA2/MEFE)
Subalpine fir/Cascade azalea-beargrass (ABLA2/RHAL-XETE)
Subalpine fir/beargrass (ABLA2/XETE)
Subalpine fir/broadleaf arnica-elk sedge (ABLA2/ARLA-CAGE)
Subalpine fir/grouse huckleberry (ABLA2/VASC)
Subalpine fir/big huckleberry (ABLA2/VAME)
Engelmann spruce/horsetail (PIEN/EQUIS)

REGION 6

INTERIM OLD GROWTH DEFINITION

FOR

WESTERN HEMLOCK SERIES

June 1992

Prepared by:

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STANDARD SUMMARY OF OLD GROWTH CHARACTERISTICS

Vegetative Series Western Hemlock

SAF Cover Type(s) 224

Applicable Area (Region/Sub-region,etc) Region 6 (Westside)

Site Productivity Designation Site Class 1

Live Trees						Dead Trees			
Main Canopy			Variation in Tree Diameter	Tree Decadence	Tree Canopy Layers	Standing		Down	
DBH*	TPA*	AGE*	(Yes or No)	TPA	Number	DBH	TPA	Diameter	Pieces
42" (107cm)	8 (20tph)	200	Yes	Yes	2	20" (51cm)	4 (10tph)	12" (30cm)	69 (170/ha)

*Required minimums

(Metric Equivalents in Parenthesis)

Vegetative Series Western Hemlock

SAF Cover Type(s) 224

Applicable Area (Region/Sub-region,etc) Region 6 (Westside)

Site Productivity Designation Site Class 2

Live Trees						Dead Trees			
Main Canopy			Variation in Tree Diameter	Tree Decadence	Tree Canopy Layers	Standing		Down	
DBH*	TPA*	AGE*	(Yes or No)	TPA	Number	DBH	TPA	Diameter	Pieces
35" (89cm)	8 (20tph)	200	Yes	Yes	2	20" (51cm)	4 (10tph)	12" (30cm)	37 (91/ha)

*Required minimums

(Metric Equivalents in Parenthesis)

STANDARD SUMMARY OF OLD GROWTH CHARACTERISTICS

Vegetative Series Western Hemlock

SAF Cover Type(s) 224

Applicable Area (Region/Sub-region,etc) Region 6 (Westside)

Site Productivity Designation Site Class 3

Live Trees						Dead Trees			
Main Canopy			Variation in Tree Diameter	Tree Decadence	Tree Canopy Layers	Standing		Down	
DBH*	TPA*	AGE*	(Yes or No)	TPA	Number	DBH	TPA	Diameter	Pieces
31" (79cm)	8 (20tph)	200	Yes	Yes	2	20" (51cm)	4 (10tph)	10" (25cm)	15 (37/ha)

*Required minimums

(Metric Equivalents in Parenthesis)

Vegetative Series Western Hemlock

SAF Cover Type(s) 224

Applicable Area (Region/Sub-region,etc) Region 6 (Westside)

Site Productivity Designation Site Class 4 & 5

Live Trees						Dead Trees			
Main Canopy			Variation in Tree Diameter	Tree Decadence	Tree Canopy Layers	Standing		Down	
DBH*	TPA*	AGE*	(Yes or No)	TPA	Number	DBH	TPA	Diameter	Pieces
21" (53cm)	8 (20tph)	200	Yes	Yes	2	20 (51cm)	4 (10tph)	8" (20cm)	29 (72/ha)

*Required minimums

(Metric Equivalents in Parenthesis)

INTRODUCTION

A series of 23 articles on old-growth forests of the United States and parts of Canada was published in the Natural Areas Journal (Volume 8, nos. 1 & 3; vol. 9 no. 1; and vol. 11, no. 1) between 1988-1991. Most of these articles describe old-growth characteristics of forests from various geographic areas. Some characteristics stand alone for a particular area, some differ numerically, but there are a number of characteristics which are similar for all areas.

The existence of large (diameter and height) old trees is the most common feature described, followed by the presence of snags and coarse woody material on the ground. Almost every article used 150 years or older as a lower age limit. Structural complexity was nearly always described and included terms or descriptors like gaps, fragmented communities, spatial heterogeneity, and multi-layered canopies. Other characteristics described include large numbers of stems that can endure shade, and a rich species diversity, including epiphytes and mosses.

In the Western Cascades and Coast Ranges of the Pacific Northwest old-growth forests are a continuum of ecosystems that vary in space and time, a result of a unique set of environmental circumstances (Franklin and Spies 1984, Spies and Franklin 1988). Compared to many other old-growth forest ecosystems in the United States, the ones in the Pacific Northwest are particularly long-lived, some over 1000 years. Much more is known about the structure than the function of old-growth forests, and much more is known about the above-ground system than the below-ground system. Species composition varies among community types and relatively few of these species are found only in old-growth forests. Some species of mosses and epiphytic lichens do find their optimum habitat in old growth. The spotted owl (Strix occidentalis) and the red tree vole (Clethrionomys occidentalis) are thought to be obligate old-growth species.

Though old-growth forests tend to be very productive, productivity can vary considerably. Soil characteristics and long-term climatic conditions may account for some of this variation.

The old-growth forests in the Pacific Northwest are structurally very diverse, but there are certain similar characteristics. In the forests where trees are particularly large and tall, there is a diverse habitat gradient from the top of the tree to the bottom. Shade-tolerant trees tend to increase with time and there is generally a large component of coarse woody material in the form of snags or wood on the ground.

Disturbances have played an important role in the development of old-growth forest. Depending on where you are in the region, disturbances have run the gamut of large, catastrophic upheavals like fire to smaller-scaled upheavals like wind, insect outbreaks, and ground fires. Disturbances continue to play a role in the development and distribution of old-growth forests, but many of these disturbances are human caused like clear-cuts and fire.

The mature and climax seral stages of conifer forests in the Pacific Northwest have received a lot of attention due to the rapid harvest of the forests and the

possible extinction of the spotted owl, a federally endangered species. Efforts to describe the composition and structure of these forest have been interim and have used a broad and general approach, lumping together forest types over a wide geographic range (Old-Growth Definition Task Force 1986). The Forest Service ecology program in Region 6 has been collecting data on mature stands of dominate conifer types, based on series, for over 20 years.

The objective of this paper is to use the variables collected on ecology plots in the western hemlock (Tsuga heterophylla) series: (1) to detect trends in forest stand changes over time. (2) to determine what old growth is, and (3) to describe the characteristics of an old-growth stand.

LITERATURE REVIEW

The western hemlock series occupies the most extensive vegetation zone in western Oregon and Washington. This series occupies land where western hemlock is expected to be the dominant tree species, given the opportunity to achieve a long-term stable state (Topik et al. 1986). The series is characterized by the presence of western hemlock reproducing in the shade of mature stands. Mature stands are often dominated by large, seral Douglas-fir (Psuedotsuga menziesii) that persist for hundreds of years, giving these forests their distinctive character.

The western hemlock series extends from British Columbia in the north to the Klamath mountains of Oregon in the south. In the Cascade Ranges of Washington and Oregon it extends from near sea level up to about 3000 ft. (914 m) in elevation on the western side of the crest. It also includes most of the Coast Ranges of Washington and Oregon. This zone is usually bounded by the Pacific silver fir (Abies amabalis) or white fire (Abies concolor) zones at higher elevations and the drier Douglas-fir zone near the valley margins.

The climate of the western hemlock zone is maritime and is characterized by mild temperatures, prolonged cloudy periods with considerable fog, and muted extremes of temperature with narrow diurnal fluctuations. Winters are wet and mild, while summers are cool and relatively dry. The frost-free period is fairly long, which together with abundant precipitation (60-130 in/yr; 152-330 cm), promotes the lush vegetative growth characteristic of this zone. Within the zone there is a general increase in precipitation and decrease in temperature from south to north and with increasing elevation.

Although the soils of this zone are derived from a variety of parent materials, they have some important characteristics in common. The high rates of biomass production have resulted in soils with fairly thick, organic matter-enriched topsoil layers (Franklin and Dyrness 1973). Conversely, forest floor thicknesses are not too great owing to rapid decomposition and incorporation into the mineral soil. Soil reaction is generally moderately acidic and fertility is moderate to high, with nitrogen most often limiting. These soils are classified as Haplumbrepts or Haplohumults. Where topsoil layers are thinner, the soils are Dystrochrepts or Hapludults. In areas of volcanic ash and pumice deposits, the soils are Vitrandepts or Andisols.

The forest in this zone can produce a considerable amount of biomass. Annual productivity averages about 7-11 tons/acre (15691-24658 kg/ha) in fully stocked stands on good sites. Total accumulations can be as high as 350-400 tons/acre (784,575-896,657 kg/ha) of live, above-ground biomass, 15,000 cubic ft./acre (1050 cu m/ha) of wood volume, and 400 square ft./acre (925 sq m/ha) of basal area. The large amount of biomass is manifested in very large trees. Height growth in early successional stages is quite rapid and individuals may reach heights of up to 300 ft. (91 m) with diameters of 9 ft. (274.3 cm) at maturity (Spies and Franklin 1988). An interesting and critical feature in this zone is that Douglas-fir, a pioneer species that reproduces after disturbance, can live for many centuries, allowing it to persist during extended periods of stability and reseed the area following the next disturbance (Spies and Franklin 1991).

The major tree species in the western hemlock zone are Douglas-fir, western hemlock, and western redcedar (Thuja plicata). Minor species are white fir (Abies concolor), grand fir (Abies grandis), Sitka spruce (Picea sitchensis), western white pine (Pinus monticola), lodgepole pine (Pinus contorta), sugar pine (Pinus lambertiana), Pacific silver fir, noble fir (Abies procera), and Pacific yew (Taxus brevifolia). Hardwoods are not common except in early successional stages or in stressful habitats. Red alder (Alnus rubra), big-leaf maple (Acer macrophyllum), and golden chinkapin (Castinopsis chrysophylla) are the most widespread hardwoods.

Old-growth western hemlock forests are characterized by several distinctive attributes that distinguish them from earlier (and later) successional stages. Usually included are large, live trees, often dominated by seral Douglas-fir; large, dead, standing and down trees; a multi-layered canopy; and an heterogeneous understory (Franklin and Spies 1984, Old-Growth Definition Task Force 1986). Together, these attributes provide unique habitats for organisms and help to maintain long-term ecosystem productivity. These structures usually begin to develop in about 175 to 250 years, owing to the mild climate, abundant precipitation and generally deep, fertile soils of western hemlock forests (Franklin et al. 1981). Site quality and stand history can dramatically affect the rate of development. On some less productive sites the development of old-growth attributes may be significantly delayed, while stands with similar site quality may have considerably different levels of these attributes owing to differences in the nature and frequency of disturbances (Spies and Franklin 1991). Live tree growth rates begin to decline at approximately 80 to 120 years but significant growth continues well into the old-growth stage resulting in the large diameters and great heights of old-growth Douglas-fir (and often western redcedar) that are the most striking structural feature of these forests. These large, old trees usually have deep (tall) canopies; coarse, irregularly arranged branches; and often have broken or deformed tops.

The development of a multi-layered canopy composed of two or more species occurs as the stand reaches maturity. Mortality of seral species provides space for shade-tolerant climax species to become established. As the old-growth Douglas-fir trees age they become more decadent and the resulting broken tops, gnarly branches and deep canopy, together with the multiple layers created by the shade-tolerant trees, result in a wide array of habitats for many kinds of (often specialized) forest organisms. These structures also help create a moderate microclimate, buffered against climatic extremes, and supply additional moisture by intercepting fog (Franklin et al. 1981).

Coarse woody material (CWM), snags and large down logs, is generally abundant following natural disturbances. As the new stand of trees matures, CWM is lost to decomposition, and since very little mortality is occurring, Franklin and Spies (1988) estimate this is the lowest level of CWM during stand history. At maturity various agents of mortality generate increasing amount of CWM and this accumulation continues throughout the rest of the stand history. In the climax stage the volume will likely decline due to eventual decomposition of the large Douglas-firs.

Large snags are important habitats for a number of vertebrates, especially cavity nesters, as well as an impressive number of invertebrates. Snags also serve as a future source of down logs. Large down logs also provide habitat for many species and are important for erosion protection, nitrogen fixation and mycorrhizal function (Maser and Trappe 1984). Down logs also serve as a seedbed for certain species such as western hemlock and are a source of moisture during summer drought. Logs are critical components of small to moderate sized streams. They provide stream structure by creating debris dams with attendant plunge pools and gravel deposits. Logs also dissipate streamflow energy as well as supplying energy and nutrients to the stream system (Franklin et al. 1981).

The last distinctive feature of these forests is the patchiness of the understory. Plant species diversity and heterogeneity of the understory are usually fairly high immediately following disturbances. As the canopy of the new forest closes, diversity and heterogeneity decrease until openings in the canopy are created in the mature stage and beyond. Small, scattered openings in the overstory canopy result in unequal distribution of light and climatic factors. This results in a patchy understory dominated by shade-tolerant herbs and deciduous shrubs.

METHODS

The raw data that were used in this analysis were collected from Region 6 Ecology plots over the last 20 years. These data were collected in a consistent manner in carefully selected stable stands and include measurements of productivity, snags, and down wood. Ecology data collection procedures are described in the Regional Resource Inventory Handbook and Field Instructions for Vegetative Resource Surveys. The data were analyzed using the SAS statistical procedure. A list of plant associations and number of plots by site class is shown in Table 1.

The data set for the western hemlock series is quite large - 1271 plots were sampled. To have a more manageable dataset, a randomly selected subset of 610 plots was used in the analyses.

Stand age was determined for each plot based on the oldest cohort of trees where there were at least 10 per acre (25 trees/ha). Several ecology plot variables were plotted against stand age. These variables, for both live tree and snags, were trees per acre, quadratic mean diameter, basal area, standard deviation of live diameter, and stand age. Quadratic mean diameter weighs the larger trees, which are of greater importance, more heavily. All trees greater than 5 in dbh (12.7 cm) were included in this analysis. The number of canopy layers was estimated by looking for 30 to 50 foot (9.1-15.2 m) differences in height between age groups, especially when groups included different species.

When the variables from the entire subset were plotted against stand age, the results were so varied that trends in the data were not apparent. The subset was then stratified by sub-regions (north, mid, and south Cascades, and the coast region). Again, the results were highly variable. Next, the data were stratified by plant association grouping but this, too, resulted in high variation. Finally, the data were stratified by site class, to better account for differences in the development of old-growth characteristics due to site productivity. Site index values were computed for the dominate and co-dominant trees using the curves from McCardle et al. (1949) for unmanaged stands. Average site class was determined for each ecology plot. Plots with site class 4 and 5 were combined because there were too few plots in site class 5.

Succession

Old-growth is defined as a stable condition compared to younger successional stages. The transition from young to old growth is gradual, with different characteristics changing at different rates. These rates of change slow as the stands approach old growth. The slowing of the rates of change is indicated by inflection points in the plots of attributes against stand age. The nonlinear regression program from SAS (NLIN) used a least squares technique to fit a curve to the plots which revealed inflection points and plateaus. This procedure shows the rate of change in the younger stands and the time (stand age) at which the variable becomes stable.

Determination of old growth

The ages at which the attributes became stable were summarized and a mean stand age for the attainment of old-growth characteristics resulted. This mean stand age was then used as a starting point in a discriminant analysis which assigned each ecology plot to either old-growth or non-old growth groups. This analysis was performed on all attributes simultaneously in "multi-dimensional hyperspace." Several iterations using different stand ages were performed to elicit the stand age with the best grouping of plots. Those ecology plots that were placed in the old-growth group were then summarized resulting in mean values for each attribute (Table 2).

RESULTS

Stand Changes Over Time

Live trees

The number of trees per acre in the younger stands was high, ranging from 250-500 (618-1236 trees/ha). As the stands age these numbers decline until the onset of the old-growth stage when they level out. The rate of decline and the number of trees per acre vary with site class. The number of trees per acre increased with decreasing site quality. The lower the site class the longer it took to reach stability.

The number of trees per acre in site class 1 stands declined rapidly to 76 (188 trees/ha) at age 75 (Fig. 1). In site class 2 stands the numbers declined more gradually and leveled off at 82 trees per acre (203 trees/ha) in 149 years (Fig. 2). The number of trees per acre in site class 3 stands declined at about the same rate as site class 2 stands but stabilized at 99 (245 trees/ha) at 181 years of age (Fig. 3). For site class 4 and 5 stands, the rate of decline was very gradual with stability occurring at 314 years with 166 trees per acre (410 trees/ha) (Fig. 4).

Live basal area in young stands ranged from 100 to 300 square feet (22-69 sq m). Basal area increased to approximately the same level in all site classes (Figs. 5-8). The higher site classes, however, expressed the basal area in fewer, larger trees. Stands in site classes 4 and 5 took about 197 years to reach stability while stands in site classes 1 and 2 reached stability in about 125 years. There was no apparent trend for site class 3.

Quadratic mean diameter values ranged from 10 to 20 (25.4-50.8 cm) in young stands and increased with age. The fairly rapid rate of increase was similar for site class 1, 2, and 3 stands and more gradual for site class 4 and 5 stands. Stability occurred at 43 inches (109.2 cm) at 345 years for site class 1 stands (Fig. 9); 32 inches (81.3 cm) at 217 years for site class 2 stands (Fig. 10); 29 inches (73.7 cm) at 330 years for stands in site class 3 (Fig. 11); and at 21 inches (53.3 cm) at 300 years for site class 4 and 5 stands (Fig. 12).

The values for quadratic mean diameter decreased with decreasing site quality. Stability occurred at a similar age (300-350) for site class 1, 3, 4, and 5 stands. It is unclear why stands in site class 2 stabilized more quickly (at 217 years).

The standard deviation of diameter (at breast height) is generally low in the early years for all site classes and increases with age (Spies and Franklin 1991). The rate of increase is higher in the higher site classes as are the diameter values. The standard deviation of diameter continued to increase throughout the range of the stand ages sampled (Figs. 13-16). This was expected since climax species would continue to be recruited until a stand replacement disturbance occurred.

Snags

The number of snags per acre was highly variable. For site class 1 stands the number decreased from about 50 (124 snags/ha) in young stands to 20 (49 snags/ha) at age 408 (Fig. 17). For site class 2 stands the number declined from about 60 to 36 (148-89 snags/ha) at age 625 (Fig. 18). Site class 3 stands declined gradually from about 75 to about 25 snags per acre (185-62 snags/ha) but stability was never reached (Fig. 19). Snags per acre in site class 4 and 5 stands remained at about 90 (222 snags/ha); there was no apparent trend (Fig. 20).

Snag basal area was very low in site class 1 stands but increased to 149 square feet (34 sq m) at age 115 (Fig. 21). For site class 2 stands basal area increased slightly to 168 square feet (39 sq m) at 114 years (Fig. 22). For site class 3 stands basal area decreased from about 200 to 142 square feet (19-33 sq m) at age 64 (Fig. 23). Stands in site class 4 and 5 had basal areas increase sharply from about 10 to 103 square feet (2-24 sq m) at age 93 (Fig. 24).

Snag quadratic mean diameter had no apparent trend for site class 1 stands. The values plateaued at 35 inches (88.9 cm) at age 35 (Fig. 25). For site class 2 these values rose from about 10 to 27 inches (25.4-68.6 cm) at age 68 (Fig. 26). For site class 3 stands the values gradually increased from about 22 to about 35 inches (55.9-88.9 cm) but never reached stability (Fig. 27). Snag dbh rose sharply from about 10 to 18 inches (25.4-45.7 cm) at 84 years of age in site class 4 and 5 stands (Fig. 28).

The snag data were highly variable and revealed no real trends with increasing stand age. This is probably due to differences in stand history. The nature and frequency of disturbances likely plays a more important role in the distribution of snags over time than does stand age.

Determination of Old Growth

When discriminate analyses were used to group the data, all variables were considered equally and an unbiased estimate was made of which plots belong to old growth and which belong to young growth. A good grouping of plots resulted at 200 years for all site classes. Table 3 displays the percentage of correct classifications into old- or young-growth groups by site class at age 200. Table 4 displays the stand age at which stability is reached for the various stand attributes.

In the determination of old growth grouping, the stand age, standard deviation of dbh and quadratic mean diameter were highly significant ($p < .001$) for all site classes (Table 5). Trees per acre was also highly significant for site class 3 stands as was basal area for site class 4 and 5 stands. Variables that were significant ($p < .01$) were snag quadratic mean diameter for site class 1; basal area for site class 2; snag quadratic mean diameter and snags per acre for site class 3; and trees per acre for site class 4 (Table 5).

It is important to note that the snag variables, while not significant in deciding whether or not a stand is old growth, are nevertheless very important in the functioning of an old-growth ecosystem.

Old-Growth Characteristics

Live trees

Old-growth characteristics of the four western hemlock site classes can be viewed in several ways. Tables 2 and 6 summarize data for all trees greater than 5 inches (12.7 cm) dbh in the plots that were classified as old growth. Table 7 summarizes data for plot site trees, almost always the dominant and codominant trees.

Looking just at dominant and codominant trees (table 6), total trees per acre were similar for sites 1 and 2 with an increase in sites 3, 4, and 5. These values, however, must be viewed with caution due to the considerable variability in the data. Average dbh decreased with decreasing site quality. Average age of dominants and codominants also decreased with decreasing site quality.

Snags

The differences between site classes for snags and down woody material for all species in old-growth plots were small. Average decay class for down wood across all sites was 3 (defined as trace of bark; no twigs; hard, large pieces; round; original color to faded; tree is sagging near ground; invading roots in sapwood). The average number of pieces of down wood (greater than 6 inches in diameter) per acre was 100. The average length of a piece was 29 feet (8.8 m) with an average diameter of 15 inches (38.1 cm) (Table 7).

The number of snags increased with decreasing site quality, while diameter and basal area of snags decreased with decreasing site quality (Table 2).

Canopy layers

In all site classes the average number of canopy layers is 2. There appears to be a trend toward more canopy layering with increasing site quality (Table 8).

Tree species

The diversity of tree species is indicated by the number of occurrences and percent frequency for each species (Table 9). The dominant species are Douglas-fir, western hemlock, and western redcedar. White fir is the next most common species, except in site class 1 stands. The species diversity is highest in site class 3 stands and lowest in site class 1, with site classes 2, 4, and 5 intermediate.

Frequency of occurrence for DBH, height, and age

In Tables 10, 11, and 12 the frequencies for dbh, height and age classes are presented by site class for all species combined and separately for the three dominant species: Douglas-fir, western redcedar, and western hemlock (see also Figs. 29-40). As expected, dbh and height increased with increasing site quality for all species. Douglas-fir had the largest diameters and greatest heights, followed by western redcedar, then western hemlock.

All of the Douglas-fir were taller than 200 feet (61 m) and over half were taller than 250 feet (76 m) in site class 1 stands. Sixty-nine percent were taller than 200 feet (61 m) in site class 2 stands. Site class 3 Douglas-fir had 72 percent of the individuals in the 150 to 200 foot (46-61 m) class. Sixty-four percent of site class 4 and 5 Douglas-fir were between 100 and 149 feet (30-45 m) tall.

Western redcedar stands in site class 1 had 93 percent of individuals taller than 150 feet (46 m) and 21 percent taller than 200 feet (61 m). Sixty-two percent were taller than 150 feet (46 m) in site class 2 stands. Site class 3 stands had over 90 percent taller than 100 feet (30 m) and 39 percent taller than 150 feet (46 m). Sixty-three percent of the site class 4 and 5 redcedar individuals were between 50 and 99 feet (15-30 m) tall.

The majority of site class 1 western hemlock were taller than 150 feet (46 m) while in site classes 2 through 5, the majority were shorter than 150 feet (46 m).

The majority of site class 1 Douglas-fir were over 300 years of age while in site class 2 through 5 stands the majority were younger than 300 years. Most individuals in all site classes were between 200 and 300 years of age.

Western redcedar site class 1 had individuals spread fairly evenly from 100 to 500 years. In site classes 2 through 5 the greatest proportion of individuals is between 200 and 300 years of age.

Seventy percent of the western hemlock in site class 1 were between 100 and 200 years of age. This age class has the greatest proportion of individuals in the other site classes as well. Site class 3 stands had the greatest range of ages while in site class 1 stands, no individual was older than 300 years.

DISCUSSION

The minimum attribute values for describing old-growth western hemlock stands are not readily elicited from these analyses. The greatest problem with the data is the considerable variability. Even though the stands that were sampled for the ecology program were the most stable that could be reasonably accessed, they include a wide range of ages and histories of stand establishment and development.

Diameters

Some attributes, however, can be more easily summarized. It is obvious from the review of pertinent literature that large trees are almost always present in old-growth stands. Minimum values for diameters at breast height can be established by subtracting one standard deviation from the mean value. In Table 13 minimum diameters are presented for all species greater than 5 inches (12.7 cm), for Douglas-fir greater than 5 inches (12.7 cm) and for canopy dominants.

Age

The minimum age at which the old-growth stage is reached appears to be about 200 years. There are several ways to arrive at this value. First, the age at which a good grouping of old and young stands in the discriminate analyses occurred was 200. Taking the average age to reach stability of live basal area, trees per acre and quadratic mean diameter values by site class from Table 4 and then averaging those ages yields an age of 218. Taking the mean ages of the above variables across all site classes and then averaging those values gives an age of 209. Thus, age 200 seems to be reasonable.

Intuitively, however, we would expect the higher site classes to grow large trees sooner than the low site classes. Indeed, this is apparent in parts of the Siuslaw National Forest where, on highly productive sites, there can be more than 10 trees per acre (25 trees/ha) that are 40 or more inches (102 cm) in diameter in 150 years or less. Looking at the summary values for dominants and co-dominants (Table 7) we find ages that are contrary to the expected pattern. This is likely a consequence of the fact that the higher site stands are usually in more moist environments and, therefore, burn less frequently - hence, the older ages for the canopy dominants in the higher site classes.

In any case, the age at which the large trees achieve the minimum dbh values has not been analyzed. Indeed, stand age is not the critical factor. The presence of the structural elements that provide the unique functions of the old growth stage are more important.

Trees per acre

Determining the minimum number of large trees per acre is also problematic. The mean values in Table 7 have large standard deviations. Simply subtracting one standard deviation from the mean is obviously not going to yield a reasonable minimum.

CONCLUSION

Given the extreme variability among site classes, the minimum values for variables defining the old-growth stage of western hemlock series forests are as follows: minimum dbh for canopy dominants ranges from 21 inches to 42 inches (53.3 - 106.7 cm) depending upon site quality, and average across all site classes is 32 inches (81.3 cm). Minimum age for all site classes is 200 years. Minimum number of trees per acre ranges from 8 (20 trees/ha) for site class 1 to 81 (200 trees/ha) for site classes 4 and 5 (8 (20 trees/ha) serves as minimum for all site classes).

In addition, there are variable amounts and sizes of snags, owing to a wide range of stand histories. There are also about 100 (though note large standard deviations in Table 8) down logs per acre (247 per ha) with an average diameter of 15 inches (38.1 cm) and an average length of 29 feet (9 m). The number of canopy layers is two.

These values correspond closely to the 8 trees per acre (20 trees/ha), 32 inches (81.3 cm) dbh and 200 years, presented in PNW 447 (Old-Growth Definition Task Force 1986).

Table 1. List of plant associations in the western hemlock series and number of plots by site class. TSHE (western hemlock) is the predominant tree species.

Site Class

ACCI/GASH	1	ABAM/VAME	1	ABAM/VAME	5	ABAM/VAME	1	BENE	1
ACCI/POMU	8	ACCI-GASH	3	ACCI/ACTR	1	ACMA/POMU	1	BENE-CHME	3
ACTR	8	ACCI/POMU	2	ACCI/OXOR	1	ACTR	5	BENE-GASH	1
ATFI	4	ACMA/POMU	1	ACGL/LIBOL	1	BENE	13	GASH	4
BENE	2	ALRU/POMU	1	ACTR	26	BENE-CHME	5	GASH-VAME	1
BENE/OXOR	1	ATFI	2	ATFI	1	BENE-GASH	16	GASH/XETE	1
BENE-POMU	3	ACTR	33	BENE	18	BENE/LIBOL	2	PICO/GASH	1
GASH	1	BENE	12	BENE/ACCI	2	BENE/POMU	1	PSME/AREN	1
GASH-HODI	1	BENE/ACTR	4	BENE/ACTR	6	CADE3/GASH	1	RHMA	3
GASH/POMU	1	BENE-GASH	16	BENE-GASH	22	GASH	10	RHMA-BENE	2
OPHO	4	BENE/LIBOL	4	BENE/LIBOL	7	GASH-BENE	8	RHMA-GASH	3
OPHO/POMU	6	BENE/OXOR	5	BENE/OXOR	1	GASH/XETE	1		
OXOR	1	BENE/POMU	8	BENE/POMU	14	RHMA	1		
POMU	6	CONU/ACTR	1	CADE3/GASH	2	RHMA-BENE	3		
POMU-OXOR	6	GASH	6	CONU/ACTR	3	RHMA-GASH	6		
POMU-TITR	3	GASH-BENE	1	GASH	11	RHMA-VAAL	2		
RHMA-GASH	1	GASH/HIAL	1	GASH-BENE	3	RHMA/XETE	1		
RHMA/POMU	1	GASH/OXOR	1	GASH/HIAL	1	PSME/ARME	1		
RHMA-VAOV2	1	OPHO	2	LIBO2	1	PSME/HODI	1		
RUSP	3	OPHP/POMU	5	OPHO	2	UCMA	2		
RUSP-ACCI	2	OXOR	7	OPHO-ATFI	1	VAAL/OXOR	1		
RUSP-GASH	2	POMU	10	OPHO/POMU	1	VAME/LIBOL	1		
TITR	4	POMU-OXOR	10	OXOR	1				
VAAL-GASH	1	POMU-TITR	7	POMU	9				
VAOV2	3	RHMA-BENE	2	POMU-OXOR	5				
		RHMA-GASH	3	POMU-TITR	5				
		RHMA/LIBO2	2	PSME/HODI	2				
		RHMA/LIBOL	4	RHMA-BENE	11				
		RHMA/OXOR	1	RHMA-GASH	4				
		RHMA/POMU	5	RHMA/LIBO2	1				
		RHMA/VAOV2	4	RHMA/LIBOL	1				
		RUSP	1	RHMA/OXOR	3				
		RUSP-GASH	1	RHMA/POMU	1				
		TITR	14	RHMA-VAAL	2				
		UCMA	3	RHMA-XETE	1				
		VAAL	1	TABR/RHMA	1				
		VAAL/COCA	4	THPL/OXOR	1				
		VAAL/OXOR	1	TITR	4				
		VAME/LIBOL	2	UCMA	3				
		VAOV2	1	VAAL	1				
				VAAL/COCA	11				
				VAAL/GASH	2				
				VAAL/OXOR	2				
				VAME/LIBOL	2				
				VAOV2	1				

Table 2. Means and standard deviations of discriminant analysis variables in young and old growth groups.

Variable	Old growth	Young growth
Site class 1		
Trees per Acre	54 (46)	101 (101)
Basal Area (sq ft)	317 (87)	274 (79)
Quadratic Mean Dia. (in)	39.8 (13.2)	27.6 (9.3)
Std. Dev. of dbh (in)	16.1 (8.7)	8.3 (4.6)
Snags per Acre	20 (22.5)	38 (41)
Snag Basal Area (sq ft)	167 (155)	126 (110)
Snag Quad. Mean Dia. (in)	43.1 (11.6)	31.4 (14.9)
Initial Old Growth Stand Age	200	
Number of Plots	16	41
Site class 2		
Trees per Acre	88 (62)	118 (83)
Basal Area (sq ft)	318 (113)	266 (84)
Quadratic Mean Dia. (in)	31.3 (11.6)	23.4 (7.4)
Std. Dev. of dbh (in)	12.0 (5.8)	6.1 (3.9)
Snags per Acre	43 (36)	57 (57)
Snag Basal Area (sq ft)	156 (153)	169 (160)
Snag Quad. Mean Dia. (in)	27.3 (9.3)	26.4 (12.8)
Initial Old Growth Stand Age	200	
Number of Plots	57	98
Site class 3		
Trees per Acre	107 (84)	169 (127)
Basal Area (sq ft)	305 (98)	267 (81)
Quadratic Mean Dia. (in)	27.6 (9.6)	20.0 (6.2)
Std. Dev. of dbh (in)	11.3 (6.0)	4.6 (1.9)
Snags per Acre	46 (51)	74 (77)
Snag Basal Area (sq ft)	136 (104)	160 (122)
Snag Quad. Mean Dia. (in)	27.9 (11.1)	22.9 (11.4)
Initial Old Growth Stand Age	200	
Number of Plots	92	57
Site class 4 & 5		
Trees per Acre	177 (96)	278 (163)
Basal Area (sq ft)	317 (94)	235 (87)
Quadratic Mean Dia. (in)	20.0 (5.5)	14.3 (5.6)
Std. Dev. of dbh (in)	7.4 (4.1)	3.0 (2.5)
Snags per Acre	68 (56)	91 (106)
Snag Basal Area (sq ft)	96 (66)	99 (95)
Snag Quad. Mean Dia. (in)	19.5 (10.9)	15.6 (8.5)
Initial Old Growth Stand Age	200	
Number of Plots	37	41