Ecological Definition for
Old-growth Pacific Douglas-fir
(Society of American Forester's type 229)

Prepared by:

Pacific Southwest Region Old-growth Definition Team 1
(Tom Jimerson, Team Leader, Ecologist, Six Rivers National Forest)
(Bruce B. Bingham, Botanist, PSW, Arcata, CA)
(David Solis, Wildlife Biologist, Six Rivers National Forest)
(Sue Macmeeken, Silviculturist, Six Rivers National Forest)

3/12/92

October 1991

Ecological Definition for
Old-growth Pacific Douglas-fir
(Society of American Forester's type 229)

INTRODUCTION

Old-growth forests represent a unique plant community of significant biological and social value. The once plentiful forests of old-growth in the United States have greatly diminished through past logging practices and wildfire. The management of the remaining old-growth stands, which are now primarily found on public lands (Spies & Franklin 1988), has become a critical and controversial resource issue. The distinctive structural and biological attributes of old-growth forests serve as sites of high biological and genetic diversity, as needed habitat for many wildlife species, and provide a unique recreational value. These same forests are also the source of raw material needed to produce high value lumber products. The Forest Service recognizes the values of these forests and is providing direction for the maintenance and management of old-growth habitat on National Forest lands (Robertson 1989).

Old-growth forests are fairly complex and often cannot be distinguished from other stands by one or two stand structure attributes. Several key attributes together distinguish these stands from other seral stages (Franklin & Spies 1989). Biologically, mature forest stands become old-growth when the standing cubic volume culminates (the stand reaches maximum site carrying capacity). The numbers of trees in the larger diameter classes increase significantly and the stand quadratic mean diameter culminates. Old-growth forests are characterized by large conifers in stands with multiple canopy layers and on higher quality sites have relatively dense canopy cover. Decadence is significant in the latter part of the old-growth seral stage and is evident in the accumulation of large standing snags, downed logs and malformed live trees.

Direction for resource management cannot be resolved without first defining the biological and structural features which distinguish old-growth stands from other seral stages. The Old-Growth Definition Task Group (1986) developed interim definitions for old-growth Douglas-fir and mixed-conifer forests in western Washington, Oregon and California. National direction to develop specific old-growth definitions for each forest type was established in 1989 (Robertson 1989).

The objective of this paper is to define the characteristics of old-growth stands in Society of American Foresters (1964) (SAF) type 229: Pacific Douglas-fir. The definition included herein is an assimilation of data collected in Northwest California and provides quantitative, measurable criteria to identify key features which distinguish old-growth stands from mature forest stands. Minimum values are not provided here, as we view the mean values and 95% confidence limits as being more appropriate for identifying optimal old-growth conditions. The old-growth definition goes beyond the standards for large trees, snags, and logs by providing criteria for additional understory features. The definition will also assist the resource manager in establishing standards for maintaining certain old-growth characteristics.

This old-growth definition is intended only as descriptions of the old-growth seral stage. The stated characteristic values may or may not meet all of the requirements needed to provide for other resource values, especially wildlife. A stand of timber with old-growth features may or may not equally provide for all wildlife species.

STUDY AREA

In California, the Pacific Douglas-fir type is found primarily in the northwestern portion of the state in the northern and central Coast Ranges and western Klamath Mountains.

It occurs in the same general area as the Douglas-fir/Tanoak/Madrone type but on higher elevation drier sites. The primary difference between these two closely related types is the reduction in the hardwood component, primarily tanoak. The elevational range of the The Pacific Douglas-fir SAF type extends from 2400 to 5300 feet. It is comprised of the conifer species Douglas-fir (Pseudotsuga menziesii [Mirb.] Franco), white fir (Abies concolor Gord. & Glend.), and sugar pine (Pinus lambertiana Dougl.) along with the hardwood species canyon live oak (Quercus chrysolepis Liebm.), madrone (Arbutus menziesii Pursh.), giant chinquapin (Castanopsis chrysophylla Dougl.), and black oak (Quercus kelloggii Newb.). Other plant species occurring in the Pacific Douglas-fir SAF type are listed in Table 1. We have included a species list here to allow the reader to compare the Pacific Douglas-fir SAF type with the closely related Douglas-fir/Tanoak/Madrone SAF type 234 and to provide the site specific vegetation information from which these definitions were developed.

The Pacific Douglas-fir SAF type is referred to by different names by different authors. For instance, the Regional Ecology Group (1981) refers to this forest type as the Mixed Conifer-Fir Series. Holland (1986) describes this type as Upland Douglas-fir Forests, while Franklin and Dyrness (1973) refer to these forests as Douglas-fir on mixed conifer sites.

Climate in the study area is characterized by warm, dry summers and cool wet winters. Temperatures range from 10 F to 25 F (12 C to 4 C) in the winter and up to 90 F (32 C) in the summer (Parsons and Knox 1984). Precipitation ranges from 60 to 120 inches per year (203-305 mm) (Albert 1979).

Geographically, the northern Coast Range is comprised of a series of small independent ranges orientated north north-westerly along the california coast from the Oregon border to San Francisco. The Coast Range mountains are generally lower and more rounded than the Klamath Mountains with smaller drainages. The Klamath Mountains are positioned inland from the coastal range, orientated from north to south and include South Fork mountain, the Trinity Alps, Salmon Mountains and Siskiyou Mountains. Terrain in the Klamath Mountains is generally more rugged than in the Coast Range with slopes ranging from 30 to 80 percent. Abrupt changes in slope, aspect and soils are typical of these two mountain ranges and have contributed to the mosaic of vegetation types which are characteristic of this area.

The relatively recent geological origin of these mountains is evident in the varied and diverse rock types included in the Coast and Klamath Mountains. Bedrock types include Mesozoic ultrabasic intrusive, Jurassic-Triassic meta-volcanic, pre-Cretaceous meta-sedimenary, upper Jurassic marine sedimentary formations and Mesozoic (Irwin 1966). The soils derived from these rock types are as varied as the parent bedrock type from which they came. The Douglas-fir forest types are found primarily on soils derived from meta-sedimentary and meta-igneous rock formations.

In addition to the varied geological and topographical features of these mountains, the introduction of fire has played a key role in the origin and development of Douglas-fir forests throughout the area. The repeated introduction of natural and human-caused fire altered stand structure, seral stage distribution and development within these forests. After fire control measures were adapted in the early 1900's, the role of fire became increasingly less significant. However, in more recent times, the affects of human disturbance, and in particular, logging activities, has shifted the overall forest landscape to include a higher porportion of younger seral stages and less old-growth.

METHODS

Data for these old growth definitions was collected on the Six Rivers National Forest, the Western half of the Klamath National Forest (Ukonom, Happy Camp, and the western half of Salmon River Districts).

The methods described below were previously described in Jimerson & Fites (1989). They are restated here for the benefit of the reader.

Data Collection

Data collection followed the Region 5 Ecosystems Sampling Procedures (Allen 1987). This included a modified Region 5 Compartment Inventory Analysis (CIA) (USDA 1986) sample at each plot. Sample sites were selected after a thorough review of the information on vegetation, soils, geology, landform, and an extensive aerial photo and ground reconnaissance of the study area. Sample sites were systematically selected to ensure:

a. complete coverage of the area;
b. inclusion of all forested plant associations;
c. diversity in aspect and slope;
d. sampling of all mapped parent materials,
e. and, coverage of all mapped soil units.

Sample plot locations were restricted to homogeneous forested stands (Pfister and Arno 1980). The SAF vegetation type was identified using the SAF type key contained in Appendix A.

Plots were included in all seral stages, although primarily in late seral stage stands. Early seral stage stands sampled were subjected to intensive forest management. They originated primarily from clearcut and broadcast burn treatments. Mature and late seral stands were unmanaged, originating primarily after stand replacing fires. Sampling of all seral stages was completed in order to examine the changes in stand structure over time. The principle emphasis of this paper was to identify structural characteristics that identify the end of the mature seral stage and the beginning of the old-growth seral stage.

Each plot included three variable radius sub-plots to measure tree basal area using a 20 or 40 basal area factor (BAF) prism (Bitterlich 1948). The three variable radius sub-plots were placed at 1.) plot center, and 2.) two chains north (azimuth 360), and 3.) two chains east (azimuth 90), from plot center (USDA 1986). Basal area, diameter at breast height, age, height, and 10 and 20 year radial growth data of a dominant or codominant site tree were measured at each of the three sub-plots. Structural features such as number of layers and spatial arrangement were noted for each plot on the vegetation type/seral stage characteristic card found in Appendix B. Canopy layering was completed indirectly by examining the diameter classes present. Densities of snags and logs and percent cover of logs were also measured using the methods described in Jimerson (1989) for 317 plots in the Gasquet Ranger District of the Six Rivers National Forest. Plant species and percent cover were recorded for the tree, shrub, herb, and grass layers.

Stand age was determined from the age of the oldest dominant or codominant tree measured for site index information. Pre-dominant trees, those that had their origin in a previous stand, were not used to determine stand age. The standard method of aging trees, using increment borers to bore the tree at breast height (4.5 ft.), was used to determine the stand age (Bonham 1988). Trees with rotten cores were excluded from stand age measurements. For trees with large diameters, age was estimated using the number of rings in the last inch of the core and extrapolating for the missing section. This may introduce an error in estimation of age due to the extrapolation of ring width and number in the unsampled center of the tree. However, since our primary objectives were to determine the age of transition from mature to old growth stands, and $< 5\%$ of the trees required extrapolation, this extrapolation error is thought to have little influence on the definition. Further research on the viability of old growth stands is needed. Looking at the older stands to examine viability would require other aging methods to decrease the age estimation error.

Data Analysis

The data were first stratified by major forest type to examine structural differences in old-growth due to major differences in overstory species composition. Society of American Foresters' Forest Cover Type definitions (1964) were used to identify the major forest types. Stands were classified as Pacific Douglas-fir (SAF type 229) if white fir was present and/or the hardwood canopy cover (understory and/or overstory) was less than ten percent using the SAF type key in Appendix A.

The data were stratified secondarily, within each major forest type, by site classes using Dunning site curves at base age 300 years (Dunning 1942) (Table 3). This was done to examine structural differences due to site class observed in the field.

Four hundred and fifteen plots were used to analyze the characteristics of old-growth Pacific Douglas-fir stands. The site class distribution of stands included 235 plots in site classes 1A-1, 144 plots in site classes 2-3 and 36 plots in site classes 4-5.

Compartment Inventory Analysis or Forest Inventory Analysis, R5*Convert and R5*Summary (USDA 1986) were used to calculate stand characteristics including: softwood and hardwood basal area (ft^2/acre), number of softwood and hardwood trees per acre (trees/acre), softwood bag-10 (10 year growth/acre in ft^2), softwood and hardwood cubic volume (100's ft^3/ac to utilized top), site class, and trees per acre by dbh class and species. The quadratic mean diameter (QMD) was used to describe average tree size for conifers and to determine stand density index (SDI) (Weatherhead et. al 1985). They were calculated using the respective formulas (Reineke 1933)

Quadratic Mean Diameter (QMD) = $\sqrt{\frac{\sum d^2}{n}}$, n = number of trees, d = diameter of each tree,

Stand Density Index (SDI) = $N(dq/10)^{1.605}$, N = number of trees/acre, dq = quadratic mean diameter.

Snag and log densities were calculated by multiplying the number of snags and logs per plot by the area correction factor. Log volumes were calculated using Smalian's cubic volume of logs formula (Wenger 1984):

$$V\ (\text{Smalian's}) = 0.002727(D_0^2 + D_1^2)L,$$

V = volume in cubic feet,
D_0 = diameter inches large end,
D_1 = diameter inches small end,
L = length in feet.

The stratified data were sorted by age and then examined graphically as an ecological series (Legendre and Legendre 1983) substituting space for time (Strayer et. al 1986). Stands of different ages, geographically spaced throughout the study area, were examined in order to identify trends in stand development. All of the stand characteristic variables recorded and other variables, such as herb cover, grass cover, shrub cover and tree cover, were plotted against the estimated age of the stand.

Scatter plots of variables with stand age were generated using Harvard Graphics (Software Publishing Corporation 1987). All variables were plotted and the graphs examined by three site class groups as follows: 1A-1 high site, 2-3 moderate site, and 4-5 low site. Categories of stand development (young, mature, and old-growth) were identified and used as grouping variables. These groups were analyzed using Stepwise Discriminant Analysis (Jennrich and Sampson 1985) to identify a set of discriminating variables. The variables that showed interpretable trends, consistent with previous information on stand development and climax structure (Franklin et. al 1981), were selected as core variables. Preference was also given to variables that could be easily measured in the field and provide a working definition.

Robust locally weighted regression (Cleveland 1979), was used to examine the relationship between stand structural features (cubic volume, basal area, quadratic mean diameter, trees/acre) and stand age. The program generates a set of points that form a nonparametric regression of y on x. Robust refers to an adaptation of iterated weighted least squares that prevents highly variable points (outliers) from distorting smoothed points. The data were graphed using Harvard Graphics.

Visual examination of the smoothed graphs was used to determine the stand age at which stand structure changed from an increasing mode to a maintenance mode or plateau. The ages at which stand structure maintained consistent features was interpreted as old-growth. Means, standard deviations, standard errors, snag density, and coarse woody debris volume were determined through SPSSPC+ (Norusis 1988).

The age at which stand structure was determined to be old-growth was used to develop a set of average characteristics for old-growth.

RESULTS AND DISCUSSION

The variables found to be acceptable and consistent identifiers of the age at which stand structure shifts from a increasing mode (mature seral stage) to a maintenance or plateau mode (old-growth seral stage), are listed below.

1. Culmination of standing cubic volume.
2. Culmination of quadratic mean diameter.
3. Changes in the density (trees/acre) of large diameter trees.
4. Changes in vegetative cover by stratum.
5. Significant increases in density, diameter, and height of large snags.
6. A significant increase in the number of large logs.

The numbers of diameter classes and stand density index were found to maximize during the mature seral stage. This makes it a characteristic of old-growth but not an identifier of the onset of the old-growth seral stage.

Tree species and size

Two variables, constancy and characteristic cover, are used to describe the relative association and cover of plant species. Constancy measures the frequency of occurrence within vegetation plots, while average cover for each species in plots is described by characteristic cover. Constancy varies by species along environmental gradients.

Old-growth stands in SAF forest type 229 are dominated in the overstory by the conifers Douglas-fir (100% constancy), white fir (66% constancy), and sugar pine (36% constancy) in association with a mixture of hardwood tree species. canyon live oak (28% constancy), Pacific madrone (25% constancy), giant chinquapin (21% constancy) and black oak (15% constancy) are the dominant hardwoods (Table 1). Overstory conifers attain heights which often exceed 175 feet tall and 50 inches DBH (diameter at breast height). Understory conifers attain heights of over 120 feet and 25 inches DBH.

Structure/stories

Old-growth stands in the Pacific Douglas-fir SAF type were characterized by at least two stories (Table 2). Douglas-fir dominates the overstory which is subtended by a mixture of conifers including white fir and sugar pine. Hardwoods were occasionally the dominant feature of the understory and include canyon live oak, Pacific madrone, giant chinquapin and black oak. The Pacific Douglas-fir SAF type differs from the Douglas-fir/Tanoak/Madrone SAF type in that tanoak is absent or $<$ 10 % cover in the Pacific Douglas-fir SAF type.

The structure of old-growth stands within SAF type 229 varies by age and site class. High sites (site classes 1a and 1) enter the old-growth seral stage at 180 years. This age is accompanied by a shift in the number of trees/acre by diameter class. The dominant diameter class shifts from dominance by smaller size classes (6-11, 11-18, 18-25, 25-30 in.) to dominance by trees $\geq$ 40 inches dbh. The mean number of trees/acre for the $\geq$ 40 inch dbh class was found to be 13.5 (Table 2). Large (greater than 30 inches DBH) Douglas-fir trees predominate old-growth stands on high and moderate sites. On high sites the majority (68%) of basal area (mean total basal area = 317 sq. ft. per acre) occurs in the larger (≥ 30 in. DBH) size classes of conifers, while the highest density of trees occurs in smaller (≤ 30 in. DBH) size classes of conifers. Approximately 14% of the conifer trees (mean total conifer density = 171 trees per acre) were ≥ 30 inches DBH.

Moderate sites (site classes 2 and 3) reach the old-growth seral stage at 260 years. The number of trees/acre ≥ 30 inches was the dominant feature of this group. The mean number of trees/acre ≥ 30 in. for stands ≥ 260 years was 19.2 (Table 2). On moderate sites, the majority (63%) of basal area (mean total basal area = 271 sq. ft. per acre) occurs in the larger (≥ 30 in. DBH) size classes of conifers, while the highest density of trees occurs in smaller (≤ 30 in. DBH) size classes of conifers. Approximately 11% of the conifer trees (mean total conifer density = 177 trees per acre) were ≥ 30 inches DBH.

Low sites (site classes 4 and 5) enter the old-growth seral stage at 295 years (Table 2). As with the higher site index groups, there was a shift in dominance of the number of trees/acre by diameter class with increasing age, but on these low sites it is the trees ≥ 25 in. The mean number of trees ≥ 25 in. was 26.3 trees/acre. On low sites, trees ≥ 25 in. DBH dominate the stands. The majority (64%) of basal area (mean total basal area = 239 sq. ft. per acre) occurs in the larger (≥ 25 in. DBH) size classes of conifers, while the highest density of trees occurs in smaller (≤ 25 in. DBH) size classes of conifers. Approximately 13% of the conifer trees (mean total conifer density = 192 trees per acre) were ≥ 25 inches DBH.

Snags

Snag densities change over a time as a function of pulses associated with stand development and competition induced mortality. The first significant pulse of large snags (snags ≥ 20 inches DBH and ≥ 15 feet tall) occured at culmination of mean annual increment. Here competition between trees for light, moisture, and nutrients produced a significant pulse of mortality. This pulse is followed by a series of pulses regularly spaced in time beginning at the advent of the old-growth seral stage.

Snag density (all species combined) appeared constant between site classes. Total density of snags greater than 20 inches DBH and ≥ 15 feet tall averaged 4.4 snags per acre on all sites. Hardwoods contributed 20% of the total density of snags.

Snag densities are not uniform throughout a stand. In examining the point samples used to construct these definitions it was determined that 20% of the stands fail to meet the standard of 2.4 ± 0.4 snags/acre. This does not mean that these stands should not be considered old-growth, it points to snag densities as a feature of old-growth but not a determining variable.

Down logs

Density, volume, and weight of logs appeared constant between site classes. Log densities showed a decrease with stand age from 1 to 100 years. In general, log density showed a lag behind snag density. There was a significant increase in the mean log density of logs ≥ 20 in. diameter and ≥ 10 ft. long between stands 100 to 170 years and stands greater than 180 years old, with the mean density increasing from 10 to 23.2 logs/acre (table 2).

As explained above for snags, log densities are also variable within a stand, as many as 30% of the stands considered old-growth do not meet the log density standard. This can be explained partly by the use of point counts and partly by the steepness of the terrain. Gravity plays a roll in determining which positions in the landscape have high log densities as well as periodic disturbance. Logs are a characteristic of old-growth, but should not be used as the sole determinant of whether or not a stand is considered old-growth.

The log volume showed a similar pattern to that of log density, with an initial decrease until 100 years, followed by a series of small peaks. Thereafter, there was a significant increase in the mean log volumes with stand age. The mean log volume increased from 1500 $ft.^3$ in stands between 100 to 170 years to 4250 $ft.^3$ for stands greater than 180 years and a weight of 60 tons per acre (Table 2). Hardwoods contributed 4% of the total density of logs.

Understory characteristics

Vegetation cover by layer changed over time in relation to site class. On high and moderate sites conifer cover was the dominant feature throughout the sere (the stand development sequence), averaging 71% in the old-growth seral stage. Conifers dominated the site by the beginning of the pole seral stage. On low sites conifers shared dominance with shrubs.

Hardwood cover in the Pacific Douglas-fir SAF type was much lower than the Douglas-fir/Tanoak/Madrone SAF type, averaging 10%. It increased with age, reaching a stable maximum at approximately 100 years stand age.

Shrub cover increased with age, reaching a stable cover in the old-growth seral stage. It also increased with a decrease in site quality. On high sites shrub cover averaged 27%, while moderate sites averaged 41%, and low sites averaged 53%.

High forb cover was a characteristic of the Pacific Douglas-fir SAF type. Forb cover also increased with stand age, reaching its highest level during the old-growth seral stage. Unlike shrub cover, forb cover increased with site quality. High sites averaged 25% forb cover, moderate sites averaged 15% cover, and low sites averaged 11% cover.

Grass cover was low in the Pacific Douglas-fir SAF type and does not appear to be related to site quality.

Decadence

The presence of logs and snags was a primary indicator of the decadence of old-growth stands. A full range of size and decay classes of logs and snags, which contribute to ecosystem functioning, occured in Pacific Douglas-fir old-growth stands. Most (68%) logs occured in a high state of decay (decay classes 3,4,5). While most (58%) snags were found in a low state of decay (decay classes 1 and 2).

Decadence of old-growth stands was also characterized by the presence of diseased, broken-topped,or malformed live trees. Live conifer trees possessed conks and swollen knots or were resinous. This was particulary evident in the true fir component of the Pacific Douglas-fir SAF type. While hardwoods were a minor component of this type, many live hardwood trees exhibited broken or dead tops. Both hardwoods and conifers exhibited natural and excavated cavities.

As with snag and log density, decadence should not be used as a determinant of old-growth. When stands enter the old-growth seral stage, particularly on high sites decadence is not evident. During the early phase of old-growth, overstory trees may show rounding of their crowns as their only sign of decadence.

Table 1--List of species identified in the Pacific Douglas-fir vegetation type, with summary statistics for species with constancy $\geq$ 10 percent.

	CONSTANCY	FREQ	MIN	MAX	RANGE	MEAN	S.D.	S.E.	CI- 5%
						(CHARACTERISTIC COVER)			
ELEVATION	100%	227	610	5600	4990	3879.6	826.5	54.9	107.5
SLOPE	100%	227	0	95	95	44.4	19.9	1.3	2.6
TOTAL VEGETATION COVER	100%	227	60	100	40	92.8	7.4	.5	1.0
STAND AGE	100%	227	13	570	557	235.3	120.0	8.0	15.7
TOTAL BASAL AREA	95%	216	13	747	734	300.0	106.5	7.2	14.2
TOTAL FORB COVER	100%	227	1	97	96	19.0	23.2	1.5	3.0
TOTAL GRASS COVER	100%	227	0	80	80	4.3	11.3	.8	1.5
TOTAL SHRUB COVER	100%	227	0	99	99	23.0	28.7	1.9	3.7
TOTAL TREE COVER	99%	226	0	99	99	77.3	17.8	1.2	2.3
OVERSTORY TREES									
Pseudotsuga menziesii	99%	225	1	99	98	49.4	21.5	1.4	2.8
Abies concolor	66%	151	1	75	74	20.4	12.1	1.0	1.9
Pinus lambertiana	36%	83	1	30	29	7.4	6.7	.7	1.5
Quercus chrysolepis	28%	64	1	75	74	21.2	21.5	2.7	5.4
Arbutus menziesii	25%	59	1	45	44	7.2	6.9	.9	1.8
Castanopsis chrysophlla	21%	49	1	50	49	8.8	9.4	1.3	2.7
Quercus kelloggii	15%	35	1	20	19	6.6	6.1	1.0	2.1
Lithocarpus densiflora	12%	29	1	45	44	5.5	8.2	1.5	3.1
Acer macrophyllum	12%	28	1	25	24	7.1	6.5	1.2	2.5
UNDERSTORY TREES									
Abies concolor	65%	149	1	25	24	2.6	3.6	.3	.6
Pseudotsuga menziesii	64%	147	1	15	14	1.8	2.0	.2	.3
Quercus chrysolepis	44%	101	1	25	24	3.5	4.1	.4	.8
Lithocarpus densiflorus	28%	64	1	60	59	7.6	12.4	1.6	3.1
Pinus lambertiana	23%	53	1	8	7	1.2	1.0	.1	.3
Castanopsis chrysophylla	22%	52	1	20	19	3.3	4.5	.6	1.2
Libocedrus decurrens	17%	39	1	2	1	1.1	.3	.0	.1
Arbutus menziesii	14%	33	1	2	1	1.1	.3	.1	.1
SHRUBS									
Rosa gymnocarpa	59%	136	1	8	7	1.4	1.0	.1	.2
Berberis nervosa	46%	105	1	60	59	5.1	8.0	.8	1.5
Symphoricarpos mollis	38%	87	1	10	9	1.4	1.3	.1	.3
Corylus cornuta californica	34%	79	1	20	19	3.2	3.9	.4	.8
Rubus ursinus	28%	64	1	35	34	1.7	4.3	.5	1.1
Quercus sadleriana	22%	50	1	70	69	18.1	22.0	3.1	6.3
Paxistima myrsinites	18%	42	1	40	39	3.0	6.5	1.0	2.0
Quercus vaccinifolia	18%	42	1	85	84	24.6	24.1	3.7	7.5
Holodiscus discolor	16%	37	1	7	6	2.0	1.6	.3	.5
Vaccinium parvifolium	15%	35	1	35	34	7.4	10.2	1.7	3.5
Amelanchier florida	14%	33	1	20	19	2.3	3.4	.6	1.2
Rhus diversiloba	14%	32	1	20	19	4.7	5.1	.9	1.9
Arctostaphylos nevadensis	11%	26	1	25	24	5.6	5.6	1.1	2.3
HERBS									
Chimaphila umbellata occidentale	50%	115	1	30	29	4.3	5.5	.5	1.0
Pyrola picta	46%	106	1	1	0	1.0	.0	.0	.0
Hieracium albiflorum	44%	102	1	7	6	1.2	.7	.1	.1

	CONSTANCY	FREQ	MIN	MAX	RANGE	MEAN	S.D.	S.E.	CI- 5%
Goodyera oblongifolia	40%	93	1	3	2	1.0	.2	.0	.0
Iris sp.	37%	86	1	3	2	1.1	.4	.0	.1
Whipplea modesta	36%	82	1	50	49	8.5	11.3	1.3	2.5
Polystichum munitum	34%	79	1	7	6	1.5	1.1	.1	.2
Disporum hookeri	33%	77	1	5	4	1.3	.7	.1	.2
Adenocaulon bicolor	29%	67	1	10	9	1.6	1.7	.2	.4
Chimaphila menziesii	25%	57	1	2	1	1.0	.1	.0	.0
Trientalis latifolia	25%	57	1	10	9	1.6	1.5	.2	.4
Achlys triphylla	24%	56	1	50	49	9.2	12.8	1.7	3.4
Pteridium aquilinum lanuginosa	21%	49	1	75	74	3.1	10.5	1.5	3.0
Linnaea borealis longiflora	20%	46	1	50	49	14.9	14.9	2.2	4.4
Galium triflorum	18%	43	1	10	9	1.5	1.6	.2	.5
Smilacina racemosa amplexicaulis	18%	42	1	2	1	1.0	.2	.0	.1
Campanula prenanthoides	17%	39	1	5	4	1.4	.9	.1	.3
Arnica discoidea	16%	38	1	3	2	1.3	.6	.1	.2
Xerophyllum tenax	16%	37	1	95	94	7.9	16.7	2.7	5.5
Osmorhiza chilensis	14%	33	1	10	9	2.0	2.1	.4	.8
Apocynum pumilum	14%	32	1	2	1	1.1	.3	.1	.1
Viola sempervirens	14%	32	1	15	14	2.3	3.4	.6	1.2
Pyrola secunda	13%	31	1	2	1	1.1	.2	.0	.1
Fragaria californica	12%	29	1	8	7	1.4	1.4	.3	.5
Stellaria jamesiana	12%	28	1	1	0	1.0	.0	.0	.0
Eburophyton austinae	12%	28	1	1	0	1.0	.0	.0	.0
Clintonia uniflora	11%	27	1	12	11	3.2	3.1	.6	1.2
Viola glabella	11%	27	1	2	1	1.2	.4	.1	.2
Corallorhiza sp.	11%	26	1	1	0	1.0	.0	.0	.0
Corallorhiza striata	11%	25	1	1	0	1.0	.0	.0	.0
Viola sheltonii	11%	25	1	2	1	1.2	.4	.1	.2
Cynoglossum grande	10%	24	1	5	4	1.6	1.2	.3	.5
Vancouveria planipetala	10%	24	1	25	24	3.9	5.4	1.1	2.3
Corallorhiza maculata	10%	23	1	1	0	1.0	.0	.0	.0
Trillium ovatum	10%	23	1	2	1	1.0	.2	.0	.1
GRASS									
Festuca occidentalis	20%	47	1	20	19	2.1	3.4	.5	1.0
Bromus marginatus	15%	36	1	10	9	1.4	1.5	.3	.5
Festuca subulata	15%	35	1	25	24	4.0	4.9	.8	1.7
Festuca californica	11%	26	1	80	79	15.2	24.5	4.8	9.9

Table 2. Standards for Pacific Douglas-fir old-growth stands by Dunning's site classes, base age 300 years.

Variables	Dunning site class groups 1a-1	2-3	4-5
Age (years) 1/	180	260	295
Conifer live trees (trees/acre) 2/			
≥ 40" dbh	13.5 ± 1.4	NA	NA
≥ 30" dbh	NA	19.2 ± 1.9	NA
≥ 25" dbh	NA	NA	26.3 ± 5.1
Snags (all species) 2/ Density 3/ (≥ 20" dbh & ≥ 15' tall)	4.4 ± 0.8 for all site classes		
Logs (all species) 2/ Density (logs/acre) 3/ (≥ 20" large dia. & ≥ 10' long)	23.2 ± 4.4 for all site classes		
Layers	Conifer overstory over a conifer mid-layer. Forb layer achieves prominance in ground cover during the old-growth seral stage.		

1/ Derived from robust locally weighted regression.

2/ Average values with 95% confidence interval.

3/ Snag and log densities are variable and should not be used as the sole determinant of old-growth.

Table 3. Region 5 site classes (height by age) from Dunning base age 300 years.

	Site Class					
Age	0	1	2	3	4	5
40	95	81	66	49	43	35
50	106	90	75	56	49	39
60	115	98	82	63	53	43
70	122	105	88	68	58	45
80	129	111	93	73	61	48
90	135	116	98	77	64	50
100	140	121	102	81	67	54
110	145	125	106	84	70	54
120	149	129	109	87	72	55
130	153	133	112	90	74	57
140	157	136	115	93	76	58
150	160	139	118	95	78	60
160	163	142	120	98	80	61
170	166	144	123	100	81	62
180	169	147	125	102	83	63
190	172	149	127	104	84	64
200	175	152	129	106	86	65
220	179	156	133	109	88	67
240	184	160	136	112	90	68
260	188	163	139	115	93	70
280	191	166	142	117	95	71
300	195	169	145	120	96	73
320	198	172	147	122	98	74
340	201	175	150	124	100	75
360	204	177	152	126	101	76
380	206	180	154	128	103	77
400	209	182	156	130	104	78

Note: Based on ponderosa pine, Jeffrey pine, sugar pine, Douglas-fir, red fir, and white fir. Age is in years. Total height is in feet of average dominant and predominant trees with tree age of at least 50 years. Adapted fron Dunning's site index curves for height at 300 years.

LITERATURE CITED

Albert, G. 1979. Map of average annual precipitation Six Rivers National Forest. Eureka, CA: Six Rivers National Forest, U.S. Department of Agriculture; 1 p.

Allen, B.H. 1987. Ecological type classification for California: the Forest Service approach. Gen Tech. Rep. PSW-98. Berkeley, CA: Pacific Southwest Forest and Range Experiment Station, Forest Service, U.S. Department of Agriculture; 8 p.

Bitterlich, W. 1948. Die wenkelzahl probe. Allg. Forst-u. Hulzw. Ztg. 59:4-5.

Bonham, C.D. 1988. Measurements for terrestrial vegetation. New York: John Wiley and Sons, Inc; 338p.

Cleveland, W.S. 1979. Robust locally weighted Regression and Smoothing scatterplots. Journal of the American Statistical Association 74(368): 829-836.

Dunning, D. 1942. A site classification for the mixed-conifer selection forests of the Sierra Nevaada. Res. Note 28. Berkeley, CA: Pacific Southwest Forest and Range Experiment Station, Forest Service, U.S. Department of Agriculture; ? p.

Franklin, Jerry F.; Dyrness, C.T. 1973. Natural Vegetation of Oregon and Washington. Gen. Tech. Rep. PNW-8. Portland, OR: Pacific Northwest Forest and Range Experiment Station, Forest Service, U.S. Department of Agriculture; 417 p.

Franklin, Jerry F.; Cromack, Kermit, Jr.; Denison, William; and others. 1981. Ecological characteristics of old-growth Douglas-fir forests. Gen. Tech. Rep. PNW-118. Portland, OR: Pacific Northwest Forest and Range Experiment Station, Forest Service, U.S. Department of Agriculture; 48 p.

Franklin, Jerry F.; Spies, Thomas A. 1989. Generic definition of old-growth forests. In house document. Washington D.C.

Holland, R.F. 1986. Preliminary descriptions of the terrestrial natural communities of California. Department of Fish and Game; State of California: Sacramento, CA. 156 p.

Irwin, W.P 1966. Geology of the Klamath Mountains Province, pp. 19-38. In: Geology of Northern California. E.H. Bailey (ed.). U.S. Geologic Survey. San Francisco, CA.

Jennrich, R.; Sampson, P. 1985. Stepwise Discriminant Analysis. Pp. 519-537. In: BMDP statisitical software manual. W. J. Dixon (Editor). Los Angeles, CA. University of California Press.

Jimerson, Thomas M. 1989. Snag densities in old-growth stands on the Gasquet Ranger District, Six Rivers National Forest, California. Res. Pap. PSW-196. Berkeley, CA: Pacific Southwest Forest and Range Experiment Station, Forest Service, U.S. Department of Agriculture; 12 p.

Jimerson, Thomas M.;Fites, J. 1989. Preliminary old growth definitions for Northwest California. In review. 118 p.

Legendre, L.; Legendre, P. 1983. Numerical ecology. New York, NY: Elsevier Scientific Publishing Company. 450 p.

Norusis, M.J. 1988. SPSS/PC+ V2.0 for the IBM PC/XT/AT and PS/2. Chicago, IL: SPSS Inc. 606 p.

Old-Growth Definition Task Group. 1986. Interim defintions for old-growth Douglas-fir and mixed-conifer forests in the Pacific Northwest and California. Gen. Tech. Rep. PNW-447. Portland, OR: Pacific Northwest Forest and Range Experiment Station, Forest Service, U.S. Department of Agriculture; 7 p.

Parsons, A.M.; Knox, E.G. 1984. Soils of the Six Rivers National Forest. Eureka, CA. Under the direction of S.R. Miles. Copy on file at Six Rivers National Forest. 302 p.

Pfister, R.D.; Arno, S.F. 1980. Classifying forest habitat types based on potential climax vegetation. For. Sci. 26 (1) 52-70.

Regional Ecology Group. 1981. CALVEG: A classification of California vegetation. Forest Service; U.S. Department of Agriculture. San Francisco, CA. 168 p.

Reineke, L.H. 1933. Perfecting a stand densityindex for even aged forests. Journal of Agricultural Research 46:627-638.

Robertson, F.D. 1989. Position statement on National Forest old-growth values. In house document. Washington D.C. 4 p.

Software Publishing Corporation. 1987. Harvard Graphics. Mountain View, CA. 478 p.

Spies, Thomas A.; Franklin, Jerry F. 1988. Old-growth and forest dynamics in the Douglas-fir region of western Oregon and Washington. Natural Areas Journal 8(3): 190-201.

Society of American Foresters. 1964. Forest Cover Types of North America. Wash. D.C. 144 p.

Stayer, D., J.S. Glitzenstein, C.G. Jones, J. Kolasa, G.E. Likens, M.J. McDonnell, G.G. Parker, and S.T.A. Pickett. 1986. Long-term ecological studies: an illustrated account of their design, operation, and importance to ecology. Institute of Ecosystem Studies. The New York Botanical Garden. Millbrook, NY. 38 p.

U.S. Department of Agriculture, Forest Service. 1986. R-5 FSH 2409.21b, Timber management plan inventory handbook. U.S. Department of Agriculture, Forest Service, Region 5, San Francisco, CA. 525 p.

Weatherhead, D.J., R.C. Chapman, and J.H. Bassman. 1985. Properties of the quadratic mean diameter in balanced diameter distributions. Can. J. For. Res. Vol.15: 474-476.

Wenger, K.F. 1984. Forestry handbook: second edition. edited for the Society of American Foresters. New York: John Wiley and Sons. 1025 p.

Appendix A. Key to the Society of American Foresters SAF vegetation types.

1a. Douglas-fir dominant in the overstory or cover > 50% of the canopy cover.. 2

  2a. White fir present and/or hardwoods (tree form) absent (tanoak, madrone, canyon live oak) or less than 10% cover........................... Pacific Douglas-fir

  2b. White fir absent and evergreen hardwoods (tanoak, madrone, canyon live oak) present and greater than 10% cover................. Douglas-fir/Tanoak/Madrone

1b. Douglas-fir absent in overstory or < 50% cover............ 3

    3a. Jeffrey pine dominant in overstory............. Jeffrey Pine

    3b. True fir (white or red fir) dominant in overstory 4

      4a. Red fir canopy cover > 50% or red fir basal area > 50%.................. Red fir

      4b. White fir canopy cover > 50% or white fir basal area > 50%................. White fir

Appendix B. Vegetation type/seral stage attribute data card.

PLOT ______________ **DATE** ______________ **NAME** ____________________________

MAJOR VEGETATION TYPE (CIRCLE ONE)

Douglas-Fir/Tanoak/Madrone Pacific Douglas-fir White Fir Red Fir
Jeffrey Pine Port-Orford cedar Lodgepole Pine Ponderosa Pine
Douglas-fir/Pine Other______________

LAYERS (CIRCLE ALL PRESENT) — **CIRCLE IF PRESENT**

L1 L2 L3 L4 L5 SUPPRESSED REGENERATION

AGE (BY LAYER)

L1_____ L2_____ L3_____ L4_____ L5_____ SUPPRESSED_____ REGENERATION_____

DBH CLASSES (CIRCLE ALL PRESENT)

2 8 14 21 27 35 40+

SHRUB LAYER (CIRCLE ONE)

NONE	DEPAUPERATE	MODERATE	WELL DEVELOPED	DENSE
(1% <)	(2-10%)	(10-35%)	(35-60%)	(60% >)

SNAGS (CIRCLE ALL PRESENT)

SMALL (< 20" DBH AND OR < 20' TALL) MEDIUM (> 20" DBH AND 20-50' TALL)

LARGE (> 20" DBH AND > 50' TALL) NONE

DECAY CLASSES (CIRCLE ALL PRESENT)

1 2 3 4 5

LOGS (CIRCLE ALL PRESENT)

SMALL (< 20" DIA LARGE END AND OR < 20' LONG)

MEDIUM (> 20" DIA LARGE END AND 20-50' LONG)

LARGE (> 20" DIA LARGE END AND > 50' LONG) NONE

DECAY CLASSES (CIRCLE ALL PRESENT)

1 2 3 4 5

PROJECTED SERAL STAGE (IF BETWEEN STAGES CIRCLE CLOSEST ONE AND PUT A LINE AT APPROXIMATE STAGE OF DEVELOPMENT)

SHRUB/FORB POLE MATURE OLD-GROWTH

COMMENTS: