Ecological Definition for
Old-growth Douglas-fir/Tanoak/Madrone
(Society of American Forester's type 234)

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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. Because of the distinctive structural and biological attributes of old-growth, 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 et al. 1981, Jimerson and Fites in review, Bingham and Sawyer 1991, Spies and Franklin 1991). A mature forest stand can be considered old-growth when the standing cubic volume culminates (the stand reaches maximum site carrying capacity). This is a gradual process that is affected by a number of biological and physical factors such as forest type, site quality and disturbance. With the culmination of standing cubic volume there are several other attributes indicative of old-growth structure. The numbers of trees in the larger diameter classes increase significantly and the stand quadratic mean diameter culminates. These large conifers in combination with smaller trees and shrubs form multiple canopy layers. 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. These are some of the attributes key to an ecological definition of old-growth (Franklin and Spies 1989).

Direction for resource management cannot be resolved without first defining the biological and structural features which distinguish old-growth stands from other seral stages. National direction to develop specific old-growth definitions for each forest type described by the Society of American Foresters (SAF 1964) 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 (SAF) type 234: Douglas-fir/tanoak/madrone. 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.

The 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 Douglas-fir/Tanoak/Madrone SAF type is found primarily in the northwestern portion of the state in the northern and central Coast Ranges and western Klamath Mountains. It occurs primarily inland from the coastal Redwood forests occupying the upland more xeric sites (Stuart 1987). This forest type extends up into Oregon and south into Monterey County where sites become drier and Douglas-fir is replaced by evergreen oaks, tanoak and madrone (Sawyer et al. 1977, Wainright and Barbour 1984). The elevational range of the The Douglas-fir/Tanoak/Madrone type extends from 500 to 3400 feet. It is comprised of conifer species Douglas-fir (Pseudotsuga menziesii [Mirb.] Franco) and sugar pine (Pinus lambertiana Dougl.) along with the hardwood species tanoak (Lithocarpus densiflora [H. & A.] Rehd.), madrone (Arbutus menziesii Pursh.), giant chinquapin (Castanopsis chrysophylla Dougl.), canyon live oak (Quercus chrysolepis Liebm.) and California bay (Umbellularia californica (H. & A.) Nutt.). Other plant species occurring in the Douglas-fir/Tanoak/Madrone SAF type are listed in Table 1. We have included a species list here to allow the reader to compare the Douglas-fir/Tanoak/Madrone SAF type with the closely related Pacific Douglas-fir SAF type 229 and to provide the site specific vegetation information from which these definitions were developed.

The Douglas-fir/Tanoak/Madrone SAF type is referred to by different names by different authors. For instance, Sawyer et al. (1977) refers to this forest type as Douglas-fir/hardwood to distinguish these forests from those in Oregon and Washington where Douglas-fir occurs in combination with other conifer associates instead of hardwoods. Franklin and Dyrness (1973) refer to these forests as Douglas-fir on mixed evergreen 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, have shifted the overall forest landscape to include a higher porportion of younger seral stages and less old-growth.

METHODS

SOURCE OF DATA

Data for this definition came from the Region 5 Ecology Program (732 plots from a range of seral stages) and the Old-growth Douglas-fir Research Program conducted by the Pacific Southwest Forest and Range Experiment Station (149 plots from late seral stages >200 years). Data were 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), Siskiyou National Forest (Illinois Valley District), and the Northern California Coast Range Preserve, owned by the Nature Conservancy and the Bureau of Land Management (BLM). A small number of study stands were located on privately owned lands.

The methods described below apply to the data collected through the Region 5 Ecology Program and were described previously by Jimerson & Fites (1989). Data collection and analysis methods used in the Old-growth Douglas-fir Research Program conducted by the Pacific Southwest Forest and Range Experiment Station are described in Bingham & Sawyer (1991).

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. Canopy layering was assessed 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 recordedfor 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 Douglas-fir/Tanoak/Madrone (SAF type 234) if the hardwood canopy cover (understory and/or overstory) of Tanoak equalled or exceeded ten percent.

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 4). This was done to examine structural differences due to site class observed in the field.

Seven hundred and thirty-two plots were used to analyze the characteristics of old-growth Douglas-fir/Tanoak/Madrone stands. The site class distribution of stands included 509 plots in site classes 1A-1, 168 plots in site classes 2-3 and 55 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 (Smalian's)=$0.002727(D^2 + D^2)L$, 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 Cororation 1987). All variables were plotted and the graphs examined for site classes 1A-5, groups. 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) 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 (Software Publishing Corporation 1987).

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

The relative association of a species within the Douglas-fir/Tanoak/Madrone SAF type is described using constancy. Constancy measures the frequency of occurrence of a species within the vegetation plots (Table 1). Constancy varies by species along environmental gradients.

Old-growth stands in SAF forest type 234 are dominated in the overstory by Douglas-fir (100% constancy) most frequenly in association with Tanoak (90% constancy) (Table 1). Several other species can be present in the overstory and understory. Overstory conifers can attain average heights of >130 feet and average diameters (DBH) of >30 inches. Understory hardwoods can attain average heights of >75 feet average diameters of >20 inches DBH. Individual conifers and hardwoods can have diameters >75 inches and >30 inches respectively.

Structure/stories

Old-growth stands in the Douglas-fir/Tanoak/Madrone SAF type are characterized by at least two stories (Table 2). Conifers dominate the overstory which is subtended by a mixture of conifers and hardwoods. Hardwoods are the dominant feature of the understory.

The structure of old-growth stands within SAF type 234 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 number of trees $\geq$ 40 inches continues to increase and reaches the greatest numbers at 360 years. The mean number of trees/acre for the $\geq$ 40 inch dbh class was found to be 11 (Table 2).

Moderate sites (site classes 2 and 3) reach the old-growth seral stage at 240 years. The number of trees/acre $\geq$ 30 inches is the dominant feature of this group. The mean number of trees/acre $\geq$ 30 in. for stands $\geq$ 240 years was 16.3 (Table 2).

Low sites (site classes 4 and 5) enter the old-growth seral stage at 300 years (Table 2). As with the higher site index groups, there is a shift in dominance of the number of trees/acre by diameter class with increasing age. At 300 years, the number of trees in the 27 in. dbh class sharply decreases and reaches a similar level to the number of trees ≥ 30 in. and trees in the 21 in. diameter class. The mean number of trees ≥ 30 in. is 11 trees/acre.

Large (greater than 30 inches DBH) Douglas-fir trees predominate old-growth stands. Generally, for all sites the majority (151.5 sq ft/acre; >50 %) of basal area (mean total stand basal area = 282 sq. ft. per acre) occurs in the larger (≥ 35 inches DBH) size classes of conifers (Table 2). In terms of density, approximately 25% of the conifer trees >2 inches DBH (mean total conifer density = 51 trees per acre) are ≥30 inches DBH, while the highest density of trees occurs in smaller (≤ 18 inches DBH) size classes of hardwoods.

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) occurs at culmination of mean annual increment. Here competition between trees for light, moisture, and nutrients produces 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) appears constant between site classes. Total density of snags greater than 20 inches DBH averages 2.4 snags per acre on all sites. Hardwoods typically contribute >15 % 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 found 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 densitites as a feature of old-growth but not a determining variable.

Down logs

Density, volume, and weight of logs appears constant between site classes. Log densities show a decrease with stand age from 1 to 100 years. In general, log density shows a lag behind snag density. There is a significant increase in the mean log density of logs ≥ 20 in. diameter and ≥ 10 ft. long between stands 180 to 250 years and stands greater than 250 years old, with the mean density increasing from 4.05 to 11.5 logs/acre (table 2).

As explained above for snags, log densities are also variable with as many as 30% of the stands considered old-growth not meeting 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 shows a similar pattern to that of log density, with an initial decrease until 100 years, followed by a series of small peaks. Thereafter there is a significant increase in the mean log volumes with stand age. The mean log volume increases from 889 $ft.^3$ in stands between 180 to 250 years to 1902 $ft.^3$ for stands greater than 250 years and a weight of 11.6 tons per acre (Table 2). Hardwoods contribute >20% of the total density of logs.

Understory characteristics

Vegetation cover by layer changes over time in relation to site class. On high and moderate sites hardwood cover is the dominant feature in young stands. Conifers dominate the site by the beginning of the mature seral stage. Hardwood cover increases with age, reaching a stable maximum at approximately 200 years stand age. The conifer cover decreases in the transition from mature to old growth stands, stabilizing at equal values to hardwood cover at 200 years. Shrub cover also dominates during the early stages of stand development. It however, loses dominance as both conifers and hardwoods close canopy above it. As the overstory canopy begins to open in the later part of the mature seral stage shrub cover increases.

On low sites shrub cover dominates the sites. Conifer cover peaks early with hardwood cover as a limited component.

Decadence

The presence of large logs and snags is a primary indicator of the decadence of old-growth stands, although a full range of sizes and decay classes of logs and snags, which contribute to ecosystem functioning, is characteristic. The distribution of dead wood along a gradient of decay from sound to rotten is typically normal (Harmon et al 1986). High accumulations in any particular stages of decay are often a result of input pulses related to past disturbances or events such as fire or insect infestations.

Decadence of old-growth stands is also characterized by the presence of diseased, broken-topped, or malformed live trees. Moderate to high percentages of live conifer canopy trees possess conks and swollen knots or are resinous, damaged crowns, cavities and scars related to fire (Table 3).

As with snag and log density, decadence should not be used alone 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 Douglas-fir-Tanoak-Madrone SAF type, with constancies of ≥ 10 percent.

	CONSTANCY
OVERSTORY TREES	
Psuedotsuga menziesii	100%
Lithocarpus densiflora	90%
Arbutus menziesii	51%
Castanopsis chrysophlla	31%
Quercus chrysolepis	28%
Pinus lambertiana	24%
Acer macrophyllum	14%
Chamaecyparis lawsoniana	13%
Cornus nuttallii	13%
UNDERSTORY TREES	
Lithocarpus densiflorus	95%
Pseudotsuga menziesii	70%
Quercus chrysolepis	39%
Castanopsis chrysophylla	22%
Pinus lambertiana	21%
Arbutus menziesii	18%
Umbellularia californica	17%
Chamaecyparis lawsoniana	12%
SHRUBS	
Gaultheria shallon	45%
Vaccinium ovatum	44%
Berberis nervosa	58%
Rubus ursinus	39%
Rhododendron macrophyllum	21%
Rosa gymnocarpa	54%
Rhus diversiloba	53%
Lonicera hispidula vacillan	43%
Ceanothus velutinus	18%
Vaccinium parvifolium	13%
Corylus cornuta californica	25%
Symphoricarpos mollis	13%
FORBS	
Polystichum munitum	67%
Pteridium aquilinum lanuginosa	51%
Goodyera oblongifolia	45%
Whipplea modesta	51%
Chimaphila umbellata occidentale	33%
Xerophyllum tenax	20%
Chimaphila menziesii	49%
Trientalis latifolia	38%
Achlys triphylla	31%
Viola sempervirens	20%
Disporum hookeri	37%
Iris sp.	18%
Pyrola picta	37%

Vancouveria planipetala	40%
Linnaea borealis longiflora	11%
Hieracium albiflorum	18%
Oxalis oregana	13%
Smilacina racemosa amplexic	18%
Trillium ovatum	13%
Adenocaulon bicolor	18%
Pyrola picta aphylla	11%
Corallorhiza maculata	13%
Whipplea modesta	28%
Madia madioides	11%
Polygala californica	18%
GRASS	
Festuca occidentalis	26%
	CONSTANCY

Table 2. Standards for Douglas-fir/tanoak/madrone 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	240	300
Conifer live trees (trees/acre) 2/			
$\geq$ 40" dbh	11 $\pm$ 1	–	NA
$\geq$ 30" dbh	–	16.3 $\pm$ 1.9	11 $\pm$ 2.7
Snags (all species) 2/ Density (snags/acre)/3 ($\geq$ 20" dbh & $\geq$ 15' tall)	2.4 $\pm$ 0.4 for all site classes		
Logs (all species) 2/ Density (logs/acre)/3 ($\geq$ 20" large dia. & $\geq$ 10' long)	11.5 $\pm$ 2.2 for all site classes		
Layers	Conifer layer with lower tier of hardwoods < 130 ft. tall. Conifers and hardwoods present in understory.		
Tree Cover	Dense cover exceeding 60% overstory and understory combined		Moderate cover exceeding 40% overstory and understory combined

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. Stand conditions and live-tree decadence in Douglas-fir/tanoak/madrone forests >200 years old. Mean values and 95% confidence limits are for canopy trees only. Trees present in the understory as canopy intermendiates or suppressed trees are not represented. Only characteristics that had their highest values in old-growth are reported. Characteristics that showed only minor differences between stands >200 years old and younger stands are indicated by "NA". Characteristics are not exclusive in that one tree may exhibit several conditions. For example, a single tree may contribute to the percentages for more than one disease and more than one type of cavity characteristic. Data are for all Dunning site classes (n=40).

	Conifers
Disease	
Conks on lower bole	17.6 ± 4.5 percent
Conks on mid and upper bole	7.8 ± 2.6 percent
Resinosous	9.7 ± 2.6 percent
Swollen knots	6.0 ± 1.9 percent
Crown Condition 3/	
Broken tops	5.0 ± 1.5 percent
Dead tops	4.2 ± 2.1 percent
Bole condition	
Leaning boles	30.8 ± 4.6 percent
Forked or multiple bole below breast height	7.3 ± 2.3 percent
Cavities 1/	
Root collar cavities	11.4 ± 3.2 percent
Lower bole cavities	11.4 ± 4.2 percent
Mid bole cavities	1.4 ± 0.9 percent
Excavated cavities in mid or or lower bole	5.2 ± 3.0 percent
Disturbance 2/	
Fire blackened bark	65.1 ± 7.5 percent
Fire scars	9.6 ± 3.4 percent
Fall scars	4.7 ± 2.2 percent

1/Root collar, lower bole, and mid bole cavities are natural openings that afford protection for wildlife from precipitation. Natural cavities can be caused by fire, tree fall or fragmentation, rot, or other natural phenomena and exhibit a wide range of sizes. Excavated cavities are often well formed and may be less than one inch in diameter.
2/Tree damage resulting from disturbances such as fire and tree fall include cavities and other deep scars. Fire blackened bark does not include damage below the bark surface.
3/The crown decadence features described in this table may not occur on high sites in the early phase of the old-growth seral stage.

Table 4. 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.

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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: