Ecological Characteristics of Old Growth Jeffrey Pine in California

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INTRODUCTION

The Chief, Forest Service has directed all Regions to prepare quidelines which define old growth for major forest types. These guidelines have been prepared in response to that direction. In Region 5 of the Forest Service an effort is also underway to classify forested areas into Ecological Types for purposes of management and research. Since many of the samples taken for this project were in late seral stands of Jeffrey pine (Pinus Jeffreyii), they were examined to determine which characteristics could be used to describe old growth stands in these forests. This paper describes the features of these forests useful in such a characterization, and it provides guidelines that can be used to define old growth stands that lie in the Jeffrey pine cover type (247) recognized by the Society of American Foresters (1980). Results are summarized in Table 1 on page 14.

DISTRIBUTION

In California, Jeffrey pine lies in 5 broad geographic regions. In the northern portion of the state, in the Klamath Mountains, the northern Coast Ranges, and west of the Modoc Plateau it is commonly found on xeric sites with ultramafic soils or at elevations generally above 5,000 feet. In the eastern portion of the Cascades, and on the Modoc Plateau it lies on xeric sites often in mixture with ponderosa pine (Pinus ponderosa) where stands are collectively referred to as eastside pine. Further south on the eastside of the Sierra Nevada it forms a distinct zone between the higher red fir forests and the pinyon-juniper,sage forests to the east. On the westside of the Sierra Nevada it is often found at higher elevations in open stands on glaciated sites which lie on south to southwest slopes or on ultramafic outcrops at lower elevations. In the Transverse and Penninsular Ranges of southern california stands are open and almost pure on south slopes and xeric uplands.

METHODS

Samples came from two sources. One hundred fifty nine samples were collected as part of the Ecological Type Classification being conducted by Region 5 of the Forest Service (Allen, 1987). They were intended to be used for classification purposes. The basic unit of sample was a stand, and no limits were placed on size of stand for sampling purposes. Stands were selected based on their appearance as relatively undisturbed habitats with homogeneous species composition in late seral condition. The concept used to select stands was to sample from a range of aspects, elevations, species composition, soil types, community structure, and site index. No attempt was made to include or exclude sample stands because of features suspected of describing old growth characteristics. For this reason, the samples selected are felt to represent conditions in the majority of Jeffrey pine stands in these forests. Variation in species composition, cover values, structural diversity, and habitat was sought rather than indications of the aging process. An additional 76 samples were obtained from forest inventory records for the National Forests in Southern California. Since these stands were generally lightly disturbed by logging, if at all, it was felt changes in species composition or stand structures would be minor. Visual examination of these stands verified this conclusion. The total data set from which the descriptions were developed was 235 samples.

Data collection followed the procedures described in the Region 5 Ecosystem Classification Handbook and the Region 5 Timber Management Plan Inventory Handbook. At each sample site a 1/10 acre circular plot was used to gather information on species composition, cover values, abundance and environmental setting. One tenth acre and 1/2 acre circular plots were used to obtain information on snags and logs. A 3 point "cluster" was used to establish variable radius plot centers as the basis for determining tree species composition, stand structure, basal area, and volume. Determination of site index came from a sample of height and age of dominant and codominant trees on each point in the cluster. Diameters were recorded in classes for purposes of data analysis. The diameter classes used were: 1-5.9", 6-10.9", 11-17.9", 18-24.9", 25-29.9", 30-39.9", and 40"+.

Throughout its range Jeffrey pine is associated with several other species. These species include ponderosa pine, sugar pine (Pinus lambertiana), white fir (Abies concolor), red fir (Abies magnifica and Abies magnifica var. shastensis), noble fir (Abies procera), incense cedar (Calocedrus decurrens), western white pine (Pinus monticola), lodgepole pine (Pinus contorta var. murrayana), and western juniper (Juniperus occidentalis). Quaking aspen (Populus tremuloides) is a commonly associated hardwood in the Sierra Nevada. To meet the criteria for the Jeffrey pine type, stands must contain a majority of the basal area stocking in Jeffrey pine. The stands sampled here contained more than 50% of the basal area in Jeffrey pine. The following National Forests and National Parks were represented in the sample: the Klamath, Shasta-Trinity, Modoc, Lassen, Plumas, Tahoe, Eldorado, Stanislaus, Sierra, Sequoia, Inyo, Lake Tahoe Basin Management Unit, Angeles, Cleveland, San Bernardino, Los Padres, and Toiyabe National Forests and Yosemite and Sequoia-Kings Canyon National Parks.

Stand ages were based on the age of the oldest tree measured on each site. samples used for classification purposes usually had three dominant or codominant trees measured per site. In many cases, because of species or size differences, additional trees were measured. Forest inventory plots generally had 5 trees measured per site. No attempt was made; however, to fully age each stand through a complete sample of all size classes. Furthermore, to attempt to report average stand ages from stands with skewed and irregular structures, as many of these are, could also be misleading. Therefore it was decided to use the age of the oldest tree. This is in agreement with investigators doing work in other types (Schumacher 1928, Veblen 1985).

Forty nine variables were examined. They centered around 4 areas of concern: the effects of species composition, changes in cover values, stand structure, and biomass accumulation over time. The analysis proceeded in two parts. First, information on stand structure, trees and snags per acre by diameter group, species composition and site index were determined for each sample using R5*FA.FIA-SUMMARY and R5*FS.FIA-MATRIX a series of Region 5 timber inventory and data expansion programs known as Forest Inventory and Analysis (FIA). Each plot was also processed through PROGNOSIS, a stand growth and yield simulation model developed by Stage and others (Stage 1973) to determine values for quadratic mean diameter, stand density index, and total cubic foot volume. Values from these programs were combined into a single data set for further analysis. Cover values for shrubs, forbs, and grasses were obtained from data sets developed for the classification projects where available. A subset of 105 samples where snag information was collected was used to develop the snag values reported. Insufficient data has been collected for an analysis of log and other downed woody material; so, no values are reported. Samples were then aggregated into two site index groups: Region 5 site index 0 to 3 representing high sites, and Region 5 site index 4 and 5 representing low sites.

Variables were tested for normality and transformed as necessary for statistical analysis. The analysis used regression techniques to explore diameter, height, and age relationships of individual trees by species and site group. This was followed by examining survivorship curves for individual species and stands. Scatter plots and linear regression were used to explore relationships among variables over time, and time series and regression was then used to look in detail at the data through time. The results of this analysis became the framework for which an Analysis of Variance to isolate variables correlated with differences in age was performed. Finally, the ability of those variables to differentiate between age groupings were tested using Discriminant Analysis techniques.

RESULTS

The data set for Jeffrey pine is not large for younger stands. Consequently, clear patterns of early stand development could not be fully examined. However, based on work in other types, it would appear that similar patterns of stand development through time are present. For example, red fir, an associate on many Jeffrey pine stands on the westside of the Sierra Nevada, develops features characteristic of older stands in approximately 150 years on sites 0 to 3 and 200 years on sites 4 to 5. The analysis performed for Jeffrey pine indicates similar patterns.

Height-diameter relationships indicate that Jeffrey pine usually reaches 30 inches in diameter and 100 feet in height in 150 years on sites 0 to 3, and 30 inches in diameter and 68 feet in height in 200 years on sites 4 to 5. The oldest Jeffrey pine trees sampled were 663 years on sites 0 to 3 and 587 years on sites 4 to 5. Suvivorship curves show substantial loss of trees beginning around 80 years and continuing until nearly 400 years. This would appear to indicate that losses later in the life of a stand are due to more than inter-tree competition. While early losses are probably due to natural thinning, environmental factors such as fire, drought, insects, disease, or wind eventually become major contributors to mortality. A final, prolonged period of mortality begins around 400 and continues until nearly 700 years. Losses during this time appear to reflect the effects of both environment and physiological failure.

Time series analysis showed consistent and large variation in biomass accumulation by site class in older stands. This was correlated with changes in the distribution of trees by size class, and reflected a steady mortality in large trees with concurrent recruitment of small trees through time. Examination of stand structures over time illustrated these patterns well. They showed that in most of the stands sampled many size classes are occupying sites simultaneously. Older stands are characterized by a high number of small trees, a substantial number of trees in the middle size class (25-30 inches DBH), and a significantly higher component of trees larger than 30 inches DBH.

On undisturbed sites with high site index the picture that emerges from the data is one of large numbers of small trees occupying stands at some point after a major stand replacing event. This is followed by significant losses due to thinning early in the life of the stand, a mature phase in which trees in the 24 to 30" DBH range are common, and it is followed still later by a stabilized condition characterized by a constantly changing structure in which many size classes are present on a site simultaneously. This last condition results as small gaps and openings are created in a mature overstory in response to environmental conditions such as fire, wind, or drought. Regeneration then establishes in these openings, grows, self thins, and matures. In time, several size classes, including a substantial portion of larger trees, are represented,and the stand exhibits an irregular structure. For example, on sites 4 to 5 in stands younger than 200 years, trees between 2 and 18 inches in diameter constiute 74% of the total number of trees. In stands older than 200 years they consitute 77% of the total. On sites 0 to 3 these conditions seem to occur around 150 years. It also occurs on many, but not all, low sites around 200 years. This corresponds with structures found to be representative of old growth conditions in red fir, lodgepole pine, and the California mixed subalpine type (256) in the Sierra Nevada (Potter, unpublished). It supports the hypothesis that as stands occupy sites for longer and longer periods environmental factors become more important in developing stand structures that characterize old growth conditions. These same factors continue to be important in maintaining old growth conditions until the site suffers a stand replacing event, and the cycle renews.

Often on many low sites the patterns appear to be different. Many of these stands are very open with low tree densities. Except for sites with a high shrub component, it is difficult to imagine enough fuel load to carry a stand replacing fire. Nor does experience indicate that other events such as insects or disease would replace entire stands. Avalanche would appear to be the one environmental factor capable of such an event, and while common in certain areas in the Sierra Nevada, they are not widespread in the range of Jeffrey pine. This implies that these stands do not cycle through a stand initiation phase in which high numbers of trees originate more or less simultaneously and progress through time as cohorts. Rather, stand development appears to be sporadic as opportunities arise in response to disturbance levels. Small patches or stands may react similar to better sites with simultaneous stand origin, followed by crown closure, self thinning, and stand opening as gaps are created. However, in most cases, it appears stand initiation is a prolonged process with many aborted attempts. Stand development occupies considerable periods of time, and during these long periods the probability is high that an environmental event will impact the stand and recycle portions back to an earlier period. Inevitably, some individuals escape environmental damage and mature into larger members of the stand. In time, the stand takes on a very open appearance with an irregular stand structure dominated by large trees which are the survivors of several stand altering events. Thus, these stands arrive at an overall structure similar to better sites but with lower densities, a greater proportion of large trees, and through a different process of development. Other than in early stages of stand initiation, mortality appears to be responding to environmental circumstance more than competition.

Variables that could be used to distinguish between age groups were examined by One-way Analysis of Variance and Discriminant Analysis techniques. Several variables were identified, and those that would be useful in field applications were incorporated into the descriptions In most cases snag numbers were highly variable with skewed distributions, and reliable comparisons with Analysis of Variance techniques could not be developed.

When comparing stands less than 150 years with those over 150 years on sites 0 to 3 and those less than 200 with those over 200 on sites 4 to 5 several variables were found to be significantly different at the 95% probability level. These results are summarized as follows:

Variables significantly higher by age group

Sites 0-3

<150 Years	>150 Years
Trees per acre 18-24" DBH	Stand Density Index
	Cubic Foot Volume
	Total Basal Area
	Height of Dominant Trees
	Trees per acre >30" DBH

Sites 4-5

<200 Years	>200 Years
Trees per acre 18-24" DBH	Total Basal Area
	Quadratic Mean Diameter
	Cubic Foot Volume
	Height of Dominant Trees
	Trees per acre >30" DBH

These variables were then examined by Stepwise Discriminant Anlaysis. On sites 0 to 3, a 95% correct classification function was attained using Stand Density Index and height of dominant trees. In essence, this means the presence of denser stands and the attainment of most of the height growth potential of the site by dominant trees could be used to discriminate older stands on sites 0 to 3.

On sites 4 to 5 an 82% correct classification function was attained using the number of trees between 18 and 24" and the number of trees between 30 and 40 inches. Theoretically, the higher numbers of trees per acre between 18 and 24 inches could be used to differentiate stands less than 200 years, while the number of trees per acre between 30 and 40 inches could be used to differentiate stands older than 200 years.

In actual practice, the use of several variables is preferred to a paired down list. The variability of many characteristics of these stands is often wide, and if more variables can be used in concert to distinguish between older and younger stands a better solution on the ground is likely. On the other hand, some of the variables identified in the analysis are impractical for field use. Stand Density Index, Quadratic Mean Diameter and Total Cubic Foot Volume are examples. For this reason, variables which were felt to be more easily observed on the ground are included.

DISCUSSION

Models of stand dynamics in old growth forests are not abundant. Foresters commonly use the culmination of mean annual increment to define the point at which stands are considered mature. In California, yield tables have not been developed for Jeffrey pine. The only commonly associated species for which such work has been done is red fir. In red fir forests, available yield tables (Schumacher, 1928) indicates the culmination of mean annual increment to be around 140 years. The age at which stands assume old growth characteristics is unclear using this guide.

The Society of American Foresters cover types provide a description of vegetation existing on sites at the moment. They convey little insight into the change of vegetation over time. Conceptual models such as successional change, climax conditions, or potential natural vegetation that may be useful in gaining insights into old growth conditions are not a part of such descriptions. They do not, for example, explore the variation in species composition, stand structure, or ecosystem functioning that links particular plant communities to specific habitats over time. They do, however, provide a practical tool that can be used in large scale inventory and for cross regional comparisons.

Vegetation in the forests occupied by Jeffrey pine has been stabilizing over long periods of time. In the Sierras, for example, the last major glacial advance appears to have ended around 10,000 years ago, and the vegetaion on vacated sites has been sorting itself out ever since. In other areas, volcanism or climatic shifts have been creating similar conditions. Time in these forests is a continum of which human perception catches only a glimpse. Relatively few stands of Jeffrey pine originate within a specific period, develop as cohorts, and die simultaneously. Stand destroying fires do occur in Jeffrey pine. Except under eastside conditions, however, this does not appear to be a widespread or large scale phemomenon. Neither do blowdown, insects, disease, lightning, or avalanche appear to be the type of impacts which replace entire stands of Jeffrey pine. Records (Potter, unpublished) indicate that all of these factors are operating in these forests continuously, but generally on a small scale. This results in a constantly changing species composition and structure within a stand as individuals and small groups of trees and other vegetation are cycled into and out of the stand in different amounts at different times. This makes it difficult to define the age of a stand other than in a general sense, but it does focus attention on charactersitics other than age which are suggestive of the passing of time within a particular stand.

A model felt to be applicable to better sites and some low sites, and one which seems to fit observations in the field, is that outlined by Peet and Christiansen (1987) and developed initially by Oliver (1981). Under this model four phases of stand development are recognized: establishment, thinning, transition, and the steady state. Competition induced mortality is a key feature of stands in the thinning phase, which can last for relatively long time periods depending on species; however, the transition and steady state phases are of most interest here. During the transition phase mortality becomes independent of stand density, gaps in the canopy occur, and these are filled with young age classes. This phase may last for several decades. The steady state forest is then typified by an uneven age or irregular structure composed of relatively small even age patches. This pattern cycles over time as younger patches become established, thin themselves, and form gaps. All three of the earlier phases are present simultaneously. This stage can be terminated by a stand replacing disturbance such as fire. As noted earlier, this model does not fit all cases on lower sites. The model described in the Results section seems to provide better agreement with field observations in these cases; nevertheless, the steady state forest does seem to develop essentially the same general structure over time. It appears this form can be used to define old growth forests of Jeffrey pine, and that is the approach used here.

The distinction between transition and steady state is not sharp. It may cover several decades. Therefore, attention was focused on identifying variables that could be used to approximate the age at which stands developed features typical of a transition phase. Once this age was identified it was assumed that older stands would be in a transition or steady state condition if they continued to exhibit characteristics such as an irregular or uneven age structure, presence of larger trees, and relatively high stand density for the site. No attempt was made to differentiate between the transition and steady state phases since forests in both phases have similar characteristics.

The point at which a period of increasing Quadratic Mean Diameter in younger developing stands is followed by a significant decrease was one feature that might suggest the beginning of the transition phase. A decrease in Quadratic Mean Diameter would imply the stand was breaking up. It would be expected to coincide with an increase in regeneration and smaller size classes (saplings and poles). This would indicate the formation of gaps in the canopy that could not be filled by crown closure and became available for regeneration. The presence of large numbers of these smaller trees reduces the quadratic mean diameter. Stand density index usually increases at this time as well. As noted earlier, the data set for Jeffrey pine forests contains few samples in early seral condition, and the point at which Quadratic Mean

Diameter increases substantially and is followed by a sharp decline was not obvious. What is clear from the data is that most of these stands have apparently already arrived at a condition that can be described as old growth. Considerable variation in productivity, Quadratic Mean Diameter, and density is occuring, and this variation is reflected in the structure of the stands. Many size classes are present including regeneration and small trees. This indicates the opening of the stand and establishment of younger age classes has occurred.

Development of larger size trees is a trait that progresses over time, and this can often be used to indicate advancing stand age. Generally, at the point of transition the number of larger trees increases to levels that are typical from that point on. This is usually further substantiated when the number of trees in the smaller size class decreases significantly at the same time. This decrease results from both growth of smaller size classes into larger classes as well as a response to competition-induced mortality which tends to thin suppressed individuals of smaller size classes. As noted above, the data set for Jeffrey pine does not provide a clear picture of early stand development, and most of the stands in the sample are felt to already be in an old growth condition. What can be observed is that trees larger than 30 inches are present in somewhat larger numbers. They vary over time in response to environmental conditions, but they have essentially become permanent features of the stand.

Generally, mortality becomes independent of density as stands age. This does seem to be the case for these forests. Survivorship curves on both high and low sites show a steady decline in individuals punctuated by periods of increased mortality. Losses in young stands are obviously density related and represent competition induced mortality. Higher mortality rates in older stands are also apparent. These are less obviously related to stand density, and presumably they reflect higher losses due to environmental conditions. Time series show low correlation between numbers of large snags and stand density index. These conditions would seem to indicate that at least some mortality is occuring which is independent of density.

Under the model presumed to describe these forests, an irregular or uneven age structure would be present in stands past the transition phase. This structural pattern has been noted elsewhere as characteristic of "old growth" (Assman, 1978; Baker, 1962; Veblen, 1985; Parker, 1985; Taylor, 1991). Profiles of diameter distributions indicate structures skewed to the right with high numbers of trees less than 11 inches during the thinning phase. Large size classes are few. Past the thinning phase, few of the samples fit an ideal "reverse J" pattern of an optimally distributed uneven age stand, but an irregular or somewhat bimodal structure in which regeneration is low, trees less than 12 inches are overrepresented, and those between 25 and 30 inches are also overrepresented is common. In most stands at least 3 size classes appear to be present. While there are many patches that exhibit the "normal" distribution of even age stands, they generally do not cover large, continuous areas. Trees from different size classes tend to be distributed randomly or in small patches within a stand. If the general structure was irregular or uneven age in appearance with dominants in at least 3 size classes then it was presumed this condition had been satisfied and the stands were in the transition or steady state phase. The stands in this data set do reflect such a structure.

Probably the single most obvious characteristic of older Jeffrey pine trees is the attainment of a "platy" and yellowed bark structure. Generally, trees younger than those proposed in these descriptions have darker, fissured bark, while older individuals have a plate like bark structure which is quite yellow or bright orange. Decadence as reflected in broken and missing tops, scars, the presence of bole, root, and foliage disease, group kills, and lack of crown vigor is an important, but not widespread, component of these older forests. Equally important is the presence of decay fungi, and other organisms involved in the decomposition of woody material. The occurance of broken and multiple tops or the frequency and severity of disease related mortality as stands age may have important ramifications in seed production and dissemination and eventual species compostion and site occupancy. These characteristics were not sampled in the initial phases of the classification project, however, and they must remain as general observations at this time.

The Jeffrey pine forest cannot be viewed apart from its general setting. The characteristics used to describe these forests are representative of only a portion of the forest. Specifically, only stands with greater than 10% crown cover are described. The Jeffrey pine forest is an ecosystem, however, wherein non-forested areas are equally a part of the landscape and fulfill important roles in the overall functioning of that ecosystem. To describe only older stands of trees neglects the "totality" of the Jeffrey pine forest. Thus, when using these guides it must be realized that only forested areas are described. The old growth Jeffrey pine forest is larger than a simple summary of older stands.

Linked to the general view of the Jeffrey pine forest outlined above is the consideration of stand size. The size of stands that function as ecological units is important in understanding Jeffrey pine ecosystems. Whatever our preconceptions are as to the "optimal" size they must fit with the patterns these forests have evolved over a long period of time. Field observation indicates the Jeffrey pine forest is spatially complex with a range of stand sizes. It is not uncommon to observe undisturbed stands smaller than 5 acres, and stands smaller than 1 acre are not uncommon in these forests. Such stands appear to be complete components of the surrounding ecosystem with full complements of flora and fauna. On the other hand, stands covering large areas are not common. Seldom do stands exceed 100 acres. In most cases a change in relief, topography, aspect, soil, history, or some other environmental condition will cause a corresponding change in species and stand structure. The guides presented here are intended to be used in stands of all sizes.

Another important consideration in old growth Jeffrey pine forests is the amount of disturbance these stands have undergone. The stands sampled for this analysis were late seral with as little disturbance as possible. However, timber harvest has been increasing for the past 40 years, and several stands sampled had logging adjacent to them. Grazing also has been a factor of these forests since the middle to late 1800's. This activity peaked in the early part of the 1900's, but most stands continue to be grazed. Fire suppression activities started to become effective in the 1930's, and mining activity has been important in localized situations. More recently, air quality is being reduced over many areas by the current activities of man. Of course wind, fires, insects and disease, cutting by indigeneous pre-European populations, and browsing by herbivores has been present over long periods. The point is that old growth Jeffrey pine forests are not in an undisturbed condition, nor have they been necessarily free of broad ranging effects of man for many decades. For practical purposes, however, the stands described have been undisturbed except for natural phenomenon, fire suppression, and grazing. In most cases timber harvest has not been a part of the stand history.

These guides were developed from and intended for use in stands that became established and developed for long periods under naturally occuring processes (except for grazing). These processes include: natural fires, insect and disease activity, browsing by indigeneous herbivores, wind, avalanches, climatic cycles, lightning, competition, and species selection processes. Establishment has been the result of natural distribution of seed from parents generally in close proximity to a stand. Stand density, diameter distribution, spacing, growth patterns, and vertical arrangement are generally the result of these naturally occuring processes.

CONCLUSION

From the analysis it appears Jeffrey pine stands begin to assume old growth characteristics around 150 to 200 years. Since old growth forests are too complex for simple descriptions to be useful, multiple characteristics are used in the descriptions. Variables which were felt to be readily observed on the ground but could not be statistically compared are also included. Numbers of snags and stand structure are examples. Most have been used by others in describing old growth forests. However, judgement will be necessary when using the guides since overlaps occur, and not all characteristics will be present in any one stand or area at any one time. The general setting and characteristics of surrounding stands must be considered as well as the stand under examination. The variables that are used to describe old growth characteristics in this type are: species composition, age, height of dominant trees in the stand, stand structure, canopy layering, stems and basal area per acre of live trees in larger size classes, and stems and basal area per acre of dead trees in larger size classes.

DESCRIPTIONS

The following outlines the characteristics and significant observations of old growth forests in the Jeffrey pine cover type. They are arranged by site and summarized in Table 1 (page 14). To many, the variation in some of the basic attributes may seem unsettling. They would prefer simpler, more concrete definition. Such definition, however, often raise more questions than it answers. Variation is a fundamental feature of nature and certainly of old grwoth stands, and it must be recognized. Consequently, the mean, standard deviation, and range are shown where appropriate. In addition, where possible, probability statements are included which define minimums expected at a specified level of probability. It was felt this would be more useful to a variety of users in different settings and give a clearer picture of the characteristic over a range of samples. The mean $\pm$ one standard deviation will capture the expected values in most situations, and the range will alert one to extreme values that may be outliers. Probability values can be used to assess realistic minimum values. Interpretations can then legitimately be made by users. Regeneration layers are not used in stand structure descriptions. All values are given on a per acre basis.

Jeffrey Pine - SAF Cover Type (247)

Sites 0 to 3

1.Species composition: Conifer tree cover is moderate on these sites. The mean tree cover is 54%. The standard deviation is 18%. Values range from 3 to 85%. Jeffrey pine constitutes more than 50% of the basal area stocking.

2.Age: Stands on these sites assume old growth characteristics at approximately 150 years.

3.Tree height: Dominant Jeffrey pine on the site will have attained 100 feet.

4.Stand Structure: An irregular structure is most common on these sites. Different size classes are distributed in patches throughout the stand. At least 3 size classes must be present. Trees $\geq$30"DBH or $\geq$150 years old are present as indicated below.

5.Canopy Layering: canopy layers coincide with diameter distributions. In those stands which approach an even age structure, a single canopy layer predominates. In stands with several diameter classes, several canopy layers are present.

6.Live Trees:

Conifer trees $\geq$30"DBH

Number of trees - The average number of trees per acre in these size classes is 9.4. The standard deviation is 6.2. Values range from 0 to 25.2. At the 80% probability level more than 4.3 trees per acre $\geq$30" DBH will be present.

Basal Area - The average basal area per acre in these size classes is 75.4. The standard deviation is 61.9. Values range from 0 to 226.8. At the 80% probability level more than 23.4 square feet per acre will be present in trees $\geq$30" DBH.

7.Snags:

Conifer snags ≥30"DBH

Number of snags	The average number of snags per acre in these size classes is 0.4. The standard deviation is 0.9. Values range from 0 to 3.6.
Basal Area	The average basal area per acre in these size classes is 3.5. The standard deviation is 9.0. Values range from 0 to 40.0

Sites 4 to 5

1.Species composition: Conifer tree cover is moderate on these sites. The mean tree cover is 48%. The standard deviation is 17%. Values range from 4 to 72%. Jeffrey pine constitutes more than 50% of the basal area stocking.

2.Age: Stands on these sites assume old growth characteristics at approximately 200 years.

3.Tree height: Dominant trees on the site will have attained 68 feet.

4.Stand Structure: An irregular structure is most common on these sites. Different size classes are distributed in patches or singly throughout the stand. At least 3 size classes must be present. Trees ≥30"DBH or ≥200 years old are present as indicated below.

5.Canopy Layering: canopy layers coincide with diameter distributions. In those stands which approach an even age structure, a single canopy layer predominates. In stands with several diameter classes, several canopy layers are present.

6.Live Trees:

Conifer trees ≥30"DBH

Number of trees -	The average number of trees per acre in these size classes is 5.6. The standard deviation is 4.2. Values range from 0 to 17.6. At the 75% probability level more than 2.2 trees per acre ≥30" DBH will be present.
Basal Area -	The average basal area per acre in these size classes is 43.9. The standard deviation is 33.5. Values range from 0 to 160.0. At the 75% probability level more than 4.2 square feet per acre will be present in trees ≥30" DBH.

7.Snags:

Conifer snags >30"DBH

Number of snags	The average number of snags per acre in these size classes is 0.2. The standard deviation is 0.8. Values range from 0 to 4.0.
Basal Area	The average basal area per acre in these size classes is 1.9. The standard deviation is 6.8. Values range from 0 to 40.0.

TABLE 1

CHARACTERISTICS OF OLD GROWTH
JEFFREY PINE FORESTS

	R5 SITE CLASS 0-3	R5 SITE CLASS 4-5
1. SPECIES COMPOSITION	BASAL AREA STOCKING ≥50% JEFFREY PINE	BASAL AREA STOCKING ≥50% JEFFREY PINE
2. AGE	≥150 YEARS	≥200 YEARS
3. HEIGHT OF DOMINANTS	JEFFREY PINE DOMINANTS ≥100 FEET	JEFFREY PINE DOMINANTS ≥68 FEET
4. STAND STRUCTURE	IRREGULAR. AT LEAST 3 DIAMETER CLASSES PRESENT	IRREGULAR. AT LEAST 3 DIAMETER CLASSES PRESENT
5. CANOPY LAYERING	MULTILAYERED. LAYERS CORRESPOND TO DIAMETER DISTRIBUTION	MULTILAYERED. LAYERS CORRESPOND TO DIAMETER DISTRIBUTION
6. LIVE TREES >30" DBH		
NUMBER	9.4 ± 6.2 80% OF STANDS: ≥4.3	5.6 ± 4.2 75% OF STANDS: ≥2.2
BASAL AREA (SQ FT)	75.4 ± 61.9 80% OF STANDS: ≥23.4	43.9 ± 33.5 75% OF STANDS: ≥4.2
7. SNAGS >30" DBH		
NUMBER	0.4 ± 0.9	0.2 ± 0.8
BASAL AREA (SQ FT)	3.5 ± 9.0	1.9 ± 6.8

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