

Ecological Characteristics of  
Old Growth Red Fir  
in California

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## INTRODUCTION

The Chief, Forest Service, has directed all Regions to prepare guidelines 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 currently underway to classify these forests into Ecological Types for purposes of management and research. Since many of the samples taken for this project were in late seral stands, they were examined to determine which characteristics could be used to describe older California red fir (*Abies magnifica* and *Abies magnifica* var. *shastensis*) 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 red fir cover type (207) recognized by the Society of American Foresters (1980). Results are summarized in Table 1 on page 15.

## DISTRIBUTION

California red fir occurs from the vicinity of Crater Lake Oregon south through the Cascades and Sierra Nevada into northern Kern County at Sunday Peak. An arm of the range also extends south through the Coast Ranges to Snow Mountain in Lake County. It is limited to higher elevations. The lower elevational limits lie near 5,300 feet in the north and increase to the south. Lower limits reach 7,000 feet in the southern Sierra Nevada. The Red Fir Type covers these same geographic regions.

## METHODS

Samples came from data 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 the size of stand for sampling purposes. Stands were selected based on their appearance as relatively undisturbed habitats with a 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 stands because of features suspected of describing old growth characteristics. For this reason, the stands selected are felt to represent conditions on the majority of red fir stands in these forests. Variation in species composition, cover values, structural diversity, and habitat was sought rather than indications of the aging process.

Data collection followed the procedures described in the Region 5 Ecosystem Classification Handbook and the Region 5 Timber Management Plan Inventory Handbook. At each stand a 1/10 acre circular plot was used to sample 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 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"+.

To meet the criteria for the red fir cover type, stands must contain greater than 50% of the basal area stocking in red fir. Although many stands in the type are almost pure red fir several species are often found in mixture with red fir. Thus, white fir (Abies concolor), Jeffrey pine (Pinus jeffreyi), lodgepole pine (Pinus contorta var. murrayana), western white pine (Pinus monticola), mountain hemlock (Tsuga mertensiana), western juniper (Juniperus occidentalis), and quaking aspen (Populus tremuloides) are common associates of red fir. It is known from classification work in these forests (Potter, unpublished) that the presence of these species above a threshold level often indicates different environmental conditions. This classification was therefore used as the basis for selecting samples that were used to describe the type. For purposes of old growth description, samples were screened and separated in three steps. First, samples containing more than 50% of the basal area stocking in red fir were identified in the data set. Next, from this list those containing more than 25% lodgepole pine were removed and assigned to the Lodgepole Pine Type (218). Finally, samples containing more than 10% western white pine, whitebark pine, mountain hemlock, western juniper, and quaking aspen were removed and assigned to the California mixed subalpine type (256).

To date 740 stands have been sampled for classification purposes in the region from Lake Tahoe south to the Sequoia National Forest. Among them a subset of 340 stands met the minimum criteria for the red fir type and were selected as the data set from this source. The following National Forests and National Parks were represented in the sample: the Eldorado, Stanislaus, Sierra, Sequoia, Inyo, Lake Tahoe Basin Management Unit, and Toiyabe National Forests and Yosemite and Sequoia-Kings Canyon National Parks. In addition, a data set containing many younger stands was provided by Leroy Dolph of the PSW Research Station in Redding. Forty nine plots from the Klamath, Lassen, Six Rivers, Plumas, Shasta-Trinity, Tahoe, Eldorado, Stanislaus, Sierra, and Sequoia National Forests were contained in this set. The final data set contained 389 samples.

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 sampled. No attempt was made; however, to fully age each stand through a complete sample of all size classes. Cases supplied by Dolph did have a complete sample of ages. However, to attempt to develop a combined average from the ages supplied by each data set would be meaningless. Furthermore, to attempt to report on stand age from stands with skewed and irregular structures as many of these are, could also be misleading, and it was therefore decided to use the age of the oldest tree. This is in agreement with investigators doing work in Red Fir (Schumacher, 1928) as well as other types.

Forty nine variables were examined. They centered around 5 areas of concern: the effects of species composition, changes in cover values, stand structure, and biomass accumulation over time, and stand size. 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\*FS.FIA-SUMMARY and R5\*FS.FIA-MATRIX, a series of Region 5 timber inventory and data expansion programs. 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, mean annual increment, 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 project. A separate data set for logs had been developed for the classification effort, and it was used to derive values reported for logs. 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. To examine stand size, existing data bases on each of the National Forests in the study area were queried for number of stands that existed in certain size classes. The size classes examined were: 0-10 acres, 10-20 acres, 20-30 acres, 30-50 acres, 50-100 acres, and those exceeding 100 acres.

Variables were tested for normality and transformed as necessary for statistical analysis. The analysis then proceeded using 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 was also 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 broad differences in age was performed. The ability of those variables to differentiate between age groupings were tested using Discriminant Analysis techniques. Finally, Chi square was used to evaluate differences in stand size.

## RESULTS

The analysis indicated patterns that emerge through time in these forests. Height-Diameter relationships indicate red fir on sites 0 to 3 can reach 112 feet in height in 120 years and over 135 feet in 200 years. Diameters can exceed 30 inches in 120 years and 40 inches in 200 years on these same sites. On sites 4 to 5 trees can reach 89 feet in height and 31 inches in diameter in 200 years. The oldest tree sampled was 531 years on sites 0 to 3 and 586 years on sites 5 to 5. Survivorship curves showed high loss of trees in young stands between 50 and 110 years due to mortality related to natural thinning. Mortality rates moderate until about 160 years when they increase again until nearly 325 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 in stands are due to natural thinning, environmental factors such as fire, drought, insects, disease, or wind appear to become major contributors to

mortality in later years. A final, prolonged period follows in which reduced but steady mortality indicates loss to both environment and physiological failure.

Time series analysis showed considerable variation in biomass accumulation by site class in older stands. This was correlated with changes in the distribution of trees by size class, and reflect steady mortality of large trees with concurrent recruitment of small trees through time. An initial drop in small trees was indicative of the early mortality mentioned above. From that point forward in time, small trees cycle in and out of stands at a relatively constant rate. Large trees, on the other hand, start at low numbers and increase steadily to a point. They too then die and are replaced through time. Often during this stage, large tree numbers are high, when small tree numbers are low, and large tree numbers are low, when small tree numbers are high. This suggests that mortality in later periods is opening stands up and allowing establishment of regeneration and young trees. Examination of stand structures over time illustrated these patterns well. Young stands are characterized by little regeneration, a high number of small trees, and few large trees. At some point in time stands assume an irregular structure and many size classes are occupying sites simultaneously. Older stands are then characterized by higher levels of regeneration, substantially fewer small trees, significant numbers of trees in several size classes, and a significant component of large trees.

On high sites the picture that emerges from the data is one of high numbers of 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, 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 becomes established 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. On sites 0 to 3 this seems to occur around 150 years. It also occurs on many, but not all, low sites around 200 years. These patterns support 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.

On many low sites the patterns are different. First, 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 to carry a stand replacing fire. Nor is it reasonable to expect 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, they are not widespread. Second, in the Red Fir Type few stands on low sites were found that were less than 200 years old. This carries the implication that few stands less than 200 years old are present on low sites.

Apparently, 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 similarly 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 a structure similar to better sites but with lower densities 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. In most cases snag and log numbers were highly variable with skewed distributions, and reliable comparisons could not be made. Reliable transformations of the data could not be developed except for the larger snags and logs on sites 0 to 3. Several variables were identified in each association, and those that would be useful in field applications were incorporated into the descriptions.

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

Sites 0-3	Variables significantly higher by age group	
	<150 Years	>150 Years
Total trees per acre		Quadratic Mean Diameter
Trees per acre <30" DBH		Total cubic foot volume
Logs per acre <30"		Height of the tallest tree
		Trees per acre >30" DBH
		Snags per acre >30" DBH
		Logs per acre >30"
		Total basal area
		Trees per acre in regeneration
		Diversity index

# Sites 4-5

## <200 Years

## >200 Years

Total trees per acre  
Stand Density Index  
Trees per acre <18" DBH

Quadratic Mean Diameter  
Total cubic foot volume  
Height of the tallest tree  
Trees per acre >30" DBH  
Trees per acre in regeneration

These variables were then examined by Stepwise Discriminant Analysis. On sites 0 to 3, a 94.4% correct classification function was attained using number of trees in size classes smaller than 30 inches DBH, number of trees larger than 30 inches DBH, and snags larger than 30 inches in diameter. In essence, this means the presence of higher numbers of trees smaller than 30 inches can be used to discriminate younger stands, while number of trees larger than 30 inches and the higher number of logs larger than 30 inches diameter can be used to discriminate older stands on sites 0 to 3.

On sites 4 to 5 a 90.3% correct classification function was attained using the number of trees between 11 and 18 inches, the Quadratic Mean Diameter, and the number of trees larger than 30 inches DBH. It appears then, that the high number of trees per acre between 11 and 18 inches can be used to differentiate stands less than 200 years. The presence of larger diameters, generally expressed in trees larger than 30 inches diameter are the characteristics which best discriminate stands older than 200 years.

In actual practice, the use of several variables is preferred to a paired down list. The variability of many features 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. Quadratic Mean Diameter, Stand Density Index, and Trees per acre in regeneration are examples. For this reason, variables which are felt to be readily observed on the ground are included.

Chi Square analysis of the distribution by size class confirms what had been observed in the field: the red fir forest is a mosaic of different size stands intertwined with non-forested areas. Distributions toward smaller size stands were significant. Thus, the number of stands smaller than 20 acres is higher than might be expected, and the number of stands greater than 100 acres is smaller than might be expected. This would probably also be true in smaller sizes except that most forest data bases do not track stands smaller than 10 acres. Comparisons were made with roaded and unroaded areas and between forested and non-forested areas (shrub stands) with similar results. Thus, the red fir forest appears as a spatially complex ecosystem with a general pattern of relatively small to middle size stands.

## 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 red fir forests, available yield tables (Schumacher, 1928) indicates this point 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 these 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 cross regional comparisons.

Vegetation in the forests occupied by red fir 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 vegetation on vacated sites has been sorting itself out ever since. In other areas of red fir, volcanism or climatic shifts have been creating similar conditions. Time in these forests is a continuum of which human perception catches only a glimpse. Relatively few stands of red fir originate within a specific period, develop as cohorts, and die simultaneously. Stand replacing fires do occur in red fir, but this does not appear to be a widespread or large scale phenomenon. Neither are blowdown, insects, disease, lightning, or avalanche. Records (Potter, unpublished) indicate that all of these factors are operating in these forests continuously, but 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 characteristics other than age which are suggestive of the passing of time within a particular stand.

A model felt to be more applicable to red fir forests, 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; 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 is most likely 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; 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 red fir, and that is the approach used here.

The distinction between transition and steady state is not sharp, and as noted, 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 the transition or steady state condition if they continued to exhibit characteristics such as an irregular or uneven age structure or the presence of larger trees. 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 is thought to be a feature that would suggest the beginning of the transition phase. Such decreases were observed around 150 years on sites 0 to 3 and 200 years on sites 4 and 5, but the relationships were not strong. There was considerable variation in Quadratic Mean Diameter before and after these ages, and this tended to obscure the correlations. Typically, however, around these ages a decrease in Quadratic Mean Diameter was associated with an increase in regeneration and smaller size classes (saplings and poles). This indicated 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 reduced the Quadratic Mean Diameter. Stand density index usually increased as well, and this appeared to further indicate the opening of the stand and establishment of younger age classes with high densities. This pattern of changing size classes reflecting changes in Quadratic Mean Diameter became a more or less permanent characteristic in stands past these ages.

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 had increased to levels that were typical from that point on. This was further substantiated when the number of trees in the smaller size class had decreased significantly at the same time. This decrease seems to result both from growth of smaller size classes into the larger class as well as a response to competition-induced mortality which thus suppressed individuals of this size class. The analysis shows a substantial drop in small trees up to ages of 150 years on sites 0 to 3 and 200 years on sites 4 and 5. The feature that emerges at this time is an increase in the number of large trees.

Generally, mortality becomes independent of density as stands age. This does not seem to be the case for these forests. The time series for snags illustrated a high correlation between the number of smaller snags and the number of small trees up to 150 years on sites 0 to 3 and 200 years on sites 4

and 5. This is to be expected as the result of heavy thinnings during this period. However, stands past the thinning phase on sites 0 to 3 also show mortality to be somewhat correlated with density. From the beginning of the Transition phase and continuing, an increase in stand density is usually accompanied by higher numbers of small snags. This reflects continuing thinning in patches of younger trees. Large snags, however, show a somewhat different pattern. From the beginning of the Transition phase until approximately 300 years on sites 0 to 3, an increase in density is usually accompanied by an increase in large snags. After 300 years a decrease in density generally results in an increase in large snags. This appears to suggest that some competition induced mortality is still occurring in stands up to nearly 300 years, and it would account for a portion of the increased levels of mortality indicated by the survivorship curves during this period. Mortality on sites 4 and 5 does appear to be 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, 1970; Baker, 1962; Veblen, 1985; Parker, 1985; Taylor, 1991). Profiles of diameter distributions in these stands indicate structures skewed to the right. High numbers of trees less than 11 inches are present during the thinning phase. Regeneration at this time, however, is sparse, and large size classes are missing. Past the thinning phase, few of the samples fit an ideal "reverse J" pattern of an optimally distributed uneven age stand, but an irregular structure in which large size classes are overrepresented and regeneration is generally underrepresented is common. In over 90% of the stands at least 3 size classes appeared 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. An important structural feature of red fir forests is that different size classes are often aggregated into patches. That is, small patches of fairly uniform size trees are distributed in a mosaic throughout the stand. Trees from different size classes tend not to be distributed randomly or uniformly 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.

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 component of these forests. Equally important is the presence of decay fungi, and other organisms involved in the decomposition of woody material. The occurrence 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 composition 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 red fir 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

canopy were sampled and described. The red fir 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 red fir forest. Thus, when using these guides it must be realized that only forested areas are described. The old growth red fir forest is larger than a simple summary of old growth stands.

Linked to the general view of the red fir forest outlined above is the consideration of size. Size of stands that function as ecological units is important in understanding red fir ecosystems. Whatever our preconceptions are as to the "optimal" size they must fit with the patterns these forests have evolved over long periods of time. Obviously, these forests are spatially complex, with a range of stand sizes. It is not uncommon to observe undisturbed stands smaller than 5 acres in the field, 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. The guides presented here are intended to be used in stands of all sizes.

Another important consideration in old growth red fir 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. Only two showed signs of logging within 10 years; however, as noted earlier, timber harvest has been increasing for the past 40 years, and many 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 was 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 made that old growth red fir forests are not in an undisturbed condition, nor have they been particularly free of broad ranging effects of man for many decades. For practical purposes, however, the stands described have been undisturbed except for natural occurrences, fire suppression, and grazing. Timber harvest has not been a part of the stand history.

Thus, these guides were developed from and intended for use in stands that became established and developed for long periods under naturally occurring processes (except for grazing). These processes include: natural fires, insect and disease activity, browsing by indigeneous herbivores, wind, avalanches, wet and dry 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 occurring processes.

## CONCLUSION

From the analysis it appears red fir stands begin to assume old growth characteristics around 150 to 200 years. The descriptions that follow are based on these characteristics. Since old growth forests are too complex for simple descriptions to be useful, multiple characteristics are necessary to describe them. Variables which were felt to be readily observed on the ground but could not be statistically compared are also included in the descriptions. Numbers of snags, number of logs, and stand structure are examples. Most have been used by others in describing old growth forests. 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, stems and basal area per acre of dead trees in larger size classes, and number of logs in larger size classes.

## DESCRIPTIONS

The following outlines the characteristics and significant observations of old growth forests in the red fir cover type. They are summarized in Table 1 (page 15). To many, the variation in some of the basic attributes may seem unsettling. They would prefer simpler, more concrete definition. Such definition, however, often raises more questions than it answers. Variation is a fundamental feature of nature, 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 expected minimums 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. 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.

### Red Fir - SAF Cover Type (207)

#### Sites 0 to 3

1. Species composition: Conifer tree cover is high on these sites. The mean tree cover is 75%. The standard deviation is 14%. Values range from 21 to 97%. Red fir constitutes 90% of the stand. Other conifer species constitute 10%.

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

3. Tree height: Dominant red fir trees on the site will have attained 108 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 are 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 29.0. The standard deviation is 13.6. Values range from 2.9 to 65.4. At the 90% probability level more than 11.6 trees per acre  $\geq 30$ " DBH will be present.

Basal Area -

The average basal area per acre in these size classes is 255.1. The standard deviation is 127.2. Values range from 30.0 to 586.7. At the 90% probability level more than 92.3 square feet will be present in trees  $\geq 30$ " DBH.

7. Snags:

Conifer snags  $\geq 30$ " DBH

Number of snags The average number of snags per acre in these size classes is 3.0. The standard deviation is 3.7. Values range from 0 to 25.8

Basal Area

The average basal area per acre in these size classes is 25.9. The standard deviation is 28.3. Values range from 0 to 146.7

8. Logs:

Conifer logs  $\geq 30$ "

Number of logs

The average number of logs in these size classes is 5.4. The standard deviation is 5.3. Values range from 0 to 20.

## Sites 4 to 5

1.Species composition: Conifer tree cover is moderate on these sites. The mean tree cover is 51%. The standard deviation is 23%. Values range from 11 to 90%. Red fir constitutes 89% of the stand. Other conifer species constitute 11%.

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

3.Tree height: Dominant red fir trees on the site will have attained 84 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  $\geq 30$ "DBH or  $\geq 200$  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 $\geq 30$ "DBH

Number of trees - The average number of trees per acre in these size classes is 16.8. The standard deviation is 7.4. Values range from 6.9 to 33.4. At the 90% probability level more than 7.3 trees per acre  $\geq 30$ " DBH will be present.

#### Basal Area -

The average basal area per acre in these size classes is 137.6. The standard deviation is 63.6. Values range from 48.0 to 293.4. At the 90% probability level more than 56.2 square feet per acre will be present in trees  $\geq 30$ " DBH.

### 7.Snags:

#### Conifer snags $\geq 30$ "DBH

Number of snags The average number of snags per acre in these size classes is 1.1. The standard deviation is 1.8. Values range from 0 to 6.3.

#### Basal Area

The average basal area per acre in these size classes is 10.5. The standard deviation is 16.0. Values range from 0 to 53.4.

8.Logs:

Conifer logs  $\geq 30"$   
Number of logs

The average number of logs in these size classes is 2.7. The standard deviation is 2.1. Values range from 0 to 6.

TABLE 1  
CHARACTERISTICS OF OLD GROWTH  
RED FIR FORESTS

	<u>R5 SITE CLASS 0-3</u>	<u>R5 SITE CLASS 4-5</u>
1.SPECIES COMPOSITION	BASAL AREA STOCKING IS $>50\%$ RED FIR. PERCENT COVER IN RED FIR IS $90\% \pm 15\%$ .	BASAL AREA STOCKING IS $>50\%$ RED FIR. PERCENT COVER IN RED FIR IS $89\% \pm 17\%$ .
2.AGE	$\geq 150$ YEARS	$\geq 200$ YEARS
3.HEIGHT OF DOMINANTS	RED FIR DOMINANTS $\geq 108$ FEET	RED FIR DOMINANTS $\geq 84$ 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	$29.0 \pm 13.6$ 90% OF STANDS: $\geq 12$	$16.8 \pm 7.4$ 90% OF STANDS: $\geq 7$
BASAL AREA (SQ FT)	$255.1 \pm 127.2$ 90% OF STANDS: $\geq 92$	$137.6 \pm 63.6$ 90% OF STANDS: $\geq 56$
7.SNAGS $>30"$ DBH		
NUMBER	$3.0 \pm 3.7$	$1.1 \pm 1.8$
BASAL AREA (SQ FT)	$25.9 \pm 28.3$	$10.5 \pm 16.0$
8.LOGS $>30"$ LARGE END		
NUMBER	$5.4 \pm 5.3$	$2.7 \pm 2.1$



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