<u>Ecological Characteristics of Old Growth Lodgepole Pine in California</u>

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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 these forests into Ecological Types for purposes of management and research. Since many of the samples taken for classification were in late seral stands of lodgepole pine (Pinus contorta var. murrayana), they were examined to determine which characteristics could also be used to describe older lodgepole pine 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 lodgepole pine cover type (218) recognized by the Society of American Foresters (1980). Results are summarized in Table 1 on page 14.

DISTRIBUTION

Lodgepole pine covers a wide range in the west. It extends from the Yukon to Baja California and east to South Dakota (Griffin and Critchfield 1972). In California the Sierra Nevada-Cascade form is known as Pinus contorta var. murrayana, and it extends from the eastern Siskyou mountains in the north to the Modoc Plateau and south through the Sierra Nevada to the penninsular ranges of southern california. Elevations range from near sea level to almost 12,000 feet. Throughout most of the range in California it occupies middle to upper elevations. It commonly occurs in pure stands, but just as often it is mixed with other species.

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 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 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 lodgepole pine 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 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 at breast height 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"+.

To meet the criteria for the lodgepole pine cover type, stands must contain a plurality of the basal area stocking in lodgepole pine. That is, lodgepole pine must comprise the largest proportion in stands of mixed composition. In California, lodgepole pine is commonly associated with red fir (Abies magnifica and Abies magnifica var. shastensis), Jeffrey pine (Pinus Jeffreyii), white fir (Abies concolor), western white pine (Pinus monticola), mountain hemlock (Tsuga mertensiana), western juniper (Juniperus occidentalis), and quaking aspen (Populus tremuloides). These species are often in intimate mixtures. This is partucularly true in the Sierra Nevada Range where many stands in which lodgepole pine is a significant component actually contain more basal area in red fir. And yet, it is known from classification work in these forests (Potter, unpublished) that the presence of lodgeple pine above a threshold level often indicates different environmental conditions. Therefore, the rule used to select lodgepole pine samples from the larger data set was that lodgepole pine must represent more than 25% of the total basal area stocking, and it must represent a plurality of the basal area stocking of species other than red fir.

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 91 stands met the criteria for lodgepole pine and were selected as the data set to be used in the analysis. Approximately 30% of the stands contained 100% of the basal area stocking in lodgepole pine. In 52% of the stands lodgepole pine comprised more than 50% of the basal area stocking, and in 18% of the stands lodgepole comprised a plurality of the stocking in species other than red fir. 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. As noted, these samples were taken on undisturbed sites.

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. No attempt was made; however, to fully age each stand through a complete sample of all size classes. To attempt to report on stand age 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 as the measure of stand age. This is in agreement with investigators doing work in associated red fir (Schumacher 1928) as well as other types.

Forty nine variables were examined. They emphasized 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 part of 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, 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 data set for lodgepole pine is not large for younger stands. Consequently, clear patterns of stand development over long time periods could not be fully determined. However, based on work in red fir, which is a common associate in these forests, it would appear that similar patterns of stand development through time are present. Red fir 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 this type indicates similar patterns.

Height-diameter relationships indicate that lodgepole pine is smaller in diameter and shorter in height than red fir at comparable ages. While stands may appear younger due to smaller diameters, they are not necessarily different from associated red fir or white fir in age. The oldest lodgepole pine measured on sites 0 to 3 was 364 years while on sites 4 to 5 the oldest tree was 443 years. Survivorship curves shows steady but substantial mortality over a relatively long period in both site groups. Substantial losses commence around 80 years and continue at high rates until nearly 300 to 350 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 eventually become major contributors to mortality.

Time series analysis showed consistent 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 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 at some point in time stands assume an irregular structure and several size classes are occupying sites simultaneously. Young stands are characterized by little regeneration, a high number of small trees, and few large trees. Older stands are characterized by moderate regeneration, substantially fewer small trees, 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 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. This corresponds well with ages found to be representative of old growth conditions in red fir, a commonly associated species. 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.

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 Lodgepole Pine Type few stands on low sites were found that were less than 200 years old. This confirms what has been found in red fir and mixed subalpine stands associated with lodgepole pine. Few stands less than 200 years old are present on low sites. 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 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 in each of the associations 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 and log numbers were highly variable with skewed distributions. Reliable comparisons with Analysis of Variance techniques could not be developed except for snags larger than 40 inches and logs less than 18 inches on sites 0-3.

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 11-18"	Quadratic Mean Diameter
	Height of dominant trees
	Trees per acre >30" DBH
	Snags per acre >40" DBH
	Logs per acre <18"

Sites 4-5

<200 Years	>200 Years
Total trees per acre	None
Trees per acre <11" DBH	

These variables were then examined by Stepwise Discriminant Anlaysis. On sites 0 to 3, a 78.6% correct classification function was attained using number of trees in size classes between 11 and 18 inches, and height of dominant trees. In essence, this means the presence of higher numbers of trees between

12 and 18 inches can be used to discriminate younger stands, while the attainment of most of the height growth potential of the site by dominant trees can be used to discriminate older stands on sites 0 to 3.

On sites 4 to 5 a 77.1% correct classification function was attained using the number of trees <11 inches. It appears then, that higher number of trees per acre smaller than 11 inches can be used to differentiate stands less than 200 years old.

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 and total trees per acre are examples. For this reason, variables which were 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 lodgepole pine forest is a mosiac 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 lodgepole pine forest appears as a spatially complex ecosystem with a general pattern of relatively small to middle size stands.

DISCUSSION

Often lodgepole pine forests are viewed as being relatively even aged as a result of fire. They are perceived to exhibit a normal distribution of size classes or a two storied or bimodal distribution. Interior stands of lodgepole pine in the Rocky Mountains and Pacific Northwest, for example, do exhibit an even sized structure, apparently from fire, but this does not seem to be the case in many areas of California. Fire frequency and intensity appear to be low in these forests (Parsons,1980; J. van Wagtendonk personal communication; Potter unpublished), and thus the patterns of development are different. Individual stands may exhibit even aged characteristics, but often they do not. Even age or bimodal structures do appear commonly at the edge of meadows, and in moist areas. The most common distribution,however, is one approaching the reversed J-shape of an uneven aged stand.

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 lodgepole pine. The only 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 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 lodgepole 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 lodgepole pine originate within a specific period, develop as cohorts, and die simultaneously. Stand replacing fires do occur in lodgepole pine, but this does not appear to be a widespread or large scale phemomenon. Neither are blowdown, insects, disease, lightning, or avalanche. It appears that all of these factors are operating 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 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; 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 in many 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 lodgepole 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 characteristics 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, 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 at that point 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 lodgepole 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 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 develops 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 thins suppressed individuals of this size class. As noted above, the data set for lodgepole 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 25 inches are present in somewhat stable 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. The time series for snags illustrates a 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. Logs smaller than 18 inches are also significantly more abundant in stands less than 150 years on sites 0 to 3. This is to be expected as the result of heavy thinnings during this period. Time series for most of the stands in the data set show mortality of larger size classes to be somewhat uncorrelated with density. Survivorship curves on both high and low sites show a steady decline in individuals over time. This would also 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 older stands (Assman,1970; 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. Regeneration at this time is low, 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 most 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. 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.

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 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 lodgepole 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 lodgepole 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 lodgepole pine forest. Thus, when using these guides it must be realized that only forested areas are described. The old growth lodgepole pine forest, however, is larger than a simple summary of individual old growth stands.

Linked to the general view of the lodgepole pine forest outlined above is the consideration of size. Size of stands that function as ecological units is important in understanding lodgepole pine 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.

An important consideration in old growth lodgepole pine forests is the amount of disturbance these stands have undergone. The stands sampled for this analysis were in late seral condition with as little disturbance as possible. However, as noted earlier, 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 latter 1800's and 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 lodgepole pine 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 phenomenon, fire suppression, and grazing. 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 lodgepole 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, 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 lodgepole 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 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 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 ± 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.

Lodgepole Pine - SAF Cover Type (218)

Sites 0 to 3

1.Species composition: Conifer tree cover is moderate on these sites. The mean tree cover is 65%. The standard deviation is 16%. Values range from 25 to 95%. Lodgepole pine constitutes 67% of the stand. Red fir constitutes 26%. Other conifer species constitute 7%.

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

3.Tree height: Dominant lodgepole pine on the site will have attained 85 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 ≥25"DBH or ≥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$25"DBH

Number of trees - The average number of trees per acre in these size classes is 21.8. The standard deviation is 8.9. Values range from 8.0 to 41.8. At the 90% probability level more than 10.4 trees per acre $\geq$25" DBH will be present.

Basal Area - The average basal area per acre in these size classes is 143.2. The standard deviation is 65.3. Values range from 40.0 to 346.6. At the 90% probability level more than 59.6 square feet per acre will be present in trees $\geq$25" DBH.

7.Snags:

Conifer snags $\geq$25"DBH

Number of snags The average number of snags per acre in these size classes is 3.6. The standard deviation is 6.7. Values range from 0 to 36.0

Basal Area The average basal area per acre in these size classes is 24.9. The standard deviation is 44.4. Values range from 0 to 240.0

8.Logs:

Conifer logs $\geq$25" large end

Number of logs The average number of logs in these size classes is 2.8. The standard deviation is 3.4. Values range from 0 to 8.

Sites 4 to 5

1.Species composition: Conifer tree cover is moderate on these sites. The mean tree cover is 50%. The standard deviation is 18%. Values range from 15 to 80%. Lodgepole pine constitutes 73% of the stand. Other conifer species constitute 23%.

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 70 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 ≥25"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 ≥25"DBH

Number of trees - The average number of trees per acre in these size classes is 17.3. The standard deviation is 21.4. Values range from 3.3 to 133.3. At the 75% probability level more than 2.9 trees per acre ≥25" DBH will be present.

Basal Area - The average basal area per acre in these size classes is 83.9. The standard deviation is 47.4. Values range from 16.0 to 239.9. At the 80% probability level more than 42.7 square feet per acre will be present in trees ≥25" DBH.

7.Snags:

Conifer snags ≥25"DBH

Number of snags The average number of snags per acre in these size classes is 1.8. The standard deviation is 2.7. Values range from 0 to 10.0.

Basal Area The average basal area per acre in these size classes is 11.9. The standard deviation is 16.8. Values range from 0 to 66.6.

8.Logs:

Conifer logs ≥25"

Number of logs The average number of logs in these size classes is 1.4. The standard deviation is 1.5. Values range from 0 to 6.

TABLE 1

CHARACTERISTICS OF OLD GROWTH
LODGEPOLE PINE FORESTS

	R5 SITE CLASS 0-3	R5 SITE CLASS 4-5
1. SPECIES COMPOSITION	PERCENT COVER IN LODGEPOLE PINE 68% ± 26%	PERCENT COVER IN LODGEPOLE PINE 73% ± 27%
2. AGE	≥150 YEARS	≥200 YEARS
3. HEIGHT OF DOMINANTS	LODGEPOLE PINE DOMINANTS ≥85 FEET	LODGEPOLE PINE DOMINANTS ≥70 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 >25" DBH		
NUMBER	21.8 ± 8.9 90% OF STANDS: ≥10	17.3 ± 21.4 75% OF STANDS: ≥3
BASAL AREA (SQ FT)	143.2 ± 65.3 90% OF STANDS: ≥60	83.9 ± 47.4 90% OF STANDS: ≥23
7. SNAGS ≥25" DBH		
NUMBER	3.6 ± 6.7	1.8 ± 2.7
BASAL AREA (SQ FT)	24.9 ± 44.4	11.9 ± 16.8
8. LOGS >25" LARGE END		
NUMBER	2.8 ± 3.4	1.4 ± 1.5

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