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**Jackson Advisory Group Recommendations**

**to the**

**California State Board of Forestry and CAL FIRE**

**on**

# Late-Seral Development Prescription

# and Experimental Protocol

# for Camp Three Timber Harvest Plan

September 19, 2008

# Contents

## Executive Summary (New)

This Report from the Jackson Advisory Group to the Board of Forestry and the Director of CAL FIRE recommends an amended timber harvest prescription to be applied to the Camp Three timber sale at Jackson Demonstration State Forest (JDSF). This prescription results from a directive from the Director to develop an approach to timber management that accelerates the development of late-seral forest conditions in the context of recreation use, establishes an applied research protocol, identifies an approach to baseline inventory and monitoring, and suggests an approach to interpretation and public education.

In developing its recommendations, JAG was heavily constrained by time, the terms of the Settlement Agreement, and substantial diversity in stand structure and composition in the treatment area. In proposing its base treatment aimed at accelerating late-seral forest conditions, JAG chose to utilize the same prescription that it recommended for the Brandon Gulch THP (JAG Report to the Director, Aug. 8, 2008). This treatment harvests 30 percent of standing basal area, an amount JAG considers moderate. A second and contrasting treatment is proposed that involves removing 45 percent of the basal area. Both treatments are aimed at promoting the growth of the largest trees by harvesting trees primarily in the intermediate and co-dominant crown classes. A third area, set aside as part of the Settlement Agreement, has the potential to serve as a “control". The applied research protocol involves testing whether there is any difference in these two approaches to accelerating late-seral forest conditions. JAG recommends that these two treatments be reapplied in a continuing sequence of entries until such time as late-seral habitat is deemed attained. The timing of successive entries should be based on evaluations of stand development and growth.

JAG recommends that CAL FIRE initiate a call for research proposals, stimulated by a small funding allocation. This action should attract independent researchers to conduct studies aimed, especially, at understanding and enhancing the development of elements of late-seral forest conditions and the response of various stand components.

The Settlement Agreement's proposed new hiking trail should incorporate both recreational and education aspects. This trail would provide the public with an opportunity to gain knowledge regarding the application of modern silviculture and forest management to securing a balance between wood products, recreation use, and sustaining diverse ecological values. Further, its alignment and design can assist the Forest to learn about the public’s aesthetic experiences in managed forests. This new hiking trail, crossing both the Reserve and both treatment areas, should incorporate a self-guided approach consisting of marked stops with relevant supporting information.

## 1. Introduction

The Objective (Modified from Brandon Report)

The Jackson Advisory Group (JAG, Appendix 1) was requested by the Director of CAL FIRE to provide recommendations on a timber harvest prescription for Camp Three that meets the goals of the Settlement Agreement. This Agreement (Appendix 2) resolving various legal contentions among several parties including CAL FIRE directed that an outstanding Timber Harvest Plan (THP) for Camp Three "be amended, using more than one approach, such that the treatment objective shall be 'acceleration of the development of late seral forest conditions' (ALSF)." An important component of the Agreement was that "Any ALSF treatment area that includes removal of more than 30 percent of the volume of timber in the treatment area outside of protected stream zones shall be the minimum acreage necessary for scientific validity of the results of the research".

The Settlement specified that "The amended THP shall be treated as an applied research project in ALSF. A further important provision in the Settlement Agreement was that "Recreation use will be considered when devising the THP amendments".

Late-Seral Condition (Similar to Brandon Report)

A challenge in approaching this task is that there is no one definition of "late-seral condition". The JDSF Management Plan (p. 163) defines late-seral forest as "having biological characteristics and functions similar to old growth forests." It is part of the forest successional continuum that culminates in "old growth" or "climax forest", but is better described in terms of the elements of stand composition and crown structures of dominant trees found in mature redwood forests. "Late seral" is best considered a condition of a stand, and not an individual tree. This multi-parametric description leads to another challenge – what character(s) should be the focus of management action and monitoring?

While some effort has been put into managing previously harvested stands to accelerate late-seral condition, most of these have been in substantially younger stands, for single species purposes, or in other forest types. Little knowledge and experience exist about actively managing100-year-old stands to accelerate development of late-seral conditions. Camp Three is hundreds of years away from being an "old growth" stand, regardless of the treatments made now or in the future. The opportunity to actively manage a 100-year old stand for late-seral conditions is nearly unique. At the same time, the limitations of knowledge make designing a management plan a formidable challenge.

Approach

JAG chooses an approach that compares a base-level treatment -- the same as recommended for accelerating late-seral forest conditions at Brandon Gulch -- with a heavier treatment aimed at reaching the same forest conditions but at a faster rate. Along with the unharvested Reserve, these two stand treatment areas are designed to provide applied research opportunities that should provide new information on the relationships and balance among modern silviculture, forest management, recreation use, and other diverse forest values.

## 2. Goal (New)

The goal of this report is to document JAG's recommendations pursuant to the Settlement Agreement regarding prescriptions and an experimental protocol to support CAL FIRE's charge to:

- Amend the Camp Three Timber Harvest Plan by initiating applied research comparing more than one approach using an appropriate experimental protocol.
- The overall objective should be to accelerate the development of late-seral forest conditions.
- Incorporate practical baseline inventory and monitoring. This will include objectives, measurements to be made over time, and the calculation of baseline resource inventories in such areas a timber, botanicals, wildlife, hillslope conditions and stream characteristics.
- Removal of more than 30 percent of timber volume (basal area) to be the minimum acreage necessary for scientific validity of research results.
- Consider recreation uses and values, particularly in relation to the layout of a proposed hiking trail.

## 3. Late-Seral Forest Conditions (Similar to Brandon Report)

The term "late-seral" is a broad category of stand conditions typified by large trees, slowed tree growth (senescence), and occurrence of features such as snags, down logs, and mortality of overstory trees (decadence). In an ecological sense, "late-seral" is an inclusive but broader concept than "climax." As succession continues from mature forests into late-seral forests, canopy gaps created as dominant trees fall are filled in with shade-adapted understory trees and ground cover. With sufficient time, and without disturbance such as stand-replacing wildfire, shade-tolerant species will become a dominant stand component.

In redwood forests, stand-replacing events such as fire are rare. More commonly, fires in redwood forests are under-burns. Burned redwood trees commonly stay alive and replace their crowns with epicormic branches (small side branches formed following increased exposure to light or fire). Since redwood is shade-tolerant it often remains the characteristic, dominant species at climax conditions. With increasing age, redwood is more likely to topple than form standing snags. Redwood's proclivity to topple coupled with its decay-resistance suggests that down logs are often a better diagnostic character of late-seral conditions than are snags. In an ecological sense, "late-seral" is an inclusive but broader concept than "climax." For further discussion, see Dagley and O'Hara 2003 and Giusti 2007. Descriptions of historic old-growth redwood forests in the JDSF area are provided in Section 5, Background Information. Examples of some late-seral forest elements present on JDSF are shown in Figures 1a and 1b.

Managing stands to accelerate the development of late-seral conditions can be suitable for a variety of goals including increasing the proportion of old forests, wildlife habitat, ecological

diversity, aesthetic enjoyment, recreation, and park management. Development towards late-seral conditions does not necessarily preclude production of forest products. However, accelerating and retaining late-seral conditions may not be the primary goal of timber production for some industrial or small, non-industrial owners of redwood land.

This initiative on Camp Three, together with a companion demonstration at Brandon Gulch, to study factors that might accelerate the development of late-seral forest conditions is an initial attempt for stands of this type. We expect that more information on such approaches will be developed over time as similar efforts are undertaken and associated monitoring and experimentation yield results. Experience and information developed on Camp Three and Brandon Gulch should help this learning process.

## 4. Camp Three Description (Similar to Brandon Report)

The Camp Three THP is a 100-year-old, 373-acre, second-growth stand dominated by redwood trees, but having substantial variability in species mix and density across the stand. It is located within the North Fork of the South Fork of the Noyo River watershed (Figures 2 and 3 and Appendix 3).

An outcome of the Settlement Agreement that forms the basis for JAG's recommendations is that the Camp Three THP was divided into two portions: a no timber harvesting Reserve area of 158.5 acres and an area of 214.5 acres available for applied research.

The forest consists of young redwood/Douglas-fir forest that regenerated following early logging of the old-growth forest in the late 1800s and early 1900s. Productivity is Site Quality II and III with a high percentage of redwood trees. Most of the young redwood is arranged in clumps around the stumps of the former old-growth trees. Other tree species include grand fir, hemlock, tanoak, and Pacific madrone. Scattered remnant old-growth trees exist at a density of approximately one tree per 10 acres. The Noyo River outside the THP boundary is bounded by a narrow strip of alder.

The THP averages 147 trees per acre greater than 12 inches in diameter (dbh). The proportion of trees by number is redwood 73 percent, Douglas-fir 10 percent, grand fir and hemlock 3 percent, and hardwoods 14 percent. The distribution of trees by diameter class is shown in Figure 4 and Appendix 4.

The basal area of all trees greater than 12 inches in diameter averages 423 square feet per acre. Of this total, young redwood represents 80 percent, young Douglas-fir 13 percent, grand fir and hemlock 2 percent, and hardwoods 5 percent. Total conifer volume averages 86,000 board feet per acre (gross Scribner Scale, greater than 12 inches dbh). Of this total, young redwood represents 78 percent, young Douglas-fir 19 percent, and grand fir and hemlock 3 percent.

Since Camp Three is a young forest it contains few late-seral components such as basal cavities, epicormic branches, or broken tops. Some of the larger, remnant old-growth trees have large crowns with large-sized limbs. There are few snags (about one per acre greater than 20 inches in diameter). Down logs are infrequent, distributed in clumps, and consist of wind-

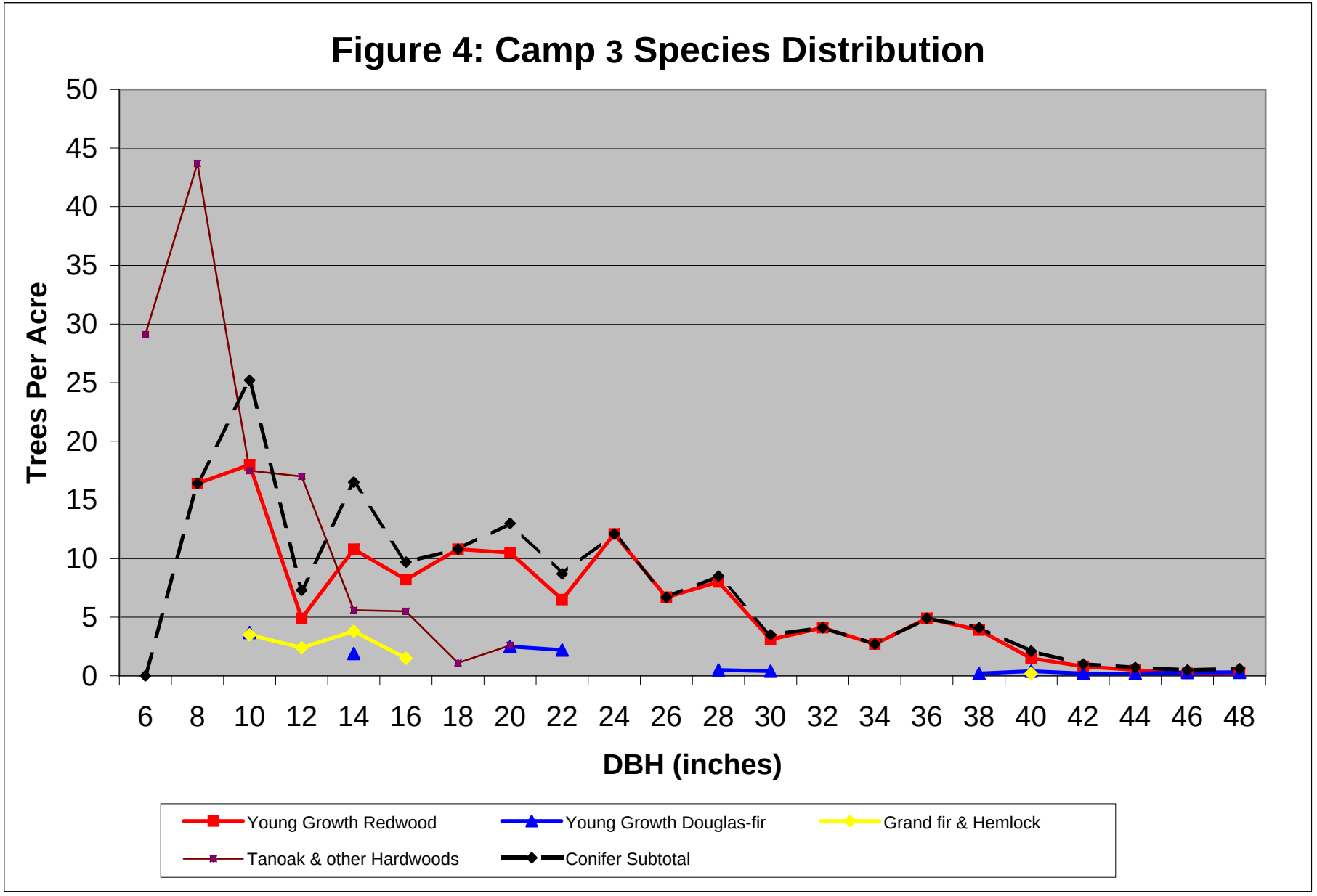


Figure 4: Camp 3 Species Distribution
Trees Per Acre
50
45
40
35
30
25
20
15
10
5
0
6
8
10
12
14
16
18
20
22
24
26
28
30
32
34
36
38
40
42
44
46
48
DBH (inches)
Young Growth Redwood
Young Growth Douglas-fir
Grand fir & Hemlock
Tanoak & other Hardwoods
Conifer Subtotal

thrown young Douglas-fir and remnant old-growth redwood remaining from the original logging of the old-growth. Some old-growth redwood stumps and trees contain basal cavities.

## 5. Background Information (Same as Brandon Report)

Purpose

This section is intended to provide a brief overview of some of the background information used by the JAG and its Late-Seral Forest Development Committee to inform their development of a prescription intended t hasten the development of late-seral forest characteristics on the Camp Three THP area. As previously stated the available information regarding the treatment of 100-year-old second-growth redwood and Douglas-fir stands for this goal was limited.

Issues Considered

Forest management most directly influences forests through the practice of silviculture, which can be defined as "the theory and practice of controlling forest establishment, composition, structure, and growth" (Smith et al. 1997, p.3). The application of silvicultural treatments affects the species composition of stands, the range and distribution of tree age and size classes present, presence or absence of snags and down wood, and to some extent tree form. Section 2, above, discusses the characteristics of these and related factors found in late-seral forests.

Since these are the key characteristics of late-seral forests that are most directly responsive to management actions, the research on and practice of acceleration of late-seral forest conditions has focused on these characteristics and how they might be influenced through management. This fact has driven the research that is briefly reviewed below and the approach to management of the Camp Three THP that is recommended here. JAG recognizes that there may be important trade-offs in choosing or weighting the characteristics of primary management emphasis. For example, focusing heavily on advancing tree size (height and diameter) could result in changed wood density that might affect decay rates.

Information Used and Its Utility

A survey of literature on late-seral conditions and old-growth stands in redwood forests showed that most information relates to highly productive forests in state parks and industrially-owned forests in the northern parts of the redwood range and alluvial flats (Dagley and O'Hara, 2003; Lindquist 2004; Giusti 2004, 2007). Of special interest is the 1929 report on "virgin forest" from the original Caspar Lumber Company, an ownership of what is now JDSF. It shows stands having an average of 51 trees per acre – 24 trees in the 10-30 inch diameter class and 27 trees greater than 30 inches in diameter (Mason and Stevens, 1929). This report provides some idea of size-class distribution on the original forests of JDSF. Data from Mason and Stevens' report can be used to show the cumulative tree density by diameter classes for stands having different volume. Figure 5 shows, for example, cumulative tree density by species in stands in excess of 80,000 board feet per acre. This Figure shows that 100 percent of all white fir trees were less than 42 inches in diameter, and that 50 percent of all redwood trees were less than 30 inches in diameter. Appendix 5 provides similar graphs for stands of Caspar Lumber Company having different levels of standing volume in terms of both tree density and

basal area. These graphs provide valuable insights regarding tree species and density in the historic old-growth, virgin redwood forests in what is now JDSF.

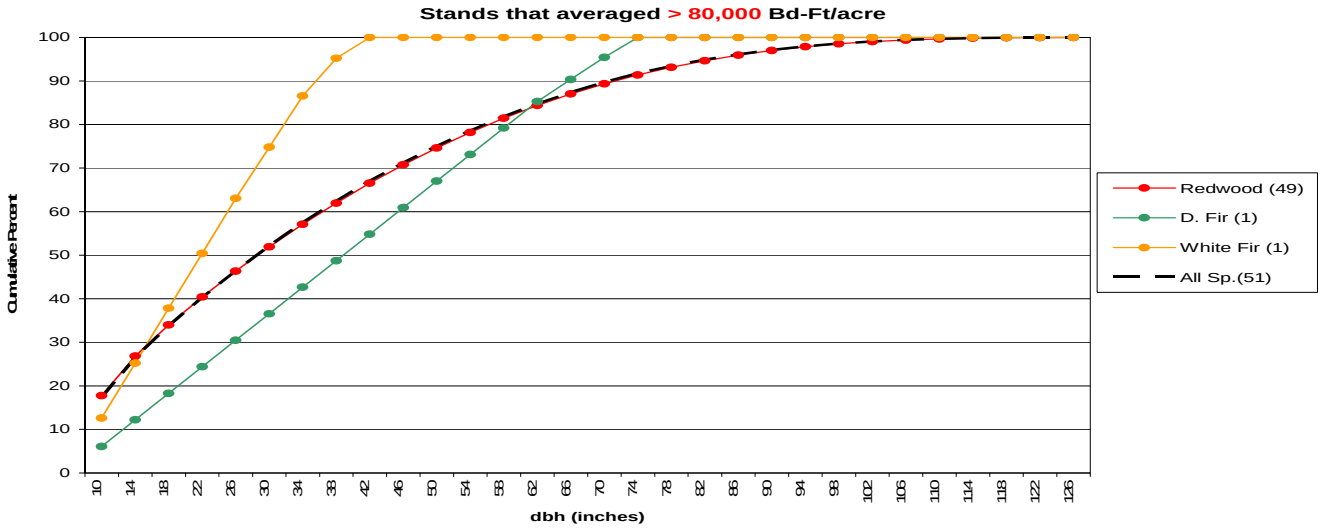



Figure 5: Cumulative tree density (trees per acre) by diameter class for old forest stands in the JDSF area (Caspar Lumbar Company ownership) by stand volume (source Mason and Stevens 1929).

Use of Models to Test Prescription Sensitivity

To provide guidance on the sensitivity of redwood stands to alternative prescriptions, five preliminary runs projecting growth and yield were made using the CRYPTOS growth model using a 60-year growth period. The model showed, in the long term, relatively little sensitivity to different prescriptions of light, medium, and heavy thinnings in terms of likely development of tree size, basal area, volume, and yields (see Appendix 6). However, JAG notes that the CRYPTOS model was designed for short-term projections rather than long-term simulations.

To provide further insight, the MASAM model that projects leaf area development was run using the same CRYPTOS prescriptions (see Appendix 7). Although this model was developed using data from redwood stands that are more productive than those at JDSF, it supports the view that the prescriptions being considered are likely to result in rapid crown closure. Moderate harvests of trees mainly in lower canopy classes should ensure that light levels will be sufficiently low to slow down the growth of sprouting redwood clumps. This is desirable to meet the goal of enhancing the development of old forest conditions. The importance of focusing prescriptions on canopy conditions is supported by Lindquist, 2004, who reported that "the growth of redwood regeneration is inversely proportional to overstory canopy".

Gaps in Knowledge

A few of the key gaps in our knowledge about how to accelerate the development of late-seral forest characteristics in second-growth forests are identified here. As previously stated, in general little information is available on the manipulation of young-growth stands for the purpose of accelerating late-seral forest characteristics and conditions. Information that would

be most useful for guiding prescription development for Camp Three would be long-term (e.g., covering a treatment-response span of multiple decades) and would be from forests of similar age, species composition, and site quality as found in the Camp Three area.

Although models can provide useful information on many aspects of stem distribution and stand development, these models typically have been developed to make projections related to productivity for commercial timber production. They tend to focus on commercial timber "rotation" lengths of less than 100 years. Thus, use of these models to project forest performance from mature to late-seral conditions extrapolates beyond the data used for model development. The limited information on many of the most important late-seral conditions and associated structural elements these models may generate should be accepted with caution.

While we have substantial knowledge of tree growth and mortality in response to a wide range of silvicultural treatments, there is little information on the processes and timing for the initiation and formation of a number of the structural features of late-seral forests, such as epicormic branches or large, moss-covered "platform" branches that can serve as nest sites for marbled murrelets. Time is strong a correlate of achieving late-successional characteristics and functions. However, JAG notes that time may not necessarily constrain management to these conditions. For example, one character of late seral forests is large trees. While growth implicitly takes time, it can be accelerated through stand density management. Likewise, deformity and decadence elements of late-seral forests require time for mechanical injuries to accrue and for the trees to respond by developing such features as reiterated branches. Canopy manipulations might be able to hasten their onset. Colonization of arboreal vegetative mats depends on the time needed to accumulate canopy soil. Similarly, time is needed for the establishment and development of epiphytes. Active management (e.g., transplanting) might shorten the time required for these features to develop. Each of these processes should be considered for basic and applied research.

## 6. Prescriptions (Same as Brandon Report -- except "Dense Wood" added)

### 1) Approach

Although we do not know how forests advance into old growth, we can observe characteristics of old forests. To the extent that we can encourage development of these characteristics without doing harm, we should be aiding late-seral development.

- Big trees. The most obvious characteristic of old-growth redwood forests is the population of very large diameter, very tall trees.

  The population of bigger trees in Camp Three can be enhanced by creating open space around the crowns of the existing larger trees. This should enhance their growth rate. Given the uncertainty about growth rates and long-term survivability, it seems prudent to aim for a moderate increase in growth and to retain some areas of greater competition.

- Dense wood. A less obvious condition of late-seral redwood forests is wood density that reflects the high level of competition under which old-growth trees commonly grew. The density of wood can affect its disease/decay resistance and drive the abundance and decay dynamics of snags and logs in forested stands.

Increasing growth rates of the larger diameter and taller trees may affect wood density. The application of JAG's recommended prescription recognizes this issue by providing varied levels of competition and tree growth throughout the THP. In addition, subdominant trees and regeneration will continue to grow slowly under low light conditions and should provide for dense heartwood when they assume dominant positions.

- Diversity and complexity. Late-seral, natural forests have a lot of variability, due to the wide variability in soils, degrees and directions of slopes, disturbance factors and the duration over which they accumulate, and effects of weather and terrain.

  Camp Three at 100-years of age already possesses substantial variability and complexity. The harvest in Camp Three should enhance the diversity and the complexity. One way the complexity can be increased is to vary the fraction of trees thinned within sprout clumps.

- Complex crown structures. Less obvious but equally important is the complex crown structure of old trees. The vicissitudes of long life lead to broken tops and growth of big, multi-divided branches. A whole ecosystem lives among these tops. Damage done in logging has been observed to cause trees to mimic some of the apparent growth-responses of old-growth trees to mechanical damage.

  In Camp Three, trees that have early signs of old-growth crown complexity should be retained. Additional top "damage" may be possible during the logging operations.

- Complete overstory canopy. In an old-growth forest, the high-level canopy is generally continuous, but with gaps formed by tree fall, land slides, etc. This canopy provides the shady environment that causes understory trees to grow sparsely and slowly and that supports the typical old-growth biology.

  The canopy in Camp Three, which is now generally closed, will be opened by clearing spaces around the trees selected for enhanced growth. The amount and size of the openings should be such that the openings will close sufficiently quickly to prevent substantial growth of a new generation of tree sprouts from this entry.

- Lots of large wood on the ground. Old-growth forests have a large accumulation of fallen trees of widely varying ages and degree of decay. Most are old-growth redwood trees and thus survive on the floor for a very long time. These trees in various stages of decay provide habitat for animals and microbes. They constitute an important part of the ecology of late-seral stands.

  In Camp Three, large down logs are scarce compared to that in old growth forests. Much of what exists is distributed unevenly, is from fir trees having less longevity than redwood, or from remnant material that resulted from prior harvesting. Non-dominant redwood trees that will eventually die and fall should be retained as potential recruitment for long-lasting large woody debris.

**2) Recommended Treatments** (New)

a) Rationale

The following guidelines were used in developing a rationale and approach to prescriptions:

- The treatment approaches must be relevant to forest owners, managers, researchers, and the public and have long-term value and interest such that the study will be continued by others in the future.

- Initial entries of the two or more approaches should create two markedly different initial stand structures aimed at accelerating late-seral conditions. These differences are needed to provide corresponding differences in ground and canopy flora, animal habitat, and other ecological attributes that can be quantitatively differentiated and described through monitoring.

- Within each of the two different prescriptions there will be substantial variation in stand characteristics across the landscape. This will occur because of substantial variability in initial stand characteristics and the use of random variations in thinning intensity designed to maintain and enhance stand diversity and complexity.

- The initiation and timing of successive entries should be based on an evaluation of stand response to the previous entry in terms of structural development and growth, not on an arbitrary time interval such as a given number of years.

- Hopefully, numerous research projects will be able to take advantage of the variable stand conditions and base monitoring information.

- Aesthetic considerations are important in carrying out stand treatments.

b) Approach

Five different approaches to accelerating late-seral forest conditions that provide divergent stand conditions were considered. These are outlined in Appendix 8. The final selection of treatments and areas allocated reflects JAG's best judgment of what is possible for providing applied research and demonstration opportunities given the constraining factors.

JAG recommends the harvestable area be divided into two treatment areas (see Figure 6):

1) Approximately 164.5 acres (Areas A, B, and D) to be treated to accelerate late-seral conditions by removing, on average, 30 percent of standing basal area (an easily-measured surrogate for volume).

2) Approximately 50 acres (Area C) to receive a contrasting treatment aimed at accelerating late-seral conditions by removing, on average, 45 percent of standing basal area.

**3) Entries** (Modified from Brandon Report)

Current Entry: For treatment #1 remove 30 percent and for treatment #2 remove 45 percent of standing basal area, both treatments removing trees primarily from intermediate and co-dominant crown classes. Figures 7 and 8 show the current distribution of conifer diameter classes prior to harvest, immediately after harvest, and

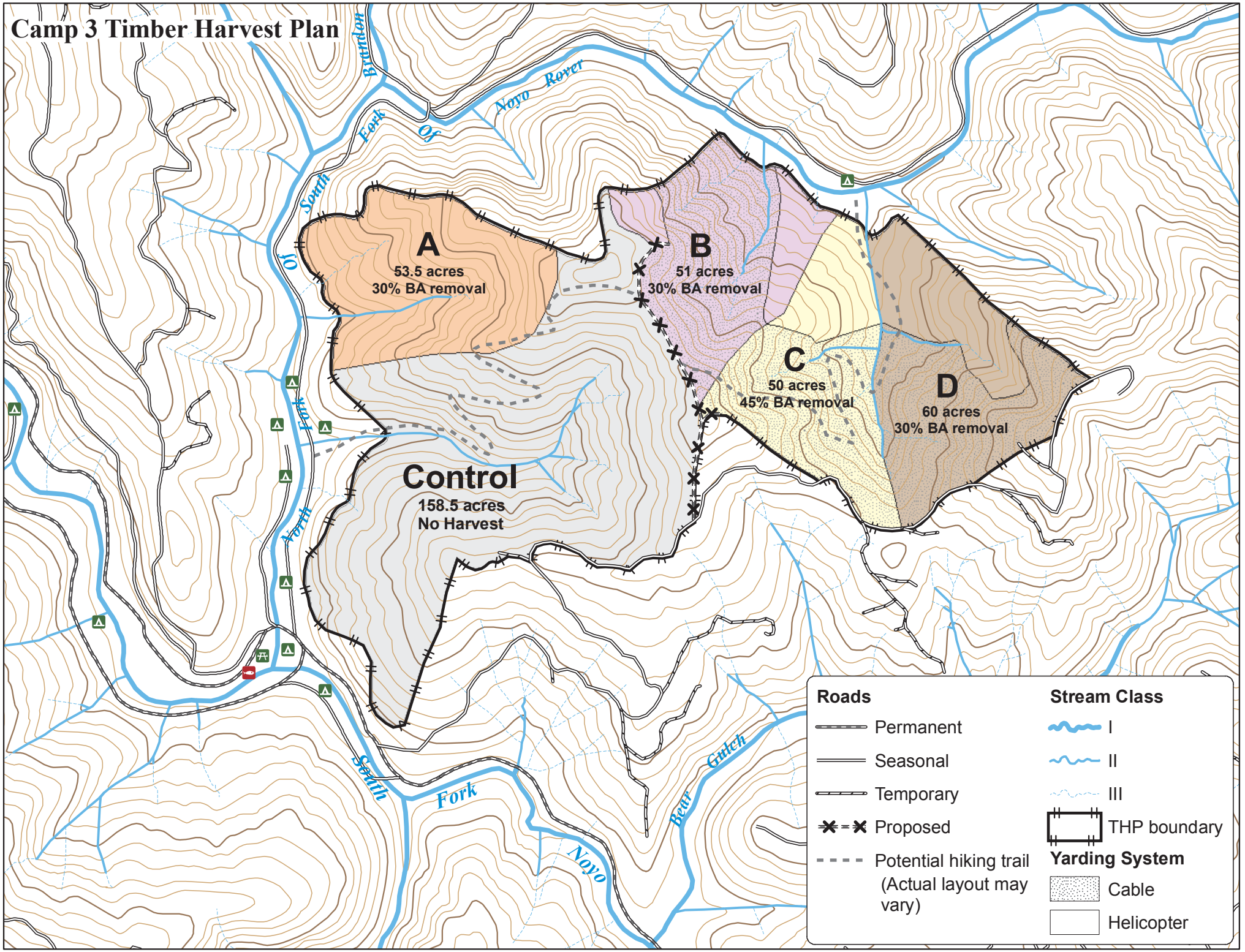

Camp 3 Timber Harvest Plan
Brandon
Fork
Of
Noyo River
South
Of
North
Fork
A
53.5 acres
30% BA removal
B
51 acres
30% BA removal
C
50 acres
45% BA removal
D
60 acres
30% BA removal
Control
158.5 acres
No Harvest
South
Fork
Noyo
Bear
Gulch
Roads
Permanent
Seasonal
Temporary
Proposed
Potential hiking trail
(Actual layout may vary)
Stream Class
I
II
III
THP boundary
Yarding System
Cable
Helicopter

**Figure 7: Camp 3 --- all conifers**
**30% basal area removal**

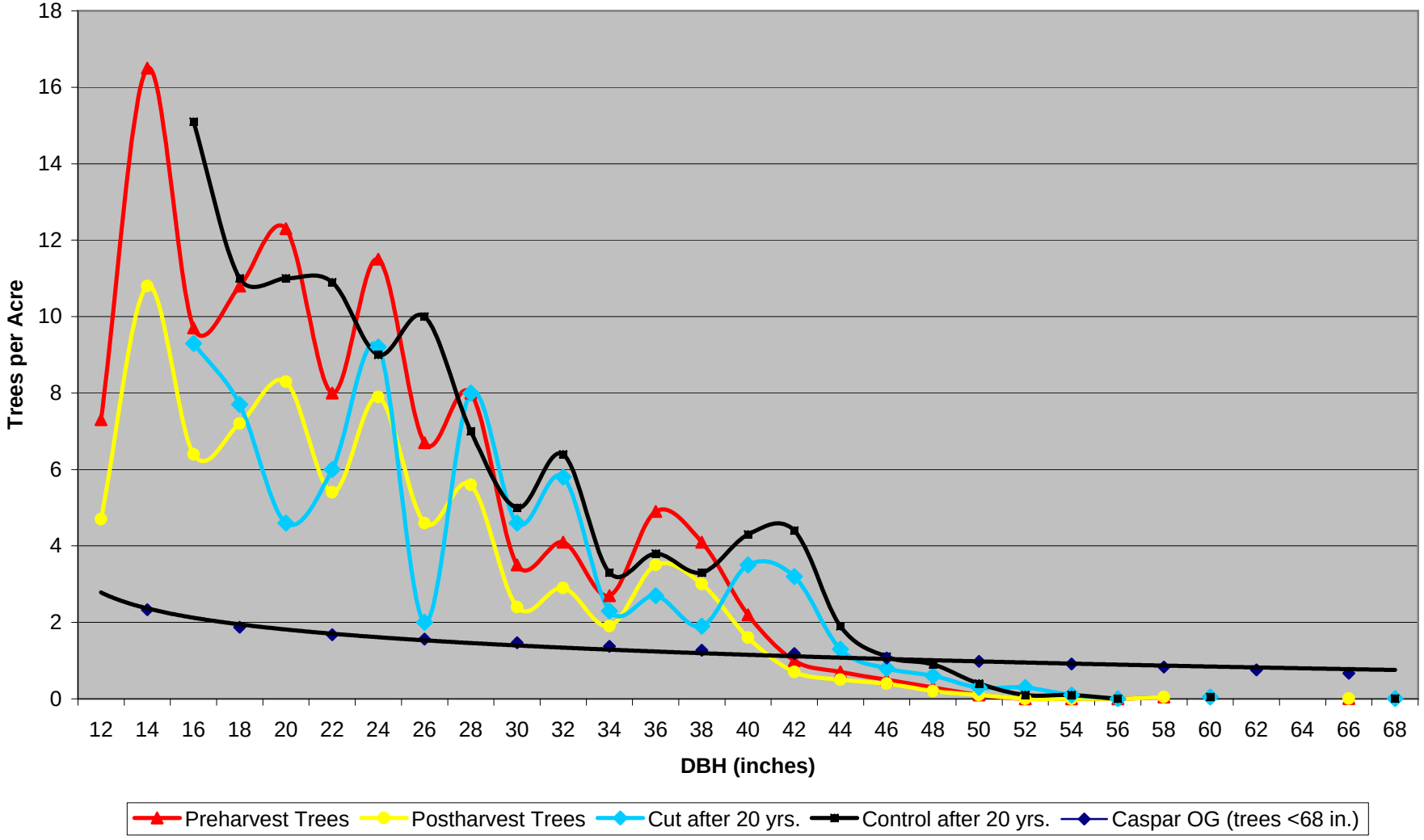
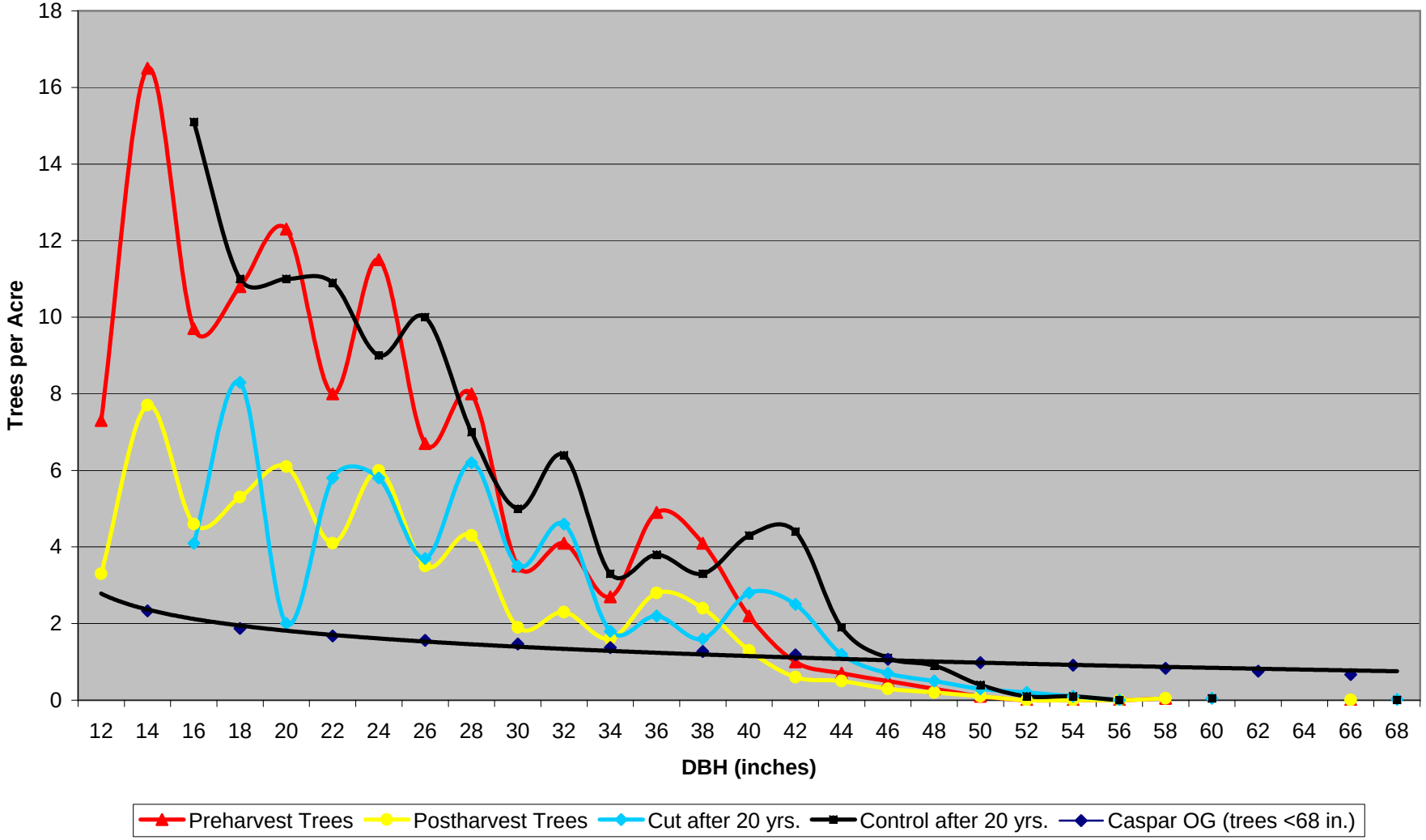


**Figure 8: Camp 3 --- all conifers**
**45% basal area removal**



after 20-year's projected growth. These Figures show the diameter distributions "moving down and to the right", indicating progression towards fewer and larger trees characteristic of older forest conditions.

Figures 7 and 8 also show the frequency distributions of diameter classes that were present in the "virgin forest" in the Caspar Lumber Company ownership in 1929 (Mason and Stevens, 1929) that can be used as an example of old growth condition.

A continuing sequence of entries is recommended. Rather than stipulating an arbitrary time between entries, the timing of each sequential entry should be based on an evaluation of development of stand structure and growth responses in relation to meeting the goals of accelerating late-seral forest conditions. In addition, operational issues should be considered in terms of availability of timber volume to ensure economic feasibility. For operational reasons, both treatment areas should receive successive entries concurrently, despite the probability that the prescriptions might precipitate achieving reentry conditions at different times.

**4) Emphasis and Application** (Same as Brandon Report)

The JAG-recommended-prescriptions differ from standard prescriptions for timber production. They emphasize:

1) developing complex, multi-layered forest structure
2) minimizing regeneration so that it is similar to natural levels in late-seral stands
3) creating diverse horizontal stand variability
4) providing for enhancing ecological diversity
5) increasing the proportion of larger diameter trees, and
6) increasing stand and crown complexity
7) retaining trees of various vigor conditions to maintain an on-going process of dead-wood elements recruitment.

The primary intent of the prescription is to provide selected large trees with increased growing space, yielding accelerated growth. Prescription emphasis will focus on: 1) accelerating the growth of dominant and co-dominant trees into larger size classes, and 2) retaining and developing other basic elements of late-seral conditions such as deformity, decadence, and abundant dead wood.

Existing groupings or clumps of redwood will be the source of most harvested trees and most will be thinned to variable levels to promote random stem distribution and variable growth responses. Entire clumps should not be removed to minimize establishment of a new cohort of regeneration. About 10 percent of the clumps should remain unthinned to promote slow tree growth, fine tree rings, and enhance heterogeneity in stand structure. About 10 percent of the clumps should be heavily thinned to create patchy diversity.

Prescribing desired harvest goals in terms of stand basal area provides an overall guide to accelerating development of late-seral conditions. This does not, however, recognize existing variability in stand density and diversity or how to apply the prescription to maintain or enhance irregular, old forest structure. The task of professional staff should be

to determine an effective and practical thinning approach, possibly with input from JAG in the initial phase of field implementation. One approach is to develop rules using a list of thinning options together with a random number generator (designed to remove a stand average of 30 percent, or 45 percent for the second prescription, of basal area reflecting treatment goals) to select the specific proportion of trees to be removed from redwood clumps and individual trees. The rules would be constrained to leaving larger diameter trees, Douglas-fir retained for diversity and future snag production, and other desired ecological and diversity outcomes described below.

Stand Structure Old forests are characteristically very diverse and have heterogeneous structure both vertically through various canopy layers and horizontally across the landscape.

a) Vertical Structure and Canopy Diversity
Vertical structure can be promoted by developing multiple tree layers. These provide varied light and microclimates favorable to diverse populations of understory plants, animals, fungi, and lichens characteristic of late-seral redwood forests. Based on professional judgment and data available from other areas, species composition within a mature redwood forest at JDSF would probably range from 65-90 percent redwood, 5-20 percent other conifers, and 0-15 percent hardwoods, depending on site quality and successional condition. These proportions should be used to guide treatments that affect overall vertical structure and canopy diversity.

b) Horizontal structure and spatial distribution
Encourage variable density and species composition across the landscape.

Old Growth The existing JDSF old-growth retention policy should be implemented (Page 104 JDSF Management Plan). This specifies retention of (i) large old-growth trees and (ii) old growth trees of any size that exhibit unique structural characteristics as described in the policy. The recommended prescriptions should be entirely consistent with this Management Plan guidance.

Tree Retention In general, all dominant trees should be retained except where their removal will enhance desired stand structure. Emphasis should be placed on developing stand variability, minimizing impacts on ecosystem components and functioning, and sensitivity to aesthetics.

Suppressed and Small Low-Canopy Trees will mostly be left unthinned to provide shade and site occupancy and to repress new regeneration. Their numbers, however, will be reduced through light harvest and related logging activity.

Regeneration No targets should be set to manage for regeneration and its occurrence will be incidental to stand treatments. The moderate thinning prescribed should limit light levels sufficiently to reduce the development and competitiveness of regeneration and redwood sprouts, which is needed to promote the development of late-seral conditions in this stand.

Tanoak and Other Hardwoods Hardwoods should generally be retained for wildlife and other values. This may depart from the JDSF Management Plan guideline (page 107) of retaining hardwood tree composition at approximately 10 percent (West end of Forest) to 15 percent (East end of Forest) of stand basal area. Hardwood composition and quality should be evaluated prior to the second entry and treatments considered to balance or enhance their role in the late-seral forest. Because of the prevalence of tanoak in some parts of Camp Three, a post-harvest evaluation should be made to determine whether treatments should be made to either enhance the growth or diminish the proportion of tanoak relative to the goals of enhancing and balancing late-seral forest conditions.

Sanitation/Salvage Cutting
Limited cutting to salvage mortality or to mitigate the effects of insect or disease infestation or wildfire could be undertaken if these natural disturbances are so extensive as to detract from the goal of achieving late-seral conditions. Given that high density of dead wood elements is a key character of late-seral stands, care should be taken not to diminish meeting wildlife habitat and ecological goals.

## 7. Research (New)

### 1) Factors Affecting Research Approach

There are several major factors that affect the capacity to meet JAG's directive that "the amended THP shall be treated as an applied research project in ALSF (acceleration of late-seral development". The most important factors considered were:

a) Area available for treatment is limited to 214.5 acres. The usual approach to experimental design amendable to statistical analysis involves providing for replication and assigning treatments at random. Research on silvicultural methods to accelerate the rate of development of late seral stand conditions is still in its infancy, and little knowledge exists in the received literature. This study is presented more as a methodological contribution to economically feasible silvicultural methods and long term monitoring to achieve this goal than a formal, controlled experiment. We envision this study as a first attempt at this kind of study, which we hope will stimulate further work in this area, and replications of similar studies elsewhere in the redwood region.

Dividing the THP to provide three replicates of two treatments limits the area devoted to each treatment block to 35.75 acres. Incorporating the control replicates further constrains the area available for each treatment block to 23.8 acres. The “Reserve” area can be used as a control, but its pre-set establishment limits the statistical basis for this use. These small areas are, in effect, further reduced in size as measurements cannot be made near bock boundaries due to the edge effects from adjacent treatments.

However, given the very long time periods for significant late-seral characteristics to emerge, the most useful variables that can be measured are those related to tree growth. If substantial differences in these variables occur in the two treatments, relatively small acreages of treatment should suffice to obtain valid results in non-replicated studies.

b) Class II stream protection buffers are likely to remove approximately 12 percent of the forest area from potential treatment.

c) There is considerable within-stand and, potentially, within-experimental-block variability in such factors as dominant tree cover types, species distribution, aspect, soil depth, and position on slope. This variability can overwhelm treatment responses due to limitations on number and size of replication blocks. JAG has not determined the relative mix of cover types across the THP area, nor confirmed that the treatment units partition these equitably. JAG considered elevation, aspect, and slope in allocating treatments to the THP.

d) Portions of the treatment area with steep slopes require harvesting by helicopter and the remaining area is too steep for use of tractors and will be harvested using a cable-yarding system. These yarding system boundaries are pre-established and do not necessarily lend themselves to unique treatment unit boundaries or random allocation of treatments. Also, there may be interactions between yarding methods and response variables of interest. This potential confounding might be severe if the reentry needs of the two prescriptions are not coincident (a likely and appropriate outcome if the prescriptions are not constrained).

e) The Settlement Agreement states: "Any ALSF treatment area that includes removal of more than 30 percent of the volume of timber in the treatment area outside of protected stream zones shall be the minimum acreage necessary for scientific validity of the results of the research."

This provision makes it difficult to develop a robust experimental design utilizing two divergent treatments that allows "the amended THP (to) be treated as an applied research project in ALSF". Also, thinning that removes less than 30 percent of standing volume by harvesting trees from the intermediate and co-dominant crown classes would have little effect on accelerating late-seral conditions, and removing more than 30 percent of standing volume is constrained by the Agreement.

Taken together, and following extensive Committee discussion, these factors resulted in limiting the number of feasible prescriptions to two, plus using the Reserve area as a control.

**2) Recommended Experimental Protocol** (New)

a) Hypothesis

Test the null hypothesis that "The two silvicultural prescriptions have no effects on accelerating late-seral forest conditions".

b) Parameters of Interest

In order to test the null hypothesis, JAG suggests that the parameter used to test the hypothesis is one or two of the following:

i 20-year stand cubic foot volume growth,

ii the extent of accelerated growth in 20 years of trees in the upper $50^{th}$ to $80^{th}$ percentile of tree diameter. These parameters could serve as a proxies for achieving an increase in rate of moving towards late-seral conditions.

iii 10-year stand diameter growth from increment cores, before the first treatment and at elapsed time 20 years, immediately before the second treatment, if applicable.

iv Average stand diameter, before the first treatment and at elapsed time 20 years, immediately before the second treatment, if applicable.

c) Treatments

Three treatments will be applied, a no harvest control and two contrasting thinning prescriptions to the treatable area to test the null hypothesis and to provide diverse research opportunities for interested scientists.

Treatment 1: remove approximately 30 percent of pre-harvest basal area, primarily from the intermediate and co-dominant crown classes.

Treatment 2: remove approximately 45 percent of pre-harvest basal area, primarily from the intermediate and co-dominant crown classes.

Treatment 3: no harvest.

c) Protocols

Due to the factors affecting research design listed above, JAG recommends the following paired approach:

i) The THP as an applied research project

As mentioned above, JAG recommends dividing the area into two parts: 164.5 acres to be treated by removing a stand average of 30 percent of the basal area (areas A, B, and D in Figure 6), and 50 acres (area D) to be treated by removing 45 percent of the basal area. Although the treatments are not arranged in a formal controlled experimental design, they do serve as a basis for subsequent replications of this study elsewhere, and it provides a basis for the research protocol described below.

ii) Testing two approaches to accelerating late-seral conditions

Within the 50-acre area C (Figure 6), JAG recommends that an appropriate number of inventory plots be established, together with an equivalent number of comparable plots (preferably) in Area B, to test the null hypothesis that "Silvicultural prescriptions have no effect on accelerating late-seral forest conditions". The number and size of plots should allow for analysis and accommodate variability in stand characteristics (e.g., tree species, size, density, soil differences, and position on slope). Plots should be established prior to harvest to enable measurement of pre-harvest growth rates and stand conditions, and then relocated after harvest. Since it is infeasible to retain small plots as controls within the harvestable areas, "control plots" could be established in the Reserve area. Although not having treatments and control treatments allocated at random among experimental units, this research layout will provide, through periodic

remeasurement, empirical, applied-research and demonstration data that allows a comparison of the two treatments in terms of their relative effects on accelerating late-seral forest conditions.

**3) Call for Research Proposals**

Using harvesting prescriptions to accelerate tree growth is only one way of encouraging development of late-seral characteristics. There are other direct approaches aimed at accelerating the development of late-seral structural elements, but because JAG was directed to recommend acceleration methods in the context of a timber harvest plan, we do not propose incorporating these other methods at this time.

JAG recommends that JDSF actively encourage the testing of diverse approaches to accelerating late-seral conditions in Camp Three by establishing a "Call-for-proposals". This Call should be supported by an allocation of at least $30,000 for research initiated in the Camp Three area. Especially promising is the active manipulation of limbs and tops to promote the complex canopy structure characteristic of old-growth trees. Another possibility is to create basal cavities (for wildlife habitat), snags, and coarse woody ground cover. Other studies could include the dynamics of floristic composition of stands and introducing epiphytes, studying down-log decay rates, and population dynamics of amphibians, reptiles, and small mammals.

Using the tree marking guides indicated in Section 4 page 16, both the moderately and more heavily thinned experimental areas should have substantial horizontal, spatial diversity with some redwood clumps and groups of individual trees left unthinned and others thinned substantially. This diversity should provide attractive opportunities for research to be conducted on small plots throughout the treatment area. In addition, the Reserve area is available for research and might act as a control for the harvest scenarios and other studies.

Associated research and demonstration should be strongly encouraged, but projects need to be done in such a way as to not compromise the basic premise of accelerating late-seral forest conditions through application of the two silvicultural treatments, i.e., allotting treatments in an equivalent manner within the two prescriptions and providing documentation that enables their effects to be coordinated with the goals and objectives of the two base prescriptions.

## 8. Baseline Inventory Monitoring (New)

The Settlement Agreement specifies: “Development of baseline resource inventories shall be focused, practical, within available CAL FIRE resources as determined by the Director, and able to be accomplished by April 1, 2009". Therefore there are limitations on the amount and breadth of baseline monitoring due to time and budget constraints. This largely prevents collection of data on such factors as botanical, mammalian, and reptile/amphibian populations.

In developing a baseline inventory, measurements of stand growth and structural development should be carried out in both the control areas (located in portions of the Reserve) and in the two treatment areas (30 percent and 45 percent removal of basal area). JAG recommends that this be done by establishing permanent, CFI-type 1/5-acre plots sufficient in number to provide a precision of a suggested 15 percent standard error in cubic volume or basal area. In order for the plots to be integrated into the existing CFI plot grid, the location of these baseline inventory plots should be located at a multiple of the existing CFI grid, at a density that will ensure the specified sampling error is achieved.

Factors to be included in a baseline inventory and monitoring systems should be the minimum needed to effectively test the experimental hypothesis and to provide an understanding of change in ecological condition and acceleration of late-seral forest conditions. We note the need to ensure that factors listed for inventory and monitoring "are focused, practical, and within available CAL FIRE resources as determined by the Director" as stated in the Settlement Agreement.

We recommend establishing the permanent baseline inventory and monitoring system prior to implementing the harvesting treatments. Subsequent monitoring should be done at 5-year intervals if feasible and no later than elapsed time 20 years.

JAG recommends the following factors be monitored:

1) Late-Seral Characteristics -- Plot-based

These factors could be incorporated within the standard CFI-type plot measurements:

- Tree species
  - diameter, height, basal area, increment growth, live-crown ratio
    (diameter distribution a surrogate for multi-layered or continuous canopy)
  - assignment of redwood to clumps or individuals
  - mortality/decadence
  - clump descriptors
- Canopy density
- Snags/snagtops/"defects"
- Basal cavities
- Crown characteristics (large branches, broken tops)
- Reiterated branching in redwood
- Disturbance descriptors: evidence of roads, skid trails, cable corridors, etc.
- Photo record (four cardinal directions)

2) Associated Variables -- Transect-based

These variables will be measured using transects from plot center of the CFI-type plots:

- Soil disturbance and down log loading – 30 feet transect
- Surface fuels and down woody debris – Brown’s transect
- Shrub cover

The following factors may be incorporated depending on staff capacity and funds available:

- Epiphytes
- Reptile and amphibian populations

Small mammal populations
Ground cover floristics, including invasive species
Mushrooms and fungi

## 9. Special Considerations (Recreation section new, remainder same as Brandon Report)

a. Recreation and Aesthetics

Although there is extensive public recreation use of the Camp One day-use area and the several camp sites and picnic areas along the North Fork of the South Fork of the Noyo River adjacent to Roads 360 and 361, these areas and associated trails and vistas along the North Fork of the South Fork of the Noyo River as well as the lower South Fork of the Noyo River should only be impacted by the activities (noise from cable and helicopter yarding) associated with the harvesting treatments. Due to distance and the degree of setback from roads and campgrounds viewsheds should not be affected by the operations (see Figures 3 and 6).

1) Roads A seasonal road and several landings will be constructed departing from Road 305 to permit cable yarding on the east side of the treatable area (Areas B, C, and D, see Figure 6). As stated in the Settlement Agreement: "The general intent … is to maintain natural stand conditions along both sides of the road …".

2) Proposed New Trail As indicated in the Settlement Agreement:

> "A hiking trail shall be laid out, but not built as part of this agreement…. Actual layout is expected to vary from the mapped line, based on on-the-ground considerations. The potential recreation use of this potential trail will be considered when devising the THP amendments. Potential harvest modifications to reduce visual impact on recreational trail users, including but not limited to those provided by the Management Plan and the Forest Practice Rules, shall be considered for incorporation in the THP amendments."

This proposed hiking trail, which may have a final location differing from that shown in Figure 6, should be an important means of enabling recreation users to view both the Reserve area and treated areas for educational and demonstration purposes.

JAG recommends that the proposed trail route be laid out, but not constructed, prior to harvest to enable JDSF staff and the timber operator to apply the prescription with sensitivity towards demonstrating the compatibility of recreation with careful forest management. In order to be able to demonstrate to trail users modern techniques of silviculture and forest management, no special buffers or setbacks should be incorporated. It is recommended that the harvest treatments come to the trail's edge, in order to maximize opportunities for public education and demonstration in the accelerated development of late-seral forest conditions.

After applying the research treatments, the proposed trail should be re-flagged and perhaps its location modified to account for on-the-ground considerations or to capture demonstration opportunities. JAG recommends that the trail be constructed as soon after harvesting as possible while the slash is still green so that lopping is facilitated. At the time

of trail construction, any remaining logging slash should be uniformly lopped to within 30 inches above the ground for a distance of 100 feet or sight-distance from the trail edge, whichever is less.

3) Cable Corridors should be kept as narrow as possible and, if practicable, aligned to minimize visibility. Care must be taken to avoid injuring leave trees at the edge of corridors although it is recognized that incidental tree crown damage may lead to the development of decadent stand structures.

4) Landings and Access Routes should be limited to the minimum size needed consistent with providing safe working areas. Landings (including those from previous logging entries) should be cleaned up unless designated for reuse. All newly-constructed, temporary access roads and landings should be covered with slash to limit non-authorized use, stabilize surface soil, and enhance regeneration of native plants. Special care should be taken to avoid conditions conducive to establishment of exotic plants, including post-harvest evaluation and potential vegetative treatment.

5) Helicopter Logging may require log landings (already designated) that are somewhat larger than those used for cable yarding in order to ensure safe and efficient operations. If possible, helicopter operations should be done before the opening of the campgrounds near Camp One or after their fall closure.

b. Wildlife and Fisheries (Same as Brandon Report)

Wildlife species likely to occur on JDSF are listed in the Management Plan (page 42). Over the course of time after the prescription has been applied, increased diversity of wildlife populations is likely to develop corresponding to enhanced diversity of vegetation and other flora, size of trees, and increasing amounts and conditions of late-seral elements such as snags, down logs, and basal cavities.

Wildlife expected to occur in stands of different type can be predicted using the California Wildlife Habitat Relations model. Although the model is not explicitly designed to address "late-seral" as a distinct type, it can be simulated. A “Species Comparison” model predicts that redwood stands with canopy cover greater than 40 percent of trees greater than 24-inches in diameter, and with a multi-layered canopy to be inhabited by 167 wildlife species. Of these, none were found exclusively in vigorous stands, 44 were found in both vigorous and those with late-seral characteristics, and 123 species were predicted only in forests having elements typical of late-seral conditions, 123. A “Habitat Value” model predicts that 60 species were insensitive to the modeled stand conditions, 56 minimally sensitive, 19 species moderately sensitive, 9 species strongly sensitive, and 23 species predicted to have no habitat value in young stands. These predictions suggest that a broader array of species is expected to find suitable habitat in forests with adequate amounts of the decadent elements that typify late-seral forests (see Appendix 9).

The North Fork of the South Fork of the Noyo River provide habitat for coho salmon and steelhead trout and both species are found during most years. Over most of the past 20 to 30 years, juvenile populations have been dominated by steelhead, but during some periods when

ocean conditions and spawning coho populations are high, coho are dominant. Historically, coho spawning and juvenile populations were much larger than steelhead and this situation may return when streams are restored to previous conditions. Although large woody debris is critically important to both fish species, Coho, especially, favor deep pools and cover provided by down logs, slower water, and clean gravels. The current, low occurrence of logs is due to historic logging practices and mis-guided stream restoration efforts in the 1950s and early 1960s. An important component of accelerating late-seral stand conditions is to increase recruitment of large woody debris in the two streams and take other measures as prescribed in the Jackson Management Plan (pages 8, 23, 63, 104, and elsewhere).

Camp Three has been surveyed for potential marbled murrelet nesting habitat with none identified, thus there is little likelihood of "take or impact" (Management Plan pages 26, 110, 267 and elsewhere). Surveys should continue to be conducted annually for northern spotted owl and habitat protected as outlined in the Management Plan, page 267.

Species protection and Habitat Management: Prior to each treatment entry, the Camp Three THP area should be surveyed for species protection using standard protocols and guidelines endorsed by the appropriate federal or state agency (JDSF Management Plan, beginning page 110).

c) Snags and Coarse Woody Debris

Snags: JDSF Management Plan guidelines (page 106) should be followed for the first entry, and preferably exceeded, requiring no less than three snags per acre -- two greater than 20-inches dbh and one greater than 30-inches dbh -- distributed unevenly across the landscape. Active creation of Douglas-fir snags in the first entry might not be feasible due to their current small size. The Management Plan guidelines are unlikely to adequately meet levels of snags and snag-topped trees normally found in stands approaching late-seral condition, and specific targets should be evaluated prior to a second entry.

Conifer and hardwood trees having current or potential value for wildlife, mast production, or as hosts for other biota such as epiphytes, fungi, and lichens should be retained considering both the short-term period between treatments and the long-term period beyond the second entry. Trees retained for potential wildlife values, snags, and coarse woody debris should vary in vigor. In particular, dominant Douglas-fir should be retained that exhibit low vigor and slow-growth (finer rings), are diseased, and have heavy limbs and cavities. Exceptions are trees that must be removed for safety reasons, for example near trailheads.

Coarse Woody Debris: Management Plan guidelines are unlikely to adequately meet levels of coarse woody debris loading normally found in stands approaching late-seral condition. During the first entry, JDSF Management Plan guidelines (page 107) should be followed, and preferably exceeded, requiring no less than three down logs per acre 20 feet long -- two greater than 16 inches dbh and one 24 inch dbh at the large end -- distributed unevenly across the landscape. If the stand is found to be deficient in this material prior to the second entry, methods for increasing the supply should be considered. Existing down logs and larger, dead trees should, as far as possible, be left undisturbed to maintain wildlife values.

Coarse woody debris from hardwood trees should be encouraged to provide needed habitat diversity for animals and plants.

The presence and quality of snags and coarse woody debris should be assessed against desired targets prior to considering the second entry. Specific targets and treatments can be developed at that time in light of changed conditions.

d. Forest Ecosystems

Biological diversity (fauna and flora) should be evaluated prior to each entry to determine what management activities are needed to ensure long-term conservation of existing or needed species common to late-seral forests in the Camp Three area (see JDSF Management Plan, page 107). Attention should be addressed not only to the presence of these species, but ensuring conditions for diverse and healthy ecosystem processes and functions by providing habitat (retaining old forest elements) and encouraging the use of prescribed fire. Attention should be given to enhancing diverse populations of understory plants, animals, fungi, and lichens. As stated in the Management Plan (page 108), survey protocols should be established after consultation with state and/or federal agencies, recognizing that the goal of the Camp Three treatment area is primarily for applied research purposes as well as having high recreation and education values.

1) Understory: Shrubs and groundcover should be impacted as little as possible. Some level of disturbance will occur from logging operations but those impacts should be limited and restricted to skid trails, landings, roads and other necessary infrastructure needed for harvesting.

2) Legacy trees, snags, and down logs

Avoid locating skid trails, treatments, and causing logging damage in areas where adverse impacts would occur to existing ecosystem components and structures needed to provide critical elements of ecosystem and late-seral structures. The largest trees commonly left from early logging, snags, and down logs constitute important ecological "legacies" and should be protected.

3) Elevated Structure Development:

Late-seral redwood forests are characterized by elevated deformities in trees that typically result from mechanical damages that accumulate over time due to wind, wildlife damage, adjacent tree fall, etc. Important tree characteristics include reiterated trunks (redwood stems in which large, upturned branches form complex, multiple-crown structures), large branches with varied growth patterns, snag tops, and broken tops. To ensure that harvesting does not inadvertently set back the amount and development of these elevated structures, retention of existing trees with these features should be a high priority.

e. Exotic Invasive Plants

Special effort should be made to control any exotic invasive plants that are evident on the roads surrounding and within the Camp Three THP using guidelines established in the JDSF Management Plan (pages 10, 28, 38, 51, 93).

## 10. Demonstration, Interpretation, and Education (New)

The Settlement Agreement states that "There shall be included in the protocol a plan for educating the public, including persons using the area for recreation". JAG recognizes that the Camp Three area provides an important opportunity for demonstration, interpretation, and education due to the proposed new hiking trail that passes through both the Reserve and treated areas. Because of the proximity to heavily-used recreation sites, JAG recommends that this trail be utilized for providing the public with information on forest ecology and stand dynamics in the context of accelerated late-seral development using and modern approaches to silviculture, harvesting, and forest dynamics over time.

The new trail should be a self-guided trail with marked stations and information brochures. Providing information stations would occur after construction of the trail, which should occur independently of the educational effort.

a) Reserve This portion of the trail should provide information on such forest characteristics as:

- soils -- productivity and stability
- trees -- species, health, basal cavities, crown characteristics, growth, mortality, basal cavities, stocking levels, fuels
- down logs and woody debris - uses and values
- shrubs -- species, Native American uses
- ground cover -- species, Native American use
- animals -- evidence and habitat suitability
- fungi, lichens, epiphytes
- late-seral forest elements and stand dynamics

b) Treated Area This portion of the trail should provide information on the role of silviculture in managing forests for wood products while accelerating the development of late-seral forest conditions. Explanations could be provided on the same characteristics as listed for the Reserve area with the intent of providing comparisons and contrasts between the non-treated and treated areas in relation to late-seral forest conditions.

In addition, information could be provided on such topics as:

- amount of wood removed (in house-equivalents)
- jobs and economic contributions to County
- cable corridors and harvesting information
- redwood sprouts and their growth following treatment
- tree growth response to treatment
- slash treatments

c) Questionnaires Professionally-developed questionnaires should be developed to gauge public reaction, over time, to understanding the role of forest management in providing a balance between diverse forest values including wood, jobs, recreation, ecological

values, forest recovery/stand dynamics after thinning, and acceleration of late-seral forest conditions.

## 11. Literature Cited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## 12. Appendices

1. Members of the Jackson Demonstration State Forest Advisory Group and the Late-Seral Forest Development Committee
2. Prescription Goals from the Settlement Agreement
3. Camp Three Forest Stand and Resource Description
4. Camp Three Unit Forest Resource Inventory Report

5. Cumulative tree density (trees per acre) and basal area by diameter for old forest stands in the JDSF area by stand volume (source Mason and Stevens 1929, Giusti 2007).
6. Projections of Preliminary Prescriptions for Brandon Gulch Using the CRYPTOS Simulation Model (Note: These projections can be used for Camp Three since the tree inventories are so similar)
7. Projections of Leaf Area Index for Brandon Gulch Preliminary Prescriptions Using the MASAM Simulation Model (Note: These projections can be used for Camp Three since the tree inventories are so similar)
8. Alternative Prescription Approaches Considered
9. California Wildlife habitat Relations Assessment of Consequences of Late-Seral Management on JDSF

# Appendix 8

## Alternative Prescription Approaches Considered

Factors such as diversity of species composition and density, topography, application of two harvesting methods, provisions of the Settlement Agreement, requirements of experimental design and statistical analysis, and the short time available for report development, all limited the prescription approaches that were potentially feasible.

For simplicity and logistical reasons, the approaches considered should aim at accelerating the growth, in the long run, of the same large dominant and co-dominant trees. This would involve, for each approach, harvesting proportions of intermediate and co-dominant trees. This tends to create similar stand structures regardless of approach.

For both research and demonstration purposes two contrasting treatments that create immediate initial differences in stand structure and measurably-different rates of accelerating late-seral conditions would be desirable.

Alternative potential approaches discussed were:

1) Compare traditional forest practice with one aimed at accelerating late-seral conditions. This could be approached by utilizing the existing THP tree marking on one part of Camp Three with changed marking on the other part. This approach was not considered further as the current mark was aimed at removing about 30 percent of the basal area and was intended to provide for regeneration and enhance growth of the best trees. New tree marking aimed at enhancing late-seral development would probably favor the same large trees and apart from avoiding establishment of new regeneration would not likely lead to measurable differences in stand growth response.

2) Compare two approaches to modifying vertical canopy layers using the extremes of silviculture methods -- one to promote even-aged (or even-sized) diameter distributions by thinning smaller trees and the other to promote uneven-aged (or uneven-sized) diameter distributions by harvesting competing co-dominants through single-tree selection. Thinning from below would create an opportunity for substantial levels of regeneration, which should be avoided as this is contrary to meeting the goal of advancing late-seral conditions. In addition, horizontal stand diversity may not be enhanced, depending upon the target number of large leave trees.

3) Two approaches to modifying horizontal stand structure -- one to maintain current level of mixed mosaics of heterogeneity and the other to encourage openings through group selection harvesting. This would involve comparing relatively uniform distribution of trees across the landscape with grouped distribution developed through group selection or cluster harvesting. This approach has doubtful relationship to promoting overall late-seral conditions across the landscape due to substantial regeneration and development of young stands contrasted with retention needs to achieve large tree size and decadence within the within the groups. This method may warrant future consideration, since it may offer an opportunity to mimic natural gap development in old stands.

4) The use of prescribed fire to manipulate stand structure and ground cover. Although legitimate from a research standpoint, this approach was not considered further due to the assigned task of JAG of recommending a prescription intended to accelerate late-seral forest conditions through amending a Timber Harvesting Plan, risk of implementation, uncontrolled effects on stand structure, and likely confounding of experimental goals.

5) Two approaches to modifying stand density -- one through relatively light harvest with frequent entries and the other through a relatively heavy harvest but with less frequent entries. The Settlement Agreement requires that the harvest should not exceed 30 percent removal of basal area unless necessary for scientific validity. This severely limits the proportion of the treatment area that can receive a heavy treatment and thus limits applied research opportunities. Variations in stand entry timing could produce significant operational difficulties.