# Salt Timber Harvest and Fuels Hazard Reduction Project

## Silviculture Report


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**For:**

Hayfork Ranger District
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# Introduction

The Salt Project is being proposed as part of the Shasta-Trinity National Forest's Vegetation Management program. The treatments being proposed provide for timber sale activities including Timber harvest and removal, biomass removal, fuel treatments, fuel break improvements, and young timber stand improvement activities.

Two of the four objectives in the purpose and need for this project are analyzed in detail in this report.

- Improve forest health and resiliency
- Provide timber products

The measure of success to assess how well each alternative meets these objectives will be:

| **Purpose and Need** | **Measure of Success Related to Silviculture** |
|---|---|
| Improve forest health and resiliency | Acres of overstocked stands thinned to a SDI (stand density index) of 200-250 |
| | Acres of overstocked plantations thinned to approximately 150 trees per acre |
| | Acres regenerated that are not meeting growth and yield potential due to heavy pathogen impacts. |
| Provide timber products | Merchantable timber products harvested (million board feet –MMBF) |
| | Merchantable biomass harvested (bone dry tons-BDT) |

The key issues identified during scoping related to silviculture were related to how prescriptions would affect other resources and those issues are covered under those resource discussions. No analysis issues were identified related to silviculture.

Other questions or issues raised through scoping are shown in an appendix to the DEIS and are addressed narratively in this report as appropriate.

# Management Direction

The Salt Project is located on the South Fork Management Unit of the Shasta –Trinity National Forest. The project area is within the Hayfork Adaptive Management Area (AMA) and Management Area 19 (Indian Valley/Rattlesnake) of the Shasta-Trinity Land and Resource Management Plan (LRMP).

The Forest Plan specifies several land allocations for forest lands identified in this project. These specific allocations are:

- Roaded Recreation – Within the Roaded Recreation land allocation, "The emphasis of vegetation management activities will be to meet recreation, visual and wildlife objectives while maintaining healthy and vigorous ecosystems". Applicable management practices include: "Fuels reduction and management, vegetation treatment by burning,

Integrated Pest Management and Timber". The Forest Plan ecosystem objectives are to obtain stocking control (thinning), and minimize mortality.

- Commercial Wood Products Emphasis. – The objective is "to obtain an optimum timber yield of wood fiber products within the context of ecosystem management." Management emphasis pertaining to this project include fuels reduction and management, vegetation treatment by burning, integrated pest management, timber and wildlife habitat management .The Forest Plan desired ecosystem objectives are to obtain an sustained yield of wood fiber products from productive lands and to maintain and enhance habitat for big game, small game, upland game, birds, and species dependant on early seral stages. There is also than objective to reduce fire intensity in thinned stands.

- Riparian Reserves. – Forest Plan direction for Riparian Reserve land allocations states, "Apply silvicultural practices for Riparian Reserves to control stocking, reestablish and manage stands, and acquire desired vegetation characteristics needed to attain Aquatic Conservations Strategy objectives." The Forest Plan ecosystem objectives are to provide connecting travel.

Further direction is derived from the Shasta-Trinity National Forest Management Plan (LRMP) as identified in Forest Goals #10 and #11 for fire and fuels, and in Goals #34, #35, and #36 for Timber (LRMP pages 4-4 and 4-5). Specific direction for green-tree and snag retention in Matrix management is also given (LRMP pages 4-61and 4-62).

The LRMP Land Allocation further identifies the proposal as being within matrix lands of the Hayfork Adaptive Management Area identified in the Northwest Forest Plan. The Northwest Forest Plan in this area emphasizes prescriptions for Roaded Recreation, Commercial Wood Products, and Riparian Reserves. The Northwest Forest Plan Standards and Guidelines (p.C-30 through 31 and C-35 through C-36) provide specifics that relate to thinning in the Riparian Reserves in the Salt Project.

In July 2004, Region Five Regional Forester Jack A. Blackwood sent a letter to Forest Supervisors and Directors concerning conifer density management in California (Blackwood 2004). Direction in the letter included designing thinning activities to "achieve the multiple objectives of increased resistance to damage from crown fires, reduced surface/ladder fuels, reduced insect damage, and inter-tree competition, and restoration of densities more characteristic of the past under the influence of natural fire regimes." The letter also included direction to design projects that would be "effective for longer timeframes" by designing thinning to ensure "that density does not exceed an upper limit (for example…60% of maximum stand density index)" and "that this level will not be reached again for at least 20 years after thinning."

# Methodology for Analysis

Selected vegetation components were sampled in 2008 using Common Stand Exam protocol (USDA 2009a). A total of 160 field plots were taken in the major vegetation types in the project area. Vegetation types sampled include the M2G, M2N, M3N, XX1 and XX2 strata. Please see Tables 2, 3, and 4 for descriptions of these vegetation types. These sampled vegetation types represent 98 percent of the vegetation found on the project area. In addition to the stand exams, vegetation in the project area has been reviewed using aerial photos and unit walk-throughs. Specific field observations including stocking information for each stand was recorded. In this

analysis common names for tree species are used. See Appendix D for a list of tree common and scientific names.

Current stand attributes and future stand attributes for the alternatives considered were modeled from the 2008 stand exam data using the Forest Vegetation Simulator (FVS) Version 6.21, Inland California/Southern Cascades variant (Appendix A).

Available GIS electronic files including cover types, contours, and LRMP land allocations were used in the analysis. Specific vegetation layers used for the Salt Project include ExistingVeg 1980, allveg 1991.shp and seral_2005.shp.

Initial and periodic review was also made of the Shasta-Trinity Land and Resource Management Plan and the Northwest Forest Plan.

# Affected Environment

## Existing Condition

The Salt Project area was first settled by westerners in the 1850's and has experienced impacts to the forest vegetation since then. With the advent of fire suppression and minimal forest management in the early 1900's many stands in the area have increased in stand density and given management directions, can be considered to be over-stocked.

These dense stands contain well-developed forest floor fuels, ladder fuels consisting of dense midstory and understory trees and shrubs, and continuous canopies of hardwood and conifer over-story trees. These stand conditions are predisposed to intense fire behavior under extreme weather conditions that occur every year. Stand replacement fires are likely to pose a major threat to sustainability of conifer forests that are important for forest vegetation as well as aesthetics, recreation, wildlife habitat, and watershed function on the Hayfork District.

The Salt Project is located in the Rattlesnake Creek drainage in the Klamath Mountains of northern California. Elevations range from about 2500 to 5800 feet. The entire Project area is 4,278 acres in size. A summary of the vegetation distribution by size and strata is included in Table 1. See Tables 2, 3 and 4 for Strata code descriptions for forest type, tree size class, and tree density group.

**Table 1. Vegetation Distribution by size and Strata**

| Assemblage * | Strata ** | Tree Size Class* | ACRES |
|---|---|---|---|
| Chap | SX | 0 | 48 |
| Open | SX | 0 | 2 |
| Cliff | NF | 0 | 28 |
| Late | M3N | 3 | 3532 |
| Open | M2G | 2 | 94 |
| Open | M2N | 2 | 64 |
| Open | XX1 | 1 | 285 |
| Open | XX2 | 1 | 225 |
| **Grand Total** | | | **4278** |

* Vegetation Distribution Information from corporate seral_2005.shp
** Vegetation Strata determined from 2008 stand exam data.

Overstory vegetation types within the assessment area generally include an open Grey pine/live oak type, a well stocked mixed conifer type, and a Jeffery pine type on serpentine soils. The Grey pine/live oak type is typically found on low-elevation sites with shallow, rocky soils. As elevation increases, conifer species become more prevalent, primarily a function of more favorable environmental conditions. The deeper, more developed soils support mixed conifer stands of Douglas-fir, ponderosa pine, incense cedar, and sugar pine. A generalized vegetation table further defines major overstory dominate vegetation types (Table 5).

**Table 2. Description of the first position in the strata code, forest type**

| Position 1 | Forest Type |
|---|---|
| M | Mixed Conifer |
| P | Pine (Ponderosa or Sugar pine) |
| R | Red Fir |
| L | Lodgepole Pine |
| K | Knobcone Pine |
| XX# | Plantation (# is1, 2, or 3, and defines the age or size of trees) |
| NF | Non-forested |
| GR | Grassland |
| HDW | Hardwood (aspen) |
| NT | No Treatment |

**Table 3. Description of the second position in the strata code, tree size class**

| Position 2 | LRMP Size Class – Crown Diameter |
|---|---|
| 2 | Pole-size timber (6-12 feet) |
| 3 | Small sawtimber (13-24 feet) |
| 4 | Medium/large sawtimber ((25+ feet) |
| 6 | Two-storied, understories size 1 of 2 (0 – 12 feet) |

**Table 4. Description of the third position in the strata code, tree density group**

| Position 3 | Density Group | Percent Canopy Cover |
|---|---|---|
| S | Sparse | 10-19 Percent |
| P | Light | 20-39 Percent |
| N | Medium | 40-69 Percent |
| G | Heavy | 70-100 Percent |

**Table 5: Major Overstory Vegetation Types**

| Major Overstory Vegetation * | Acres* | Percent of Area |
|---|---|---|
| Mixed Conifer | 253 | 6 |
| Douglas-fir | 648 | 15 |
| Jeffery Pine-Ponderosa Pine | 2363 | 55 |
| Montane | 48 | 1 |
| Clearcuts/Type Conversions | 491 | 11 |
| White Fir | 446 | 10 |
| Other | 29 | |

*Vegetation Distribution Information from corporate seral_2005.shp

Hardwood species, predominately black oak, madrone, white oak, live oak and white alder comprise a substantial stand component throughout the assessment area. Black oak and madrone tend to occupy more productive sites while white oak and live oak are found on less productive sites. White alder is generally a substantial stand component along perennial stream-courses and adjacent to year-round wet areas.

The vegetation on the landscape of the project area can be grouped into several general conditions.

- Multi-aged, multi-storied under-stocked or over-mature mixed conifer stands which have had previous partial removal harvest activities. These stands are exhibiting moderate mortality and increasing decadence due to a number of biological agents. Stands are impacted by dwarf mistletoe in the ponderosa pine, Jeffery pine, incense cedar and white fir. Black oak is being impacted by leafy mistletoe. Mountain pine beetles are active in the Jeffery pine, ponderosa pine and sugar pine stands, killing both individuals and groups of these species. Fir engraver beetles are active in the white fir stands and in overstocked mixed conifer stands with a substantial white fir component. White pine blister rust is a serious and continuing problem throughout the assessment area, affecting primarily younger age-class sugar pine.

- Single-storied, intermediate-sized, young mixed conifer stands which have had previous harvest entries. Many of these stands have trees that currently exhibit a live crown ratio of 30-40 percent, a level that is considered the minimum to maintain adequate tree growth and vigor. The high density of these trees in the suppressed and intermediate crown positions is expected to result in high tree mortality in these classes, increasing down woody fuels and wildfire hazard. These stands also have the same insect and disease problems as the older stands, but are impacted to a lesser degree.

- Single-storied, young stands that are the result of site prepared and planted units that were reforested in the 1970’s and 80’s. These plantations are now in a well-stocked to overstocked condition with over 400 trees per acre, but tend to be free of serious insect and disease impacts.

- Specific areas that have been developed for fuel breaks in the past. These stands are multi-aged, multi-storied, mixed-conifer stands that have been partially cut or sanitized in the past. Mortality and insect and disease impacts are still occurring resulting in increasing fuel loads in the fuelbreak area.

- Stands that need handwork fuel reduction activities to reduce fuel loading. This activity will take place where fuel loading has created a high fire risk situation, but no merchantable timber material will be removed from the stand.

## Stand Characteristics

One hundred and sixty formal stand exam plots were taken in 2008 in the 5 major vegetation strata that exist within the project area. A summary of current formal stand exam data is included in Table 6. Although not displayed or discussed in this document, tables displaying the strata data that existed in the corporate data base prior to the 2008 stand exams and the relationships between the corporate database classification and the classification used in this analysis can be found in the project records. The 2008 stand exams showed that the existing vegetation is denser than the data in the corporate data base indicated, and so the 2008 stand exam data was used for the this

analysis. The figures quoted in Table 6 are for existing tree data only and do not include understory brush species.

Table 6 shows that most (84 percent) of the forested area in the analysis area can be considered mixed-conifer, small sawtimber with about 66 percent canopy cover. About 12 percent is in young sapling to pole-sized stands (plantations) and about 4 percent is in mixed-conifer pole to small-sawtimber sized stands.

Exam data shows the current stand density in terms of trees-per-acre (TPA) for young plantations (XX1 and XX2) to average from 1000 to 1210 TPA including hardwoods. Stand density index for the other strata (SDI, Reineke 1933) ranges from about 500 to 600. Stand density index is chosen in this analysis as the preferred measure of stocking level for most stands because it is based upon both tree diameter-at-breast-height (DBH) and TPA and provides the best measure of the degree to which site resources are being utilized by trees (Appendix B). TPA is being used in this analysis for young plantations. The SDIs displayed in Table 6 place the strata stocking levels well within the “zone of imminent mortality” (Appendix B) in which competition for site resources is so great that for some trees to live and grow larger, other trees have to die. These stocking levels are well above the point at which density-related bark beetles such as mountain pine beetle, western pine beetle and fir engraver beetle increase their activities (Appendix B) and the stands can be considered “high risk.”

Note that in Table 6, forest canopy density values are expressed in terms of percent canopy cover. These values are FVS modeled “canopy cover” which is “proportion of the forest floor covered by the vertical projection of the tree crowns” (Jennings et al. 1999). For this project, tree canopy density criteria have been established in terms of percent “canopy closure” which is “the proportion of the sky hemisphere obscured by vegetation when viewed from a single point” (Jennings et al. 1999). These are two different measurements and the means to measure and model them can give greatly different values (Jennings et al. 1999, Fiala et al. 2006). Values of percent canopy cover modeled by Forest Vegetation Simulator have been shown to be much lower than measured canopy closure values produced by several different means (Fiala et al. 2006). In the forests they studied, Fiala et al. (2006) showed that FVS modeled canopy cover was an average of 14.05 percentage points lower than measured closure values for young light-thin stands and an average of 23.73 percentage points lower than measured closure values for mature forest. The M2G and M2N strata fit within the young light-thin forest described in Fiala et al. (2006) in terms of TPA and BA stocking although they do have some trees older than the age range cited in Fiala et al. (2006). The M3N stratum fits within the mature forest described in Fiala et al. (2006) in terms of TPA and BA stocking and the stratum is dominated by trees within the age class range. In this analysis, we are using FVS’s modeled canopy cover to model thinning activity effects on forest canopy density by adjusting the modeled canopy cover values to better display and discuss forest density in terms of canopy closure. We are adjusting the FVS canopy cover up 10 percentage points, which is less than the differences Fiala et al. (2006) found. This “conservative” approach would maintain canopy closures higher than the minimum 50 percent canopy closure prescribed for Alternative 2 and minimum 60 percent canopy closure prescribed for Alternative 3. For a more detailed discussion concerning canopy cover and canopy closure see Appendix B.

**Table 6. Major Forested Strata Current Conditions**

| Vegetation Assemblage | Strata | Percent Canopy Cover | Stocking Level SDI | Stocking Level TPA | Stocking Level BA | Acres (Percent Forested Area) |
|---|---|---|---|---|---|---|
| Open | M2G | 78 % | 590 | 1425 | 253 | 94 (2%) |
| | | | | | | |
| Late | M3N | 66 % | 548 | 862 | 269 | 3532 (84%) |
| | | | | | | |
| Open | M2N | 68 % | 492 | 1131 | 209 | 64 (2%) |
| | | | | | | |
| PCT | XX1 | 36% | 164 | 1210 | 64 | 285 (7%) |
| | | | | | | |
| PCT | XX2 | 42% | 164 | 1000 | 58 | 225 (5%) |

## *Typical Stand Characteristics*

A multi stand summary of basic stand characteristics is provided for the project area in Table 7. A current condition diameter distribution and species composition chart can be found for the M3N stratum in Appendix C.

**Table 7. Major Overstory Vegetation Types**

| All Species Live | | | | | Recent Mortality | | | | Older Dead | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Dia. Class | TPA | BA/A | SDI | Avg. HT | TPA | BA/A | QMD | Avg Ht | TPA | BA/A | QMD | Avg. Ht |
| **0.1-2** | 401 | 3.1 | 45 | 7.0 | | | | | | | | |
| **2.1-4** | 103 | 6.7 | 22 | 15.9 | | | | | | | | |
| **4.1-6** | 58 | 11.3 | 26 | 27.3 | | | | | | | | |
| **6.1-8** | 31 | 10.7 | 22 | 34.1 | | | | | | | | |
| **8.1-10** | 30 | 16.5 | 32 | 40.9 | 1 | .7 | 10.0 | 27 | 2 | 1.3 | 10.0 | 12 |
| **10.1-12** | 25 | 19.9 | 37 | 50.2 | | .3 | 12.0 | 43 | 2 | 1.7 | 12.0 | 16 |
| **12.1-14** | 16 | 16.7 | 30 | 58.2 | 2 | 1.7 | 14.0 | 59 | | | | |
| **14.1-16** | 13 | 17.6 | 31 | 65.8 | | | | | 1 | 1.1 | 16.0 | 44 |
| **16.1-18** | 6 | 11.4 | 19 | 73.0 | | .6 | 18.0 | 86 | 1 | 1.4 | 18 | 56 |
| **18.1-20** | 5 | 10.3 | 17 | 79.2 | 1 | 1.1 | 20.0 | 87 | | .5 | 20.0 | 31 |
| **20.1-22** | 5 | 13.8 | 23 | 89.1 | | | | | 1 | 2.1 | 22.0 | 55 |
| **22.1-24** | 3 | 8.7 | 14 | 89.7 | | .8 | 24.0 | 94 | | .2 | 24.0 | 22 |
| **24.1-26** | 2 | 7.4 | 12 | 93.5 | | | | | | 1.1 | 26.0 | 77 |
| **26.1-28** | 2 | 7.8 | 12 | 94.2 | | .1 | 28.0 | 91 | | .7 | 28.0 | 73 |
| **28.1-30** | 1 | 6.2 | 10 | 110.5 | | | | | | .2 | 30.0 | 20 |
| **30.1-32** | 1 | 2.9 | 5 | 106.8 | | | | | | .1 | 32.0 | 92 |
| **32.1-34** | | 2.1 | 4 | 114.5 | | | | | | .6 | 34.0 | 37 |
| **34.1-36** | | 2.4 | 4 | 100.6 | | | | | | .1 | 36.0 | 10 |
| **36.1-38** | | 1.3 | 2 | 114.2 | | .2 | 38.0 | 125 | | | | |
| **38.1-40** | | 2.5 | 4 | 118.4 | | | | | | .3 | 40.0 | 56 |
| **40.1-42** | | 1.1 | 2 | 141.9 | | | | | | | | |
| **42.1-44** | | 1.0 | 2 | 129.2 | | | | | | | | |
| **44.1-46** | | .8 | 1 | 137.7 | | | | | | | | |
| **46.1-48** | | | | | | | | | | | | |
| **48.1-50** | | .5 | 1 | 122.9 | | | | | | | | |
| **50.1-52** | | .3 | | 139.7 | | | | | | | | |
| **52.1-54** | | .7 | 1 | 122.7 | | | | | | | | |
| **54.1-56** | | | | | | | | | | | | |
| | **703** | **183.7** | **378** | **7.3** | **5** | **5.6** | **16.7** | **66** | **8** | **11.5** | **18.2** | **28** |

# Desired Condition

The need for the project is evident when comparing existing site specific conditions with the goals and desired future conditions for Management Area 19 (Indian Valley/Rattlesnake) (USDA 1995, p. 4-158 through 4-160) and the objectives for the Forest Plan management prescriptions and current literature on forest management. The desired future condition for each treatment unit is guided by direction from the LRMP. Specific direction for this project is given for each of the allocations MA III, MA VIII, MA IX.

Management Direction for vegetation management includes that derived from the LRMP (pages 4-4, 4-5, and 4-27) which specifies:

> # 10. Restore fire to its natural role in the ecosystem when establishing the Desired Future Condition of the landscape.
>
> # 11. Achieve a balance of fire suppression capability and fuels management investments that are cost effective and able to meet ecosystem objectives and protection responsibilities.
>
> # 34. Implement practices designed to maintain or improve the health and vigor of timber stands, consistent with the ecosystem needs of the other resources.
>
> # 35. Provide a sustained yield of timber and other wood products to help support the economic structure of local communities and supply regional and national need.
>
> # 36. Provide a sustained supply of firewood for personal use.
>
> e. Emphasize the regeneration harvest of understocked and poorly–growing stands, whether using even or uneven-aged systems. Intermediate cuttings in overstocked stands (thinning) and the salvage of dead and dying trees will also be emphasized.
>
> k. Use commercial thinning to maintain or improve tree health and vigor and to provide a marketable supply of wood products.
>
> l. Timber stand improvement projects will emphasize maintaining and improving growth, and healthy, vigorous trees, through release and thinning.

Specific direction for green-tree and snag retention in Matrix management is also given (LRMP pages 4-61and 4-62).

> 1. Retain at least 15 percent of the area associated with each cutting unit (stand). Only Matrix lands count toward the 15 percent. This limitation does not apply to intermediate harvests (thinning) in even age young stands because leaving untreated portions of young stands will retard stand development and be detrimental to the objective of creating late-successional patches.

Vegetation treatment Prescriptions (LRMP) for management activities for the vegetative conditions on the Salt project include:

- Multi-aged, multi-storied understocked or overmature mixed conifer stands which have had previous partial removal harvest activities.
    - Stands will be treated using LRMP Prescriptions MA III and MA VIII.

- Single-storied intermediate-sized young growth mixed conifer stands which have had previous harvest entries.
    - Stands will be treated using LRMP Prescriptions MA III, MA VIII, and MA IX.
- Single-storied, young growth stands that are the result of site prepared and planted units that were reforested in the 1970's and 80's.
    - Stands will be treated using LRMP Prescriptions MA III, MA VIII, and MA IX.
- Specific areas that have been developed for fuel breaks in the past, and any additional hand treatment area.
    - Stands within the large fuel-break area will be treated using LRMP Prescriptions MA III, MA VIII, and MA XI.
    - Hand treatment for fuels reduction will be treated using LRMP Prescription MA III.

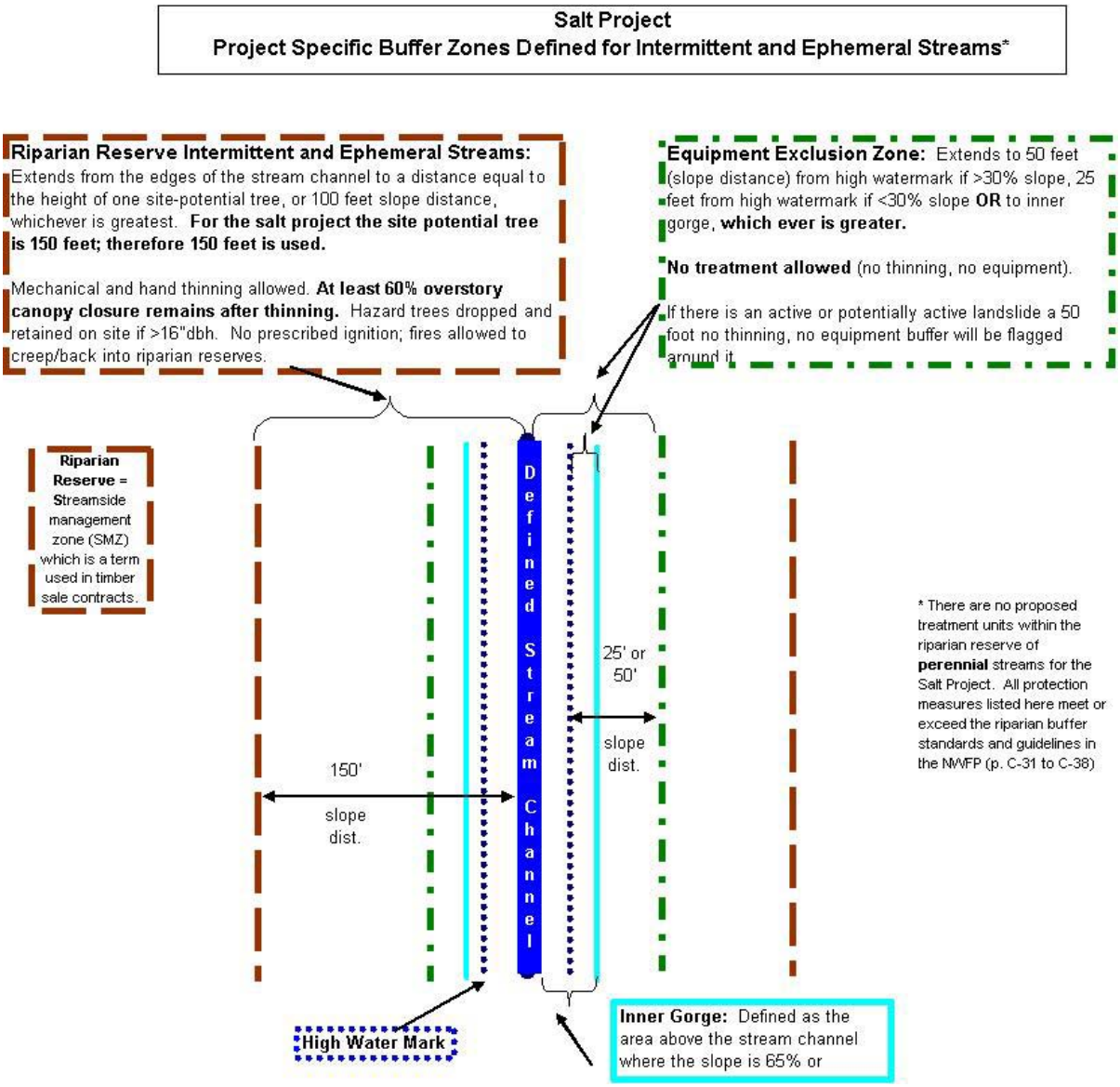
Additional project specific guidance and restrictions are also being applied to this project for activities adjacent to intermittent and ephemeral streams. These restrictions will help maintain or meet Aquatic Conservation Strategy Objectives (Interagency SEIS Team 1994, pp. C30-31). This direction is summarized in table 8.

**Table 8. Summary Table of Project Specific Riparian Restrictions.**

| Stream Class | Stream Type | Hillside Slope (%) | Equipment Exclusion Zone (EEZ) Width (feet) | Riparian Reserve Overstory Canopy Closure (%)* | NWFP and STFP Standard Riparian Reserve Width (feet)** | Salt Project Minimum Riparian Reserve Width (feet)** | Rationale for increase in Riparian Reserve width** |
|---|---|---|---|---|---|---|---|
| I | Perennial stream with fish | [redacted] | [redacted] | [redacted] | 300 | 300 | NA |
| | | | | | 300 | 300 | NA |
| II | Perennial stream with no fish | | | | 150 | 225 | Used 1 ½ site tree distance in order to protect the riparian microclimate for nonfish aquatic animals |
| | | | | | 150 | 225 | |
| III | Intermittent and ephemeral | Slope > 30% | 50 | 60 | 100 | 150 | Average site potential of 200 yr. old tree (150') |
| | | Slope < 30% | 25 | 60 | 100 | 150 | Average site potential of 200 yr. old tree (150') |

** The NWFP standards and guidelines state that for seasonal flowing or intermittent streams, at a minimum, the riparian reserve must include " …extension from the edges of the stream channel to a distance of one site-potential tree, or 100 feet slope distance, whichever is greatest. " (USDA Forest Service and U.S.D.I. Bureau of land Management, 1994, p. C-31) For perennial moonfish bearing streams the NWFP standards and guidelines state that riparian reserves consist of the stream and the area on each side of the stream extending from the edges of the active stream channel to the top of the inner gorge, or to the outer edges of the 100-year floodplain, or the outer edges of riparian vegetation, or to a distance equal to the height of one site-potential tree, or 150 feet slope distance (300 feet total, including both sides from the stream channel), whichever is greatest." (USDA Forest Service and U.S.D.I. Bureau of land Management, 1994, p. C-30)

For this project area the average site potential of a 200 year old tree has been determined to be 150 feet.




# Environmental Consequences

## Alternative 1 – No Action

### *Direct Effects*

None identified.

### *Indirect Effects*

With no action, forest vegetation would continue to decline in vigor and health due to heavy site occupancy (stocking) relative to available resources, primarily water. Mortality in the conifers

would increase, primarily due to increased bark beetle mortality. Down woody fuel loading would increase. Risk to catastrophic stand replacement events such as fire would continue to be high and would increase. Loss of large areas of vegetation would affect water-vegetation relations, with increased risk of downstream flooding events, erosion, or other watershed level impacts.

There would be no harvest of merchantable timber and biomass from the assessment area during this planning period.

Under-stocked and over-mature decadent conifer stands would not be regeneration harvested. The opportunity to move the assessment area toward a regulated condition would be foregone. Net stand growth and yield would continue to be at less than site capacity. The opportunity to provide for increased tree vigor, increased resistance to insects and diseases, and increased growth through conversion to a younger age class would be foregone within these stands. These stands would continue to be at high risk to fires.

Medium-sized, young mixed conifer and ponderosa pine stands would not be thinned. Stand vigor and resistance to insects and diseases would not be improved. Competition for sunlight, nutrients, and soil moisture would continue to increase, stand vigor to decrease, tree growth rates to decrease, and mortality due to competition, insects and diseases to increase. Stand vertical structural diversity would not be maintained or improved. Understory stand components, including hardwoods, would diminish as stand components due to increased overstory competition. The ability of trees to withstand future drought conditions, especially drought sensitive species such as white fir, would decrease. Risk of widespread insect attack, especially from the fir-engraver beetle, western pine beetle, mountain pine beetle and turpentine beetle within the project area would increase. Seral tree species such as ponderosa pine, Jeffery pine and sugar pine would continue to die out of the mixed-conifer stands and they would progress further toward dominance by the climax species, white fir.

In young conifer plantation, riparian areas around ephemeral and intermittent streams would not be thinned. The opportunity to improve stand vigor, tree growth rates, and resistance to insects and diseases would not be realized within the stands. Increasing competition would decrease stand vigor, increase tree mortality, and increase susceptibility to insects and diseases. Stand vertical structural diversity will not be maintained or improved.

Down woody fuels, and fuel ladders would not be reduced. Opportunities to reduce fire risk with the development of fuel breaks and hand fuel work would be foregone.

Stand growth and development following the commercial thinning treatments in Alternatives 2 and 3 below, were modeled for the 3 vegetation strata in the project area in which commercial thinning is being proposed in the action alternatives. In the modeling exercise, treatments are modeled as occurring in the year 2009. For comparison with the alternatives, in Table 9 we display selected strata attributes for the year 2029 and 2059 for the strata with no treatment. We also display the growth in quadratic mean diameter (QMD, Appendix B) for trees larger than 8 inches DBH for the 20 years following treatment and the number of years for the stand to achieve a 30 inch QMD assuming no future stand treatment activities or natural disturbances such as wildfires, insect activity, or windthrow events.

**Table 9. Strata attributes in the year 2029 and 2059.**

| Vegetation Strata | SDI in 2029 | QMD for Trees ≥ 8" DBH in 2029 | Percent Canopy Closure in 2029 | QMD Growth for Trees ≥ 8" DBH in Inches from 2009 to 2029 | QMD for Trees ≥ 8" DBH in 2059 | Percent Canopy Closure in 2059 | Years to achieve 30 inch QMD for Trees ≥ 8" DBH |
|---|---|---|---|---|---|---|---|
| Open M2G | 494 | 16 | 86 | 1.4 | 17 | 78 | >100 |
| Late M3N | 566 | 21 | 80 | 3.3 | 24 | 77 | >100 |
| Open M2N | 555 | 18 | 81 | 3.2 | 22 | 73 | >100 |

# Alternative 2 – Proposed Action

This Alternative is designed to meet land management objectives as identified in the existing Forest Plan and Regional Foresters direction. Stand management prescriptions emphasize the maintenance of stand health and vigor through commercial thinning of younger stands, the regeneration of selected understocked, diseased or over-mature stands, the reduction of fire hazard through fuels treatments and fuel break construction, and precommercial thinning of overstocked young stands.

This proposal will harvest an estimated 9.4 MMBF of merchantable timber and an estimated 15,073 bone dry tons (BDT) of biomass from within the assessment area during the planning period.

The project activities include;

- 984 acres of Intermediate Thinning (Thin from Below), 31 units.
- 27 acres of regeneration harvest with Green Tree Retention, 2 units.
- 31 acres of shelterwood regeneration with Green Tree Retention, 2 units.
- 103 acres of Intermediate Thinning (Reconstructed Shaded Fuel Break), 1 unit.
- 481 acres of precommercial thinning of young stands, 60 units.
- 14 acres of hand fuel treatment.

Some roads, not needed for management, will be decommissioned after the vegetation management is completed. Resource protection measures will include retaining existing snags and down logs greater than 19 " in diameter, unless they need to be felled for safety reasons.

## *Activities Specific to Alternative 2*

### Intermediate Thinning

As described above, timber stands proposed for intermediate thinning are in a condition where there is substantial intertree competition for sunlight, water, growing area and nutrients and competition-related individual tree mortality is imminent. Bark beetle risk can be considered high. The current SDI ranges from 500 to 600 and the desired SDI is 200-250. This level of removal generally equates to a retained basal area of 120-190 sq. ft. /acre.

The objective of this treatment is to improve stand health, vigor and growth rates by removing smaller trees. In this "thinning from below" treatment, smaller trees would generally be removed

to provide reduce competition on larger trees. In the treatment, approximately 50 percent canopy closure (Appendix B) would remain after treatment and generally the largest and healthiest trees would be retained on site. Within the context of a thin-from-below treatment, management objectives involving restoring fire to its natural role, and improving stand health, would mean that at times smaller trees of fire-resistant species-such as ponderosa pine, Jeffery pine, and sugar pine-would be retained over larger non-fire-resistant species-such as white fir-and younger non-diseased trees would be retained over larger diseased trees. Understory hardwood species would be retained as a stand component. Following thinning activities, woody debris would be “treated on site” (Table 12) which could involve a variety of methods, or handpiled and burned. Treatment on site includes any combination of the following depending on site-specific conditions: no additional treatment necessary, cutting down small or un-merchantable trees that would act as ladder fuels, mastication, chipping, lopping and scattering, concentrating fuels and burning concentrations, and under-burning. Mastication reduces forest vegetation in the stand by grinding, shredding or chopping material, and may be used in conjunction with any other fuel treatments. Mastication can lower fuel bed depth, raise crown base height, and increase fuel-ground (soil) contact to promote decomposition of fuels.

Additional guidance will also be in effect for those treatment areas that are identified as Riparian Reserves with non-perennial streams. Restraints are in effect for fuel reduction and equipment activities, and overstory canopy cover will be retained at the 60 percent level or greater (Table 3).

## Regeneration Harvest (Green Tree Retention)

These units are within the matrix-commercial woods products emphasis land allocation in the Forest Plan where “The purpose of this prescription [land allocation] is to obtain an optimum timber yield of wood fiber products from productive forest lands within the context of ecosystem management.” USDA 1995, page 4-67. There is no riparian reserve land allocation in these stands. These are multi-aged, multi-storied understocked or overmature conifer stands that are experiencing high levels of mortality and decadence. The overmature condition of these stands makes them susceptible to increased activity (outbreaks) of insects and disease. Due to the degree of decadence and disease presence, an intermediate treatment (thinning) would not meet management objectives to manage for healthy and vigorous stands. Regeneration of these stands is needed to develop vigorous stands that would be resilient to drought, insects, disease and fire. As requested by the District Ranger, only understocked and overmature stands that needed to be treated in this management cycle (within the next 3 to 20 years) were identified at this time for a regeneration treatment. If the stands are healthy enough to be managed in 20 years or more, or if thinning would effectively move the stand toward desired future conditions they were not included for this treatment.

The treatment objective is to harvest and regenerate these areas to provide stands that are healthy and vigorous with increased resistance to insects and diseases. All merchantable sugar pine, Jeffery pine, ponderosa pine and incense-cedar would be retained in the treatment units unless the tree is in poor health and is not expected to survive for 15 years or more. Hardwoods would also be retained. Green tree retention areas will be maintained on 15% of the unit area to provide older-stand components for late successional species habitat requirements (USDA 1995, page 4-61) and replacement snags (USDA 1995, page 4-14, 4-63). All other trees would be removed.

Adequate large, relatively healthy trees capable of providing seed for natural regeneration do not exist in the stands. Following harvest, fuels reduction and site preparation for artificial regeneration would be by tractor piling of debris followed by burning of the debris piles. The units would be planted with disease-resistant species such as sugar pine, ponderosa pine or

incense cedar the actual species composition used being determined on a unit-specific basis. Either container or bare root stock would be used. The trees would be planted at densities determined on a unit and site-specific basis, and would usually vary between 222 TPA (14' spacing) and 436 TPA (10' spacing). Stocking exams after five years will determine if stocking is adequate to meet Forest Service stocking standards. If stocking is inadequate then the units would be inter-planted.

### Shelterwood Harvest (Green Tree Retention)

These are multi-aged, multi-storied understocked or overmature conifer stands that are experiencing high levels of mortality and decadence. The overmature condition of these stands makes them susceptible to increased activity (outbreaks) of insects and disease. Due to the degree of decadence and disease presence, an intermediate treatment (thinning) would not meet management objectives to manage for healthy and vigorous stands. Large, relatively healthy trees capable of providing seed and shelter for natural regeneration do exist. Shelterwood harvest would regenerate the stands to younger trees that are more resilient to drought, insects, disease and fire.

The treatment objective is to harvest and regenerate these areas to provide stands that are healthy and vigorous with increased resistance to insects and diseases. All merchantable sugar pine, Jeffery pine, ponderosa pine and incense-cedar would be retained in the treatment units unless the tree is in poor health and is not expected to survive for 15 years or more. Poor health could be caused by blister rust infections, disease, insect attacks or weather damage such as lighting or snow breakage.

Hardwoods would also be retained. Green tree retention areas will be maintained on 15% of the unit area to provide older-stand components for late successional species habitat requirements (USDA 1995, page 4-61) and replacement snags (USDA 1995, page 4-14, 4-63). All other trees would be removed.

Following harvest, fuels reduction and site preparation for natural regeneration would be by tractor piling of debris followed by burning of the debris piles. The units would be allowed to naturally regenerate using the residual shelterwood trees as a seed source. Stocking exams would be done to determine if stocking is adequate to meet Forest stocking standards, and if stocking is unsuccessful at the end of 5 years, the units would be planted with disease-resistant species such as sugar pine, ponderosa pine or incense cedar the actual species composition used being determined on a unit-specific basis. Either container or bare root stock would be used. The trees would be planted at densities determined on a unit and site-specific basis, and would usually vary between 222 TPA (14' spacing) and 436 TPA (10' spacing).

### Intermediate Thinning/Shaded Fuelbreak

The objective of a fuelbreak is to act as a point of control for wildfire and prescribed burning activities. Fuelbreaks are typically strips of land about 200-300 feet wide on which vegetation has been modified so that fires burning into these areas are more easily controlled. In this treatment, overstory trees would be thinned to about 40 percent canopy closure and most understory vegetation would be removed. Canopies of the remaining trees would provide enough shade to inhibit ingrowth of brush and understory species. Following the thinning, woody debris would be tractor jackpot piles and burned.

## Precommercial Thinning

Selected young plantations would be thinned to improve stand vigor, increase resistance to insects and disease, and improve growth rates. Plantations that currently have over 400 trees per acre would be reduced to about 150 trees per acre. Large conifers and hardwoods would be retained for species and structural diversity.

## Hand Fuel treatment

This stand would receive a hand fuel treatment activity. No merchantable harvest of larger trees would occur. Fuels would be treated by a combination of handpiling and pile burning to reduce fuel loading to acceptable levels. The objective for treating this stand is to improve stand health, resulting in retained trees that are more vigorous, with improved growth. The resulting stand would be more resilient to drought, insects, disease and fire. Stands would be thinned to about 150 trees per acre, but larger diameter trees would be retained. Suppressed and intermediate crown class trees would be removed if they are providing ladder fuels and contributing to increased fire-hazard. Generally trees less than 10 inches DBH would be thinned.

Breakout of various units, including land allocation, estimated harvest volumes, and proposed treatments under this proposal are included in Tables 10, 11 and 12.

**Table 10. Alternative 2 Individual Unit Characteristics.**

| Unit | Treatment | Ac | MA III Road. Rec. | MA VIII Com. Wood | MA IX Rip. Reserve | Est. Vol (mbf) | Biomass Est.Tons (BDT) | Sub-merch Fuels Treat. | Rough Prescription (species mix of harvested) | Ave. Diam. |
|---|---|---|---|---|---|---|---|---|---|---|
| **1** | Intermediate Thin | 84 | 84 | | | 721 | 1388 | TOS | DF/WF 50%, PP/SP 50% | 15 |
| **2A** | Intermediate Thin | 10 | 9 | | 1 | 94 | 163 | TOS | DF/WF 50%, PP/SP 50% | 16 |
| **2B** | Intermediate Thin | 50 | 47 | | 3 | 353 | 613 | TOS | DF/WF 50%, PP/SP 50% | 16 |
| **2C** | Intermediate Thin | 87 | 79 | | 8 | 609 | 1350 | TOS | DF/WF 65%, PP/SP 35% | 16 |
| **3** | Intermediate Thin | 12 | 9 | | 3 | 106 | 206 | TOS | DF/WF 60%, PP/SP 40% | 14 |
| **4** | Intermediate Thin | 8 | 8 | | | 76 | 132 | TOS | DF/WF 35%, PP/SP 65% | 14 |
| **5** | Intermediate Thin | 19 | 15 | 3 | 1 | 178 | 309 | TOS | DF/WF 50%, PP/SP 50% | 14 |
| **6** | Intermediate Thin | 3 | 3 | | | 25 | 44 | TOS | DF/WF 50%, PP/SP 50% | 17 |
| **7** | Intermediate Thin | 21 | 19 | | 2 | 199 | 345 | TOS | DF/WF 50%, PP/SP 50% | 17 |
| **9A** | Intermediate Thin | 12 | 12 | | | 108 | 188 | TOS | DF/WF 60%, PP/SP 40% | 18 |
| **9B** | Intermediate Thin | 17 | 15 | | 2 | 148 | 258 | TOS | DF/WF 60%, PP/SP 40% | 18 |
| **10** | Intermediate Thin | 24 | 22 | | 2 | 221 | 383 | TOS | DF/WF 60%, PP/SP 40% | 18 |
| **11** | Intermediate Thin | 17 | | 16 | 1 | 158 | 274 | TOS | DF/WF 65%, PP/SP 35% | 17 |
| **12** | Intermediate Thin | 35 | | 33 | 3 | 324 | 562 | TOS | DF/WF 60%, PP/SP 40% | 18 |
| **13** | Intermediate Thin | 9 | 7 | | 2 | 78 | 135 | TOS | DF/WF 60%, PP/SP 40% | 18 |
| **14** | Intermediate Thin | 19 | 19 | | | 173 | 299 | TOS | DF/WF 80%, PP/SP 20% | 18 |
| **17** | Shelterwood with Green Tree Ret. | 15 | 15 | | | 225 | | TSP/BP | DF/WF 50%, PP/SP 50% | 19 |
| **18** | Shelterwood with Green Tree Ret. | 16 | 16 | | | 240 | | TSP/BP | DF/WF 50%, PP/SP 50% | 19 |
| **20** | Intermediate Thin | 19 | 4 | 15 | | 124 | 215 | TOS | DF/WF 50%, PP/SP 50% | 15 |
| **21** | Intermediate Thin | 19 | | 17 | 2 | 164 | 284 | TOS | DF/WF 50%, PP/SP 50% | 17 |
| **22** | Intermediate Thin | 76 | 15 | 61 | | 712 | 1235 | TOS | DF/WF 50%, PP/SP 50% | 18 |
| **25A** | Intermediate Thin | 8 | 8 | | | 75 | 130 | TOS | DF/WF 50%, PP/SP 50% | 18 |
| **25B** | Intermediate Thin | 5 | 5 | | | 51 | 88 | TOS | DF/WF 50%, PP/SP 50% | 18 |
| **25C** | Intermediate Thin | 4 | 4 | | | 40 | 70 | TOS | DF/WF 50%, PP/SP 50% | 18 |
| **25E** | Intermediate Thin | 34 | 34 | | | 321 | 557 | TOS | DF/WF 50%, PP/SP 50% | 18 |
| **26** | Intermediate Thin | 12 | 12 | | | 117 | 203 | TOS | DF/WF 50%, PP/SP 50% | 18 |
| **30A** | Intermediate Thin | 17 | 8 | 9 | | 123 | 309 | TOS | DF/WF 50%, PP/SP 50% | 18 |
| **30B** | Intermediate Thin | 13 | 13 | | | 109 | 189 | TOS | DF/WF 50%, PP/SP 50% | 19 |
| **32** | Intermediate Thin | 138 | 33 | 103 | 2 | 1228 | 2129 | HP/BP | DF/WF 70%, PP/SP 30% | 20 |
| **33A** | Intermediate Thin | 109 | | 103 | 6 | 977 | 1695 | TOS | DF/WF 70%, PP/SP 30% | 20 |
| **33B** | Intermediate Thin | 16 | | 16 | | 147 | 260 | TOS | DF/WF 70%, PP/SP 30% | 20 |
| **33C** | Intermediate Thin | 31 | | 31 | | 287 | 497 | TOS | DF/WF 70%, PP/SP 30% | 20 |
| **36** | Intermediate Thin | 35 | | 33 | 2 | 325 | 564 | TOS | DF/WF 70%, PP/SP 30% | 19 |
| **37** | Green Tree Ret. | 10 | | 10 | | 120 | | TSP/BP | DF/WF 50%, PP/SP 50% | 19 |

| Unit | Treatment | Ac | MA III Road. Rec. | MA VIII Com. Wood | MA IX Rip. Reserve | Est. Vol (mbf) | Biomass Est.Tons (BDT) | Sub-merch Fuels Treat. | Rough Prescription (species mix of harvested) | Ave. Diam. |
|---|---|---|---|---|---|---|---|---|---|---|
| **40** | Green Tree Ret. | 17 | | 17 | | 306 | | TSP/BP | DF/WF 50%, PP/SP 50% | 19 |
| **45** | Shaded Fuel Break | 103 | 46 | 55 | 2 | 103 | | TJP/BP | DF/WF 70%, PP/SP 30%. Thin approx. 40% of canopy closure | 19 |
| | **SUB TOTAL** | **1145** | | | | | | | | |
| | | | | | | | | | | |
| **25D** | Hand Fuel Treatment | 14 | 14 | | | | | HP/BP | DF/WF 50%, PP/SP 50% | |
| **Various** | Precommercial Thin | 481 | | | | | | TOS | | |
| | | | | | | | | | | |
| | | | | | | | | | | |
| | **TOTAL** | **1619** | **575** | **522** | **41** | **9365** | **15073** | | | |
| | | | **51%** | **46%** | **4%** | | | | | |
| | | | | 100% | | | | | | |

* TOS -Treat On Site, removal, chipping, or concentration for burning within treatment units; TSP- Tractor Site Prep; HP - Handpile; TJP - Tractor Jackpot Pile; BB - Broadcast Burn; YUM - Yard Unutilized Material.

**Table 11. Summary of Harvest Activities.**

| Treatments | Acres | Percentage of Treatments |
|---|---|---|
| Intermediate Thinning | 963 | 59% |
| Shelterwood-Green Tree Retention | 31 | 2% |
| Shaded Fuel Break - Thin | 103 | 6% |
| Precommercial Thin | 481 | 30% |
| Hand Fuel Treatment | 14 | 1% |
| Regeneration Harvest Green Tree Retention | 27 | 2% |
| **TOTAL** | **1619** | **100%** |

**Table 12. Summary of Fuel Treatments**

| Treatments | Acres | Percentage of Treatment Acres |
|---|---|---|
| TOS - Treatment on Site | 1306 | 81% |
| TSP/BP- Tractor Site Prep and Burn Piles | 58 | 3% |
| HP/BB/YUM -- Handpile, Broadcast Burn and yard unutilized materials | 0 | 0% |
| HP/BB -- Handpile, Burn piles | 152 | 9% |
| TJP/BP -- Tractor Jackpot Pile and Burn Piles | 103 | 6% |
| **TOTAL** | **1619** | **100%** |

## *Direct Effects*

The direct effect of implementing Alternative 2 would be that the treated areas would be more open with fewer trees. Disease presence would be reduced due to the selective removal of diseased trees. Regeneration treatments would create very open stand areas necessary for the establishment and growth on a new cohort of trees. About 9.4 MMBF of merchantable timber volume would be harvested and 15,073 oven-dry tons of biomass would be available for removal and utilization.

## *Indirect Effects*

Alternative 2 would result in increased growth and yield over time on 14 acres of hand fuel treatment units, 1087 acres of harvest units including the shaded fuelbreak, 58 acres of regeneration and 481 acres of precommercial thinning units. The greatest increases would result from the combination of commercial thinning and non-commercial thinning in the intermediate treatments described above. Residual trees in thinned units would grow in an environment with reduced stress, resulting in decreased competition-related mortality. In addition, the thinned stands would be more resistant to diseases and insects, especially bark beetles, due to increased tree vigor (Appendix B). Post treatment SDI in intermediate thinning units would range from 200 to 250 making the stands resistant to epidemic levels of bark beetles (Oliver and Uzoh 1997). Canopy closure immediately following treatments would be about 50 percent. Stand species composition would be modified to some degree by the treatments because the thinning regimes would favor retaining seral species such as Jeffery pine, ponderosa pine, and sugar pine over white fir. Appendix C displays pre-treatment and post-treatment diameter distributions and species compositions for the M3N stratum. These two figures show how the commercial thinning would reduce stocking in the smaller DBH classes and reduce white fir stocking.

Regeneration treatments would result in increased growth and yield over time on 58 acres because the current stands are slowly growing and the new stands would be young and vigorous with high growth rates. The treatments would also greatly change tree species composition

because most of the white fir, which currently comprises most of the stocking, would be removed and the stands regenerated to Jeffery pine, ponderosa pine, sugar pine and incense cedar.

Stand growth and development following the commercial thinning activity was modeled for the various vegetation strata in the project area and is displayed in Table 13. In the modeling exercise, treatments were modeled as occurring in the year 2009. In Table 13 we display selected strata attributes for the year 2029, 20 years following the thinning treatment and 2059, 50 years following the treatment. We also display the growth in QMD for trees larger than 8 inches DBH for the 20 years following treatment and the number of years for the stand to achieve a 30-inch QMD. In making these future projections we are assuming that no other future activities other than those under the proposed action, and that no natural disturbances such as wildfires, insect activity, or windthrow events would occur.

**Table 13. Alternative 2 future modeled strata attributes.**

| Vegetation Strata | SDI in 2029 | QMD for Trees ≥ 8" DBH in 2029 | Percent Canopy Closure in 2029 | QMD Growth for Trees ≥ 8" DBH in Inches from 2009 to 2029 | QMD for Trees ≥ 8" DBH in 2059 | Percent Canopy Closure in 2059 | Years to achieve 30 inch QMD for Trees ≥ 8" DBH |
|---|---|---|---|---|---|---|---|
| Open M2G | 423 | 23 | 73 | 8.3 | 27 | 86 | 90 |
| Late M3N | 380 | 25 | 62 | 7.7 | 29 | 68 | 70 |
| Open M2N | 344 | 19 | 65 | 4.7 | 21 | 70 | >100 |

Fuel loading and fuel ladder effects in treated stands will be reduced. See fire/fuels report for more details.

Ten routes (29N55A, 30N07, 30N07A, 30N16Y, 30N18C, 30N45A, U29N31E, U30N28F, U30N28H, U36TRIO3B), totaling 9.2 miles, will be decommissioned with Alternative 2 that are considered to provide some, though minor value for future commodity production and or vegetation management access (Table 5, Figure 6 in Chapter 2). Access to all of the units proposed for regeneration or shelterwood harvest with green tree retention with this entry would still exist so no affect to management of these units would occur. Only two of the routes (30N07 and 30N07A) have significant value for access from a commodity output perspective, however closure of these routes will have benefits to water quality and hydrologic processes. The effect of decommissioning these roads would not preclude future vegetation management in the areas accessed by these routes, but it may increase the costs.

## Alternative 3

This Alternative is designed to respond to comments received during scoping. Differences in treatments between Alternative 2 and 3 include the following;

- Alternative 3 would retain approximately 60 percent canopy closure in all thinning units.
- Alternative 3 would not thin dense vegetation within ephemeral and intermittent stream riparian reserves.
- Alternative 3 would not propose treating any regeneration harvest –green tree retention treatments (except for shelterwoods, see below).
- Alternative 3 would not remove or downgrade spotted owl habitat

This proposal would harvest an estimated 3.3 MMBF of merchantable timber and an estimated 4,680 bone dry tons (BDT) of biomass from within the assessment area during the planning period.

The project activities include;

- 850 acres of Intermediate Thinning (Thin from Below), 31 units.
- 30 acres of shelterwood regeneration with Green Tree Retention, 2 units.
- 100 acres of Intermediate Thinning (Reconstructed Shaded Fuel Break), 1 unit.
- 421 acres of precommercial thinning of young stands, 60 units.
- 14 acres of hand fuel treatment.

## *Activities Specific to Alternative 3*

Breakout of various units, including land allocation, estimated harvest volumes, and proposed treatments under this proposal are included in tables 14, 15 and 16.

**Table 14. Alternative 3 Individual Unit Characteristics.**

| Unit | Treatment | Ac | MA III Road. Rec. | MA VIII Com. Wood | MA IX Rip. Reserve | Est. Vol (mbf) | Bio- mass Est. Tons (BDT) | Sub-merch Fuels Treat. | Rough Prescrip. (species mix of harvested) | Ave. Diam. |
|---|---|---|---|---|---|---|---|---|---|---|
| **1r** | Intermediate Thin | 82 | 82 | | | 246 | 870 | TOS | DF/WF 50%, PP/SP 50% | 15 |
| **2Ar** | Intermediate Thin | 9 | 9 | | | 18 | 100 | TOS | DF/WF 50%, PP/SP 50% | 16 |
| **2Br** | Intermediate Thin | 44 | 44 | | | 132 | 500 | TOS | DF/WF 50%, PP/SP 50% | 16 |
| **2Cr** | Intermediate Thin | 74 | 74 | | | 222 | 950 | TOS | DF/WF 65%, PP/SP 35% | 16 |
| **3** | Intermediate Thin | 7 | 7 | | | 21 | 130 | TOS | DF/WF 60%, PP/SP 40% | 14 |
| **4** | Intermediate Thin | 8 | 8 | | | 24 | | TOS | DF/WF 35%, PP/SP 65% | 14 |
| **5r** | Intermediate Thin | 17 | 15 | 2 | | 51 | | TOS | DF/WF 50%, PP/SP 50% | 14 |
| **7r** | Intermediate Thin | 17 | 17 | | | 34 | 220 | TOS | DF/WF 50%, PP/SP 50% | 17 |
| **9Ar** | Intermediate Thin | 11 | 11 | | | 44 | 120 | TOS | DF/WF 60%, PP/SP 40% | 18 |
| **9Br** | Intermediate Thin | 13 | 13 | | | 039 | 170 | TOS | DF/WF 60%, PP/SP 40% | 18 |
| **10r** | Intermediate Thin | 19 | 19 | | | 38 | 240 | TOS | DF/WF 60%, PP/SP 40% | 18 |
| **11r** | Intermediate Thin | 15 | | 15 | | 45 | | TOS | DF/WF 65%, PP/SP 35% | 17 |
| **12r** | Intermediate Thin | 30 | | 30 | | 90 | | TOS | DF/WF 60%, PP/SP 40% | 18 |
| **13r** | Intermediate Thin | 6 | 6 | | | 12 | 90 | TOS | DF/WF 60%, PP/SP 40% | 18 |
| **14** | Intermediate Thin | 19 | 19 | | | 76 | 260 | TOS | DF/WF 80%, PP/SP 20% | 18 |
| **17** | Shelterwood-Green Tree Ret. | 15 | 15 | | | 158 | | TSP/BP | DF/WF 50%, PP/SP 50% | 19 |
| **18r** | Shelterwood-Green Tree Ret. | 15 | 15 | | | 158 | | TSP/BP | DF/WF 50%, PP/SP 50% | 19 |

| Unit | Treatment | Ac | MA III Road. Rec. | MA VIII Com. Wood | MA IX Rip. Reserve | Est. Vol (mbf) | Bio- mass Est. Tons (BDT) | Sub-merch Fuels Treat. | Rough Prescrip. (species mix of harvested) | Ave. Diam. |
|---|---|---|---|---|---|---|---|---|---|---|
| **20r** | Intermediate Thin | 18 | 3 | 15 | | 54 | | TOS | DF/WF 50%, PP/SP 50% | 15 |
| **21r** | Intermediate Thin | 16 | | 16 | | 48 | | TOS | DF/WF 50%, PP/SP 50% | 17 |
| **22r** | Intermediate Thin | 74 | 13 | 61 | | 148 | | TOS | DF/WF 50%, PP/SP 50% | 18 |
| **25A** | Intermediate Thin | 8 | 8 | | | 40 | 130 | TOS | DF/WF 50%, PP/SP 50% | 18 |
| **25B** | Intermediate Thin | 5 | 5 | | | 10 | 50 | TOS | DF/WF 50%, PP/SP 50% | 18 |
| **25C** | Intermediate Thin | 4 | 4 | | | 10 | 40 | TOS | DF/WF 50%, PP/SP 50% | 18 |
| **25E** | Intermediate Thin | 34 | 34 | | | 102 | 340 | TOS | DF/WF 50%, PP/SP 50% | 18 |
| **26** | Intermediate Thin | 12 | 12 | | | 36 | 170 | TOS | DF/WF 50%, PP/SP 50% | 18 |
| **30A** | Intermediate Thin | 17 | 8 | 9 | | 51 | 170 | TOS | DF/WF 50%, PP/SP 50% | 18 |
| **30B** | Intermediate Thin | 13 | 13 | | | 39 | 130 | TOS | DF/WF 50%, PP/SP 50% | 19 |
| **32Ar** | Intermediate Thin | 81 | 33 | 48 | | 405 | | HP/BP | DF/WF 70%, PP/SP 30% | 20 |
| **32Br** | Intermediate Thin | 32 | | 32 | | 160 | | HP/BP | DF/WF 70%, PP/SP 30% | 20 |
| **33Ar** | Intermediate Thin | 97 | | 97 | | 485 | | TOS | DF/WF 70%, PP/SP 30% | 20 |
| **33B** | Intermediate Thin | 16 | | 16 | | 32 | | TOS | DF/WF 70%, PP/SP 30% | 20 |
| **33Cr** | Intermediate Thin | 21 | | 21 | | 84 | | TOS | DF/WF 70%, PP/SP 30% | 20 |
| **36** | Intermediate Thin | 31 | | 31 | | 93 | | TOS | DF/WF 70%, PP/SP 30% | 19 |
| **45r** | Shaded Fuel Break | 100 | 45 | 55 | | 100 | | TJP/BP | DF/WF 70%, PP/SP 30%. Thin approx. 40% of canopy closure | 19 |

| Unit | Treatment | Ac | MA III Road. Rec. | MA VIII Com. Wood | MA IX Rip. Reserve | Est. Vol (mbf) | Bio- mass Est. Tons (BDT) | Sub-merch Fuels Treat. | Rough Prescrip. (species mix of harvested) | Ave. Diam. |
|---|---|---|---|---|---|---|---|---|---|---|
| | **SUB TOTAL** | **980** | | | | | | | | |
| | | | | | | | | | | |
| **25D** | Hand Fuel Treatment | 14 | 14 | | | | | HP/BP | DF/WF 50%, PP/SP 50% | |
| **Various** | Precommercial Thin | 421 | | | | | | TOS | | |
| | | | | | | | | | | |
| | | | | | | | | | | |
| | **TOTAL** | **1415** | **548** | **446** | | **3305** | **4680** | | | |
| | | | **55%** | **45%** | | | | | | |
| | | | | 100% | | | | | | |

* TOS -Treat On Site, removal, chipping, or concentration for burning within treatment units; TSP- Tractor Site Prep; HP - Handpile; TJP - Tractor Jackpot Pile; BB - Broadcast Burn; YUM - Yard Unutilized Material.

**Table 15. Summary of Treatment Activities.**

| Treatment | Acres | Percentage of Treatments |
|---|---|---|
| Intermediate Thinning Commercial Harvest | **622** | **44%** |
| Int. Thin Biomass Removal only (no merch timber removal) | **228** | **16%** |
| Shaded Fuel Break - Thin | **100** | **7%** |
| Precommercial Thin | **421** | **30%** |
| Hand Fuel Treatment | **14** | **1%** |
| Shelterwood Harvest Green Tree Retention | **30** | **2%** |
| **TOTAL** | **1,415** | **100%** |

**Table 16. Summary of Fuel Treatments**

| Treatment | Acres | Percentage of Treatments |
|---|---|---|
| TOS - Treatment on Site | **1158** | **82%** |
| TSP/BP- Tractor Site Prep and Burn Piles | **30** | **2%** |
| HP/BB/YUM -- Handpile, Broadcast Burn and yard unutilized materials | **0** | **0%** |
| HP/BB -- Handpile, Burn piles | **127** | **9%** |
| TJP/BP -- Tractor Jackpot Pile and Burn Piles | **100** | **7%** |
| **TOTAL** | **1415** | **100%** |

## *Direct Effects*

The desired future condition of the vegetation and management objectives for the project area would be only partially achieved with this alternative. Post-treatment SDIs in the intermediate thinning units would range from about 265 to 402. Stands in the M2G (265 SDI) and M3N (294 SDI) strata would be below the zone of imminent mortality and into the zone of “full site occupancy.” Stands in the M3N stratum would still be somewhat at risk to bark beetles. Stands in the M2N stratum-with the 402 post-treatment SDI-would still be in the zone of imminent mortality and could be considered at a high risk to insect activity.

By maintaining 60 percent canopy closure in all intermediate thinning stands, many units would have few, if any, dominant or co–dominant trees thinned because the thin-from-below treatment would meet the minimum 60 percent canopy closure before having to do so. These units would only receive minimal ladder fuel reduction. This also applies to Unit 45, the shaded fuelbreak.

Most precommercial thinning activities would be precluded as well, since most stands are currently below 60 percent canopy closure. Those that are over 60 percent canopy closure are only slightly over, and pre-commercial thinning them to 60 percent canopy closure would accomplish very little stocking reduction. None of the pre-commercial thinning stands would be thinned to 150 TPA.

In this alternative an estimated 3.3 MMBF of timber volume would be harvested and 4,680 BDT of biomass would be available for removal.

Two regeneration units (37, 40), portions of units 32 and 33C, riparian reserves and unit 6 would not be treated in Alternative 3, resulting in 204 acres not being treated for disease and insect concerns. Thirty acres would receive a shelterwood regeneration treatment and so would be naturally regenerated to young and vigorous stands.

## *Indirect Effects*

Alternative 3 would result in increased growth and yield over time on 14 acres of hand fuel treatment, 950 acres of harvest units including the shaded fuelbreak, 30 acres of regeneration and 421 acres of precommercial thinning units. Due to the relatively light nature of the thinning treatments, the increases would be relatively moderate and short-term. This condition would exist in both harvest units and pre-commercial thinning units. Stand species composition would be modified to some degree by the treatments because the thinning regimes would favor retaining seral species such as Jeffery pine, ponderosa pine, and sugar pine over white fir.

Regeneration treatments would result in increased growth and yield over time on 30 acres because the current stands are slowly growing and the new stands would be young and vigorous with high growth rates. The treatments would also greatly change tree species composition because most of the white fir, which currently comprises most of the stocking, would be removed and the stands regenerated to Jeffery pine, ponderosa pine, sugar pine and incense cedar.

Stand growth and development following the commercial thinning activity was modeled for the various vegetation strata in the project area. As above, treatments were modeled as occurring in the year 2009. In Table 17 we display selected strata attributes for the year 2029, 20 years following the thinning treatment and 2059, 50 years following the treatment. We also display the growth in QMD for trees larger than 8 inches DBH for the 20 years following treatment and the number of years for the stand to achieve a 30-inch QMD. In making these future projections we are assuming that no other future activities other than those under the proposed action, and that no natural disturbances such as wildfires, insect activity, or windthrow events would occur.

**Table 17. Alternative 3 future modeled strata attributes.**

| Vegetation Strata | SDI in 2029 | QMD for Trees ≥ 8” DBH in 2029 | Percent Canopy Closure in 2029 | QMD Growth for Trees ≥ 8” DBH in Inches from 2009 to 2029 | QMD for Trees ≥ 8” DBH in 2059 | Percent Canopy Closure in 2059 | Years to achieve 30 inch QMD for Trees ≥ 8” DBH |
|---|---|---|---|---|---|---|---|
| Open M2G | 526 | 20.3 | 80 | 2.8 | 24 | 87 | >100 |
| Late M3N | 508 | 22.4 | 77 | 3.1 | 27 | 75 | >100 |
| Open M2N | 507 | 17.1 | 74 | 2.9 | 19 | 82 | >100 |

## *Cumulative Effects*

As with the direct and indirect effects, the cumulative effects analysis area being considered is the 4,278 acre project area. The baseline year used for this analysis is the year 2008 as the existing condition. In this analysis, all past activities and events are included in the existing condition description. In the cumulative effects analysis below, cumulative effects are discussed as changes in the existing condition due to present and future activities, including the effects of the alternative being discussed. In the discussion below, “short-term” effects refers to effects over the 20-year period from the time the activity was accomplished. Beyond 20-years we will be considering effects as “long-term.”

In the project area, there are no present projects to consider. The only foreseeable project in the project area that may involve tree thinning is a 14-acre precommercial thin proposed as part of the Hayfork Forest Health #2 project.

Alternative 2 would contribute to meeting LRMP goals. Under this alternative, about 32 percent of the forested area outside of young plantations would be thinned or regenerated. About 94 percent of the young plantations would be thinned by the Salt project, and with the additional 14 acres mentioned above, about 97 percent of the young plantations would be thinned. Growing conditions for residual trees will be improved and sustained over the next 20-years, decreasing insect risk, disease impacts and growing larger trees faster. Long-term effects would be increased growth and yield of timber products and presence of large trees.

Alternative 3 would also contribute to meeting LRMP goals, but to a lesser degree than Alternative 2. Under this alternative, about 27 percent of the forested area outside of young plantations would be thinned or regenerated. About 83 percent of the young plantations are included as proposed for thinning, by the Salt project, but due to canopy closure constraints, very little would be accomplished of that area. With the additional 14 acres mentioned above, about 85 percent of the young plantations are proposed, but the 14 acres of the Hayfork project may be the only acreage thinned resulting in only 2 percent of the plantations being substantially thinned. Growing conditions for residual trees will be improved by intermediate thinning activities, but the thinning effects would largely not be sustained over the next 20-years. Insect risk and disease impacts would be reduced by the thinning treatments for a lesser period of time. Tree growth would be accelerated, but to a much lesser degree than in Alternative 2. Stands within the project area would continue to produce less than the desired growth and yield and long-term effects would not be great.

## Alternative Comparison

In this section, we summarize and compare the three alternatives in terms of management direction and purpose and need objectives.

In Table 18, we compare the three alternatives in terms of how they are meeting the forest health and timber production objectives stated above. Alternative 2 would meet the objective of thinning stands to a stand density index of approximately 200-250 on 1087 acres of intermediate thinning where the other two alternatives would not. In Alternative 1 no thinning would be done. Alternative 3 would propose intermediate thinning on 950 acres, but as shown in Table 19, the thinning regime would not totally achieve the objective.

Alternative 2 would thin a substantial acreage of overstocked plantations. Alternative 3 proposes pre-commercial thinning in 421 acres of plantations, however, as discussed above, meeting a minimum 60 percent canopy closure in these treatments would mean that the treatments would not occur or if they did, the treatment would do little to reduce stocking. None of the Alternative 3 precommercial thin treatments would reduce stocking in the plantations to the desired 150 TPA. Alternative 1 would not thin any overstocked plantations.

No area considered too heavily diseased, over-mature, or understocked with manageable stocking to warrant being thinned would be regenerated in Alternative 1, whereas both action alternatives propose regeneration treatments with Alternative 2 proposing almost twice the area as Alternative 3.

Under Alternative 1 no wood products would be produced. Alternative 2 and 3 would both produce merchantable timber and utilizable biomass with Alternative 2 proposing to remove substantially more than Alternative 3.

**Table 18. Comparison of alternatives in meeting the forest health and timber production objectives for this project**

| Purpose and Need Objective | Alternative 1 | Alternative 2 | Alternative 3 |
|---|---|---|---|
| **Improve Forest Health and Resiliency** | | | |
| ▪ Acres of overstocked stands thinned to a stand density index of approximately 200-250. | 0 | 1087 | 0 |
| ▪ Acres of overstocked plantations thinned to approximately 150 trees per acre. | 0 | 481 | 0 |
| ▪ Acres regenerated that are currently not meeting growth and yield potential due to heavy pathogen impacts. | 0 | 58 | 30 |
| **Provide timber products** | | | |
| ▪ Merchantable timber harvested (MMBF) | 0 | 9.4 MMBF | 3.3 MMBF |
| ▪ Merchantable biomass harvested (bone dry tons- BDT) | 0 | 15,073 tons | 4,680 tons |

Table 19 displays the current condition SDI, post-intermediate thinning SDI for both action alternatives, and SDIs in the year 2029 for the three major forested strata involved. Under Alternative 1, stocking would not be reduced in any strata. The stands would remain in the zone of imminent mortality and could be considered to be at high risk to bark beetles and to have relatively low resistance to diseases. In Alternative 2, stand stocking would be lowered and would be considered at or a little within the zone of imminent mortality (greater than 55% of maximum SDI) by the year 2029. However, stocking would still be considerably less than the current condition, and tree vigor, growth rates, and resistance to insects and disease would still be higher than before the treatment. In Alternative 3, stand stocking would be lowered by the treatments to a lesser degree than in Alternative 2. In Alternative 3, post-treatment SDI would be below the zone of imminent mortality in M2G and M3N strata, but would still be within the zone of imminent mortality in the M2N stratum. By 2029, Alternative 3 stocking would be well within the zone of imminent mortality and tree vigor, growth rates, and insect and disease resistance, would be close to the current condition. Note that in Alternative 1 M2G, with the default values for maximum SDI in the variant used, the M2G species composition and diameter distribution, plus site factors, FVS considers the M2G stand stocking to be very high and reduces the stocking by 2029 through modeled mortality.

Given the stocking levels in Table 19, we can say that the intermediate thinning in Alternative 2 adequately meets Regional Forester’s direction to ensure that density does not exceed a desired upper limit, in this analysis the zone of imminent mortality which is 55% of maximum SDI (Appendix B). We can also say that the regeneration treatments would not need additional treatments for at least 20 years, their next potential treatment being a pre-commercial thin, and we can say that the pre-commercial thinned units would not need an additional treatment for at least 20 years, their next potential treatment being a commercial thin. In Alternative 3, the regeneration treatments would, as in Alternative 2, not need additional treatment for 20 years. The proposed precommercial thinning would not accomplish any stocking control objective and would need treatment within 20 years, and although the intermediate thinning treatments do decrease stocking from the current condition, they would also need additional treatment within 20 years to continue meeting the same objectives.

**Table 19. Intermediate thinning strata stand density index post-thinning and in 2029.**

| | Alt 1 (No Action) | Alt 1 | Alt 2 | Alt 2 | Alt 3 | Alt 3 |
|---|---|---|---|---|---|---|
| **Vegetation Strata** | **SDI in 2008 (current condition)** | **SDI in 2029** | **SDI in 2009** | **SDI in 2029** | **SDI in 2009** | **SDI in 2029** |
| Open M2G | 590 | 494 | 200 | 423 | 265 | 526 |
| Late M3N | 548 | 566 | 250 | 380 | 294 | 508 |
| Open M2N | 492 | 555 | 250 | 344 | 402 | 507 |

Reducing stocking increases tree growth, resulting in increased yield of commercial wood products and reduces the time required to meet wildlife habitat objectives involving large trees. Table 20 displays the QMD for all trees greater than or equal to 8 inches DBH for all alternatives in the year 2029 as well as the increase in QMD for those trees from 2009 to 2029. Both action alternatives would increase tree growth rates over Alternative 1, with Alternative 2, due to the heavier thinning regimes proposed, substantially higher than Alternative 3.

**Table 20. Intermediate thinning strata QMD in 2029, QMD growth from 2009-2029.**

| | Alt 1 | Alt 2 | Alt 3 | Alt 1 | Alt 2 | Alt 3 |
|---|---|---|---|---|---|---|
| **Vegetation Strata** | **QMD for Trees ≥ 8" DBH in 2029** | **QMD for Trees ≥ 8" DBH in 2029** | **QMD for Trees ≥ 8" DBH in 2029** | **QMD Growth for Trees ≥ 8" DBH in Inches from 2009 to 2029** | **QMD Growth for Trees ≥ 8" DBH in Inches from 2009 to 2029** | **QMD Growth for Trees ≥ 8" DBH in Inches from 2009 to 2029** |
| Open M2G | 16 | 23 | 20.3 | 1.4 | 8.3 | 2.8 |
| Late M3N | 21 | 25 | 22.4 | 3.3 | 7.7 | 3.1 |
| Open M2N | 18 | 19 | 17.1 | 3.2 | 4.7 | 2.9 |

# Compliance with the Forest Plan and Other Regulatory Direction

Alternative 1 (No action) does not meet the identified purpose and need to maintain and improve the health and vigor of forested areas and reduce the risk of stand replacing fires consistent with the ecosystem needs of other resources (USDA Forest Service, 1995).

## *Findings Pertinent to NFMA, Certification of Stocking and CMAI*

### Timber Harvest on Lands Classified as not suited for Timber Harvest (36 CFR 219.27c1).

All stands proposed for harvest treatment under all alternatives are classified as suitable.

### Adequate Restocking of Lands within 5 Years after Final Harvest. (16USC 1604g 3e ii and 36CFR 219.27c3)

Reforestation will occur within five years of final harvest. Any stand that receives any harvest activity will not be maintained as a permanent opening and will be fully stocked, or can be adequately restocked with natural regeneration within 5 years of harvest. Any live green trees retained on each unit will serve as seed sources where regeneration is inadequate.

### Timber Resource Sale Schedule-Culmination of Mean Annual Increment. (36 CFR 219.16a2iii).

Regulations require that all even-aged stands scheduled to be harvested during the planning period generally have reached the culmination of mean annual increment (CMAI). The CMAI

requirement is applicable to actual even-aged stands that are being managed by even-aged treatment methods for timber purposes. In general, stands scheduled for regeneration cut for timber purposes have reached CMAI. The regulation goes on to say that "…exceptions to these standards are permitted for the use of sound Silvicultural practices, such as thinning or other stand improvement measures; for salvage or sanitation harvesting…"

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# Appendix A – Models and Assumptions

## Forest Vegetative Simulator/Fire Fuels Extension

The Forest Vegetation Simulator (FVS) was developed in the early 1970's as the "Prognosis" model (Stage 1973). Since that time, FVS has undergone continual and continuing research and development efforts to expand FVS's range and capabilities, validate, update, and modify FVS's predictions, and increase the FVS program's usefulness and usability. Over the last three decades, the USDA Forest Service has invested a substantial amount annually on research and development of FVS. For the Fiscal Year 2008 the Forest Service budget for FVS staff alone was about $653,000 (Havis 2008). An additional uncounted millions has also probably been spent by other entities such as universities, other countries, and private industry on development and validation efforts.

Currently, the FVS is used almost exclusively by the USDA Forest Service, and is used heavily by other US government agencies such as the Bureau of Land Management, Bureau of Indian Affairs, Park Service, Geological Survey, Department of Defense, and Department of Energy (Dixon 2008, USDA 2008a). Most state departments of natural resources utilize FVS and it is heavily used in the private forestry sector. Most major university forestry programs in the US teach the use of FVS.

International use of FVS includes use in the Canadian provinces of British Columbia, Ontario, Alberta and Nova Scotia. FVS is also being used, or variants are being developed for use in Russia, China, Austria, South Korea, Japan, Costa Rica, Portugal, Indonesia, and the United Kingdom as well as other European countries.

Over the last several decades, the Forest Vegetation Simulator has become the most used forest vegetation modeling program in the US and the world.

The Forest Vegetation Simulator is the product of hundreds of contributors over the past three decades (Dixon 2007). It is not a single growth and yield "model" but consists of a number in integrated models including those for predicting large-tree height and diameter increment, small-tree height and diameter increment, tree mortality, crown change, tree regeneration establishment, shrub development, shrub and tree vertical canopy distribution, mountain pine beetle risk, Douglas-fir tussock moth hazard and impacts, economic analysis, western spruce budworm hazard and impacts, western root disease impacts, dwarf mistletoe impacts, white pine blister rust impacts, and fire effects.

The Forest Vegetation Simulator has expanded its range of applicability from its original Northwest US roots through the creation of "geographic variants" that utilize research from various geographic regions of the US to tailor equations such as those for tree growth, mortality and volume to those regions. There are currently over 20 variants representing forests within the US. In developing some the variants, the Forest Vegetation Simulator has evolved from a growth and yield model into a framework supporting regional models such as TWIGS (Miner, Walters, and Belli 1988) and GENGYM (Edminster et al.1991) further incorporating the extensive research undertaken in developing these models into FVS.

Since FVS uses stand exam data, geographical variant equations for growth are further calibrated using the stand data. This, coupled with the use of site variables such as slope, aspect, elevation, habitat type, plant association, or ecoclass code, location (nearest National Forest, and in some cases Ranger District), site index, and stand density index maximums or basal area maximums

and tree measurements such as species, diameter-at-breast-height, total tree height, tree height to a dead or broken top, diameter increment, age, crown ratio, and damages or diseases enables FVS to make very accurate predictions.

Dixon (2006) describes FVS as “a semi-distant-independent individual tree growth and yield model”. He considers it semi-distant-independent because certain parts of the model localizes competition and site variables to a plot (or point) basis within a stand where other parts do not. Because FVS uses stand exam data, it keeps track of the plot on which trees are located enabling the user to simulate group selection or differentially treat a stand based on density within a stand. One must realize when one is modeling treatment simulations based upon plots that although the plots may be modeled independently in FVS, the FVS outputs will still be showing the average of all trees on all plots. Portions of the FVS that do not model on a plot basis are the VSS classification module and the Fire and Fuels Extension.

Fire effects are modeled in FVS through the Fire and Fuels Extension (FFE) which simulates fuel dynamics and potential fire behavior over time in the context of stand development and management (Reinhardt and Crookston 2003). The FFE uses existing fire fuel models for fire behavior and effects and adds new submodels for snag and fuel dynamics. The FFE uses Rothermel’s (1972) fire behavior model as implemented by Albini (1976) in FIREMOD and subsequently by Andrews (1986) in Behave to predict fire intensity, approaches developed by Van Wagner (1973, 1977) and Scott and Reinhardt (2001) to predict the onset of crowning, and methods from FOFEM (Reinhardt and others 1997) for predicting tree mortality, fuel consumption and smoke production.

In this analysis we used stand exam data collected during 2008 in selected analysis area stands. Stands were sampled in the M2G, M2P, M3G, M3P, XX1 and XX2 vegetation strata. Since more than one stand was sampled in each strata, using FVS we modeled current and future conditions for each stand and averaged the results for strata averages.

With FVS we modeled proposed tree removals (thinning) to occur in the year 2009. We modeled fuels characteristics that is, crown bulk density, stand height, and crown base height, and changes in those fuels characteristics due to treatments using FVS-FFE. We used those modeled characteristics along with other weather and fuel model parameters to model fire characteristics using FlamMap (Lewis 2008).

## FlamMap

FlamMap (Finney 2006) is a fire behavior mapping and analysis program that computes potential fire behavior characteristics (spread rate, flame length, fireline intensity, etc.) over landscapes. It uses as input constant weather and fuel moisture conditions, fuel models, fuels variables such as crown bulk density, canopy base height, stand height, and percent canopy cover, and topographic variables such as elevation, percent slope, and aspect.

## Limitations of the Models

“It should be noted a model is a simplification or approximation of reality and hence will not reflect all of reality (Stratton 2006). The use of models such as FVS depends upon sample data, validity of the model itself and assumptions made by the modeler. All three affect the results. The use of FVS in this analysis is to generally characterize and display existing conditions and the nature and magnitude of treatment effects to support decisions to be made. The modeling results are not to be taken as reality, although effort is taken during the modeling exercise to make the

exercise reflect reality. In the growth and yield modeling for this analysis, we allowed the FVS program to use the default parameters for maximum SDI and plant associations. The default parameters are developed for the variant of FVS from data collected in the area the variant is tailored for, but can be modified for individual stands if the site (e.g. plant association, slope, aspect, elevation) and tree-specific (e.g. diameter growth increment, height growth increment) information is available. Using the default parameters probably led to some differences in predicted growth and mortality than if we had available and used more site-specific data for those parameters, however the differences would not be to the degree that they would change the effects of treatment and non-treatment described in the analysis.

# Appendix B – Silvicultural Terms and Concepts

## Percent Canopy Cover and Canopy Closure

The terms “canopy cover” and “crown cover” are synonymous as are the terms “canopy closure” and “crown closure”, however canopy cover and canopy closure are not the same. Unfortunately over time these terms have often been used as if they were the same, resulting in some confusion. We attempt in the following discussion to clarify these terms and how they are being used in this analysis.

A number of means to measure and model forest canopy density have been developed over the years. The means to measure and model most of the time do not produce the same values and some argue that some of the means to measure and model are not directly comparable because they are measuring or modeling two different things. Jennings et al. (1999) discusses the two basic ways of measuring forest canopies. The first way is to measure “canopy closure” which is the proportion of the sky hemisphere obscured by vegetation when viewed from a single point. Canopy closure is often called “canopy density.” The opposite of canopy closure is often called the “canopy openness” which is the proportion of the sky hemisphere not obscured by vegetation. The second way is to measure “canopy cover” which is the proportion of the forest floor (as a horizontal surface) covered by the vertical projection of the tree crowns.

Instruments such as spherical densiometers, hemispherical photography, and moosehorns measure canopy closure. Instruments such as sighting tubes—with which the operator looks straight up and measures coverage at a point—can be used to measure canopy cover. The line-intercept method in which the proportion of a transect length is under a vertical projection of the tree crowns is measured can also be used to measure canopy cover, and can be expected to provide the least-biased, most accurate estimates of vertical canopy cover (Fiala et al. 2006). FVS models percent canopy cover by computing crown width and area for each tree in the stand dataset, randomly locating the trees on a “virtual forest” and then computing and subtracting crown overlap (Crookston and Stage 1999). Remote sensed data can represent canopy cover or closure through analysis of reflectance values and the relationship between those reflectance values and canopy covers or closures measured on training sites or modeled from training site exam data. What values the remote sensed data represents depends upon what was measured or modeled and how it was measured or modeled when the remote sensed layer was developed. In CALVEG’s tree density classification, the training site data was acquired by measuring canopy cover through aerial photo interpretation.

In using any measurement technique there is always some variation in the measurements and operator bias. One instrument commonly used but found to be difficult to use without a great deal of variation and bias is the spherical densitometer (Cooke et al. 1995). Cooke et al. (1995) found concave and convex spherical densiometers to produce similar results, but that they “overestimated cover substantially, and were insensitive to substantial variations in forest cover.” They also concluded that: “Spherical densiometers are not suitable for estimating forest cover for most applications in forest ecology and management.” Ganey and Block (1994) also found the accuracy and precision of spherical densiometers to be “questionable.” Bunnell and Vales (1989) compared 13 techniques for measuring canopy closure and found a degree of observer bias but mostly the values and variation produced by the techniques varied due to the width of the angle of view in which forest canopy coverage was being measured. They found that with increasing angle of view, mean estimates increased and the standard deviation decreased, which they attributed to the wider angles of view being less likely to encounter open spaces with no canopy. They

describe two consequences of using techniques with a wide angle of view: (1) the potential role of small gaps in canopy is masked, and (2) object not directly above the point are included as overstory cover and what is recorded is an angular view of the canopy, including much of the depth of the surrounding tree crowns. Moosehorns have a 10.2 degree angle of view and spherical densiometers have about a 60 degree angle of view.

Fiala et al. (2006) compared five means of measuring forest canopies, including means that measured closure (moosehorn, densitometer, hemispherical photography) and cover (line-intercept) as well as FVS's computed canopy cover. They found that FVS produced values less than all other methods for five forest stand structures: unthinned, lightly thinned, and heavily thinned young stands (38-52 years old), mature stands (120-180 years) and old-growth (>250 years). Fiala et al. (2006) showed the difference between FVS modeled canopy cover and measured canopy closure to be an average of 14.05 percentage points lower than closure values for young light-thin stands and an average of 23.73 percentage points for mature forest. In this analysis, the M2G and M2N strata fit within the young light-thin forest described in Fiala et al. (2006) in terms of TPA and BA stocking although they do have some trees older than the age range cited in Fiala et al. (2006). The M3N stratum fits within the mature forest description in Fiala et al. (2006) in terms of TPA and BA stocking and the stratum is dominated by trees within the age class range. The Fiala et al. (2006) study was in Douglas-fir, western hemlock, western redcedar forest type which is a different species composition from the white fir, Douglas-fir, pine forests in the Salt project area. A comparison of crown widths for western hemlock and western redcedar computed from the West Cascades FVS variant (USDA 2008b) and white fir from the Inland California variant (USDA 2009b) under similar stocking levels shows that modeled crown widths for the white fir for 10 to 20 inch DBH trees to be about 70 percent of the western redcedar and western hemlock of the Filal et al. (2006) study area. A comparison of Douglas-fir crown widths in the two areas shows them to be about equal. In this analysis, we are using FVS's modeled canopy cover to model thinning activity effects on forest canopy density by adjusting the modeled canopy cover values to better display and discuss forest density in terms of canopy closure. We are adjusting the FVS canopy cover up 10 percentage points, which is 71 to 42 percent of the differences Fiala et al. (2006) found. This "conservative" approach would underestimate estimated canopy cover and so would maintain canopy closures higher than the minimum 50 percent canopy closure prescribed for Alternative 2 and minimum 60 percent canopy closure prescribed for Alternative 3.

## Tree Stocking and Bark Beetle Hazard

There are a number of measures of tree stocking levels; some that are very easy to measure and apply, and others that are very difficult to measure and apply. When prescribing a stocking level, foresters generally attempt to take into account a number of factors including site quality, tree size, and tree numbers. The simplest measures of stocking--trees per acre (TPA) and basal area (BA), which is the cross sectional area of the trees at 4.5 feet from ground level expressed in terms of square feet per acre--are commonly used by foresters for stand-level prescriptions and marking guides because they are the easiest to measure and implement. When prescribing a stocking level for a stand in terms of BA or TPA, a forester has already taken into account factors such as site quality, tree species, and tree sizes. It is very difficult, however, to use these measures when making prescriptions for multiple stands or for landscape-level stocking recommendations because diameter distributions (tree sizes) and site quality within and between stands vary. These measures alone give little information as to what the forester is fundamentally managing, that is, how site resources are being utilized and allocated. These simple measures, without additional information of tree size, can be very biased when used to determine how site resources are being

used. For example, a stand of 100 TPA that are 10 inches in diameter at breast height (DBH) use a lot less site resources than 100 TPA that are 20 inches DBH. Conversely, a BA of 100 square feet of trees that are 10 inches DBH use a lot more site resources than a BA of 100 square feet of trees that are 20 inches DBH.

## Quadratic Mean Diameter

Quadratic mean diameter has a long history of use in forestry and is often seen in the literature as the “average diameter” and is the diameter of the tree with the average basal area. It differs from the arithmetic mean tree diameter in that the quadratic mean diameter ($DBH_q$) is the average diameter of the trees in the stand expressed as the diameter of the tree of the mean basal area. It is computed by converting the individual diameters ($DBH_i$) to basal area, multiplying the basal area times the expansion factor (TPA), summing the basal area, dividing by the total TPA to get mean basal area, then converting that mean basal area back to diameter.

The arithmetic average (AveDBH) is computed by summing the diameters multiplied by the expansion factor (TPA) for each record and then dividing by the total TPA.

Quadratic mean diameter gives greater weight to large trees and is equal to or greater than the arithmetic mean (Curtis & Marshall 2000). If the primary interest in diameter is to permit calculation of basal area or volume, then a better average is the quadratic mean (Husch et al. 2003). It is also stable for modeling purposes, being better correlated to stand density and directly convertible to basal area. The Forest Vegetation Simulator (FVS) uses $DBH_q$ in many of its growth and mortality equations.

## Stand Density Index

The Reineke Stand Density Index (SDI, Reineke 1933) takes into account both tree size (DBH) and numbers (TPA) to determine better than BA and TPA how site resources are being used. The SDI equation is $SDI=TPA(DBHq/10)^{-1.6}$ where DBHq is the “quadratic mean diameter” of a stand. Although originally developed for even-aged stands, SDI has been applied to uneven-aged stands. For uneven-aged stands, SDI is computed by summing values for individual trees or for DBH classes (Cochran 1992). The method of computing current or desired stocking for uneven-aged stands by apportioning SDI to size classes should be done carefully, however, because SDI may overpredict site occupancy for reverse J-shaped diameter distributions with more small trees than large ones, and it may underpredict occupancy with non-reverse J-shaped diameter distributions (Woodall 2003).

Reineke developed the SDI in about 1933 from empirical observations (Reineke 1933). He apparently plotted data (TPA versus $DBH_q$ on log-log paper) for fully stocked, even-aged stands and drew a free hand line skimming the highest data points. He proposed that the slope of the line (-1.605) was the same for all species but that the y-intercept value differed with species. Since that time, evidence has suggested that slope, as well as the intercept varies with species (Puettmann et al. 1993). Evidence also suggests that differences in intercept values for plant associations for a given species indicate that the density of a fully stocked stand changes with site conditions (Cochran et al. 1994).

There are at least two ways to express SDI, the maximum SDI ($SDI_{max}$) and normal SDI ($SDI_n$). If you plot TPA (x-axis) against $DBH_q$ (y-axis), as Reineke did for many observations, and draw a line along the outside of all of the observations, you are establishing the $SDI_{max}$ for the species. If you draw the line through the middle of the observations, you would be establishing the $SDI_n$.

Both means are commonly used in forestry; FVS uses $SDI_{max}$ whereas Cochran uses $SDI_n$ in his research concerning stocking levels required to reduce bark beetle risk. For this analysis we will generally be using FVS and $SDI_{max}$, but may refer occasionally to $SDI_n$ where necessary.

Several general SDI points-of-interest have been established for managing stand stocking levels. In terms of SDI, trees are not competing for site resources until stand density reaches about 25 percent of maximum SDI (Long 1985). This point is about 40 percent of $SDI_n$ and Long (1985) considered the point to be that at which the stand has reached crown closure. Long (1985) considered crown closure to be the maximum amount of crown cover--the proportion of ground surface area covered by a vertical projection of the tree crowns--expected for the species and site. Since that time other authors have used the term crown cover and crown closure with at least somewhat different meaning. At about 35 percent of maximum SDI (50 percent $SDI_n$), site resources are fully being utilized and trees in the stand are competing for those site resources. This is the point of “full site occupancy.” At about 60 percent of maximum SDI (75 percent $SDI_n$), the stand has reached the “zone of self thinning” or the “zone of imminent mortality” where a suppressed layer of trees begins developing (Long 1985). In this zone, for some trees to continue to grow, other trees have to die. In most variants of FVS, the zone of imminent mortality is set at 55 percent of maximum SDI. Above this point, FVS’s “mortality model” begins computing tree mortality and “killing trees” from the modeled stands above a constant background level. Bark beetle risk and activity increase far before stand stocking reaches the zone of imminent mortality (Cochran et al. 1994, Oliver 1995).

Conifer tree species found in the Salt project area include ponderosa pine, Jeffery pine, sugar pine, Douglas-fir, white fir, and incense cedar. In this analysis we will be using a maximum SDI for 430 for the pine species, 600 for Douglas-fir, 570 for incense cedar and 760 for white fir (USDA 2009c).

Maximum stand density indices are developed for tree species based upon sample data from single-species, even-aged stands (Reineke 1933). Some research has been done on developing maximum stand density indices for mixed-species stands but the research is limited. Research by Woodall et al. (2005) indicates that in mixed-species stands, the maximum SDI that any one species may attain is affected to varying degrees by the species composition, and that the maximum SDI for individual study species increased as the species basal area increased relative to total stand basal area. Cochran et al. (1994) suggested that stands with mixed tree species should be managed by using the stocking level curves for the single species prescribing the fewest number of trees. Torres-Rojo and Velázquez-Martínez (2000) developed models for computing maximum stand density index for stands containing a mixture of several species based upon the proportion of stocking represented by each species. Stout and Nyland (1986) modified the SDI model to consider the proportion of basal area stocking in individual species to improve maximum stand density estimates.

In this analysis, we computed a maximum SDI of 687 based upon the maximum SDI for each species discussed above and the proportion of each species in the M3N stratum following the intermediate treatment. SDI values for the zones discussed above are displayed in Table 21.

**Table 21. SDIs at important percentages of maximum SDI for Salt project area stands.**

| Percent of Maximum SDI | SDI |
|---|---|
| 25 | 172 |
| 35 | 240 |
| 55 | 378 |

## Tree Growth and Vigor

Individual tree growth is inversely proportional to stand stocking except at low stocking levels. Trees that are growing at greater rates are considered more vigorous and able to combat the effects of insects and diseases. Increases in growth rates also mean that the time required to grow large trees to meet management objectives is reduced. More open-grown trees also tend to retain deeper crowns with larger limbs.

## Thinning to Reduce Bark Beetle Risk

Bark beetles are characterized by foresters as primary and secondary. Aggressive bark beetles thought of as primary killers of trees are those that attack and kill apparently healthy trees. These primary killers include Douglas-fir beetle (*Dendroctonus pseudotsugae*), mountain pine beetle(*Dendroctonus ponderosae*) , western pine beetle (*Dendroctonus brevicomis*), Jeffery pine beetle (*Dendroctonus jeffreyi*), roundheaded pine beetle (*Dendroctonus adjunctus*), spruce beetle (*Dendroctonus rufipennis*) , and fir engraver(*Scolytus ventralis*) . Secondary bark beetles infest severely stressed, dying, or freshly dead trees as well as stressed tree tops and branches. Pine engraver (*Ips pini*), red turpentine beetle (*Dendroctonus valens*) and striped ambrosia beetle (*Trypodendron lineatum*) are mostly considered secondary bark beetles. Depending upon stand conditions and beetle population levels, some bark beetles that typically act in a secondary role can act as a primary killer of trees. Pine engraver, for example, normally reproduces in logging slash, wind-blown trees, broken limbs, and severely stressed trees like other secondary bark beetles, but when populations increase due to an abundance of host material, it frequently invades and kills small live trees or the tops of larger trees. Bark beetle risk concerns in the project area involve primary bark beetles, not secondary, and the following discussion addresses only those listed above as primary bark beetles.

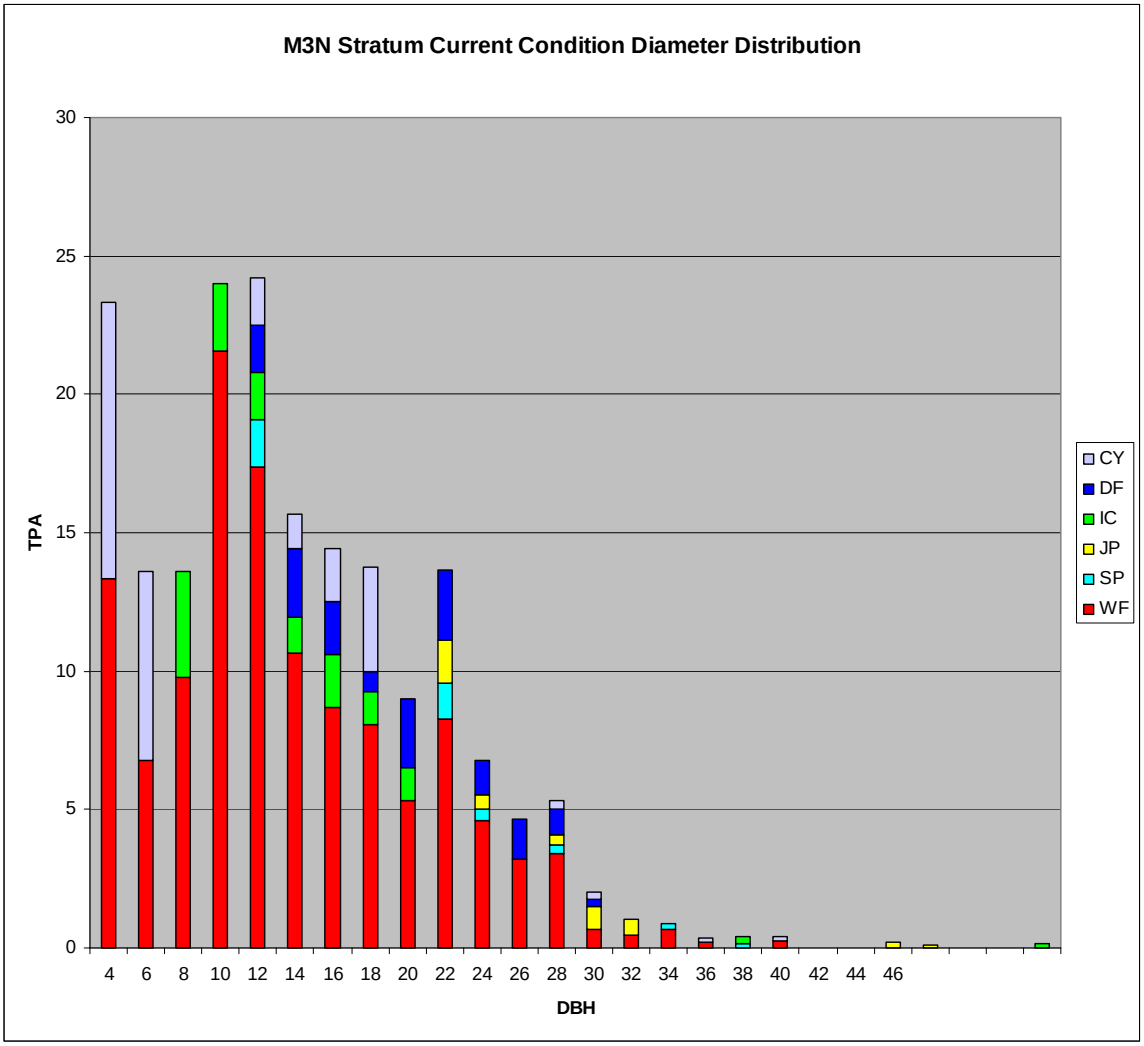
Researchers began to recognize the importance of tree stocking control to reduce bark beetle activity in about 1941 (Eaton 1941 in Oliver 1995). In 1953, Clements was the first to recognize the relationship between stand density and mountain pine beetle activity (Clements 1953 in Oliver 1995). Since then, Sartwell and Stevens (1975) worked to further establish the links between tree stocking levels and bark beetle activity. Based upon the works of Sartwell and others, Oliver (1995) investigated the relationship between the stand density index (SDI) threshold of self-thinning mortality due to competition and SDI thresholds for mortality due to bark beetles. Oliver (1995) concluded that stand density for ponderosa pine stands was limited by *Dendroctonus* bark beetles to lower levels than the level of self-thinning.

Within the last several decades, a number of studies examined the relationships between tree thinning to reduce bark beetle activity and risk. Many of the studies observed decreased bark beetle activity with decreased tree stocking levels. These studies include: (1) observations of low bark beetle activity within thinned stands during long term stocking studies (Cochran and Barrett 1995 ,Cochran and Barrett 1999a, Cochran and Barrett 1999b, Cochran and Dahms 2000), (2) control studies measuring bark beetle mortality within pine stands thinned to various stocking

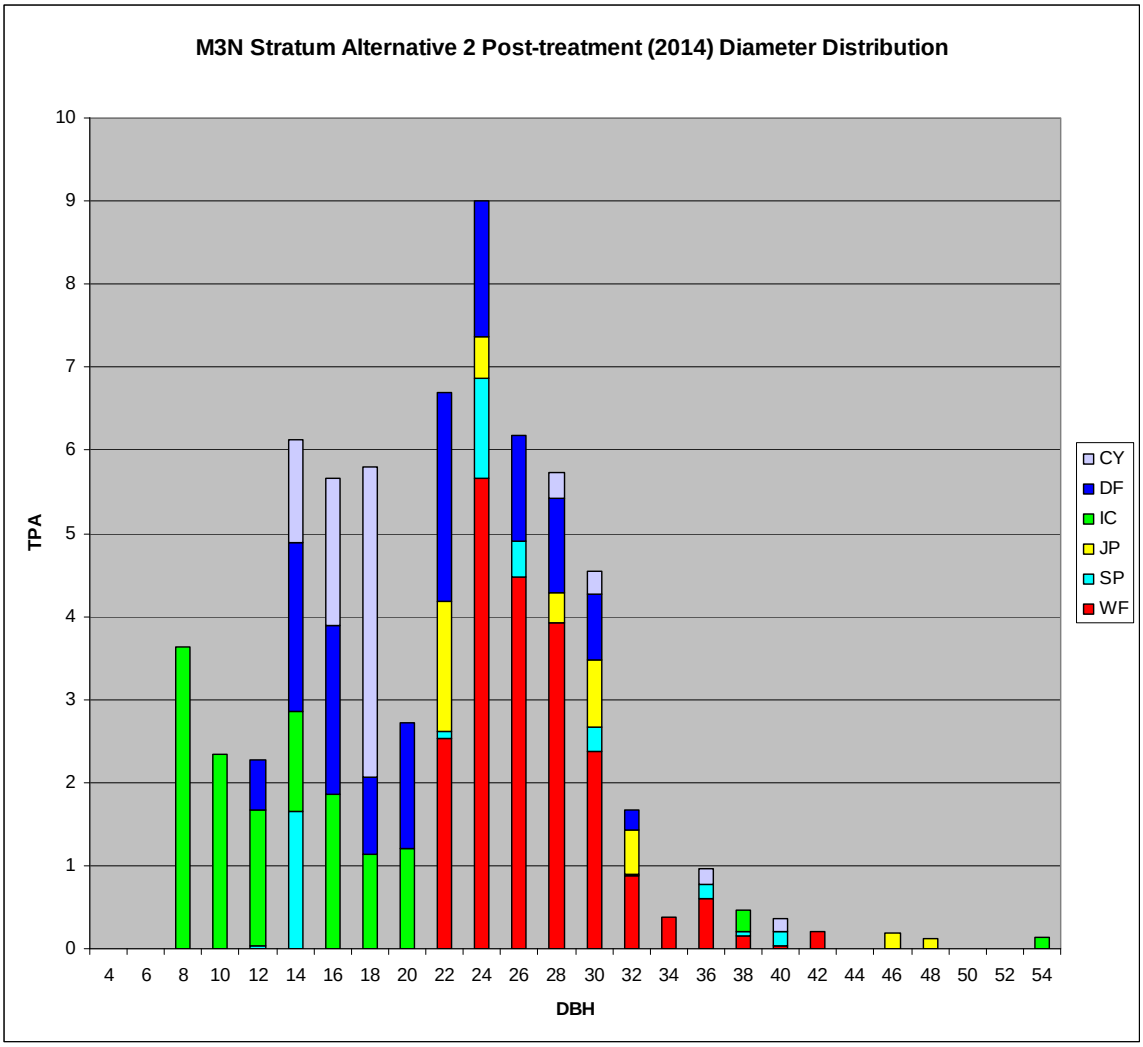
levels and un-thinned areas (Amman 1988a, Amman 1988b, Amman et al. 1988a, Amman et al. 1988b, Cole and McGregor 1985, Cole et al. 1983, Fiedler and Morgan 2002, Fiddler et al. 1995, McGregor et al. 1987, Mitchell et al. 1983, Safranyik et al. 2004, Schmid and Mata 2005, Whitehead and Russo 2005) and (3) control studies measuring bark beetle activity as a function of the number of beetles trapped in stands thinned to various stocking levels as well as unthinned stands (Bartos and Booth 1994, Sanchez-Martinez and Wagner 2001, Schmitz et al. 1981, Zausen et al. 2005). Of the mortality studies, only Mitchell et al. (1983) did not demonstrate a difference in mortality between lightly thinned stands and unthinned controls, but they did observe that the heavily thinned stands had no mortality. Only one trapping study, Sanchez-Martinez and Wagner (2001), did not observe fewer trapped beetles in thinned stands compared to unthinned. Sanchez-Martinez and Wagner's (2001) measurements found no significant difference between bark beetles trapped in thinned and unthinned ponderosa pine stands on the Coconino plateau in Arizona. However, their data was collected during low levels of bark beetle activity (endemic) in the area and they observed that the average tree size within the unthinned stands was very small, (22.2 cm) making the trees undesirable habitat for the most aggressive bark beetles found in the area--western pine beetle and mountain pine beetle. Given the results all studies mentioned, we conclude that available research provides strong evidence for the utility of thinning to reduce tree stocking and so the level of bark beetle mortality and the risk of epidemic levels of mortality.

In a research paper pertinent to the Salt project area, Oliver and Uzoh (1997) discussed stocking levels required to prevent endemic and epidemic levels of bark beetle mortality in pine stands in Northern California. They noted that "Stands that approach SDI 365 usually suffer large losses from bark beetle epidemics" and that "beetle kills from endemic populations can begin when stands reach SDI 230." They considered SDI 230 to be the "zone of imminent bark beetle mortality."

# Appendix C – M3N Stratum Pre-treatment and Post-treatment Diameter Distribution




CY – canyon live oak (*Quercus chrysolepis*)
DF – Douglas-fir (*Pseudotsuga menziesii*)
IC – incense cedar (*Libocedrus decurrens*)
JP – Jeffery pine (*Pinus Jefferyi*)
SP – sugar pine (*Pinus lambertiana*)
WF – white fir (*Abies concolor*)

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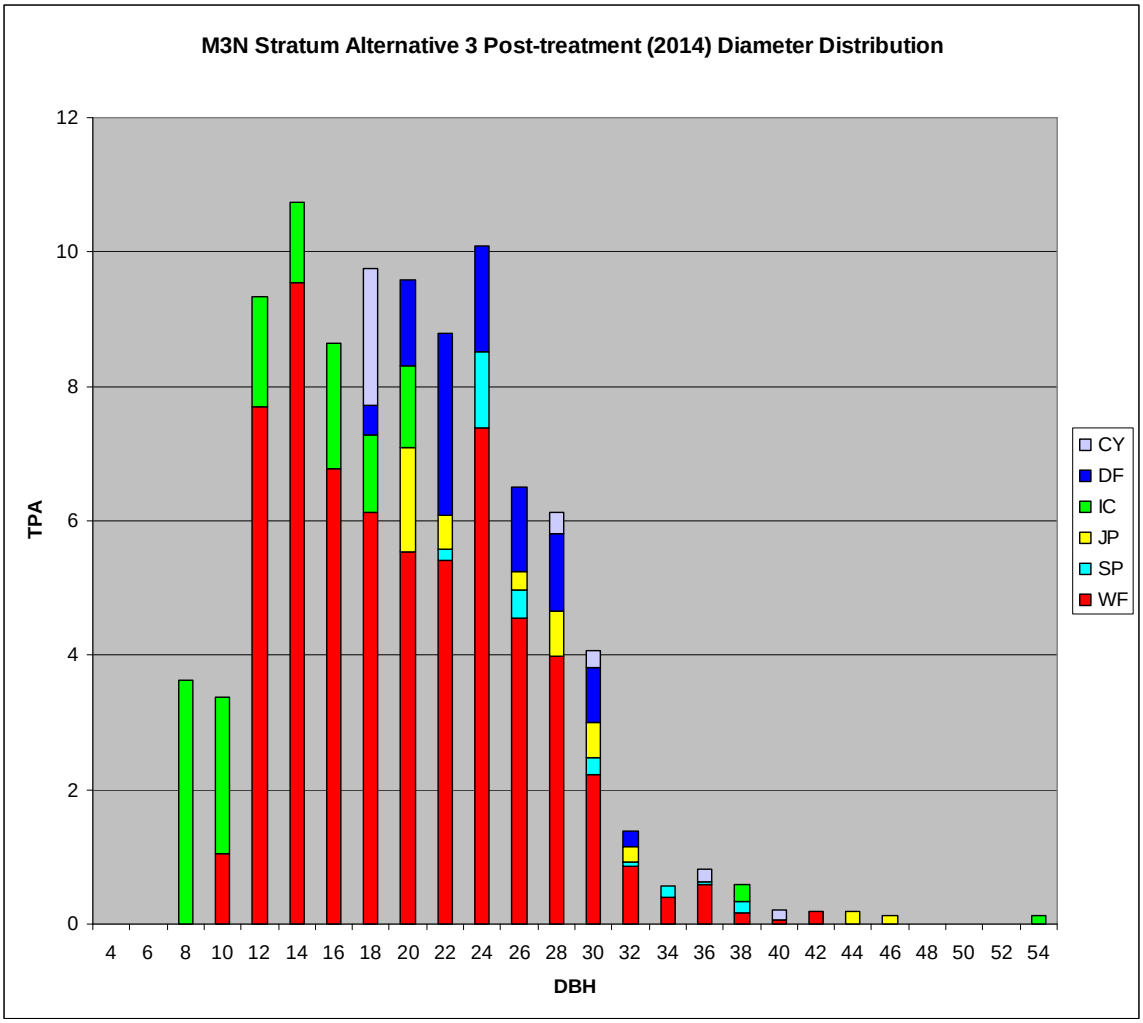


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SP – sugar pine (*Pinus lambertiana*)
WF – white fir (*Abies concolor*)

# Appendix D - Tree Species common and Scientific Names

| Common Name | Scientific Name |
|---|---|
| California Black Oak | *Quercus kelloggii* |
| Canyon Live Oak | *Quercus chrysolepis* |
| Douglas-fir | *Pseudotsuga menziesii* |
| Incense Cedar | *Libocedrus decurrens* |
| Jeffrey Pine | *Pinus jeffreyi* |
| Oregon White Oak | *Quercus garryana* |
| Pacific Madrone | *Arbutus menziesii* |
| Ponderosa Pine | *Pinus ponderosa* |
| Sugar Pine | *Pinus lambertiana* |
| White Alder | *Alnus rhombifolia* |
| White Fir | *Abies concolor* |