Highway 89 Safety Enhancement and Forest Restoration
Silviculture Report

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for:
Shasta/McCloud Management Unit
Shasta Trinity National Forest

Date:
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Introduction

With the Highway 89 Safety Enhancement and Forest Restoration Project (Hwy 89 project), the Shasta-Trinity National Forest (Forest) is proposing to improve public safety along approximately ten and a quarter miles of California State Highway 89 (Hwy 89) and restore forest ecosystems by addressing forest health, fire restoration and infrastructure on approximately 13,514 acres. The project is located in Siskiyou County, California, both north and south of Highway 89 from near the Interstate 5 (I-5) junction with Highway 89 (near Mount Shasta, California), east to Cattle Camp Campground approximately 10 miles east of McCloud. Project treatments will include:

- Thinning along the Highway 89 corridor out to approximately 275 feet along the south side of the highway’s edge and approximately 200 feet on north side of the highway.
- Thinning in plantations less than 10 inches diameter at breast height (dbh) and plantations greater than 10 inches dbh.
- Thinning in mixed conifer natural stands.
- Thinning in pine dominated natural stands.
- Reduction of dying, decadent knobcone pine with artificial regeneration with the appropriate mix of Jeffery pine, ponderosa pine, incense cedar and black oak.
- Thinning of an oak stand to a basal area target of 80-100 sqft/acre.
- Bitterbrush management by removing encroaching conifer from within the historic bitterbrush field.
- Fuels only treatments utilizing mechanical treatments such as mastication and/or machine piling in places deemed necessary to achieve specific objectives.
- Thinning and hazard tree removal will occur in campgrounds and along trails.
- Prescribed burning and development of a helispot.

Affected Environment

Historical Condition

The goal of this project with regard to forest and ecosystem health is to increase diversity in the plantations, as well as increase resilience to fires, insects and disease and restore the natural role of fire on the landscape. The definition of restoration as it is defined in the 2008 Society of American Foresters Dictionary is;

1. *Ecology* the process of returning ecosystems or habitats to their original structure and species composition. 2. *recreation* the removal of non-historical elements from a historic structure and the replacement of any missing elements

The Hwy 89 project has been categorized into six forest stand types which are; pine plantations 10 inches dbh or greater, pine plantations less than 10 inches dbh, pine dominated natural stands, mixed conifer natural stands, knobcone pine dominated stands and a black oak stand. All of these stands are considered to be on moderately xeric sites with a greater proportion of tree species being dry site species. The exception to this is within riparian corridors. In these areas the mix of species is considerably different and much more mesic.

Fire has played an important role in developing stand structures across the fire prone west. Historically these structures included fire adaptive species such as ponderosa pine, sugar pine, Jeffery pine, lodgepole pine, knobcone pine and Douglas-fir, aspen and black oak. This project area historically had a natural fire return interval in the pine stands every 5-15 years, while the mixed conifer stands had a return interval anywhere
from 5-30 years, not to mention the use of fire by native people to meet their resource needs. Anecdotes can be found indicating that several tribes lived in classic “Fire Environments” capable of recurring low intensity underburns within the dry conifer forest of California. Much of the McCloud Flats Ecosystem Analysis focus area lies within the Wintu and Achomawi territories. It can be assumed that these native people’s cultures used fire for several reasons ranging from improved hunting, forage and enhancing desired vegetation for specific uses (McCloud Flats Ecosystem Analysis 1995, pg. 55). These frequent fire return intervals created a forest structure in both pine and mixed conifer forests that could be understood as a mosaic of three elements: openings, single trees and clumps of trees with adjacent or interlocking crowns (Larsen, Churchill, 2011). Under frequent fire regimes the more fire resistant species such as ponderosa pine, sugar pine, Douglas-fir, lodgepole pine, (aspen, black oak) and knobcone pine, would survive the more frequent less severe fires, while the white fir and incense cedar would typically get killed. These frequent fires would naturally keep the stands thinned out and create a mix that was more fire resistant (Mt. Shasta Watershed Analysis 2012, pg. 111-112). Topography and the position on the slopes also had a role in how frequent and how severe the fires are. On north and east facing slopes, fires are typically less frequent and are lesser severe. This is also found at the bottoms of slopes and to lesser extent mid-slopes. (Skinner, Tayler, Southern Cascades Bioregion 2006, Chapter 10, pages 203-205)

Plantations have been relatively recent manmade creations. In many cases, areas that were dominated by brush got wind rowed and then planted. Wind rowing was a management action which freed up planting spots from brush competition by piling the brush into rows and planting the clear ground in between the piled brush with ponderosa pine.

The mixed conifer stands are made up of various conifer species (Douglas-fir, ponderosa pine, white fir, incense cedar, sugar pine, lodgepole pine and knobcone pine), along with a California black oak component. Frequent fire played an important role in maintaining the black oak with in these stands by excluding conifer encroachment. Frequent low intensity fires would remove the small conifer understory and help initiate the black oak and (aspen) sprouting. With the exclusion of fire over the past hundred or so years, hardwood species have slowly been out competed by the conifers. Without low intensity, high frequency fires many of these stands are starting to lose the oak and (aspen) component to the competing shade tolerant conifer (Mt. Shasta Watershed Analysis 2012, pg. 114).

Knobcone pine stands within the project area are typically found on shallow rocky to sandy sites that are harsh and less productive than other sites in the project area. The soil type that these knobcone pine stands occur are identified as have ponderosa pine as the adaptive species (Lanspa, Kenneth E. 1983. Soil Survey of the Shasta-Trinity National Forest Area, California). The lifespan of knobcone pine is relatively short. Some trees reach ages of 75 to 100 years, but in a typical 60 year old stand over half of the trees could be dead. These trees rapidly grow and have shallow roots (10.4 inches) on shallow soils to very wide and deep roots on less restrictive sites. The cones remain closed and attached to the tree for the tree’s life. The enclosed seeds are small and light, with thin seed coats and long seed wings. Trees begin seed production between 10 and 12 years of age. Average production of trees over 20 years old is 176 cones per tree. Limited tests show seed viability does not decline with age. Seeds enclosed in cones for 27 to 60 years have proved viable. Following release, seeds require cold stratification for 60 days. Hot fires probably kill some of the seed. Knobcone pine reproduction is controlled primarily by fire. Unlike other closed-cone species whose cones open with hot weather, upon falling, or with age, unburned knobcone pine cones remain closed even after trees have decayed and fallen. Cones are sealed with a hard resin that requires high temperatures (average: 397 degrees F) to liquefy, boil and vaporize. Cone scales open gradually following heating. The first seeds fall within 1 to 12 hours after fire, when the ground has cooled. The small, light seeds are wind dispersed and with the greatest seed wing length: seed size ratio of all the California closed-cone pines, this allows for seed dispersal well beyond the edges of a fire. As fire is the primary means of seed dissemination, birds such as scrub jays, Steller jays as well as Hairy and downy woodpeckers, are also thought to help spread seed (Howard, Janet L. 1992. Pinus attenuata).
With knobcone not having any real value in the historic lumber market, knobcone pine wasn’t commercially harvested for the most part. The trees harvested were trees of value other than knobcone pine. This over time, along with the successes of fire suppression, changed the overall conditions of these stands. Part of the reason was due to the removal of the seed sources of the other species and the other reason was due to the removal of the thinning effects of a frequent fire regime. All of this has created stands that have way more trees than these poorer sites historically did with a species composition that is more skewed towards knobcone than what historically occurred.

**Existing Condition**

Across the project area the higher densities have created stand conditions that are diverging from their normal natural conditions.

Dense stand conditions as well as mortality are also found along Highway 89. These dense stand conditions lead to increased shading along the highway in the winter time causing increased hazards to icing as well as dying trees and it also reduces the visibility of drivers to wild animal hazards along the highway.
Pine plantations are found scattered across the project area and are classified into two categories below 10 inches dbh and plantations above 10 inches dbh. Conditions of these plantations range from overly dense to well managed and manicured. The plantations that are found in overly dense conditions are at high risk of a large scale outbreak of insects and disease.

In the mixed conifer stands the shade intolerant species such as ponderosa pine, Jeffery pine, sugar pine, black oak and quaking aspen are getting out competed by more shade tolerant species such as white fir and incense cedar. This competition is causing many of these shade intolerant species to die leaving behind larger than desirable fuel loads in many places. More mesic white fir species are also beginning to die as the current stocking levels are too high for the site conditions.

In the pine dominated natural stands, which makes up the majority of the stand types in the project, there are places where white fir and incense cedar are very minor components of these stands. These dense ponderosa pine stands are seeing an increase in western pine beetle (*Dendroctonus brevicomis*) activity, which is
resulting in considerable mortality. Years of drought has also contributed to the increased mortality by reducing the trees natural defense mechanisms thereby increasing vulnerability to bark beetle attacks. This elevated mortality is also contributing to increased natural fuel loading. The pine trees are dying and are unable to protect themselves from beetle attacks which is causing increased fuel loads in the areas of higher mortality.

Figure 4. Ponderosa Pine dominated stands stocking and mortality

In many of the harsher sites knobcone pine is found in greater numbers than what was thought to have been the historical condition. Due to past logging activities, taking the most valuable species and leaving the least valuable species, the stand conditions of these stands has shifted to a denser knobcone pine population and less of the other species. This increase in knobcone pine has also created an increase in fuel loading in places, due to the short lived life span of knobcone pine.

Figure 5 knobcone pine dominated stocking and condition
Black Oak Stand
The 16 acre black oak stand found in the Azalea block is seeing dense conditions that is stunting the oak growth as well as encroaching conifer growth, which threatens in time to out compete the black oak. These conditions also lends itself to a higher risk of loss in the case of an uncontrolled wildland fire.

![Figure 6. Black oak stand](image)

**Measureable Indicators**
The measureable indicators were developed based on the Purpose and Need for the project. The indicators are measures of stand health over the effective treatment time for the project. The indicators are;

- Stand Density Index (SDI) for 20 years- Proper SDI levels to protect and promote shade intolerant and fire adaptive species.
- Reduction in mortality for 20 years- An indicator of forest health.
- Acreage change in species composition of primarily the two stand types that have seen the largest shift from historic conditions, mixed conifer and knobcone pine dominated stands.

**Management Direction**
Vegetation management of this project follows the Shasta Trinity Land and Resource Management Plan (Forest Plan) guidelines as it pertains to the timber resource (page 4-18 Forest Pests b.) and growth (page 4-27 Timber Stand Improvement and Forest Health k.). All proposed treatments of timber stands have been written to meet the Forest Plan guidelines for the areas in which they reside.

**Vegetation Diversity- Watershed level**
The Forest Plan (p. 4.14) directs provision for and maintenance of at least five percent of each timber/type seral stage combination shown in the Forest Plan on Table 4-3. The Forest Plan also has special direction for Matrix Lands for fifth field watersheds in which federal forest lands are currently comprised of 15 percent or less of late-successional forest (p. 4-63). The Highway 89 project area is located within portions of five fifth-field watersheds (Ash Creek, Box Canyon, Squaw Valley Creek, Upper McCloud River and Upper Sacramento River). See Appendix A of this report for more detailed information on how this project complies with watershed level vegetation diversity.
**Desired Condition**

**Forest Health**

Plantations with trees primarily 10 inches diameter at breast height (dbh) or greater have a more multi-aged structure with variable sizes and spacing, and plantations with trees primarily less than 10 inches dbh are moving toward stands with larger sized trees. Natural stands have densities at levels that improve and protect forest health and vigor. The stands have structural diversity with varied species, multiple canopy layers, other types of vegetation, and appropriate levels of coarse woody debris and snags. Plantations and natural stands are resilient to epidemic insect or disease attack. Knobcone pine dominated stands more closely resemble their historic conditions of other species such as ponderosa pine, incense cedar and white fir mixed in with the knobcone.

Hardwoods, especially oaks and aspen, remain a healthy and vigorous component of forest stands where they are naturally located. In hardwood-dominated stands, there are fewer conifers competing for resources (sunlight, nutrients, water) with the hardwoods. Bitterbrush stands have a mix of age and condition classes and also have limited competition from conifers. In riparian areas, the species composition and structural diversity of the native vegetation maintain a healthy riparian ecosystem, without excess competition for resources from conifers.

All stands and vegetation types experience fires at intervals that are historic to the area, have appropriate coarse woody debris and snag levels, but do not have excess fuel loads. Wildfires that occur within the project area during dry summer conditions are beneficial to the ecosystem, as occurred historically.

**Highway 89**

Sunlight is able to reach the Highway 89 road surface during winter months, enabling snow and ice to melt from the roadway more quickly. There are fewer trees with branches hanging over Highway 89. Drivers along Highway 89 have adequate sight distance and an open view of wildlife entering the roadway to respond as necessary.

Sufficient gaps in vegetation exist along Highway 89 to allow for efficient snow removal during heavy snowfalls.

Vegetation conditions and predicted fire behavior along Highway 89 are such that a wildfire during summer months is less likely to spread along or across the highway, is less likely to threaten surrounding forests and communities, and would not limit access for firefighters, or egress for citizens.

**Regulatory Framework**

**Forest Plan**

The Hwy 89 Project is located on the Shasta-McCloud Management Unit of the Shasta-Trinity National Forest. The project area is within Management Areas 2 (McCloud Flats), 3 (Mt. Shasta) and 10 (McCloud River) of the Shasta-Trinity Land and Resource Management Plan (Forest Plan).

<table>
<thead>
<tr>
<th>Forest Plan Land Allocation</th>
<th>Forest Plan Management Prescription</th>
<th>Acres</th>
<th>Percent of Total Treatment Area</th>
</tr>
</thead>
<tbody>
<tr>
<td>Matrix</td>
<td>Commercial Wood Products (VIII)</td>
<td>164</td>
<td>99.4%</td>
</tr>
<tr>
<td></td>
<td>Roaded Recreation (III)</td>
<td>11,255</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Wildlife Habitat Management (VI)</td>
<td>1,722</td>
<td></td>
</tr>
</tbody>
</table>
The Forest Plan specifies several land allocations for forest lands identified and proposed for treatments in this project. These specific allocations are:

- **Roaded Recreation** – Approximately 85% of the project area is 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. The prescription emphasizes recreational opportunities associated with developed road systems and dispersed and developed camp sites. Fish and wildlife management, which supports the recreational use of wildlife species (hunting, fishing and viewing), is also emphasized”.

- **Wildlife Habitat Management**. – Within the project area, approximately 13% is allocated as wildlife habitat management. The primary purpose of this prescription is to maintain and enhance big game, small game, upland game bird and non-game habitat, thereby providing adequate hunting and viewing opportunities. Vegetation is manipulated to meet wildlife habitat management objectives and to maintain healthy, vigorous stands using such tools as silviculture and prescribed fire. Objectives specific to this project include the need to emphasize habitat for early and mid-level seral stage development species. Forest stands would be managed to maintain lower tree stocking levels and greater amounts of understory cover and forage.

- **Commercial Wood Products Emphasis**. – Approximately 1% of the project area is allocated to commercial wood products emphasis. The objective is “to obtain an optimum timber growth and yield of wood fiber products within the context of ecosystem management. The timber stand will be managed to obtain optimum growth and yields using cultural practices which control competing vegetation (release and weeding), obtain stocking control (thinning) and minimize mortality (pest management) within the context of the Matrix Standards and Guidelines described”.

- **Late Successional Reserve/Administratively withdrawn** – Less than 1% of the Project area includes the LSR and Administratively withdrawn areas. Approximately 0.5% of the project is located within the McCloud and Algoma LSRs (DD-76, RC-357). The proposed treatments in these areas are designed to provide safe conditions for the public, reduce the risk of habitat loss, and enhance characteristics of the LSRs. The treatment in the Algoma LSR is primarily designed to increase visitor safety in the Cattle Camp Campground. Two small sections of special interest areas are included in the project area. Approximately 1.4 acres of the Shasta Mudflow Research Natural Area (RNA) is included in the northwest corner of the McCloud segment of the project. This area is being excluded from treatment to allow researchers to study the natural processes at work. No natural fuels treatment or construction of shaded fuel breaks are permitted without appropriate planning and approval by the Regional Research Natural Area Committee (LRMP 4-49). Less than one acre of the Bigelow Meadow Special Interest Area (SIA) is included along the southern boundary of the project area near Lakin Dam. This area will be included in the riparian area restoration treatments. There are approximately 13 acres of Heritage Resource Management that are accounted for in the Matrix and LSR prescription acreage.

- **Further direction is derived from Forest Plan as identified in Forest Goals #10 and #11 for fire and fuels, and in Goals #34, #35, and #36 for timber (USDA Forest Service 1995, p.4-4 and 4-5). Specific direction for green-tree and snag retention in Matrix management is also given (USDA Forest Service 1995, p. 4-27, 4-61and 4-62).**
Management Direction for vegetation management 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 harvest of under stocked 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.

Selection

1. Includes both single-tree and group selection systems. Regeneration and intermediate cuttings are usually done in one operation, with entries occurring about every 10 to 15 years. Reforestation can be done either artificially or naturally. This treatment is most commonly employed in areas where timber production is not the primary objective (LRMP page J-3).

This management practice includes the use of uneven aged silvicultural systems to achieve resource objectives. There are two options available: single tree selection or group selection. Normally, group selection cutting methods will be used with stands typically ranging from about a tenth of an acre to two acres in size. Under the uneven-aged option, practices will be employed in special management situations where the land is suitable for timber management, but where it is more appropriately allocated to purposes which make it desirable to maintain a continuous forest cover over time. Three or more distinct size/age classes will be present in a stand at all times (Forest Plan, page L-8).

2. As a minimum, snags are to be retained within the harvest unit at levels sufficient to support species of cavity-nesting birds at 40 percent of potential population levels based on published guidelines and models and 100 percent population levels for white headed and Black-backed woodpecker, pygmy nuthatch and Flammulated owl. An average of 1.5 snags per acre greater than 15 inches in diameter and 20 feet in height is what is needed for the 40 percent of population levels of cavity-nesting birds. For white-headed and Pygmy nuthatch it is 0.6 snags per acre 15 inches in diameter or greater. For black-backed it is 0.12 snags per acre 17 inches dbh or greater. The Flammulated owl will use any snags that from the other three species (White-headed, Black-backed woodpeckers and Pygmy nuthatch). The objective is to meet the 40 percent and 100 percent minimum standard throughout the
Matrix, with per-acer requirements met on average areas no larger than 40 acres. To the extent possible, snag management within harvest units should occur within the areas of green-tree retention. The needs of bats should also be considered in these standards and guidelines as those needs become better known. Snag recruitment trees left to meet an identified, near-term (less than 3 decades) snag deficit do not count toward green tree retention requirements.

In July 2004, Region Five Regional Forester Jack A. Blackwell sent a letter to Forest Supervisors and Directors concerning conifer density management in California (Blackwell 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.” (Blackwell, 2004)

Special Area Designations
Two small sections of special interest areas are included in the project area. Approximately 1.4 acres of the Shasta Mudflow Research Natural Area (RNA) is included in the northwest corner of the McCloud segment of the project, but like mentioned previously, is not having any treatments. Less than one acre of the Bigelow Meadow Special Interest Area (SIA) is included along the southern boundary of the project area near Lakin Dam. This area will be included in the riparian area restoration treatments.

Federal Law
National Forest Management Act
The National Forest Management Act requires projects to be consistent with the Forest Plan and to make the following findings [16 U.S.C. 1604 (g)(3)(E)]:

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.

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. Areas proposed for treatment are diseased stands of mature knobcone pine in decline. In general, these stands scheduled for sanitation 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…”
Environmental Consequences

Methodology

Descriptions of the project area were developed using information from the McCloud Flats Ecosystem Analysis (February 2004) and the Mount Shasta Watershed Analysis (May 2012), Forest Plan Management Area discussions for McCloud Flats and Mount Shasta (USDA Forest Service 1995), as well as stand data and field reconnaissance. Initial stand typing was done utilizing Region 5 Remote Sensing Data breaking the stands out into dominant species type as well as size classes (pole/small sawlog, sawlog and large sawlog size classes). Stand inventory would then help to verify or negate these findings. Lidar information was also utilized to determining average diameter and stocking of the plantations within the project. This data too, was ground verified prior to running stand modeling.

Selected vegetation components were sampled in 2014 and 2015 using Common Stand Exam quick plot protocol (USDA March 2009). A total of 387 field plots were taken within 133 stands representing approximately 6,185 acres. Specific field observations including stocking information for each stand was recorded. In this analysis common names for tree species are used.

Table 2. Tree Species in the Project Area

<table>
<thead>
<tr>
<th>Common Name</th>
<th>Scientific Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>California black oak</td>
<td>Quercus kelloggii</td>
</tr>
<tr>
<td>Douglas-fir</td>
<td>Pseudotsuga menziesii</td>
</tr>
<tr>
<td>incense cedar</td>
<td>Libocedrus decurrens</td>
</tr>
<tr>
<td>Jeffrey pine</td>
<td>Pinus jeffreyi</td>
</tr>
<tr>
<td>knobcone pine</td>
<td>Pinus attenuata</td>
</tr>
<tr>
<td>lodgepole pine</td>
<td>Pinus contorta</td>
</tr>
<tr>
<td>ponderosa pine</td>
<td>Pinus ponderosa</td>
</tr>
<tr>
<td>quaking aspen</td>
<td>Populus tremuloides</td>
</tr>
<tr>
<td>sugar pine</td>
<td>Pinus lambertiana</td>
</tr>
<tr>
<td>white fir</td>
<td>Abies concolor</td>
</tr>
</tbody>
</table>

Current stand attributes and potential future stand attributes for the alternatives considered were modeled from the 2014 stand exam data using the Forest Vegetation Simulator (FVS) Version 2.06, South Central Oregon/Northeastern California variant for the project. Available GIS electronic files including cover types, contours, and Forest Plan land allocations were used in the analysis as well.

Proposed treatments for each alternative are summarized in the EIS, chapter 2, and include required resource protection measures.

Incomplete and Unavailable Information

For those stands lacking common stand exam data, data from similar stands was used as a proxy for those that didn’t have formal data collected for this modeling exercise. Plantation data was gathered using both Lidar imagery to determine trees per acre and size as well as field reconnaissance to help verify the Lidar findings. Stocking was determined using GIS by incorporating 1/5th acre random plots within each plantation. From these plots an estimated trees per acre was determined.

Spatial and Temporal Context for Effects Analysis

To determine relevant past, present, and foreseeable future projects, spatial and temporal boundaries must be defined (§ 220.4 (f)). For the effects analysis, the direct and indirect effects of the Highway 89 project relative to silviculture are conditions influencing tree resilience and growth. Spatially, the conditions influencing tree resilience and growth (e.g. stand density, availability of resources, disease) in the project affects the treated area and may affect adjacent stands (e.g. microclimate changes, spread of insects and/or disease, resource competition). As such, the spatial context being considered is approximately the 13,254 acres of project area not counting the 260 acres of private property within the project boundary. This is because this encompasses the area potentially influenced by effects from proposed silvicultural treatment activities. The temporal context being considered is activities 20 years into the future; 20 years is approximately how long the
treatments are expected to remain effective, and how long proposed treatments would affect tree growth and resilience.

**Alternative 1 – No Action**

With Alternative 1, no management actions would occur. There are numerous areas within each stand that are experiencing poor health and vigor due to stocking, insects/disease or a combination of all the above (as described under Affected Environment section) with stocking levels in the inventoried ponderosa pine dominated natural stands ranging from 96-349 square feet of basal area per acre. Conditions range anywhere from 64% below recommended basal area to 232% above the recommended 150 square feet of basal area for ponderosa pine, above which mortality increases greatly. The corresponding stand density indices range from 184-831 that are predominantly above the recommended level of 230 (Oliver, 1997). Without treatment, stocking densities in many of the stands will continue to increase over time resulting in loss of diameter growth as well as increased western pine beetle activity leading to increased mortality.

As both basal area per acre and associated SDI indices continue to rise above the recommended levels for resistance to insects, more and more mortality will occur. (Fiddler, page 5) showed tree mortality of 20 trees per acre per 10 years for the unthinned control plot versus 1-3 trees per acre per 10 yrs for stands thinned to 100-140 sqft per acre.

Within the mixed conifer stands conditions would continue to deteriorate where the shade intolerant fire adapted species, such as California black oak and ponderosa pine, are being out competed and giving way to the more shade tolerant non fire adapted species, such as white fir and incense cedar. These areas currently have stocking levels that range from approximately 100-296 square feet per acre the corresponding stand density indices range from approximately 194 on the low end up to 579 on the high end. With the average stand densities averaging approximately 379, which is well above the recommended target levels for the shade intolerant species, such as ponderosa pine, that are in decline across these stands.

Under this alternative all the diseased and dying trees would be left in all the stands, continuing the mortality cycle, while adding to the fuel loads. Where stands are infected with *Leptographium wageneri* (black stain root disease), mortality would continue as root-to-root contact is made with adjacent healthy trees, creating ever widening pockets of mortality at a rate of 4-12 feet per year. Where stocking is the prime reason for the mortality problems, trees will continue to die and fall creating unnatural fuel loads. Shade tolerant tree species will continue to grow in the understories and add to the already high ladder fuels that are found in the mixed conifer stands.

The knobcone stands would continue on with its current cycle. The species would continue to dominate the sites and would continue to die and fall adding to the already high fuel loads, which would in turn put the areas in and around these stands at elevated risk for uncharacteristically extreme wildfires.

The black oak stand in the project would continue to see stagnation due to higher than desired densities and would continue to see conifer encroachment to the point where the conifer could eventually out compete the oak for sunlight and nutrients.

The black oak and quaking aspen found in some of the conifer stands will also see continued mortality if left untreated. The hardwood component is one that could easily be lost across the project area.

Alternative 1 would forego opportunities for improvements to timber stand health and growth; in addition, no timber volume (yield) would be provided toward sustained yield objectives. The desired future condition of the timber resource as identified in the Forest Plan for the project area is to minimize mortality within the context of the matrix standards and guidelines (Forest Plan, page 4-67) and also to develop forest stands that are resistant to epidemic insect attack or disease (Forest Plan, page 4-5, page 4-82). Therefore Alternative 1 would not achieve these management goals as described in the Forest Plan.
Cumulative Effects

Without treatment the stands that are currently seeing mortality would continue to see the mortality spread while additional stands would see additional mortality begin as the densification of the understories continued. These stands would not provide good forest cover, the dead trees would lead to an increase in the amount of fuels and associated fire danger and insect and diseases would continue to spread and infect the surrounding stands. The mortality that results from overstocking, insect attack and root disease would cause continued fuel buildups.

The cumulative effect of the no action alternative and the unmanaged growth across the entire landscape is increased density and an increased mortality rate. The landscape will see increased acres becoming susceptible to bark beetle attack. As the areas that exceed the level of imminent insect attack grow larger, these areas will begin to form large patches at risk to epidemic bark beetle attack. These large contiguous acres with low resistance to bark beetle attack will make the effects of a wildfire far more severe. The cumulative effect of high density stands across large landscapes will create low resilience across these areas and thus a landscape with poor forest health.

Alternative 3 – Modified Proposed Action (Preferred Alternative)

Direct and Indirect Effects

Alternative 3 would treat approximately 9,754 acres of overstocked stands with thinning prescriptions. Thinning would be used to reduce ladder fuels and tree densities in proposed treatment areas (plantations and second growth stands). Thinning is a silvicultural treatment that reduces stand density primarily to improve growth or enhance forest health (Helms 1998, page 210). Research shows how reducing stand density helps reduce the incidence of pest damage to a stand (Fiddler, G.O., D.R. Hart, T.A. Fiddler, P.M. McDonald. 1989, page 6). In western North America, thinning has long been advocated as a preventive measure to alleviate or reduce the amount of bark beetle-caused tree mortality. (Feeney et al. 1998) assessed the effects of thinning from below (alone and in combination with prescribed burning) on tree growth, leaf physiology and several environmental factors in ponderosa pine on the Gus Pearson Natural Area in Arizona. Soil water content was greater in thinned treatments than in the untreated control. Similar findings have been reported in northern Arizona (Kolb et al., 1998; Skov et al., 2005; Zausen et al.2005) and western Montana (Sala et al., 2005) and can be attributed to increased water availability resulting from decreased tree competition. Residual trees in thinned stands had greater foliar nitrogen content, needle toughness and basal area increment. Resin flow was also greater in the thinned and prescribed burned treatment than in the thinned treatment and control. The results suggest that restoration treatments improved tree vigor, growth and decreased the likelihood of bark beetle attacks on individual trees (Feeney et al., 1998). In a few stands, thinning will be combined with group selection and sanitation with thinning.

Group selection and sanitation areas are scattered among the thinning of healthy areas and are proposed to address specific stand problems. Group selections will create openings up to 2 acres in size. The groups typically create openings a given distance from known black stain disease centers. The sanitation prescriptions focus on the removal of diseased and dying trees in pockets associated with root diseases or in areas that are seeing density dependent mortality and have high amounts of bug kill. Such treatments would reduce the amount of disease vectors in the stand and would slow the rate of mortality to levels that are consistent with the Forest Plan. Openings greater than 1 acre (as a result of group selection or in rare instances sanitation) will be evaluated and prepared for planting (e.g., removal of slash and/or brush), if needed and planted with an appropriate mix of seedling species.

Three indicators were used to help assess the effectiveness of the prescribed treatments on improving forest health and tree vigor: Stand density index (SDI) for 20 years, percentage of decreased mortality for 20 years and the percentage change in species composition following treatment for the stands most departed from their
historical norm, such as the knobcone pine dominated stands and the mixed conifer stands. An SDI of less than 230 for 20 years following treatment, along with an increase growth either diameter or cubic foot volume and a reduction in tree mortality, would meet the stand health objectives.

To assess the effectiveness of the treatments on forest health, stand density index was modeled to determine the amount of stress on the trees both with and without treatment. A stand density index of less than 230 for 20 years following treatment would meet the stand health objectives for ponderosa pine stands by reducing the stocking enough to allow the tree’s natural defenses to properly function and maintain tree health. The following graphs in Figure 6 shows how the stands will respond to the prescribed treatment over 20 years (from 2023 to 2055). If the modeled ponderosa pine stands have no treatment the stand density index 20 years following treatment averages approximately 377, well above the zone of imminent mortality for ponderosa pine. The thinned stands have a stand density index in 20 years that averages 188.

![Average SDI over time no treatment vs. treatment PP dominated](image)

Figure 7 average sdi no treatment vs. with treatment PP dominated stands

In the ponderosa pine dominated stands, planned to be thinned to a target basal area of 80-120 sqft/ac for trees 4 inches dbh and up, with radial release around legacy sugar pine and ponderosa pine approximately 50 feet from the bole of the legacy tree. In some pine-dominated stands, clumps of non-pine trees will be retained and not thinned where operationally feasible (see clumps description in mixed conifer section above). Some trees with decadence, cavities and greater than 50% cull will be retained where available. Also retain some trees with broken tops or dead tops, sweeps, crooks or visible scars for wildlife habitat. Modeling showed a decrease in mortality between Alternative 1 and Alternative 3. Where the inventory picked up mortality the modeling is able give a generalized prediction of spread. In areas where there is high density with no treatment the model is able give a generalized prediction of mortality as well. Comparing the untreated stands
to the treated stands showed the rate of mortality slowing, but not stopping, which was never the objective. The figure below shows the mortality comparison.

![Figure 8 cubic foot mortality for PP dominated stands no treatment vs. with treatment](image)

The mixed conifer stands will see the majority of the treatments as thinning’s across the stands with the target basal area of 125 to 150 square feet per acre. These mixed conifer stands also benefit from being managed at an SDI level of 250 or less which is between the lower limit of full site occupancy (35% of max SDI) and just inside the lower limit of the zone of imminent mortality (60% of max SDI). For alternative 3, the prescriptions were modeled in FVS as thinning through diameter classes from 10 inches dbh and up to a basal area per acre average for the stand types. Some trees with decadence, cavities and greater than 50% cull will be retained where available. Also retain some trees with broken tops or dead tops, sweeps, crooks or visible scars for wildlife habitat. These stands will have clumps of non-pine species retained for wildlife habitat purposes and will implement group selections in areas where pine mortality is currently occurring due to *Leptographium wageneri* (black stain root disease) and where white fir mortality is occurring due to *Heterobasidion annosum* (annosus) and other factors such as density dependent mortality. These stands are also going to see radial release around legacy ponderosa pine and sugar pine approximately 50 feet from the bole of the legacy tree. The small understory trees (0-9.9 inches DBH) will be left during the initial commercial entry, but the trees 4-9.9 inches will be assessed following the harvest to determine if more trees will need to be cut to meet fuels needs prior to burning and wildlife habitat needs. Due to the FVS program’s limitations, the spatial distribution of the clumps as well as the radial release are not able to be modeled. And
the adjustments that are made during the controlled burn process, in order to meet the proposed objectives, are not able to get modeled.

The mortality of the mixed conifer stands also will see a decrease in the rate if preferred alternative is implemented. Though the mortality is slowed it won’t be stopped, due to the fact that it’s understood that the dead and dying trees are needed for a healthy and sustainable ecosystem. Just as in the ponderosa pine dominated stands, the cubic foot mortality following the prescribed burn spikes at a high rate, but what the program does not do is model the on the ground changes in the firing techniques in order to meet the objectives of the project. Following the spike in mortality, after the thinning and prescribed burning treatment, the rate of mortality for the preferred alternative is measurably less than the mortality levels of the no action alternative.

Figure 10 cubic foot mortality for mixed conifer

Many of the knobcone pine stands are seeing conditions that are outside their natural range of variability. Stocking levels in many areas are extremely high. These stands are being proposed for stocking control by removing the knobcone pine and thinning other overstocked areas to a spacing that is thought to be more consistent with the historic condition. Knobcone pine trees down to 4 inches dbh will be removed, leaving all other non-pine species that show little to no signs of insects or disease. These other areas will be thinned to a basal area target of 80-120 sqft/ac. These basal area targets are meant for ponderosa pine health, which based on soil type and the adapted species group is in fact ponderosa pine. The knobcone pine dominated stands will have prescribed fire within its natural occurring frequency. Following the first prescribed fire, areas that are deemed to need planting will be planted with a mix of species such as Jeffery pine, ponderosa pine, incense cedar and possibly black oak. The second burn will be done at a time prior to sexual maturity of the knobcone pine reproduction, which will help control the overall numbers of knobcone pine. With the proposed treatment the stand density index will be well below the zone of imminent mortality for ponderosa pine, which is the adapted species group for these soils.
The knobcone pine dominated stands are currently seeing a high rate of mortality, but following the alternative 3 treatment the mortality will fall to zero or nearly zero compared to the no action alternative.

Across the mixed conifer stand type, equaling 1,272 acres and the knobcone pine dominated stand type, equaling 653 acres, tree composition has shifted from what was the more natural condition prior to wildfire suppression and modern logging, to what we have today. If alternative 3 is implemented the mix will be shifted more towards a historic condition than if no action is done.
The knobcone dominated stands, will also see an increase in species diversity following treatment along with a decrease in the shade tolerant species such as white fir. The modeling indicates some of these changes but not all, based in inventory results. The black oak component will be an increased response due to the reintroduction of fire. These stands will also see increased health and vigor due to proper stocking levels as well as a decrease in fuel loads due to the removal of diseased and dying knobcone trees. These treatments will help the stands get on a path towards their historical condition, although not all at once.

Many of the plantations will see small changes in both mortality and species composition because they are young vigorous growing trees. Where the stocking is high the treatments will be in such a way as to bring them down to levels that are sustainable and resilient to insect and disease outbreaks. Where the plantations are most dense or are seeing ongoing mortality, these are the areas that will see the greatest benefits from the treatments. The modeling shows cubic foot growth as well as cubic foot loss due to mortality. With the decreased number of stems per acre there is also a decreased amount of growth that is showing for the plantations. What the graphs don’t show is that the diameter growth over time is greater in the treated stands than the untreated. For the plantations that are less than 10 inches dbh there was a half an inch increase in diameter growth by 2040. The plantations that are over 10 inches dbh there was one full inch in diameter growth in the treated plantations versus the untreated plantations by 2040. The treatment of the plantations would call for retaining all species other than knobcone over ponderosa pine which lends itself to species
Highway 89 Safety Enhancement and Forest Restoration Project

diversity, but due to the low numbers of these other species they did not show up in the modeling even though they were identified in many of the plantations.

![Graph](image1)

Figure 15 accretion vs. mortality greater than 10 inch plantations

![Graph](image2)

Figure 16 accretion vs. mortality less than 10 inch PP plantations

There is a dense black oak stand that is approximately 13 acres in size that will be thinned to a target basal area of 80-100 sqft/ac followed approximately three years later by a prescribed fire. Research has shown that treatments such as this has allowed the oak greater room to grow and provided the needed disturbance to allow new young suckering (McDonald, 2007, Cocking et.al, 2012).

The project also has a bitter brush field that has been seeing encroaching conifer over the years. Studying aerial photos over time form 1968, 1975 and 2003, it is clear that the bitter brush field has seen the establishment of conifer in that time. The prescribed silvicultural treatment for the field is to remove understory and mid-story conifer mimicking conditions that one might see prior to fire suppression a century ago. The hope of this treatment is to try and get the meadow back on a trajectory that in time get it to it more historic condition.
**Cumulative Effects**

Alternative 3 would silviculturally treat approximately 9,754 acres. After treatment these stands would meet the Forest Plan objectives for healthy growing conditions, lowering the incidence of insect attacks and disease, and lowering the risk of insect and disease problems in the future. The growth rates would be greater for the remaining trees and less mortality would lead to lower dead fuel levels and subsequent reduced fire liability over the landscape. Thinning would reduce stocking in natural stands and plantations resulting in stands with lower risk to bark beetle attack.

Implementation of the group selects and sanitation treatments would decrease the amount of diseased trees and disease centers in the affected stands, which will lead to a decrease in root disease spread within and adjacent to the project area. Treatments within the project area will cumulatively add to an increase in overall forest health and create stands that are more similar to historical conditions.

With species selection in the thinning treatments along with radial release of hardwoods and the planting of a mix of site appropriate species, the preferred alternative would see a shift in species composition from shade tolerant species to a more shade intolerant mix.

The bitter brush field would see many of the encroaching conifer getting removed and would also see the reestablishment of fire into the field helping to stimulate new growth of bitter brush and reduce the levels of conifer encroachment to more historic levels.

Proposed underburning will help to restore and maintain the historical open conditions that are described in the purpose and need by reducing the current amount of conifer seedling and sapling encroachment. Road reconstruction and piling of activity fuels should have no effect on the health and resilience of the remaining leave trees.

Alternative 3 treatments would contribute an additional 9,754 acres toward improving forest conditions, representing 74% of the forested acres within the cumulative effects area. Ongoing and future activities which may influence silviculture include fuelwood cutting, removing dead trees which could benefit the establishment of young trees by not falling on them and adding to the future resiliency of the stand with the reduction of fuel loading. Along with fire suppression activities, which typically uses water and fertilizer in the suppression of wildfires, as well as the reduction of tree competition from the mortality a fire will create, will have a net benefit on tree growth for the surviving trees following wildfire.

**Alternative 4 - No new temporary roads other than those required for landing access would be constructed. No machine piling.**

Inaccessible stands would be dropped from treatment, or treated using longer skid trails. Fire lines would be constructed by hand, rather than by machine.

**Direct and Indirect Effects**

Alternative 4 will see a reduction in silvicultural treatment acres from approximately 9,754 acres for alternative 3 down to approximately 9,150 acres for alternative 4. There will be a reduction in the plantations greater than 10 inches, the mixed conifer stands, the ponderosa pine dominated stands, the knobcone stands and the black oak stand. This reduction in treatment will see an increase in mortality in all of these shade intolerant species as well as in the knobcone pine stands that are currently in decline due to the short life span of the species.

**Cumulative Effects**

The reduction in treatment will have similar effects as the no action for the areas that will be dropped.
Alternative 4 would contribute approximately 9,150 acres toward improving forest health and growth with regards to stand susceptibility to insect infestation and drought-related mortality. All other cumulative effects would be similar to Alternative 1.

**Alternative 5 - No group selection treatments. No treatments in TES habitat. No yarding in Riparian Reserves.**

Other silvicultural treatments would be developed for group selection areas.

**Direct and Indirect Effects**

The stands that would be affected by no group selection treatments would be the mixed conifer stands. These stands are the stands that are seeing mortality predominantly in the ponderosa pine due to insects and disease, typically brought on by higher than desired stocking levels. The group select treatments are being prescribed to help slow the spread of mortality while reforesting those areas with a species mix that is appropriate for the site. An alternate treatment for trying to control the mortality in such areas might be a sanitation treatment. These treatments remove diseased and dying trees, but sometimes the signs of disease aren’t easy to identify and there is a greater chance of leaving diseased trees behind following harvest, to continue to spread, though hopefully at a much slower rate. Also if alternative 5 is selected no actions would be taken in the stands that are deemed to have threatened and endangered species habitat. These stands would then in effect have the same results as the no action alternative. As stated above, “under this alternative all the diseased and dying trees would be left in all the mixed conifer stands, continuing the mortality cycle, while adding to the fuel loads. Where stands are infected with *Leptographium wageneri* (black stain root disease), mortality would continue as root-to-root contact is made with adjacent healthy trees, creating ever widening pockets of mortality at a rate of 4-12 feet per year. Where stocking is the prime reason for the mortality problems, trees will continue to die and fall creating unnatural fuel loads. Shade tolerant tree species will continue to grow in the understories and add to the already high ladder fuels that are found in the mixed conifer stands”.

Also the black oak in these stands would continue to see stagnation due to higher than desired densities and would continue to see conifer encroachment to the point where the conifer could eventually out compete the oak for sunlight and nutrients.

**Cumulative Effects**

The cumulative effects of alternative 5 would be an overall reduction in the overall species composition shift, due to the fact that planting spots would not be created within the mortality pockets. There would also be a slight increase in the mortality rate due to the fact that disease problems would not be properly treated, though it would be reduced from the no action alternative. In the stands that are deemed threatened and endangered species habitat, no action would be taken. In these stands that are predominantly mixed conifer, shade intolerant trees would continue to get out competed and die as well as the hardwood species within these stands.

Alternative 5 would contribute approximately 8,631 acres toward improving forest health and growth with regards to stand susceptibility to insect infestation and drought-related mortality. All other cumulative effects would be similar to Alternative 1.

**Conclusions**

When comparing the action alternatives 3, 4 and 5 as well as the no action alternative 1, the alternative that best meets the purpose and need is alternative 3. Table 3 is an excerpt from Table 7 in the EIS. For all of the key issue indicators alternative 3 came the closest to achieving or exceeding all the objectives for overall forest health along with other resource objectives.
Table 3. Alternative Comparison

<table>
<thead>
<tr>
<th>Resource</th>
<th>Alternative 1 (No Action)</th>
<th>Alternative 3 (Modified Proposed Action)</th>
<th>Alternative 4 (No new Temporary Roads, Machine Piling or Fireline Construction)</th>
<th>Alternative 5 (No Group Selection, Treatments in Threatened, Endangered, or Sensitive Species Habitat, or Yarding in Riparian Reserves)</th>
</tr>
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</table>
| **Key Issue Indicator – Issue 1**<br>Stand Density Index (SDI) for 20 years – As compared to the recommended SDI of 230 (60% of maximum SDI of 365 for ponderosa pine) | - Existing condition is SDI of 184 – 831 across the project area (mixed conifer averages 328). Average SDI:  
  - 379 (ponderosa pine-dominated and mixed conifer stands);  
  - 151 (knobcone stands)  
- SDI in many stands will increase over time to well above recommended levels. In 21 years SDI of:  
  • 332 (ponderosa-pine dominated stands);  
  • 411 (mixed conifer);  
  • 196 (knobcone) | - 9,754 acres thinned to SDI of:  
  • 159 (pine-dominated stands);  
  • 217 (mixed conifer); and  
  • 41 (knobcone).  
In 21 years estimated SDIs of:  
  • 196 (ponderosa pine),  
  • 264 (mixed conifer), and  
  • 92 for knobcone | - 9,204 acres thinned to SDI of:  
  • Same as Alternative 3 for thinned stands  
  • Same as Alternative 1 for unthinned stands. | - 8,631 acres thinned to SDI of:  
  • Same as Alternative 3 for thinned stands  
  • Same as Alternative 1 for unthinned stands. |
| **Key Issue Indicator – Issue 1**<br>Mortality (Forest Health) - Reduction in tree mortality for 20 years as a percentage decreased mortality compared to Alternative 1 | - Mortality Rate in 20 Years in Cubic Feet Per Acre Per Year  
  • Pine-dominated 24 ft³  
  • Mixed Conifer 34 ft³  
  • Knobcone 11 ft³  
- Blackstain mortality pockets expected to increase in diameter 4-12 feet per year | - Reduction in Mortality Rate in 20 Years over Alternative 1  
  • Pine-dominated 71%  
  • Mixed Conifer 74%  
  • Knobcone 91%  
- Blackstain mortality pockets expected to increase in diameter 4-12 feet per year | - Reduction in Mortality Rate in 20 Years over Alternative 1  
  • Same as Alternative 3 for thinned stands (9,024)  
  • Same as Alternative 1 for unthinned stands. | - Reduction in Mortality Rate in 20 Years over Alternative 1  
  • Same as Alternative 3 for thinned stands (8,631)  
  • Same as Alternative 1 for unthinned stands. |

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| **Key Issue Indicator – Issue 1**| Change in Species Composition Trending Toward (Historic Conditions) – Change in species composition in Mixed conifer stands reducing the number of shade tolerant species (white fir and incense cedar) and favoring more fire adaptive species (ponderosa pine, sugar pine, Jeffrey pine, lodgepole pine, Douglas-fir and black oak). In knobcone pine dominated stands reducing the numbers of decadent and dying knobcone pine while reintroducing ponderosa pine, Jeffrey pine and favoring non-knobcone species, such as incense cedar, black oak and white fir. | Species Composition in 2040 estimated as:  
- Mixed conifer – 1,273 acres  
  - Incense cedar – 54%  
  - White fir – 40%  
  - Douglas-fir – 4%  
  - Sugar pine – 1%  
  - Ponderosa pine – 1%  
- Knobcone – 653 acres  
  - Knobcone pine -54%  
  - Ponderosa pine – 27%  
  - Black oak – 18%  
  - White fir – 1%  
- Black oak in the azalea stand would continue stagnation and eventually be outcompeted by conifer  
  - Scattered black oak and aspen found in conifer stands would continue mortality and trend towards elimination in the project area. | Species Composition in 2040 estimated as:  
- Mixed conifer - 1,273 acres  
  - Incense cedar – 36%  
  - White fir – 27%  
  - Douglas-fir – 25%  
  - Sugar pine – 6%  
  - Ponderosa pine – 6%  
- Knobcone – 653 acres  
  - Knobcone pine -61%  
  - Ponderosa pine – 17%  
  - Black oak – 20%  
  - White fir – 0%  
  - Jeffrey pine – 2%  
- Black oak in the azalea stand would persist and be healthier (13acres)  
  - Scattered black oak and aspen found in conifer stands would continue mortality and trend towards elimination in the project area. | Species Composition in 2040 estimated as:  
- Same as Alternative 3 for thinned stands – 1,250 acres of mixed conifer (23 fewer acres) and 638 acres of knobcone (15 fewer acres)  
- Same as Alternative 1 for unthinned stands  
- 0 acres for the azalea black oak stand (13 fewer acres)  
- Same as Alternative 3 for knobcone stands and the Azalea black oak stand  
- Same as Alternative 1 for unthinned stands. |
Climate Change

Five weather stations on the Shasta-Trinity National Forest have shown significant increases in temperature over their periods of record. As each of the stations, the increases are being driven by a significant increase in mean minimum (nighttime) temperatures, which have risen by between 1 deg and 2.5 deg F. The increase in minimum mean (nighttime) temperature when compared to mean and maximum (daytime) temperatures are consistent with findings across California and the globe. Significant increases in nighttime temperatures have also been observed at several stations on the Mendocino, Klamath and Six Rivers National Forest. In addition to increases in nighttime temperatures, significant increases in maximum mean daytime temperatures were observed at the Shasta Dam, Whiskeytown Reservoir and McCloud weather Stations.

The occurrence of nighttime freezing temperatures is holding steady or decreasing at all available stations, with a significant decrease observed at the Weaverville station. At the beginning of the Weaverville data record, approximately four and a half months per year could be expected to have average nighttime temperatures that fall below freezing. Today the average is over three and the trend is decreasing.

McCloud has seen no change while Mt. Shasta has seen a general trend upward in all three categories (minimum, mean and maximum) except for the years 2012-2014 in which the highs were spiking, but not much higher than highs from previous years in most cases.

![Figure 2. Annual mean, maximum, and mean minimum temperatures at five weather stations. Linear regression equations, coefficients of determinations, and statistical significance shown for significant regressions only. No transformations were employed. Data from WRCC 2015.](image1)

![Figure 17 temperature measures for McCloud and Mt. Shasta last 13 yrs](image2)

Even though California has experienced a record setting drought that includes the lowest yearly precipitation on record, with 2012-2014 being the most severe in the past 1,200 years. Despite the current drought conditions, climate data analyzed suggests long-term slight to moderate increases in precipitation in the vicinity of the Shasta Trinity National Forest and is supported by precipitation trends from the four weather stations with available precipitation data on and adjacent to the Shasta Trinity National Forest. There are no statistically significant changes in mean annual precipitation at any of the four weather stations analyzed. There is very high interannual variability in all five precipitation records, such that the value predicted by the regression line in each figure is rarely representative of the actual annual mean. There were no significant increases in seasonal precipitation at any station, and the distribution of precipitation across the year has remained similar through the record.
For the three stations with available snowfall records, all show declining trends in annual snowfall, with significant decreases at Shasta Dam and McCloud of 12 and 69 inches respectively. Snowfall data for Weaverville and Mt. Shasta were too incomplete to allow for analysis. Snowfall data for Weaverville and Mt. Shasta were too incomplete to allow for analysis.

There has not been any temporal trend in the annual proportion of fire area burning at high severity with fires larger than 400 hectares occurring on the four Northwest Californian Forests between 1987 to 2008. However, the mean and maximum fire size and total annual area burned all increased over the period from 1910 to 2008 and regional fire rotation fell to 95 years by 2008. For the period of 1987-2008, fire severity was also shown to be greater in forests that had smaller overall diameters and lower cover versus stands that had larger diameters and higher cover. Also, it was shown that stands that burned more than once (a measure of the effect of fire on vegetation), during the same time span (1987-2008), severity in the conifer and hardwood forests was higher the second time burned versus the first time. It was also found that years with larger fires and greatest area burned were produced by region wide lightening events and were characterized by less winter and spring precipitation than in years dominated by small human ignited fires, but that the percentages of high severity fires was generally less in region wide lightening events.

Upslope and poleward shifts in vegetative species is thought to be occurring due to climate change, but it has been very hard to identify. What has been noticed more, due to fire suppression, has been the increase in stand densities and the decrease in drought tolerant and shade intolerant species. Natural openings have decreased and so have the large old growth pine stands as they have seen increased competition from shade tolerant species such as white fir, incense cedar and Douglas-fir. This is happening across the west including in Northern California.

As of today, no published climate change or vegetation change modeling has been carried out for the Shasta-Trinity National Forest. General Circulation Models (GCM) are currently the most widely used models for predicting future climate scenarios. These models have limitations based on area. Most models have outputs that are tens of thousands of square kilometers in area. For this reason, getting specific information for a certain area, even the size of the state of California, is difficult. Based on this, a series of algorithms and assumptions are used in order to get down to a finer scale that might be more useful. This is adding uncertainty to already uncertain data. With that said, the climate in California is predicted to become warmer with varying amounts of precipitation depending on where you are. Increased water demand, extended drought periods and high precipitation variability are likely to increase ecosystem vulnerability in a changing climate. Despite global projections for increases in precipitation extremes, it was found that only modest increases in the number and magnitude of large precipitation events would occur in California. However, analysis of 34 global climate models projects increases in the frequency of interannual precipitation extremes over California, with extremely dry wet seasons becoming roughly 1.5-2 times more common and wet extremes generally tripling in frequency by the end of the century. The north and south coasts of California are also projected to experience the largest increase in humid nighttime heat wave events (Butz, Sawyer and Stafford, December 2015).

Shasta Trinity National Forest Entomologist, Cynthia Snyder in a March 2017 memo explained that the mortality seen in the pine stands is caused by two driver’s drought and the pine trees inability to withstand western pine beetle attacks, due to the drought. Competition for limited soil moisture among trees growing in dense stands increases their susceptibility to bark beetles even during periods of normal precipitation and can render them defenseless to bark beetle attacks during periods of drought. Densely stocked stand with high levels of standing and down dead trees are also at extreme risk for stand replacing wildfire. Her recommendation to forest managers is, even though managers cannot control drought, they can control stand density and reduce fuels. An increase in active management can change the trajectory of our forest ecosystems from one that is at extreme risk to bark beetle outbreaks and stand replacing wildfire in a warmer and drier climate, to one that is more resilient to disturbance. Reducing stand density, reducing fuels, reintroducing fire and creating heterogeneity in tree species and there
spatial arrangement on the landscape is the best strategy to maintaining functional forest ecosystems in our area.

Based on the above findings, implementing this project would help meet the projected changes to the local climate by reducing the stand densities, which would reduce the competition for resources during the dry times. This reduction in stand densities would also have an effect on the rate of growth of the residual trees, which equates to increased rates of carbon sequestration. These treatments would also potentially lessen the effects of a wildfire by reducing the overall fuels, both ladder fuels and ground fuels. Also if implemented, the species composition would be shifted more towards a species type that is both more drought and fire resistant making these stands more prepared for the anticipated changes instore.

**Glossary**

**Basal Area** - The cross-sectional area of a single stem, including the bark, measured at breast height (4.5 ft or 1.37 m above the ground).

**Conifer/Coniferous** - A cone bearing tree.

**Co-dominant** - A tree whose crown helps to form the general level of the main canopy and receiving full sunlight from above and comparatively little sunlight from the sides.

**Cubic foot** - A unit of true volume that measures 1’ L x 1’ W x 1’ H.

**Cull** - Any item of production, e.g. trees, logs, lumber or seedlings, rejected because it does not meet certain specifications of usability or grade.

**Diameter at breast height (dbh)** - Is measured 4.5 feet up from the root collar on the uphill side of the tree.

**Dominant** – That component of a community, typically a species, exerting the greatest influence on its character because of its life form or great abundance. An individual or species of the upper layer of the canopy or crown class.

**Group selection** - trees are removed and new age classes are established in small groups typically in areas not over 2 acres in size.

**Hardwoods/ deciduous** - Naturally shed, e.g., leaves or fruit. Of perennial plants that are normally more or less leafless for some time during the year.

**Heterobasidion annosum (Annosus)** - A fungus that attacks the root system increasing susceptibility to bark beetles, the effects of drought and causes mortality. Long distance spread is by wind-borne spores that infect fresh cut stumps and trees with basal scares and spreads into the stumps and roots and survives in living or dead trees as well as fresh or rotting tree stumps, and can persist for many years.

**Intermediate** - A tree whose crown extends into the lower portion of the main canopy, but that is shorter in height than the co dominants and receiving little direct sunlight from above and none from the sides.

**Leptographium wageneri (black stain root disease)** - Infection centers may be initiated by root-feeding weevils that carry fungal spores on their bodies and infect (ponderosa pine trees in our area), that are disturbed when the weevils feed on damaged and disturbed roots. The black stain is identified by the distinctive dark brown or black sapwood stain in the root crown that sometimes streaks upward into the lower bole, as well as thin and faded crowns.
Legacy Tree- A tree, usually mature or old-growth, that is retained on a site after harvesting or natural disturbance to provide a biological legacy.

Machine piling- The piling of forest debris with the use of a bulldozer or an excavator.

Mechanical Harvesting - cutting with mechanized equipment such as a carrier mounted shear or a feller-buncher instead of by hand with a power saw. Mechanical harvesting - cutting with mechanized equipment such as a carrier mounted shear or a feller-buncher instead of by hand with a power saw.

Mastication- To grind or crush. To soften or reduce to pulp by crushing or kneading.

Mesic- Of or relating to or adapted to an environment having a balanced supply of moisture.

Natural Regeneration - The establishment of a plant or a plant age class from natural seeding, sprouting, suckering, or layering.

Plantations- A stand composed primarily of trees established by planting or artificial seeding.

Reforestation- The reestablishment of forest cover either naturally (by natural seeding, coppice, or root suckers) or artificially (by direct seeding or planting).

Relative Density- The ratio, proportion, or percent of absolute stand density to a reference level (in this case stand density index) defined by some standard level of competition.

Shade tolerant species- Having the capacity to compete for survival under shaded conditions.

Shade intolerant species- Having the capacity to compete for survival under direct sunlight conditions.

Silviculture- The branch of forestry that is concerned with the cultivation of trees.

Stand Density Index (SDI)- A widely used measure developed by Reineke (1933) that expresses relative stand density in terms of the relationship of a number of trees to stand quadratic mean diameter 2. Any index that expresses relative stand density based on a comparison of measured stand values with some standard condition.

Single tree selection- single tree selection individual trees of all size classes are removed more or less uniformly throughout the stand, to promote growth of remaining trees and to provide space for regeneration.

Sanitation – The removal of trees to improve stand health by stopping or reducing the actual or anticipated spread of insects and disease.

Variable Density Thinning- This type of thinning deliberately creates non-uniform conditions through a stand. Non-uniform thinning, often called variable-density thinning, has some advantages over uniform thinning in accelerating the development of wildlife habitat and a preserving or developing biodiversity.

Xeric- Of or relating to or adapted to a dry environment.

References Cited


Feeney, Kolb, Covington and Wagner 1998. Influence of thinning and burning restoration treatment on presettlement ponderosa pines at the Gus Pearson Natural Area.


Fry, Dawson and Stephens 2012. Age and structure of mature knobcone pine forests in the Northern California Coast Range, USA.


Kolb, Holmberg, Wagner and Stone 1997. Regulation of ponderosa pine foliar physiology and insect resistance mechanisms by basal area treatments.


McDonald and Vaughn 2007. Growth of thinned and unthinned hardwood stands on a good site in northern California.

Mt. Shasta Watershed Analysis May, 2012


Sala, Peters, McIntyre and Harrington 2005. Physiological responses of ponderosa pine in western Montana to thinning, prescribed fire and burning season.

Skinner & Taylor 2006. Fire in California Bio Region’s, Chapter 10, Southern Cascades Bioregion


Appendix A  Vegetation Diversity at the Watershed Level

Affected Environment

Biological diversity is provided by an array of vegetation types, their successional stages and their localized special components such as rock outcrops, snags and down logs. The Forest Plan provides for vegetation diversity through the Forest Goals and Forest-wide Standards and Guidelines. One of the Forest Goals is to achieve biodiversity at all ecosystem scales (LRMP, page 4-4). Forest-wide Standards and Guidelines provide for and maintain at least five percent of each timber type/seral stage, including both suitable and unsuitable timber lands (LRMP, page 4-14). Standards and Guidelines also maintain a minimum level of 15 percent late-successional forest within each 5th-field watershed (LRMP, page 4-63). Definitions for late-successional seral stages are found on page 4-15 of the Forest Plan. Late-successional forests are forest in their mature and/or old growth stages. Mature stands are those where the annual growth rate has peaked (Report of the Forest Ecosystem Management Assessment Team, July, 1993, Glossary). Mature Forest ecosystems are dry to moist forests dominated by conifer or deciduous tree species over 80 years old. Understory becomes well developed and canopy opens up, but moss layer remains thin. Mature Forests often lack large snags, fallen logs and other large woody debris of older stands (Island Trust).

The project area is located within portions of five 5th-field watersheds, the Box Canyon, Upper Sacramento River, Squaw Valley Creek, Upper McCloud River and Ash Creek Vegetation types within the project area are typical of the southern Cascades and the McCloud Flats area and are dominated by ponderosa pine, white fir and incense-cedar, with minor amounts of Douglas fir and sugar pine. Within the five 5th-field watersheds, red fir occurs on the upper slopes of Mt. Shasta, generally above 6000 feet. Brush species (greenleaf manzanita, whitethorn ceanothus, bitterbrush) and knobcone pine is scattered throughout the watersheds and often are the result of past fires. Barren areas are present on the upper slopes of Mt. Shasta, generally above 7500 feet elevation.

Table A-1. Current vegetation types within the Ash Creek and Box Canyon 5th field watersheds in the Highway 89 project

<table>
<thead>
<tr>
<th>Vegetation Type*</th>
<th>Ash Creek Watershed</th>
<th>Box Canyon Watershed</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>acres</td>
<td>% of all lands on National Forest</td>
</tr>
<tr>
<td>Mixed Conifer</td>
<td>27,148</td>
<td>32</td>
</tr>
<tr>
<td>Ponderosa Pine</td>
<td>15,716</td>
<td>19</td>
</tr>
<tr>
<td>Red Fir</td>
<td>14,137</td>
<td>17</td>
</tr>
<tr>
<td>White Fir</td>
<td>12,757</td>
<td>15</td>
</tr>
<tr>
<td>Lodgepole Pine</td>
<td>2,899</td>
<td>3</td>
</tr>
<tr>
<td>Whitebark Pine</td>
<td>921</td>
<td>1</td>
</tr>
<tr>
<td>Knobcone Pine</td>
<td>468</td>
<td>1</td>
</tr>
<tr>
<td>Hardwood</td>
<td>103</td>
<td>0</td>
</tr>
<tr>
<td>Douglas-fir</td>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td>Wet Meadow</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Grasses &amp; Forbs</td>
<td>904</td>
<td>1</td>
</tr>
<tr>
<td>Shrub</td>
<td>5,211</td>
<td>6</td>
</tr>
<tr>
<td>Water</td>
<td>3</td>
<td>0</td>
</tr>
</tbody>
</table>
## Table A-2. Current vegetation types within the Squaw Valley Creek and Upper McCloud River 5th field watersheds in the Highway 89 project

<table>
<thead>
<tr>
<th>Vegetation Type *</th>
<th>Squaw Valley Creek Watershed</th>
<th>Upper McCloud River Watershed</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>acres</td>
<td>% of all lands on National Forest</td>
</tr>
<tr>
<td>Barren (including urban)</td>
<td>21,181</td>
<td>62</td>
</tr>
<tr>
<td>Mixed Conifer</td>
<td>518</td>
<td>2</td>
</tr>
<tr>
<td>Ponderosa Pine</td>
<td>2,553</td>
<td>7</td>
</tr>
<tr>
<td>Red Fir</td>
<td>2,011</td>
<td>6</td>
</tr>
<tr>
<td>White Fir</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Lodgepole Pine</td>
<td>255</td>
<td>0</td>
</tr>
<tr>
<td>Whitebark Pine</td>
<td>610</td>
<td>2</td>
</tr>
<tr>
<td>Knobcone Pine</td>
<td>1,631</td>
<td>5</td>
</tr>
<tr>
<td>Hardwood</td>
<td>2,731</td>
<td>8</td>
</tr>
<tr>
<td>Wet Meadow</td>
<td>10</td>
<td>0</td>
</tr>
<tr>
<td>Grasses &amp; Forbs</td>
<td>226</td>
<td>0</td>
</tr>
<tr>
<td>Shrub</td>
<td>1,420</td>
<td>4</td>
</tr>
<tr>
<td>Water</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Barren (including urban)</td>
<td>1,264</td>
<td>4</td>
</tr>
<tr>
<td>Total: all National Forest Lands</td>
<td>34,410</td>
<td>100</td>
</tr>
</tbody>
</table>

## Table A-3. Current vegetation types within the Upper Sacramento River 5th field watershed in the Highway 89 project

<table>
<thead>
<tr>
<th>Vegetation Type *</th>
<th>Upper Sacramento River Watershed</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>acres</td>
</tr>
<tr>
<td>Mixed Conifer</td>
<td>17,128</td>
</tr>
<tr>
<td>Ponderosa Pine</td>
<td>1,109</td>
</tr>
<tr>
<td>Red Fir</td>
<td>288</td>
</tr>
<tr>
<td>White Fir</td>
<td>1,745</td>
</tr>
<tr>
<td>Lodgepole Pine</td>
<td>0</td>
</tr>
<tr>
<td>Whitebark Pine</td>
<td>11</td>
</tr>
<tr>
<td>Knobcone Pine</td>
<td>88</td>
</tr>
<tr>
<td>Hardwood</td>
<td>377</td>
</tr>
<tr>
<td>Douglas-fir</td>
<td>1,019</td>
</tr>
</tbody>
</table>
Currently all the 5th field watersheds in the project are seeing below desired levels for the seral stage 1 (grasses and forbs) on national forest lands, as well as large tree with open canopy (seral stage 4a). Desired levels are 5% of each seral stage, including both suitable and unsuitable timber lands (Forest Plan, pg. 4-14).
Table A-4. Current seral stage distribution on National Forest lands within the 5th Field Watersheds

<table>
<thead>
<tr>
<th>Seral Stage</th>
<th>All lands on National Forest</th>
<th>Forested land on National Forest</th>
<th>Box Canyon (331 project acres in WA)</th>
<th>Squaw Valley Creek (321 project acres in WA)</th>
<th>Upper McCloud River (9,611 project acres in WA)</th>
<th>Upper Sacramento River (2,772 project acres in WA)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>acres</td>
<td>%</td>
<td>acres</td>
<td>%</td>
<td>acres</td>
<td>%</td>
</tr>
<tr>
<td>1 Grass/forb</td>
<td>942</td>
<td>1</td>
<td>918</td>
<td>2</td>
<td>235</td>
<td>0</td>
</tr>
<tr>
<td>2 Shrub/seedling/sapling **</td>
<td>12,697</td>
<td>15</td>
<td>7,486</td>
<td>10</td>
<td>5,989</td>
<td>10</td>
</tr>
<tr>
<td>3a Medium tree w/open canopy</td>
<td>11,115</td>
<td>13</td>
<td>11,115</td>
<td>15</td>
<td>8,005</td>
<td>14</td>
</tr>
<tr>
<td>3b-c Medium tree w/closed canopy</td>
<td>37,848</td>
<td>45</td>
<td>37,848</td>
<td>51</td>
<td>23,395</td>
<td>40</td>
</tr>
<tr>
<td>4a Large tree w/open canopy</td>
<td>483</td>
<td>0</td>
<td>483</td>
<td>1</td>
<td>633</td>
<td>1</td>
</tr>
<tr>
<td>4b-c Large tree w/closed canopy</td>
<td>10,914</td>
<td>13</td>
<td>10,914</td>
<td>15</td>
<td>8,376</td>
<td>15</td>
</tr>
<tr>
<td>4c older Large tree; old growth</td>
<td>5,823</td>
<td>7</td>
<td>5,823</td>
<td>8</td>
<td>6,750</td>
<td>12</td>
</tr>
<tr>
<td>Barren</td>
<td>5,000</td>
<td>6</td>
<td>3,581</td>
<td>6</td>
<td>1,253</td>
<td>2</td>
</tr>
<tr>
<td>Urban</td>
<td>4</td>
<td>0</td>
<td>43</td>
<td>0</td>
<td>11</td>
<td>0</td>
</tr>
<tr>
<td>Water</td>
<td>3</td>
<td>0</td>
<td>150</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Total</td>
<td>84,829</td>
<td>100</td>
<td>73,669</td>
<td>100</td>
<td>57,840</td>
<td>100</td>
</tr>
</tbody>
</table>

**The acreage displayed for Seral Stage 2 on NF forested lands does not include the brush/shrub component.**
Vegetation Trends

Project Level
Vegetation patterns across the project area have primarily developed from three occurring disturbance factors; mudflows, fire suppression and timber harvest. Three major mudflow events have been identified in the past 1200 years that have impacted a large area within the project boundary. The most recent of these occurred from 1924-1926. Mudflow events would bury much of the smaller vegetation in the area of the mudflow, but also left ideal seedbeds for the establishment of dense stands of ponderosa pine. Mudflow activity and subsurface water patterns maintained a system of wet meadows in the western edge of the McCloud Block of the project area. Frequent natural fires maintained variable density with dense patches along with open conditions. Many of these fires would remove understory trees while retaining larger overstory trees and reduce the overall vegetation density across a landscape. Natural fire also maintained the open character of meadows as well as the species composition of the other forested stands by removing the less fire adapted species.

Historic records from the general area, prior to logging also described conditions as being more open than what they are today (Mt. Shasta W.A., page 106). Logging began on the McCloud Flats in the late 1800’s, early 1900’s with the advent of railroad logging. An emphasis on harvesting large shade intolerant trees at that time left the residual forest in a very open condition with many of the lesser than desirable species.

Aerial photography since 1944 also indicates a trend of increasing stocking of the conifer forest and a decline in the extent and connectivity of the wet meadow systems, both within the project area and throughout the five fifth-field watersheds. Seral stage diversity is moving toward a more closed canopy, mature forest as a result of effective fire suppression and reduction of large-scale wildland fires. Large brushfield conversion projects in the 1970’s replaced areas of early seral habitat with ponderosa pine plantations that are currently approaching mid-seral habitat conditions.

There has been a shift in both vegetation type and seral stage levels within the project area on approximately 3,842 acres of ponderosa pine dominated stands in areas that have seen mortality due to density, drought, insects and disease. These areas have generally declined from 3b-c and 4b-c seral stages to 3a and 4a seral stages due to the mortality. The impacts of the mortality have previously been discussed in the section in existing condition section.

Watershed Level
Portions of all of the 5th-field watersheds within the project area include areas that have been withdrawn from intensive timber management with the existence of wilderness, Roadless areas and LSR’s. Timber harvest was restricted on approximately 3,000 acres in the Upper McCloud River 5th Field Watershed by the establishment of the Shasta Mudflow Research Natural Area (RNA) in 1971. Fuel treatments within the RNA are only permitted following appropriate planning with and approval by the Regional RNA Committee (Forest Plan, page 4-49). The establishment of the West Girard Roadless Area in the late 1970’s restricted timber harvest on approximately 19,000 acres (55%) of the Squaw Valley Creek 5th Field Watershed. The roadless designation, combined with a lack of earlier timber harvest in the area, has resulted in the high level of late-seral habitat in this watershed. The Mount Shasta Wilderness as well as the Castle Crags Wilderness include stands of late-successional forest in portions of all five watersheds that are protected from timber harvest.

There has been a shift in both vegetation type and seral stages within the Upper McCloud River 5th Field Watershed on approximately 1500 acres of predominantly ponderosa pine forest that have been heavily infected by root disease. The recent Mudflow project had approximately 280 acres of reforestation with the Algoma LSR within had approximately 200 acres of reforestation. All of these totaling approximately 1,980 acres have create seral stage 1 or 2, all within the Upper McCloud River Watershed.
Due to current management restrictions within roadless areas, it is unlikely that the Squaw Valley Creek 5th Field Watershed will see any harvest below the minimum level of 15 percent late-successional forest within the watershed in the foreseeable future, although a future underburning fuels project is planned, the underburning combined with implementation of the Highway 89 Project is not expected to reduce the levels of late-successional forest. The current level in this watershed is approximately 43 percent and is not likely to be reduced except in the case of extensive wildfire. Much of the Upper McCloud River 5th Field Watershed has been intensively managed for several decades and the current level of late-successional forest is approximately 17 percent on federal forest lands. Late-successional forest in this watershed is expected to remain above the 15 percent level as younger stands develop and replace stands that are lost to insects, disease and fire.

**Alternative 1: No Action**

*Direct and Indirect Effects (Vegetation Diversity)*

Under Alternative 1, no activity would occur and therefore, no direct or indirect effects. The natural progression towards 3a and 4a seral stages (unless large scale stand mortality occurs) will slowly progress across the project area, except in areas of high density and where there is currently pine mortality. A shift in vegetation types can currently be seen in areas where the ponderosa pine trees are dying and sites are being replaced by a younger cohorts of conifer trees. The potential for stand replacing wildfire will continue to increase as pine mortality continues and bark beetle related mortality increases causing heavy fuel loads in the mortality areas.

**Alternatives 3, 4 and 5: Action Alternatives**

*Direct and Indirect Effects (Vegetation Diversity)*

Within the Ash Creek, Box Canyon, Squaw Valley Creek and Upper Sacramento 5th Field Watersheds, there will be no immediate measurable change to seral stage and vegetation type distribution as a result of implementing any of the action alternatives. Within the Upper McCloud River 5th Field Watershed Alternative 3 proposes treatment of approximately 653 acres within knobcone pine stands in which the seral stage will change from effectively a 3a or b (medium tree open/closed) to a seral stage 2 (shrub seedling/sapling). This in fact will not be every acre of the 653 acres because there are going to be reserve trees left in the stand, but on a whole this is the easiest description. Alternative 4 proposes no new temporary roads and will reduce silviculture treatments by approximately 550 acres. Thinning treatments in natural conifer stands and hardwood stands will reduce stand densities, but not to an extent that would result in a change of seral stage. Because the largest healthy trees in a stand will be retained, with exceptions in LSR and MLSA where these prescriptions do not apply and a greater proportion of larger, diseased trees will be retained to promote late-successional conditions, there will be no reduction in size class. Radial thinning around conifers, and oak and aspen treatments, would reduce canopy cover in small areas but would not change the seral stage at the stand level. Sanitation/thinning treatments are scattered and will be done where pockets of pine mortality have occurred, and do not cause a change in seral stage at the stand level. Of all treatments, only the knobcone pine treatment will shift seral stage at the stand level. Approximately 653 acres identified for knobcone removal in all three action alternatives are currently identified as seral stages 3a or 4a (Approximately 40 percent canopy closure). All action alternatives will thin stands to more desirable density levels that will make the stands more resilient in the event of a wildfire or an outbreak of disease. They will also manage for a species diversity that is more representative of the historic condition. The only measurable effect on seral stage will be in the knobcone stands. The other areas that will have regeneration done will have no measurable effect on the overall diversity.

With all of the thinning treatments there will be no immediate measurable change to seral stage and vegetation type distribution in areas proposed for thinning, sanitation areas, or within the highway 89 treatment corridor. These treatments will reduce stand densities but not to an extent that would result in a
change of seral stage. Because the treatments will leave the largest healthiest dominant and codominant trees in a stand, there will be no reduction in size class.

Within the Upper McCloud River 5th Field Watershed, the Hwy 89 project proposes planting openings in knobcone pine stands with a mix of appropriate species for the sites. These openings will occur in portions of stands totaling 653 acres. Although stand conditions will be modified, the residual large green trees in these stands will provide adequate crown canopy to meet conditions specified for Seral Stages 3a and 4a. Post treatment the number of trees per acre will be approximately 40 trees per acre lending itself to an open stand condition. Large healthy trees will be retained in these areas, the existing 4a seral stage will be reduced to Seral Stage 1 in some areas, but not all.

Bitter brush restoration activities are proposed on approximately 61 acres in all of the action alternatives where conifers are encroaching into open areas. The majority of this area is in the early seral stage and treatment will not result in a measurable change to the existing seral stage. The encroaching conifer will be removed and the meadow will be returned to its historic boundary, per 1944 aerial photography, improving the natural vegetation composition.

**Cumulative Effects (Vegetation Diversity)**

The cumulative effect analysis for vegetation diversity is bound by the five fifth-field watersheds described above based on Forest Plan direction for assessing the existing percent of late-successional forest and the effects of the alternatives on that successional stage (Forest Plan, page 4-63).

Under current management direction no old growth stands within the Hwy 89 project or within the five 5th field watersheds will be treated. Since all of the 32,691 acres of old growth forest (approximately 12 percent of federal forest lands in the watersheds) are not going to be treated, no changes are expected.

The Mountain Thin project will artificially regenerate approximately 98 acres of decadent knobcone pine. Mudflow will have approximately 27 acres of artificial regeneration, Pilgrim will have approximately 64 acres, Pilgrim plantation will have approximately 82 acres, Elk LSR will have approximately 88 acres, Car A 4 acres and Trout Creek will have 19 acres regeneration of the knobcone pine stands will shift approximately 382 acres from Seral Stage 3bc to Seral Stage 1. Future and foreseeable projects within the five 5th field watersheds are currently not expected to have treatments that greatly affect the vegetation diversity. In order to have a large affect to the vegetation diversity a very large scale event would have to occur such as a large scale wildland fire.

| Table A- 5. Reasonably foreseeable future commercial thinning projects in all five 5th field watersheds |
|-------------------------------------------------------------|------------------|------------------|
| **Project**                                                | **Natural stand Commercial Thinning** | **Plantation Thinning** |
| Mt. Shasta plantation maintenance                          | 0                | 977              |
| Mt Thin veg and fuels                                      | 553              | 0                |
| Mudflow veg management                                     | 721              | 0                |
| Pilgrim plantation insect and disease                      | 0                | 453              |
| McCloud plantation maintenance                             | 0                | 257              |
| Pct of plantations in LSR’s                                | 0                | 10               |
| Algoma veg management                                      | 1,142            | 0                |
| **Totals**                                                 | **2,416**        | **1697**         |

The commercial thinning of 798 acres of conifer stands will occur within plantations in seral stages 2 to 3bc. Therefore, thinning treatments will not generally result in an immediate change of vegetation type or seral stage. Thinning will have a long term positive effect by accelerating the development into later seral stages.

The proposed Hwy 89 project will have no measurable cumulative effect on seral stage and vegetation type distribution within any of the 5th Field Watersheds, including the 653 acres to be treated in the knobcone pine
stands, due for the fact that we are not removing the species, but bringing the stands closer to species composition that would have historically existed. There will be no reduction in the amount of old growth forests in the watersheds, which will remain at roughly 12 percent.

The cumulative effect of the project on vegetation diversity, along with the other seven reasonably foreseeable future commercial thinning projects within the HUC 5 Watersheds (as listed in Table 3-19), will have no reduction in seral stages because they are commercial thinning projects which have only an effect on the density and not the seral stage. Therefore, none of the proposed alternatives in the project would cumulatively reduce the amount of old growth habitat.

In the long term (20 years and longer), these watersheds will have a greater percent of the landscape in late-successional and old-growth forests as thinning treatments accelerate tree growth and stands mature into late-successional and old-growth forest, absent catastrophic events such as wildfire, insects or disease.
Appendix B Marking Guidelines

The marking guidelines for this project are broken down into nine main treatment types:

- Highway 89 corridor
- Ponderosa Pine Plantations greater than 10 inches dbh
- Ponderosa Pine Plantations less than 10 inches dbh
- Mixed conifer
- Ponderosa pine dominated natural stands
- Knobcone pine dominated stands
- Developed Recreation Areas
- Bitterbrush
- Wildland Urban Interface Treatment and powerline corridors

The actual stand by stand treatments will be found on the individual stand record cards, but for a general discussion, this will cover the general mark as it will be found on the ground.

To help with the discussions schematics are provided below to help define crown class as well as radial release.

![Crown Class Illustration](image)

**Figure B-1. Crown Class Diagram**

- **OP** = Open Grown trees have little to no competition from other trees and receive full light from above and all sides.
- **CO** = Codominant are trees that’s crowns help to form the general level of the main canopy. Receiving full sunlight from above and comparatively little from the sides.
- **OV (Suppressed)** = Overtopped or suppressed trees are those that’s crowns are completely overtopped by the crowns of one or more neighbors.
- **DO** = Dominant trees are those that’s crown extends above the general level of the main canopy and receiving full light from above and partial light from the sides.
**IN** = Intermediate trees are those that’s crown extends into the lower portion of the main canopy, receiving little direct light from above and none from the sides.

**RE** (Legacy) = Remnant or Legacy trees are trees that are surviving from an earlier time. Predating the initiation of the current stand. Considerably the largest trees in the stand.

Figure B-2. Diagram of oak release radius by quadrant

In all stands, radial thinning will be done around individual black oak trees 3 in dbh or greater. The extent of the radial thinning will be 30 ft from the tree dripline on the north, east and west sides, and 60 ft from the dripline on the south side.

Black oaks >8 to 10” DBH with cavities or damage/structure that may contribute to the formation of cavities will not be released such as major forks, breaks, sweeps. Microsite components (i.e. mixed-conifer understory) that may contribute to thermal or visual cover for TES species will be retained in some of the mixed conifer stands (see mixed conifer treatment below).
Highway 89 Safety Enhancement and Forest Restoration Project

Highway 89 Treatment

The treatment along the highway 89 corridor will extend 150 to 200 feet from the edge of the highway on the north side and 150 to 275 feet from the edge of the highway on the south side. The prime objective of the treatment will be to remove trees that pose a hazard to hitting the highway either whole or in part. Trees that will be considered for removal will be trees that are diseased and dying and aren’t expected to persist into the future, have an uncorrected lean of 15° or greater towards the highway, trees that have dead tops that could hit the highway, trees that have forked tops that pose a threat to hitting the highway. Other trees that will be considered for removal will be trees that cast large shadows onto the highway and/or have overhanging branches that have the risk of dumping branches and/or snow loads onto the highway. The remainder of the corridor will be thinned down to 100 sqft/ac on the north side and 80 sqft/ac on the south side. Species preference will be similar to that of the stand the highway 89 treatment lies.

In addition, ladder fuels will be reduced by thinning down to 4 inches dbh and removing suppressed, intermediate then codominant trees in that order until the basal area targets are met. Retain free to grow 4-9.9 inch trees where they exist. Where mortality is a problem, a sanitation treatment may be necessary to deal with the problem and maintain driver safety. In general species preference will be SP, DF, PP, JP, IC, WF and LP. Remove all KP.

Plantations ≥ 10 inches dbh

Thinning will be done to reduce the relative stand density down to 35-55% of the maximum stand density index (sdi) of 365 as a part of trying to get the plantations ready for prescribed burning and helping them

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**Figure B-3.** The Hawksworth six-class dwarf mistletoe rating system

<table>
<thead>
<tr>
<th>Instructions</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Step 1</strong> Divide live crown into thirds.</td>
<td>If this third has no visible infections, its rating is (0).</td>
</tr>
<tr>
<td><strong>Step 2</strong> Rate each third separately.</td>
<td></td>
</tr>
<tr>
<td>Each third should be given a rating of 0, 1, or 2 as described below.</td>
<td></td>
</tr>
<tr>
<td>(0) no visible infections</td>
<td></td>
</tr>
<tr>
<td>(1) light infection (1/2 or less of total number of branches in the third infected)</td>
<td></td>
</tr>
<tr>
<td>(2) heavy infection (more than 1/2 total number of branches in the third infected)</td>
<td></td>
</tr>
<tr>
<td><strong>Step 3</strong> Add ratings of thirds to obtain rating for total tree.</td>
<td>The tree in this example gets a rating of 0 + 1 + 2 = 3.</td>
</tr>
</tbody>
</table>

On a tree or stand basis, light infection is a rating of 1 to 2; moderate is 3 to 4; and severe is 5 to 6. For a stand, the rating is calculated as the average rating of all infected trees. Incidence is the percentage of susceptible trees infected by dwarf mistletoe.
flourish into the future. In general these targets will be met using a standard formula developed by Reineke in 1933 that helps calculate sdi, which is \( (sdi = tpa(Dq/10)^{1.6}) \). Non pine species will be retained over pine species, except for knobcone pine, for diversity and sanitation treatments will be prescribed in areas where mortality is occurring. Conifers will be removed within 150 feet of aspen stands (groups of 5 or more stems greater than 12 inches in height within 20 feet of each other) and individual aspen trees 3 inches dbh or greater. Eight to 10 healthy legacy conifers per acre may be left to provide structure and wildlife habitat without inhibiting aspen growth.

Areas that have residual trees that pre-date the planting of the surrounding stand will be left unthinned.

**Plantations ≤ 10 inches dbh**

Thinning will be done mechanically or by hand, down to a relative stand density of 35-55% of max sdi. In general these targets will be met using a standard formula developed by Reineke in 1933 that helps calculate sdi, which is \( (sdi = tpa(Dq/10)^{1.6}) \). Diversity will be enhanced by retaining non pine species when thinning the plantations. These young plantations might also have a weed/release prescribed either by hand or masticator as a part of trying to get the plantations ready for prescribed burning and helping them flourish into the future. Radial release will be implemented around oak 3 inches and larger where they exist. Conifers will be removed within 150 feet of aspen stands (groups of 5 or more stems greater than 12 inches in height within 20 feet of each other) and individual aspen trees 3 inches dbh or greater. Eight to 10 healthy legacy conifers per acre may be left to provide structure and wildlife habitat without inhibiting aspen growth.

Areas that have residual trees that pre-date the planting of the surrounding stand will be left unthinned.

**Mixed conifer**

Stands will be variably thinned 10 inches dbh or greater to an average basal area of 125-150 sqft/ac. The treatment will focus predominantly on thinning the suppressed, intermediate than codominant trees in that order until basal area targets are met. Trees 4-9.9 inches will be retained during the initial harvest whenever operationally feasible to maintain habitat structure. Some clumps of non-pine species will be retained while shade intolerant and less frequent species will be released.

Some trees with decadence, cavities and greater than 50% cull will be retained where available for wildlife habitat.

All legacy trees will be retained unless determined to be a hazard.

Legacy sugar and ponderosa pine will be released from surrounding conifer competition on a spacing of 50 feet from the bole of the legacy tree.

Where mortality is an issue group select harvests will be implemented, not to exceed two acres in any one opening, to slow the mortality. Since pine species are of low frequency in this forest type, larger group selections (approximately 2 acres each) will be planted to pine. Smaller openings (less than 1 acre) will be evaluated to determine whether or not site preparation and replanting will be necessary. If planting is needed, the openings will be planted with non-pine species that are found within the stand.

Where they occur and can provide wildlife microhabitat function, clumps of trees will be retained and not thinned. Clumps will consist of tightly-grouped mixed conifer species (i.e. white fir, Douglas fir, incense cedar, Pacific yew, and/or sugar pine and with little or no ponderosa pine present) and will vary in size. Clumps may be as small as 4-6 trees and will generally be under 1/10th acre in size. Trees of varying size classes will be retained to provide shading, cover, structure (e.g. prominent lateral branching, forked tops, mistletoe brooms, etc. and visual cover for these structures), and heterogeneity important for wildlife microhabitat function (thermal and visual cover from predators and/or for use as resting and nesting/denning
Highway 89 Safety Enhancement and Forest Restoration Project

sites). Clumps will be retained at a rate of up to 10% of each mixed conifer treatment stand. Retention rates will be variable, and will depend on the availability of habitat structure.

Radial thinning will be done around some individual black oak trees 3 inches dbh or greater with the exception of a stand in the snowmans block and one stand in the pine tree hollow area. The extent of the radial thinning will be 30 feet from the tree dripline on the north, east and west sides, and 60 feet from the dripline on the south side. However, in some areas of mixed conifer stands, some black oaks greater than 8-inch dbh will not be released. These are black oaks with structure and/or deformities such as existing cavities, prevalent forked branches, and/or surrounded by mixed-conifer, multistoried trees that contribute to the oak’s microsite function (as fisher resting or denning habitat and/or NSO or bat roosting habitat).

Pine Dominated Natural Stands

Stands will be variably thinned down to a basal area of 80 to 120 sqft/ac across all diameter classes 4 inches dbh and greater. The treatment will predominantly focus on thinning the suppressed, intermediate than codominant trees in that order until basal area targets are met and as a part of trying to get the stands ready for prescribed burning and helping them flourish into the future.

All legacy trees will be retained unless they are determined to be a hazard.

Legacy sugar and ponderosa pine will be released from surrounding conifer competition on a spacing of 50 feet from the bole of the legacy tree.

Some trees with decadence, cavities and greater than 50% cull will be retained where available for wildlife habitat.

In general with all things being equal species preference will typically be SP, DF, PP, JP, IC, WF and LP.

In areas of rock that have trees growing amongst the rock, leave unmarked if logging cannot get done without damage to the harvest equipment.

Remove all KP when encountered.

Stands that show an ongoing mortality problem might have a sanitation treatment or group select treatment prescribed. The sanitation treatment portion within these stands will treat the insect and disease problems appropriately, slowing the rate of the spread of the mortality due to disease and western pine beetle activity. These openings will be large enough to treat the insect and disease problems but will be limited to no more than 1/3 of the stand area. Any openings that are created will be evaluated to determine whether or not site preparation and replanting will be necessary. Replanting will include a mix of tree species appropriate for the site.

In some pine-dominated stands, clumps of non-pine trees will be retained and not thinned where operationally feasible (see clumps description in mixed conifer section above).

Knobcone Pine Dominated Stands

Knobcone pine trees down to 4 inches dbh will be removed, leaving all other non-pine species that show little to no signs of insects or disease. Trees that show signs of insects and/or disease will also be removed. After removal of knobcone, residual ponderosa pine would be thinned to a basal area target of 80-120 sqft/ac where it exists. The thinning would primarily focus on suppressed, intermediate then codominant trees in that order, until basal area targets are met.
In areas of rock that have trees growing amongst the rock, leave unmarked if logging cannot get done without damage to the harvest equipment.

Suitable openings will be planted with species other than knobcone pine, such as ponderosa pine, Jeffrey pine, incense cedar and black oak following the initial prescribed burn.

After the silviculture treatments, stands will be underburned to reduce brush and fuels to desirable levels, and then re-burned before new knobcone pine mature and produce seeds that can germinate. The intent is to set back their establishment and growth and to allow for the establishment and growth of other tree species.

**Developed Recreation Areas**

Areas will be variably thinned across all diameter classes in developed recreation areas. To retain privacy screening, there will be limited thinning between campsites and all other high traffic areas like trails, roads, campsites and picnic sites and other recreation areas.

Group selection or sanitation/ thinning treatments will be implemented in areas of mortality to reduce the rate of spread of disease and mortality.

Thinning treatments along the McCloud River Trail will be determined based on topography. Where machinery can access the site, the treatment will be incorporated into the surrounding timber stands. In areas that are too steep for machinery, hand treatment may be necessary to accomplish the treatment.

All recreation sites will incorporate the District Recreation Officers input during the marking of those sites.

**Bitterbrush treatment**

Encroaching conifers within the bitterbrush field will be cut by hand or machine to release the bitterbrush. Some conifers will be retained based on the historical conditions (as per 1944 aerial photographs and old stumps) of the field, including legacy trees. Large snags will also be retained as safely feasible.

**Wildland Urban Interface (WUI) and powerline corridors**

Treatments within a quarter of a mile of private structures will have different treatments than the surrounding stand which contains the WUI. These treatments will be developed to reduce the ladder fuels as well as breakup the crown to crown contact continuity. These treatments will be variably thinned down to 4 inches dbh to a target basal area range of 60–100 sqft/ac, thinning from below up to the codominant size class, maintaining the biggest best trees available. Treatments along the powerlines will also meet that basal area targets for WUI zones 300 feet either side of the powerline corridor. Hazard trees will also be targeted for removal which include trees that have a probability of all or portions of the tree hitting the powerlines.
Appendix C Highway 89 Borax Report

1. Safety Plan for Application of Sporax® and Cellu-Treat®

Both Sporax® and Cellu-Treat® are applied to recently cut tree stumps. No broadcast application methods are used in forestry applications of these borates. Coupled with the natural occurrence of boron (Section 2.2), this limited use of borates is a limiting factor in risks potentially posed by the use of borates in Forest Service programs.

The anticipated presence of root disease within the project area includes primarily blackstain root disease as well as annosus in pine and white fir trees across the project area. The presence of root disease has had a long history across the McCloud Flats with blackstain root disease infection centers being recognized in densely stocked ponderosa pine stands in the early 1970’s and annosus root disease centers identified in 1980. ¹

Annosum root disease is caused by the fungus, *Heterobasidion annosum*, which infects cut conifer stumps following thinning or cutting operations. Overland infection in regards to annosum root disease is through spores produced by the fungus which occupy freshly cut stump surfaces. The disease colonizes the stump and major lateral roots where it may remain up to 50 years depending on site conditions. The potential increase in annosum infection as a result of harvest activities is limited through the use of Borax applied on stump surfaces ≥ 14” diameter during harvest operation. Borax is toxic to annosus spores and therefore prevents infection. ²

For stump applications, Cellu-Treat® is labelled only for liquid applications; while, Sporax® may be applied as either a liquid or solid. Thus, the liquid application exposure scenario applies to both Cellu-Treat® and Sporax®.

Sporax® (Na₂B₄O₇·10H₂O sodium tetraborate decahydrate) is used as a registered pesticide (fungicide) EPA Reg. No. 2935-501, EPA Est. No. 66196-CA-01 (WILBUR-ELLIS SPORAX®). The granular borax (or similar formulation) is applied to freshly-cut stump surfaces at a rate of one pound per 50 square feet of stump surface within four hours of creation. This is equivalent to one pound of sporax on 36 sixteen-inch stumps (Sporax label, Wilbur-Ellis Company).

Cellu Treat® (Na₂B₈O₁₃·4H₂O Disodium octaborate tetrahydrate) is used as a registered pesticide (fungicide) EPA Reg. No. 64405-8, EPA Est. 64405-TN-1, label specifies a concentration for 0.5 lbs formulation per gallon of water and indicates one gallon will treat 200 square feet. Sporax applications will follow all State and Federal rules and regulations as they apply to pesticides (e.g. Sporax label and material safety data sheet, below).

Both used for the prevention of *Heterobasidion annosum* (annosus) root disease. It is estimated that approximately 1 pound of sporax/acre would be applied in thinning prescription stands. Application of sporax in the manner proposed with the Hwy 89 project is to apply a thin layer on fresh cut conifer stumps similar to salting a steak. In terms of formulations, the application rate for Cellu-treat is less than the application rate for Sporax by a factor of about 8. In terms of boron equivalents, the stump application rate for Cellu-Treat is less than the stump application rate for Sporax by a factor of about 4.3

The Sporax® and Cellu-Treat® label and material safety data sheets are displayed below:

¹ Freeman, Wilfred, Biological Evaluation of Tree Mortality on McCloud Flats, Forest Insect and Disease Management, May, 1977
² Kliejunas, John and Bill Woodruff, Pine Stump Diameter and Sporax Treatment in Eastside Pine Stands, Report No R04-01, June 2004
ACTIVE INGREDIENT
SODIUM TETRABORATE DECEHYDRATE
(Na₂B₄O₆·10H₂O) .................................................................................................................. 100%
Boric Oxide (B₂O₃) equivalent .................................................................................................. 37.50%

EPA Reg. No. 2935-501 EPA Est. No. 2935-CA-01

KEEP OUT OF REACH OF CHILDREN DANGER

FIRST AID

If in eyes: Hold eyelids open and rinse slowly and gently with water for 15-20 minutes. Remove contact lenses, if present, after first 5 minutes, then continue rinsing eye. Call a poison control center or doctor for treatment advice.

If swallowed: Call a poison control center or doctor immediately for treatment advice. Have person sip a glass of water if able to swallow. Do not induce vomiting unless told to do so by the poison control center or doctor.

If on skin or clothing: Remove contaminated clothing and wash skin with soap and water. Rinse skin with plenty of water for 15-20 minutes. Call poison control center or doctor for treatment advice.

If inhaled: Move person to fresh air. If person is not breathing, call 911 or ambulance, then give artificial respiration, preferably by mouth-to-mouth, if possible. Call a poison control center or doctor for further treatment advice.

DIRECTIONS FOR USE

It is a violation of Federal law to use this product in a manner inconsistent with its labeling.

USE FOR CONTROL OF ANNOTUS ROOT DISEASE IN CONIFER STANDS: It has been established that the fungus, Heterobasidion annosum, often infects cut conifer stumps following thinning or cutting operations, and that the disease can spread from infected stumps to residual trees in the stand.

Several chemical agents have been used to limit the development of annosus root disease. Research has shown that borax prevents establishment and growth of annosus in cut conifer stumps of conifer species not already infected with the disease.

Before using the WILBUR-ELLIS SPORAX for stump treatment control of annosus infection, contact local, State or Federal Forestry or plant pathology specialists to verify the most economical and efficient methods and materials for your situation.

Use of WILBUR-ELLIS SPORAX for this purpose includes all conifer tree species occurring in the stand being treated. WILBUR-ELLIS SPORAX should be applied to stump surface of the cut tree as soon as possible after sawing. For most efficient use, apply immediately after cutting, but avoid delaying treatment more than one day.

The best method of application is to sprinkle the material "salt-shaker" style on the freshly cut stump surface. Complete coverage, including exposed side areas and any splinters, is necessary. Also level surface or sloping stump surfaces are preferred, especially in areas of high rainfall. "Shaker-top" applicators are available in most farm and garden shops in one or two pound sizes.

Apply enough WILBUR-ELLIS SPORAX to lightly cover entire stump surface. At proper rates of application, one pound of this product will adequately cover 50 square feet of stump surfaces; that is, 262 six-inch stumps, 158 eight-inch stumps, 80 ten-inch stumps, or 60 twelve-inch stumps.

When dry method is used, moisture in the exposed wood from freshly cut stumps, dew or rain, will dissolve the product and leach it into the wood.

STORAGE AND DISPOSAL

PROHIBITIONS: Do not contaminate water, food or feed by storage or disposal. Do not store where children or animals may gain access. Open burning and dumping prohibited. Do not use more empty container.

PESTICIDE DISPOSAL: Pesticide, spray mixture or rinse that cannot be used or chemically reprocessed should be disposed of according to procedures approved by Federal, State or Local disposal authorities.

CONTAINER DISPOSAL: Consult Federal, State or Local disposal authorities for approved procedures.

PRECAUTIONARY STATEMENTS
HAZARDS TO HUMANS AND DOMESTIC ANIMALS

DANGER

Corrosive. Causes irreversible eye damage. Harmful if swallowed. Do not get in eyes or on clothing. Wear goggles or face shield. Wash thoroughly with soap and water after handling. Remove contaminated clothing and wash clothing before reuse. Do not leave container where children or animals may gain access.

PERSONAL PROTECTIVE EQUIPMENT (PPE)
Applicator and other handlers must wear: Long-sleeved shirt and long pants, shoes, socks and waterproof gloves.

ENVIRONMENTAL HAZARDS
Do not apply directly to water, or to areas where surface water is present or to intertidal areas below the mean high-water mark. Do not contaminate water when disposing of equipment washwaters or rinses. Borax carelessly spilled or applied to cropland or growing plants - including trees or shrubs - may kill or seriously retard plant growth.

IN CASE OF EMERGENCY, CALL CHEMTREC: (800) 424-9300

NET CONTENTS: 25 POUNDS

WARRANTY STATEMENT

WILBUR-ELLIS COMPANY warrants that this product conforms to the chemical description on the label and is reasonably fit for the purposes stated on such label only when used in accordance with directions under normal use conditions. It is impossible to eliminate all risks inherently associated with use of this product. Crop injury, ineffectiveness or other unintended consequences may result because of such factors as weather conditions, presence of other materials or the manner of use or application, all of which are beyond the control of WILBUR-ELLIS COMPANY. In no case shall WILBUR-ELLIS COMPANY be liable for consequential, special or indirect damages resulting from the use or handling of this product. All such risks shall be assumed by the buyer. The exclusive remedy of any buyer or user of this product for any and all losses, injuries, or damages resulting from or in any way arising from the use, handling or application of this product, whether in contract, warranty, tort, negligence, strict liability or otherwise, shall not exceed the purchase price paid for this product or at WILBUR-ELLIS COMPANY's election, the replacement of this product. WILBUR-ELLIS COMPANY MAKES NO WARRANTIES OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE OR ANY OTHER EXPRESS OR IMPLIED WARRANTY EXCEPT AS STATED ABOVE.

WILBUR-ELLIS Logos and IDEAS TO GROW WITH® are registered trademarks of WILBUR-ELLIS COMPANY.

Manufactured by:

WILBUR-ELLIS COMPANY
P.O. Box 16458 - Fresno, California 93755
MATERIAL SAFETY DATA SHEET

PRODUCT/TRADE NAME:
SPORAX

I. NAME
PRODUCT/TRADE NAME: SPORAX
OSHA PEL ACGIH TLV
Sodium Tetraborate Dehydrate 1303-96-4

II. HAZARDOUS INGREDIENTS

Chemical Name: Sodium Tetraborate Dehydrate
CAS#: 1303-96-4
OSHA PEL: NE
ACGIH TLV: NE

III. PHYSICAL DATA

SPECIFIC GRAVITY (H20 = 1): NA
MELTING POINT: 62°C
VAPOUR DENSITY (AIR = 1): NA
% VOLATILES BY VOL.: NA
ODOR: None
APPEARANCE: White Crystalline Solid
FLASH POINT/METHOD: NA
VAPOUR PRESSURE (mmHg): NA
SOLUBILITY IN H2O: Partially

IV. FIRE & EXPLOSION HAZARD

EXTINGUISHING MEDIA: [] Water Fog [] Foam [] Alcohol Foam
[] CO2 [] Dry Chemical [] Other

RECOMMENDED FIRE FIGHTING PRECAUTIONS & HAZARDS:
This product is not flammable. It also can act as a fire retardant.

V. CARCINOGEN STATUS

[] OSHA [] NTP [] IARC [X] No Listing Type

VI. REACTIVITY

[X] Stable
HAZARDOUS POLYMERIZATION
[ ] Unstable [ ] May Occur [X] Will Not Occur
AVOID: Elemental Zinc
HAZARDOUS DECOMPOSITION PRODUCTS: NA

VII. SPILL OR LEAK PROCEDURES

STEPS TO BE TAKEN IN CASE OF SPILL: Vacuum or sweep up and reuse or
place in a disposal container.

DECONTAMINATION: Treat area with detergent and water. Repeat as neces-
sary until area is clean.

ENVIRONMENTAL HAZARDS: None

DISPOSAL: Dispose of in accordance with federal, state and local regulations.

VIII. HEALTH PRECAUTION DATA

INGESTION: Acute oral LD50 (rat) 613 g/kg (U.S. Borax). Do not ingest. Wash
thoroughly before eating, drinking or smoking.

INHALATION: May cause slight nasal irritation

SKIN ABSORPTION: Not expected to cause irritation.

EYE EXPOSURE: Causes irreversible eye damage. Wear proper eye protec-
tion to prevent exposure.

EFFECTS OF OVEREXPOSURE: Symptoms of overexposure are sneezing,
coughing and eye damage. Ingestion may cause nausea, vomiting, diarrhea
and facial flushing.

FIRST AID: In all cases, get prompt medical attention. If ingested, give several
ounces of water. Do not induce vomiting. For skin exposure, wash with water.
For eye exposure, irrigate a minimum of 15 minutes with water. If infected,
remove to fresh air.

IX. SPECIAL PROTECTION INFORMATION

RESPIRATORY PROTECTION: Use NIOSH/MSHA-approved respiratory
protection for nuisance particulates.

PERSONAL PROTECTIVE EQUIPMENT: Safety goggles or glasses with side
shields and brow protection.

VENTILATION: Local exhaust ventilation recommended for control of nuisance
dust.

X. SPECIAL PRECAUTIONS

Keep out of the reach of children. Read and follow all label instructions.

XI. REGULATORY DATA

SARA HAZARD CLASS: [X] Acute [ ] Chronic [ ] Flammable
[ ] Pressure [ ] Reactive [ ] None
SARA 313: [ ] Yes [X] No Chemical:
SARA 302: [ ] Yes [X] No Chemical:

CERCLA: [ ] Yes [X] No Chemical:

RCRA: [ ] Yes [X] No
NFPA HAZARD RATING:
Fire: [0] 0 = Minimal 3 = Serious
Reactivity: [0] 1 = Slight 4 = Severe
Special: [ ] 2 = Moderate

HIMS CODES:
Health: [2] 0 = Minimal 3 = Serious
Fire: [0] 1 = Slight 4 = Severe
Reactivity: [0] 2 = Moderate

DATE PREPARED: March 31, 1993
REVISED DATE: February 5, 2002

Notice: This information was developed from information on the
constituent materials. No warranty is expressed or implied regarding
the completeness or continuing accuracy of the information contained
herein, and Wilbur-Ellis disclaims all liability for reliance thereon. The
user should satisfy himself that he has all current data relevant to his
particular use.

*Technical Material NE-Not Established NA-Not Applicable

24 Hour Emergency Phone Number
CHEMTREC: (800) 424-9300

wescom@Sporax.PN65
Material Safety Data Sheet
DOT Cellu-Treat®
WOOD PRESERVATIVE

Health Emergencies: CHEMTREC® (800) 424-9300

SECTION I – COMPANY AND PRODUCT IDENTIFICATION

Manufacturer: Nius Corporation
100 Nius Drive
Rockford, TN 37853
(800) 264-0870  Fax: (865) 577-5825

Product name: Cellu-Treat®

Product use: Wood Preservative

Chemical formula: Na8B4O11 • 4H2O

Chemical name/synonyms: Disodium octaborate tetrahydrate

Chemical family: Inorganic borates

CAS registry number: 12289-03-4

EPA registration number: 64905-8
(Refer to Section IS for TSCADSL Chemical inventory listing)

SECTION II – HAZARD IDENTIFICATION AND PERSONAL PROTECTIVE EQUIPMENT INFORMATION

EMERGENCY OVERVIEW: Cellu-Treat is a white, odorless, powdered substance that is not flammable, combustible, or explosive and has low acute oral and dermal toxicity.

POTENTIAL ECOLOGICAL EFFECTS: Large amounts of Cellu-Treat can be harmful to plants and other species. Therefore, releases to the environment should be minimized.

POTENTIAL HEALTH EFFECTS: Routes of exposure: Inhalation is the most significant route of exposure in occupational and other settings. Dermal exposure is not usually a concern because Cellu-Treat is poorly absorbed through intact skin.

INHALATION: Occasional mild irritation effects to nose and throat may occur from inhalation of Cellu-Treat dust at levels greater than 10 mg/m³.

EYE CONTACT: Cellu-Treat is non-irritating to eyes in normal use.

SKIN CONTACT: Cellu-Treat does not cause irritation to intact skin.

INGESTION: Products containing Cellu-Treat are not intended for ingestion. Cellu-Treat has a low acute toxicity. Small amounts (e.g., a teaspoonful) swallowed accidently are not likely to cause effects; swallowing amounts larger than that may cause gastrointestinal symptoms.

Cancer: Cellu-Treat is not a known carcinogen.

Signs and symptoms of exposure: Symptoms of accidental over-exposure to Cellu-Treat might include nausea, vomiting, and diarrhea, with delayed effects of skin redness and peeling.

Personal protection: Eye protection, protective clothing, and water proof gloves may be necessary under certain high exposure conditions. Otherwise, refer to label for actual regulatory personal protection requirements.

Occupational exposure limits: Disodium octaborate tetrahydrate (Cellu-Treat) is considered to be a nuisance dust by OSHA, Cal OSHA, and ACGIH. The OSHA PEL is 15mg/m³ total dust and 5mg/m³ respirable dust. The Cal OSHA PEL and ACGIH TLV are 10mg/m³.

Use local exhaust or engineering controls to prevent exceeding exposure limits if possible.

SECTION III – FIRST AID MEASURES

Inhalation: If symptoms such as nose or throat irritation are observed, remove person to fresh air.

Eye Contact: Use eye wash fountain or fresh water to cleanse eye. If irritation persists for more than 30 minutes, seek medical attention.

Skin Contact: No treatment necessary because non-irritating.

Ingestion: Swallowing small quantities (one teaspoon) will cause no harm to healthy adults. If larger amounts are swallowed, give two glasses of water to drink and seek medical attention.

SECTION IV – ACCIDENTAL RELEASE MEASURES

General: Cellu-Treat is a water-soluble white powder that may, at high concentrations, cause damage to trees or vegetation by root absorption.

Land spill: Vacuum, shovel or sweep up Cellu-Treat and place in container for disposal in accordance with applicable local regulations. Avoid contamination of water bodies during cleanup and disposal.

Spillage into water: Where possible, remove any intact containers from the water. Advise local water authorities that none of the affected water should be used for irrigation or for the abstraction of potable water until natural dilution returns the boron value to its normal environmental background level.

Cellu-Treat is a non-hazardous waste when spilled or disposed of, as defined in the Resource Conservation and Recovery Act (RCRA) regulations (40 CFR 261).

SECTION V – PHYSICAL AND CHEMICAL PROPERTIES

Appearance: White, odorless, powder

Bulk density: 320 to 450 kg/m³

Vapor pressure: Negligible @ 20°C

Solubility in water: 0.7% @ 20°C; 34.3% @ 50°C

Melting point: 815°C

pH @ 20°C: 8.3 (3.0% solution)

7.6 (10.0% solution)

SECTION VI – FIRE FIGHTING MEASURES AND HANDLING INSTRUCTIONS

Fire Fighting Measures

General Hazard: None, because Cellu-Treat is not flammable, combustible or explosive. The product is itself a flame retardant.

Extinguishing Media: Any extinguishing media may be used on nearby fires.


General: Cellu-Treat is a stable product.

Hazardous decomposition: None.

Handling Instructions

General: No special handling precautions are required, but dry indoor storage is recommended. Good housekeeping procedures should be followed to minimize dust generation and accumulation.

Storage Conditions: Ambient air temperatures and a low moisture environment.

Incompatible materials and conditions to avoid: Reaction with strong reducing agents, such as metal hydrides or alkali metals, will generate hydrogen gas, which could create explosive hazard.

SECTION VII – TOXICOLOGICAL INFORMATION

Acute Toxicity

Ingestion: Low acute oral toxicity; LD₅₀ in rats is 2,560 mg/kg of body weight.

Skin/dermal: Low, acute dermal toxicity; LD₅₀ in rabbits is greater than 2,000 mg/kg of body weight. Cellu-Treat is poorly absorbed through intact skin.

Inhalation: Low acute inhalation toxicity; LD₅₀ in rats is greater than 2.0 mg/L (org/gm³).

Skin Irritation: Non-irritant.

Eye Irritation: Dried test in rabbits produced mild eye irritation effects. Years of occupational exposure to Cellu-Treat indicates no adverse effects on human eye. Therefore, Cellu-Treat is not considered to be a human eye irritant in normal industrial use.

Sensitization: Cellu-Treat is not a skin sensitizer.
SECTION VIII – ECOLOGICAL INFORMATION

Ecotoxicity Data
General: Boron (B) is the element in disodium octaborate tetrahydrate (Cellu-Treat) which is used by convention to report borate product ecological effects. To convert disodium octaborate tetrahydrate into the equivalent boron (B) content, multiply by 0.2096.
Phytotoxicity: Boron is an essential micronutrient for healthy growth of plants; however, it can be harmful to boron sensitive plants (e.g. grass and ornamentals) in high quantities.
Algal Toxicity: Green algae, Scenedesmus subspicatus
96-hr EC50 = 24 mg B/L
Invertebrate Toxicity: Daphnids, Daphnia magna straup
24-hr EC50 = 242 mg B/L
Test substance: sodium tetraborate
Fish Toxicity:
Seawater:
Dab, Limanda limanda
96-hr LC50: 74 mg B/L
Freshwater:
Rainbow trout, S. gairdneri (embryo-larval stage)
24-day LC50 = 88 mg B/L
32-day LC50 = 54 mg B/L
Goldfish, Carassius auratus (embryo-larval stage)
7-day LC50 = 65 mg B/L
3-day LC50 = 71 mg B/L

SECTION IX – DISPOSAL CONSIDERATIONS

Disposal Guidance: Consult state and local authorities for disposal guidelines.
RCRA (40 CFR 261); Cellu-Treat is not listed under any sections of the Federal Resource Conservation and Recovery Act (RCRA).

SECTION X – REGULATORY INFORMATION

OSHA/Cal OSHA: This MSDS document meets the requirements of both OSHA (29 CFR 1910.1200) and Cal OSHA (Title 8 CCR 5194 (g)) hazard communication standards. Refer to Section 8 for regulatory exposure limits.
FIFRA: Cellu-Treat is registered with the EPA (EPA Reg. No. 64405-8), in accordance with Section 3 of FIFRA, as a pesticide product. U.S. EPA TSCA Inventory 12006-41
RCRA: Disodium octaborate tetrahydrate is not listed as a hazardous waste under any sections of the Resource Conservation and Recovery Act (RCRA) or regulations (40 CFR 261 et seq).
California Proposition 65: Disodium octaborate tetrahydrate (Cellu-Treat) is not listed on the Proposition 65 list of carcinogens or reproductive toxicants.
Superfund: CERCLA/SARA. Disodium octaborate tetrahydrate is not listed.
Safe Drinking Water Act (SDWA): Disodium octaborate tetrahydrate is not regulated under the SDWA, 42 USC 300g-1, 40 CFR 141 et seq. Consult state and local regulations for possible water quality advisories regarding boron compounds.
Clean Water Act (CWA) (Federal Water Pollution Control Act); 33 USC 1251 et seq.
- Disodium octaborate tetrahydrate (Cellu-Treat) is not itself a discharge covered by any water quality criteria of Section 304 of the CWA, 33 USC 1314.
- It is not on the Section 307 List of Priority Pollutants, 33 USC 1317, 40 CFR 129.
- It is not on the Section 311 List of Hazardous Substances, 33 USC 1321, 40 CFR 116.
Transportation Information: DOT hazardous classification. Disodium Octaborate Tetrahydrate (Cellu-Treat) is not regulated by the U.S. Department of Transportation.
For further information contact: Nisus Corporation
Technical and Sales Support: 1-800-284-0870

SECTION XVI – OTHER INFORMATION

The information and recommendations contained herein are based upon data believed to be correct. However, no guarantee or warranty of any kind expressed or implied is made with respect to the information contained herein. This information and product are furnished on the condition that the persons receiving them shall make their own determination as to the suitability of the product for their particular purpose and on the condition that they assume the risk of their use thereof.

Nisus Corporation
100 Nisus Drive • Rockford, TN 37853
(800) 264-0870 • www.nisuscorp.com
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The following contract clauses are included in the timber sale contract for the prevention and removal of spilled hazardous substances and to provide instructions for the application of borax or similar borate compounds to stumps.

**B6.34 – SANITATION AND SERVICING** Purchaser shall take all reasonable precautions to prevent pollution of air, soil, and water by Purchaser’s Operations. If facilities for employees are established on Sale Area, they shall be operated in a sanitary manner. In the event that Purchaser’s Operations or servicing of equipment result in pollution to soil or water, Purchaser shall conduct cleanup and restoration of the polluted site to the satisfaction of Forest Service.

Purchaser shall maintain all equipment operating on Sale Area in good repair and free of abnormal leakage of lubricants, fuel, coolants, and hydraulic fluid. Purchaser shall not service tractors, trucks, or other equipment on National Forest lands where servicing is likely to result in pollution to soil or water. Purchaser shall furnish oil-absorbing mats for use under all stationary equipment or equipment being serviced to prevent leaking or spilled petroleum-based products from contaminating soil and water resources. Purchaser shall remove from National Forest lands all contaminated soil, vegetation, debris, vehicle oil filters (drained of free-flowing oil), batteries, oily rags, and waste oil resulting from use, servicing, repair, or abandonment of equipment.

**B6.342 – HAZARDOUS SUBSTANCES** Purchaser shall notify the National Response Center and Contracting Officer of all releases of reportable quantities of hazardous substances on or in the vicinity of the Sale Area that are caused by Purchaser’s employees or contractors, directly or indirectly, as a result of Purchaser’s Operations, in accordance with 40 CFR 302.

**C6.412# - TREATMENT OF STUMPS** (9/2004) Within areas shown on Sale Area Map, Purchaser shall treat stumps of all live and dead conifer trees equal to or greater than 14 inches stump diameter, unless otherwise agreed in writing. Treatment shall be with an EPA registered borate compound, or similar formulation, which is registered in California for prevention of annosus root disease.

Treatment shall consist of removal of sawdust and other loose debris from the cut surface of the stump and application of a thin layer of the borate compound uniformly over the entire cut surface of the stump, including exposed wood surfaces on the sides, at the rate specified on the product label. For colorant use, Purchaser shall follow directions on the colorant label. Treatment shall be completed within four hours after felling.

Any surface irregularities on the stump which will prevent application of a uniform layer of borax shall be cut level prior to treatment. Purchaser shall provide the borate compound and apply it in compliance with the State of California laws and regulations pertaining to pesticides and pest control operations. Purchaser shall provide Forest Service with a copy of the “Monthly Summary of Pesticide Use Reports” submitted to the appropriate County Agricultural Commissioner.
II. Effectiveness of Borate Applications such as Borax® and Cellu-Treat®

Use of borates on stumps in the Hwy 89 project is limited to stumps 14 inches in diameter and greater based on the latest scientific research by Kliejunas and Woodruff (2004). This research paper cites survey results from the Mt. Shasta/McCloud Management Unit which is where the Hwy 89 project is located. “Stump diameters were measured during a survey on the McCloud Ranger District, Shasta-Trinity NF (DeNitto 1988). Results suggested that stumps less than 14 inches (35.6 cm) in diameter will not support active annosus infection centers.” This same survey was also cited in Dave Schultz’s report for the Edson Sale where he described no infection of 14 inch diameter pine stumps, less than 5% infection of 18 inch diameter stumps and approximately 10% infection of 22 inch diameter pine stumps. However, he did note that “the percent of pine stumps infected with H. annosum increases abruptly in the 18 inch stump class, so there would be serious consequences if there was less than 100% compliance by the applicator.”

Several other studies have demonstrated the efficacy of using borax as a stump treatment in California. Graham (1971) in a study on the Lassen National Forest found that less than 1% of borax treated Jeffrey and ponderosa pine stumps (8 to 16” in height) became colonized 4 weeks after artificial inoculation with annosum compared to over 61% of the untreated control stumps similarly inoculated and examined became colonized. Smith (1970) in a study on the Eldorado National Forest and the Lassen National Forest demonstrated that borax treatment of stumps in a white fir pole stand reduced infection significantly with 50 to 70% of the non-treated stumps becoming infected after inoculation compared to none of the borax treated stumps becoming infected. Kliejunas (1989) summarized the existing literature on borax effectiveness in the eastside pine type. In recreation areas there is direction to apply sporax to stumps 3 inches in diameter outside bark.

III. Alternatives to Borate Applications

Discontinue Logging: Discontinuing all timber harvesting is not a feasible alternative as thinning over-dense stands to meet objectives for late successional stand characteristics, forest health and fire reduction is essential to meeting the purpose and need of the proposed project. The No Action alternative in the EIS details the effects of no harvesting of trees.

Present logging techniques help prevent damage to residual trees and thereby reduce the points of entry for annosum spores. Design techniques in the Hwy 89 Project such as directional felling, the use of feller/bunchers and the adherence to Best Management Practices will reduce the incidence of tree wounding.

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4 Dave Schultz, Forest Entomologist, Input for Edson Sale (Report No. 04-02), March 2004
8 FSH 3409.11 – FSH 3409.11 - Forest health protection handbook Chapter 60 - management of specific pests, pg. 10 Chapter 60 - management of specific pests
Seasonal Restrictions: Cutting when annosus spores are lowest has been suggested, but there are no data or studies to support the efficacy of such a treatment in California. Morrison (1999) determined there was no significant difference in season of cutting in coastal British Columbia. Schmitt et al (2000) state that restricting cutting to summer months may reduce potential of stump and wound colonization, but give no data to evaluate, nor do they state that this would eliminate the need for Sporax. Ammon and Patel (2000) recommend thinning during dry, hot months in the SE US or during winter months in the NE US, but also give no data to evaluate, nor do they state that this would eliminate the need to treat the stumps otherwise. Phelps et al (undated) demonstrated that in the SE US, summer thinning only slightly reduced infection over controls and that borax treatment was much more effective. Filip and Morrison (1998) and Stambaugh (1989) report that cutting in the summer (April thru August) in the SE US, south of latitude 34°N appears to reduce losses caused by annosus root disease. Filip and Morrison (1998) state that seasonal logging has not been demonstrated in the interior west to be effective.

Seasonal Restrictions (cont): In Russell et al (1973), monthly spore patterns in Washington and Oregon peaked in the fall, with a lesser peak in the spring, but airborne spores were present in large numbers nearly year-round. In James and Cobb (1984), spores are produced in the Stanislaus and San Bernardino National Forests throughout the year. In their summary, Filip and Morrison (1998) state that although many materials have been tested, in the western US only borax is recommended and used operationally. Based on the data in James and Cobb (1984) and Russell et al (1973), it is likely that in the relatively mild climate of California where spores are produced throughout the year, restricting logging to a certain season would not be effective in reducing annosus root disease infection.

Prescribed Burning: There is no literature supporting prescribed burning as a control of annosus in California ecosystems. In the Western US, annosus conks are most often found inside stumps or under the bark. In the Southeast US, where the burning method was developed, conks are formed in the duff at the base of trees and could be killed by prescribed fire. Prescribed burning would not be feasible as a control method for annosus because of the need to destroy the stumps. In 1994, a field trial was attempted in which fire would be used to destroy infected stumps (Pronos 1994). This trial was unsuccessful because the stumps were still too wet to burn, even three years after harvest.

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Froelich et al 1978\textsuperscript{17} studied prescribed burned plots versus unburned plots in loblolly and slash pine plantations in the Coastal Plain of the southern United States. The study concluded that prescribed burned plots developed less infection than unburned plots. However, they also point out that other studies have resulted in an apparent increased severity of annosus root rot and that prescribed burning to reduce annosus root rot may not have practical application outside of the Coastal Plain or on soils with heavier texture than those in the study. The study further concludes that “borax, when applied to the fresh stump, has proved to be the most effective treatment in preventing losses”.\textsuperscript{18}

Froelich et al 1978 and Ammon & Patel 2000 are focused on management of forests in the Coastal Plain of the southern United States. Flip & Morrison 1998 mention prescribed burning only in their discussion of impacts and management in the southeastern United States — but in none of the other regions of North America. There is no literature supporting prescribed burning as a control of annosus in California ecosystems.

**Removal of Injured Trees:** There is no literature supporting the removal of injured trees as an effective control method of annosus in California ecosystems. Damaged and injured trees are routinely designated for removal during marking of all silvicultural treatments. Trees damaged during logging are routinely removed by the purchaser under timber sale contract clause B2.131(b). While the removal of injured trees will eliminate some sources of infection, there are no data or studies that indicate that the practice will eliminate the need for borax application.

**Mechanical Removal of Stumps:** Mechanical removal of stumps is not feasible due to high costs and environmental impacts. Kliejunas et al 2005 reports that results 12 years after treatment indicate that removal of infected trees and roots in a southern California campground may have significantly reduced conifer mortality caused by annosus root disease.\textsuperscript{19} Treatment consisted of removing all conifer trees, stumps, and visible roots from six annosus centers prior to development of a campground. The largest of these sites was approximately 0.75 acre.

Removal of infected stumps and roots would be effective in preventing the spread of annosus through trees roots but would not prevent annosus infection through freshly cut stumps surfaces unless all new stumps were also removed.

While stump removal may be appropriate on a small scale in high-value sites such as campgrounds, it is not a suitable method of controlling annosus root disease over large acreages due to high costs and environmental impacts. Of particular concern are:

- the potential for increased erosion due to disturbance of soil and ground litter.
- additional soil compaction from heavy equipment.
- impacts to visual quality due to soil disturbance and burn piles.
- impacts to habitat for sensitive mollusks and fungi (including S&M species).
- the increased risk of noxious weeds becoming established in areas of exposed soil.

**Use of Bio-pesticides:** \textit{Phlebiopsis gigantean} and/or \textit{Streptomyces griseoloalbus} are not currently registered for use as a biopesticide by the US Environmental Protection Agency and California. This method of control may be feasible in the future if efficacy can be demonstrated in California and if they are registered as

\textsuperscript{18} Froelich et al 1978, pages 98-99
\textsuperscript{19} Kliejunas et al 2005, page 158.
biopesticides by both US Environmental Protection Agency and California. Until such time as both efficacy and registration are met, these two remain indefensible options.

Cultural Control: This is already recognized as a method to reduce impacts from annosus root disease. From the R-5 Supplement to FSH 3409.11 (Chapter 60) (USDA Forest Service 1994a): Species Conversion. Because of host specificity of H. annosum favor the non-infected host species.

Both strains of annosus root disease are assumed to be present in the Hwy 89 project area. The P-group infects pines and incense-cedar. The S-group infects true fir and Douglas-fir. Since all conifer species in the area are affected by one of these strains borax would be applied to all stumps 14 inches in diameter and greater except in recreation areas where the minimum diameter is 3 inches.

IV. Human Risk Assessment

A peer reviewed Human Health and Ecological Risk Assessment 20 is a document written by professional toxicologists concerning the risks of using borax for stump treatments. Confirmation with David Bakke, Regional Pesticide Specialist/Invasive Plants Program Manager, indicates the most definitive study of the effects of borax is still the Human Health and Ecological Risk Assessment for Borax (Sporax®) Final Report (USDA FS 2006), which is incorporated by reference. The 2006 publication concludes that except for the most extreme exposure scenario considered in this risk assessment – i.e., the direct consumption of Sporax from a tree stump by a child – the use of Sporax in Forest Service programs will not substantially contribute to boron exposures in humans. In addition, the use of Sporax in Forest Service programs will not typically or substantially contribute to concentrations of boron in water or soil. (page x, 2nd paragraph)

The Human Health Risk Assessment details three scenarios:

- worker exposure via spill of granular product to the lower legs and hands
- ingestion of applied Sporax by a child
- exposure via consumption of water contaminated by accidental spill or by run-off

For worker exposure from granular Sporax spilled on the lower legs and hands, hazard quotients are well below the level of concern. Thus, workers do not appear to be at risk from Sporax under typical application conditions. (page xiv, 2nd paragraph)

For the general public, hazard quotients for consumption of Sporax from a tree stump by a child...are below levels of exposure associated with nonlethal effects such as diarrhea and vomiting... Thus, while this exposure scenario raises concern in that the Reference Dose (Rfd) could be substantially exceeded in a child directly consuming Sporax from a treated stump, the most likely adverse effects would probably be vomiting and diarrhea.

For consumption of water from a pond contaminated by Sporax due to runoff, none of the hazard quotients exceed the level of concern, even for the highest application rate of 5 lbs Sporax/acre. The highest hazard quotient for consumption of water contaminated by an accidental spill is 0.7, associated with child consuming water contaminated by the spill of 25 pounds of Sporax into a small pond. Thus, based on this risk assessment, the only exposure scenario that appears to present a significant potential risk is exposure by direct consumption under upper bound conditions.

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Details of the assumptions and calculations involved in the exposure assessments are included in the final reports both for 2006 and 2016. A summation of the 2006 and 2016 Human Health Risk Assessment’s findings is listed below:

**Workers**

…based on the available information and under the foreseeable conditions of application, there is no route of exposure or scenario suggesting that workers will be at any substantial risk from acute exposures to Sporax. *(page 3-25, 1st paragraph, SERA 2006)*

...Given the poor dermal absorption of boric acid, the hazard quotient for all of the accidental exposure scenarios are far below the level of concern. *(page 54 line 32, 2016 SERA)*

…even if workers were to repeatedly spill granular Sporax on the lower legs and hands every day, the hazard quotient associated with longer term exposures would be far below the level of concern. *(page 3-25, 3rd paragraph, SERA 2006)*

…eye irritation is likely to be the only overt effect as a consequence of mishandling Sporax. This effect can be minimized or avoided by prudent industrial hygiene practices during the handling of the compound. The Sporax label requires eye protection during application. *(page 3-25, last paragraph, SERA 2006)*

The MSDS for Cellu-Treat indicates that this product caused only mild eye irritation in rabbits *(Nisus 2009)*. Nonetheless, the product labels for both Cellu-Treat *(Nisus 2015)* and Sporax *(Wilbur-Ellis 2013)* indicate that protective eyewear is required when handling these products. *(page 31 line 26, SERA 2016)*

**General Public**

With the exception of the direct consumption of Sporax applied to a tree stump by a small child, none of the hazard quotients exceed the level of concern. *(page 3-26, 1st paragraph, SERA 2006)*

All of the hazard quotients for accidental exposures associated with liquid applications of either Cellu-treat or Sporax are also below the level of concern. The highest accidental hazard quotient for a liquid application is 0.02 (i.e. the upper bound of hazard quotient associated with the consumption of contaminated water by a child following an accidental spill. This hazard quotient is below the level of concern by a factor of 50. *(page 55 line 10, SERA 2016).*

…even at the highest application rate, there does not appear to be a risk associated with acute or chronic exposure to water contaminated by runoff. *(page 3-26, 4th paragraph, SERA 2006)*

**Sensitive Subgroups**

…exposure of pregnant women to borate compounds places the developing fetus at risk. *(page 3-27, 2nd paragraph, SERA 2006)*

…males with underlying testicular dysfunction could be at increased risk for boron-induced testicular toxicity. However, no data are available to quantify this risk. *(page 3-27, 2nd ¶, SERA 2006)*

The current risk assessment should be protective of reproductive effects. As noted in the previous Forest Service risk assessment, males with underlying testicular dysfunction could be increased for boron-induced testicular toxicity *(SER 2005a, page 3-27)*. While this may be the case, the uncertainty factors
used by U.S. EPA (U.S. EPA/ OPP/HED 2015a, page 11) and incorporated into the current risk assessment are intended to accommodate sensitive individuals in the human population. (page 55 line 40, SERA 2016)

Application of Sporax does not require mixing of any components therefore reports of accidents involving mixing would not make sense and are not known in the Region. If there have been spill incidents into streams, these have not been reported to the Regional Office. As per FSH 2109.14, (USDA Forest Service 1994b) all pesticide incidents must be reported to the Regional Office (Regional Pesticide-Use Specialist). All applications of pesticides on Forest Service projects in California follow all applicable Federal and California rules and regulations, including requirements for worker protection, storage, and environmental protection. Personnel are instructed to scoop up any spilled material and place it back in the application container. Using proper spill procedures, it is highly unlikely that humans or the environment would be harmed from borax treatments. Cellu-Treat mixing requires one gallon of water for every half pound of Cellu-Treat.

V. Ecological Risk Assessment
The 2006 and 2016 Human Health and Ecological Risk Assessment uses the following scenarios to access the risk of borax application:

Exposure of wildlife species
- direct consumption of applied Sporax
- ingestion of contaminated water
Exposure of aquatic species
- water contaminated by an accidental spill or by runoff
Exposure of terrestrial plants
- soil contaminated by runoff

Details of the assumptions and calculations involved in the exposure assessments are included in the final report. A summation of the 2006 and 2016 Human Health Risk Assessment’s findings are listed below:

Terrestrial Organisms

Terrestrial Vertebrates

…the exposure scenarios considered in this risk assessment are the direct consumption of Sporax applied to tree stumps (acute exposure), consumption of water contaminated by an accidental spill (acute exposure), and acute and chronic exposure by consumption of water contaminated by runoff. With the exception of direct consumption of Sporax applied to tree stumps, none of the exposure scenarios are associated with hazard quotients that exceed the level of concern. (page 4-19, 2nd paragraph, SERA 2006)

For the direct consumption scenario, there appears to be very little risk to either mammals or birds. Sporax applied to tree stumps does not appear to have attractant effects for deer and no clinical signs of toxicity were observed in deer allowed free access to Sporax-treated stumps. (page 4-19, 3rd paragraph, SERA 2006) Also as with mammals and for the same reasons, it is likely that the hazard quotients for liquid applications rate for the borates (e.g., Cellu-Treat) are overestimated and perhaps substantially so, given that all of the hazard quotients for birds are below the level of concern, the probable overestimate of potential risk does not have a qualitative impact on the risk characterization (page 85, lines 10-13, SERA 2016)
Based on the hazard quotients a deer must consume all of the borate on stump surfaces equivalent to 50 square feet following applications of CelluTreat or 12.5 square feet following applications of Sporax. These types of exposures seem unlikely, particularly for liquid applications. No credible incidents involving poisonings to mammals were identified in the available literature. (Page 84, lines 5 and 8, SERA 2016).

Risks associated with other exposure scenarios are very low…risk of exposure via the longer term consumption of contaminated water is characterized for a small mammal and range from 0.000003 to 0.005 and are below the level of concern by factors of about 200 to over 330,000. …this reflects the fact that the use of Sporax in Forest Service programs will not substantially contribute to or increase concentrations of boron in water or soil beyond those that are associated with the normal occurrence of boron in the environment. (Page 4-19, 4th paragraph, SERA 2006)

**Terrestrial Plants**

…non target terrestrial plants do not appear to be at risk from exposure to borax at the maximum application rate used by the Forest Service. However, this risk assessment is based on data from relatively few terrestrial plant species. It is possible that more sensitive species exist and may be at risk for boron-induced toxicity. (page 4-20, 1st paragraph, SERA 2006)

…The exposure assessment (Section 4.2.3) for plants indicates that stump applications will not lead to substantial and wide-spread increases in boron levels in soil. Consequently, formal dose-response assessments for terrestrial plants and microorganisms associated with soil exposures are not derived. As discussed further in Section 4.4.2.5 (risk characterization in terrestrial plants), this is not a serious limitation in the current risk assessment because all hazard quotients associated with drift are substantially below the level of concern. (page 76, lines 21and 33, SERA 2016)

According to the product labels for Sporax and Cellu-Treat (Wilbur-Ellis Company, no date; DOT Cellu-Treat, 01/09), borax carelessly spilled or applied to crops may retard plant growth or kill plants. The label does not specify which plants species are at greatest risk for borax-induced phytotoxicity (SERA, 2006 and 2016). The available toxicity data on boron in terrestrial plants are expressed in units of soil concentration – i.e., mg boron/kg soil which is equivalent to parts per million (ppm) concentrations in soil. The GLEAMS modeling discussed in Section 3.2.3.4 (page 3-18, SERA 2006) and (page 45, SERA 2016) provides estimates of concentration in soil as well as estimates of off-site movement (runoff, sediment, and percolation). Based on the GLEAMS modeling, concentrations in clay, loam, and sand over a wide range of rainfall rates are summarized in Table 4-1 (SERA 2006, Tables-7). As indicated in this table, peak soil concentrations in the range of about 0.46 ppm boron are likely in arid loam at an application rate 4-11 of 1 lb. Sporax/acre (0.11 lb. boron/acre). As rainfall rate increases, maximum soil concentrations are substantially reduced for each soil type because of losses from soil through percolation. The potential consequences of such exposures are discussed in Section 4.4 (Risk Characterization). Based on monitoring data, which show that normal boron concentrations range from 10 to 30 ppm, it is not expected that runoff from application of Sporax to tree stumps will contribute significantly to boron soil concentrations.

**Other Terrestrial Organisms**
Since borax is used effectively in the control of fungi and insects, adverse effects of environmental exposures to insects and nontarget microorganisms is possible. However, given the atypical application method for Sporax, widespread exposures are not likely. *(page 4-20, 2nd paragraph, SERA 2006)* As discussed (page 76 line 19-36, SERA 2016), all hazard quotients associated with drift are substantially below the level of concern (HQ=1).

**Aquatic Organisms**

**Aquatic Animals**

With the exception of amphibians, all HQs associated with exposure of aquatic animals to water contaminated by an accidental spill are well below the level of concern. For worst-case scenario of the spill of 25 pounds of Sporax into a small pond, the HQ for amphibians of 1.3 only marginally exceeds the level of concern; HQs for spill of 6.25 and 12.5 pounds of Sporax are below the level of concern. Based on the results of this analysis, if large amounts of borax accidentally contaminate surface waters, amphibians may be at risk. However, for all other aquatic animals, there is no indication that adverse effects will occur. *(page 4-20, 4th paragraph)*

Hazard quotients for acute and chronic exposure of aquatic animals to water contaminated by runoff are all below the level of concern, even at the maximum application rate of 5 lbs Sporax/acre. *(page 4-20, 5th paragraph, SERA 2006)*

…there is no basis for asserting that effects on nontarget aquatic species are likely for either acute or longer-term exposures. *(page 4-21, 1st paragraph, SERA 2006)*

The highest accidental hazard quotient is 0.7 and is also associated with a sensitive aquatic invertebrate. The accidental scenario is associated with a spill, based on the application rate and the amount of pesticide required to treat 5 acres. A somewhat more severe accidental scenario (the amount of pesticide required to treat about 14 acres) would lead to concentrations in surface water that would reach the level of concern for a sensitive species of aquatic invertebrates. The most reasonable characterization of the accidental scenarios is that adverse effects to some sensitive species of aquatic organisms could not be ruled out in the event of a serious accident spill. The level of risk would be highly dependent on site specific circumstances, including the magnitude of the spill and the size and possible flow characteristics of the water body *(Page 87 lines 20-29, SERA 2016)*.

Sporax is typically not transported in quantities more than 5 pounds by applicators. In the event of a spill, personnel are instructed to scoop up any spilled material and place it back in the application container. By adhering to proper spill procedures, it is highly unlikely that humans or the environment would be harmed from borax application. Borax will not be applied to stumps that are within 20 feet of any running surface water (see RPM RD-1).

**Aquatic Plants**

The highest HQ for any exposure scenario is 0.3 associated with algae for the accidental spill of 25 pounds of Sporax into a small pond. All other HQs for the accidental spill scenario and for acute and longer-term exposures to water contaminated by runoff are well below the level of concern. Thus, based on this analysis, there is no basis for asserting that effects on aquatic macrophytes or algae are likely for either acute or longer-term exposures. *(page 4-21, 3rd paragraph)*

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21 HQ = Hazard Quotient. The estimated dose divided by the toxicity value.
Aquatic Microorganisms

The results of this risk assessment indicate that more sensitive microorganisms may be at risk following accidental spill of large quantities of Sporax into a small pond, but that exposure via runoff does not present a risk to aquatic microorganisms. (page 4-21, 5th paragraph SERA 2006)

Summary

The use of Sporax and Cellu-Treat in the control of annosum root disease does not present a significant risk to humans or wildlife species under most conditions of normal use, even under the highest application rate. Given the highly focused application method for Sporax, application in granular form, or Cellu-Treat in liquid form, to cut tree stump surfaces, exposures considered for both the human health and environmental risk assessments are limited to those which are expected to result in significant exposure. Stump applications of borates will not substantially increase concentrations of boron in soil, with the exception of areas immediately adjacent to treated stumps. Consequently, there is no basis for asserting that stump applications of borates would cause adverse effects in terrestrial plants, invertebrates, or microorganisms through soil exposures. The potential for adverse effects associated with foliar exposures also appears to be remote. Liquid stump applications of herbicide because the borate solution will be applied essentially at ground level (the height of the treated stump); hence off site drift should be minimal. Nonetheless, hazard quotients for terrestrial plants based on estimates of drift lead to hazard quotients that are substantially below the level of concern (page 83 lines 5-13, SERA 2016).