Mt. Ashland LSR Habitat Restoration and Fuels Reduction Project

Silviculture Report

Prepared by: __/s/ *Carl Varak*_____ _01/23/07__
Carl Varak, Silviculturist Date

Mt. Ashland LSR Silviculture Report

I. Introduction

The purpose of the Mt. Ashland LSR Project is to expedite the development of late successional stand conditions through conifer density reduction and reduce the risk of large-scale, stand replacing fires by removing forest biomass.

The project is located to the south and west of Mount Ashland below the Siskiyou Crest. The entire proposed Project is within the Mt. Ashland Late Successional Reserve (KLRMP 1995) and is located within the Deer-Beaver, Long John and Beaver/Grouse 7th field watersheds on the Oak Knoll Ranger District of the Klamath National Forest.

The effects from early 20th century logging, heavily stocked mid-successional stands, forest disease and pests, periods of drought, mortality and years of fire exclusion have put this area at substantial risk of a wildfire which would compromise the ability of the area to meet desired future conditions as specified in the Klamath National Forest Land and Resource Management Plan (KLRMP) (USDA 1995). Therefore there is a need to take action and reduce tree density and fuel levels in the area. The role of the silviculturist in this project is to insure that the methods used to achieve project objectives will maintain the productive capacity of the forested sites as defined in the KLRMP.

All of the stands proposed for treatment are currently in either the early-successional (stands averaging less than 10 inches in diameter) or mid-successional (stands averaging 11–24 inches in diameter) stages. Post treatment, these same stands would be in the larger diameters of mid-successional stage or the smaller diameters of late successional (diameters greater than 24 inches) stage. Based on computer generated simulations it would take these same stands 50 or more years to grow to these average diameters without silvicultural treatments (Forest Vegetation Simulator model runs 3-06).

A. Proposed Action

The silvicultural prescriptions are designed to promote the development of late successional habitat while retaining those attributes of late-successional habitat (i.e. large trees) the stands may currently exhibit. All stands would receive an intermediate type harvest prescription. A variable density thinning from below would take place with modifications for the stands topographic aspect, slope position and relationship to other key habitat features.

The objective is to concentrate growth on the residual trees, which are the larger and more vigorous trees in the stand with the most ability to respond when competition is reduced. It has been shown that a strategy for developing large-diameter conifers in immature stands includes precommercial thinning as an initial entry to begin stabilizing overstocked and stagnating stands (Cochran and Barrett 1999, Reukema 1975). A strategy for maintaining larger-diameter conifers in stands where they currently exist focuses on commercial and precommercial thinning of understory vegetation (Main and Amaranthus 1996). Thinning from below, while retaining the larger, healthier trees will maintain overall stand growth (Oliver 1988). These trees have bigger crowns and a greater capacity to photosynthesize and increase their size as more light reaches the full canopy. These trees also have the best

root systems and the greatest potential to extend their roots to take advantage of the increase in site resources made available after thinning.

These prescriptions would be applied to the overstocked stands (stands that have interlocked tree crowns and whose radial growth is declining). Typically trees in the lower crown classes (intermediate and suppressed) and those of poorest vigor and form are removed. Due to the objective of retaining attributes of late-successional habitat, trees greater than twenty inches in diameter will not be selected for removal in stands being treated to promote habitat development.

The resultant stands would be dominated by healthier trees which are more resistant to insect and disease attacks. These trees also have larger root systems which increase windfirmness and provide for greater slope stability. Stand composition would favor more drought tolerant species. Reduction in stocking levels and the previously mentioned attributes would lessen tree mortality and subsequent fuel loading increases.

1. Actions common to all Prescriptions

The following action would be implemented in any stand where a silvicultural treatment is proposed.

Fuels Treatment—All stands proposed for management activities will receive some type of fuels treatment. The method of treatment and the degree of fuels reduction may vary by stand and alternative. The fuels treatment methods are discussed in detail in the Fire/Fuels Assessment.

2. Actions Associated with Retaining Forested Structure

The following actions may occur in stands receiving a commercial thinning prescription. These treatments would be applied to the one to nine inch diameter trees found in the lower layer of the stand. Site specific prescriptions for each action can be found on the stand record cards.

Precommercial thinning—Some stands currently have a young component of overstocked trees that are growing and developing slowly due to inter-tree competition (approximately 408 acres). Thinning these areas would increase growth to provide for larger trees in a shorter period of time (DeBell et al. 1997). Spacing will be somewhat variable depending on species, aspect, site quality and slope position. Thinning is done by crews using chainsaws. Cut material is usually lopped and scattered to decompose, or handpiled and burned.

Weeding and Cleaning of understory trees—This is similar to precommercial thinning but there is no implied spacing and pertains more to scattered individuals and clumps of understory trees that are not healthy and thrifty. It involves the removal of small (two to nine inches in diameter) trees of poor vigor and form, or diseased trees that will not develop into a larger healthy tree in the future. Also small trees of less desired species would be removed. It is not a technique to eliminate disease within a stand but rather to lessen its impacts. This treatment removes small trees from an already disease infected

stand, reducing the number of trees getting infected and concentrating growth on the remaining trees in the stand. By removing small diameter trees, ladder fuels are reduced and stands are more resistant to high intensity fire. This work would usually be done by crews using chainsaws but could be accomplished mechanically in those stands planned for tractor or mechanized harvesting operations. Cut material would be lopped and scattered, handpiled and burned or removed to a designated disposal area.

II. Alternatives

Alternative 1—No Action

This alternative implements no activity at this time and leaves the project area in its present condition. The No Action alternative provides a point of reference from which to evaluate the action alternatives.

Alternative 2—Proposed Action

This alternative proposes to treat vegetation on approximately 4586 acres of land. The treatments are designed to reduce anticipated wildfire intensities and also current stand densities. This will promote individual tree growth and develop stands that will persist and assume late successional characteristics through time. There would be approximately 3875 acres of variable density commercial thinning and 711 acres of precommercial thinning. A combination of ground based (tractor and mechanized harvester), cable and helicopter logging systems would be used. Ground based logging systems would treat 1202 acres, cable yarding 1602 acres and aerial systems another 1071 acres. There would be no new permanent road construction. Existing non-system roads would be used to access treatment stands and 6.86 miles of temporary spur road would be constructed. Project generated fuels would be treated by either mechanical or manual methods. The mechanical fuels treatment would be accomplished by masticating (grinding into small pieces) the slash on slopes less than 45% while handpiling and pile burning or underburning would take place on the steeper slopes.

Alternative 4

This alternative treats fewer acres than the Proposed Action and constructs fewer temporary spur roads. The silvicultural prescriptions would be the same for the stands to be treated. The mix of logging systems would change. There would be approximately 3,378 acres of mid-successional stands treated by variable density commercial thinning and 711 acres of pre-commercial thinning proposed. Ground based logging systems would treat 965 acres, cable yarding 1,569 acres and aerial systems another 844 acres. No new permanent roads would be built. Approximately 4.96 miles of temporary spur road would be constructed. As in the proposed action an array of fuel treatments would occur after logging to abate some of the existing, as well as, newly created woody fuels.

Alternative 5

This alternative recommends the same stand treatments (prescriptions) as the proposed action, the differences being the mix of logging systems and amount of temporary spur road construction. There would be approximately 3,781 acres of variable density

commercial thinning and 711 acres of precommercial thinning stands to be treated. Ground basesd logging would occur on 1,065 acres, cable yarding on 1,471 acres and aerial systems on the remaining 1,245 acres. Approximately 2.27 miles of temporary spur road would be built. As above, varying fuel treatments would occur on the acres affected.

III. Affected Environment

A. Background

The stands in this project area have been designated as Late Successional Reserves MA-5 (KLRMP 1995). Management goals are to protect and enhance conditions of late successional and "old growth" forest ecosystems. Management direction emphasizes accelerating development of late successional conditions while making the future stand less susceptible to natural disturbances (KLRMP 1995).

As a result of past management actions, stands in the Mt. Ashland LSR Project Area are in the early to mid-successional stages and lack structural diversity. Railroad logging in the early part of the 20th century removed over 90% of the trees from the original stands. Large pines were the desired species to make box shook for citrus fruit shipping. Douglas-fir also was removed. While smaller trees were not harvested many were destroyed during the logging leaving the stands very poorly stocked. The area reforested naturally via seed cast from those trees that remained. Sanitation of dead and dying trees was the most common harvest prescription in the 1940s. Unit Area Control (UAC) was the prescription implemented in the 1950s. Thinning, individual tree selection, sanitation, and small group selection openings were intermixed across the hillside in the UAC prescription. Starting in the 1960s, clear-cutting was the most frequently chosen prescription. Partial cutting was resumed in the 1970s until even-aged management prescriptions (clear cuts) were again implemented in the 1980's and 1990's. All of these past harvests focused on removal of the larger trees in the stands logged with little pre-commercial or weeding and cleaning to remove undesirable sub-merchantable stems. The end result for the project area are 80 to 90 year old natural stands with few, if any, large diameter trees and numerous, 5-15 year old, seedling to pole sized even aged, conifer plantations.

The elevation range for the project area is 3,200 to 6,500 feet; the composition of the vegetation is influenced by the elevation. At the upper elevations (generally above 6,000 feet) forested stands are primarily red fir with incidental occurrence of mountain hemlock. Between 5,000 and 6,000 feet, the true fir stands are a mix of red fir and white fir. White fir becomes more dominant as elevation decreases. Douglas-fir, incense cedar, and sugar pine occur as minor species in the lower reaches of the true fir zone. Approximately 35% of the project area lies within the true fir zone.

Mixed conifer forest types are found at the mid and lower elevations (generally below 5,200 feet). Aspect strongly influences stand composition with Douglas-fir and white fir dominating the north and east facing slopes. The pine species, incense cedar, and Douglas-fir are more commonly found on the south and west facing aspects. In the absence of

naturally occurring low intensity wildfires due to fire suppression, white fir has significantly increased in magnitude and distribution.

Soils within the Project area are considered productive (Forest Survey Site Classes 2-4). Productivity is linked to the availability of water and nutrients, which affect overall stand vigor and growth. The availability of moisture is the most limiting factor for conifer survival and growth. Annual precipitation is around 45–55 inches, with about 90% occurring between October and May. At the higher elevations, the precipitation is predominantly snowfall.

Stand density influences the amount of water and nutrients available to individual trees. High stand density, such as what is found in the Project Area, leads to competition for limited resources needed for growth and survival. Competition, in turn, leads to reduced growth and vigor, increased susceptibility to insects and disease, and to eventual mortality. Stand density affects stand health and the ability of trees to respond to disturbance mechanisms. High tree densities lead to increased competition for the limited resources needed to remain alive and growing. Weakened trees are more likely to succumb to the effects of disturbance mechanisms such as disease, insects and fire.

Stand Density Index (SDI) is a relative measure of stocking levels expressed as a number of 10-inch diameter trees per acre. Reineke (1933) first introduced SDI as a measure of site occupancy.. He found that SDI could be consistently applied to calculate a maximum density expected for a given average stand diameter. SDI has an advantage over basal area because it is not significantly affected by age and site quality. Maximum SDI values have been developed for a variety of species including red and white fir, ponderosa pine and Douglas-fir. The maximum SDI value for each species is 800, 759, 571, and 547, respectively.

A zone of imminent mortality, or where self-thinning begins to occur, is reached at 55% of maximum SDI. This would equate to SDI values of 440 for red fir, 417 for white fir, 314 for ponderosa pine, and 300 for Douglas-fir. Recent research in red fir stands in northeastern California found a strong correlation with SDI values and tree mortality (Zhang et al. 2005).

In order to minimize self-thinning and associated fuels build-up, and to promote growth, stands should be below 55% of maximum SDI . (Reineke 1933) (See Table 2 for current stand density indexes in the project area). Since all the stands are above 55% of maximum SDI, mortality is occurring and fuel loading is increasing. As shown below in Photographs #1, #2, #3, and #4, there are few, if any, large trees and the stands are overstocked. Photographs #5, #6 and #7 depict the mortality that is occurring and how fuel loads are increasing.

Photo #1: Overstocked mixed conifer stand, Mt. Ashland LSR Project Area.

Photo #2: Overstocked ponderosa pine stand, Mt. Ashland LSR Project Area.

Photo #3: Overstocked mixed conifer stand; Mt. Ashland LSR Project Area.

Photo #4: White fir encroachment; Mt. Ashland LSR Project Area

B. Disturbance Mechanisms

Stand health is also shaped by the types and amount of disturbance the stand has experienced over time. Fire, insects and disease, as well as past management actions are all mechanisms which influence stand health.

Fire is an important disturbance mechanism in these stands. The project area is considered to be in a mixed severity fire regime [i.e. a fire would naturally result in a reduction of the basal area of the dominant vegetation by 20–70% (Agee 1993)]. In a mixed severity regime, some areas would burn at a low intensity with minimal mortality; other areas would burn with moderate intensities; and still other areas would burn at high intensities, killing more than 75% of the dominant vegetation. The high intensity type fires will leave a mosaic of open ground with scattered pockets of timber. Stands burned at high intensity would not meet objectives for multi-layered, dense closed canopy forest desired in the late successional reserve.

The amount of area burned at the different intensity levels is influenced in part by the length of the fire free interval. Long periods without fire result in conditions more conducive to higher intensity fires as ground fuels accumulate, ladder fuels develop and stand densities increase. No large fires have burned in the Project Area since the railroad logging era (early 1900s). The long fire-free interval has resulted in dense growth of poles and saplings (ladder fuels) and accumulations of ground fuels (refer to Figures x through x). Fire as a disturbance process is discussed in detail in the Fire and Fuels Assessment.

Photo #5 Self-thinning And Resultant High Fuel Loading In A True Fir Stand

Photo #6 White Fir Mortality in A Mixed Conifer Stand

Poto #7 High Fuel Loading From Insect Mortality in A Mixed Conifer Stand

Dwarf mistletoe (*Arceuthobium* spp.) is commonplace throughout the project area and has a definite influence on stand health. Dwarf mistletoe is a host specific parasitic seed plant. Evidence of mistletoe infection was found in the major conifer species that are present in the Project Area (Douglas-fir, white fir, incense cedar, ponderosa pine and red fir) indicating that several different dwarf mistletoe species are present.

Dwarf mistletoe is completely dependent on its host for support, including all water and nutrients. The pathological results of dwarf mistletoe infection are seen as reductions in reproduction, growth, and longevity. The nature and magnitude of these effects are determined by the mistletoe and host species involved, infestation severity and vigor of the host (Geils and Hawksworth 2002). Dwarf mistletoe produces swellings in the branches and open wounds on the boles of the host. These injuries to the tree provide opportunities for invasion by a number of pathogens and insects often resulting in the death of the tree.

Dwarf mistletoe is an endemic disease, which is always present to some degree in conifer forests. The amount and intensity is now greater than it was 100 years ago (personal communication B. Mathiasen 3-05). Mistletoe severity is usually described by a relative index for the amount of host crown affected (Hawksworth et al. 2002). The dwarf mistletoe rating system (DMR) developed by Hawksworth in 1977 is commonly used method of rating mistletoe infection. Published recommendations for management of stands infected with dwarf mistletoe often use the Hawksworth system as a basis for defining management implications and recommendations. The rating system divides the host crown into thirds and each section is independently rated. The rating is zero if no live branches appear to be infected, the rating is one if less than half the branches appear infected, and the rating is two if more than half the branches appear infected. The level of infection for the entire tree is determined by summing the values of the crown thirds. Stand dwarf mistletoe infection is an average of the ratings of the infected trees within the stand. Plot data was taken across the project area to provide overall stand conditions including mistletoe presence along with individual stand data taken when preparing individual stand diagnosis.(refer to table 1)

Average lateral spread of mistletoe within a stand is approximately 10 meters per decade (Dixon and Hawksworth 1979). Disease intensification within an individual tree is one dwarf mistletoe class per decade (Geils and Mathiasen 1990). The anticipated half life of a tree with a DMR of six is about ten years (Hawksworth and Geils 1990). Many factors influence the rates of spread, intensification, and mortality. These generalities suggest the magnitude of the rate of change and are not intended as specific management guidelines (Muir and Geils 2002). Upon reaching a DMR of three, diameter growth begins to slow and is reduced by 50%. In Douglas-fir height growth is reduced at all infection levels and by 15–25% in DMR classes 3–5 (Hawksworth and Wiens, 1996).

Dwarf mistletoe typically begins in the lower tree crown, and vertical spread is slow enough that trees with rapid height growth can outgrow or at least keep pace with mistletoe infection. Productive forest soils allow for rapid conifer height growth at high stocking densities. The balance between the growth of the host and that of the pathogen can be influenced by density management (Muir and Geils 2002). Greater crown closure reduces light within the canopy, reducing mistletoe reproduction, increasing the rate of crown lift; and reducing the distance of seed dispersal in a dense stand. At some point however, inter

tree competition begins to slow tree growth and the parasitic effects of the mistletoe plant outpace the trees growth. Thinning in stands with a DMR less than three is practical (Muir and Geils 2002).

Dwarf mistletoe does cause certain phenotypic abnomalities that are beneficial to wildlife. Deformed branches and witches brooms are commonly utilized by spotted owls as resting perches and nest sites (Hawksworth and Weins, 1996). Attempts to eradicate mistletoe in an LSR would not be prudent. It also is not practical as the disease is endemic. Retaining some trees, particularly Douglas-fir, that are infected with mistletoe and are located on the lower one third of north and east facing slopes is desirable. Since trees greater than twenty inches will be retained, many mistletoe infected trees automatically will remain. There is a definite trade-off in tree growth and longevity and mistletoe infection.

With a diameter of ten inches (slightly larger than an average tree in the project area according to plot data) the modeling suggests six to twelve inches of diameter growth in the next fifty years for a disease free tree. Current inventory data indicates a DMR of two to three for trees that presently have mistletoe. As noted above the disease could intensify to a Hawksworth six over the next forty years. Tree growth reduction would begin in the next ten or so years and continue to decline over the next thirty years. Thus it is unlikely that the tree would reach twenty inches in diameter before succumbing to the mistletoe, or the more likely scenario of death due to the combined effects with other pathogens and insects as such trees are so predisposed. Stands dominated with trees less than twenty inches would not provide some of the attributes required in late successional stands. Also dead trees do not provide nesting habitat. Finally the witches brooms, often associated with mistletoe infections, are good receptors for sparks from wildfires and provide ladder fuels into the tree crowns when ignited. This condition enhances the probability of stand replacement due to fire.

Forest pests occur naturally in stands within the Project Area, most commonly fir engravers and western pine beetles. As stand densities increase and mistletoe infections increase an environment favorable to increased insect infestation is provided. Decreased availability of soil water, such as occurs in dense stands, reduces a tree's ability to pitch out attacking insects. Trees weakened by disease have similar difficulties. Increasing density and competition within stands in the Project Area will encourage increasing insect mortality in trees.

Fir engraver --- The fir engraver (*Scolytus ventralis*) attacks most true fir species in the western United States. The attacks by this under the bark-burrowing beetle can result in patch kill around the bole, top kill, and tree mortality. Top kill and tree mortality are often associated with trees weakened by root disease, over stocking, drought, and heavy dwarf mistletoe infection (Keen 1952).

Western pine beetle --- The western pine beetle (*Dendroctonus brevicomis*) is the most important insect affecting ponderosa pine in California and Oregon. Normally this beetle breeds in windfall, unhealthy trees, or in trees weakened by drought, stand stagnation, or fires, and beetle infestations usually lead to tree mortality (Keen 1952).

C. Current and Desired Stand Conditions

Approximately 90% of the stands proposed for treatment in the Project Area were naturally regenerated after the railroad logging that occurred in the early 1900s. Currently the stands are densely stocked as evidenced by declining radial growth, interlocked crowns, and self-thinning. In-growth of white fir has occurred as it is a species capable of establishing itself and growing under the canopy of other less shade tolerant conifers. As evidenced by cruise records from the 1920s, the original stands were dominated (as much as 60%) by ponderosa pine and sugar pine. Douglas-fir made up most of the remaining stocking. White fir now constitutes 30–50% of these same areas today. The average tree diameter ranges from 6 to 9 inches. The stocking in the project area is currently between 500–1000 stems per acre while pre-European stocking was typically 150–350 stems per acre and averaged 12–15 inches in diameter for 90-year-old stands (Dunning and Reineke 1933). Fire suppression and the resulting lack of natural fire have led to the higher stocking rates observed today. White fir has established itself at much lower elevations than would have occurred had historic fire return intervals not been interrupted (refer to Photo #4 for an example of white fir encroachment in a pine stand). Periodic low intensity wildfires would have killed the encroaching, shade tolerant white fir when they were in the seedling to sapling size classes while not damaging the pine and Douglas-fir overstory.

Many of the stands are experiencing density related mortality. Most of those trees are now on the ground and adding to the fuel load (refer to Photos #5-7 for examples of fuel loading). Due to their small diameters, few trees remain standing more than four to six years after they die. A significant pulse of drought and insect induced mortality occurred in the mid-1990s. Within a few years, this created many one-tenth to one-half acre pockets of dead and down, snapped off, or completely uprooted small diameter trees scattered throughout the project area. Even though mortality continues, the stocking levels are still abnormally high, dead fuel loading continues to increase, and the live crowns of many trees are still near the ground. This scenario provides conditions which favor the occurrence of large stand replacing fires. Dwarf mistletoe, particularly in Douglas-fir, is also quite prevalent. The current infection on an individual tree averages a DMR in the 2–3 range (Hawksworth, 1977). A large tree component (those greater than 36 inches in diameter) is severely lacking in the project area and averages less than one tree per 5–10 acres. Hardwoods are not common to the project area either. Harvesting since the 1960s has resulted in the formation of 558 acres of conifer plantations which are currently in need of stocking control. Tree crowns are touching and radial growth is declining in most of these plantations. Ponderosa pine and Douglas-fir are the dominant species. Live crowns extend nearly to the ground making even a low intensity summertime fire lethal to most of these trees.

Inventory plots were located in many of the stands to determine current stand attributes including the site class, canopy closure, basal area, trees per acre, snag densities level of dwarf mistletoe infection, and stand density (summarized in table 1).

The Klamath National Forest LSR Assessment (1999) grouped vegetation in the LSR into three main categories based on aspect and species composition. Mixed conifer stands were divided into two groups, the north and east facing slopes, and the south and west facing slopes. The other category identified was true fir which includes all slopes regardless of

aspect. The interdisciplinary team further refined the breakdown of areas to include slope position (i.e., upper and lower halves of the slopes).

Mixed Conifer North & East Slopes

Current Condition:
As displayed in Table 1, current stand conditions are heavily overstocked with over 800 small stems per acre. The average tree diameter is 6.8 inches at breast height. Normal stocking would be in the 150-350 trees per acre range and average 12-15 inches in diameter for stands that are 90 years of age (Dunning and Reineke 1933). Stand Density Index at 323 is well above the zone of imminent mortality. And 92% of the trees are less than 12 inches in diameter. White fir is the primary species in many of the stands that were once primarily ponderosa, sugar pine and Douglas-fir dominated as evidenced by cruise records from the 1920s. Due to suppression of fires, white fir also occurs much lower in elevation than would be found had natural fire intervals not been interrupted. Mortality has been occurring with a significant pulse in the mid 1990's and Due to the small size of the dead trees most are now on the ground.

Desired Condition:
About half of the project area below the true fir zone falls into the category of mixed conifer forest on north and east slopes. The desired conditions for these stands are structurally diverse, late successional conditions with canopy closure greater than 60% on the lower slopes and 40–60% on the upper slopes. Douglas-fir would be the dominant species with lesser amounts of ponderosa pine, sugar pine, and incense cedar. This condition would not be uniform across the landscape as variability is important. Patches of denser stands would still be intermixed with the more open nature of the upper slopes. There will be gaps created by natural mortality where early successional vegetation is present. Desired basal area is in the range of 120-150 feet^2 post-project and would increase to 245-280 feet^2 when stands reach 150-200 years of age. Denser stands should be intermixed with these stands on 10–20% of the landscape. This will allow for areas of higher stocking, higher levels of mortality, undisturbed debris and size differentiation (Forest Wide LSR Assessment, 1999).

Mixed Conifer South and West Slopes

Current Condition:
Stands are overstocked at more than 900 trees per acre and average 6.0 inches in diameter. The stand density index is at 411, well above the density where mortality from inter-tree competition would begin. 93% of the trees on these slopes are less than 12 inches in diameter. The crowns of the trees are often interconnected and radial growth is declining. Although white fir encroachment is not as severe as on the north and east slopes it is now a significant cohort that historically was not there. See table 1 for additional current stand information.

Desired Condition:
The other half of the stands below the true fir zone comprise this category. These stands are generally open grown with canopy closure ranging from 40–60%. The sites will be

dominated by conifer vegetation. There should be a presence of hardwoods. Due to fire behavior on steep slopes the upper one third to one half of the slopes may have as little as 25% canopy closure. The stands will be single layered. There will be gaps created by natural mortality where early successional vegetation is present. Diversity of age classes will be scattered over the landscape on these aspects, but a majority of the stands will contain late mature to old growth characteristics. Ponderosa pine would be the dominant conifer species, but will be intermixed with Douglas-fir, sugar pine and incense cedar. Desired basal area is in the range of 120-150 feet^2 post-project and would increase to 210-245 feet^2 when stands reach 150-200 years of age. Denser stands should be intermixed with these desired ranges over ten to twenty percent of the landscape. This will allow for areas of higher stocking levels, higher levels of mortality, undisturbed debris, and size differentiation (Forest wide LSR Assessment, 1999).

These stands are eighty to ninety years of age and still fairly thrifty with good potential for development. Dwarf mistletoe causes certain tree attributes, such as witches brooms, which are a desirable characteristic particularly in Douglas-fir on lower slopes for owl nests and roosts.

True Fir Sites

Current Condition:
At elevations above 5200 feet, the vegetation changes from mixed conifer to true fir. The sites are dominated by white fir lower in the zone to nearly pure stands of red fir along the crest.

Here again the stands are very heavily stocked with over 500 stems per acre and averaging less than 9 inches in diameter. Stand Density Index is right at the level where mortality is beginning and in some stands, as witnessed in Photo #5, has already been occurring. The vast majority (83%) of the trees are still small (less than 12 inches in diameter).

Desired Condition:
The desired future condition for these stands are structurally diverse, late successional conditions with canopy closures at or above sixty percent regardless of aspect or slope position. Desired basal area is in the range of 150-200 feet^2 post-project and would increase to 210-300 feet^2 when stands reach 150-200 years of age. To provide diversity, ten to twenty percent of the landscape within this vegetative component should have denser stocking levels, approaching ninety to one hundred percent of normal. This would allow for the higher stocking levels, higher levels of mortality, undisturbed debris and size differentiation (Forest Wide LSR Assessment, 1999).

Defensible Fuel Profile Zones

Current Condition:
The defensible fuel profile zones (DFPZ) are a composite of the previous three categories and follow main ridges from the upper reaches of the project area to creek bottoms. As the DFPZs extend for up to a quarter mile on either side of the ridgeline they encompass all aspects and slope positions. Therefore the current conditions for them are found within the

descriptions of the other stand types above. As is to be expected, the DFPZs share the same overstocked conditions, competition induced mortality, and a preponderance of small diameter, 6”-8” dbh, trees.

Desired Condition:
The desired stand conditions for the various DFPZs would be the same as the category stand type it is found in (ie. north and east slopes, or south and west slopes or the true fir zone) with the following differences: the DFPZ would be a place where surface fuels are reduced to levels that generate low fireline intensity; ladder fuels are reduced to limit potential for spread into crowns; canopy fuels are reduced to limit potential spread between crowns and to maintain an overstory of large healthy trees, minimizing the potential for competition induced mortality and creation of snags.

D. Evaluation of Alternatives

No Action

As stand densities increase, the effects of inter-tree competition will intensify. Density related mortality will have the greatest effect on the smaller trees in the lower canopy classes but will also affect larger trees that are in a weakened condition. Also white fir, regardless of crown position, is more likely to succumb particularly under drought conditions. As fewer trees occupy the available growing space there will be a gradual increase in the average stand diameter.

As trees continue to compete for resources they will remain susceptible to the diseases and insects that are present. The mistletoe infection will continue. As time passes infection intensity will increase and heavily infected trees will succumb. While stand level infections are currently low, the modeling suggests significant increases in the disease (Hawksworth 2-4) with the passage of time, reducing growth rates by ten to twenty percent. With the passage of time fuel levels will continue to increase in all areas.

The following table (Table 1) displays relative trends for the No Action Alternative for various stand attributes. The three primary stand types are compared. The defensible fuel profile zone is not listed as it is a subset of the other three types.

Table1. Current Stand Conditions & in 50 years with No Treatment

Stand Attribute	North & East Slopes		South & West Slopes		True Fir	
	2006	2056	2006	2056	2006	2056
Average Diameter (in.)	6.8	12.2	6.0	11.9	8.9	11.2
Trees Per Acre	823	380	920	375	519	340
Basal Area (ft2)	202	298	183	288	224	318
Stand Density Index	433	508	411	493	431	524
55% of max SDI	323	323	340	340	429	429
DMI	2.0	3.9	2.1	3.7	2.2	3.8
Canopy Closure	65%	66%	64%	66%	57%	62%

Snags > 16 in.	3.0	5.1	3.5	5.6	5.7	1.9
Trees < 12 in.	92%	72%	93%	76%	83%	78%
TPA > 24 in.	9	31	9	31	10	34
TPA > 30 in.	1	9	3	9	3	7

North and East Slopes Mixed Conifer

Currently over ninety percent of the trees in this category are less than twelve inches in diameter. Stands are already in a condition that is not sustainable (greater than 55% of SDI) and competition induced mortality will continue to increase. Even after fifty more years over seventy percent of the trees in the stand will still be less than twelve inches in diameter. Individual tree architecture will also be altered when subjected to such dense conditions; the live crown will be reduced, limbs will be shorter and smaller in diameter, and needles will not be retained for as many years as the trees drop the foliage sooner due to competition for light and moisture. Approximately fifty four percent of the trees will have died (380 trees per acre). Fuel loading will increase dramatically.

Disease conditions will accelerate. The average mistletoe rating will double. This indicates that an average infected Douglas-fir tree will be experiencing fifteen to twenty percent loss in both height and diameter growth (Hawksworth, 1996). Those trees with even greater mistletoe infection, Hawksworth 5-6, will be experiencing increased mortality. Since the stands are overwhelmingly comprised of small diameter trees they will constitute most of the dead stems. Canopy cover will basically remain unchanged with the passage of time.

These stands will not be meeting desired conditions in a number of areas. The vast majority of the live and dead trees will be small (less than twelve inches in diameter). This accompanied by the increasing on-the-ground fuel load will put the residual stems at much higher risk of stand replacing wildfire. The large tree component will be less than desired. White fir, not a desired species, will dominate many of these stands.

South and West Slopes Mixed Conifer

At present more than ninety percent of the trees are less than 12 inches in diameter for stands in this category. Again the stands are at densities that are above 55% of SDI where competition induced mortality is occurring and will continue. On sites dominated by pine trees this overstocked condition puts the stands at additional risk from western pine beetle attack as the stands are already well above SDI levels of imminent beetle induced mortality and getting worse each passing year (Oliver,1995). The loss of the existing pine component would place these stands further from meeting the desired future condition. With another fifty years of tree growth three quarters of the stems would still be smaller than twelve inches in diameter. As above the trees architecture will be affected living in such heavily stocked conditions; crown reduction, reduced branch size and needle retention. An estimated sixty percent of the trees will die during this fifty year period (375 trees per acre) adding significantly to the current fuel loading.

The average dwarf mistletoe rating for this vegetation category would nearly double. Fifteen to twenty percent reductions in growth will occur and infected trees would be

predisposed to other insects and diseases. Trees heavily laden with dwarf mistletoe will succumb. Few, if any, large snags will be created as the majority of the stand is comprised of small diameter stems and still will be in fifty years. Canopy cover will remain at the same level.

True Fir Zone

Current stand inventories show over eighty percent of the trees are less than 12 inches in diameter. These stands are now at levels where competition induced mortality is occurring. The modeling indicates stand density indexes will remain above those levels for the projected period. At the end of this projection over three quarters of the stand will be made up of stems still less than twelve inches in diameter. Trees in this category will also experience the effects from overstocking with shrinking crowns, reduced branch size and needle retention. There will be a loss to mortality of thirty five percent of the trees in the stand (180 trees per acre).

Dwarf mistletoe on the average infected tree would nearly double during this time projection for those in this zone. Infection levels will be about the same as in the other two categories so similar reductions in growth would be anticipated. Trees weakened by the mistletoe infection would be more susceptible to attacks by the fir engraver (Keene, 1952). The canopy closure for these stands will increase slightly, about a five percent increase.

Action Alternatives

The proposed treatment prescriptions for each of the vegetative categories are similar for all action alternatives. The primary differences between alternatives are logging systems, the number of acres treated, and the fuels treatment method. This report focuses on the results of proposed silvicultural treatments. The proposed action will be described for each vegetative group, followed by a discussion of the differences between alternatives.

Stand dynamics have been modeled using the Forest Vegetation Simulator (FVS). The FVS model incorporates data collected from a representative sample of stands in each of three categories; north and east slopes mixed conifer, south and west slopes mixed conifer, and true fir. The modeled results from FVS display relative trends in stand development for each of the defined categories and are best used to make comparisons between alternatives. Model results are not intended to be absolute values. Wildlife biologists will work with the marking crews to ensure that specific stand attributes will meet project objectives post treatment.

It is important to note that models are only able to approximate natural processes and most models are inherently inexact. Thus, it is essential to understand the models limitations when assessing or analyzing model results. Although, the FVS models are developed from actual stand data, stand attributes within the three categories are averaged before predictive models are created. Therefore, the existing within-stand variability is not captured in the modeling process. Additionally, the FVS model applies a silvicultural treatment uniformly across a stand and can not model more complex treatments such as the variable density thinning prescriptions and habitat retention standards proposed in this project. Thus, the FVS model does not incorporate the untreated areas within a stand. These no cut areas

would have slower growth, greater canopy closure, higher mortality and an increasing build-up of fuels. There would be an effect on vegetation surrounding the uncut patch in the form of reduced growth and increased fire hazard. Plant aggregations within treated stands where only trees less than nine inches are growing are generally removed from the stand (thinning from below) in the model yet in reality they would receive a precommercial thinning treatment and many of the stems would be retained as an integral part of the resultant stand. All of these nuances within the treated stands would occur on the ground but are not well reflected in the modeling results.

Despite these limitations, the FVS model is still a powerful tool in that it simulates tree and stand growth over time using site specific data on tree species, forest type, and stand condition. The FVS model can also be calibrated to specific geographic areas.

Stand development was modeled for a fifty year period. That is adequate time in which to display the differences on stand development between treating and not treating stands in the project area.

Direct Effects

North and East Slopes Mixed Conifer

The proposed treatment for stands in this category emphasizes reduction of present stocking levels (density reduction) to enhance development of late successional structural components. Included in this treatment is biomass reduction to improve current and future stand resiliency to wildfire. Canopy cover post treatment would range from forty to sixty percent depending on slope location and stand condition. Thinning of both commercial and pre-commercial sized conifers at variable densities would occur.

On the lower portions of the slopes higher canopy closures would be retained with a general decrease in canopy closure as the ridgetops are approached. Trees up to twenty inches would be removed with the majority being the smallest trees in the stands. All hardwoods would be retained. The treatments would favor Douglas-fir for retention. White fir would be the least desirable species to retain, particularly at the lower elevations, those less than 4500 feet. Individual large trees would be cultured by removing most of the surrounding trees that are competing for moisture and sunlight. Approximately fifteen percent of the area in stands on the lower slopes will remain untreated for diversity. Areas containing late-successional attributes (large trees, snags, heavy mistletoe infections, on the ground large logs) would be selected for retention. The stands that are further upslope, including defensible fuel profile zones along selected ridgelines, would be thinned more heavily, mimicking historical conditions on ridges (KNF Forestwide LSR Assessment 1999 and Beaver Creek Ecosystem Analysis 1996).

After treatment the average tree diameter would be twice as large had the stand been left untreated. Snags greater than fifteen inches will be retained. Current inventories indicate, that on the average, stands in this category are deficient in large snags due to past harvest of large trees.

South and West Slopes Mixed Conifer

The proposed treatment for stands in this category emphasizes reduction of present stocking levels (density reduction) to enhance development of late successional structural components. Included in this treatment is biomass reduction to improve current and future stand resiliency to wildfire. Thinning of both commercial and pre-commercial sized conifers at variable densities would occur.

On the lower portions of the slopes higher canopy closures would be retained, up to sixty percent, with a general decrease in canopy closure as the ridgetops are approached. In comparison to the north and east slope category canopy closure would be ten to twenty percent lower for the same slope position. A thinning from below would remove trees up to twenty inches in diameter. All hardwoods would be retained. The treatments would favor sugar pine for retention. White fir would be the least desirable species to retain particularly below 4500 feet. Individual large trees would be cultured by removing most of the surrounding trees that are competing for moisture and sunlight. Approximately fifteen percent of the area in stands on the lower slopes will remain untreated. Spots containing some late successional attributes (large trees, snags, heavy mistletoe infections, on the ground large logs) would be the type of places selected for retention. The stands that are further upslope, including defensible fuel profile zones on selected ridgelines, would be thinned more heavily.

After treatment the average tree diameter would be four and one half times larger than if left untreated. Snags greater than fifteen inches would be retained. As with the north and east slopes the current inventories indicate a snag deficiency.

True Fir Zone

The proposed treatment for the stands in this category is very similar to the previous two. To enhance certain desired structural components of late successional stands current stocking levels (density) would be reduced. Biomass reduction for wildfire resiliency would be included in the treatment. Thinning of both commercial and pre-commercial sized conifers would occur.

Higher canopy closure is desired, up to sixty percent, similar to north and east lower slopes, regardless of slope position or elevation. Only where defensible fuel profile zones are to be established is decreased canopy proposed. A thinning from below would remove trees up to twenty inches with most being the smallest in the stands. Sugar pine and Douglas-fir where they occur would be the species of preference for retention. To encourage some vertical and age differentiation occasional small, less than one acre openings may be created on no more than ten to fifteen percent of the area in a stand. Up to an additional fifteen percent of the stand will remain untreated. Spots containing some late successional attributes (large trees, snags, on the ground large logs) would be the places selected for retention.

After treatment the average tree diameter would be twice as large if the stands go untreated. There are more snags greater than fifteen inches in this category than the previous two, however, still fewer than desired.

Table 2. Post Treatment Stand Conditions

Stand Attribute	N & E Slopes	S & W Slopes	True Fir
Average Diam. in.	18.6	20.0	19.0
Basal Area sq. ft.	140	133	188
SDI	201	185	268
TPA	75	61	96
Canopy Cover % *	37	37	41

*Canopy cover estimates are FVS model predictions based on a uniform treatment across stands. This estimate does not incorporate the untreated portion of stands (i. e., the ≥15 percent of each stand untreated in the variable density thinning prescription, habitat retention areas, etc.). Thus, the FVS model underestimates average canopy cover post treatment.

Indirect Effects

Reducing stand densities will lessen the amount of future mortality. It will provide large trees sooner than stands that are left untreated (refer to Tables 1 and 2). Large trees, live or dead, is a structural component currently lacking in these stands due to past harvest. Cultivating large trees will provide large snags in the future.

Table 3. Current Stand Conditions & in 50 Years with Treatment

Stand Attribute	North & East		South & West		True Fir	
	2006	2056	2006	2056	2006	2056
Trees Per Acre	823	66	900	56	519	81
Avg. Diameter inches	6.8	25.5	6.0	27.0	8.9	24.1
Basal Area sq. ft.	202	230	183	216	224	257
SDI	433	292	411	269	431	332
DMI	2.0	2.8	2.1	2.7	2.2	2.9
Canopy Cover	65%	51%*	64%	50%*	57%	47%*
TPA >24”	9	36	9	41	10	35
TPA>30”	1	14	3	15	3	14

*Canopy Cover estimate based on a more uniform stand treatment. Does not include retention areas or small sized material that will be retained.

North and East Slopes Mixed Conifer

Based on the modeling predictions for the next fifty years there would be fifteen percent more trees greater than twenty four inches in diameter and eleven percent more trees greater than thirty inches in diameter than if left untreated. Stands would remain at densities below the point where inter-tree competition induced mortality is anticipated. The resultant stands would be one dwarf mistletoe rating class lower. Seventy percent of the trees in the treated stand would be larger than twenty four inches in diameter, while only eight percent would be in those larger diameter classes if left untreated. If there is an insufficient number of snags they can be created from trees in the existing stand as the majority will be in the desired size classes, (above twenty four inches).

South and West Slopes Mixed Conifer

Projections for fifty years from now indicate an increase in trees greater than twenty four inches of twenty five percent than if left untreated and a fifteen percent increase in the number of trees greater than thirty inches in diameter. Reduced stocking densities would preclude inter-tree competition induced mortality. As above a reduction of one full dwarf mistletoe rating class by treating the stand. Treating these stands will result in sixty eight percent of the trees being larger than twenty four inches compared to eight percent in the untreated. As above, if there is a shortage of snags the stands would be dominated by trees larger than twenty four inches.

True Fir Zone

The forest vegetation simulator indicates a small increase in trees larger than twenty four inches in diameter than if left untreated. However, a seventeen percent increase in trees greater than thirty inches is anticipated. There would be a decrease in dwarf mistletoe by a full rating class. Treating these stands would show forty five percent of the trees being greater than twenty four inches in diameter while the untreated would only have only ten percent. Stand densities would remain below the level where mortality from inter tree competition occurs. Again snags may be fewer than desired but can be recruited from the cohorts of the larger than twenty four inch trees.

Cumulative Effects

The geographic area selected for cumulative effects for the vegetative resource is the project area. The removal or continued growth of trees outside the project area does not effect stand conditions in the project area. As previously described current stand conditions are result of past logging practices, insects, disease and time. Railroad logging about eighty years ago left the stands very poorly stocked with the majority of the pine species removed. Natural regeneration restocked the stands at very high densities, (800-1200 trees per acre). In the 1960's 400 to 500 acres of clearcutting occurred followed by conifer tree planting. During the 1970's selective harvesting was done on over 2000 acres removing most of the residual trees from the railroad days. In the 1980's to early 1990's another round of evenaged harvesting took place on over 600 acres with follow-up planting (incorporated by reference are the Mt. Ashland Cumulative Effects Summary). During droughty periods, endemic insect populations increased, resulting in short term pulses of mortality. Conifer diseases have resulted in growth loss and some some mortality.

No other projects are being planned at this time for this area on federal land. There is some small scale logging anticipated on one of the private parcels in the project area. This will constitute some roadside hazard tree removal.

While the past logging history has shaped these stands current structure no current actions or any in the reasonable foreseeable future will have any cumulative impacts on the vegetative resource other than the proposed action with this project. When implemented the stands treated would be placed on a trajectory to achieve the desired future conditions previously stated of late successional forest.

Field Investigation

All stands planned for treatment received an on-site field review by a certified silviculturist. Stand diagnosis and site specific prescriptions were then developed.

Analysis and Report Time

A total of fifty five days were spent in the field collecting vegetation data, formulating stand diagnosis, and writing preliminary silvicultural prescriptions by a certified silviculturist. A field crew of three to five people spent forty five days collecting vegetation and fuels data to be used in the forest vegetation simulator to model existing and projected stand structures. Approximately seventy five days were spent analyzing data, writing this report, completing a Stand Record Card for each stand, providing input into the NEPA process, and attending interdisciplinary meetings.

Education and Professional Experience

Carl Varak has a Bachelor of Science degree in forest management from Michigan Technological University, received in 1977.

His professional experience includes twenty nine years as a forester. Three years were in private industry with Homestake Forest Products in the Black Hills of South Dakota. For the past twenty six years, he has worked as a forester on the Oak Knoll, Scott River, Salmon River and Goosenest Ranger Districts of the Klamath National Forest. Work responsibilities have included timber sale preparation (unit layout, logging system design, cruise design, timber marking and appraisal development), reforestation and timber stand improvement work (contract preparation and administration for as many as five thousand acres a year). Carl has been a USFS Region Five Certified Silviculturist since 1989 and has maintained a state of California Qualified Applicators Certificate since 1986. He has written silvicultural prescriptions for vegetation management projects for sixteen years. Annually he has certified hundreds to thousands of acres as successfully reforested, either from planting or natural regeneration, using Region Five reforestation surveys. Animal damage, competing vegetation and stocking levels on thousands of acres are assessed annually and any necessary silvicultural treatments are prescribed. He field reviews and/or oversees the field reviews on the effectiveness of these treatments.

Literature Cited

Agee, James K. 1993. Fire Ecology of Pacific Northwest Forests. Covelo, CA: Island Press 493 p.

Cochran, P.H. and Barrett, J.W. 1999. Thirty-Five-Year Growth of Ponderosa Pine Saplings in Response to Thinning and Understory Removal. U.S.D.A. Forest Service. Pacific Northwest Research Station. Research Paper PNW-RP-512. 28 p.

DeBell, D.S.; Curtis, R.O.; Harrington, C.A.; Tappeneir, J.C. 1997. Shaping Stand Development Through Silvicultural Practices. In: Creating a Forestry for the 21st Century, Kohm and Franklin, eds. Pages 141-149.

Dixon, G.E. and Hawksworth, F.G. 1979. A spread and intensification model for southwestern dwarf mistletoe in ponderosa pine. Forest Science. 25(1):43-52.

Dunning, D. and Reineke,L.H., 1933. Preliminary Yield Tables for Second-Growth Stands in the California Pine Region. Washington D.C. U.S. Department of Agriculture. Technical Bulletin 354. 23 p.

Geils, B.W. and Hawksworth, F.G. 2002. Damage, Effects, and Importance of Dwarf Mistletoes. Chapter 5 of Mistletoes of North American Conifers. U.S.D.A. Forest Service. Rocky Mountain Research Station. Gen. Tech. Report RMRS-GTR-98.

Geils, B.W. and Mathiasen, R.L. 1990. Intensification of Dwarf Mistletoe on southwestern Douglas-fir. Forest Science. 36:955-969.

Hawksworth, F.G. 1977. The 6 Class Dwarf Mistletoe Rating System. General Technical Report RM-48. Fort Collins, CO: U.S. Department of Agriculture, Forest Service. Rocky Mountain Forest and Range Research Station. 7 p.

Hawksworth, F.G. and Geils, B.W. 1990. How long do mistletoe infected ponderosa pines live? Western Journal of Applied Forestry. 5:47-48.

Hawksworth, F.G., Geils, B.W. and Weins, D. 2002. Arceuthobium in North America. Chapter 4 of Mistletoes of North American Conifers. U.S.D.A. Forest Service. Rocky Mountain Research Station. Gen. Tech. Rep. RMRS-GTR-98.

Hawksworth, F.G. and Weins, D. 1996. Dwarf Mistletoes: Biology, Pathology, and Systematics. Agriculture Handbook 709. Washington D.C.: U.S. Dept. of Agriculture, Forest Service. 410 p.

Keen, F.P. 1952. Insect Enemies of Western Forests. Miscellaneous Publication 273. Washington D.C. U.S. Department of Agriculture. 280 p.

Keyes, 2002.

Main,M.L. and Amaranthus, M.P. 1996. Reducing Stand Densities in Immature and Mature Stands, Applegate Watershed, Southwest Oregon. U.S. Department of Agriculture. Forest Service. Pacific Northwest Research Station. Research Note PNW-RN-518.

Muir,J.A. and Geils, B.W. 2002. Management Strategies for Dwarf Mistletoe: Silviculture. Chapter 8 of Mistletoes of North American Conifers. U.S.D.A. Forest Service. Rocky Mountain Reseach Station. Gen. Tech. Rep. RMRS-GTR-98.

Oliver, W.W. 1988. Ten Year Growth Response of a California Red and White Fir Sawtimber Stand to Several Thinning Intensities. Western Journal of Applied Forestry 3(2): 41-43.

Oliver, W.W. 1995. Is Self-Thinning in Ponderosa Pine Ruled by Dendroctonus Bark Beetles? Pages 213-218 in Lane G. Eskew, comp. 1995. Forest Health Through Silviculture-Proceedings of the 1995 National Silviculture Workshop; 1995 May 8-11; Mescalero, New Mexico. Gen. Tech. Rpt. RM-GTR-267. Fort Collins, CO: US Department of Agriculture, Forest Service, Rocky Mountain Range and Experiment Station. 246 p.

Reineke, L.H. 1933. Perfecting a stand-density index for even aged forests. Journal of Agricultural Research 46:627-638.

Reukema, D.L. 1975. Guidelines for precommercial thinning of Douglas-fir. U.S.D.A. Forest Service. Pacific Northwest Range and Experiment Station. General Technical Report PNW-30. 10 p.

USDA Forest Service. 1995. Klamath National Forest, Land and Resource Management Plan. Yreka, CA: U.S. Department of Agriculture, Forest Service, Klamath National Forest.

USDA Forest Service. 1996. Klamath National Forest Beaver Creek Ecosystem Analysis. Yreka, CA: US Department of Agriculture, Forest Service, Klamath National Forest.

USDA Forest Service, 1999. Klamath National Forest Forest-Wide Late Successional Reserve Assessment. Yreka,CA: US Department of Agriculture, Forest Service, Klamath National Forest.

Zhang, J.; Oliver, W.W.; Powers, R.F. 2005. Long-term Effects of Thinning and Fertilization on Growth of Red Fir in Northeastern California. Canadian Journal of Forestry Research 35:1285-1293.