SP-PNW-4577-____

# STUDY PLAN

# FOREST DYNAMICS AFTER THINNING AND FUEL REDUCTION IN DRY FORESTS

February 25, 2009

Prepared by: _____ Date: Dec. 10, 2008

ANDREW YOUNGBLOOD
Research Forester
Managing Disturbance Regimes Program
PNW Research Station, LaGrande, OR

Recommended by: _____ Date: 2/25/09

EDWARD J. DePUIT
Program Manager
Managing Disturbance Regimes Program
PNW Research Station, Wenatchee, WA

Approved by: _____ Date: 3/3/09

BOV EAV
Station Director
Pacific Northwest Research Station
Portland, OR

This study plan was peer-reviewed by the following individuals, and their comments were either incorporated or noted in a separate reconciliation document:

| | |
|---|---|
| Reviewed by: Martin Ritchie, PSW Research Station | Date: Feb. 26, 2008 |
| Reviewed by: Steve Fitzgerald, Oregon State University | Date: March 15, 2008 |
| Reviewed by: Rick Kelsey, PNW Research Station | Date: March 12, 2008 |
| Reviewed by: Paul Hessburg, PNW Research Station | Date: Feb. 26, 2008 |
| Reviewed by: Jane L. Hayes, PNW Research Station | Date: March 15, 2008 |
| Reviewed by: Tim Max, PNW Research Station | Date: March 13, 2008 |

In addition, this study plan was the subject of a double-blind external review process with seven reviewers external to the Pacific Northwest Research Station, with all comments addressed in a single reconciliation document made part of the study file.

### *I. Problem reference*

This study plan describes research to be conducted in Pringle Falls Experimental Forest. The proposed work addresses questions identified within this study plan. The proposed work also establishes a framework for other studies to be conducted concurrently or subsequently that use treatments established by this study plan. These additional studies, pursued by partners and collaborators, will be guided by separate and distinct study plans.

This study plan proposes a suite of treatments (vegetation manipulations) within Pringle Falls Experimental Forest. The treatments, in addition to providing the platform for research addressed herein, also address management issues within the experimental forest. These management issues are briefly described within this study plan, however, a full and complete analysis of these management issues is beyond the scope of this study plan. An environmental analysis will be conducted in partnership with the Deschutes National Forest and Bend/Ft. Rock Ranger District to outline and consider the management issues, options, and environmental effects of the treatments.

The Managing Disturbance Regimes Research, Development, and Application Program (MDR) is one of seven programs of the Pacific Northwest Research Station (PNW). The mission of the MDR Program is to provide new insights and scientific knowledge about the role of natural and human-caused disturbances as agents of change in ecosystems, and the degree to which they can be effectively managed to achieve or sustain desired ecologic conditions, functions and socioeconomic values of forest and rangeland ecosystems. This mission is pursued primarily through:

- creation and communication of fundamental knowledge on the nature, role and effects of disturbances and other change agents (e.g., climate) at varying spatial and temporal scales
- development and dissemination of integrated resource management tools, models, strategies and other products based on knowledge of disturbance regimes and their manipulation
- application and evaluation of knowledge on disturbance regimes and associated science-based products to resolve current and projected future land management problems.

Work within the MDR Program is arrayed across five problems[1]:

- Issue/Problem 1: Understanding and managing wildland fire
- Issue/Problem 2: Understanding and managing insects, pathogens and invasive species
- Issue/Problem 3: Understanding and managing herbivory and wildlife
- Issue/Problem 4: Understanding and managing forest and rangeland vegetation dynamics
- Issue/Problem 5: Understanding and addressing climate change/atmospheric influences on ecosystems

[1] MDR Charter Revision, unpublished paper (draft, December, 2007), on file, Wenatchee Forestry Sciences Laboratory.

This study will focus on effects of various forest vegetation manipulations, specifically treatments that potentially affect overstory and understory vegetation over time, and therefore addresses problem 4, understanding and managing forest and rangeland dynamics. Under this problem, the MDR Charter recognizes that forest and rangeland ecosystems have been significantly altered since Euro-American-settlement due to modified land uses, land management practices, and disturbance regimes coupled with climate/weather fluctuations. In some cases, vegetation changes may have become chronic due to crossing of ecological thresholds that make re-attainment of historic ecosystem states either difficult or impossible without extensive massive management intervention. Concerns for forest and rangeland health have become national, regional, and local issues. Restoring resiliency of degraded forest and rangeland ecosystems has therefore emerged as an important national priority. Addressing this priority is made difficult by the incongruity between desired vegetation conditions and the conditions and patterns that have developed in response to land uses and management of disturbance regimes that have been imposed without full, integrated knowledge and due consideration of ecosystem responses. Land managers need information on the response dynamics of vegetation composition and pattern at multiple scales to define options for management that promote development of desired ecosystem attributes and values over time.

In addition to improving understanding for forest vegetation dynamics, the research also will produce information pertinent to fuels management/fire risk (problem 1) and forest insect/disease issues (problem 2), and may indirectly and over the longer term address herbivory and wildlife habitat (problem 3) and climate change issues (problem 5).

### *II. Background*

Pre-Euro-American low elevation dry conifer forests of the western United States were fundamentally shaped by frequent low- or mixed-severity disturbances such as wildfires (Agee 1993, Taylor and Skinner 1998, Everett et al. 2000, Ottmar and Sandberg 2001, Wright and Agee 2004, Youngblood et al. 2004, Hessburg et al. 2005, Arabas et al. 2006) and insect attacks (McCullough et al. 1998, Hayes and Daterman 2001) mediated by diverse environmental gradients of topography, soils, and weather. The challenge that now faces resource managers is to integrate knowledge of these same disturbances or their potential surrogates, coupled with poorly-defined shifts in regional climate, to better understand how these various agents determine forest structure and composition.

Surface fires, ignited predominantly by lightning during the time of year when moisture content of fine fuels was lowest (Agee 1993, Rorig and Ferguson 1999), controlled regeneration of fire-intolerant species, reduced density of small-diameter stems, consumed litter and down wood, opened the stands to increased sunlight, led to vertical stratification of fuels by eliminating fuel ladders between the forest floor and the overstory canopy, and maintained relatively stable plant associations. Consequently, the structure of these low elevation dry forests generally consisted of open, predominantly widely spaced

medium to large and old live trees, scattered dead trees, low levels of ground fuels, and continuous low herbaceous understory vegetation (Wickman 1992, Agee 1994, Youngblood et al. 2004, Arabas et al. 2006).

Insects are major components of forest ecosystems, representing most of the biological diversity and affecting virtually all processes and uses. Bark beetles (Coleoptera: Curculionidae, Scolytidae) heavily influence the structure and function of low elevation dry conifer forests by regulating certain aspects of primary production, nutrient cycling, ecological succession and the size, distribution and abundance of forest trees (Fettig et al. 2007). While we know little about pre-Euro-American arthropod abundance and their interspecific relationships (Short and Negrón 2003), these forests likely supported many indigenous phytophagous insect species that killed trees. Phloem-boring bark beetles and cambium and wood boring beetles (Coleoptera: Buprestidae and Cerambycidae) were especially prevalent, with some preferring large, old, slow growing trees, some attacking lower boles and roots exposed after fires, some attacking the tops of trees weakened by fire, and others attacking trees with growth rates slowed by density-dependent competition, drought stress, or other localized disturbances that enabled the beetles to circumvent tree defenses (de Groot and Turgeon 1998, McCullough et al. 1998). Attacks often led to mortality of individual and small groups of trees, created snags, altered the accumulation of fuels and vegetation, and created canopy gaps that provided opportunities for new seedling cohorts (Hessburg et al. 1994, Hayes and Daterman 2001).

Today, many of these same dry forests have characteristics that place them at greater risk of uncharacteristic disturbances. These features include an accumulated mass of down woody debris and continuity of the fuels mosaic at landscape scales, more small trees and fewer large trees, greater amounts of young multi-storied forests with fire-intolerant conifers in both understory and overstory strata, increased fuel ladders that contribute to greater flame lengths during fires, and new or altered forcing of regional climate on plant community structure and organization (Agee 1993, Covington and Moore 1994, Arno et al. 1997, Taylor and Skinner 1998, Harrod et al. 1999, Youngblood et al. 2004, Hessburg et al. 2005, Stephens and Gill 2005, Youngblood et al. 2006, McKenney et al. 2007). In many dry forests of the Pacific Northwest, the altered fuelbeds and shifts in forest structure and composition resulted from fire exclusion and suppression, livestock grazing, timber management activites, and changes in climate (Bergoffen 1976, Steele et al. 1986, Dolph et al. 1995, Arno et al. 1997, Richardson et al. 2007). Increases in overall stand density over the past century have led to increased competition among trees for below-ground nutrients, water, and growing space. Increased competition among trees and reduced tree vigor increases susceptibility to attack from bark beetles and other forest insects and diseases (Mitchell 1990, Hessburg et al. 1994, Oliver 1995, Fettig et al. 2007). Mortality in ponderosa pine attributed to mountain pine beetle is positively correlated with high stand density (Sartwell and Dolph 1976, Fettig et al. 2007). Thinning has been shown to reduce the amount of ponderosa pine mortality

caused by mountain pine beetle unless surrounding areas are allowed to develop epidemic population levels (Fettig et al. 2007). The mountain pine beetle often kills extensively when contiguous stands or landscapes become vulnerable. These changes have occurred more recently against a backdrop of natural and human-caused climate change that may first be manifest in the distribution of herbaceous species and woody shrubs, and may eventually result in a redistribution of tree species (McKenney et al. 2007, Richardson et al. 2007). Collectively, these altered structural conditions contribute to increased probability of multiple, interacting stresses and may lead to altered or new disturbance regimes.

In the past two decades, unusually large and catastrophic wildfires across the western United States have heightened public awareness of forest ecosystems and raised concern for forest health. There is broad agreement that some form of fuel reduction treatment is necessary to move stands from their current structure and developmental trajectory to conditions that are healthier, more resilient to fire, and which may incorporate natural disturbance regimes prevalent under pre-Euro-American influences (Starr et al. 2001, Allen et al. 2002, Brown et al. 2004, Graham et al. 2004). Recent presidential initiatives such as the National Fire Plan, the 10-year Comprehensive Strategy, and the Healthy Forests Initiative, and legislation such as the Healthy Forests Restoration Act of 2003 (P.L. 108-148), have promoted the consideration of large scale and strategically located fuel reduction and restoration projects to manage landscapes within the context of ecological processes (USDI and USDA 2006). These fuel reduction and restoration treatments often are applied in dry forests as thinning or prescribed burning projects and are designed to reduce surface fuels, decrease crown density while retaining large live and dead trees of fire resistant species, increase the height to the live crown, and promote late seral structures, with the goal of reducing the risk of unnaturally severe surface and crown fires (Brown et al. 2004, Agee and Skinner 2005). Recent work within the national Fire and Fire Surrogate study has demonstrated that thinning and underburning result in at least short-term reductions in the mass of woody fuels and thus the potential fire behavior and severity (Stephens et al. in press, Youngblood et al. 2008), that there is substantial variability in taxa-specific responses to the treatments by small mammals and in avian composition and nest success and thus adaptive management approaches to wildlife may be beneficial (Converse et al. 2006, Gaines et al. 2007, Farris et al. in press), and that the treatments have little effect on most native perennial shrubs and forbs but may lead to short-term increases in non-native invasive plant species (Youngblood et al. 2006, Metlen and Fiedler 2006, Dodson et al. 2007, Erickson and White 2007).

There remains uncertainty in the ecological consequences of these treatments. First, responses often have been assessed only over the short-term. Few studies are built on platforms, such as experimental forests, where long-term studies with periodic remeasurements can be pursued. Second, treatments often have been designed to restore fuelbed conditions or forest composition and structure to historical conditions, but have ignored the risks, uncertainties, and benefits of multiple environmental stresses (Parker et al. 2006). For example, recent work suggests that in forests where water was not limiting,

climate change over the past six decades may have had a generally positive effect on forest productivity (Boisvenue and Running 2006), yet over the most recent two decades, many western forests have experienced increased tree mortality due to temperature-driven drought stress (van Mantgem and Stephenson 2007). With widespread recognition by scientists and policy makers that climate change is occurring, management options are needed that recognize and accommodate uncertainty in the manifestation of climate change.

Knowing when and how much growing stock to manipulate in order to meet some future stand structure projection and prevent losses from a stand-replacement disturbance is one of the largest challenges facing silviculturists who work with ponderosa pine (*Pinus ponderosa*). Much of the past management of ponderosa pine was focused on young stands. Current management is increasingly focused on producing larger and older trees. Reducing stand density provides growing space, water, and nutrients for the residual trees, and their growth affects the future stand structure directly as tree density, average stand diameter, crown shape, height growth, and the amount of tree mortality. Stand density index (SDI) (Reineke 1933) is a relative density measure based on the relationship between mean tree size and number of trees per unit area in a stand, and has proved useful for quantifying relative density across a wide variety of stand conditions because it is independent of site quality and stand age (Long and Daniel 1990). While originally developed for single-cohort stands, it is equally relevant for multi-cohort stands (Shaw 2000), and can be applied to mixed species stands with consideration of individual species characteristics. Cochran and Barrett (1995) followed the development of young ponderosa pine stands in the Blue Mountains under 6 stocking levels for 24 years and determined that mean annual cubic volume growth was greatest when SDI was about 210, and high mortality from mountain pine beetle occurred when SDI was greater than 140. As part of the West-Wide Levels of Growing Stock study, Cochran and Barrett (1999) reported on the growth and development over 30 years for stands thinned to six levels, and showed that continued mortality from mountain pine beetle occurred when the SDI was above 240. Cochran et al. (1994) used the concepts underpinning SDI to set an upper management zone (UMZ) for SDI to sustain healthy stand conditions for forest stands throughout the Blue Mountains based on the dominant plant association. The same procedure was used to set UMZs for the Deschutes National Forest in central Oregon (Booser and White)[2]. Upper management zones defined specifically for the Deschutes National Forest represent the level of stocking or relative density beyond which there is imminent risk of catastrophic loss of overstory trees to bark beetles.

[2] Booser, J, and J. White. Calculating maximum stand density indexes (SDI) for Deschutes National Forest plant associations. Unpublished paper, on file, Deschutes National Forest.

### *III. Study area description*

This study is located entirely within Pringle Falls Experimental Forest. Experimental forests and ranges constitute a national network of outdoor laboratories designated by the U.S. Department of Agriculture, Forest Service for the express purpose of providing sites for research. Research use was reaffirmed under the Forest and Rangeland Renewable Resources Research Act of 1978. Experimental forests and ranges have a rich legacy of providing information to guide forest management activities. They provide a unique research platform from which to address forest management questions at various scales and offer an important advantage for collaborative research. The PNW Station has responsibility for managing Pringle Falls Experimental Forest, one of a network of 81 similar experimental forests and ranges across the nation. Pringle Falls Experimental Forest (lat. 43°42' N, long. 121°37' W) lies within the Deschutes National Forest in central Oregon about 48 kilometers (30 miles) southwest of Bend, Oregon, and was established in May 1931 as a center for silviculture, forest management, and insect and disease research in ponderosa pine forests east of the Oregon Cascade Range. The entire experimental forest is addressed in the Deschutes National Forest Management Plan as a single management area, with Forest-level standards and guides applying when they do not conflict with research.

The 1430 ha (3,535-acre) Lookout Mountain Unit of the experimental forest was added to the Pringle Butte Unit in 1936. The Lookout Mountain Unit lies on an ancient shield volcano with an upper elevation of 1900 m (6,223 ft). Currently, this relatively large block of closed-canopy forest has undergone little major disturbance since about 1845 when a single stand-replacement fire resulted in the establishment of dense ponderosa pine at lower elevations and Douglas-fir (*Pseudotsuga menziesii*), grand fir (*Abies grandis*), white fir (*Abies concolor*), sugar pine (*Pinus lambertiana*), western white pine (*Pinus monticola*), and mountain hemlock (*Tsuga mertensiana*) at higher elevations. These closed-canopy stands have grown exceptionally well, and may represent some of the most productive ponderosa pine sites in central Oregon. Limited low thinning occurred about 40 years ago when the road network was established. Lookout Mountain is the site of limited past research, but several silvicultural studies continue as long-term work with regional and national significance, such as the Lookout Mountain installation of the Levels-of-Growing Stock study (Figure 1, Table 1).

The Deschutes National Forest Plant uses a system of vegetation plant association to group similar parts of environmental gradients. Plant associations (Volland 1988) represent units of land that respond similarly to management activities and support similar plant communities throughout different stages of development. Plant associations within the Lookout Mountain Unit strongly reflect both elevation and aspect influences. The Pinus ponderosa/Purshia tridentate-Ceanothus velutinus plant association (CPS-312) represents the warmest and driest plant association in the Lookout Mountain Unit; it occurs on toeslopes and undulating slopes with east aspects at elevations up to about 1,370 m (4,500 feet). From about 1,370 m upslope to about 1,500 m (4,900 feet) on east to southeast aspects is the Mixed

conifer/Ceanothus velutinus-Arctostaphylos patula plant association (CWS-112). Ponderosa pine is the sole dominant tree species on more southerly aspects, while grand or white fir increases in prevalence on east to northeast aspects. On more southern and eastern aspects up to about 1,615 m in elevation (5,300 feet) is the Mixed conifer/Ceanothus velutinus-Carex stoliferus plant association (CWS-115). This plant association supports predominantly ponderosa pine as a major seral tree species, and small amounts of white/grand fir, sugar pine, and Shasta red fir (*Abies x shastensis*) as advance regeneration. The tall

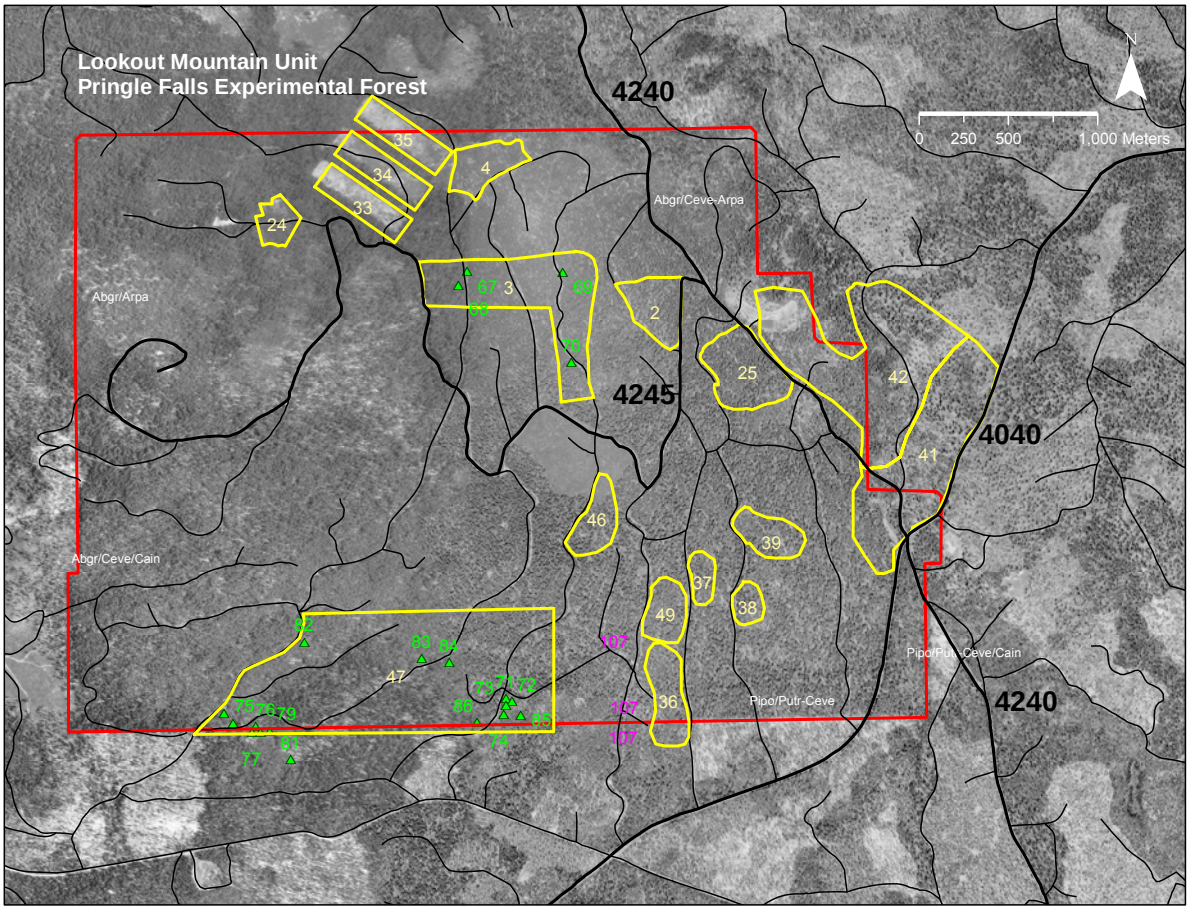


Figure 1. Past research units and major roads

Table 1. Past research activities shown on Lookout Mountain map from GIS database

| Unit | Activity | Scientist | Publication |
|---|---|---|---|
| 2 | Underburning for shrub control in 1976, 1979, 1980 | R. Martin | Martin, 1982. Shrub control by burning before timber harvest |
| 3 | Pruning in 1941 in a 55-year-old stand | E. Mowat<br>W. Dahms<br>J. Barrett<br>J. Cahill | Barrett, 1968. Pruning of ponderosa pine… effect on growth. Res. Pap. PNW-68.<br>Cahill, 1991. Pruning young-growth ponderosa pine: product recovery and economic evaluation. Forest Products Journal 41: 67-73.<br>Fight, Bolon, Cahill, 1992. Res. Pap. PNW-449. |
| 4 | Ponderosa pine-grand fir spacing study | K. Seidel | |
| 24 | Release and thinning in a 43-year-old suppressed grand fir and Shasta red (noble) fir stand. | K. Seidel | Seidel, 1977. Suppressed grand fir and Shasta red fire respond well to release. Res. Note PNW-288. |
| 25 | Thinning from above in 1938 in a 94-year-old stand | E. Mowat<br>J. Barrett | Barrett and Newman, 1974. High yields from 100-year-old ponderosa pine. Res. Note PNW-220. |
| 33-35 | Ponderosa pine-grand fir plantation in a spacing study | K. Seidel | Seidel, 1985. A ponderosa pine-grand fir spacing study in central Oregon: results after 10 years. Res. Note PNW-429. |
| 36-42 | P and L sale: commercial thinning in 1949 | E. Mowat<br>J. Sowder | Sowder, 1953. Lumber grade recovery from young ponderosa pine. Res. Note RN-88. |
| 46 | Underburned | R. Martin | Evans, L. 1983. Hydrophobicity of cindery typic cryorthents. OSU M.S. thesis. |
| 47 | Level-of-Growing-Stock established in 1965 in 65-year-old ponderosa pine with 6 growing-stock levels | J. Barrett<br>P. Cochran<br>W. Oliver | Barrett, 1983. Growth of ponderosa pine poles thinned to different stocking levels in central Oregon. Res. Pap. PNW-311.<br>Cochran and Barrett, 1999. Growth of ponderosa pine thinned to different stocking levels in central Oregon: 30-year results. Res. Pap. PNW-RP-508.<br>Oliver, 2005. The west-wide ponderosa pine levels-of-growing-stock study at age 40. Gen. Tech. Rep. PSW-GTR-198. |

shrub *Chrysolepis chrysophylla* (giant chinquapin) occurs throughout both these plant associations. At higher elevations is the Mixed conifer/Arctostaphylos patula plant association (CRS-111) that supports white-grand fir, Shasta red fir, western white pine, and Douglas-fir. This plant association is not part of this study.

The direct scope of inference is the Lookout Mountain Unit of Pringle Falls Experimental Forest. Extension of any inference will be made through the use of similarity in environments such as plant association. On this basis, work at Lookout Mountain will have wide applicability in stands of similar structure throughout the Deschutes and Fremont-Winema National Forests. Similar stand conditions may also occur west of Yakima, Washington.

### *IV. Management issues*

Pringle Falls Experimental Forest, and specifically the Lookout Mountain Unit, provides a unique platform on which to research forest dynamics after thinning and fuel reduction. In addition to research into the forest dynamics after thinning and fuel reduction, there are management issues within the Lookout Mountain Unit that could be addressed in concert with the planned research. These management issues include the following:

- Restore tree vigor and reduce the risk of landscape-scale stand-replacement disturbance
- Protect and enhance future research opportunities
- Protect the Lookout Mountain installation of the *West-Wide Levels-of-Growing-Stock Study* and the *Ponderosa Pine-Grand Fir Spacing Study* from wildfire.

The general provisions of the Organic Administration Act of 1897 (16 USC 551), the McSweeney-McNary Act of 1928, and the Forest and Rangeland Renewable Resource Research Act of 1978 (16 USC 1643) authorize the Secretary of Agriculture to designate experimental forests and ranges. Responsibility for establishment and administration is delegated to the Chief under regulations (7 CFR 2.60(a)). The McSweeney-McNary Act of 1928 was further implemented by Regulation L-20 in 1930, directing the Chief of the Forest Service to define experimental forests as dedicated to and used for research, and to make them permanently available. Station Directors are the line officers responsible to the Chief for assigned research activities, including research and management of experimental forests (FSM 1236.21). Within PNW Station, individual experimental forests and ranges are recognized as components of a national network, with administration assigned to Research Programs. The MDR Program has responsibility for Pringle Falls Experimental Forest. This responsibility includes protecting and ensuring a wide array of future research opportunities. Pringle Falls Experimental Forest was established as a center for research in ponderosa pine forests east of the Oregon Cascade Range.

Most of Lookout Mountain consists of stands of a single age cohort (163 years). A small portion along the southern edge is younger. Stands with similar ages, density, and productivity are uncommon across the east slope of the Cascades because of past disturbances, including wildfires, insects, and cutting practices. The most similar stands may be young “black-bark” pine stands on some 40,500 ha (100,000 acres) within the US 97 corridor. James Barrett (PNW Research Forester, retired) first documented the increase in diameter and the decrease in radial growth of ponderosa pine at Lookout Mountain in 2005. He found 0.1 acre (0.04 ha) plots with basal area in excess of 275 $ft^2acre^{-1}$ (63.1 $m^2ha^{-1}$) and SDI over 400, and suggested that attacks from mountain pine beetle and possibly western pine beetle were imminent. A larger inventory was conducted in 2007, with 0.1 acre (0.04 ha) reconnaissance plots located systematic across a uniform grid of the ponderosa pine portion of Lookout Mountain; the highest elevation portion of Lookout Mountain that supports mountain hemlock and grand fir was not sampled. A complete census of all trees ≥ 10 cm in diameter at breast height was recorded to develop a diameter distribution, the plant association was identified, and large-diameter down woody fuel mass was estimated. The plant association recorded in the field provided a verification of mapped plant associations in the Deschutes Forest-wide GIS database. Ponderosa pine at Lookout Mountain average 17.5 inches (43 cm) in diameter and about 162 $feet^2$ $acre^{-1}$ (37 $m^2ha^{-1}$) in basal area, or about 121% of the total basal area reported for live and dead stems in old-growth ponderosa pine stands on Pringle Butte (Youngblood et al. 2004). In addition, stands at Lookout Mountain range from about 132 to 224% of the Upper Management Zone in stand density index. With the exception of a few small study plots, the entirety of Lookout Mountain has continuous canopy cover, high levels of accumulated ground fuels, and high tree density of almost uniform diameter.

Historical disturbance regimes (especially insects and fire) are well documented for central Oregon. Recent landscape-scale mortality of ponderosa pine in the Southwestern United States has been linked to “climate change type drought” (e.g., dry and warm) that occurred in this region in the early 2000s, with several bark beetle species, including the western pine beetle, responded to the vast landscapes of drought-stressed trees and causing widespread tree mortality (Forest Service Climate Change Resource Center, http://www.fs.fed.us/ccrc). Similar declines in tree vigor and similar bark beetle-caused tree mortality could occur at Lookout Mountain if tree density remains high. The mountain pine beetle often kills extensively when contiguous stands or landscapes become vulnerable. The combination of large area with consistent structure (host availability), high tree density with declining vigor, and average tree diameter greater than 12 inches (30 cm) is a condition conducive to a landscape-scale outbreak of mountain pine or western pine beetle. Both lightning and human-caused ignitions are responsible for wildfires on the Deschutes National Forest. Notable recent fires include Eyerly (23,573 acres) and Cache Mountain (3,894) in 2002 and Davis (21,181 acres), Link (3,574 acres), 18 (3,800 acres), and the B&B complex (90,769 acres) in 2003. In one single storm event in August 2003, 53 fires were started by lightning, resulting in suppression activity. Likelihood of a fire starting from lightning is discussed by Agee

(1993); lightning data for central Oregon is available from Vaisala's U.S. National Lightning Detection Network, a lightning information system monitoring cloud-to-ground lightning activity across the continental United States, 24 hours a day, 365 days a year. The combination of large area, abundant ground and ladder fuels, frequent lightning strikes (because of aspect and location), consistent stand structure, and absence of natural fuelbreaks is a condition conducive to a landscape-scale wildfire. Lookout Mountain ponderosa pine stands are relatively young, have grown exceptionally well but have declined in radial growth over the past decade, and currently have structural characteristics which place them at imminent risk of catastrophic loss to bark beetles and high risk of loss to wildfire. Thinning and fuel reduction treatments on about 3,000 acres (1413 ha) of Lookout Mountain are needed to restore tree vigor, reduce susceptibility to insect infestation, and reduce the risk of stand-replacement wildfire. While wildfire and insect outbreaks are not a 100% certainty, there is a recognized risk from both fire and insects and this risk increases with time.

Within this portion of the west-wide distribution of ponderosa pine, individual trees can easily survive for 600 years (Youngblood et al. 2004). Protection and enhancement of future research opportunities at Lookout Mountain that focus on ponderosa pine can best be realized by ensuring that existing canopy cover of the 163-year-old cohort of ponderosa pine is maintained and allowed to develop old-growth structural characteristics. The time required for a single-cohort stand to develop old-growth characteristics is unknown. What is known for certain is that loss of the existing cohort by insects or fire will reset the clock and the process of stand development will begin again. Fire exclusion over the past 100 years at Lookout Mountain has maintained high stand density, led to high basal area, and allowed high fuel accumulation. In the absence of fire exclusion, frequent, low or mixed severity fire over time would gradually reduce the density of live trees, create snags and large down logs, and maintained low fine fuel accumulations. At the same time, insects have caused fine-scale mortality, especially in lodgepole pine (*Pinus contorta*). Because of past fire exclusion, landscape-scale stand-replacement disturbance by fire or insects will eliminate many future research opportunities by erasing mature stands and preventing all research except studies that focuses on the initial stages of stand establishment. Thinning and fuel reduction treatments on about 3,000 acres (1413 ha) of Lookout Mountain are needed to protect and enhance future research opportunities.

Two long-term studies currently in place at Lookout Mountain require special consideration in any plan for vegetation manipulation. As previously mentioned, the *Lookout Mountain Levels-of-Growing-Stock Study* is one installation in a west-wide study of reserve thinning densities. Similar installations occur in the Black Hills of South Dakota, the Coconino Plateau in Arizona, the southern Blue Mountains in Oregon, and on the west side of the Sierra Nevada in California. These installations, and the combined study, have demonstrated long-term stand development in single-cohort ponderosa pine and provide numerous implications for current resource management objectives. The Lookout Mountain installation was

established in 1966, and received subsequent thinning in 1985 and 1995 (Cochran and Barrett 1999). It now needs a third thinning, however, rethinning of the lower reserve densities is no longer possible without modifying the number of target trees because any further density reduction would leave less than the minimum needed to characterize growth response (Oliver 2005). Close collaboration with the Ecology and Management of Western Forests Influenced by Mediterranean Climate Research Unit in Redding, CA, will be essential to successfully design and implement a third thinning. In addition, thinning and reducing ground fuels around the 0.5 acre (0.2 ha) plots is needed to create a fuelbreak or buffer that prevents ground fire from eliminating this important set of plots and terminating the study. Similarly, the *Ponderosa Pine-Grand Fir Spacing Study* is a long-term study of the competitive interaction of these two species at different densities. The study was established in 1975 on about 20 acres (8.1 ha) in the mixed conifer portion of Lookout Mountain, and the first 10 year results were reported by Seidel (1985). Responsibility for this study currently is held by the Forest Science Department of Oregon State University. This study has potential to product new insights in stand development of mixed stands that are especially relevant in current and future management regimes. The study site is surrounded by mixed conifer forests with high fuel accumulations. Any ignition in the surrounding forest could easily spread across the study site, eliminating the study plots and terminating the study. Thinning and reducing ground fuels around the study site is needed to create a fuelbreak or buffer that prevents ground fire from eliminating this set of plots and terminating the study.

### *V. Research goals and questions*

The broad goal of this project is to refine management options for restoring resiliency in forest ecosystems. Restoration of degraded forest and rangeland ecosystems continues to be the number one national research and development priority[3]. Under this broad goal, planned research will:

- determine the nature of short and longer-term responses of forest vegetation and processes to thinning and fuel reduction in ponderosa pine stands, and
- evaluate the effects of thinning and fuel reduction treatments on long-term susceptibility to fire, insects, wind, climate change, and other forest disturbances.

Specific research questions or objectives include the following:

1. What set of fuel reduction treatments best accelerates the development of large trees while over the long-term reintroduce natural disturbance processes that provide greater ecosystem resiliency?
2. What is the long-term influence of climate change interacting with a set of fuel reduction treatments on vegetation dynamics and forest structure?
3. Can single cohort stands be readily converted to multi-cohort stands?
4. Do multi-cohort stands share the same risks of multiple, interacting stresses as single-cohort stands?

[3] (USDA-FS, Research and Development Strategic Plan for 2008-2012)

5. How does the dominant shrub, giant chinquapin (*Chrysolepis chrysophylla*), respond in the near-term to a set of fuel reduction treatments?
6. How does the residual stand structure resulting from a set of fuel reduction treatments interact locally and in the near-term with wind to cause additional structural changes?

### *VI. Treatments, experimental design, and hypotheses*

Five levels of treatment will be implemented:

1. Thin from below[4] to the Upper Management Zone (UMZ) specified for the dominant plant association, based on stand density index values for ponderosa pine. Follow with ground fuel reduction using a combination of mowing and underburning.
2. Thin from below to 75% of the UMZ specified for the dominant plant association, based on stand density index values for ponderosa pine. Follow with ground fuel reduction using a combination of mowing and underburning.
3. Thin from below to 50% of the UMZ specified for the dominant plant association, based on stand density index values for ponderosa pine. Follow with ground fuel reduction using a combination of mowing and underburning.
4. Regeneration cut[5] (conducted in the form of a free thin) across the entire diameter distribution to 75% of the UMZ specified for the dominant plant association based on stand density index values for ponderosa pine, to begin transition to an all-aged stand structure. Because this treatment involves limited removal of dominant and codominant trees, small canopy gaps (0.1 ha average) will be created. These will build on existing canopy gaps where they exist and initiate some where they do not exist. Ground fuel reduction using a combination of mowing and underburning may be incorporated in the near-term and will be evaluated as an additional activity in the mid-term.
5. Control or untreated- retain for the near-term the current structure without manipulation. No follow-up ground fuel reduction with either mowing or underburning will occur.

Four treatment blocks with relatively homogeneous elevation, aspect, and plant association were delineated using, where possible, existing roads. Five treatment units were delineated in each block, based, where possible, on topography and roads (Figure 2). Units assigned treatments 4 and 5 were specifically designed to be smaller in size because a large, untreated block only preserves the inherent risk of beetle-caused or fire-cause mortality that the treatments are planned to reduce. During the randomization process within a block, the first assignment of treatment 4 or 5 resulted in slitting a unit. Treatments 4 and 5 intentionally were assigned to units half the size of treatments 1, 2, and 3. This full

[4] Cultural treatment made to reduce stand density by removing trees from the lower crown classes or smaller diameters to improve growth and overall forest health of trees in the upper crown classes or the larger trees; a low thin.

[5] Regeneration cut, removing individual trees and small groups of trees in all size classes more or less uniformly throughout the stand to promote growth of remaining trees and to provide space for regeneration, as part of a selection method for uneven-aged or all-aged management.

randomization is based on the assumption that variation among units was the same regardless of unit size.

The experimental design consists of treatment structure and design structure. The treatments structure consists of the set of five treatments to forest stands at Lookout Mountain. The design structure consists of four block designed to better ensure homogeneity in elevation and aspect. The resulting experimental design is a randomized complete block design. Specific treatment guides are listed in Table 2.

Control and multi-aged units were specifically designed to be half the size of other treatment units. Large control units present an inherent risk from multiple disturbance threats and indirect risks to adjacent treated units because of contagion influences. Control units only have short-term value because the more important contrasts will be among actively treated structures. The assignment of “control” status to certain units is an arbitrary nomenclature used here for ease of study design interpretation. Use of this term is made while fully acknowledging a history of past treatments, including thinning and fire exclusion. It implies a no-action treatment. Status of the control units will be assessed after collection of $5^{th}$-year post-treatment data; nothing in this study plan precludes assignment of other treatments after this period. The four control units could be retained to facilitate additional comparison, converted to multi-cohort trajectories to facilitate comparisons with treatment 4, or retained as a single-cohort stand and thinned to an as yet unspecified density.

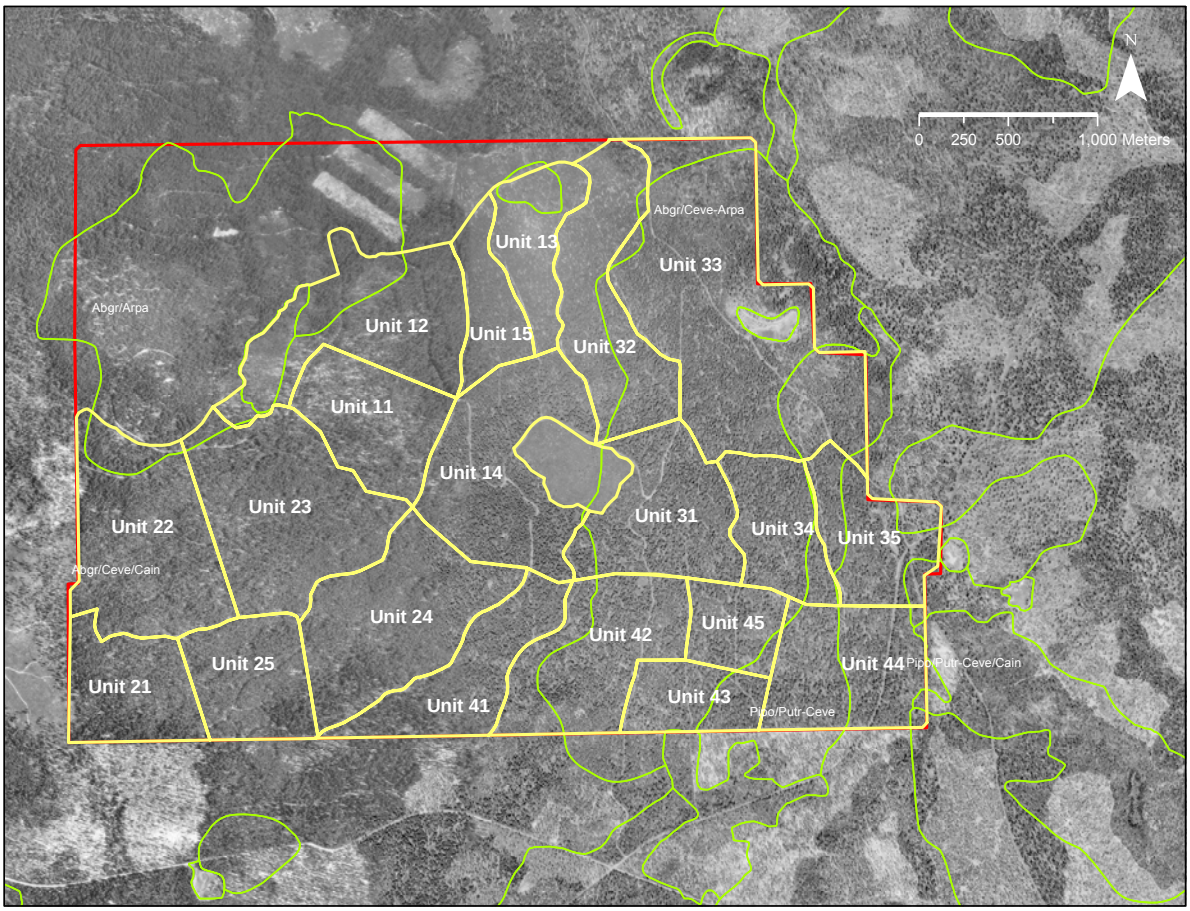


Figure 2. Treatment unit delineation overlaying plant association type boundaries, Lookout Mountain, Pringle Falls Experimental Forest

Low thinning prescribed for treatments 1, 2, and 3 will be marked to retain the existing spatial distribution of dominant and codominant trees; any clumped or random distribution of large trees will be preserved. Cutting preference by species is listed in Table 3.

Mowing will consist of a mechanical treatment to reduce the height of shrubs and ladder fuels. It is commonly used on the Deschutes National Forest as a precursor to underburning because it directly affects fuelbed structure. Underburning will require individual burn plans to be developed for each unit to account for differences in site physical features and fuel accumulations, and may include both backing and strip head fires under conditions conducive to low flame heights. Mortality targets for overstory trees will be consistent across burn plans. Burns will be designed for late season in the year after the completion of thinning to allow curing of all activity fuels.

Table 2. Treatment by unit, with target stand density index and basal area values based on dominant plant associations at Lookout Mountain, Pringle Falls Experimental Forest.

| Unit | Plant Association | Treatment | Acres | Stand Density Index | Basal area (feet$^2$ acre$^{-1}$) | Density (Trees acre$^{-1}$) | Mean diameter (inches) |
|---|---|---|---|---|---|---|---|
| | | | | **Current conditions** | | | |
| Block 1 | CWS 115 | | 651 | 214 | 140 | 101 | 15.9 |
| Block 2 | CWS 115 | | 841 | 257 | 180 | 92 | 18.9 |
| Block 3 | CWS 113 | | 899 | 267 | 185 | 101 | 18.3 |
| Block 4 | CPS 312 | | 554 | 223 | 150 | 93 | 17.2 |
| | | | | **Target conditions** | | | |
| Block 1 | | | | | | | |
| 11 | | 2 | 118 | 117 | 76 | | |
| 12 | | 3 | 192 | 78 | 51 | | |
| 13 | | 4 | 83 | 117 | 76 | | |
| 14 | | 1 | 194 | 156 | 101 | | |
| 15 | | 5 | 64 | 212 | 138 | | |
| Block 2 | | | 206 | | | | |
| 21 | | 4 | 106 | 117 | 83 | | |
| 22 | | 2 | 206 | 117 | 83 | | |
| 23 | | 3 | 225 | 78 | 56 | | |
| 24 | | 1 | 196 | 156 | 111 | | |
| 25 | | 5 | 108 | 245 | 174 | | |
| Block 3 | | | | | | | |
| 31 | | 3 | 148 | 101 | 70 | | |
| 32 | | 1 | 164 | 202 | 140 | | |
| 33 | | 2 | 384 | 152 | 105 | | |
| 34 | | 4 | 94 | 152 | 105 | | |
| 35 | | 5 | 109 | 266 | 184 | | |
| Block 4 | | | | | | | |
| 41 | | 3 | 116 | 51 | 35 | | |
| 42 | | 1 | 160 | 102 | 70 | | |
| 43 | | 4 | 70 | 77 | 53 | | |
| 44 | | 2 | 147 | 77 | 53 | | |
| 45 | | 5 | 61 | 229 | 154 | | |

Table 3. Marking guide for Lookout Mountain, Pringle Falls Experimental Forest, with species preferences for cutting.

| Cutting preference | Species |
|---|---|
| 1 | Lodgepole pine |
| 2 | Grand/white fire |
| 3 | Small diameter Ponderosa pine |
| 4 | Small diameter Mountain hemlock |
| 5 | Small diameter Douglas-fir |

This study uses the term “long-term” to mean beyond the immediate effect of the treatments as proposed, extending forward in time several hundred years. This study uses the term “near-term” to mean the immediate effect of the treatments as measured during the 5$^{th}$ year post-treatment. To fully realize the research values of the proposed treatments, future treatments will be necessary to maintain the desired structure. These future treatments, while intentionally not incorporated as part of this study plan, will be essential to realign the desired structure along target SDI values as established in this plan for treatments 1, 2, and 3 (100, 75, and 50% UMZ) and will likely need to occur after about 40 years. In addition, additional treatments will need to occur to continue the trajectory of stand development as initiated by treatment 4 (multicohort). These repeated treatments could occur at about 50 year intervals. Surface and ladder fuels may also need repeated mowing or underburning at about 20 year intervals. Nothing in this study plan precludes future, higher priority research from occurring within the Lookout Mountain Unit of Pringle Falls Experimental Forest. Nothing in this study plan obligates the PNW Station to any future fiscal commitment.

The proposed treatments were simulated with respect to near-term changes in stand structure using the Forest Vegetation Simulator and Stand Visualization System and reconnaissance data collected from Lookout Mountain stands. These simulations indicated that the proposed treatments would result in clearly distinguishable residual structures. For example, treatment 1 in Block 1 would result in a residual stand with about 33 live trees per acre with diameters ranging from 15.7 to 39.9 and averaging 23.5 inches, and 12 dead trees per acre with diameters ranging from 7.2 to 19.0 and averaging 12.7 inches (Figure 3 and 4). In contrast, treatment 2 in Block 4 would leave about 10 live trees per acre with diameters ranging from 26.1 to 33.1 and averaging 28.8 inches, and 4 dead trees per acre with diameters ranging from 6.5 to 19.3 and averaging 12.3 inches (Figure 5 and 6).

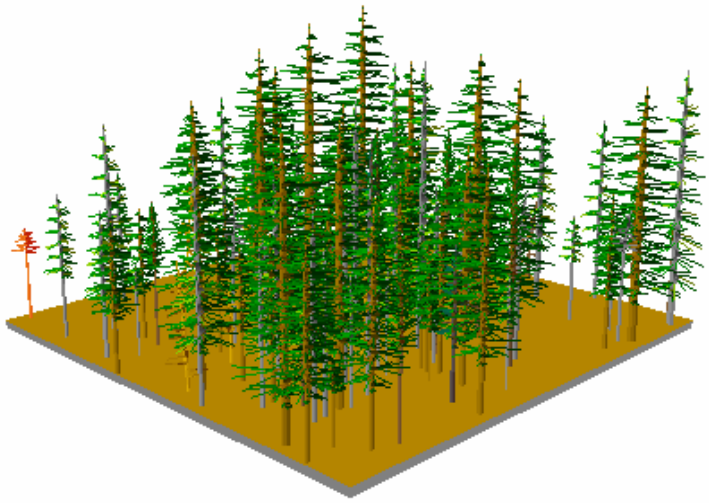

Figure 3. Simulated forest structure before treatment in Block 1, Lookout Mountain, Pringle Falls Experimental Forest

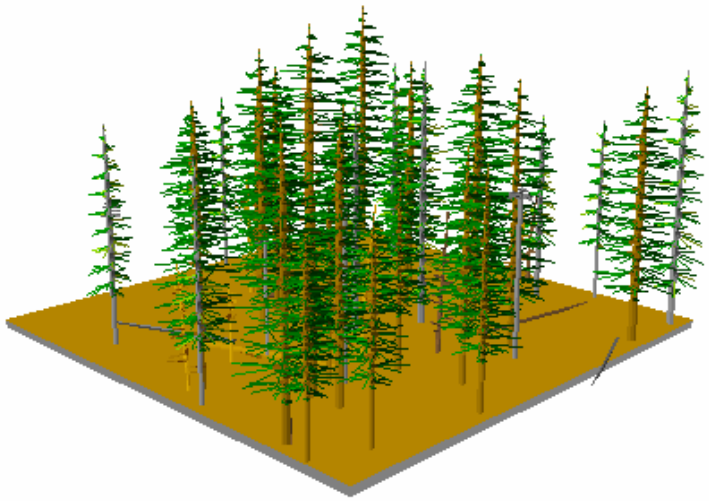

Figure 4. Simulated forest structure the first year after thinning to the Upper Management Zone (treatment 1) in Block 1, Lookout Mountain, Pringle Falls Experimental Forest

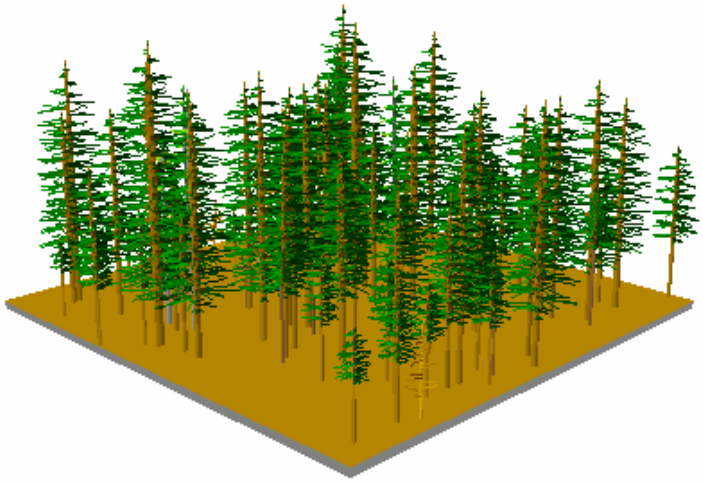

Figure 5. Simulated forest structure before treatment in Block 4, Lookout Mountain, Pringle Falls Experimental Forest

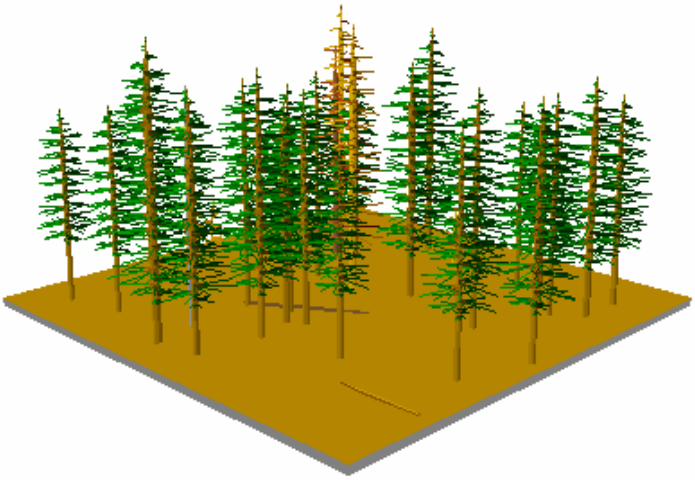

Figure 6. Simulated forest structure the first year after thinning to 75% of the Upper Management Zone (treatment 2) in Block 1, Lookout Mountain, Pringle Falls Experimental Forest

The first research question deals specifically with structural changes, especially the restoration of radial growth rates leading to larger tree diameters, while reintroducing surrogates for low and mixed severity disturbance events. In the context of this study, the combination of thinning, mowing, and underburning are considered surrogates for low and mixed severity disturbance events. The combination of thinning and underburning may be more effective in reducing fuels and changing diameter distributions, but may produce more varied results that depend, in part, on the amount of fuels added during the thinning activity (Youngblood et al. 2008). We know that young ponderosa pine stands respond positively to density reduction (Cochran and Barrett 1999). Because mean annual basal area growth is directly related to SDI and thus density, the working hypothesis is that treatments that remove greater levels of tree density eventually result in greater quadratic mean diameter, or more simply, removing more small trees should allow the residual trees to grow to larger diameters. This means that radial growth and ultimately diameter after thinning from below to 50% of the UMZ would result in larger trees than after thinning from below to 75% of the UMZ, with thinning to the UMZ resulting in less change (Annual radial growth in Treatment 3 > Treatment 2 > Treatment 1). While this hypothesis is known to hold true for young, pole-size stands of ponderosa pine, it is not known if it holds equally true for stands of larger trees when thinning treatments are combined with mowing and underburning. If so, it provides managers additional justification to consider restoration treatments options across a wider array of stand types.

The second research question introduces climate change as an additional form of disturbance that has not been adequately addressed in thinning and fuel reduction research. This portion of central Oregon has gone through at least five distinct periods of warming climate over the past 110 years (NASA Global Climate Change Website http://climate.jpl.nasa.gov). In the Western United States and at the continental scale (1 km), long-term satellite data show consistently earlier onsets of spring greening and corresponding increases in length of growing season (Forest Service Climate Change Resource Center: http://www.fs.fed.us/ccrc). Small changes in growing season duration may result in expansion of species that have relatively narrow habitat requirements. Lookout Mountain provides a unique opportunity to explore vegetation dynamics under a changing climate regime because it is topographically simplistic and contains essentially uniform or homogenous soils (deep pumice derived from the explosion of Mt. Mazama). It also contains several relatively clear and distinct ecotones (boundaries between easily recognized plant associations). Treatment blocks differentiate two elevation zones (above 4,200 feet (91280 m) or below) and two aspect zones (southeast and south). Under this task, the working hypothesis is that initial or early indications of vegetation dynamics are most likely to become apparent in the shrub and herbaceous strata, and these dynamics will be manifest as expansion of species from drier sites to those that are currently more moist as conditions become increasingly stressed. This means that shrubs and herbaceous species that dominate in plant associations on flat topography outside the treatment area or only on the edges of Block 4, such as antelope bitterbrush (*Purshia tridentata*), will

expand upward in elevation. Under this hypothesis, the niche space of individual species and entire assemblages of species will shift from Block 4 and Block 2 to Block 1 and eventually to Block 3. Within each block, shifts can be expected where disturbance provides access and growing space, and will most likely be manifest under Treatment 2 and 3 and perhaps 4. This work will provide a validity assessment for current efforts to downscale vegetation dynamic projections to 80 m resolution (personal communication, R. Neilson). This will provide insights into the effects of climate change at the community scale, and provide managers much needed information on the restructuring of plant composition as a result of regional climate interacting with legacies of past management. These insights will inform management options to better incorporate these changes.

The third question is one that has plagued silviculturists for decades. Pre-Euro-American dry ponderosa pine forests were predominantly multi-cohort. Within the pumice-dominated zone of eastside forests, remaining old-growth ponderosa pine forests retain this multi-cohort structure, with sometimes ten distinct cohorts in the overstory (Youngblood et al. 2004). Past management, however, has converted most of the old-growth, multi- cohort stands to young, single-cohort stands, and much of the ponderosa pine resource is now managed under an even-aged system. Essentially all of our knowledge base for managing ponderosa pine ecosystems is derived from studies conducted in even-aged stands. The uneven-aged management regime that maintains multi-cohort stands is often recognized as advantageous for management of ponderosa pine because of productivity, aesthetics, and its ease in restoring pre-settlement stand structures (O'Hara 2005). Few if any empirical comparisons of even-aged and uneven-aged systems exist across any suite of treatments. A fundamental question is how to convert single-cohort stands that are a legacy of past management to multi-cohort stands that may more closely resemble those that developed under pre-Euro-American conditions. This question is well-timed under the hypothesis that the structural characteristics in multi-cohort stands may provide greater resiliency to low and mixed severity disturbances compared to the structural characteristics in single-cohort stands. It is unlikely that any answer to this question will come from any short-term study; multi-cohort stands of ponderosa pine developed over centuries. Initiation of the conversion from single-cohort to multi-cohort in this study in four treatment units as a result of Treatment 4 will begin the long-term process. In this case, the objective will be the establishment of a new (the second) cohort. Given that the vast majority of ponderosa pine-dominated landscapes for currently managed under an even-aged regime and there are recognized benefits to using the uneven-aged system, this work will provide managers much needed information into the process of restructuring single-cohort stand to multi-cohort stands. Under the framework of this study plan, only a single trajectory for multi-cohort structure will be established in the near-term. There is, however, the opportunity to convert units assigned the "control" or no-treatment alternative (Treatment 5) to a contrasting trajectory for multi-cohort structure once their immediate value as controls has been fully realized.

The fourth question deals specifically with the risks from multiple, interacting stresses. Pre-Euro-American dry ponderosa pine forests were predominantly multi-cohort, and this structure developed in response to multiple, interacting stresses. We know much about the legacy of fire in these stands because burning often leaves a signature in fire scars, tree rings, and recruitment of a new age-class. Likewise, insects leave signatures in tree rings, or kill trees and create snags. Differences in regional climate are reflected in the dendrochronology record. We know little about how fire, insects, and climate change will continue to serve as drivers of structural change in multi-cohort stands when compared to single-cohort stands within the same ecosystem. Recent work using structural equation modeling after thinning and underburning (Youngblood, Grace, and McIver, in press, *Ecological Applications*) has shown the effect of fire and insects leading to tree mortality. This same approach will be used in this work at Lookout Mountain. The working hypothesis is that climate change and insects, and perhaps fire, will interact to increase tree mortality in relation to relative tree density, density management will delay large tree mortality, and selection cutting will provide the greatest degree of resiliency to the interaction of climate change, insects, and fire (Residual tree mortality in Treatment 1 > Treatment 2 > Treatment 3 > Treatment 4). Like the second question, this work will provide insights into the effects of climate change at the community scale and provide managers much needed information on the restructuring of forest stands as a result of interacting disturbance regimes, and management options to better incorporate these interactions.

The fifth question deals specifically with how the dominant shrub, giant chinquapin (*Chrysolepis chrysophylla*), responds to thinning and fuel reduction treatments. Giant chinquapin is a native, broad-leaved, sclerophyllous evergreen. In the central Oregon portion of its distribution, it is an understory arborescent shrub, or rarely a small tree; heights generally do not exceed 16 feet (5 m). It regenerates both sexually and vegetatively. Seedling reproduction is generally restricted to mesic sites, while vegetative regeneration is more prevalent on increasingly xeric sites. It is a long-lived, moderately shade-tolerant species. Thin bark provides little insulation from radiant heat, so fires usually kill the cambium around the base of the stem. After these fires which kill aerial stems, giant chinquapin resprouts from adventitious buds located on stumps or dormant buds located on an underground regenerative organ known as a burl. Burls are aggregations of buds, and newly resprouted giant chinquapin individuals occur as "sprout clumps" and are characterized by a large number of sprouts (McMurray 1989). Sprouts are tolerant of direct sunlight and develop well in exposed postburn environments. Preburn canopy coverage and density are usually regained within 2 to 5 years on mixed-conifer sites in the southern Oregon Cascades (Volland 1985). Sprouting vigor can, however, be greatly reduced when plants are subjected to repeated underburns that consume much of the duff (Martin 1982). Little is known of how this species contributes to fuel loading and fire behavior in underburns after various levels of thinning, how it may respond to mowing, and how it may respond to climate change. The working hypothesis is that disturbances that are surrogates for low severity wildfires, such as thinning, mowing, and underburning,

will stimulate resprouting. More canopy exposure will encourage sprout growth. This means that aboveground shrub density and biomass should be greatest with the greatest amount of thinning and fuel reduction, and remain at current levels where canopies are undisturbed (Treatment 3 > Treatment 2 > Treatment 4 > Treatment 1). At the same time, shifts in composition because of climate change will drive giant chinquapin upslope and to more mesic environments. This means that the distribution of giant chinquapin at Lookout Mountain will shift upward and eastward (Block 3 > Block 1 > Block 4 > Block 2). Like the second question, this work will provide insights into the effects of climate change, but focuses on a specific shrub species of interest. The work also will provide managers much needed information on the fire effects and fire ecology of a dominant species that is not well understood.

The sixth question is designed to evaluate the long-term susceptibility of stands managed under thinning and fuel reduction regimes to windthrow. Models of disturbances for eastside forest have not incorporated wind as a common event, yet it has long been known that wind affects forest structure. Windspeed may increase in mountainous areas, and prevailing winds are usually greater when winds confront large objects such as isolated mountains. Wind can break stems or uproot trees (windthrow). Management practices such as thinning and underburning may contribute to wind damage because individual trees are made more susceptible as stands are opened, the roughness factor is increased, and trees that were in the interior of closed stands become more exposed. In addition, rooting systems may be affected by mechanical equipment or fire. Lookout Mountain provided a unique opportunity to evaluate the effects of wind after thinning and fuel reduction because the site is an exposed volcanic cone with little surface topography other than elevation and aspect. The study site has south- and southeast-facing aspects. Prevailing wind in the region is southwesterly, especially during winter storms. In addition, Lookout Mountain is prone to strong localized downdrafts associated with summer thunderstorms that again track from the southwest to the northeast. The working hypothesis is that windthrow and stem breakage in residual trees from wind initially will increase with increasing levels of opening (Treatment 3 > Treatment 2 > Treatment 1> Treatment 4). In addition, windthrow and stem breakage may vary with elevation and aspect; Block 1> Block 2 = Block 4 > Block 4. This work will provide manager new information on the interaction of disturbance processes that affect forest structure, and provide information on management options that best incorporate wind as a disturbance process.

### *VII. Field methods*

Data collection for select measurement variables will occur pre-treatment, and the first, third, and fifth year post-treatment. Within each operational treatment unit, a 9 ha (22.2 acre) experimental unit will be established. Sample plots (25 points centered on 50 m by 50 m grid points will be established and used to collect measurement data. Grid points will be established along compass lines with tape and staff compass and incorporate at least 50 m from any stand boundary, road, or concentration of skid trails. Grid points will be geo-referenced by GPS, and monumented after the full suite of treatments is

completed. Circular 400-$m^2$ reconnaissance plots will be centered on each grid point. On each plot, the following environmental parameters will be collected to characterize the plot: elevation to the nearest meter by using a hand-held GPS, aspect to the nearest 1° by using a compass, slope to the nearest 1°by using a clinometer, and a measure of total live overstory canopy cover taken as five observations with a GRS densitometer at five regularly spaced points. All tree stems will be inventoried by species and noted as live or dead, diameters measured to the nearest 0.1 cm with a diameter tape at 1.37 m in height, total tree height measured to the nearest 0.1 m with a clinometer or telescoping height pole, live crown ratio estimated ocularly to the nearest 10%, and the height to the lower live crown estimated to the nearest meter. Within the whole plot, canopy cover by species of all vascular plants will be ocularly estimated to the nearest 1% below 10% and to the nearest 10% above 10% after the peak of the growing season. Ground and surface fuels will be sampled pre- and post-treatment in all units using the grid points as starting points for planar intercept transects.

### *VIII. Analysis methods*

In general, the response variable of interest is the index represented by the difference between pre-treatment and post-treatment value for a given variable summarized by treatment unit. The resulting experimental design is a randomized complete block design with the following general analysis of variance table:

**Analysis of variance table for a given response variable**

| Source of variation | *df* |
|---|---|
| Block | 1 |
| Response | 4 |
| Error | 12 |

Vegetation field measurements will be summarized for stem density, basal area, and diameter class distribution per ha by species, live and dead for each treatment unit (20 total) across plots. Stand density index (Cochran 1994) will be computed for each treatment unit based on the dominant species by averaging across plots. Constancy and canopy cover of vascular plant species, canopy cover of advance regeneration, and treatment unit overstory canopy cover will be computed by averaging across plots. Diversity of non-conifer vascular species for each treatment unit will be computed for each treatment unit. Multivariate tests for differences in community composition among and between treatments will be calculated with pre- and post-treatment data by using multi-response permutation procedures (MRPP in PC_ORD), a non-parametric randomization-based alternative to multivariate ANOVA (McCune and Grace 2002). Indicator species analysis and non-metric multidimensional scaling ordination (NMS) (McCune and

Grace 2002) will be used to compare community composition within and among treatments. This ordination method is well suited to non-normal ecological data because it avoids the assumptions of linear relationships among variables and is robust with respect to large numbers of zero values. In a similar effort, NMS was used to show little change in community composition over time after thinning and underburning in northeastern Oregon (Younblood et al. 2006). Measured fuelbed characteristics from each treatment unit will be used to synthesize properties and predicted fire potentials by using the Fuel Characterization Classification System. This tool will be used to construct fuelbeds with quantitative fuel characteristics (physical, chemical, and structural properties) and probable fire parameters for each unit from inventoried data collected both pre-and post-treatment as a part of monitoring structural changes resulting from thinning and fuel reduction.

### *IX. Application of research results*

This work will result in a body of scientific knowledge and understanding through the refereed and peer-reviewed literature, and other products that are recognized for their scientific leadership and utility. The ultimate application of information generated by this work will be incorporation in planning, evaluation, monitoring, and management tools used by federal agencies and private land owners

### *X. Safety and health*

PNW and R6 personnel will be conducting much of the fieldwork under normal field conditions of spring, summer and fall. All Federal personnel will be informed of and operate under approved safety procedures as detailed in FSH 6709.11– Health and Safety Code Handbook. Supervisors will ensure appropriate Job Hazard Analyses are completed before work begins. Safety and health issues for those operating under contract, cooperative agreement, or joint venture agreement are not addressed here.

### *XI. Quality assurance/Quality control procedures*

This planned research will be conducted as a team effort between the Deschutes National Forest and PNW Station scientists. It will require a high degree of cooperation and coordination with the Bend/Ft. Rock Ranger District. Personnel performing data collection functions are responsible for operational maintenance and calibration of any measuring or recording instrument. Accuracy of each instrument will be maintained using manufacture's recommended procedures for daily calibration and annual maintenance. Approximately 10 percent of morphological measures (tree diameters, tree height, canopy cover of herbaceous species, etc.) will be remeasured (blind resampling) to determine precision levels. For computer entry and data reduction, the identified personnel are responsible for verification of data entry, documentation of data completeness, accuracy, precision, and implementation of corrective action.

Data will be stored in log books, computers, and backup disks. Numeric data will be entered and stored in spreadsheet form compatible with MS Excel. File headers will identify fields, units, experimental conditions, and other relevant information. All files will be readily convertible to a MS ACCESS database. Hardtop backups and the complete study file, including documentation of methods and equipment used, training and certification of personnel, any notes from field personnel, study plan amendments, copies of manuscripts and technology transfer materials, and safety documentation will be housed in fireproof storage at LaGrande.

### *XII. Environmental analysis considerations* (see FSM 1950 and FSM 2150)

All NEPA issues will be addressed by an environmental assessment conducted by the Bend/Ft. Rock Ranger District.

### *XIII. Personnel assignment, time of completion, and cost*

About 0.3 SY is currently devoted to this project. Timing and cost are left unresolved pending final NEPA and awarding of contract(s) for treatment implementation. Priority is for collection of pre-treatment measurement. Research questions 5 (Response of giant chinquapin) and 6 (Post-treatment blowdown) can be addresses initially in about 5 years. Research questions 1 (Development of large trees and resiliency), 2 (Climate change), and 3 (Transition from single-cohort to multi-cohort) will require several decades. Research question 4 (Multiple, interacting stresses in mult-cohort stands) may require the longest time to fully address. This study plan designs the platform to ultimately bring insight to these questions. Monitoring of vegetation dynamics and shifts in stand structure, using the plot structure developed under this study plan, will need to occur at about 5-year intervals after the first 5 years to address research questions 1, 2, 3 and 4. Current staffing and funding limitations preclude obligation of resources beyond the near-term.

### *XIV. Study files*

A study file serves as a permanent record of this study. Because of the long-term nature of this study, the study file is considered a living, work in progress, with periodic updates and additions. It includes information that would be needed to reconstruct or continue the study, and to ensure the usefulness and validity of the data from the study. This study file is maintained as a hard copy with electronic components as backup. The study file will reside at the LaGrande Forestry Sciences Lab. in a fire-proof cabinet. It will include the following information:

1. The draft study plan and comments from all peer and technical reviewers; the reconciliation document detailing responses to reviewer's comments, and the final approved study plan.
2. A listing of measurements and their expected quality.
3. Documentation of the methods used in the study.

4. Documentation of equipment used in the study.
5. Documentation of training and certification of personnel.
6. Quality assurance documents, such as audit results or quality control data.
7. Notes to the file by scientists, field personnel, technicians, and others involved in data collection or data management.
8. Data archiving procedures including references to the location of the raw data.
9. Meta-data, describing the location, types, and physical relationship of all data.
10. Any pertinent correspondence, including notes to the file, study plan amendments, other important information needed to understand or recreate the study.
11. Study products, such as copies of manuscripts and technology transfer materials.
12. Manuscript review comments and authors' responses.
13. Safety documentation.
14. NEPA documentation.

### *XV. Ancillary or related research opportunities*

Late in 2006, a field review and workshop was held to identify potential partners and collaborators (see appendix material). As a result of this workshop and subsequent discussions, a list was generated of potential research questions or opportunities that could be tied to or overlaid on this study at Lookout Mountain. This list is by no means a complete list, but it does represent the varied and integrated nature of multi-disciplinary work that could stem from the research platform represented by this study design.

| Potential research topic | Partner |
|---|---|
| Define linkages between mid-scale analyses and project-level analyses | PNW (FSD) |
| Expand and develop the current use of the west-wide pine beetle model to incorporate western, mountain, pine engraver, and red turpentine beetle | PNW (MDR and WWETC) |
| Refine and demonstrate a burn probability and fire risk analysis using a fire modeling/actuarial risk approach | PNW (MDR and WWETC) |
| Evaluate the use of biological control agents to manipulate aboveground biomass of the dominant shrub, snowbrush (*Ceanothus velutinus)* and thereby encourage enhanced herbivory and defoliation to create more predictable burning conditions and potentially greater natural regeneration of ponderosa pine | PNW (MDR) |
| Refine models of product recovery for different tree sizes | PNW (HNRI) |
| Test the effects of removing woody biomass on fire severity and on the | PNW (HNRI) |

| | |
|---|---|
| supply and quality of woody biomass over time and space | |
| Role of plant stress in shifting insect dynamics | PNW (MDR) |
| Application of free thinning to modify forest structure | RMRS |

***XVI. Literature***


Agee, J. K. 1993. Fire ecology of Pacific Northwest forests. Island Press, Washington, D.C., USA.

Agee, J. K. 1994. Fire and weather disturbances in terrestrial ecosystems of the eastern Cascades. USDA Forest Service General Technical Report PNW-GTR-320.

Agee, J. K., and C. N. Skinner. 2005. Basic principles of forest fuel reduction treatments. Forest Ecology and Management 211:83-96.

Allen, C. D., M. Savage, D. A. Falk, K. F. Suckling, T. W. Swetnam, T. Schulke, P. B. Stacey, P. Morgan, M. Hoffman, and J. T. Klingel. 2002. Ecological restoration of southwestern ponderosa pine ecosystems: a broad perspective. Ecological Applications 12: 1418-1433.

Arabas, K. B., K. S. Hadley, and E. R. Larson. 2006. Fire history of a naturally fragmented landscape in central Oregon. Canadian Journal of Forest Research 36:1108-1120.

Arno, S. F., H. Y. Smith, and K. A. Krebs. 1997. Old growth ponderosa pine and western larch stand structures: influences of pre-1900 fires and fire exclusion. USDA Forest Service Research Paper INT-RP-495.

Bergoffen, W. W. 1976. 100 years of Federal forestry. USDA Forest Service Agriculture Information Bulletin 402.

Boisvenue, C., and S. W. Running. 2006. Impacts of climate change on natural forest productivity-evidence since the middle of the 20$^{th}$ century. Global Change Biology 12: 862-882.

Brown, R. T., J. K. Agee, and J. F. Franklin. 2004. Forest restoration and fire: principles in the context of place. Conservation Biology 18:903-912.

Cochran, P. H., and J. W. Barrett. 1995. Growth and mortality of ponderosa pine poles thinned to various densities in the Blue Mountains of Oregon. USDA Forest Service Research paper PNW-RP-483.

Cochran, P. H., and J. W. Barrett. 1999. Growth of ponderosa pine thinned to different stocking levels in central Oregon: 30-year results. USDA Forest Service Research Paper PNW-RP-508.

Cochran, P. H., J. M. Geist, D. L. Clemens, R. R. Clausnitzer, and D. C. Powell. 1994. Suggested stocking levels for forest stands in northeastern Oregon and southeastern Washington. USDA Forest Service Research Note PNW-RN-513.

Converse, S J., G. C. White, K. L. Farris, and S. Zack. 2006. Small mammals, and forest fuel reduction: national-scale responses to fire and fire surrogates. Ecological Applications 16: 1717-1729.

Covington, W. W., and M. M. Moore. 1994. Postsettlement changes in natural fire regimes and forest structure: ecological restoration of old-growth ponderosa pine forests. Journal of Sustainable Forestry 2:153-181.

de Groot, P., and J. J. Turgeon. 1998. Insect-pine interactions. Pages 354-380 *in* D. M. Richardson, editor. Ecology and Biogeography of *Pinus*. Cambridge University Press, Cambridge, UK.

Dodson, E. K., K. L. Metlen, and C. E. Fiedler. 2007. Common and uncommon understory species differentially respond to restoration treatments in ponderosa pine/Douglas-fir forests, Montana. Restoration Ecology 15: 696-708.

Dolph, K. L., S. R. Mori, and W. W. Oliver. 1995. Long-term response of old-growth stands to varying levels of partial cutting in the eastside pine type. Western Journal of Applied Forestry 10:101–108.

Erickson, H. E., and R. White. 2007. Invasive plant species and the Joint Fire Science Program. USDA Forest Service General Technical Report PNW-GTR-707.

Everett, R. L., R. Schellhass, D. Keenum, D. Spurbeck, and P. Ohlson. 2000. Fire history in the ponderosa pine/Douglas-fir forests on the east slope of the Washington Cascades. Forest Ecology and Management 129: 207-225.

Farris, K. L., S. J. Converse, S. Zack, A. J. Amacher, T. Contreras, W. Gaines, E. Kilpatrick, J. D. Lanham, D. Miles, D. Roberson, G. Rompre, K. E. Sieving, and J. Woolf. In press. Short-term effects of fire and fire surrogate treatments on avian nest survival: a national-scale, interdisciplinary analysis. Ecological Applications.

Fettig, C. J., K. D. Klepzig, R. F. Billings, A. S. Munson, T. E. Nebeker, J. F. Negrón, and J. T. Nowak. 2007. The effectiveness of vegetation management practices for prevention and control of bark beetle outbreaks in coniferous forests of the western and southern United States. Forest Ecology and Management 238: 24-53.

Fiedler, C. E., S. F. Arno, C. E. Carlson, M. G. Harrington. 1992. Management prescriptions for storing biodiversity in inland northwest ponderosa pine-fir forests. Northwest Environmental Journal 8: 211-213.

Gaines, W. L., M. Haggard, J. F. Lehmkuhl, A. L. Lyons, and R. J. Harrod. 2007. Short-term response of land birds to ponderosa pine restoration. Restoration Ecology 15: 670-678.

Graham, R. T., S. McCaffrey, and T. B. Jain. 2004. Science basis for changing forest structure to modify wildfire behavior and severity. USDA Forest Service General Technical Report RMRS-GTR-120.

Harrod, R. J., B. H. McRae, and W. E. Hartl. 1999. Historical stand reconstruction in ponderosa pine forests to guide silvicultural prescriptions. Forest Ecology and Management 114: 433-446.

Hayes, J. L., and G. E. Daterman. 2001. Bark beetles (Scolytidae) in eastern Oregon and Washington. Northwest Science 75: 21-30.

Hessburg, P. F., R. G. Mitchell, and G. M. Filip. 1994. Historical and current roles of insects and pathogens in eastern Oregon and Washington forested landscapes. USDA Forest Service General Technical Report PNW-GTR-327.

Hessburg, P. F., J. K. Agee, and J. F. Franklin. 2005. Dry forests and wildland fires of the inland Northwest USA: contrasting the landscape ecology of the pre-settlement and modern eras. Forest Ecology and Management 211:117-139.

Long, J.N., and T. W. Daniel. 1990. Assessment of growing stock in uneven-aged stands. West. J. Appl. For. 5: 93-96.

Martin, R. E. 1982. Shrub control by burning before timber harvest. Pages 35-40 *in* Site preparation and fuels management on steep terrain: Symposium proceedings. Pullman, WA: Washington State University.

McCullough, D. G., R. A. Werner, and D. Neumann. 1998. Fire and insects in northern and boreal forest ecosystems. Annual Review of Entomology 43: 107-127.

McCune, B, and J.B. Grace. 2002. Analysis of ecological communities. MjM Software Design, Gleneden Beach, OR, USA.

McKenney, D. W., J. H. Pedlar, K. Lawrence, K. Campbell, and M. F. Hutchinson. 2007. Potential impacts of climate change on the distribution of North American trees. BioScience 57: 939-948.

McMurray, N. E. 1989. *Chrysolepis chrysophylla*. *In*: Fire Effects Information System. USDA, Forest Service, Rocky Mountain Research Station. Available online at: http://www.fs.fed.us/database/feis/

Mitchell, R. G., 1990. Effects of prescribed fire on insect pests. Pages 111-116 *in* J. D. Walstad, S. R. Radosevich, and D. V. Sandberg, editors. Natural and prescribed fire in Pacific Northwest forests. Oregon State University Press, Corvallis, Oregon, USA.

Mutch, R. W., S. F. Arno, J. K. Brown, C. E. Carlson, R. D. Ottmar, and J. L. Peterson. 1993. Forest health in the Blue Mountains: a management strategy for fire-adapted ecosystems. USDA Forest Service General Technical Report PNW-GTR-310.

O'Hare, K. L. 2005. Multiaged silviculture of ponderosa pine. Pages 58-70 *in* Ritchie, M. W., D. A. Maguire, and A. Youngblood, eds. Proceedings of the symposium on ponderosa pine: issues, trends, and management. USDA Forest Service General Technical Report PSW-GTR-198.

Oliver, W. W. 1995. Is self-thinning in ponderosa pine ruled by Dendroctonus bark beetles? Pages 213-218 *in* Proceedings of the 1995 national silviculture workshop. USDA Forest Service General Technical Report GTR-RM-267.

Oliver, W. W. 2005. The West-wide ponderosa pine levels-of-growing-stock study at age 40. Pages 71-79 *in* Ritchie, M. W., D. A. Maguire, and A. Youngblood, eds. Proceedings of the symposium on ponderosa pine: issues, trends, and management. USDA Forest Service General Technical Report PSW-GTR-198.

Ottmar, R. D., and D. V. Sandberg. 2001. Wildland fire in eastern Oregon and Washington. Northwest Science 75: 46-54.

Parker, T. J., K. M. Clancy, and R. L. Mathiasen. Interactions among fire, insects and pathogens in coniferous forests of the interior western United States and Canada. Agricultural and Forest Entomology 8: 167-189.

Reineke, L. H. 1933. Perfecting a stand-density index for even-aged forests. J. Agric. Res. 46: 627-638.

Richardson, D. M., P. W. Rundel, S. T. Jackson, R. O. Teskey, J. Aronson, A. Bytnerowicz, M. J. Wingfield, S. Proches. 2007. Human impacts in pine forests: past, present, and future. Annual Review Ecol. Evol. Syst. 38: 275-297.

Rorig, M. L., and S. A. Ferguson. 1999. Characteristics of lightning and wildland fire ignition in the Pacific Northwest. Journal of Applied Meteorology 38: 1565-1575.

Sartwell, C., and R. E. Dolph, Jr. 1976. Silvicultural and direct control of mountain pine beetle in second growth ponderosa pine. USDA Forest Service Research Note RN-PNW-268.

Shaw J. D. 2000. Application of stand density index to irregularly structured stands. Western J. Applied For. 15(1): 40-42.

Seidel, K.W. 1985. A ponderosa pine-grand fir spacing study in central Oregon: results after 10 years. USDA Forest Service Research Note PNW-429.

Short, K. C., and J. F. Negrón. 2003. Arthropod responses: a functional approach. Pages 286-305 *in* P. Friederici, editor. Ecological restoration of southwestern ponderosa pine forests. Island Press, Washington, DC.

Starr, L., J. L. Hayes, T. M. Quigley, G. E. Daterman, and S. Brown. 2001. A framework for addressing forest health and productivity in eastern Oregon and Washington. Northwest Science 75: 1-10.

Steele, R., S. F. Arno, and K. Geier-Hayes. 1986. Wildfire patterns change in central Idaho's ponderosa pine-Douglas fir forest. Western Journal of Applied Forestry 1: 16-18.

Stephens, S. L. 1998. Effects of fuels and silvicultural treatments on potential fire behavior in mixed conifer forests of the Sierra Nevada, CA. Forest Ecology and Management 105: 21-34.

Stephens, S. L., and S. J. Gill. 2005. Forest structure and mortality in an old-growth Jeffrey pine-mixed conifer forest in north-western Mexico. Forest Ecology and Management 205: 15-28.

Stephens, S. L., J. J. Moghaddas, C. Edminster, C. E. Fiedler, S. Hasse, M. Harrington, J. E. Keeley, E. Knapp, J. McIver, K. Metlen, C. Skinner, and A. Youngblood. In press. Fire and fire surrogate treatment effects on vegetation structure, fuels, and potential fire behavior and severity from six western United States coniferous forests. Ecological Applications.

Taylor, A. H., and C. N. Skinner. 1998. Fire history and landscape dynamics in a late-successional reserve, Klamath Mountains, California, USA. Forest Ecology and Management 111: 285-301.

Van Mantgum, P.J., and N.L. Stephenson. 2007. Apparent climatically induced increase of tree mortality rates in a temperate forest. Ecology Letter 10: 909-916.

Volland, Leonard A. 1985. Plant associations of the central Oregon Pumice Zone. R6-ECOL-104-1985. USDA Forest Service, Pacific Northwest Region.

Wickman, B. E. 1992. Forest health in the Blue Mountains: the influence of insects and disease. USDA Forest Service General Technical Report PNW-GTR-295.

Wright, C. S., and J. K. Agee. 2004. Fire and vegetation history in the eastern Cascade Mountains, Washington. Ecological Applications 14: 443-459.

Youngblood, A., T. Max, and K. Coe. 2004. Stand structure in eastside old-growth ponderosa pine forests of Oregon and northern California. Forest Ecology and Management 199: 191-217.

Youngblood, A., K. L. Metlen, and K. Coe. 2006. Changes in stand structure and composition after restoration treatments in low elevation dry forests of northeastern Oregon. Forest Ecology and Management 234: 143-163.

Youngblood, A., C.L. Wright, R. D. Ottmar, and J. D. McIver. 2008. Changes in fuelbed characteristics and resulting fire potentials after fuel reduction treatments in dry forests of the Blue Mountain, northeastern Oregon. Forest Ecology and Management 255: 3151-3169.

Youngblood, A., J. B. Grace, and J. D. McIver. Delayed conifer mortality after fuel reduction treatments: interactive effects of fuel, fire intensity, and bark beetles. Ecological Applications, in press.

Appendix A. Chronology of events leading to implementation of Lookout Mountain fuel reduction

| Date | Event |
|---|---|
| 2002-2003 | A. Youngblood (Research Forester, PNW) discussed management needs and research opportunities with J. Schlaich (Presale Forester, Bend/Ft. Rock RD) during implementation of the Dilman Project located on Pringle Butte, Pringle Falls Experimental Forest |
| July 27, 2005 | A. Youngblood facilitated a fieldtrip and site review with PNW scientists discussing options for managing low elevation forest to provide wildlife habitat and reduce the risk of stand-replacement fire. During this site review, E. Forsman (Research Wildlife Biologist, PNW) suggested that Lookout Mountain was generally above the elevation zone that had the potential for developing suitable habitat for the Northern Spotted Owl. |
| Sept. 27, 2005 | A. Youngblood provided an overview of Pringle Falls Experimental Forest for E. DePuit (MDR Program Manager, PNW) and discussed the need for active management to address fuel accumulation and the threat for bark beetles and wildfire. |
| Oct. 7, 2005 | A. Youngblood received a letter from J. Barrett (Research Forester, PNW, retired) detailing current low growth rates and the need to thin co-dominant, intermediate, and suppressed trees to avoid attacks from mountain and western pine beetles. |
| May 23, 2006 | A. Youngblood facilitated a site review at Lookout Mountain with P. Cruz (District Ranger, Bend/Ft. Rock RD, Deschutes NF), Bill Peterson (Silviculturist, Bend/Ft. Rock RD), and J. Schlaich. A request for assistance in planning and conducting a fuel reduction project was sent to the Forest Supervisor. |
| June 22, 2006 | A. Youngblood facilitated a site review at Lookout Mountain with E. DePuit, G. Beatty (Center Director, WWETAC) and T. Shaw (Science Team Leader, WWERAC) and discussed opportunities for collaborative research. |
| Aug. 8, 2006 | A. Youngblood met with L. Weldon (Forest Supervisor, Deschutes NF), E. DePuit, and P. Cruz to discuss opportunities for a large-scale fuel reduction/forest health enhancement project at Lookout Mountain and agreed on the schedule for activities leading to NEPA analysis. |
| Oct. 11, 2006 | A. Youngblood facilitated a site review of Lookout Mountain for 21 invited partners and collaborators, including PNW scientists from the MDR, ECOP, HNRI, and FSD programs and the WWETAC, Forest Service scientists from PSW and RMRS, and scientists from Oregon Department of Fish and Wildlife, The Nature Conservancy, and Wildlife Conservation Society. |
| Oct. 12, 2006 | A. Youngblood facilitated a strategic planning discussion with fieldtrip participants to identify research priorities and opportunities for collaboration. |
| Oct. 18, 2006 | A. Youngblood facilitated a site review of Lookout Mountain for an ad-hoc group of PNW scientists exploring opportunities for addressing landscape ecology research. |
| June 20, 2007 | A. Youngblood facilitated a fieldtrip and site review of Lookout Mountain for the Forest Service Research Executive Team (FSRET) with Deputy Chief, WO staff directors, PNW Executive Team, and P. Cruz. |
| July 16-20, 2007 | A. Youngblood worked with J. Schlaich, D. Schneider (Fuels Planner, Bend/Ft. Rock RD), P. Brna (Silviculturist, Bend/Ft. Rock RD) gathering initial stand inventory for treatment delineation. |
| Dec. 3-5, 2007 | A. Youngblood worked with J. Schlaich, D. Schneider, and P. Brna to define treatment blocks, units within blocks, and treatment randomization. |

| | |
|---|---|
| Dec. 12, 2007 | A. Youngblood provides Bend/Ft. Rock RD the project description with study goals, treatment objectives, and unit marking guides. |
| Feb. 5, 2008 | A. Youngblood outlines project goals and research opportunities during MDR Program Review. |

Appendix B. Support letters from M. Ritchie, PSW Research Station; D. Maguire, Oregon State University; and J. Hayes, PNW Research Station.

**United States Department of Agriculture** | **Forest Service** | **Pacific Southwest Research Station** | **3644 Avtech Parkway Redding, CA 96002 (530) 226-2551 mritchie@fs.fed.us**

**Date:** April 1, 2008

**To:** Andrew Youngblood
Research Forester
PNW Research Station
1401 Gekeler Lane
LaGrande OR 97850

**Subject:** Lookout Mountain Experimental Forest treatments

As recent events at Blacks Mountain Experimental Forest have shown, efforts to protect our research investments are important for the long-term maintenance of experimental forests. Wildfire and insects present a very real threat to the existing studies and the potential for future research. The Redding Silviculture Laboratory has been maintaining three ponderosa pine Levels-of-Growing-Stock installations, including one at Lookout Mountain. The LOGS study has been providing valuable information on management of ponderosa pine for 40 years. We intend to continue to support and maintain these research installations. The Lookout Mountain LOGS installation continues to be viable and should help researchers and managers better understand the long-term consequences of density management. The proposed treatments for Lookout Mountain Experimental Forest should provide a significant measure of protection for the LOGS site and other existing long-term projects. I look forward to continuing our research partnership at Lookout Mountain and hope that the treatments can be implemented in a timely manner.

Sincerely,

/s/ Martin Ritchie
Martin Ritchie, Ph.D.
Research Statistician and Team Leader

DEPARTMENT OF
FOREST SCIENCE

April 2, 2008

Dr. Andy Youngblood
Forestry and Range Sciences Lab
1401 Gekeler Lane
La Grande, OR 97850-3368

Dear Andy:

Thanks for the update on the planned Lookout Mountain treatments.

I applaud your efforts to move ahead with active management of this unit as part of the Pringle Falls Experimental Forest. It is impossible to overstate the case for protecting the ongoing field trials at Lookout Mountain, particularly the three that my group at OSU continues to maintain: the ponderosa pine stand density study, the mixed species trials in ponderosa pine and grand fir, and the true fir stand density study. The mixed species spacing trials are the oldest in the region, having been started by researchers at the Bend Lab in the early 1970s. Due to their age and the interactions appearing between species mix and stand density, the results are attracting increasing attention from a wide range of forest managers, even those from the Westside due to lack of comparable long-term studies. The ponderosa pine and true fir stand density studies are similarly irreplaceable.

Please let me know if I can do anything to expedite implementation of this plan.

Sincerely,

Douglas A. Maguire
Edmund Hayes Professor of Silviculture

OSU
Oregon State
UNIVERSITY
College of Forestry

321 Richardson Hall
Corvallis, Oregon
97331-5752

Telephone
541·737·2244

Fax
541·737·1393

Jane Hayes
<jhayes@eoni.com>
04/02/2008 01:43 PM

To Andy Youngblood <ayoungblood@fs.fed.us>
cc
bcc
Subject Re: Lookout Mountain

Dear Andy:

Thank you for the opportunity to review the draft study plan for Lookout Mountain. As we have discussed on several occasions while standing in the amazing 160 year-old stands within this unit of Pringle Falls Experimental Forest, there is the potential to link some critically important research efforts with the vegetation manipulations proposed for these stands. In particular, given availability of necessary funding, I would be very interested in conducting research aimed at evaluating the changes in insect threats (specifically from western and mountain pine beetles) in relationship to the proposed vegetation treatments over time. This is an area of considerable interest as land managers move forward in meeting the objectives of the Healthy Forest Restoration Act, which calls for thinning and fuels reduction managements throughout western forests. While the reduction of fire risk has been demonstrated, the impacts of these vegetation treatments on reducing risk from and interactions with other disturbance agents, such as weather events (e.g., windthrow) and insects, is less clear. A recent synthesis of the literature on vegetation management and bark beetles draws attention to gaps in our knowledge in this area (Fettig et al. 2007). And as you point out in you write up of Research Question 4, “We know little about how fire, insects, and climate change will continue to serve as drivers of structural change in multi-cohort stands when compared to single-cohort stands within the same ecosystem.” I envision a collaborative study to assess your working hypothesis concerning the level of mortality in treatment units specifically addressing the issue of insect-caused mortality but also in relationship with other sources of mortality. There also exists an excellent opportunity, in conjunction with this work, to address a significant need identified by the Bark Beetle Technical Working Group. Pheromone-baited traps have been used extensively to monitor beetle population fluctuations; however, there is limited ability to translate trap capture data into actual tree mortality. A study addressing this knowledge gap may be competitive in the Special Technology Development Program, which provides funds for projects the development of management tools.

I look forward to working with you and others as the Lookout Mountain project moves ahead. Please keep me posted concerning your progress.

Jane L. Hayes

Research Biological Scientist
USDA Forest Service, PNW Research Station
LaGrande Forestry Science Laboratory
1401 Gekeler Lane
LaGrande OR 97850
Phone: 541-962-6549
e-mail: jlhayes@fs.fed.us