View metadata, citation and similar papers at core.ac.uk

brought to you by CORE

provided by DigitalCommons@University of Nebraska

University of Nebraska - Lincoln
DigitalCommons@University of Nebraska - Lincoln

JFSP Research Project Reports U.S. Joint Fire Science Program

2010

Effect of season and interval of prescribed burns in a ponderosa pine ecosystem on tree growth and understory vegetation.

W. G. Thies
USFS, wthies@fs.fed.us

Becky K. Kerns
Pacific Northwest Research Station, bkern@fs.fed.us

Douglas J. Westlind
Pacific Northwest Research Station, dwestlind@fs.fed.us

Follow this and additional works at: http://digitalcommons.unl.edu/jfspresearch

Part of the Forest Biology Commons, Forest Management Commons, Natural Resources and Conservation Commons, Natural Resources Management and Policy Commons, Other Environmental Sciences Commons, Other Forestry and Forest Sciences Commons, Sustainability Commons, and the Wood Science and Pulp, Paper Technology Commons

Thies, W. G.; Kerns, Becky K.; and Westlind, Douglas J., "Effect of season and interval of prescribed burns in a ponderosa pine ecosystem on tree growth and understory vegetation." (2010). *JFSP Research Project Reports*. 122.
http://digitalcommons.unl.edu/jfspresearch/122

This Article is brought to you for free and open access by the U.S. Joint Fire Science Program at DigitalCommons@University of Nebraska - Lincoln. It has been accepted for inclusion in JFSP Research Project Reports by an authorized administrator of DigitalCommons@University of Nebraska - Lincoln.

Project Title: Effect of season and interval of prescribed burns in a ponderosa pine ecosystem on tree growth and understory vegetation.
Final Report: JFSP Project No. 06-2-1-10
Project Location: Burns, Harney County, Oregon (Malheur National Forest)

Principal Investigator:
Walter G. Thies, Pacific Northwest Research Station, Forestry Sciences Laboratory, 3200 SW Jefferson Way
Corvallis, OR 97331, Email: wthies@fs.fed.us

Co-Principal Investigators:
Becky K. Kerns, Pacific Northwest Research Station, Forestry Sciences Laboratory, 3200 SW Jefferson
Way, Corvallis, OR 97331, Phone: (541) 750-7497 Email: bkern@fs.fed.us

Douglas J. Westlind, Pacific Northwest Research Station, Forestry Sciences Laboratory, 3200 SW Jefferson
Way, Corvallis, OR 97331, Phone: (541) 750-7376 Email: dwestlind@fs.fed.us

This research was funded in part by the Joint Fire Sciences Program.

ABSTRACT
After decades of fire exclusion many stands now have historically unprecedented (high) levels of fuels and overstocking. As a result these stands have developed a variety of health issues. In response to these problems land managers are using prescribed fire to restore fuel loads and stand stocking to pre-fire exclusion levels. The impacts of season of prescribed burn as well as burn interval are not well understood. Managers need the ability to better predict these impacts on such things as tree mortality from fire, associated insect attack and disease development, tree growth, and plant communities. The "Season of Burn" study complex was established in 1997 in six stands of mixed-age ponderosa pine (*Pinus ponderosa* Dougl. ex Laws.) with scattered western junipers at the south end of the Blue Mountains near Burns, Oregon. Three treatments, a fall burn, spring burn, and unburned control, were randomly assigned to 12-ha experimental units within each stand. Within each experimental unit, six 0.2 ha-plots were established to evaluate responses to the burns. Prescribed burns occurred during mid-October of 1997 or mid-June of 1998. In summer 2002 the objectives of the original study were expanded to include an examination of the impact of interval of burn and cattle grazing on the trees and understory vegetation. Each of the burn units was split and units were randomly assigned to either a 5-year or 15-year burn interval. Within each of the controls and the 5 year interval treatment units 0.2 ha cattle exclosures were randomly located to study the effects of the interaction of cattle grazing and season of burn on the understory vegetation. The 5 year interval units were prescribed burned for a second time in fall 2002 and spring 2003.

The JFSP project reported here continued the expanded Season of Burn study. The five year interval of burn treatment units were successfully burned for the third time in fall 2007 and spring 2008 and previous protocols for monitoring were continued. Our results indicate that Ponderosa Pine growth rates are not negatively impacted and the incidence of insect attack or disease does not increase as a response to repeated prescribed burns. With each burn iteration further reducing the fuel load accumulated during the period of fire exclusion, repeated prescribed burns may be needed to significantly reduce fuel loads after prolonged fire exclusion. We found that removing cattle after prescribed fire reburns significantly enhanced the native plant community. Five years of grazing exclusion increased: (1) total vegetative cover, (1) native perennial forb cover, (3) shrub cover (4) grass stature and, (5) grass reproductive success. Remarkably, total cover increased by more than one-third. Neither spring nor fall reburning increased perennial native species cover or richness, and reburning reduced sedge cover. Fall reburning increased cover of native colonizers and exotic species cover and richness. We demonstrate that removing a novel disturbance process such as grazing significantly benefits the native plant community, but we document few benefits associated with adding the historic disturbance of fire, even in the absence of grazing.

BACKGROUND AND PURPOSE

Purpose: The purpose of this JFSP Project (06-2-1-10) was to examine the effects of two independent variables, season of burn and burn interval, of prescribed fires on ponderosa pine stands in the southern Blue Mountains. This project is being conducted on study sites established in 1997, and is the third prescribed burn of these units at five year intervals (fall/spring in 1997/98, 2002/03, and 2007/08).

Specific Project Objectives:
a) Develop and maintain the study areas to evaluate 5-year and 15-year intervals for spring and fall prescribed burning.
b) Compare impact on residual fuels of 5-year and 15-year intervals between burns.

c) Determine the influence of multiple burns, season of burn, and grazing on plant community composition, including exotic and invasive species.
d) Develop management guidelines that predict tree growth and mortality due to first (fire) and second (insects and diseases) order fire effects after prescribed burning.
e) Use tree growth and mortality information to improve existing fire effects models.
f) Determine the influence of season and 5-year interval of burn on growth of ponderosa pine.

Background: While some fire dependant ecosystems, such as the longleaf-pine ecosystems in the southeastern United States, have been extensively studied using prescribed fire with various season and interval of burn treatments, there are few such studies in western coniferous forests. Agee (1996) stressed that a critical need for all vegetation types in the Blue Mountains are studies regarding the effect of repeated burns; but, at what interval and what season? Heyerdahl and others (2001) established fire history in four mixed conifer watersheds in the Blue Mountains and found fire intervals as short as 5 years on the dryer sites. Our study area, further south and dryer than those examined by Heyerdahl, is thought to have a fire return interval of 3 to 29 years (Mark Loewen, silviculturist Emigrant Creek Ranger District, personal communication). In the southwest United States, fire intervals in ponderosa pine forests were 2- to 3-years in the highest fire frequency sites (Swetnam and Baisan 1996). Assessing a range of prescribed burn intervals in Arizona, Sackett and others (1996) reported that the most effective interval for fuels reduction was 4-years. Intervals of 1- to 2-year did not allow enough fuel accumulation while 6-year intervals accumulated fuel loads that cause fire intensities resulting in undesirable damage to the overstory. Attempting to determine and then duplicate the historical fire return interval may be less important in the short term than using short interval burns to reduce fuels and the risk of catastrophic wildfire. For this study we chose an initial burn interval of 5-years, as a starting point to learn about the interaction of interval and season of burn with the ponderosa pine ecosystem.

As prescribed landscape underburns are planned the season of burn needs to be considered. Prescribed fires are frequently conducted in the spring, but most historic fires in the Pacific Northwest burned in the summer or fall (Agee, 1996; Heyerdahl, and others 2001). Air quality, weather, fuel loadings, fire control, outdoor recreation and other factors often preclude summer burning options. Typical spring weather and fuel conditions generally allow fuel consumption and fire behavior to be more easily controlled, but spring prescribed fires may not be preferable from an ecological viewpoint (Agee, 1993). Harrington (1987) found that two to three times greater mortality of similarly scorched ponderosa pines resulted from growing-season burns than from fall burns. Spring burning is often a concern for the forest understory because plants are thought to be particularly susceptible to damage and mortality during growth initiation and prior to carbohydrate assimilation. Also supporting a fall burn is the finding that with heavy accumulations of duff, small diameter roots close to the soil surface can be damaged even with low intensity underburns during the active growing season causing growth reductions and mortality (Grier 1989). As fire is returned to fire-dependent ecosystems, more site-specific, local knowledge regarding the effects seasonality of burn in ponderosa pine ecosystems is badly needed (Scott et al. 1996).

Prescribed burns can cause various first-order fire effects on trees that may promote unintended consequences to forest resources. In southern Oregon, Swezy & Agee (1991) found that live, fine roots of ponderosa pine were concentrated in the forest floor and upper 10 cm of soil, and that these depths received lethal temperatures during prescribed burning. In mature ponderosa pines, cambium mortality after prescribed burning increased with duff depth and tree diameter (Ryan & Frandsen 1991). Given the thick duff layers that have built up after decades of fire suppression, particularly in ponderosa pine type where decomposition is relatively slow, death of trees when their cambium or fine roots are damaged by smoldering fires, is of great concern.

Numerous sources have observed that ponderosa pines with crowns scorched more than 50 percent usually become attractive to bark beetles. However, the relationships between beetle infestations and other measurements of fire severity, such as duff consumption, have not been substantially addressed. Primary attraction of bark beetles to volatiles released by stressed host trees has been documented for numerous scolytid species; therefore disturbance caused by burning and other management activities is likely to make stands more attractive to bole infesting beetles. In addition, trees scorched or wounded by fire are weakened and are less resistant to insect attack. There is a growing need to provide land managers with information that will help them to predict which trees, and under what conditions, will succumb to primary and secondary effects of fire. Virtually no hard data exists regarding the effect that season of burning has on the spread of diseases, such as black stain root disease (BSRD) via insect vectors in ponderosa pine stands. Some guidelines presently exist for bark beetle caused mortality (Scott and others 1996), but the database is small and has been collected almost exclusively following wildfires rather than from planned experiments.

Prescribed fire, including fire frequency, fire intensity, and season of burning, can strongly influence understory vegetation composition and dynamics and effects of seasonal burning on understory plant species composition and abundance in ponderosa pine communities are not well known. Although some studies have shown that understory production may initially increase in response to prescribed fire (e.g. Covington and others 1997), production usually then declines due to increasing litter layers and immobilization of nutrients in dead biomass. In terms of fire frequency, fire sensitive species tend to decrease with frequent fires while fire-adapted species increase in abundance with burning. Repeated prescribed burning in ponderosa pine forests in northern Arizona produced substantial changes in understory species composition including the dominance of exotic invasive species on severely burned sites (Sackett and others 1996).

Five years after the first prescribed fires associated with this study (1997/1998), areas burned in the fall had significantly more exotic/native annual/biennial species and greater cover of these species compared to spring and unburned areas (Kerns and others 2006). These patterns are likely related to indirect fire effects associated with fire severity and resource availability, rather than direct fire effects due to burn timing. No treatment differences were found for native perennial grasses, forbs and sedges. Therefore, expectations for increased native perennial plant diversity and abundance following prescribed fires may not necessarily be met and exotic species spread may compromise other ecosystem attributes.

For decades investigators have used grazing exclosures to evaluate grazing effects. Such studies have been important to rangeland conservation due to concerns regarding native plant diversity and exotic and invasive species spread (Stohlgren and others 1999). Comparisons of grazed and ungrazed areas can also yield valuable insight into the role of herbivory and competition in structuring plant communities. Because animals preferentially select particular species, grazing can have large impacts on species composition. Commonly, livestock grazing will reduce palatable perennial grasses and increase forbs, exotic and invasive species and inedible woody plants. Although the bunchgrass vegetation and rhizomatous sedges and grasses of the ponderosa pine forests of the Blue Mountains are well adapted to grazing, overgrazing by livestock has produced deleterious effects throughout the western interior forests (Johnson 1994). Many of the current ongoing and published prescribed fire studies exclude livestock and large ungulate grazing. Our study is unique in that the effect of grazing is being tested in a split plot design (JFSP project 03-3-3-28). Preliminary results from this study indicate that cattle exclusion significantly increased total plant cover, forb cover, sedge cover, and grass height and that the synergist effect of prescribed fire and cattle grazing may actually lead to reduced plant cover, especially for native perennials, and increases in exotic invasive weed species (Kerns and others 2005).

History of Current Study Area: At the request of local land managers we began to investigate the influence of stand treatments on black stain root disease (BSRD) and its potential insect vector(s). Beetle trapping demonstrated significantly greater numbers of potential vectors in burned or thinned pine stands than in undisturbed areas. That beetle flight generally occurs during and immediately after spring burning, added to the urgency for information with which to plan the timing of prescribed burns. In response, in 1997, we began a 3-year study to examine the effect of season of prescribed burning on BSRD and possible root feeding beetle vectors. The study area is located in ponderosa pine type in the south end of the Blue Mountains in southeastern Oregon (Emigrant Creek Ranger District, Malheur National Forest) (Thies and others 2005). Observations were expanded to include: primary fire effects, bole-infesting beetles, understory vegetation, soil nutrients, decomposition, and soil and litter arthropods. Support to establish the season of burn study and expansion to examine various elements of the ecosystem came from Region Six, Forest Health Protection.

In 2002 we overlaid an examination of burn interval on the season of burn study funded largely by JFSP (01B-3-3-16). Using a randomized complete block design three treatments (no burn, fall 1997 burn, and spring 1998 burn) were assigned randomly to three units in each of six replicates (stands). In 2002 the study was expanded to include burn interval using a split-plot design. Each original experimental unit was bisected and one randomly selected subunit of each pair was designated to be burned each 5 years following the first burn (fall 2002 or spring 2003), the other subunit was designated to be used to test a 15 year interval. We also established randomly located grazing exclosures in each treatment at four of the stands to examine understory response to the reburns with and without cattle grazing. Exclosures excluded cattle but were accessible to other grazers. That is, other grazers could walk under the fences or jump over them. Additionally, gates on the exclosures were opened after cattle had been removed in the fall and closed again before cattle were returned to the areas in the early summer. The exclosures have been maintained since June 2003.

In 2007 we conducted the third burn (original, first reburn, and second reburn) on the same units identified in 2002 (above) funded largely by the JFSP project (06-2-1-10) being reported here. Data was collected using the same protocols that were used with the 2002/2003 burns with the addition of more growth data from coring.

Strengths of this study complex include: burning units are operational in size, thus results are easily adapted to management needs; the study design includes replication and random assignment of treatments to experimental units including controls; because of the timing of the burns, at each examination all treatment plots will have developed without further disturbance for the same number of growing seasons; and a wide range of ecological consequences are being studied on the same experimental units and sample plots. To our knowledge, this is the only study examining seasonal and interval prescribed-fire effects and the interaction of livestock grazing in ponderosa pine forests. Further, success of the partnership established with local land managers to install the existing season of burn study, and the first and second 5-year interval of burn assured that the units would be burned on time and within prescription. The tree growth, fuels, and first-order-fire-effects data will be useful to help improve models being developed by others. Data from this study is available to share with other projects currently funded by the Joint Fire Science Program or to integrate into the Forest Vegetation Simulator and pest models or to improve the First Order Fire Effects Model with data from ponderosa pine.

To our knowledge, there are no other studies where the effects of season of burn and burn interval on biotic elements of the ponderosa pine ecosystem are examined simultaneously. Further, there has been little published on the ecological effects of underburning ponderosa pine stands in the Blue Mountains.

STUDY DESCRIPTION AND LOCATION

Study Site

The study was established in six stands of mixed-age ponderosa pine with scattered western junipers in the south end of the Blue Mountains near Burns, Oregon. The elevation of plots ranges from 1600 – 1700 m (5200 - 5600 ft). Stand age is generally 80 - 100 years with intermittent individuals of about 200 years. The average DBH ranges from 25 – 32 cm (10 - 13 in), and average tree height ranges from 12 – 16 m (40 to 54 feet). Plots average from 193 – 338 trees ha^{-1} (78 to 137 trees/ ac), and basal area averages range from 17.6 – 22.2 m^2 ha^{-1} (72 to 91 ft^2/ac). Each stand was thinned in 1994 or 1995, designated for underburning, and had some known root disease. Additional detail can be found in Thies and others 2005.

Sampling Design

The initial statistical design was a randomized complete block with each of the six stands as a replicate. In order to compare season of burn, interval of burn, grazing and their interactions we will use a randomized complete block with split-split plot design.

Methods

Treatment application. Original Treatment: Each stand was designated as a replicate and divided into three contiguous experimental units similar in type, aspect, and slope and approximately 12 - 24 ha (30 - 60 ac) each. Unit boundaries were established along topographic features with consideration for control of the underburning. Three treatments (no burn, fall burn, and spring burn) were assigned randomly to the three experimental units in each stand. Underburning was planned to reduce fuel loading and stocking of regeneration. Experimental units were burned during mid-October of 1997 or mid-June of 1998. All burns were carried out within the burn prescription.

First Reburn Treatment: Each of the original 18 experimental units (6 each of fall burn, spring burn and no burn) were bisected and one subunit of each pair was randomly selected for the 5-year interval burn and the other designated to be used for the 15-year interval burn. The season of burn for each subunit remained the same as it was in the established study, and will remain the same for all future interval burns. The subunits, which are 6 – 8 ha (15 - 20 acres), were burned in either the fall 2002 or the spring of 2003. All subunits received the same burn prescription.

Current reburn Treatment: Each of the original 12 experimental units that were burned in either the fall 2002 or the spring of 2003 were burned again in the fall 2007 or the spring of 2008 maintaining the same season for each treatment block. All burns had the same burn prescription.

Data collection plots. Within each of the original experimental units, six 0.2-ha (0.5-ac) circular data collection plots were established to evaluate responses to the burns. Plots were located at least 100 m (330 ft) apart, on areas that represented the average stand and burn conditions on the experimental unit. Plot centers were marked and mapped to facilitate relocation. At the time of the first 5-year-interval burn (2002/2003), each experimental unit was divided in half to result in three plots on each subunit. The same plots and trees will to be evaluated with each interval burn.

Tree data and first order fire effects: On each plot, standing conifers dead or alive (with the exception of junipers) greater than 7.5 cm (3.0 in) DBH were tagged. In fall 1998, the end of the first growing season after the prescribed burns, the following data were collected from tagged trees (n = 5436): species, condition (live/dead), needle complement, top kill (insect), top damage (other than fire), total height, height to live crown before fire, DBH, diameter stump height (DSH). The following were collected on each quadrant of the tree: maximum height of charring, degree of charring at the base, consumption of litter. Bark thickness was measured for every fifth tree on the control plots and on the burn plots any trees with bark that appeared fully scorched or consumed.

In 2002 preburn data were collected during the summer: total height, DBH, and for those that have died the cause of mortality. Radial growth on each tree was collected. Every fifth tree was sampled by selecting trees whose number ended in "0" or "5". Two increment cores per tree were taken at DBH on the uphill side and at 90^o in a clockwise direction to determine 10-year growth pre-burn and 5-year growth post-burn. In summer 2007 the same preburn data was collected with the exception that we sampled 10-year growth pre-burn and 10-year growth post burn.

Tree condition (live/dead) was assessed pre-burn (2007) and two seasons post reburn (fall of 2008 and 2009) and will be assessed again fall 2010. During the season immediately following the reburn (2008) all plot trees in the burn units were evaluated for crown scorch, bole scorch height, basal charring, and duff consumption. Beginning in 1999, annually, the newly dead trees have been evaluated for the presence of root disease by chopping into the base of the tree and examining roots.

Fuels inventory: Inventories of woody fuels by size class and litter and duff was accomplished by using the line intersect method (Brown 1974). Inventories were conducted on all plots in summer 2007 and on burn plots immediately following fires (2008).

Understory vegetation assessment: Plants were measured on all subunits prior to the reburn during July-August 2007, and in the same season in 2008 and 2009 (post-burn). Protocols will follow previous sampling methods (Kerns and others 2006) so that temporal trends can be analyzed. Each plot will be sampled by establishing four sample points, each 5 meters from the plot center along cardinal directions. At each sample point data will be collected from one 2x1 meter micro-plot. On each micro-plot, plant cover will be visually estimated by species to the nearest percent. Shrubs cover will be visually estimated on a larger nested plot (radius 10 meters). Measurements will include: overstory canopy cover, sapling density (trees < 7.5 cm dbh), and litter depth (O horizon). Cover will also be estimated for other ground types such as moss and lichen, cryptogrammic soil, bare soil, rock, woody debris, etc.

KEY FINDINGS

Tree Mortality: A mortality model (Malheur model) was developed (Thies and others 2006) from data collected from the trees (n=3415) on the subunits that were burned. The Malheur model was presented as an easily used graph (mortality probability calculator, see Fig. 1) by Thies and others 2008. The graph is an expedient tool that allows the user to quickly determine post fire mortality probability for ponderosa pine in the field. When tested against 3,237 fire damaged ponderosa pine from 10 additional stands in the Blue Mountains the model was found to correctly classify (live/dead)

92.4% of the trees. This validation step is important to establish both the accuracy and the geographical area within which the model can effectively be used. The results of this initial validation study have been reported (Thies and others 2008).

In fall 2009, final data was collected on an additional 15 validation stands, 8 prescribed burns and 7 wildfires. Within the total 24 validation stands 10,109 ponderosa pine were evaluated. The data support the following conclusions: (1) There is good agreement between the mortality predicted by the Malheur model and the mortality observed three years postburn in the 25 validation stands. The predicted probability of mortality was determined for each tree and summed for all validation trees. The Malheur model predicted a total mortality of 2410 trees. Three growing seasons postburn the actual observed mortality was 2550 trees, a difference of 5.5 percent of the predicted mortality from the observed mortality. (2) The geographic area of inference for using the Malheur model has now been expanded to include all of eastern Washington and Oregon. (3) The Malheur model can be used to determine probability of fire-caused delayed mortality in individual ponderosa pine regardless of whether the fire is a prescribed fire or a wildfire. (4) The Malheur model can be used to determine the probability of fire-caused delayed mortality of big ponderosa pine. (5) The observed proportion of big ponderosa pine killed by fire was less than expected. While thicker bark would argue for more fire resistance it is argued that mounds of detritus against the base of big trees and over their surface roots would result in mortality than in smaller trees. We observed that of 4530 trees 25cm to 53 cm dbh that 734 or 12.7 percent were fire killed. While of 954 trees over 53cm dbh that 87 or 7.9 percent were fire killed. A paper describing the validation study will be submitted for publication in 2010. Distribution of the stands used for validation and those used for model development is shown on a map presented as figure 2.

Vegetation and Grazing: We found that removing cattle significantly enhanced the native plant community. Five years of grazing exclusion increased: (1) total vegetative cover, (1) native perennial forb cover, (3) shrub cover (4) grass stature and, (5) grass reproductive success. The increase in total cover of more than one-third that we document is dramatic.

Vegetation and Fire: Neither spring nor fall reburning increased perennial native species cover or richness, and reburning reduced sedge cover. Fall burning increased cover of native colonizers and exotic species cover and richness.

Vegetation and Fire/Grazing Synergistic Effects; We found no interaction between fire and grazing. That is, grazing exclusion was beneficial across all treatments, even in controls. Likewise, fire had few effects on native perennial plants even in the absence of grazing.

Growth: Analysis of ponderosa pine growth shows no negative impacts from either burn season or interval. A comparison of basal area increase from the 5 years following the initial burns with the basal area increase from the subsequent 5 years (years 5-10 post-burn) shows basal area growth in both the spring and fall burn treatments to be increasing. We interpret this to mean that after an initial stable period of growth that growth rates are increasing in response to the burn treatments. A paper addressing growth of the test trees following prescribed fires was submitted, is now in revision, and will be resubmitted in 2010.

Fuels reductions; Preliminary analysis of the fuels data collected indicate that after many years of fire exclusion multiple prescribed burn cycles will be necessary to significantly reduce fuel loads. We found that each iteration of the 5-year burn reduced the residual fuel load observed when the study started. We interpret this to mean that after many years of fire exclusion that many prescribed burns may be required to reduce the fuel load to acceptable levels to avoid a catastrophic stand replacement fire. A paper is being prepared for submission in 2010.

FUTURE WORK NEEDED

Stable funding is needed to assure that the burns are completed on schedule to maintain this unique interval (5-year and 15-year) of burn /season of burn study platform. Of immediate concern is funding to complete the next set of burns which will include reburns of the study areas being used to test both the 5-year and 15 year intervals of burn during fall 2012 and spring 2013. Additionally, to take maximum advantage of the study platform, ecosystem responses should be monitored. At a minimum the collection of tree response data should be maintained and tree mortality should be recorded for the three years following the burn. Collection of the vegetation response to the season and interval of burn is unique and should be continued with possible expansion to measure other elements that are being impacted such as the lichens or soil chemistry.

Project Objectives and Status of Completion: Objectives from the original proposal are in bold italic. To summarize; all major objectives have been met and publications *are* either already available or will be in the near future.

a) Develop and maintain the study areas to evaluate 5-year and longer intervals for spring and fall prescribed burning.

Fully successful. The second 5-yr interval burn (third burn in the series for these study areas) were conducted in fall 2007/spring 2008, each set was completed within one week, and designated sites were burned as intended and within prescription. All planned data collection (fuels, tree mortality, tree growth, and understory vegetation data) and plot maintenance activities were completed as proposed.

b) ***Determine impact on residual fuels of 5-year intervals between burns and compare it to longer intervals***.

Fully successful. Data documenting the impacts of season and interval of burn on residual fuels were successfully collected, analysis is ongoing and a paper documenting the results will be forthcoming.

c***) Determine the influence of multiple burns, season of burn, and grazing on plant community composition, including exotic and invasive species***.

Fully successful. Data documenting the impacts of the second interval burn (including pre-reburn data) on understory vegetation were successfully collected. In addition, soil data were collected and analyzed. One paper was published examining understory response to the first interval reburn (Kerns et al. 2006) and one paper is in review (Kerns et al. in review) examining response to the second interval of reburns and grazing exclusion

d***) Develop management guidelines that predict tree growth and mortality due to first (fire) and second (diseases) order fire effects after prescribed burning.***

Fully successful. Data was collected and analyzed on fire damaged pine mortality and a USDA Forest Service General Technical Report (Thies and others 2008) was published describing a method to predict mortality of fire damaged Ponderosa Pine. A publication describing the observed impact on fire on tree growth is expected.

e) ***Use tree growth and mortality information to improve existing fire effects models.***

Successful. Growth and mortality data from this project has been summarized and will be made available to any working on current fire effects models. Actual model development or improvement goes beyond the scope of this project.

f) Determine the influence of season and 5-year interval of burn on growth of ponderosa pine. Successful. Growth data was collected and analyzed from all study units. A paper is in progress addresses growth differences between burn season and interval.

Deliverables and their status:

Proposed	Delivered	Status
Impact of season and interval of burn on growth of ponderosa pine.	Submitted, now being revised.	In progress
Presentations.	(1) Two presentations were made to the leadership teams of the Malheur NF and the Burns Fire Center (2) Kerns et al. 2009. Forest understory response to prescribed burning and cattle grazing. (3) Kerns et al. 2009. Ponderosa pine forest understory response to post-fire cattle grazing.	In progress
Impact of severity and intensity of burn on understory vegetation dynamics.	Kerns et al. Reintroducing a historic disturbance in the presence of a novel disturbance: Implications for HRV-based restoration. Ecological Applications.	In review.
Field tour and workshop.	A tour of the study sites, discussion of results and demonstration of the field guide for predicting mortality has been scheduled.	Sept. 2010
Annual progress reports and final report.	Completed	Completed
Unanticipated journal articles.	(1) Thies et al. 2008. A field guide to predict delayed mortality of fire-damaged ponderosa pine: Application and validation of the Malheur Model.	(1) Completed

Outputs from Project 06-2-1-10 (as of 1/2010)

Publications

Thies, W.G., Westlind, D.J., Loewen, M. and Brenner, G. 2008. A field guide to predict delayed mortality of fire damaged Ponderosa Pine: Application and validation of the Malheur model. Gen. Tech. Rep. PNW-GTR-769.

Publications in process

Kerns, B.K., M. Buonopane, W.G. Thies and C. Niwa. Post-fire cattle grazing hinders restoration success for forest understories. Submitted to: Ecological Applications.

Abstract. For two decades, land managers have relied heavily on the historic range of variability (HRV) concept in implementing ecosystem management and ecological restoration. But the appropriateness of using HRV to guide management is increasingly being questioned. To understand when HRV-based approaches are appropriate for restoration, more detailed knowledge is needed regarding how historical disturbance processes interact with contemporary ecosystem conditions and novel disturbances. We explore this issue using a common management situation: reintroduction of historical repeat fire in the presence of cattle grazing in *Pinus ponderosa* forests. Our focus is on the restoration of native plant communities. We found that removing cattle after prescribed fire reburns significantly enhanced the native plant community. Five years of grazing exclusion increased: (1) total vegetative cover, (1) native perennial forb cover, (3) shrub cover (4) grass stature and, (5) grass reproductive success. Remarkably, total cover increased by more than one-third. Neither spring nor fall reburning increased perennial native species cover or richness, and reburning reduced sedge cover. Fall reburning increased cover of native colonizers and exotic species cover and richness. We demonstrate that removing a novel disturbance process significantly benefits the native plant community, but we document few benefits associated with adding a historic disturbance, even in the absence of the novel disturbance. Historic range of variability provides important insights into ecosystem dynamics under specific conditions but interpretation and application of HRV-based restoration has been overly simplistic, particularly in highly altered systems subject to multiple and novel disturbances. More nuanced and intensive HRV-based restoration approaches may provide near-term benefits, but prior to adoption of an HRV-based approach we suggest a critical examination of the wisdom of anchoring management to historic disturbance processes and explicit accounting for contemporary conditions and multiple disturbances. Ultimately the unique ecologic history of a place will determine whether or not using HRV-based management and reintroducing historic disturbance regimes will benefit native ecosystems.

Thies, W.G., Westlind, Douglas J. xxxx Season and interval of prescribed burn in ponderosa pine forests in eastern Oregon: impact on tree growth.

Thies, W.G., Westlind, D. J. xxxx Validation results in 24 stands in eastern Oregon and Washington of the Malheur model for predicting delayed mortality of fire damaged ponderosa pine.

Oral Presentations

Kerns, B.K., M. Buonopane, W.G. Thies and C. Niwa. 2009. Ponderosa pine forest understory response to post-fire cattle grazing. Oral Presentation. 4th International Fire Ecology & Management Congress: Fires as a Global Process. Nov 30 – Dec 4th, Savannah, GA.

Poster Presentations

Kerns, B.K., M. Buonopane, and Thies, W.G. 2009. Forest understory response to prescribed burning and cattle grazing. Poster Presentation. 94th Ecological Society of America Annual Meeting. Aug 2 – 7th, Albuquerque, NM.

Literature Cited

Agee, J.K. 1993. Fire ecology of Pacific northwest forests. (Island Press: Washington, DC) 493 pp.

Agee, J.K. 1996. Fire in the Blue Mountains: a history, ecology, and research agenda. Pages 119-145 *in* R. G. Jaindl, and T. M. Quigley, editors. Search for a Solution. American Forests. Washington D. C.

Brown, J.K. 1974. Handbook for inventorying downed woody material. USDA Forest Service, Intermountain Forest and Range Experiment Station, Gen. Tech. Rept. INT-16 24 pp.

Covington, W.W., Fulé, P.Z., Moore, M.M., Hart, S.C., Kolb, T.E., Mast, J.N., Sackett, S.S., and Wagner, M.R. 1997. Restoration of ecosystem health in southwestern ponderosa pine forests. Journal of Forestry, 95: 23-29.

Grier, C.C. 1989. Effects of prescribed springtime underburning on production and nutrient status of a young ponderosa pine stand. *In:* Multiresource management of ponderosa pine forests. Gen. Tech. Rept. RM-185. U.S. Dept. Agric., Forest Service. Rocky Mountain Research Station, Fort Collins, CO. p.71-76.

Harrington, M.G. 1987. Ponderosa pine mortality from spring, summer, and fall crown scorching. West. J. Appl. For. 2:14-16.

Heyerdahl, E.K., L.B. Brubaker, and Agee, J.K. 2001. Spatial controls of historical fire regimes: a multiscale example from the interior west, USA. Ecology 82:660-678.

Johnson, C. G. 1994. Forest health in the Blue Mountains: a plant ecologist's perspective on ecosystem processes and biological diversity. USDA Forest Service, PNW-GTR-339

Kerns, B.K. Thies, W.G., and Niwa, C. 2005. Prescribed burn and grazing in ponderosa pine forests: implications for the herbaceous understory. Proceedings of the Ecological Society of America Annual Meeting, Montréal, Canada.

Kerns, B.K., Thies,W.G., and Niwa, C. 2006. Season and severity of prescribed burn in ponderosa pine forests: implications for understory native and exotic plant species. Écoscience 13(1): 44-55.

Ryan, K.C. and Frandsen, W.H. 1991. Basal injury from smoldering fires in mature *Pinus ponderosa* Laws. Int. J. Wildland Fire 1: 107-118.

Sackett, S.S.,Haase, S.M., and Harrington, M.G. 1996. Lessons learned from fire use for restoring southwestern ponderosa pine ecosystems. Pages 53-60 in Covington, W. and P. K. Wagner (tech. cords.), Conference on adaptive ecosystem restoration and management: restoration of cordilleran conifer landscapes of North America, USDA Forest Service GTR RM-GTR-278, Rocky Mountain Forest and Range Experiment Station.

Scott, D.W., Szymoniak, J., and Rockwell V. 1996. Entomological concerns regarding burn characteristics and fire effects on tree species during prescribed landscape burns: burn severity guidelines and mitigation measures to minimize fire injuries. USDA Forest Service, Pac. NW Region, Blue Mts. Pest Mgt. Zone, Report No. BMZ-97-1

Stohlgren, T. J., Schell, L.D., and Heuvel, B.V. 1999. How grazing and soil quality affect native and exotic plant diversity in Rocky Mountain grasslands. Ecological Applications 9(1): 45-64.

Swetnam, T.W., and Baisan, C.H. 1996. Historical fire regime patterns in the southwestern United States since AD 1700. Pages 6-17 *in* J. S. Krammes, technical coordinator. Effects of Fire Management of Southwestern Natural Resources. USDA Forest Service General Technical Report GTR RM-286.

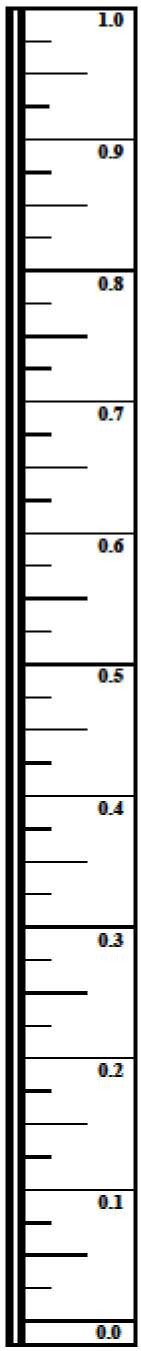
Swezy, D.M. and Agee, J.K. 1991. Prescribed-fire effects on fine-root and tree mortality in old-growth ponderosa pine. Can. J. For. Res. 21: 626-634.

Swetnam, T.W., and Baisan, C.H. 1996. Historical fire regime patterns in the southwestern United States since AD 1700. Pages 6-17 *in* J. S. Krammes, technical coordinator. Effects of Fire Management of Southwestern Natural Resources. USDA Forest Service General Technical Report GTR RM-286.

Thies, W.G., Westlind, DJ, and Loewen, M. 2005. Season of prescribed burn in ponderosa pine forests in eastern Oregon: Impact on pine mortality. International J. of Wildland Fire 14:223-231.

Thies, W.G., Westlind, D.J, Loewen, M., and Brenner, G. 2006. Prediction of delayed mortality of fire-damaged ponderosa pine following prescribed fires in eastern Oregon, USA. International J. of Wildland Fire 15:19-29.

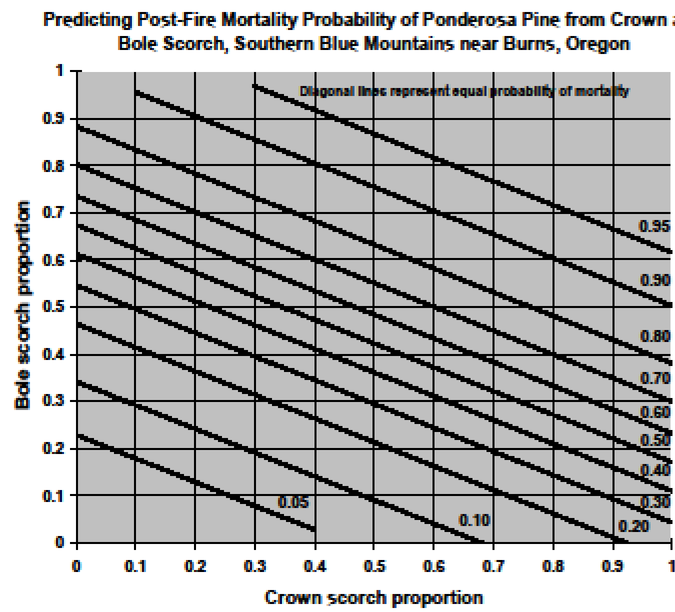
Figure 1. Field Guide for Determining Probability of Mortality – Ponderosa Pine Malheur model.



Proportion Gauge

Appendix 1 Malheur model - field guide.

Field Guide for determining probability of mortality – ponderosa pine.



To use this chart measure both the bole and crown scorch proportions from the ponderosa pine of interest. Find the corresponding bole scorch proportion on the left hand vertical axis then move horizontally to the right and locate the corresponding crown scorch proportion. Then interpret the probability of mortality from the diagonal lines of equal mortality probability. As an example assume a pine with 0.40 bole scorch proportion and 0.80 crown scorch proportion. The corresponding probability of mortality will be 0.70.

To estimate proportions:

1. Fold along double line and align the edge of the paper parallel to the bole of the subject tree.
2. **Bole scorch**: Orient yourself and the paper until the bottom and top of the subject tree align with the "0" and 1.0" lines respectively of the proportion gauge.
3. Note the number on the proportion gauge corresponding to the highest bole scorch. Read to the nearest 0.025, example 0.300, 0.325, 0.350 or 0.375).
4. **Crown scorch**: Orient the paper until the bottom and top of the subject crown align with the "0" and 1.0" lines respectively. Note the number on the proportion gauge corresponding to the highest level of crown scorch at the bole. Crown scorch is seldom a horizontal line and is judged at the bole to be the mean between where at least half the needles on a branch are scorched and a branch where all the needles are green.
5. Determine the probability of mortality from the chart above. Examples: Assume the management designated cut-off for probability of mortality is 0.6. Example 1: proportion of bole scorch is 0.3; proportion of crown scorch is 0.5. Enter the chart at 0.3 for bole and 0.5 for crown and note from the diagonal lines that the probability of mortality is slightly more than 0.3. If the designated cut-off is 0.6 the example tree would be scored as likely to live. Example 2: proportion of bole scorch is 0.6; proportion of crown scorch is 0.6. From the chart the probability of mortality is approximately 0.82. If the designated cut-off is 0.6 the tree would be scored as likely to die. The chart shows probability of mortality of individual trees given the proportion of bole and crown scorch.

Note: Individuals who are red/green color blind may have difficulty determining the height of crown scorch.
Version 03/10/07

Figure 2 . Location of stands used to collect validation data in eastern Washington and Oregon for the Malheur model.