Final Report
Task Order No. 1422RAH02-0016 (BLM)
Agreement No. 02-IA-11046000-034 (FS)

Project Title: Impacts of Prescribed Burning on the Survival of Douglas-fir and Ponderosa Pine in the Boise National Forest

Project Location: The Danskin/Gallagher project is located within the Payette River Basin in southwest Idaho. The project area encompasses 8,126 acres located approximately 12 miles east of Garden Valley on the Emmett Ranger District, Boise National Forest, Boise County, Idaho.

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This final report details findings to date and proposed and accomplished deliverables.

Objectives:
This study was generated by the need for information on the impact of prescribed burning on the primary and secondary mortality of ponderosa pine (*Pinus ponderosa* Dougl.) and Douglas-fir (*Pseudotsuga menziesii* var. *glauca* (Beissn.) Franco) in the Intermountain Region and addresses Task 2 of the Request for Proposals. This need is particularly amplified since prescribed burning is specified as a tool for the management of fuels in the National Fire Plan. The objectives of this study were to evaluate the the relationship between fuel load and primary and secondary impacts of prescribed fire on tree mortality in a fire dependent ecosystem in the Intermountain region.

Accomplishments:
To assess the impacts of prescribed fire, 800 randomly selected, single-tree plots were located in four treatment areas. To examine the influence of fire impacts on tree size, each treatment area contained ten trees each of ten two-inch size classes (7-25 in. dbh) of Douglas-fir and ponderosa pine. Treatment areas 1 & 2 were established in 2001. Prescribed fire treatments were applied in May 2002 when vegetation was dormant. Treatment areas 3 & 4 were established during the summer of 2002. Each year from 2003-2006 we prepared to apply treatments to areas 3 & 4 by updating the burn plan and clearing the access route of snow. However, we did not obtain a proper burn window within the prescription to apply treatments. (Please refer to the attached document titled "Summary of events related to the Danskin/Gallagher Fuels Reduction Prescribed Burn Project, Emmett Ranger District, Boise National Forest".

Among the four hundred trees that were treated in treatment areas 1 & 2, 94 Douglas-fir and 95 ponderosa pine showed evidence of fire injury and were used in the analysis. Only 19 of the nearly 200 trees showing fire injury were killed by fire. There was insufficient fire related tree mortality to evaluate the relationship between fuel and fire

caused tree death. However, we were able relate fuel loading to fire injury. This information is valuable to fuels managers and is presented in our final report.

Each individual tree-plot radius was correlated with the diameter at breast height, varying from 11.3 ft. to 17.6 ft. The fuel load by size-class was measured and counted within the drip-line of each plot tree. These were separated into duff, litter, 10-hr, 100-hr, and 1000-hr, fuels and converted to tons per acre. Habitat type, vegetation, insect activity, and tree attributes were also measured at each sample plot. Mortality was assessed each by visiting each plot-tree each year from 2001-2005.

Impact of Prescribed Burning on Fine Roots and mycorrhizae:
For a Master's degree thesis on the impact of prescribed fire on fine root and mycorrhizal mortality, a graduate student collected soil core samples from thirty plots within each of two treatment areas, 1 & 2, in 2001 (pre-burn) and in 2002 (post-burn) by taking samples at the drip line and midway to the bole of each plot tree. The distribution, density and biomass of fine roots and mycorrhizae were measured in each soil horizon. In 2002, thirty additional pre-burn samples were collected from each treatment area. Post burn samples were collected in 2003.

Fine root and ecto-mycorrhizal (mycorrhizal) densities were evaluated to assess distribution patterns and response to prescribed fire of ponderosa pine and Douglas-fir trees in a central Idaho forest. An impact driven soil coring device was used to extract a vertical soil profile, including litter, duff, and "shallow" (upper 10 cm), and "deep" (10 cm and below) mineral soil fractions before and after a mixed severity prescribed fire. Pre-fire fine root weights and mycorrhizal densities were generally highest in shallow mineral soil for both Douglas-fir and ponderosa pine (1.43 to 3.30 g/l and 47.95 to 123.53 root tips/l) and significantly lower in litter and duff horizons than in the other soil horizons. Fine roots and mycorrhizae were completely absent in about 80% of the litter and duff samples, whereas nearly 100% of shallow and deep mineral soil horizons contained these structures. Compared to levels prior to burning, fine root and mycorrhizal densities were lower by 45 to 78% and 68 to 94%, respectively, in shallow mineral soil (depending on fire severity and host species) at 12 months after burning in May 2002. Although no reductions were observed in the fine root biomass of shallow mineral soil in the control plots, mycorrhizal density decreased significantly (59-69%) in this horizon. The only significant post-fire change in deep mineral soil was an increase (2.21 to 2.96 g/l) in fine root biomass between the pre- and post-fire sample periods in the unburned Douglas-fir. Fine root and mycorrhizal densities in litter and duff horizons of burned sample points were not significantly reduced, probably due to the low proportion of samples containing fine roots or mycorrhizae. For Douglas-fir plots, pre-fire total organic depth (litter depth + duff depth) was significantly correlated with pre-fire fine root biomass in shallow mineral soil. A regression model was fit to predict fine root biomass associated with Douglas-fir using these variables. For ponderosa pine, the reduction in fine root weight (pre-fire weight – post-fire weight) in shallow mineral soil, was significantly correlated with both the reduction (cm) of duff and litter (fine root change), and the residual depth of duff and litter (cm) of burn plot samples. A regression model used these 'indicator' variables to predict the reduction in fine root biomass in

shallow mineral soil in ponderosa pine plots. No linear patterns were detected for either fine root weight or mycorrhizal densities based on diameter at breast height or distance from the tree bole. Fine root biomass was significantly different between species in the shallow mineral soil.

Results suggest that even low severity prescribed burning may significantly reduce the biomass of fine roots and density of mycorrhizae in shallow mineral soil for ponderosa pine and fine roots for Douglas-fir in the study area. Additional research is needed to evaluate annual patterns in fine root and mycorrhizal densities in the absence of fire, to assess levels and rates of recovery following fire, and to assess long term impacts. The models developed in this study should be tested across a variety of sites to determine their application in other forest conditions.

Relation Between Fuels and Fire Severity:

% Crown Scorch:
There was no difference in the relationship between fuel loading and crown scorch of Douglas-fir and ponderosa pine ($p=0.596$).

There was evidence that % crown scorch was dependent upon total woody fuels consumed ($p=0.0114$). After accounting for mean litter consumed, an increase of 1 ton/acre of total woody fuels consumed will result in a median % scorch increase of 1.304% (95% confidence interval of from 1.1% to 1.6%).

There was evidence that % crown scorch was dependent upon mean litter consumed ($p<0.000$). After accounting for mean duff consumed an increase of 1 ton/acre of mean litter consumed resulted in a median increase in % crown scorched of 2.5% (95% confidence interval of from 2.3% to 2.7%).

Maximum bark char height:
There was no evidence that the relation between fuel load and maximum bark char height was different between Douglas-fir and ponderosa pine ($p=0.1509$).

There was evidence that maximum bark char height was dependent upon mean litter consumed ($p<0.000$). After accounting for mean duff consumed an increase of 1 ton/acre of litter consumed will result in an increase in the median maximum bark char height of 1.1 feet (95% confidence interval of from 0.8 to 1.4 feet).

There was evidence that maximum bark char height was dependent upon mean duff consumed ($p<0.000$). After accounting for mean litter consumed an increase of 1 ton/acre of mean duff consumed will result in a median increase in the maximum char height of 0.14 feet (95% confidence interval of from 0.071 to 0.21 feet).

Sum Ground char:

There was suggestive evidence that the relation between fuel load and ground char was different between Douglas-fir and ponderosa pine (p=0.0515).

There was no evidence that ground char around Douglas-fir was dependent upon the total woody fuel consumed (p=0.3864), however there was evidence that ground char was dependent upon the mean litter consumed (p<0.000). After accounting for mean duff consumed a 1 ton/acre increase in mean litter consumed will result in an increase in the mean ground char sum of 6% (95% confidence interval of from 3% to 8%).

There was evidence that ground char surrounding Douglas-fir is dependent upon the mean duff consumed (p=0.0019). After accounting for mean litter consumed, a 1 ton/acre increase in the mean duff consumed will result in an increase in the ground char sum of 0.8% (95% confidence interval of from 0.5% to 1.2%).

There was evidence that the ground char sum for ponderosa pine is dependent upon the total woody fuel consumed (p=0.0017). After accounting for mean litter consumed and mean duff consumed an increase in the mean consumed woody fuel will result in an increase in ground char of 3% (95% confidence interval of from 1% to 5%).

There was evidence that ground char for ponderosa pine is dependent upon the mean litter consumed (p=0.0001). After accounting for mean woody fuel and mean duff consumed an increase of 1 ton/acre of mean litter consumed will result in an increase in the ground char sum of 3% (95% confidence interval of from 2% to 5%).

There was strong evidence that ground char for ponderosa pine is dependent upon the mean duff consumed (p<0.000). After accounting for the mean woody fuel and mean litter consumed a 1 ton/acre increase in the mean duff consumed will result in an increase in the ground char sum of 0.9% (95% confidence interval of from 0.5% to 1.4%).

***Bark char sum**:*
There was evidence that the relation between fuel load and bark char sum is different between Douglas-fir and ponderosa pine (p=0.0185).

There was no evidence that the Douglas-fir bark char is dependent upon total woody fuels consumed (p=0.2139).

There was evidence that the Douglas-fir bark char is dependent upon the mean litter consumed (p<0.000). After accounting for mean duff consumed a 1 ton/acre increase in the mean litter consumed will result in an increase in the bark char sum of 7% (95% confidence interval of from 5% to 11%).

There was evidence that the Douglas-fir bark char is dependent upon the mean duff consumed (p=0.0164). After accounting for mean litter consumed a 1 ton/acre increase in the mean duff consumed will result in an increase in the Doug Fir bark char sum of .7% (95% confidence interval of from 0.12% to 1%).

There was evidence that the ponderosa pine bark char sum is dependent upon the mean total woody fuel consumed ($p=0.0355$). After accounting for mean litter and mean duff consumed an increase in the mean total woody fuel consumed will result in an increase in the ponderosa pine bark char sum of 2% (95% confidence interval of from 0.1% to 4%).

There was evidence that the ponderosa pine bark char sum is dependent upon mean litter consumed ($p<0.000$). After accounting for mean woody fuel and mean duff consumed a 1 ton/acre increase in the mean litter consumed will result in an increase in the Ponderosa Pine bark char sum of 4.5% (95% confidence interval of from 3% to 6%).

There was evidence that the ponderosa pine bark char sum is dependent upon the mean duff consumed ($p=0.0003$). After accounting for mean total woody fuel and mean litter consumed a 1 ton/acre increase in the mean duff consumed will result in an increase in the Ponderosa Pine bark char sum of 0.86% (95% confidence interval of from 0.4% to 1.3%).

***Sum cambium condition**:* There was evidence that the cambium condition sum is predicted by the %girdling estimate ($p<0.000$) $R^2=0.966$. There is no evidence that the relationship is dependent upon species ($p=0.9327$).

Deliverables

Proposed	***Accomplished/Status***
Annual progress reports	Annual progress reports completed
Masters student thesis	Thesis completed
Poster	Impacts of Prescribed Burning on the Survival of Douglas-fir and Ponderosa Pine in the Boise National Forest R.A. Progar (Forest Health Protection), Tom Jackson (Emmett RD), Kathy Geier-Hayes (Boise National Forest), Tammy Cook (Emmett RD), R.T. Graham (Moscow Forestry Sciences Lab), Sharon Hood (Missoula Fire Lab), and Kevin Ryan (Missoula Fire Lab), USDA Forest Service
Presentation	Impacts of Prescribed Burning on the Survival of Douglas-fir and Ponderosa Pine in the Boise National Forest R.A. Progar (Pacific Northwest Research Station), Tom Jackson (Emmett RD), Kathy Geier-Hayes (Boise National Forest), Tammy Cook (Emmett RD), R.T. Graham (Moscow Forestry Sciences Lab), Sharon Hood (Missoula Fire Lab), and Kevin Ryan (Missoula Fire Lab), USDA Forest Service
Two journal papers: A thesis paper "Fire effects on fine roots and ectomycorrhizae of ponderosa pine and Douglas-fir following prescribed fire in a central Idaho forest. A paper describing the relationship between fuels and fire severity.	 In progress In progress