FHP TECHNOLOGY DEVELOPMENT PROJECT PROPOSAL
Use for projects not previously funded.

PROJECT STATUS: New, not previously funded.

PROJECT NUMBER: R6-2000-2

PROJECT TITLE: Predicting Insect-Caused Tree Mortality Following Prescribed Burning in Ponderosa Pine Communities of Eastern Oregon.

SUBJECT: Insect Technical Committee, insect/fire interaction, bark beetles

PROJECT OBJECTIVE(S):
1) Develop management guidelines which predict tree mortality due to insects after prescribed burning, based on stand and tree characteristics, fire season and severity, and resident insect levels.
2) Identify measures to minimize fire injuries that are most likely to lead to subsequent insect mortality.
3) Collect data which will lead to the development of a probability model of post-fire insect caused mortality that will be compatible with the Fire and Fuels Extension (FFE) of the Forest Vegetation Simulator (FVS) model.

BRIEF DESCRIPTION OF PROJECT: Twelve areas in east side ponderosa pine type, presently designated for underburning, will be selected for the project. Half of the areas will be scheduled for burning in fall 2000 and the other half in spring 2001. Stand and tree characteristics and resident insect levels will be measured pre-fire in summer 2000. In late summer 2001, after burning has been completed and peak beetle flight has occurred, plots will be assessed for fire severity and beetle attacks. Beetle damage will continue to be monitored in all plots until 4 years post-fire. Stand tables and logistic regression analysis will be used to determine the characteristics that best predict insect-caused tree mortality after prescribed burning. This information will provide the basis for burning guidelines and will be a used in the construction of a probability model to predict post-fire insect mortality.

FHP LEAD CONTACT: Don Scott, Zone Entomologist, Wallowa-Whitman NF

PRINCIPAL INVESTIGATOR: Christine Niwa, PNW Research Station, Corvallis, OR

COOPERATORS: Roger Ottmar, PNW Research Station; Nick Crookston, RMS; and Kevin Ryan, RMS will contribute their expertise on fuel loading and consumption, the FFE model, and fire effects, respectively.

JUSTIFICATION: While prescribed burning has become an accepted forest practice, little attention has been paid to the possibility that some pest problems could be worsened, and new insect problems could be created as a result of fire damage to trees. The potential for insect caused mortality is high due to the steady increase in the number

of acres undergoing prescribed burning and the preponderance of spring burns, occurring just before the peak flight of many beetle species and at a time when plants are physiologically active.

There is a growing need for FID to provide land managers with information that will help them to predict which trees, and under what conditions, will succumb to bark beetles as a secondary effect of fire. In addition to predicting tree mortality after fires, knowledge of the severity and season of fire damage that make a tree susceptible to beetle attack will help managers to write burning prescriptions that minimize damage by both fire and insects. Some guidelines presently exist (Weatherby et al. 1994, Flanagan 1996, Scott et al. 1996, Steele et al. 1996), but the data base is small and has been collected almost exclusively following wildfires. Previous work has not addressed season of burning or resident insect levels, and lack of pre-fire stand exams precludes the use of the existing data sets with the FVS model. This work compliments and can potentially add a temporal component a current project funded by the Joint Fire Science Program to integrate the FVS and pest models (N. Crookston, pers com).

URGENCY: As decisions are made to implement ecosystem management, it becomes increasingly important to know that proposed activities will move forested communities toward the desired future condition. Management activities, such as prescribed burning, must be planned with full knowledge of the influence that such an activity will have on the development and spread of insect infestations. At both National and Regional levels of fire management there is currently an emphasis on the reduction of hazard fuels, with the highest priority on ponderosa pine type because it is the most out of balance with historic fire regimes and is the most at risk for wildfires. In R-6 alone, prescribed burning of natural fuels increased to almost 100,000 acres in 1999, about 85% of which is in ponderosa pine communities. Even if burning is conducted within prescription boundaries, subsequent tree mortality caused by insects attacking fire injured hosts may well cause impacts that were neither foreseen or desired, including mortality of larger diameter trees and the spread of beetle infestations to neighboring green stands.

LINK TO NATIONAL FHP TECHNOLOGY DEVELOPMENT PRIORITIES: The project addresses two of the national steering priorities:
2. Develop guidelines for the integration of silvicultural procedures, prescribed burning, and other tools and techniques to reduce the adverse impacts of insects and diseases.
3. Develop techniques to quantify the impact (forest structure and function) of insects and diseases as disturbance agents in forest ecosystems including their interaction with other disturbance agents such as fire, wind, and exotic vegetation.
This project directly addresses priority 2 in the development of management guidelines to reduce mortality by insects following prescribed burning. Priority 3 is addressed through development of a probability model to predict effects of post-fire insect-caused mortality.

SCOPE OF APPLICATION: Management guidelines developed as a result of this project will be immediately usable for interior ponderosa pine type (R-1, R-3, R-4, R-5 & R-6). The study will assess bole infesting beetles (bark beetles and wood borers). The tools developed in this project will be applied as long as prescribed burning is used as a

management practice in ponderosa pine type. In addition, this project is meant to act as a prototype for continued investigations into fire and insect interactions in other forest types such as mid- and high-elevation mixed-conifer stands, where the Douglas-fir beetle and other bark beetles have been found to cause substantial mortality after fire.

RESEARCH BASIS: Volatiles released by stressed host trees following burning 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. In many regions of the Northwest, wildfire has been followed by outbreaks of bark beetles (Mitchell & Martin 1980, Geiszler et al. 1984, Amman & Ryan 1991, McCullough et al. 1998). While rarely considered a serious pest, a program of systematic prescribed burns could stimulate a population of *Dendroctonus valens* to the point where they would kill trees outright or weaken trees for attack by other insects.

Numerous sources have observed that ponderosa pines with crowns scorched more than 50 percent usually become attractive to bark beetles (Salman 1933, Miller & Keen 1960, Mitchell 1990). However, the relationships between beetle infestations and other measurements of fire severity, such as duff consumption, have not been substantially addressed. 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, the attraction of beetles to trees with their cambium or fine roots damaged by smoldering fires is of great importance. The fact that the majority of prescribed burning occurs in the spring rather than in the late summer and fall when wildfires historically burned is also reason for concern. Spring burns occur when trees are actively growing, a time when fire injury would be most deleterious; and just before or during peak flight of many beetle species.

METHODS: A total of twelve prescribed burns will be selected on four Malheur NF Districts. Half of the areas will be underburned in fall 2000 and half will be burned in spring 2001. Beginning with 12 study sites helps to assure that we will have adequate replication incase some of the units are lost to circumstances beyond our control.

Before burning, a series of variable radius stand exam plots measuring all trees 3 inches dbh and over will be established. Within each burned area, 10 “FVS” plots and 20 “Bug” plots will be laid out in a grid and permanently marked. In FVS plots, species, tree history (live or dead) dbh, crown class, live crown ratio, height, and bark beetles will be recorded for all trees; age and 10 year radial growth will be taken for each growth sample tree per plot; and a 1/300 acre fixed radius plot will be used to count seedlings and saplings under 3 inches dbh. In Bug plots, only dbh and bark beetles will be recorded. This information will provide a data set to run the FVS model as well as determine the resident level of beetle infestation in each area. District fire personnel will quantify pre-burn fuels by size class (Ottmar et al. 1998), measure organic and litter layer depth, and

determine percent mineral soil exposure. At the time of burning, District fire personnel will record temperature, relative humidity, wind speed, wind direction, flame height, and possibly duff moisture content. Fire and fuel measurements will be collected in a manner that is compatible with the FFE model (Beukema et al. 1999). After all prescribed burning is completed and the peak beetle flight has occurred, FVS and Bug plots will be monitored for fire injury (% crown scorch, total scorch height on bole, 100% scorch height on bole, 50% scorch height on bole, and severity of bole scorch at the duff line) and beetle attacks. Assessment of insect damage will continue to be monitored until 4 years post-fire, until all beetle caused mortality is fully realized.

The primary question being asked is: which stand, tree, fire, and insect parameters best predict which trees within and outside of prescribed burns will be killed by beetles? Recent advances in statistical methods makes the analysis of this experimental design, which is a split-split-split plot (split on season of burn, plot within burn, and tree within plot) possible. Logistic regressions can be used to answer a multitude of specific questions such as: holding all other factors constant, what are the odds of beetle attack given a spring vs. a fall burn? Answers to these types of questions will be used by R-6 FID personnel (see Cooperators below) in the development of a probability .

With limited funding, two units on the Bear Valley RD were pre-burn surveyed this year and will be burned in fall of 1999 and spring of 2000. In addition, units suitable for this STDP that are scheduled to be burned in 2000/2001 were located on the Long Creek RD and Prairie City RD

MEASURE OF SUCCESS: The Region will judge the project as a success if usable decision tools are developed, accepted and used by land managers. As a result of managers implementing these guidelines, a reduction in tree mortality due to fire damage and subsequent insect infestation is expected.

COOPERATORS: Project coordination and management will be by Christine Niwa, PNW Research Station; contributions: salary (8 weeks per year for C. Niwa and for a term professional) and laboratory costs. Four Ranger Districts on the Malheur NF will contribute personnel to identify sites, take fuels and fire information, and conduct stand exams and post-fire evaluations. Tommy Gregg and Kathy Sheehan, R-6 FID, will develop a program to run stand tables for this data set and develop a probability model.

PRODUCTS:
1) The primary product will be burn management guidelines for insects in ponderosa pine stands that are ready for prescribed burning; this will be produced in 2005/6.
2) Refined data on insect caused tree mortality following prescribed burning in ponderosa pine systems; produced throughout the project and presented at workshops for entomology, fire and land management users.
3) A probability model of post-fire insect-caused tree mortality in ponderosa pine type; will be produced in 2006/7.

PUBLICATIONS:

1) A General Technical Report for forest resource managers will give guidelines for the use of prescribed burning in ponderosa pine habitats.
2) A peer-reviewed technical paper will be prepared describing the interaction of fire and insects given different stand and tree characteristics, burning season and severity, and resident insect populations.
3) A General Technical Report describing the probability model and it's relationship to the FFE and FVS models.

TECHNOLOGY TRANSFER: The target audience for the tools to be developed by this proposal are land managers in Federal, State and private forestry organizations working in ponderosa pine stands east of the Cascades. Papers directed both at managers and researchers will be published and talks will be presented to the Western Forest Insect Work Conference to transfer this technology to land managers and other FHP specialists. FID zone entomologists in eastern Oregon and Washington will be the primary means of ongoing technology transfer to silviculturists and fire managers on Districts.

PROJECT DURATION: FY 2000 - FY 2004; Completion expected in fiscal year 2006/7

LONG TERM BUDGET:

FY	**FHP Funds Requested**	**Other Sources**
00	$46,811	$40,771
01	$36,280	$41,380
02	$30,174	$41,895
03	$31,634	$42,126
04	$33,104	$45,870
Total	$178,003	$212,042

FY 2000 BUDGET REQUEST:

Item	**Requested FHP STDP Funding**	**Other Sources amount**	**Organization Name**
Admin items:			
Salary	$19,272		
.		$17,520	PNW Res Sta
		$ 7,140	4 Malheur RD's
Overhead	$ 4,240	$ 8,760	PNW Res Sta
		$ 1,823	4 Malheur RD's
Travel	$12,960	$ 2,160	PNW Res Sta
Procurements:			
Contracting	$ 0		
Equipment	$ 5,000		
Supplies	$ 2,000		
Vehicle	$ 3,339	$ 2,232	PNW Res Sta
		$ 1,136	4 Malheur RD's
TOTAL FY 2000 Budget			
	$46,811	$40,771	PNW & Malheur

BENEFIT AND COST:

STDP PRODUCTION FUNCTION

PROJECT NUMBER: R6-2000-2

PROJECT COST: $390,045

PROJECT OBJECTIVE:
The incidence of beetle attack will be assessed after spring and fall burning and at a range of fire severities. We expect that more insects will be attracted to areas burned in the spring because disturbed host trees will be emitting volatiles that are attractive to beetles which fly in the late spring and summer. Stand and tree characteristics, fire severity and level of resident beetle populations will also influence the attraction and suitability of host trees to beetles. Burning guidelines developed as a result of this project will indicate which of these factors are most important in minimizing the impact of insects following prescribed burning in east side ponderosa pine stands.

ASSUMPTIONS:
1. Management guides that lead to a reduction in tree mortality due to insects will have a positive influence on overwintering habitat for big game. However, due to the difficulty of quantifying these benefits, they will not be factored into this production function.

2. Fall burning would result in a greater reduction in fuels and therefore a reduced risk of wildfires compared to spring burning. However, this may be offset by increased smoke emissions in the fall. These factors are difficult to quantify and so will not be assessed in this analysis.

3. Without FHP input developed from the project, burning would occur at the wrong season and/or at a severity that leaves trees susceptible to beetle attack, resulting in about 20% additional beetle-caused mortality within burned areas. It is likely that in some instances beetle populations will build up and spread to green trees adjacent to burned areas, causing even greater losses, but this is difficult to quantify and so will not be assessed in this analysis.

4. With FHP input, prescribed burning would occur at the correct time and severity to reduce beetle activity, resulting in no increase in tree mortality over background levels, and only about 0.5% of the total area burned each year would be out of production due to insects.

5. Of lands managed for fiber production, assume a sustained average of 100,000 acres with natural fuels prescribed burned each year for the duration of the analysis period. Assume that 85% are predominantly ponderosa pine cover type. Assume that 60% of these acres are burned in the spring and that half of those acres (i.e. 30:70 spring:fall ratio) could be shifted to fall burning (due to smoke emission constraints). Also, assume

that of the 70% of the acres burned in fall, a quarter of the trees are damaged by fire and subsequently are killed by insects. This gives a total of 40,375 acres that are potentially impacted annually.

6. Underburning occurs at an average stand age of 80 years. Benefits will be discounted at 4% real growth rate beginning at the time of underburning. We assume only one underburn during the 130 year rotation, there would likely be additional burns before harvest and these would increase the benefits accordingly.

7. Additional cost of $10/acre for fall burning as extra personnel are needed to prevent escape of the fire under dry fuel conditions. This will be subtracted from the green stumpage price in the calculations.

8. Opportunity for success of the project is rated as at least 50%.

9. It will take five years to complete the project, and about two years to analyze results, prepare management guidelines and distribute them to the field. Benefits will be calculated based on the guidelines being used for 15 years (the time it would likely take managers to discover and implement new technology without this project), beginning in year seven (FY 2006) through year 21 (2020). Since the implementation of new management tools is neither immediate or complete, benefits will be calculated at 25%, 50% and 75% the first three years respectively, and at 95% the remaining 12 years.

BACKGROUND DATA:

1. Average yield/acre of east side pine type forests = 25 mbf

2. Average rotation age = 130 yrs

3. Green stumpage = $77/mbf

CALCULATIONS

EXPENDITURE & OUTPUT VALUES (EOV) WITHOUT PROJECT:

40,375 acres - (40,375 X 20% loss) = 32,300 acres productive

32,300 X (25 mbf X $77/mbf) = $62,177,500

$62,177,500 discounted 80 years = $2,697,529 annually

EXPENDITURE & OUTPUT VALUES (EOV) WITH PROJECT:

40,375 acres - (40,375 X 0.5% loss) = 40,173 acres productive

40,173 X (25 mbf X $67/mbf) = $67,289,775

$67,289,775 discounted 80 years = $2,919,322 annually

BENEFIT (CHANGE IN EOV) ATTRIBUTABLE TO PROJECT:

$2,919,322 - $2,697,529 = $221,793 annually

FY2006 discounted savings = $168,544 X 25% = $ 42,136
FY2007 discounted savings = $162,062 X 50% = $ 81,031
FY2008 discounted savings = $155,829 X 75% = $116,872
FY2009 discounted savings = $149,835 X 95% = $142,344
FY2010 discounted savings = $144,073 X 95% = $136,869
FY2011 discounted savings = $138,531 X 95% = $131,605
FY2012 discounted savings = $133,203 X 95% = $126,543
FY2013 discounted savings = $128,080 X 95% = $121,676
FY2014 discounted savings = $123,154 X 95% = $116,996
FY2015 discounted savings = $118,417 X 95% = $112,496
FY2016 discounted savings = $113,863 X 95% = $108,169
FY2017 discounted savings = $109,483 X 95% = $104,009
FY2018 discounted savings = $105,272 X 95% = $100,009
FY2019 discounted savings = $101,223 X 95% = $ 96,162
FY2020 discounted savings = $ 97,330 X 95% = $ 92,464

Total = $1,629,381

Discounted project costs FY 1999 = $87,582
FY 2000 = $74,674
FY 2001 = $66,632
FY 2002 = $65,573
FY 2003 = $67,508

Total = $361,969

BENEFIT/COST RATIO:
B/C = $1,629,381 / $361,969 = 4.5

BENEFIT ATTRIBUTABLE TO STDP:
4.5 X $178,003 = $801,014

PNV OF PROJECT:
$1,629,381 - $361,969 = $1,267,412

PNV OF STDP:
$801,014 - $178,003 = $623,011

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