TITLE: Effects of bark beetle outbreaks on landscape fuel loading and potential fire behavior in Southwestern pine forests **INT-F-07-01**

LOCATION: National Forests in Arizona (year 1), National Forests in other Southwestern states (year 2)

DURATION: Year 1 of 2 year project **FUNDING SOURCE:** Fire Plan EM

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PROJECT OBJECTIVES:

1. Quantify the contribution of bark beetle outbreaks to fuel loading in ponderosa and pinyon pine forests of the Southwest.
2. Model potential fire behavior in areas of high, moderate, low and no beetle-caused tree mortality.

BACKGROUND:

Landscape-level bark beetle outbreaks in ponderosa pine forests and pinyon-juniper woodlands occurred throughout the Southwest during 2001-2003 in response to severe drought and dense forests conditions (USDA Forest Service 2004), causing significant biological impacts (Shaw et al. 2005). Forest Health Monitoring (FHM) aerial detection surveys found more than 3 million acres of ponderosa and pinyon impacted by bark beetles during 2002 and 2003. Several bark beetles worked in concert to kill the ponderosa pine, *Ips* spp. western pine beetle, roundheaded pine beetle, while pinyon pine was killed primarily by pinyon ips and twig beetles. This widespread disturbance event has also had strong political importance throughout the Southwest.

Tree mortality caused by bark beetles and other factors can affect fire behavior attributes through increases in fuel loads and through changes in the stand structure. Previous studies in other geographic locations and with other bark beetle-host systems have demonstrated that bark beetle outbreaks can result in increases in predicted flame length and fire rate of spread due to increased fuel loading (Negrón and Popp 2003). Tree mortality can also create more open stands and allow higher wind speeds and quicker drying of fuel compared to closed canopy stands (Agee et al. 2000). These findings suggest that bark beetle outbreaks can cause significant increases in fuel loads, influence fire behavior, and perhaps increase the severity of the fires. These findings can have profound implications for managing dead trees resulting from extensive bark beetle outbreaks and restoration of damaged ecosystems.

A FHM-funded project (**INT-EM-03-01**) resulted in the establishment of over 1,100 monitoring plots across Arizona during 2003 and 2004, which were designed to quantify overstory impacts (reductions in trees/ac, basal area) and correlations with pre-existing ponderosa and pinyon stand conditions. Much of the initial tree mortality was associated with poor site quality, shallow soils, cinder hills, south facing aspects and lower elevation range of host types. Analyses indicate reductions in basal area as high as 48 % in pinyon pine and 23 % in ponderosa pine on some Forests, and that up to 40 % of pinyon that died within the last 3 years had already fallen to the ground based on re-measurement of plots in 2005.

This previously FHM-funded study will allow us to conduct a robust examination of how bark beetle outbreaks affect fuel loading and fire behavior. The established network of plots occur across a wide range stand characteristics and site conditions, and encompass an array of beetle-caused tree mortality levels. Using standardized methodology for measuring fuel loads and modeling fire behavior (Fulé et al. 2001), we will efficiently quantify the role these large disturbance events play in potentially catastrophic fires.

Methods:

Sampling protocols were previously developed for measuring pine bark beetle impacts to ponderosa and pinyon pine forests in a collaborative effort by USFS FHP, USFS RMRS, and NAU. GIS maps showing the distribution of ponderosa and pinyon pine, Forest boundaries and FS road systems for each National Forest were generated. These maps were then populated with sampling points for each forest type using a 3-mile grid laid over the forest. At each sampling point a 1/20th acre fixed radius plot (26.33 feet radius) was installed. Between 2003 and 2004 a total of 1,181 permanent plots were established on the Prescott, Kaibab, Coconino, Apache-Sitgreaves and Tonto National Forests. Mensurational information was recorded on all trees, including: tree species, diameter at breast height (ponderosa pine) or root collar (pinyon pine), crown class, tree condition and damaging agent. Site characteristics were recorded for each plot, including: aspect, slope, elevation, and soil type.

We propose to select plots with similar pre-existing stand and site conditions, but varying levels of beetle-caused tree mortality, from the total pool of plots (25 plots/mortality severity category/forest type; 200 plots total). For each tree, we will also measure total height and height to the lowest live branch. Surface fuels will be measured within the plots using Brown's (1974) planar intersect method. Transects will be placed in a randomly selected direction but with the center of the transect coinciding with plot centers. Along the first 6-12 feet of each transect in a plot, the numbers of 1- and 10-hour fuels (0- to 0.25-inch diameter and 0.25- to 1-inch diameter, respectively) and 100-hour fuels (1- to 3-inch diameter) will be tallied. All fuels > 3 inches in diameter will be classified as 1,000-hour fuels and their diameters will be recorded along the entire length of each transect. 1,000-hour fuels will be grouped by diameter, length, and decay

class (solid or rotten). At 5-foot intervals along each transect, we will measure litter depth, duff (fermentation + humus layers) depth, and down and dead woody fuel height.

We will model predicted fire behavior under moderate and extreme fire weather conditions using the NEXUS Fire Behavior and Hazard Assessment system (Scott and Reinhardt 1999) to estimate fire intensity, spread, flame length, wind speeds required for fires to transition from surface to crown fires, and the proportion of various fire types (such as surface or crown). NEXUS, which links separate models of surface and crown fire behavior to assess crown fire potential of a given stand, relies on Rothermel's (1991) equations to predict fire rate of spread and Byram's (1959) equation to predict fire line intensity. These are the most commonly used equations in the United States for estimating fire behavior attributes (Pastor et al. 2003). This approach has been used to assess the role of varying levels of dwarf mistletoe infestation on fuel loading in southwestern ponderosa pine stands (Hoffman et al. in press).

Based on this methodology, the proposed study will have wide inference across the range of pinyon-juniper woodlands and ponderosa pine forests and provide managers with a quantitative, objective assessment of the fire hazards associated with beetle-kill-affected forests.

Products:

Primary products will be a technical report and peer-reviewed manuscript. Transfer of information to land managers through local and regional meetings, and via web-based media products. In addition, we will describe potential for other studies using the same plots (e.g., snag longevity, non-native invasive plant colonization) and what products could be generated.

Schedule of Activities:

Year 1. Collect plot data on fuel loading on National Forests in northern Arizona. Run fire behavior models. Complete progress report and summarize findings in a poster at the FHM Working Group meeting.

Year 2. Validate results found in Year 1 by comparing plot data on fuel loading collected on additional National Forests in the Southwest. Complete final report, technical report, and peer-reviewed manuscript.

Citations available upon request

Costs: provided below

COSTS:	Item	Requested FHM EM Funding	Other-Source Funding	Source
YEAR 1 Administration	Salary	24,000*	20,000	FHP,NAU,RMRS
	Travel	6,000*	1,500	FHP R3
Procurements	Supplies	2,000		
Total, Year 1		**32,000**	**21,500**	
YEAR 2 Administration	Salary	25,000*	20,000	FHP,NAU,RMRS
	Travel	7,000*	1,500	R3 FHP
Procurements	Supplies	2,000		
Total, Year 2		**34,000**	**21,500**	

*Salary and Travel Costs for two GS-4/5 seasonal biological technicians for data collection, entry, and fire behavior modeling.
No Overhead, Contracting, or Equipment Costs.