

**TITLE:** Development of a monitoring program to better understand the ecological impacts of wildfire under warmer, dryer conditions on a major forest defoliator, pandora moth

**LOCATION:** Kaibab National Forest, Grand Canyon National Park

**DATE:** 09/14/2009

**DURATION:** Year 1 of 3-year project

**FUNDING SOURCE:** Fire Plan Evaluation Monitoring

**PROJECT LEADER AND SPONSOR:**

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**PROJECT OBJECTIVES:**

This work will develop technologies to better monitor, predict and quantitatively assess the risk of pandora moth, *Coloradia pandora* Blake, outbreaks under changing climate and land use patterns that have ultimately resulted in different patterns of fire intensity at a landscape scale. We will be better equipped to predict when and where moth epidemics occur and respond appropriately through the use of these technologies.

**JUSTIFICATION:**

Pandora moth outbreaks occur periodically throughout the western US causing significant damage to pine forests. Fire exclusion and current trends of drought and warmer climate have resulted in changes in fire characteristics and post-fire effects (including the influence on forest pest potential). There are currently no monitoring programs in place for predicting when and where pandora moth outbreaks will occur. This monitoring program will allow us to evaluate a forest defoliator within and adjacent to fires of different intensities and scale. We propose to use sex-pheromone baited traps to monitor and detect moth abundance, and use historic and current remotely sensed data to develop a model that will better predict and quantitatively assess the risk of pandora moth outbreaks and their association to wildfire. Our study area will cover ponderosa pine, *Pinus ponderosa* Dougl. ex Laws., forests in northern Arizona including the north rim of Grand Canyon National Park.

a. **Linkage** to FHM Detection Monitoring – Historic and current aerial detection survey (ADS) data, satellite imagery, fire data, climate and soil data, and common stand exam data will be assessed to better understand the last known pandora moth outbreak that occurred and better understand current conditions.

b. **Significance** in terms of the geographic scale – Pandora moth is widespread in pine forests from Arizona and Colorado to Oregon and California, and periodically exhibits large population outbreaks (Patterson 1929, Wygant 1941, Carolin and Knopf 1968, Schmid and Bennett 1988). Outbreaks occur at intervals of 20-30 years and typically last 6-8 years (Patterson 1929, Schmid and Bennett 1988, Speer et al. 2001). The last outbreak in northern Arizona occurred on the Kaibab National Forest and north rim of Grand Canyon National Park in the late 1970s through the mid 1980s (Schmid and Bennett 1988). Egg masses or larval colonies were recently detected on 5 to 30% of trees sampled per plot within the >10,000 ha previous outbreak area. This indicates the widespread distribution of low population levels and initiation of the building phase of a pandora moth outbreak. In one more generation, the outbreak will be too large to effectively manage and another opportunity will not present itself for many years. The

previous outbreak occurred during wet and cool conditions (Schmid and Bennett 1988). The scope and intensity of the current outbreak may be orders of magnitude greater under a warmer and dryer climate.

c. **Biological impact** and/or political importance of the issue – Drought conditions, increased annual temperatures, and dry, warm winters, have occurred in the Southwest since the mid 1990s and have resulted in increased fire intensity and severity. There has also been continued alteration of forest structure and intensification of dwarf mistletoe, *Arceuthobium* spp., caused by land use policy throughout northern Arizona. We expect increased severity and extent of this outbreak as a result of these conditions. Also, this outbreak would occur near the northern gateway to the Grand Canyon NP and possibly within the Park. Millions of visitors would witness this event over its 2-3 year period. Information from this project will be critical in educating both the public and resource managers related to pandora moth outbreak dynamics and host impacts.

d. **Scientific Basis/Feasibility** – Current methods for estimating pandora moth populations are based on ground sampling of egg masses and larval colonies (Schmid et al. 1983, Schmid and Bennett 1988). However, McElfresh et al. (2000) recently identified the sex pheromone for pandora moth and it may be used to efficiently detect and monitor moth populations. A time series of LANDSAT images will be used to investigate temporal and spatial patterns in pandora moth defoliation and historic fire events across the monitoring area. Changes in spectral reflectance of the canopy in near infrared and red wavelengths will be used map defoliation over space and time. This work will enable us to test the effectiveness of a sex-pheromone, and map and quantify the extent and severity of pandora moth outbreaks in relation to historic fire events in order to better understand and predict the impact of these events, including their magnitude under different climate scenarios.

e. **Priority Issues** addressed from Request for Proposals – Three of the five priority issues are encompassed in the proposal. This work will incorporate climate change, ecological impacts of fires, and fire-damaged ecosystems into a spatially explicit risk model for predicting and assessing pandora moth impacts to ponderosa pine stands over space and time.

## **DESCRIPTION:**

### **a. Background:**

The pandora moth has a 2-year life cycle with defoliation typically occurring biennially. However, asynchronous behavior has been reported (Gerson et al. 1999) with pupation sometimes lasting two years. The influence of wildfire (severity, intensity, and post-fire effects), climate, drought, soil, forest fragmentation, and resource availability on population asynchrony needs to be better understood. A one-year life cycle was successfully demonstrated under lab conditions and changes in climate and precipitation could result in a greater proportion of moths completing a one-year life cycle in the field. Defoliation events significantly affect tree growth and health (Cochran 1998, Miller and Wagner 1984, Speer and Holmes 2004), and can predispose trees to colonization by bark beetles and pathogens (Patterson 1929, Carolin and Knopf 1968). Defoliation over consecutive years may result in extensive mortality to previously healthy trees. Outbreaks of the pandora moth in and around developed recreation sites and heavily visited areas such as the Grand Canyon National Park can result in allergenic effects on visitors that ultimately result in economic impacts to businesses (Schmid and Bennett 1988).

### **b. Methods:**

Detection and monitoring of pandora moth populations will be accomplished using traps baited with a previously identified sex pheromone (McElfresh et al. 2000). Relationships between trap catches and subsequent damage will be quantified by comparing trap data with on-ground surveys of eggs, larvae and defoliation level at each sampling site (within and adjacent to areas of various fire intensity, scale, and severity). Procedures for ground surveys and defoliation estimates have been developed by Schmid and Bennett (1988). Traps will be strategically located across the Kaibab National Forest and Grand Canyon

National Park to maximize forest area sampled, to determine the extent of the moth distribution, and to cover a range of fire intensities and scales. Because pandora moth is known to be transported into new areas by vehicles (Schmid and Bennett 1988), primary transportation corridors through selected ponderosa pine forests in northern Arizona will also be targeted. Thus, sampling locations will cover a range of conditions and we will be able to determine the effectiveness of pheromone-baited monitoring traps across variable population densities. A time-series of LANDSAT images will be acquired through USGS using GloVis to capture pre-defoliation and defoliation conditions during the last and current defoliation events. Pre-outbreak LANDSAT data will be used to identify determining factors for pandora moth population levels and peak-outbreak imagery will be used for detecting actual defoliation. Spectral mixture analysis will be performed using spectrometer measurements of ponderosa pine needles and bark. The output products will be overlaid with climate, precipitation, soil, and fire data and further analyzed for trends and potential relationships.

**c. Products:**

A better understanding of fire characteristics and post-fire effects on a potentially major forest defoliator. An effective sex-pheromone for pandora moth in the Southwest; An accurate detection and monitoring system for estimating abundance to better predict moth outbreaks, and; A quantitative method to predict when moth outbreaks will occur and the potential influence of wildfire on a forest defoliator.

**d. Schedule of Activities:**

**Year 1**

1. Examine current/historic ADS, fire, and LANDSAT data, available ground plot data, and historic climate data to determine scope and extent of past and current defoliation events and their proximity and potential relationship to historic fire events.
2. Use sex pheromone trapping system to detect and estimate pandora moth abundance. Traps will be located in areas that encompass a wide range of pandora moth densities.
3. Survey egg and larval abundance and defoliation level to compare with pheromone trap catches.
4. Develop progress report and poster of findings.

**Year 2**

Repeat the same steps of year one.

**Year 3**

1. Incorporate 2012 ADS data, LANDSAT imagery, and climate data to the existing data set.
2. Compare defoliation with population estimates based on trap data and egg and larval abundance.
3. Analyze data and develop a model, develop final report and manuscript preparation, and transfer of developed technologies FHP personnel, forest managers, and other cooperators via publications, reports, and presentations. Provide final poster of findings.

<b>FY 2010</b>	<b>Item</b>	<b>Requested FHM EM Funding</b>	<b>Other-Source Funding</b>	<b>Source</b>
<b>Administration</b>	Salary	\$15,500	\$6,000	NAU
	Travel	\$5,000	\$1,000	NAU
<b>Procurements</b>	Equipment	\$2,500	\$1,500	NAU
	Supplies	\$1,000		
<b>Year Totals:</b>		\$24,000	\$8,500	

<sup>a</sup> A similar budget is expected in 2011 and 2012

<sup>b</sup> Most of the requested funds will be used to support 2 summer temporaries at GS-5 and their travel.

**LITERATURE CITED:** provide upon request