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

INT-EM-F-10-01

LOCATION: Kaibab National Forest, Grand Canyon National Park

DATE: 09/29/2011

DURATION: Year 2 of 3-year project **FUNDING SOURCE:** Fire Evaluation Monitoring

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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 – Seven of the eight priority issues are encompassed in the proposal. This work will incorporate climate change, drought (deviations from normal precipitation), tree mortality, poor crown conditions, soil conditions, and forest fragmentation into a spatially explicit risk model for pandora moth that will attempt to predict and quantitatively assess how ponderosa pine stands will respond to defoliation 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 1968).

b. Methods: See FY2010 and FY2011 proposal and progress report

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.

e. Progress/Accomplishments:

In 2010:

On-ground Surveys of Defoliation and Larval Densities - We installed 100m vegetation transects within the ponderosa pine type across the range of the last Pandora moth outbreak on the Kaibab National Forest. Screen emergence traps (N=100) were placed along randomly selected transects to collect emerging moths and relate densities to surrounding defoliation levels. No adult moths were collected in the emergence traps, representing low moth densities from previous year. We are currently in the process of conducting an egg mass and larvae sample across 93 plots. This sample will continue through the fall and will be followed.

Baited Traps - A total of ten pupae were collected from ground surveys and analyzed for a sex pheromone. Our collaborators were able to confirm the presence of two of the compounds previously seen in a pandora moth population in Oregon. Five pheromone treatments were then established over five plots using 25 traps. 4 of 5 moths captured with EZAld + EZAc.

Light Traps - Three light traps were used to monitor adult activity from July 17 – September 12. Adults were counted daily and sex ratios were determined. A total of 24,231 pandora moths were captured during this monitoring period with a maximum daily total of 2,370.

LANDSAT Imaging- some potential defoliation was detected

In 2011:

GPS coordinates were taken at each plot and were used to create maps in ARCGIS. Maps were made for the plot location, larvae density, and defoliation density. Larvae density and defoliation density were estimated for the range of ponderosa pine on the N. Kaibab National Forest using an inverse distance weighted function (IDW) utilizing the nearest 5 plots for comparison.

2011 Results:

On-ground Surveys of Defoliation – overall defoliation levels were low and no significant levels of defoliation were detectable with the naked eye. However, most defoliation using our survey methods was detected on the east side of the Kaibab national forest.

Baited Traps – no baited traps were placed in the field during summer of 2011 because no moths were expected to fly (emerge). However, see results from Light traps. Additionally, over 600 larvae were reared to pupation, and 100 pupae were sent to our collaborators for pheromone identification for the 2012 trapping season.

Light Traps – Although 2011 is a year where no adult moths should occur, we did collect moths at our light traps. Approximately 130 male and 20 female moths were captured.

FY 2012	Item	Requested FHM EM Funding	Other-Source Funding	Source
Administration	Salary [a]	$19,000	$5,500	NAU
	Travel	$2,000	$2,000	NAU
Procurements	Equipment	$0	$1,500	NAU
	Supplies	$800	$1,000	
Indirect costs		$2,180		
Year Totals:		$23,980	$10,000	

[a] Most of the requested funds will be used to support a graduate students last year and student technician.

LITERATURE CITED: provide upon request