TITLE: Impact of Southern Pine Beetle on Fuel Loading and Fire Danger in Wildfire-prone Landscapes.

LOCATION: Southern New Jersey

DATE: September 28, 2013

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

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PROJECT OBJECTIVES: Our research is quantifying changes in hazardous fuel loads driven by recent Southern Pine Beetle (SPB) outbreaks in wildfire-prone pine forests in the mid-Atlantic region, focusing on the NJ Pinelands. We are integrating remote sensing (LIDAR) and aerial survey data with field census plots to quantify alterations to overstory, understory and forest floor structure and composition along a 10-year chronosequence of stands impacted by SPB. Information on the immediate and longer-term effects of SPB on complex fuel beds is being integrated with models of fuel moisture dynamics to assess fire danger and wildfire risk in the NJ Pinelands. Our sampling framework and fuel moisture/fire risk models will be transportable to other insect-damaged forests throughout the mid-Atlantic region.

JUSTIFICATION:

a. Linkage to FHM/FIA Monitoring: FIA sampling will soon detect increased pine mortality due to a recent invasion of SPB in the mid-Atlantic region. Enhanced FHM/FIA plots can quantify changes to understory vegetation, and fine fuels and coarse woody debris on the forest floor, but are currently used only in selected areas. Sampling efforts conducted on a finer scale will provide information that would be immediately useful to wildland fire managers for estimating fire danger in impacted stands, and generate valuable data to drive long-term simulation models of complex fuel beds in wildfire-prone forests (e.g., LANDIS 2; Scheller et al. 2011).

b. Significance in terms of the geographic scale; As SPB migrates northward, they will impact pine-dominated stands throughout much of the mid-Atlantic region. Their effect on wildfire occurrence and intensity are especially important along the Atlantic coastal plain, where high human population densities, high-value property, and air quality concerns in the adjacent large urban areas are significant issues.

c. Biological impact and/or political importance of the issue; SPB has the potential to kill pine trees, alter complex fuel beds, and increase fire danger in NE US forests. In contrast to the effects of Mountain Pine Beetle in western forests, needle abscission occurs quickly following mortality in pitch pine (*Pinus rigida* Mill.) and other pine species, thus the “red needle” phase is relatively short. However, increased fuel loading on the forest floor and subsequent regeneration will likely alter fuel beds rapidly. We currently have little information on this regeneration phase following extensive overstory mortality in naturally-regenerated pitch pine

stands, yet the structure and composition of this phase has significant implications for wildfire occurrence and intensity, especially where it resembles early successional forests of the early 1900's, which were characterized by extremely large, destructive wildfires (e.g., Clark et al. 2013a).

d. Scientific Basis/Feasibility: Our research team has extensive experience with fuel loading and fire danger issues in pine-dominated forests, collecting and processing remotely sensed (LIDAR) data, sampling FIA and FHM type field plots, and quantifying the effects of fire and insects on canopy, understory, and forest floor structure (e.g., Skowronski et al. 2011, Clark et al. 2009, 2010a,b, 2012, 2013a,b, Ayers et al. 2011). We are devoting much of 2014-15 on quantifying SPB effects on forest structure and wildfire risk, because the New Jersey Pinelands is currently one of two large, highly active outbreaks in the eastern US.

e. Priority Issues addressed from Request for Proposals: We will directly address how insects impact hazardous fuel loading and fire risk in fire-adapted ecosystems. In addition, because insect migration and population dynamics are largely a function of climate change and warmer winter temperatures, we are indirectly monitoring the effects of climate on potential frequency and severity of wildfires, as mediated by invasive insects.

DESCRIPTION:

a. Background: Southern Pine Beetle (*Dendroctonus frontalis*; SPB) is the most destructive forest insect in the Southeastern US. SPB damage is most prevalent in high density stands (Ayers et al. 2011), such as those dominated by pitch pine that have originated from stump sprouts following wildfire damage throughout the NJ Pinelands. Impacts of SPB differ from wildfire damage, however, because it causes overstory tree mortality, not just damage to crowns or above-ground portions of stems, potentially dramatically altering fuel beds in these dense stands. We hypothesize that responses to pitch pine mortality will be similarly rapid, resulting in abundant fuels on the forest floor, and dense, shrub- and young pine-dominated stands that are prone to intense wildfire activity and crowning fires.

b. Methods: We are using remotely sensed LIDAR, areal census data collected by the NJ Department of Environmental Protection, and FIA and FHM protocols in field plots to quantify changes to complex fuel beds along a 10-year chronosequence of stands impacted by SPB. Aerial censuses conducted by the NJ DEP and scanning LIDAR data obtained from an ongoing JFSP project have been used to identify recently-infested areas along the chronosequence, and to quantify impacts of SPB to canopy cover at the landscape scale. Locations of older damaged stands are well documented, and numerous locations have been "ground-truthed" by the Dartmouth College research group over the last two summers (M. Ayers pers. comm.). We are sampling 50-60 pairs of plots along this chronosequence using FIA protocols, LIDAR data, and destructive sampling to quantify changes in overstory and understory biomass and composition, with an emphasis on quantifying regeneration in infested and adjacent non-infested areas in each stand. High-resolution GPS data is collected in each plot for future census work. Upward sensing LIDAR (Riegl LD90-3100VHS-FLP Laser Rangefinder, backpack-mounted) and light attenuation data (Accupar PAR light wand) collected in each FIA plot will be used to determine how SPB-driven mortality has altered canopy cover at finer scales (e.g., Clark et al. 2013a). Sub-plots (n=5 per plot, 1 m^2 in diameter) located close to the center FIA-type plot will be destructively sampled for forest floor and understory mass, and samples will be returned to Silas Little Experimental Forest, sorted into 1-, 10-, 100-hour fuels, and dried and weighed, following protocols in Clark et al. (2009, 2010b). We have previously used remotely sensed data, LIDAR and field plots to quantify changes to fuel beds following prescribed fires, wildfires, and Gypsy moth defoliation in pitch pine-dominated stands, and will contrast these results to those obtained

from the proposed project (Clark et al. 2009, 2010, 2013a, Skowronski et al. 2007, 2011, ongoing JFSP project 12-1-03-11).

Model development for simulating fuel moisture dynamics is ongoing by our group. We operate 15 over- and understory fire weather towers in the NJ Pine Barrens, and through a cooperative agreements with the NJ State Climatologist and NJ Forest Fire Service, have access to 50 to 70 weather towers located throughout NJ to drive fuel moisture and fire risk models (http://climate. rutgers.edu/njwxnet). M. Gallagher's Ph.D. research is focused on quantifying fuel moisture dynamics under intact and insect-disturbed canopies, using a combination of field, micrometeorological and simulation approaches. We will then determine how fuels and fuel moisture dynamics in SPB damaged stands differ from those in intact stands, focusing on an evaluation of NFDRS predictions and other fire danger indices (KBDI, BUI) currently used by the NJ Forest Fire Service to evaluate fire danger.

c. Products: Our research will provide a thorough evaluation of the effects of SBP on hazardous fuels in the NJ Pinelands, which has been ongoing through NFP and JFSP-funded efforts (Skowronski et al. 2007, 2011, Clark et al. 2009, 2010a, 2013a,b). These will include a time-series of changes in fuel loading with SPB infestation, and validated fire risk models that can be implemented at the landscape scale. We meet with NJFFS on a regular basis, and will provide them written progress reports, and prepare at least two peer-reviewed journal articles.

d. Schedule of Activities: Landscape-scale LIDAR acquisitions occurred in spring 2013 (ongoing JFSP project), and NJDEP aerial surveys occurred throughout the summer months 2013. Field census plots will continue to be sampled throughout the fall of 2013 and summer and fall of 2014, for a total of 50-60 paired plots along the chronosequence of time since SBP invasion. Model code for simulating fuel moisture modeling will be finalized in early 2014, and model validation campaigns during the spring in 2014 and 2015 will be used to generate additional data to "fine-tune" fuel moisture models. Selected paired plots will be resampled on a campaign basis in spring – fall 2015 to compare to standard fuel moisture predictions.

e. Progress/Accomplishments: We did not received FHM funding in mid-August 2013, but have made significant progress. We have; 1) acquired and processed LiDAR data over areas that have and will be impacted by SBP, 2) obtained outbreak locations from NJDEP and ground-truthed plot locations with personnel from Dartmouth University, including mapping forest type and forest structure in some plots, and 3) have made significant progress in the measurement and simulation of fuel moisture dynamics under intact and damaged pitch pine canopies. We completed harvesting and processing of biometric and LiDAR data for mature pitch pine (total of 181 live trees and 85 snags; Clark et al. 2013a), thus have developed a validated framework for predicting canopy fuel loading from both biometric measurements and upward and downward-sensing LIDAR data in the paired plots. We also estimated understory and forest floor fuel loads in a range of plots (n = 10 stands, 240 1 m^2 plots) treated with prescribed fire in spring 2013 to compare to SBP-damaged plots. In late FY 2013, we obtained enough equipment to instrument 5 additional understory meteorological towers, and will deploy these across a range of canopy densities to facilitate the development of fuel moisture models.

Ayres, M. P., S.J. Martinson and N.A. Friedenberg. 2011. Southern pine beetle ecology: populations within stands. Pages 75-89 in R.N. Coulson and K.D. Klepzig, eds. Southern Pine Beetle II. Gen. Tech. Rep. SRS-140. USDA Forest Service, Asheville, NC.

Clark, K. L., N. Skowronski, J. Hom, M. Duveneck, Y. Pan, S. Van Tuyl, J. Cole, M. Patterson, and S. Maurer. 2009. Decision support tools to improve the effectiveness of hazardous fuel reduction treatments. International Journal of Wildland Fire 18, 268-277.

Clark, K. L., N. Skowronski, M. Gallagher, W. Heilman and J. Hom. 2010a. Fuel consumption and particulate emissions during fires in the New Jersey Pinelands. Proceedings of the 3rd Fire Behavior and Fuels Conference, Spokane, Washington, USA (online).

Clark, K. L., N. Skowronski, and J. Hom. 2010b. Invasive Insects Impact Forest Carbon Dynamics. Global Change Biology 16: 88-101.

Clark, K. L., N. Skowronski, M. Gallagher, H. Renninger, and K. Schäfer. 2012. Effects of Invasive Insects and Fire on Forest Energy Exchange and Evapotranspiration in the New Jersey Pinelands. Agricultural and Forest Meteorology 166-167: 50-61.

Clark, K. L., N. Skowronski, M. Gallagher, N. Carlo, M. Farrell, and M. Maghirang. 2013a. Assessment of Canopy Fuel Loading Across a Heterogeneous Landscape Using LIDAR. Joint Fire Sciences Program, Project 10-1-02-14, Final Report, 47pp.

Clark, K. L., N. S. Skowronski, H. Renninger, and R. Scheller. 2013b. Potential Impacts of Climate Change on Fire Management in the mid-Atlantic Region. Fire-Climate Interactions, a Special Issue of Forest Ecology and Management , in press .

Scheller, R. M., S. Van Tuyl, K. Clark, J. Hom, and I. La Puma. 2011. Fire and Carbon Cycling in the New Jersey Pine Barrens as a Consequence of Actual and Potential Forest Management. Ecosystems, DOI: 10.1007/s10021-011-9462-6.

Skowronski, N., K. Clark, R. Nelson, J. Hom and M. Patterson. 2007. Remotely sensed measurements of forest structure and fuel loads in the Pinelands of New Jersey. Remote Sensing of Environment 108: 123-129.

Skowronski, N. S., K. L. Clark, M. Duveneck, and J. Hom. 2011. Three-dimensional Canopy Fuel Loading Predicted Using Upward and Downward Sensing LIDAR Systems. Remote Sensing of Environment 115: 703-714.

COSTS: Funds are requested to support 2 Pathways students for 0.5 FTE's (GS 05) to assist with summer and fall fieldwork and sample processing. Clark (GS 13) and Gallagher (GS 07) will devote 0.5 FTE during the summer and fall sampling periods, and be directly involved in all field sampling, data processing, and modeling activities. The LIDAR, light wand, GPS, hypsometer, measuring tapes, and towers and meteorological equipment (dataloggers and some sensors) are available from ongoing NFP research. Travel to field sites will be by GSA leased vehicle, covered by the ongoing NFP project. Funds are requested to travel to the PI's meeting each year. We are requesting $500 a year for field sampling equipment and additional safety/first aid gear. In-kind support from the State of New Jersey will include access to field sites, aerial census data, and other supplementary information.

	Item	Requested FHM EM Funding	Other-Source Funding	Source
YEAR: 2014				
Administration	Salary	41,760	60,000	NFP
	Overhead	1,044		
	Travel	500	3,000	NFP
Procurements	Contracting			
	Equipment		20,000	NFP/JFSP
	Supplies	500	500	NFP
Total		43,804	83,500	