

**TITLE: Interactions among gypsy moth, wildfire, forest health management, and climate change**

**LOCATION:** New Jersey and development of evaluation framework for other regions

**DURATION:** 2 years    **FUNDING SOURCE:** Base EM

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**PROJECT OBJECTIVES:** The proposed study will address the following three questions: 1) how do interactions between gypsy moth defoliation and wildfire management in the New Jersey Pine Barrens affect ecosystem health? 2) Will these interactions be enhanced under climate change scenarios? 3) Are there alternative management strategies that could mitigate these interactions as the climate changes?

**JUSTIFICATION:** Gypsy moth is a major defoliator throughout the northern hemisphere. It is estimated that gypsy moth in the US are currently infesting only 23% of the land area that they could potentially occupy (Morin et. al. 2005), and will very likely spread to all of the hardwood forest in the U.S and Canada in the near future. Gypsy moth first appeared in forests in New Jersey in 1966. Since then, three major defoliation events have occurred; 1972 (256,000 acres), 1981 (798,000 acres) and 1990 (431,000 acres). The 2006 Forest Health Highlights for New Jersey indicated a dramatic increase in defoliation over the previous few years, and early detection of defoliation in 2007 shows a near doubling of area defoliated since 2006. In the New Jersey Pine Barrens (NJPB), another frequent disturbance, fire, can affect thousands of acres each year ([http://www.state.nj.us/dep/parksandforests/fire/fire\\_history.htm](http://www.state.nj.us/dep/parksandforests/fire/fire_history.htm)). Individually, these disturbances can cause strong reductions in annual forest productivity and longer-term changes in species composition, but it is unclear how insect defoliation and fire events interact and what the effects of these interactions are. A likely interaction involves changes in species composition due to linkages between insect-related tree mortality and increasing fire risk, resulting in more fire-adapted species like pines. Furthermore, climate change is likely to directly affect insect population dynamics, forest productivity and species composition, and may interact with insect defoliation and fire in ways that are as yet unknown.

Management of insect defoliation and fire in the NJPB are typically considered separately. In the last decade, however, officials in the state of New Jersey have become increasingly interested in managing carbon as indicated by participation in the Regional Greenhouse Gas Initiative ([www.rggi.org](http://www.rggi.org)) and statements by the Department of Environmental Protection regarding managing for carbon sequestration on state lands. Given that insect defoliations and fire both can alter the carbon storage and fluxes of forests, it is apparent that a system of integrated management will be necessary for achieving carbon sequestration goals in the face of defoliation events, fire, and climate change.

The proposed project will assess and predict the interactive effects of insect defoliation events (principally gypsy moth), fire management, and climate change on forest productivity, species composition, and tree mortality in the New Jersey Pine Barrens. Using management scenarios based on current management and potential carbon management practices, we will determine how interactions among these disturbances

affect management goals. We anticipate that this project will help provide a predictive framework for working through landscape to regional management scenarios in areas with multiple, interacting management priorities that can be applied across the US, especially in areas where both insect and fire disturbances occur.

## DESCRIPTION:

**a. Background:** The upland forests of the NJPB are a mix of early successional pine species and late successional oak species. Oak species act as the primary food source for gypsy moth during defoliation events, though considerable understory and pine defoliation has been observed in 2007 because of the severity of the outbreak. Pine species act as the primary fire carrier due to their fuel type and structure. Our intensive monitoring research has shown that both defoliation and fire can have significant effects on productivity that can be compounded when these disturbances occur in succession. We have also observed that repeated defoliation and/or fire disturbance can cause changes in species composition. We hypothesize that changes in species composition due to defoliation, fire, and climate change will lead to increased carbon emissions from the NJPB. These effects will take place via a multi-step interaction whereby repeated gypsy moth defoliation can shift stand composition in the NJPB towards a pine-dominated forest type, which will likely result in an increase in fire-related carbon emissions. The effects of climate change on these disturbances could serve to exacerbate this problem by increasing the amount and severity of gypsy moth defoliation annually, and by increasing the probability of large wildfires.

Our current network of research sites and field plots, in conjunction with the regular suite of FIA/FHM field plots, provides an excellent empirical data source for the simulation modeling proposed for this project. We currently have three research sites in the NJPB focused on measuring ecosystem function and productivity as well as the effects of disturbances on function and productivity. At the core of each of these sites is an eddy covariance flux tower, which measures the productivity of the forest ecosystem at high temporal resolution. Each flux tower is surrounded by a sampling grid of 24 enhanced FIA/ FHM type plots that capture the spatial variability in forest productivity and carbon sequestration, and allow extrapolation of data from the flux tower to the larger landscape and the extensive FIA/FHM grid. **We have encountered a unique range of disturbance events at our flux sites including partial defoliation, complete defoliation, and fire.** Each disturbed site has at least one year of flux and plot data collected prior to disturbance to act as a control. Our flux sites are integrated with additional extensive field plots located in disturbed areas (defoliation and fire) across the NJPB, and with the existing suite of FIA/FHM field plots. We also have a large spatial database of insect defoliation, wildfire, and prescribed fire acquired from various state and federal sources (including the FHM Detection Monitoring program).

Plot level measurements, however, are insufficient for determining the long-term effects of disturbances on forest health across the entire landscape. Likewise, it is impossible to determine, from a plot monitoring network, the effects of disturbances on forest health under future management regimes. Indeed, the only effective way to examine the interactions between disturbance, forest health, and management is to use simulation modeling strongly grounded in field observations. In this project, we propose to use a forest landscape spatial simulation model, LANDIS-II, to simulate the interactions between gypsy moth defoliation and fire disturbance under current and expected future management and under current and future climatic conditions. The LANDIS-II model has been supported by FS Research and the model results validated for North Central and Eastern forests (Scheller et al. in review, Scheller and Mladenoff 2005, Scheller et al. 2005, Sturtevant et al. 2004) and is currently being used in the West (e.g. Sierra Nevada).

**b. Methods:** We will use a combination of field measurements, FHM detection monitoring data, and New Jersey Department of Environmental Protection (NJ DEP) data to parameterize and calibrate the LANDIS-II model. The model has been partially parameterized for New Jersey fire disturbances by Scheller et al. (in review). We will augment the model for insect disturbances and climate impacts using additional data from our ongoing field studies, and updated datasets from FHM and NJ DEP will be used to further constrain the model. We will anchor our modeling of forest productivity and carbon storage to field measurements by calibrating to overall carbon storage and individual components (e.g. wood, foliage, roots, soil organic matter, etc.) of both our research sites and the overall NJPB. Our modeled estimates of insect defoliation and fire will be anchored in FHM detection monitoring data, NJ DEP data, and information from scientific literature. Climate change scenarios will be simulated using data from the Hadley GEM1 model, and multiple emissions scenarios presented in the recent Fourth Assessment Report from the IPCC.

Our previous work in the NJPB (Scheller et al. in review) demonstrates that the LANDIS-II model can accurately simulate fire disturbances in the NJPB, and the work of Sturtevant et al. has shown the same for insect defoliations elsewhere. Once the model is calibrated and parameterized for New Jersey, we will simulate the effects of gypsy moth defoliation and fire on ecosystem health, defined in terms of 1) carbon storage, 2) forest productivity, 3) tree mortality, and 4) changes in species composition. A ‘control’ simulation will represent the current management regime as defined by the level of gypsy moth and fire suppression in the NJPB at the present time. In addition, a set of simulations will be used to represent potential future management scenarios including proposed changes in management of defoliation, fire, and management for carbon sequestration.

Simulation results will be analyzed to compare the trade offs between management scenarios using carbon sequestration, defoliation acres, acres burned by fire, and disturbance related tree mortality as indices of success. In addition, we will analyze changes in forest community composition in order to investigate tradeoffs between carbon management and ecosystem restoration.

**c. Products:**

- 1) Framework to identify multiple impacts to ecosystem health and their interactions that can be used across forest types and applied to other geographic regions
- 2) Publication of results in peer reviewed scientific journal
- 3) Presentation of results to regional FHM management, NJ Department of Environmental Protection, and NJ Forest Fire Fighting Service
- 4) Research updates and results will be published on the internet

**d. Schedule of Activities:**

Jan 2008 – June 2008 – Collection of additional field data, preparation of input data sets for LANDIS-II model; supplementary development work on LANDIS-II fire, insect defoliation, and nutrient cycling extensions; analysis of local, state, regional, and national policy to inform management scenarios

July 2008 – December 2008 – Initial LANDIS-II calibration and model runs; additional development work on model extensions

January 2009 – June 2009 – Final model runs; initial data analysis of model output and field data

July 2009 – December 2009 – Final analysis of model output and field data; project write up and submission to scientific journal; presentation of project to FHM and NJ state officials; publication of results on internet

**COSTS:**

	Item	Requested FHM EM Funding	Other Source Funding	Source
<b>Year 1</b>				
	<b>Salary : Van Tuyl, GS</b>			
<b>Administration</b>	<b>11</b>	19142	57428	FS NRS
	<b>Overhead</b>	6171		
<b>Procurements</b>	<b>Contracting: Scheller</b>	22000		
<b>Total (Year 1)</b>		47313	57428	
<b>Year 2</b>				
<b>Administration</b>	<b>Salary</b>	19716	59151	FS NRS
	<b>Overhead</b>	6258		
<b>Procurements</b>	<b>Contracting: Scheller</b>	22000		
<b>Total (Year 2)</b>		47974	59151	
<b>2 Year Total</b>		<b>\$95,287</b>	<b>\$118,302</b>	

**Budget Explanation:** Salary includes: 25% of salary for Van Tuyl (\$19142 annually, including 30% benefits and 3% COLA). Contracting is for 15% of salary for Scheller (\$20000 annually, including overhead) and travel (\$2000/yr) for Scheller to attend meetings with FS group (Hom, Van Tuyl, Clark). Overhead for NRS is 15% for total costs, including Van Tuyl salary and Scheller contract. The remainder of Van Tuyl salary will be paid by the US Forest Service Northern Research Station. Study will use data from federal and non-federal lands (Silas Little Experimental Forest, Ft. Dix Army Base, and NJ Pine Barrens) and modeling will be across federal, state, and private forests.

**References:**

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