Special Technology Development Program
New Project Proposal

PROJECT NUMBER: NA-2001-02

PROJECT TITLE: Development of landscape-level models of forest risk to selected exotic pests in the eastern US.

PROJECT STATUS: new

EXPECTED PROJECT DURATION: 2 years

EXPECTED COMPLETION DATE OF THE PROJECT: Oct. 1, 2002

SUBJECT: (mark all that apply using 1 for primary category and 2 for secondary categories): Biological Control___ Invasive Species_2_ Methyl Bromide Alternatives___ Models___ Monitoring___ Organism Biology___ Pesticides: Microbial ___ Pesticides: Synthetic___ PTIPS___ Population___ Risk and Hazard_1_ Remote Sensing___ Semiochemicals___ Silvicultural Technology___ Social Values___ Spray Technology___ Other_____

STATUS OF SUBJECT SPECIES: non-native

PROJECT OBJECTIVES:

1) Develop an interpolated map of historical tree mortality rates over the previous 15 years for the eastern US (regions 8 & 9) using FIA eastwide plot data
2) Develop statistical models for estimating the component of historical regional mortality (estimated under objective 1) that can be attributed to damage by the gypsy moth, beech bark disease, and hemlock woolly adelgid using historical survey data.
3) Use the statistical model from objective 2 along with models of range expansion to map future risk to these invasive species and integrate these estimates in the national pest risk mapping effort.

BRIEF DESCRIPTION OF PROJECT:

Mapped estimates of the risk of tree mortality caused by exotic pests are critically important to a variety of FHP efforts and represent an important component of the national pest risk-mapping program coordinated by FHP-WO. Current attempts to estimate regional mortality risk are limited by the lack of models for predicting mortality caused by specific pest species from spatially extensive data. In this project, we seek to remedy this situation by developing statistical models that predict probabilities of mortality from interpolated Forest Inventory and Analysis (FIA) plot data. These models will be estimated by relating historical survey data (e.g., historical defoliation) to historical mortality estimated from measurements of standing dead trees in historical FIA data. These models will be combined with models of range expansion to predict future mortality caused by the gypsy moth, beech bark disease, and hemlock woolly adelgid over the entire northeastern US (regions 8 & 9).

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JUSTIFICATION:

To date, there have been few attempts to estimate overstory mortality over large regions. Steinman (1999) used methods similar to those proposed here to estimate mortality rates by species for selected ecoregions in the southern Appalachian Mtns. Busing et al. (1996) attempted to estimate overstory mortality rates for the state of California from Forest Health Monitoring plots. However, there is no precedent for our objectives of estimating mortality rates over an area as large as the eastern US nor have there been any attempts to model mortality as a function of specific disturbance agents over such a large region.

The models and maps developed in this project would be of considerable use for planning of management activities by S&PF, state, and other agencies. Improved estimates of how much and where future impacts will occur would be useful for both for long-range planning of population management activities (e.g., suppression, slow-the-spread) and implementing silvicultural activities to minimize impacts. The worked describe here would also provide greatly improved estimates or risk that would enhance the national risk-mapping effort. We also believe that the methods developed here could be applied to other pest species across the US and ultimately used to enhance national risk mapping and other pest risk assessments.

URGENCY:

While the proposed work does not address a crisis situation, it would provide information critical to several core FHP activities such as the National Risk Mapping effort, the STS program, cooperative suppression, and the national invasive species strategic plan. Providing improved pest risk information to these programs in a timely manner is critical to their success.

NATIONAL FHP TECHNOLOGY DEVELOPMENT PRIORITY (check one):

Priority 1: __ Priority 2: __ Priority 3: __ Priority 4: _X_

TECHNICAL COMMITTEE DEVELOPMENT PRIORITY (check one):

Priority 1: __ Priority 2: __ Priority 3: _X_ Priority 4: __

Priority 5: __ Priority 6: __ Priority 7: __ Priority 8: __

SCOPE OF APPLICATION:

The immediate scope of the results will be the eastern area (regions 8 & 9). However, the methods developed here could easily be applied to all other regions as part of the national pest risk mapping program and other national pest risk analysis efforts.

RESEARCH BASIS:

Invasions by exotic insects and diseases are one of the most important threats to the stability and productivity of forest ecosystems around the world (Liebhold et al. 1995). The forests of the eastern US seem to be particularly vulnerable to these invasions; over the last century they have

suffered devastating effects from invasions by notorious forest pests such as chestnut blight, gypsy moth, and beech bark disease (Mattson 1997). There is growing recognition of a need to develop coordinated strategies for managing the impacts of invasive species. One of the most important first steps to development of effective management strategies is to evaluate the risk of future impacts from specific exotic organisms. The generic activity, "risk assessment" is considered an important component to management of exotics both before and after their arrival in new habitats (Liebhold et al. 1995).

Considerable work has been concentrated on understanding how various forest characteristics (e.g., species composition, soils, climate, etc) are related to forest susceptibility to a variety of forest pests including many exotic pests in the northeast (e.g., Valentine and Houston 1979, Herrick and Gansner 1986). However, traditionally these efforts were conducted in specific forest stands and these models could not be directly extrapolated to make regional predictions.

This problem is particularly important to the national forest insect and disease risk-mapping effort currently coordinated by the FHP national headquarters (Lewis 2000). This is an effort to develop GIS layers for each major forest pest species in the US depicting an expectation (0/1) of >25% mortality or growth loss over the next 15 years for each 1 x 1 km pixel. To date, this effort has incorporated a variety of approaches for making these predictions. Most predictions have been developed by applying very simple models to data on forest composition in each pixel. For some pests, this has involved making predictions from forest type group maps (Zhu and Evans 1992) but for other pests, Forest Inventory and Analysis (FIA) data (Hansen et al. 1992) have been used to map forest composition. The models that have been applied to these data were generally not empirically derived, but instead were extrapolated from studies conducted in individual stands. For some pests no model was used but predictions were based on personal experience of entomologists and pathologists.

We feel that we can greatly enhance the value of the national risk-mapping effort through the development of landscape-level models that are specifically designed for mapping risk from FIA data. Ultimately FIA data are the best data available for characterizing forest composition on a regional or national scale and they are currently used extensively for RPA (Powell et al. 1992) and other national planning activities. Unfortunately, to date, there has not been a coordinated effort to quantify tree mortality on a national level that is relevant to the risk mapping effort. We propose to build models for predicting mortality from inventory data and applying these models to provide improved risk layers for specific invasive forest pests in the northeast.

METHODS:

Objective 1: Develop a map of overstory mortality rates over the previous 15 years for the eastern US. The first step to accomplishing this goal will be the estimation of percent standing dead basal area by species at each eastwide FIA data plot (Hansen et al. 1992) from the most recent survey in each state. We will then apply these data to previously published and unpublished models of snag longevity (e.g., Morrison and Raphael 1993) by species to estimate 15-year mortality rates by species at each FIA point. These data will then be used as input to a geostatistical procedure, indicator block kriging (Isaacs and Srivistava 1989), to estimate the probability of >25% mortality over each 1 x 1 km pixel in the region. A previously published forest density map (Zhu and Evans 1992) will be used to mask out any pixels with <25% forest cover.

Objective 2: Quantify the component of regional mortality that can be attributed to damage by the gypsy moth, beech bark disease, and hemlock woolly adelgid. Historical aerial survey data for the gypsy moth and county-level ground survey data for beech bark disease and hemlock woolly adelgid will be accumulated for the entire northeastern US over the interval covered by the most recent FIA survey in each state (e.g., see http://fhpr8.srs.fs.fed.us/wv/gmdigest/maps/maps.htm).

For the gypsy moth, data will be used to develop linear regressions of percent mortality as a function of years of defoliation. For beech bark disease and hemlock woolly adelgid, regressions will be fit that predict mortality as a function of years of historical infestation. Separate models will be fit for different species groups (e.g., oaks). Regression procedures will incorporate variogram models of spatial dependence to obtain unbiased parameter estimates. The intercept terms of these models can be considered the component of mortality not explained by damage and will be dropped for making predictions of mortality caused by each agent.

Objective 3: Develop models for mapping future risk to these invasive species. First we will use existing estimates of range expansion rates for these three organisms to predict range expansion over the next 15 years (e.g., Liebhold et al. 1992). For the gypsy moth we will fit regression models that predict the 15-year defoliation frequency from percent preferred species in FIA data (Liebhold et al. 1997). This model, incorporating spread predictions, will be used as input to the model described under objective 2 to predict mortality by the gypsy moth. For beech bark disease and hemlock woolly adelgid, we will use models of spread to predict future infestation areas which will then be used in the models described under objective 2 to predict future mortality by these agents.

MEASURES OF SUCCESS:

Standard of Success: The success of his project can be directly measured as the mean error in predicting mortality. This error will be estimated using historical (previous 10 years) FIA data.

Expected Outcomes: We believe that the most important outcome of this project will be the development of a scientific basis for the national pest risk-mapping program. This should result in more accurate predictions of pest risk impact but also will provide scientific credibility for this effort, which ultimately should lead to increased support for all national forest health programs.

Implementation of Products/methods: The following products will be produced:

- 1 x 1 km maps of historical mortality over the last 10 years
- 1 x 1 km maps of spread and/or defoliation probability for gypsy moth, beech bark disease, and hemlock wooly adelgid
- 1 x 1 km maps of mortality predicted to be caused over the next 15 years by gypsy moth, beech bark disease, and hemlock wooly adelgid

These maps will be made available as GIF files and Arc export files via posting along with metadata on the Forest Service web server. We also plan to publish a Forest Service General Technical Report describing the procedures used to generate the map data and a journal article that focuses on the analytical portions of the study.

PRODUCTS AND DUE DATES:

Oct. 1, 2001 – historical mortality map complete
June 1, 2002 – spread /defoliation / mortality prediction maps complete
Oct. 1, 2002 – Station paper and journal article complete

PUBLICATIONS: As stated above, we expect to produce at least one station paper and one journal article along with posting data and descriptions on the Forest Service web server.

TECHNOLOGY TRANSFER Map data will be made available via the Forest Service web server. We also plan to work closely with personnel in the FHP risk mapping, STS, and other programs to tailor map products to their needs.

LONG-TERM BUDGET REQUEST:

	Item	Requested FHP STDP Funding	Other-Source Funding	Source
FIRST YEAR				
Administration	Salary/fringes	$18,000 [1]	$30,000 [5]	NE
	Overhead	$3,220 [2]		
	Travel	$500 [3]		
Procurements	Contracting	0		
	Equipment	0		
	Supplies	$1,500 [4]		
Year Totals		$23,220	$30,000	NE
SECOND YEAR				
Administration	Salary	$19,000	$35,000	NE
	Overhead	$3,220		
	Travel	0		
Procurements	Contracting	0		
	Equipment	0		
	Supplies	$1,000		
Year Totals		$23,220	$35,000	NE
PROJECT TOTALS		$46,440	$65,000	NE

[1] Salary is 40% GS-9 Statistical Assistant
[2] Overhead is 16.1% (NE rate for internal FS funds)
[3] Travel covers cost of Lister trips (2) to Morgantown
[4] Supplies include IBM equipment usage fees
[5] NE contribution represents salary/fringes of Liebhold (10%), Lister (5%), Gottschalk (5%), and Luzader (5%; GS-11 computer assistant)

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Production Function

Project Number: NA-2001-01

Project Cost: STDP: $46,440 Total: $111,440

Project Objectives: Develop map of historical tree mortality rates; develop statistical models for estimating regional mortality; predict future risk to invasive species.

Assumptions:

1) Benefits of this project will lead to better forest management planning resulting in healthier forests.

2) Predicting mortality rates may result in forest management activities that reduce the need for suppression projects.

3) Predicting mortality may result in better and more efficient forest pest monitoring activities.

It is expected that this project would result in a 10% savings in suppression and monitoring costs due to better planning over 5 years, after which time the assessment would have to be calculated.

Background data:

Suppression costs for gypsy moth average about 5 million dollars per year.

Forest pest monitoring costs for hemlock wooly adelgid and beech bark disease average about $100,000 per year.

Quantitative Analysis:

<u>EOV without project</u>: $5,000,000 suppression costs/year for 5years

$100,000 survey costs/year for 5 years

<u>EOV with project</u>: $4,500,000 suppression costs/year for 5years
$90,000 survey costs/year for 5 years

$500,000/year savings in suppression costs
$50,000/year savings in survey costs
$550,000/year x 5 years = $2,750,000 discounted to $2,546,445 using method 3 (see below)

<u>PNV</u>: $550,000 x $[(1+.04)^5 - 1]/.04(1+.04)^5$ = $2,546,445

Discount rate, 4%

Benefit Attributable to Project: $2,546,445

<u>Benefit cost ratio</u>: $2,546,445/$111,440 = 22.8

Benefit Attributable to STDP Funds = 22.8 x $46,440 = $1,061,171