

TITLE: Climate and Air Quality Indicators of Risk to Forest Health: An On-line GIS for Integrating Climate and FHM Information

LOCATION: Riverdale, MD and East Lansing, MI

DURATION: Year 3 of 3-year project **FUNDING SOURCE:** Base

PROJECT LEADER: **Allan N. D. Auclair**, Center for Plant Health Science and Technology, USDA-APHIS, Riverdale, MD, 301-734-8312, Allan.Auclair@aphis.usda.gov

FHP SPONSOR: **Manfred Mielke**, St. Paul, MN, 651-649-5267, mmielke@fs.fed.us

COOPERATORS: **Warren E. Heilman**, USDA Forest Service, North Central Research Station, East Lansing, MI, 517-355-7740, wheilman@fs.fed.us

PROJECT OBJECTIVES:

1. Develop spatially-referenced (GIS) and time-specific estimates of the risk of winter and early spring thaw-freeze episodes, winter and early spring root-freeze occurrence, extreme low temperature events, and growing season high surface ozone concentrations that can impact forest health in the north central and northeastern U.S.
2. Correlate spatial and temporal patterns of the climate and air quality events listed in Objective 1 with observed patterns of crown dieback and ozone bioindicators obtained from FHM Detection Monitoring Plots in the north central and northeastern U.S.
3. Incorporate information from objectives 1 and 2 above into North Central Research Station's web-based Atmospheric Disturbance Climatology System, an online user-friendly GIS for displaying patterns of atmospheric-related disturbances relevant to forest health in the north central and northeastern U.S.

JUSTIFICATION:

The most recent networks such as the USDA-FS Forest Health Monitoring (FHM) Program currently have no capability to anticipate or fully explain climate and air quality impacts. The system of field plots serves as a passive system that allows interpretation and response only after well-defined patterns emerge. In contrast, managers often need frequent, updated assessments of current and developing conditions on which to base management decisions and respond to public concerns. This study is a first step in attempting to integrate climate and air quality information with information derived from the FHM Detection Monitoring Plots to provide predictions of potential forest health conditions based on weather, climate and air quality forecasts.

DESCRIPTION:

a. Background:

Since the mid 1970s, forest losses in the Northeast U.S. have increased significantly. Damage by pests, for example, has increased 54%. Dieback attributable to varied causes is 2.6 times higher than pre-1975 levels. Total natural mortality since 1975 has reached levels that are 1.4 fold higher than historic norms. Although some of the increase is associated with the larger total tree volume, there is the strong perception that disruptive weather, air quality factors, and the outbreak of exotic

pest species have played a significant role. The response by the USDA Forest Service (USDA-FS) and State agencies has included a large and increasing commitment to forest health monitoring, and to research into better techniques of health management.

b. Methods:

This study will focus on the development of risk indices of four key climate and air quality variables relevant to tree injury (damage) and loss (reduced growth, mortality) in the north central and northeastern U.S. These variables include: (1) winter and early spring thaw-freeze occurrence and severity, (2) winter and early spring root-freeze occurrence and severity, (3) extreme low temperature occurrence, and (4) regional episodes of high surface ozone concentrations. Specific tasks to develop the indices include:

Task 1 Climate, Air Quality, Ecosystem, and Forest Health Database Development: Daily maximum and minimum surface air temperature data and snow depth data for calculating variables 1-3 above will be obtained from the National Climatic Data Center's (NCDC) Summary of the Day and First Order Summary of the Day datasets. Hourly surface ozone concentration data for calculating variable 4 above will be obtained from the Environmental Protection Agency's Aerometric Information Retrieval System (AIRS) for the period 1982-present for AIRS reporting stations in the north central and northeastern U.S. Ecosystem data, including forest age, forest type, soil texture, soil depth, drainage, and topographic information will be obtained from the USDA-FS electronic databases that form part of the FHM Program network. Crown dieback and ozone bioindicator data also obtained from the FHM Program network will serve as the key forest health indicators for correlation with the climate variables.

Task 2 Development of Climatic and Air Quality Indices: We will structure a set of climate and air quality indicators related to thaw-freeze stress, root-freeze stress, extreme cold, and elevated surface ozone concentrations, which are all factors that can lead to crown dieback or biomass loss in the FHM-North region. These indicators include the following extreme climatic and air quality conditions:

Thaw-freeze stress – Winter and early spring (December-March) occurrences of daily maximum air temperature ($10\text{ }^{\circ}\text{C}$ for at least 3 consecutive days, followed by daily minimum air temperatures ($-10\text{ }^{\circ}\text{C}$) for at least one day within the succeeding 7 days since the last day of thaw.

Root-freeze stress – The number of days in winter and early spring (December-March) in which the snow depth is (5 cm , and the daily minimum air temperature is ($-10\text{ }^{\circ}\text{C}$).

Extreme cold – The number of days per year with minimum air temperatures ($-30\text{ }^{\circ}\text{C}$).

Elevated surface ozone concentrations – Three-month cumulative hourly surface ozone concentrations (60 ppb) over the maximum three months of the year (June-August or July-September).

Combinations of the set of climate and air quality indicators of forest dieback or biomass loss will also be explored and then verified and calibrated against the FHM plot observations of dieback and ozone injury.

Task 3 GIS and Graphical Output: Using appropriate interpolation and graphical mapping software (e.g. ArcInfo, Transform) within the framework of the NCRS's Atmospheric Disturbance Climatology System, the initial and interim meteorological, air quality, ecosystem, and FHM parameter data from *Task 1* and the climate and air quality indicator data from *Task 2* will be mapped across the FHM-North region.

Task 4 Analysis and Calibration: A significant part of the proposed effort will consist of verifying and

calibrating the climate and air quality indicators by testing modeled indicator values against actual FHM Detection Monitoring Plot observations. For example, the extent and severity of crown dieback observed on FHM plots in the 1991-1994 period in New England can be compared to thaw-freeze and other dieback indicator levels.

c. Products:

The investigators will publish the methods and findings of the study in one or more peer-reviewed scientific journals and at appropriate scientific conferences and workshops. A web-based data archive and map display system for displaying temporal and spatial patterns of the climate, air quality, and forest health indicators and variables for the north central and northeastern U.S. will be developed and integrated into the NCRS's Atmospheric Disturbance Climatology System (<http://www.ncrs.fs.fed.us/4401/climatology/>). Finally, we propose a workshop that brings together key FHM managers and researchers, where the concepts, scientific basis, datasets, essential algorithms, and graphical output of the study will be presented and discussed.

d. Schedule of Activities:

In Year 3 of the project, we will continue specific work elements of *Tasks 3 and 4* begun in Year 2 of the study. This includes the further development of GIS and other graphical output of meteorological, ecosystem, and FHM parameter data from *Task 1* and the climate and air quality indicator data from *Task 2*; and the analysis and calibration of the climate and air quality indicators by testing modeled indicator values against actual FHM Detection Monitoring Plot observations. We would like to present the decision support system at the annual Forest Health Monitoring Program Workshop in FY 2005.

e. Progress/Accomplishments:

In Year 2 the following tasks were accomplished: (1) A database of fifteen different global climate indices was developed, and analyses of the database were initiated to identify temporal trends in the indices from 1950-2002; (2) A forest dieback database was developed that quantifies annual dieback in three different regions (East Coast, Appalachian, Midwest) for the period ~1923-1995; (3) GIS (ArcInfo) maps of regional climate stresses (thaw-freeze and extreme cold events) were developed; (4) Development of a new decision support system web site (integrated into the Atmospheric Disturbance Climatology System) for accessing the climate and forest health data, the climate and forest health GIS maps, and the experimental models for predicting regional climate stresses and forest dieback based on global climate indices was initiated. The compiled data, maps, experimental models, and background information that will make up the web-based decision support system will enable users of the system to examine historical and projected future trends in forest dieback in the north central and northeastern U.S. and links to global and regional climate trends. A poster was also presented at the 2003 Forest Health Monitoring Program workshop in Monterey, CA that highlighted results from the project.

COSTS: (Year 3 of 3-year project)

	Item	Requested FHM EM Funding	Other-Source Funding	Source

YEAR: 2004				
Administration	Salary (APHIS)	18,962		
	Salary-Student (USDA-FS)	5,440	10,000	NC Research Station
	Salary-PI (USDA-FS)			
	Overhead (APHIS)	4,038		
	Overhead (USDA-FS)	1,560		
	Travel (APHIS)	2,000		
	Travel (USDA-FS)	1,000	1,000	NC Research Station
Procurements	Contracting			
	Equipment			
	Supplies (Data/pubs.)		3,000	NC Research Station
TOTAL		33,000	14,000	