Environmental Monitoring and Assessment Program

(EMAP)

REPORT TO CONGRESS

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EMAP

REPORT TO CONGRESS

I. Introduction

This document reports on the specific objectives, activities, and major accomplishments of the Environmental Monitoring and Assessment Program (EMAP), as required by Congress in the EPA FY92 appropriations. This report includes: documentation on EMAP's progress in research and monitoring, accomplishments in inter-/intra-agency coordination, and the role of the Office of Water and the states in EMAP design and implementation. In addition, this report focuses on how EMAP will supplement, but not duplicate the work of states and other federal programs including mechanisms to avoid duplication and ensure cost-effective resource use, through the use of existing monitoring networks where possible.

Appendices to this report include a list of Federal agencies currently participating in EMAP, several examples of multiple-agency interaction in specific EMAP projects, a list of States participating in EMAP with a brief characterization of their current function, and a list of products, or "Deliverables" produced by EMAP for FY 1991 and planned for FY 1992.

II. Overview of EMAP Objectives

EMAP represents a new direction for the Environmental Protection Agency. It is a high priority Agency initiative, responding specifically to the EPA Science Advisory Board's 1988 recommendation to *monitor ecological status and trends.* EMAP is a research, monitoring, and assessment program to determine the condition of our Nation's ecological resources. EMAP provides data to help evaluate the success of current environmental policies and to identify emerging problems before they become widespread or irreversible. The principal goal of the program is to provide decision makers with sound data on which to base environmental risk management decisions.

EMAP reports on the status and trends in indicators of the condition of ecological resources on a regional and national basis. In addition, EMAP data provides the basis for the determination of associations between human-induced stresses and ecological condition. Using a probabilistic sampling design and ecological indicators, EMAP is assessing the condition of the Nation's ecological resources (defined within EMAP as: wetlands, surface waters, Great Lakes, agroecosystems, arid ecosystems, forests, and near coastal environments). The

program is presently in the pilot and demonstration phase. EMAP will provide comparable, high quality data and assessments on the status of our nation's ecological resources. EPA is working with its Regional Offices, States, and other Federal Agencies in implementing this program.

EMAP has been designed to determine the condition of our ecological resources and provide a "National Ecological Report Card." It has three main strategic objectives:

1. Provide periodic evaluations of the current status, extent, changes, and trends in indicators of the condition of the nation's ecological resources on a regional basis, with known statistical confidence.

2. Monitor indicators of pollutant exposure and habitat condition and seek associations between human-induced stresses and ecological condition.

3. Provide annual monitoring data, statistical summaries, and interpretive reports on ecological status and trends at the regional and national level to resource managers and the public.

EMAP is designed to help answer the following questions:

- What is the current status and geographic extent of ecological resources?

- What resources are degrading or improving, where, and at what rate?

- To what levels of stress/pollution are the resources exposed, and in what regions?

- What are the possible reasons for degrading or improving conditions?

- What resources are at current or future risk?

- Are affected resources responding to control and regulatory programs?

EMAP is progressing through stages of sampling design, resource mapping, indicator development, building inter-agency coordination, and embarking on field pilots and demonstration projects to test monitoring and analysis methodology. These activities are organized by the seven major resource groups, with implementation schedules determined for each group by available EPA resources, commitments with cooperating institutions, and the ability to integrate the results with other EMAP activities. Pilot and demonstration projects began in the summer of 1990, and demonstration projects were fully implemented in the summer of 1991 for specific regions for forests and near coastal ecosystems. As well as expanding its field research into additional resource categories and geographic areas, EMAP will increase emphasis on information management and the integration and assessment of monitoring data.

EMAP takes a *holistic perspective* of the environment to address basic questions about ecological conditions. This represents a major technical and administrative transformation (a "new way of doing business") in environmental protection by recognizing the importance of long-term monitoring to detect trends, observe chronic disorders, and examine subtle responses to both stress and mitigation. EMAP takes a *multiple resource approach* because species and ecological resources do not act in isolation, rather they interact with one another through complex associations.

The EMAP approach provides an integrated perspective, with seven broad resource categories — forests, wetlands, arid ecosystems, surface waters, agroecosystems, Great Lakes, and near coastal waters. The program also incorporates air and deposition monitoring and landscape characterization to derive integrated assessments of resource condition across all resource groups. In addition, on-going research plays an important role in the program in defining how to measure ecosystem conditions on these scales.

EMAP is also a *new way of doing business* for EPA because of our insistence that EMAP must be integrated with the efforts of other EPA Offices, Federal agencies, States and geographic initiatives such as the Chesapeake Bay, Great Lakes, or Gulf of Mexico. EPA exercises leadership in the overall Program for coordination and integration of the large-scale reporting and integrated assessments to be produced by EMAP. It is, however, critical that the program be as decentralized and dispersed as possible, including participation by agencies and institutions outside of EPA.

Finally, EMAP is dedicated to *making its monitoring data and methodologies available to the public* to the maximum extent feasible. This means that once methods and data have been properly qualified and validated, EMAP is expending considerable effort to ensure that all potential data users are fully informed of the content, significance and access methods to the data. For the case of data which has to be collected for EMAP, each EMAP ecosystem resource group is committed to producing properly qualified monitoring data sets within nine months of field collection.

III. Accomplishments

A. Research: Indicators, Integration and Assessment

EMAP conducts applied research in ecological sciences that feeds into the monitoring and assessment aspects of the program. Research plays a fundamental role in EMAP in defining how to measure and assess ecological condition. The research program utilizes the inhouse staff, scientists from other agencies, and the academic community to advance the state of science. EMAP's research program includes environmental statistics, ecological indicator development, landscape ecology, and ecological risk characterization. Although active research areas encompass a wide variety of topics, two specific areas are critical to the program's success: (1) indicators and (2) integration and assessment. Recent activities in these areas have been selected for this report as examples of research activities in EMAP.

Agroecosystems

Indicator research for soil and water quality are of high interest to the EMAP-Agroecosystem group. Specifically being evaluated are indices for interpreting nematode community patterns as an indicator of soil health are being evaluated. A survey was recently conducted in soils of soybean, alfalfa, and pasture fields across the coastal plains, piedmont, and mountain regions of North Carolina. The research included participation from academic institutions and laboratories on several aspects of the project:

- extracting nematodes from soil samples;
- enumerating total and active fungi, total and active bacteria, and nematodes in soil by trophic group;
- analyzing the soil for chemical and physical properties; and
- analyzing soil texture.

Results from the research effects will be applied to field monitoring activities in the FY92 North Carolina pilot.

Arid Ecosystems

EMAP-Arid Ecosystems recently completed a study (with the EMAP-Landscape Characterization group) of the effectiveness of remote sensing for change detection using multidate, multisensor, and multispectral data. The study concluded that changes in land cover can be detected using aerial photographs and multispectral scanners. A final draft report, "Change Detection of Landscapes Using Remote Sensing," was completed from the research. Additional research is being initiated to evaluate the applicability of remote sensing to determine the cause of change.

Forests

EMAP-Forests research produced a final draft of the Forest Health Monitoring Laboratory Methods Manual. The manual is a six-part document which provides step-by-step methods for soil preparation and analysis, foliar preparation and analysis, and root pathogen/mycorrhizae analysis. The methods were developed and refined during previous field studies and will be applied nation-wide in the continuing National Forest Health Monitoring activities.

Landscape Characterization

The EMAP-Landscape Characterization group completed research comparing environmental photographic interpretation methods. The Digital Video Plotter (DVP), a low-cost, desktop stereoplotter with potential for high-efficiency generation of digital aerial photographic interpretation data was evaluated against traditional methods. The research revealed that the DVP is more accurate and time efficient than the Zoom Transfer Scope and manual digitizing methods. A final report on the study was published, "EMAP-LC Land Use and Land Cover Mapping with a Desktop Analytical Stereoplotter."

Indicators

The Indicators Group has completed two important documents: "The Indicator Development Strategy for the Environmental Monitoring and Assessment Program" (EPA/600/3-91/023) and *Environmental Monitoring and Assessment Program: Ecological Indicators* (EPA/600/3-90/060). The Indicator development strategy includes:

- a vision of how a fully functional EMAP indicator development project would operate;
- a framework for determining indicator development needs;
- criteria and protocols for selecting, evaluating, and re-evaluating indicators;
- procedures for coordinating indicator-related activities among resource groups; and

- an organization, communication, and coordination plan.

Integration and Assessment

The Integration and Assessment Group is charged with ensuring that EMAP data collected from the field can be translated for use in answering policy-relevant and managerial questions on regional scales. During the first quarter of FY92, the EPA Science Advisory Board met to review the progress of EMAP integration and assessment activities.

Most recently, the Integration and Assessment Group has begun to study approaches that would lead to the development of an assessment framework to illustrate the relationships between assessment objectives, assessment end points, conceptual models, data analysis, and integration and interpretation of EMAP data. Initially, the approach for development of the framework encompasses several EMAP components (e.g., design, indicators, landscape characterization). In addition, the Integration and Assessment Group joined with several other EMAP groups to create a pilot of the EMAP Information Management System, which will document and facilitate the transfer of data obtained from the 1990 Near Coastal Demonstration Project and the 1990 Forest 20/20 Pilot Study. Integration and Assessment also began research to identify and develop appropriate assessment tools.

B. Monitoring

This section describes accomplishments in EMAP's field implementation. Currently, most of the resource groups are in the pilot and demonstration phases of development. EMAP has adopted a four-step process to prepare for full implementation (See the diagram below). Pilot and demonstration projects are used to field test EMAP's methods, design, and indicators. These projects not only serve as developmental steps to reach implementation, they also provide data that can be used to assess the condition of ecological resources in the area under study.

EMAP's field activities were initiated in FY90 with Near Coastal and Forest Demonstration Projects. The Near Coastal Demonstration project was conducted at 217 sampling stations in estuaries throughout the Virginian Province (Cape Cod to the mouth of the Chesapeake Bay). The New England Forest Health Monitoring Project was also initiated during the summer of 1990 at over 200 sites in the six New England states.

In FY91 EMAP continued these efforts and expanded field efforts to cover other areas of the country. In addition to the Near Coastal and Forest projects, sampling began in Wetlands and Surface Waters. In FY92, these efforts will continue and pilots will be conducted in Arid Ecosystems, Great Lakes, and Agroecosystems. This year all seven EMAP ecosystem groups will conduct field studies.

There are a number of specific mechanisms employed throughout the EMAP development process which help to avoid duplication of efforts between EMAP and other monitoring efforts. These include:

Written Memoranda of Understanding (see Appendix A) with cooperating groups;

Long Planning Cycles, which provide multiple opportunities to learn about other related groups and activities;

Focus on Methods, which are being studied and adopted by related programs;

National-Level Peer Reviews involving the best informed and most broadly experienced scientists in their fields;

Joint Recruitment and Staffing of projects with other agencies; and

High Profile and Aggressive Outreach activities.

EMAP Implementation Process

Research on Indicators → Pilot → Demonstration → Implementation

The Near Coastal resource group has been a priority program for the development of EMAP monitoring processes, in part because of the importance of coastal areas to the Agency's risk-based management initiatives, and in part because of the opportunity to integrate EMAP activities with established resource management and monitoring activities involving other agencies and geographic targeting in areas such as the Chesapeake Bay and the Gulf of Mexico. EMAP-NC is also a good example of the incorporation of other organizations in EMAP.

The EMAP–Near Coastal program is *jointly planned and directed* by EPA and the National Oceanic and Atmospheric Administration (NOAA), which has great experience and demonstrated leadership in coastal and estuarine studies. (See Appendix B). For FY 1991, the value of NOAA's contribution to the program is estimated to be nearly $1 million, and this will increase substantially for FY1992. EMAP–Near Coastal has an on-going process to identify and assess the feasibility of new organizational formats which include a "joint office" to be used to execute federal near coastal research, monitoring and assessment activities in the future.

The involvement of others in the planning and development of EMAP is costly. In the experience of senior EMAP managers, it takes a minimum of three or four detailed briefings simply to provide knowledgeable scientists with a clear vision of the scope and potential of EMAP monitoring. The EMAP–Near Coastal program has expended a great deal of effort to support the development of a users network for the Virginian Province, incorporating specialists from the State and local level, regional groups such as the Chesapeake Bay Program, EPA Regional Offices (i.e., Regions I, II, and III) and their divisional leaders (especially Water and Environmental Services Divisions), and EPA's headquarters Office of Water staff. Similar efforts are going on in the Gulf Coast areas involved in the Louisianian Province demonstration which began in 1991. And this process is not complete. It will be a continuous part of the EMAP agenda.

Described below and in the following pages are the monitoring

accomplishments made for each ecosystem during FY91 and plans for FY92. Included in the descriptions are the geographic locations of the field studies and EMAP's partners in conducting the monitoring activities. Descriptions of interagency and state participation are presented in Section C.

Agroecosystems

The EMAP Agroecosystem Research Plans were completed and peer reviewed in 1991 and plans for a pilot study in North Carolina began. Plans for a Joint Pilot Study in 1992 with the U.S. Department of Agriculture are currently being finalized. The objective of the study is to evaluate indicators of agroecosystem condition.

Participating Agencies:

- U.S. Department of Agriculture
  - Agricultural Research Service
  - National Agricultural Statistics Service
  - Soil Conservation Service
- U.S. Department of Energy
  - Idaho National Engineering Lab
- North Carolina Department of Environmental Health and Natural Resources

Arid Ecosystems

The Arid Ecosystem Resource Group completed its strategic Monitoring Plan in 1991. The strategic plan includes collecting synoptic data to monitor and assess long-term trends of arid ecosystem condition throughout the western United States. The San Pedro Watershed characterization study (joint study with EMAP Landscape Characterization) was conducted in southeastern Arizona to determine arid ecosystem condition associated with sustained water sources. In 1992, an indicator pilot test will be conducted in the Colorado Plateau area (Utah, Colorado, Arizona, New Mexico).

Participating Agencies:

- U.S. Department of Agriculture
  - Forest Service
  - Soil Conservation Service
- U.S. Department of the Interior
  - Bureau of Land Management
  - National Park Service
  - Fish and Wildlife Service
  - Bureau of Indian Affairs
- U.S. Department of Energy
  - Idaho National Engineering Lab
- Desert Research Institute, Reno, Nevada
- Commonwealth Sciences and Industrial Research Organization, Australia

Near Coastal

In 1991, sampling continued in the mid-Atlantic estuaries from Cape Cod south to the mouth of the Chesapeake Bay. Samples collected included fish, sediment, benthos, and water quality. In 1991, a demonstration project was also conducted in the Gulf of Mexico estuaries extending from north of Tampa Bay west to the Mexican border. Sampling and monitoring activities will continue in 1992 in the estuaries of the mid-Atlantic and Gulf of Mexico.

Participating Agencies:

- National Oceanic and Atmospheric Administration
  - National Status and Trends Program
  - Strategic Assessment Program

  - National Marine Fisheries Service
- Delaware River Basin Commission
- Chesapeake Bay Agreement States
- EPA Gulf of Mexico Program and Gulf States

Forests

In 1991, the Forest Resource Group and the U.S. Department of Agriculture, Forest Service continued the New England Forest Health Monitoring and expanded monitoring to the mid-Atlantic states. The Southeastern Demonstration project also began in 1991. Monitoring was primarily based on visual symptoms and growth efficiency. Also, pilot studies in Georgia, California, and Colorado were conducted in 1991. Activities for 1992 include full monitoring implementation in the northeast, demonstration projects in the southeast, pilot programs in the western states, and joint reporting with the USDA Forest Service. Also for 1992, additional biological and ecological indicators are being added to the forest sampling suite, as a result of EPA research conducted during prior year demonstrations.

Participating Agencies:

- Department of Agriculture
  - Forest Service
  - Soil Conservation Service
- Department of the Interior
  - Fish and Wildlife Service
  - National Park Service
  - Bureau of Land Management
- Tennessee Valley Authority
- State Foresters

Great Lakes

The Great Lakes Resource Group is developing a program plan that uses a phased approach to integrate existing monitoring efforts for that area and supplement these efforts with pilot studies. The plan will be completed in 1992. An EMAP pilot study in Lake Michigan is planned for 1992 and will initially focus on fish and sediments.

Participating Agencies:

- National Oceanic and Atmospheric Administration
- EPA Great Lakes National Program Office
- U.S. Fish and Wildlife Service
- International Joint Commission

Surface Waters

In 1991, a Northeastern Lakes Pilot Study (New York, New Jersey, and New England) was conducted on 114 lakes. Some of the monitoring activities fulfilled mandates of the Clean Air Act Amendments. In support of the study, documents prepared included the Research and Monitoring Strategy, Implementation Plan, Field Operations and Training Manual, Quality Assurance Plan, and Methods Manual. In 1992, a demonstration project in the Lakes of the Northeast and a pilot project in the upper Midwest Lakes are planned.

Participating Agencies:

- Department of the Interior
  - Geological Survey
  - Fish and Wildlife Service
- Several States

Wetlands

Field activities for the EMAP Wetlands program began in 1991 by conducting a pilot project in the southeast (Gulf coast) to evaluate indicators. The Wetlands Resource Group conducted this pilot study in the coastal salt marshes of Louisiana. A design evaluation pilot study is also being conducted using data from four states. In FY92, there are plans to continue work in the salt marshes and for a midwestern pilot study in the prairie pothole region.

Participating Agencies:

- U.S. Fish and Wildlife Service
- U.S. Forest Service

C. Inter-/Intra-agency and State Coordination

This section and the attached Appendices present an up-to-date summary of EMAP's inter-/intra-agency relationships, including the status of memoranda of understanding with other agencies and examples of interagency cooperation. Also presented in this section are examples of states' participation in the program. EMAP is truly an interagency program, including the Nation's best scientists from over ten agencies in the federal government. The active participation of personnel from other ecological research and monitoring programs provides a critical mass of expertise. Additionally, the close interaction among programs minimizes duplication of effort. This value-added approach links existing efforts for a more cost-effective program to assess ecosystem condition.

Although EMAP's broad scope, ecological focus, and statistically-based design distinguish it from most existing programs, it is not a substitute for on-going efforts. Rather, EMAP complements and supplements research and monitoring efforts throughout EPA, other federal agencies, and the states. Within EPA, EMAP is working closely with the Chesapeake Bay Program Office, the Gulf of Mexico Program and the Clean Air Status and Trends Network (CASTNET). Furthermore, EMAP's utility to other monitoring and research programs is illustrated by its relationships with programs of the Federal government, states, and private groups. Some of these programs include: the National Atmospheric Deposition Program's (NADP's) National Trends Network, the USDA Forest Service's Forest Health Monitoring Program, the U.S. Fish and Wildlife Service's National Wetlands Inventory, NOAA's National Status & Trends Program, monitoring under the Great Lakes Water Quality Agreement by Canada and EPA's Great Lakes National Program Office, the Global Change program, and NSF's Long-Term Ecological Research Program. There are dozens of other domestic databases being studied for incorporation in EMAP, in addition to a number of international systems, such as the Global Environmental Monitoring System of the United Nations Environment Programme.

With specific reference to EPA's Office of Water and EMAP, it is important to highlight the complementary aspects that each office brings to the monitoring picture. The Office of Water, working primarily with States, compiles a biennial report to Congress titled the "National Water Quality Inventory" (also known as the Section 305 (b) Report, as required by the Clean Water Act). These reports aggregate State information, add additional data from other federal agencies, and present a combined biennial picture of water quality in the fifty States. These reports cannot be compared from year to year because the water quality standards are set by states and vary among them and over time. The reasons for this are that water quality sampling techniques are neither consistent among states nor consistent over time, and further inconsistencies derive from the fact not all states follow the EPA 305 (b) guidelines in reporting their water quality. The monitoring that the states report is usually done for the purposes of developing and assessing programs, demonstrating their success in meeting proposed use criteria for State waters, and identifying emerging problems.

EMAP provides a multi-region scope, methods, and monitoring approach that can describe water quality status and trends. EMAP will provide the first statistically consistent multi-regional monitoring coverage, and will also provide scientific work to develop appropriate indicators and monitoring methods. EMAP has Memoranda of Understanding with USGS,

NOAA, FWS and other federal agencies to ensure that methods and research are compatible.

The Office of Water has been discussing with EMAP ways to better integrate the programs of both offices in the areas of clean water goals. The major components of these discussions include the role of the States in monitoring with a focus on monitoring coverage and effective use of Federal and State resources, how EMAP information can be integrated into the 305 (b) Report, overall information management, analysis and reporting, and issuance of joint guidance to the Regions on monitoring. Also under discussion are the overall role of the Office of Research and Development in providing research support for developing indicators, methods, quality assurance, and the broader ecological risk assessment framework and ecological research foundation, and the appropriate uses of geographic targeting, watershed approaches and EMAP pilot projects.

One way to ensure active cooperation with another agency is to use its money and manpower for a joint activity, EMAP has been and will continue to be aggressive in seeking direct contributions to further the Program. The following charts list an estimate of those contributions of in-kind services to EMAP from outside Agencies. [Significant aid has also been provided by EPA regulatory Program and Regional Offices, but these are also harder to quantify, since they are usually in the form of staff support and joint task groups.]

Contributions to EMAP from Other Agencies

Agency	Program Component	1992 Funding	Proposed 1993 Funding
National Aeronautics and Space Administration	Landscape Characterization	$800,000	$1,000,000
National Oceanic and Atmospheric Administration	EMAP-Near Coastal/NOAA National Status and Trends	$1,000,000	$1,000,000
TVA	Forest sampling in Souther Appalachians	$ 1000,000	$ 200,000
USDA Agricultural Service	Agroecosystems	$136,000	$136,000
USDA Forest Service	EMAP Forests/USDA FS National Forest Health Monitoring	$3,500,000	$13,000,000
USDOI Bureau of Land Mgt.	Indicator development and monitoring on BLM lands	$ 175,000	$ 350,000
USDOI Fish and Wildlife Service	EMAP Landscape Characterization/ FWS National Wetlands Inventory	$ 500,000	$ 650,000
USDOI National Park Service	Monitoring and Tier IV research on NPS lands	$ 125,000	$ 150,000
Indian Nations	Sampling in the western U.S.	$ 50,000	$ 75,000
US DOE (Oak Ridge Lab/Idaho National Engineering Lab	Sample Design, Indicators, Landscape Characterization	$150,000	$200,000
	TOTAL	**$6,686,000**	**$17,061,000**

EMAP's commitment to a well coordinated program that includes participation from other agencies and states cannot be overemphasized. In addition to the EMAP-oriented activities described above and in the Appendices, EPA is sponsoring a study by the National Academy of Sciences/National Research Council (NAS/NRC) to improve coordination of ecological research nationwide. This study is examining ways to improve research and training in the federal government, including the prospects for new mechanisms such as the National Institutes for the Environment. EMAP has met with the NAS/NRC committee twice in the last four months to provide input to their deliberations.

EMAP has also commissioned the NAS/NRC to a three-year review of the statistical sampling methodology and other aspects of the Program. The review began in FY 1991 and is currently scheduled to conclude with a final report in FY 1993. EMAP has had several meetings with the NAS/NRC, and in the fall of 1991 other agencies presented to the NRC their involvement in the Program. EPA expects a letter report from the NRC on this subject sometime in late 1992.

In discussing the results of EMAP Pilot and Demonstration projects with scientists working in long-standing monitoring programs (such as the Chesapeake Bay Program, which has had a major scientific component for over 12 years), it is important to note the extent to which *one year* of EMAP–Near Coastal's area-wide basic estuarine indicators, reported with known statistical confidence, are providing the scientists working on the Chesapeake with new insights into the Bay's environment. Results from long-standing monitoring activities (e.g., dissolved oxygen) are being reinterpreted in light of demonstration project results. It is not the position of EMAP to speak for other agencies, but where EMAP results have received a full-blown demonstration, it is likely that — were EMAP to cease to exist — similar large-scale monitoring would soon be implemented by other agencies (but not, unfortunately, with a unified design, capable of integrating the overall results into a still larger tapestry).

EMAP is a large, complex program. It is important to understand the extent of the innovations which are embedded in its design, and to appreciate how this influences the issue of EMAP supplementing, *and being supplemented by*, other monitoring programs. EMAP provides ecologically and regionally broad generalizations about environmental conditions, with known statistical confidence. The Program innovates in: *scale* and *breadth* of ecological integration, *statistical* measures and applications, field and *laboratory methodologies*, and the speed of release of monitoring data (i.e., nine months from collection to release of properly documented and quality assured data). Fundamentally new science applications are being developed in remote sensing and landscape characterization.

Given these features, it is accurate to say both that EMAP supplements all scientifically valid environmental monitoring activity in the United States today, and that all monitoring in the US supplements EMAP. More important, however, is the *rapid rate of adoption of EMAP innovations* by other monitoring programs, and the integrated development of joint monitoring actions. Appendix B and Appendix C give a quick summary of some of the most advanced of these joint development activities, but these are really only indications of the levels of collaboration which are going on across the spectrum of environmental scientific activity.

Appendix A

Federal Agencies Participating in EMAP

Interagency Agreements and Memoranda of Understanding
(completed as of 2/1/92)

Cooperating Agency	EMAP Component
National Aeronautics & Space Administration (NASA)	Landscape Characterization
National Oceanic & and Atmospheric (NOAA)	Near Coastal
NOAA	Great Lakes
US Department of Agriculture (USDA), Agricultural Research Service	Agroecosystems and Indicators
USDA, National Agricultural Statistics Service	Agroecosystems
USDA Forest Service, NE Forest Experiment Station	Forests and Quality Management
USDA Forest Service, Pacific NW Forest Experiment Station	Forests and Indicators
USDA Forest Service, Rocky Mountain Forest Experiment Station	Forests, Landscape Characterization, and Design and Statistics
USDA Forest Service, SE Forest Experiment Station	Forests, Indicators, and Quality Management
USDA Soil Conservation Service	Forests and Landscape Characterization
Department of the Interior (DOI) Bureau of Land Management	Arid Lands and Indicators
DOI, Fish and Wildlife Service, National Wetlands Inventory	Near Coastal
DOI, Fish and Wildlife Service, National Wetlands Inventory	Wetlands and Landscape Characterization
DOI, Geological Survey (USGS), Water Division	Surface Waters (Lakes)
DOI, USGS, National Mapping Division	Landscape Characterization
DOE, Idaho National Engineering Laboratory	Design, Indicators Agro- and Arid Ecosystems
DOE, Oak Ridge National Laboratory	Design, Indicators and Landscape Characterization
National Academy of Sciences, National Research Council	Design and Statistics, and Integration and Assessment
American Statistical Association	Design and Statistics
Estuarine Research Federation	Near Coastal

Appendix B

Examples of Interagency Cooperation within the EMAP Framework

Forest Ecosystems — Field Demonstration Phase

USDA Forest Service	EPA	USDA, Soil Conservation Service
• overall administrative lead for forest ecosystems • lead for field monitoring • lead for State interface • co-reporting responsibilities	• lead for eco-indicators • lead for quality assurance • lead for information management • lead for design and statistics • co-reporting responsibilities	• soil chemistry • soil productivity

* *State* Foresters in the New England States have been extensively involved in the implementation of EMAP-Forests through the USDA Forest Service.

Near Coastal Estuaries — Field Demonstration Phase

EPA	NOAA	States: Delaware River Basin Commission
• overall administrative lead for estuaries • lead for field monitoring for the Virginian and Louisianian Provinces • lead for design and statistics • lead for eco-indicators • co-reporting responsibilities	• lead for field monitoring for the Carolinian Province • lead for characterizing sediments in the Virginian Province • lead for contaminant methodologies • co-reporting responsibilities and computer display	• enhanced field data collection

Agroecosystems — Planning Phase

USDA, Agricultural Research Service	EPA	USDA, National Agricultural Statistics Service
• overall administrative lead • co-reporting responsibilities	• lead for eco-indicators, quality assurance, and information management • co-responsible for design and statistics • co-reporting responsibilities	• lead for field monitoring • co-responsible for design and statistics

Arid Ecosystems — Planning Phase*

EPA	BLM	Others
• co-responsible for planning and implementation • Indicator selection • Classification system development • Pilot Study in 1992 • co-reporting responsibilities	• co-responsible for planning and implementation • Indicator selection • Classification system development • Pilot Study in 1992 • co-reporting responsibilities	• DOE, DOD, US Park Service, Fish and Wildlife Service, USDA Soil Conservation Service and Forest Service, and other resource and land management agencies will participate in monitoring

*EPA and BLM are jointly operating this resource area. There may be separate activities during the implementation phase.

Appendix C

STATE PARTICIPATION IN EMAP

Alabama

- Participating in field studies with EMAP-Forests/USDA-Forest Service in Forest Health Monitoring Program.

California

- Conducted a survey of fish and amphibians in streams of the Sierra Nevada using the EMAP sampling design. As a result of this project, the EMAP design is now widely used in the State's ecological monitoring.
- Participated in the Forest Health Monitoring Program.

Colorado

- Participated in the Forest Health Monitoring Program.

Connecticut

- Participating in field studies of the New England forests with EMAP and the USDA FS Forest Health Monitoring Program.
- Participating in the Near Coastal activities for the Virginian Province.

Delaware

- Participating in the Near Coastal activities for the Virginian Province.
- Participating in field studies in the Forest Health Monitoring Program.

Florida

- Used the EMAP-Near Coastal design to review and enhance theTampa Bay Monitoring Program under the National Estuary Program.
- Participating in EMAP-Near Coastal activities in Louisianian Province.

Maine

- Participating in field studies of the New England forests with EMAP and the USDA FS Forest Health Monitoring Program.
- Provided assistance in planning/implementation of FY91 Northeast Lake Pilot.

Maryland

- Participating in field studies with EMAP-Forests/USDA Forest Service in Forest Health Monitoring Program.
- Participating in the Near Coastal activities for the Virginian Province.

Massachusetts

- Participating in field studies of the New England forests with EMAP and the USDA FS Forest Health Monitoring Program.

New Hampshire

- Participating in field studies of the New England forests with EMAP and the USDA FS Forest Health Monitoring Program.
- Assisted in monitoring logistics for FY91 Northeast Lake Pilot.

New Jersey

- Participating in the Near Coastal activities for the Virginian Province.
- Participating in field studies with EMAP and the USDA Forest Service Forest Health Monitoring Program.

New York

- Participating in sampling and analysis activities in the Northeastern Lakes Pilot Study.
- Participating in the Near Coastal activities for the Virginian Province.

North Carolina

- Participating in agroecosystem pilot project in 1992.
- Participating in Southeastern regional demonstration of Forest Health Monitoring.

Ohio

- Provided EMAP with state monitoring data for indicator development use in surface waters.

Pennsylvania

- Working with EMAP Landscape Characterization personnel in characterizing land use/land cover in the state, in collaboration with the Chesapeake Bay Association, Pennsylvania has funded EMAP to conduct landscape characterization for the entire state in addition to those areas of the Chesapeake Bay watershed.

Rhode Island

- Participating in field studies of the New England forests with EMAP and the USDA FS Forest Health Monitoring Program.
- Participating in the Near Coastal activities for the Virginian Province.

South Carolina

- Participating in FY92 Southeastern regional demonstration of Forest Health Monitoring Program indicators work.
- Participating in Near Coastal activities for Carolinian Province.

Vermont

- Participating in field studies of the New England forests with EMAP and the USDA FS Forest Health Monitoring Program.
- Provided onsite logistics support for Northeast Lake Pilot.

Virginia

- Participating in the Near Coastal activities for the Virginian Province.
- Participated in 1990 Forest Health Monitoring field tests.
- Participating in Chesapeake Bay Watershed Landscape Characterization Project.
- Participating in FY92 Southeast regional demonstration of Forest Health Monitoring Program.

Association of State and Interstate Water Pollution Control Administrators

- Cooperative work with ASIWPCA's state water monitoring task force.
- Discussions are currently underway on establishment of a State/EPA Work Group on EMAP that will include participation of EPA Regions.

Delaware River Basin Commission

- Participating in the Near Coastal activities in the Virginian Province.
- Conducting sampling in the Delaware estuary on an intensified EMAP grid.

National Association of State Foresters

- Participates as the third partner in the national interagency Forest Health Monitoring Program along with EPA (EMAP) and the Forest Service. Coordinates State implementation. Reviews technical proposals. Supports budget requests. Implements field studies.

National Governors Association

- Serving as a liaison on ORD technology transfer issues for the state environmental agencies. This year they have chosen to focus on EMAP and the role states can play in EMAP to clarify what EMAP can do for the states. NGA is planning a workshop for Spring '92 to facilitate further collaborative efforts. The EPA Regions are actively involved in this effort.

Southeastern States Forestry Agencies

- Conducted field monitoring activities in forests as part of the Southeastern demonstration project.

Appendix D

EMAP FY1991 DELIVERABLES

Program Wide

- Program Plan for EMAP
- EMAP QA Program Plan
- Data User's Guide to the USEPA Long-Term Monitoring Project: QA Plan and Data Dictionary

Near Coastal

- Example Interpretive Assessment for Estuaries
- Final Research Plan for EMAP-Near Coastal
- Implementation Plan for Virginian Province FY91 Demonstration
- 1991 Lousianian Province Demonstration (Field Activities Report)

Forests

- Annual Statistical Summary for New England Forests (FY90 Results)
- Report on EMAP-Forest 20/20 Pilot Project in Northeastern U.S. (FY90 Results)
- EMAP-Forests Monitoring and Research Strategy
- Forest Indicator Pilot Plan - FY91 Activities
- FY91 Forest Health Monitoring Western Pilot Operations Report

Surface Waters

- Strategy for EMAP Surface Water Monitoring
- Plan for FY91 Northeast Lake Pilot
- Association of Surface Water Impairment with Probable Cause

Wetlands

- Research Plan for Monitoring Wetlands (Gulf Coast Pilot)

Great Lakes

- Draft Plan for Great Lakes Pilot

Agroecosystem

- National Monitoring Plan for Agroecosystems
- EMAP Agroecosystem Indicator Evaluation (Proceedings of Symposium)

Arid Ecosystems

- National Monitoring Plan for Arid Ecosystem
- Example Annual Statistical Summary for Arid Ecosystems

Integration and Assessment

- Integration and Assessment Conceptual Plan

Landscape Characterization

- Landscape Characterization 10-Hexagon Pilot Report
- EMAP-Landscape Characterization Concept (Journal Article)
- Landscape Characterization Data for Chesapeake Bay Watershed

Design and Statistics

- EMAP Statistics and Design Research Plan
- Spatial Analysis of Existing Monitoring Data

Logistics

- EMAP Logistics: Six-Year Options and Alternatives Plan

Information Management

- EMAP Information Management Standards Document
- Results of Initial Information Management Transfer Tests
- Information Management Hardware/Software Needs
- Initial Information Transfer Guidance Document
- Initial Data Catalogue/Index System Design Plan
- EMAP Data Confidentiality Report
- Information Management Mission Needs Analysis (EEI-1 Document)
- Information Management - Geographic Information System (GIS) Conceptual Plan

EXPECTED EMAP FY1992 DELIVERABLES

Program Wide

- EMAP Implementation Plan
- EMAP Strategic Plan
- Regional Implementation Strategy
- Indicator Development Strategy
- Bioscience Article on EMAP ("Long-term Ecological Monitoring: A Top-Down Approach")

Near Coastal

- Report on FY90 Near Coastal Demonstration in Virginian Province
- Annual Statistical Summary for Louisianian Province (FY91)
- Annual Statistical Summary for Virginian Province (FY91)
- Assessment Report on 1991 Louisianian Province Demonstration Project
- Implementation Plan for FY92 Virginian Province
- Implementation Plan for FY92 Louisianian Province
- Proceedings of the Gulf Breeze Symposium on Marine and Estuarine Disease Research
- Annual Report of Activities of Marine Diagnostic Center, Including Support for Indicator Development in EMAP-Near Coastal
- Review Article on Bioindicators for Marine Systems: Individuals, Populations, and Communities

Forests

- Plan for FY92 Field Activities
- Annual Statistical Summary for New England Forest Health Monitoring (FY91)
- Annual Statistical Summary for Southeastern Forest Health Monitoring (FY91)
- National Forest Health Monitoring (Joint Memoranda of Agreement with USDA-Forest Service)

Surface Waters

- Evaluation Report on FY91 Northeast Lake Pilot Study
- Comparison of Sampling Designs for Ecological Monitoring

Wetlands

- Preliminary Data for FY91 Gulf Coast Salt Marsh Pilot Study
- Response of Prairie Wetland Vegetation to Flooding

Great Lakes

- EMAP - Great Lakes Research Plan
- Implementation Plan for 1992 Great Lakes Pilot

Agroecosystem

- Plan for Agroecosystem Pilot for North Carolina
- Overview of Agroecosystem Program (Journal Article)
- Comparison of Periodic Survey Designs Employing Multi-Stage Sampling (Journal Article)
- Sustainable Agriculture (Proceedings of Symposium)
- Enumerators Manual

Arid Ecosystem

- Report on Results of Joint Arid/Landscape Characterization Pilot in Southwest
- Arid Ecosystem Indicator Study Plan
- Workshop on Arid Ecosystem Indicators
- Dry Lands Risk (Symposium Proceedings)

Integration and Assessment

- Regional Ecosystem Assessment Prototype Report
- EMAP Integration Strategy
- EMAP Client Strategy
- Pilot Indices Document for EMAP

Landscape Characterization

- Report on Results of Joint EMAP - Arid/Landscape Characterization Pilot in Southwest
- Landscape Characterization Strategic Plan
- Landscape Characterization Research Plan
- Landscape Characterization 10-Hexagon Methods Refinement
- QA/QC Program Plan for Landscape Characterization
- Sampling Frame for Gulf Coast Wetlands

- Surface Waters Sampling Frame
- Results of LUDA Simulation Study

Information Management

- Information Management Preliminary Design and Options (EEI-2 Document)
- Information Program 5-Year Management Plan
- GIS Resource Manual

Design and Statistics

- EMAP Sampling Design Perspective (Journal Article)
- Status Estimation for EMAP: Procedures and Algorithms
- Analysis of Trends with Rotating Designs

Summary Report

United States
Department of
Agriculture

Forest Service

**Environmental
Protection Agency**

**National Association
of State Foresters**

Forest Health Monitoring
New England

1990

Forest Health Monitoring: A Partnership Between

EPA Environmental Protection Agency

Forest Service

National Association of State Foresters

Acknowledgments

Forest Health Monitoring is truly a cooperative effort. Besides the numerous individuals that formed the Area and Station partnership, many other individuals of numerous agencies worked to make the program a success. The U.S. Environmental Protection Agency provided portable data recorders and technical support for the equipment. The State Foresters from Maine, New Hampshire, Vermont, Massachusetts, Connecticut, and Rhode Island gave their critical support to the program and provided the services of their staffs to help develop the program and collect the field data. Forestry Canada helped with critical decisions and their Acid Rain National Early Warning System (ARNEWS) was one model we studied in the design of Forest Health Monitoring. Without the support and participation of all, it is unlikely that Forest Health Monitoring in 1990 would have been the success it proved to be.

Summary Report

Forest Health Monitoring

New England

1990

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Northeastern Area
Northeastern Forest Experiment Station

in cooperation with
U.S. Environmental Protection Agency
Forestry Canada

May 1991

NE-INF-94-91

Forest Health Monitoring
New England

New England Forest Resource

The six-state New England region is estimated to be over 80 percent forested. With a total land area of more than 40 million acres, forestland compromises over 32 million acres. The predominance of forestland occurs throughout New England, with Maine most extensively forested (89 percent) and forestland in southern New England exceeding 60 percent of total land area.

Over 85 percent of New England forests are classified as one of four major forest-type groups: White Pine, Spruce-Fir, Oak-Hickory, and Northern Hardwoods. Across New England, 82 tree species have been recorded on forest survey plots. The most common conifers are balsam fir and red spruce and the most common hardwood species is red maple.

The New England forest is maturing, with 46 percent presently classified as sawtimber-sized stands (trees generally larger than 10 or 11 inches in diameter) and presumably containing the oldest trees. The area of sawtimber-sized stands increased 36 percent from the surveys of the 1970's. Concurrently, smaller poletimber-sized stands (trees 5 to 10 or 11 inches in diameter) and seedling-sapling-sized stands (trees less than 5 inches in diameter) decreased, respectively, 8 and 51 percent in area.

The forests of New England have been, and continue to be, exposed to a broad range of stressors, both natural and human-caused. Natural stressors include weather extremes, forest insects, and pathogens. Human-caused stressors include land-use change, air pollution (for example, ozone), and acidic deposition. A new but unsubstantiated concern is global climate change due to generation of gases that create a "greenhouse effect."

The predominance of forests in New England, their importance for recreation, water, and wood products, and the increased awareness of stress upon forest ecosystems have resulted in a demand to address concerns about forest "health" and human influences.

Forest Health Monitoring: New England

The public's concern for the "health and productivity of forests in certain regions of the United States" resulted in federal legislation mandating "such surveys as are necessary to monitor long-term trends in the health and productivity of domestic forest ecosystems" (Public Law 100-521). This mandate was implemented in the six New England states in 1990 with the cooperative efforts of the U.S. Department of Agriculture Forest Service (USDA Forest Service), U.S. Environmental Protection Agency (USEPA), and the six New England state foresters. Subsequent legislation (Public Law 101-624) encouraged the USDA Forest Service to work in partnership with state foresters or equivalent state officials to "monitor forest health."

Forest Health Monitoring (FHM) is intended to be a long term effort with a major emphasis to detect unexpected changes from established baseline forest conditions. Specific objectives of FHM are to: 1) characterize forest conditions, 2) characterize the major potential forest stressors, 3) quantify changes in forest conditions, and 4) analyze the relationships between changes in forest conditions and potential forest stresses.

Forest conditions will be described by the measurement and reporting of data from several "health" indicators. Five indicator groups have been measured: growth, foliage symptomatology, soil chemistry, foliar chemistry, and landscape characterization. Individual measurements may support one or more indicators. Measurements will be made and indicators characterized on a periodic basis; annually for those that change frequently (for example, foliar symptomatology) and on a 4 year or greater cycle for those that change less frequently (for example, soil chemistry).

FHM is based on the annual remeasurement of an extensive network of permanent locations, selected to correspond to a systematic sampling grid developed by the USEPA for their Environmental Monitoring and Assessment Program. In New England, this sampling design yields 263 sample locations on all lands, forest and nonforest.

Each location consists of a cluster of four plots. All trees, including seedlings and saplings, are located, marked, and measured. On, or adjacent to the FHM location, openings in the forest are searched for indicator plant species known to be sensitive to ozone, sulfur dioxide, and hydrogen fluoride. At each location, data are collected on the geographic and topographic position and physiographic description of the location; tree species, diameter, crown position, crown condition, and damage; other vegetation; and foliar symptoms on indicator plants. Data quality standards are specified in the field data collection manual and explained during field crew training. These standards were monitored by the remeasurement of a subset of locations and trees.

1990 Results

Sample Distribution

The 263 FHM locations in New England represent the forest resource as reported by the most recent forest surveys. The distribution of the forested plots does not differ significantly from that expected of previous forest surveys for land use, forest-type group, or stand-size class.

Number of New England Forest Health Monitoring Locations, by Major Forest-type Group and State or Region

Forest-type Group	Maine	New Hampshire	Vermont	Southern New England[1]	Total New England
E. White Pine	18	7	4	5	34
Spruce-Fir	48	1	7	0	56
Oak-Hickory	2	2	0	14	18
Northern hardwoods	37	19	10	5	71
Other groups	13	4	3	7	27
All groups	**118**	**33**	**24**	**31**	**206**
Nonforest	19	4	11	23	57
All plots	**137**	**37**	**35**	**54**	**263**

[1]Connecticut, Massachusetts, and Rhode Island.

A total of 63 species 14 conifers and 49 hardwoods, were tallied. This is less than the 76 species, 16 conifers and 60 hardwoods, tallied on the extensive forest survey plots. While the distribution of trees by species is not significantly different from that expected, the numbers of balsam fir and white pine show large deviations from expected values.

Number of Trees on New England Forest Health Monitoring Plots,[1] by Major Species and Tree Class

Species	Seedlings-saplings	Mature trees Live	Mature trees Dead	All Classes
Balsam Fir	3,378	646	228	4,252
Red Spruce	665	711	63	1,439
E. White Pine	218	716	71	1,005
N. White-Cedar	309	358	32	699
E. Hemlock	293	426	11	730
Other conifers	223	148	30	401
All conifers	**5,086**	**3,005**	**435**	**8,526**
Red Maple	1,618	1,031	49	2,698
Sugar Maple	1,543	487	29	2,059
Yellow Birch	388	272	34	694
Paper Birch	664	338	39	1,041
American Beech	505	264	21	790
White Ash	565	175	8	748
N. Red Oak	264	188	3	455
Other hardwood	2,650	721	117	3,488
All hardwood	**8,197**	**3,476**	**300**	**11,973**
All species	**13,283**	**6,481**	**735**	**20,499**

[1]Data from 204 forested FHM plots; major species determined by those with greater than 170 sample trees.

The less-than-expected number of balsam fir trees is probably a result of mortality caused by eastern spruce budworm and increased cutting in response to budworm infestation. White pine was sampled at greater-than-expected levels in both the white pine and northern hardwoods forest-type groups and at less than expected levels in spruce-fir and oak-hickory forest-type groups. While there is no full explanation for these results, gypsy moth defoliation of white pine and accelerated mortality of the species since the last extensive forest surveys must be considered as one possible cause.

The distribution of standing-dead trees by species is comparable between FHM and that expected from previous forest surveys. The distribution of trees by diameter class in the FHM sample differs significantly from that expected of earlier forest surveys for both conifer and hardwood species. The difference is found in an "undersample" of conifers 3.0 to 8.9 inches in diameter and an "oversample" of hardwood saplings.

Tree Crown Ratings

Each sampled tree was rated for three (hardwood) or four (conifer) crown characteristics: crown dieback, foliage transparency and discoloration, and needle retention. The ratings are reported only for upper-canopy trees (trees with crowns directly exposed to the atmosphere) though the data were collected for all-live trees. Across all forested plots, upper-canopy trees account for 69 percent of all sampled trees 5.0-inches or larger in diameter.

Crown dieback

Crown dieback is defined as branch mortality beginning at the outside tip of the branch and proceeding inward toward the trunk. This pattern of mortality is an indicator of premature branch death. Dead branches in the lower crown are assumed to have died of suppression or natural senescence due to tree growth and are not included in this measurement.

Ninety-six percent of all upper-canopy trees were tallied as having none-to-light crown dieback. Over all the plots, hardwood species generally had greater crown dieback than conifers. More than 13 percent of the American beech sample was recorded with greater than 20-percent crown dieback. Without further diagnosis, the cause of these symptoms cannot be specified, but the occurrence of the beech bark disease complex is a possible reason. The symptoms are compatible with this disease and the complex is well established in New England.

Distribution of Open Grown, Dominant, and Codominant Trees on FHM Plots,[1] by Percent Crown Dieback Class for Major Species

Species	Percent Crown Dieback Class			
	None (0-5%)	Light (6-20%)	Moderate (21-50%)	Severe (51+%)
	Percent of sampled trees			
Balsam Fir	91.4	7.2	1.1	0.3
Red Spruce	92.7	6.0	1.1	0.2
E. White Pine	92.4	6.6	0.8	0.2
N. White-Cedar	82.8	12.1	4.0	1.0
E. Hemlock	93.0	3.5	2.9	0.7
Red Maple	67.2	26.5	4.4	1.9
Sugar Maple	87.0	10.1	2.4	0.5
Yellow Birch	77.9	18.8	1.4	1.9
Paper Birch	68.6	27.0	3.1	1.4
American Beech	54.7	32.1	7.5	5.7
White Ash	71.3	25.0	1.5	2.2
N. Red Oak	50.0	49.4	0.0	0.6

[1]Data from 204 forested FHM plots

Foliage transparency

Foliage transparency is defined as the amount of skylight visible through the foliated portion of a tree crown and accounts for foliage reductions due to insect damage, pathogens, or environmental stress. The degree of foliage transparency differs by species and depends on branching and leafing patterns. Foliage transparency serves as an estimator of defoliation.

Almost 96 percent of all exposed tree crowns were recorded with "normal" foliage transparency levels. Of the major forest species, severe foliage transparency symptoms (greater than 1 percent of the sample trees) were reported only for yellow birch, American beech, and northern red oak.

Distribution of Open Grown, Dominant, and Codominant Trees on FHM Plots,[1] by Percent Foliage Transparency Class for Major Species

Species	Foliage Transparency Class		
	Normal (0-30%)	Moderate (31-50%)	Severe (51+%)
	(Percent of sampled trees)		
Balsam Fir	99.7	0.3	0.0
Red Spruce	99.8	0.2	0.0
E. White Pine	95.5	4.5	0.0
N. White-Cedar	91.9	7.6	0.5
E. Hemlock	97.9	2.1	0.0
Red Maple	95.6	3.5	0.9
Sugar Maple	98.9	0.8	0.3
Yellow Birch	96.2	1.9	1.9
Paper Birch	92.8	6.5	0.7
American Beech	86.8	6.9	6.3
White Ash	94.9	5.1	0.0
N. Red Oak	90.4	4.8	4.8

[1]Data from 204 forested FHM plots

At this time there is no record to determine "normal" levels of foliage transparency for any species other than sugar maple. This survey will develop the data to establish species-specific foliage transparency standards from which to identify abnormal conditions. Presently, we can examine those tree records with high levels of foliage transparency (that is, thin crowns) for other indications of health problems (for example, other crown ratings, other signs and symptoms).

Foliage discoloration

Foliage is considered discolored when the overall appearance is noticeably yellow, red, or brown. More than 50 percent of a leaf or needle must be discolored for discoloration to be tallied. The occurrence of trace amounts of discoloration is expected for any tree. Results from the 1990 field season provide no indication of health concerns expressed as early or abnormal discoloration.

Needle retention

Needle retention is defined as the number of years needles are retained by a conifer and indicates tree vigor. Needle retention is measured as the year of oldest needle-year class with more than 25 percent of the needles present. The longer the tree retains needles, the more vigorous its growth is expected. The results of needle retention provide no indication of forest health concerns as expressed by this symptom.

Signs and Symptoms

Signs and symptoms, indicative of previous injury, disease, or insects are recorded to provide an explanation of adverse growth effects or mortality. The occurrence of a sign or symptom was recorded only when significant and when likely to result in the eventual decline and death of the tree. A list of common signs and symptoms had been provided and their occurrence was recorded when observed. Results from 1990 suggest no unexplainable forest health concerns.

Indicator Plants

Exposure to ozone, sulfur dioxide, and hydrogen fluoride, the atmospheric gas pollutants, can cause recognizable foliar symptoms on certain plant species. These plants can serve as "bioindicators" of the pollutants. At and adjacent to each FHM plot, forest openings were searched for the presence of bioindicator plant species. Foliar symptoms were recorded when observed. The presence of one or more indicator plant species, for one or more of the air pollutants, was recorded on 192 locations. Ozone symptoms were recorded on 18 locations and sulfur dioxide symptoms on 6 locations; and no hydrogen fluoride symptoms were observed.

Status of Major Forest Insects and Pathogens in New England in 1990

This summary reviews the major forest insect and pathogen problems and declines of 1990 in the New England states. The information was compiled from state pest condition reports and surveys of the USDA Forest Service, Northeastern Area State & Private Forestry, Durham Field Office Forest Health Protection.

The major hardwood pests are defoliators. The New England oak — and at times white pine and hemlock — resource is still affected by extensive gypsy moth defoliation. In 1990, over 700,000 acres of defoliation were reported in the New England. Defoliation increased over the previous year's level, particularly in Maine, Vermont, New Hampshire, Massachusetts, and Connecticut. In many areas significant larval mortality occurred due to fungal infection; however, populations remain high or continue to expand in these states. Very low populations and no significant defoliation have been reported from Rhode Island in the last 2 years.

Other hardwood defoliators such as the eastern tent caterpillar, forest tent caterpillar, and the oak leaf tier were at low levels in most of the region. The incidence of pear thrips also was at a lower level than in recent years in most areas, however the insect caused increased damage in Vermont. Populations of the saddled prominent increased in Vermont and Massachusetts and caused defoliation in scattered locations.

The major conifer pests include defoliators and stem and twig insects. Spruce budworm populations continue at very low levels in northern New England. The hemlock looper infestation in Maine is expanding, and the insect caused localized defoliation in Vermont. Damage from the hemlock woolly adelgid and red pine adelgid was noted in Connecticut and Rhode Island. These insects are expanding into Massachusetts and the hemlock woolly adelgid was found at one site in Vermont. The spruce beetle is causing mortality of larger spruce in northern Maine, and the area of infestation is increasing in size and intensity. This insect also is causing spruce mortality at other sites in northern New England. The balsam woolly adelgid is causing damage to balsam fir crowns at scattered sites in northern New England.

One of the more significant diseases in the region is beech bark disease. Damage from the disease can be found throughout the region, but the amount of tree crown dieback and mortality varies. *Cytospora* canker on spruce and diplodia tip blight on pine has caused damage in several localized areas. European larch canker and scleroderris canker are still under quarantine in several states, however the incidence of these diseases is currently static. Several foliar diseases were reported this year. The most significant was anthracnose, which caused damage on maple and other hardwoods in Vermont, Massachusetts, and Rhode Island. Dutch elm disease is

common throughout the region, as a new, more virulent strain is spreading. Reports of localized drought effects and winter injury on conifers were reported in some of the states. In Maine a disease known as Stillwell's syndrome, associated with Armillaria root disease, continues to cause low levels of mortality in balsam fir stands over an extensive area previously defoliated by the spruce budworm.

Several diebacks on various species were reported. Ash dieback, commonly associated with ash yellows, caused mortality in Maine, Vermont, and Massachusetts. Larch mortality, usually in association with the eastern larch beetle is occurring in Vermont and Maine. Birch dieback is reported from Vermont and especially Maine, where several areas in the western and eastern parts of the state are affected. Dieback of maple is reported throughout the region, but in most cases less than 10 percent of the crown is affected and losses are insignificant. Spruce dieback continues to be reported, with the problem most noticeable at the higher elevations.

Summary

The objectives of the 1990 FHM field season were the establishment of the permanent plot network and the collection of 1st year crown rating and growth data. The FHM plot sample corresponds very closely to New England forest resource characteristics as reported by previous forest surveys. The distribution of locations and tree species are not significantly different from expectations. Such deviations between samples as were found can be explained from known changes since the last extensive survey in the New England forest.

The summary of crown ratings data from open grown, dominant, and codominant trees indicates no pattern of major decline in any species. For many species, these data represent the first such measurement and an exact interpretation is difficult. The full value of the data, as well as diameter measurements, will be realized with plot remeasurements in succeeding years. This year's data will establish the baseline against which to identify changes in subsequent years.

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