United States
Environmental Protection
Agency

Environmental Monitoring
Systems Laboratory
Las Vegas, NV 89193-3478

Research and Development

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EPA

# Project Summary

# Monitoring and Research Strategy for Forests — Environmental Monitoring and Assessment Program (EMAP)

**To protect, manage, and use forest resources effectively, the condition of these resources must be known. Concern about documented and potential effects of air pollutants in combination with other multiple, interacting stresses has been a major impetus behind the development of monitoring programs in forests. During the past two years, the forest component of the Environmental Protection Agency's Environmental Monitoring and Assessment Program (EMAP-Forests) has been working closely with the Forest Service's Forest Health Monitoring (FS-FHM) program and other government agencies to develop a multi-agency program to monitor the condition of the nation's forested ecosystems.**

**The purpose of this document is to present a strategy that can be used as a starting point by all government agencies interested in participating in a nationwide FHM program. Monitoring issues such as design, indicator selection, and assessment are presented along with approaches to resolving these issues.**

**This Project Summary was developed by EPA's Environmental Monitoring Systems Laboratory, Las Vegas, NV, to announce key findings of the research project that is fully documented in a separate report of the same title (see Project Report ordering information at back).**

## Introduction

Sections 1 and 2, the introductory and approach and rationale sections, provide an overview of the document's scope and purpose. An overview of the overall Environmental Monitoring and Assessment Program (EMAP) is provided along with the fundamental research questions motivating the development of the program. Specific EMAP-Forests goals and objectives designed to answer these questions for forested ecosystems are presented. A short historical background of the development of the EMAP-Forests program and the FS-FHM program is given to help the reader put the present planning process in perspective. An important theme of these sections is that a multi-agency FHM program can be successful only through effective coordination.

At present the FS and the EPA are the major agencies participating in the FHM program. The program started with monitoring and pilot studies in the east. In 1991, an effort was made to incorporate western representation into FHM. This includes the state forestry agencies and the National Forest System, the FS Forest Pest Management (FPM), Forest Inventory and Assessment (FIA) programs, and research from the FS. As FHM expands to all states, other agencies will be included in FHM. The U.S. Department of Agriculture's Soil Conservation Service (SCS) is now involved with field sampling of soils. Other agency involvement includes the National Park Service (NPS), the Bureau of Land Management (BLM), and the Fish and Wildlife Service (FWS) to name a few. By 1995, when full implementation is anticipated, the agencies that play major roles in the FHM program will be recognized. These agencies will form the nucleus for future development of the program.

## Procedures and Reporting

Section 3 describes the strategy and procedures that EMAP-Forests will use to

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develop and implement an indicator-based approach to the assessment of ecosystem condition. Ecosystem processes are linked to spatial and temporal combinations of environmental components (climate, soils, topography, vegetation, trophic structure, etc.). Therefore, the success of an indicator and of the corresponding modeling and assessment program will depend on the development of an appropriate diagnostic framework for identifying major resources of concern, suggesting research priorities, and defining attainable conditions of sustainable ecosystem health. The FHM personnel will develop an assessment framework within which indicators may be used to characterize ecosystem condition and/or be aggregated into some common index of condition (or signal of impending change). It is necessary to adopt or develop models of forested ecosystem structure and function that embody the most current hypotheses regarding the interrelationships among ecosystem functional components.

The EMAP-Forests assessment framework recognizes the different uses to which forests are placed. Societal values can therefore be described as fitting into one of three broad categories: ecological integrity, economic value, or sociologic value. To provide a structure that will bridge the gap between societal concepts and the measurement of quantifiable components of the ecosystem, a number of assessment endpoints should be identified. Using such a structure, it is possible, and likely, that any individual indicator will be interpretable in the context of several societal values. Indicators may be comprised of individual field measurements or aggregations of field measurements; they are the technical base for quantifying the characteristics of the assessment endpoints and carry no capacity to assign a value judgement. They serve as a "tag," marking the time and space that can be applied to multiple perceptions of value.

An indicator development process designed to identify indicators that provide information about an ecosystem condition that is relatively free of societal interpretation bias is proposed. The framework guides indicator development through an assessment process that considers needs and objectives, acceptable data uncertainty, appropriateness of available analytical procedures, data management procedures, statistical procedures, and the need for integrative assessment among multiple indicators. To date, EMAP-Forests is examining six of these indicators in pilot studies: percent absorbed photosynthetically active radiation (PAR), vertical vegetation abundance and structure, foliar chemistry, soil characterization and chemistry, growth (mensurational measurements), and visual symptoms of pests, pathogens, and damage. Samples collected during the summer of 1990 are being analyzed, and statistical summaries are being prepared. Preliminary examination suggests that the methodologies for all indicators except PAR are satisfactory for proceeding to the next phase in the indicator development process.

In FY91, the EMAP-Forests program plans to implement a regional pilot study in which it will add soil and foliar chemical analyses, measurement of the vertical vegetation structure, and distribution to 1/4 of the hexagons (in six New England states, Georgia, and Alabama). The FS will conduct full-scale implementation of the visual symptoms and growth mensurational measurements. Other EMAP-Forests indicators under consideration include measurement of PAR, wildlife condition, habitat, and distribution, and landscape characterization.

Section 4 presents the strategy of a monitoring network design. The design of the FHM program must permit statistical estimates of conditions and trends with corresponding precision estimates. This section tells how the statistical design will (1) provide explicit definitions of the target populations and sampling units, (2) provide a sampling frame for selecting sampling units, and (3) use probability samples on the sampling frame. The design will also permit analyses of a variety of possible subsets of the data, adapt to a variety of questions (some of which cannot be specified in advance), and have a structure that permits sampling at coarser or finer levels of resolution, as required. Also presented is a discussion of FIA's statistical designs and their relation to the EMAP-Forests sampling frame.

Section 5 presents the strategy for the field sampling design that will be used to collect measurements used to calculate the indicators. The plot selection rules are presented as is the plot design used in the 1990 pilot studies. The primary purposes for the 1990 pilot were logistics studies and assessment of variation components. With cost and time estimates from the pilots, it will be feasible to begin assessing optimal ways to sample specific indicators.

One of the primary goals of EMAP is to detect trends of ecologically significant size in a specified number of years; therefore, it is important to determine as soon as possible whether or not a specific indicator will be able to meet its data criteria. There are two requirements for criteria assessment: the components of variability must be known well enough to estimate the performance of the indicator in detecting a trend, and the size of the ecologically relevant trend must be specified so the statistician can determine if this trend can be detected.

By the start of the FY91 season, most of the first requirement and all of the second should be completed. By fall of 1991, all of the variance components of indicators should either be estimated or designated for future study. This will permit full evaluation of current and future indicators in the EMAP context.

Section 6 presents the strategy for statistical estimation and analysis, which includes the statistical procedures envisioned for estimating the indicators and sampling error with known confidence. These procedures include methods representing status and extent of current resources, techniques for the study of change and trend, analysis of associations, and methods for integrating information from multiple sources.

Section 7 presents the EMAP-Forests strategy for assessments. Since assessment is a process by which data are converted into useful information, the primary, short-term objectives of EMAP-Forests assessments are to produce periodic statistical summaries, interpretive reports, and integrated assessments that can address the regional status and trends of the nation's forests in relation to human-induced stresses. The long-term FHM assessment strategy will have to evolve to maintain consistency with the overall EMAP program. The FHM personnel can help to determine overall, long-term goals by taking an active role in client identification, question definition, and evaluation of user responses.

A peer review of the indicator strategy in May 1990 by EPA's Science Advisory Board endorsed the general approach to forest assessment, commended the progress made, and indicated that the necessary linkages between environmental concerns and measurements are possible to define.

The strategy for FHM assessments includes exploration of statistical assessment and interpretive assessment models, statistical regionalization using off-frame data, use of auxiliary data bases, and uncertainty estimation. Additional elements of the strategy are report production, infrastructure, and planning.

Section 8 describes the quality assurance (QA) program. The mission of QA in FHM is to ensure that all FHM data and

statistical products are documented and of sufficient quality to satisfy the needs of data users, policymakers, and the public. EMAP will operate within the guidelines of the EPA's Quality Assurance Management Staff. Comprehensive QA techniques will be employed to ensure the quality and usefulness of the data. The overall policies, organization, objectives and functional responsibilities designed to achieve data quality goals are described. Other topics discussed include the use of Total Quality Management, the process of establishing data quality objectives, and QA documentation and reporting.

Section 9 presents the logistics approach. Implementing a national FHM program will require detailed, comprehensive logistics planning. A logistics plan will be developed prior to implementing any operational phases of monitoring. The plan will assist in the five operational phases of field sampling, sample and data handling/shipping, sample preparation, sample analysis, and sample archiving. The FHM Logistics plan serves two purposes: 1) to provide information on the concept of FHM and detail the responsibilities for logistics, and 2) to serve as a guide to the development of regional logistics plans.

In 1991, the FS plans to implement FHM in six New England states, plus Maryland, Delaware, New Jersey, Virginia, Georgia, and Alabama, and will be responsible for logistics. The EMAP-Forests team plans on additional field work for indicators that are not fully implementable in several of the states mentioned above and will be responsible for the logistics of this activity.

Key logistics implementation components discussed are a field operations scenario for FHM, planning, staffing, training, communications, contracting, safety, scheduling, quality assurance/quality control, information management, review/recommendations of the logistics strategy and inventory/storage of supplies.

Section 10 describes the information management (IM) system for a national FHM program that is achievable five years from now. The current IM system is embedded in the description of the future IM system. The level of detail reflects the level of uncertainty concerning the future direction of FHM and the future of technology. Flexibility is a key concept in the IM system. An IM system that cannot or will not adapt to change will be obsolete before it is implemented.

The IM strategy includes establishing a Forest Information Center and designing field and laboratory systems. Key elements of these systems include use of portable data recorders (PDRs) and a geographic information system (GIS), use of a Global Positioning System (GPS), field data collection and PDR programs, sample and shipment tracking on the PDRs, field communications, and various laboratory systems. Database management will include maintaining a comprehensive data inventory, data set index, code libraries and data dictionary, and the maintenance and dissemination of FHM data to appropriate data users. Also associated with the databases will be database access and security, data confidentiality, yearly statistical summaries, and GIS interface.

Section 11 describes the strategy for reporting, which refers to the mechanical aspects of document scheduling, production, review, and clearance. Included are all documents produced by the multiagency FHM program, with a focus on the reports and roles of EMAP-Forests. The reporting strategy of EMAP-Forests is coordinated by EMAP and is implemented in cooperation with the FS and other agencies that also produce monitoring reports. Teams of analysts are comprised of individuals from several organizations. Success within these multiple contexts requires cooperation among agencies and individual participants, and division of labor is an essential ingredient of the strategy.

The types of reports delineated include plans, operations reports, database summaries, data quality reports, statistical summaries, interpretive reports, and technical proceedings. An action plan for the evolution of reporting capabilities is also discussed.

## Conclusions and Recommendations

This EMAP-Forests research strategy document presents a strategy that can be used as a starting point by all government agencies interested in participating in a nationwide FHM program. Monitoring issues such as design, indicator selection, and assessment are presented along with approaches to resolving these issues.



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