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EPA EMAP Monitor

ENVIRONMENTAL • MONITORING • AND • ASSESSMENT • PROGRAM

An interagency program to monitor the condition of the nation's ecological resources

An Overview of the Environmental Monitoring and Assessment Program

The following overview is reprinted in each issue of the Monitor to familiarize new readers with EMAP.

Both the incidence and scale of reported environmental problems have increased over the past two decades. The public is increasingly concerned that the resources upon which they rely for recreation, quality of life, and economic livelihood remain sustainable. Scientists are increasingly concerned that the impact of pollutants now extends well beyond the local scale: global climate change, acidic deposition, ozone depletion, nonpoint source pollutant and sediment discharges to waterways, and habitat alteration threaten our ecosystems on regional and global scales. Years of scientific study have not only heightened our environmental awareness, but also have convinced us that the ecological processes that determine how our ecosystems respond to both natural and anthropogenic disturbances are extremely complex. Unfortunately, the status of our environment is currently not well documented, making it impossible to assess quantitatively where and at what rate degradation may be occurring. While we believe that our policies and programs are protecting the quality of our environment, we cannot prove it with currently available data.

We cannot, for example, determine whether reported problems are increasing across extensive areas of the country, or simply reflect a more informed and vocal public or a locally visible pollution issue. Nor can we determine whether collective human impacts are a more plausible explanation for such problems than are natural causes such as drought. Finally, we are unable to fully determine whether the policies and programs we now have in place to restore our damaged resources, or to protect those perceived to be threatened, are effective. Clearly, we need a national baseline against which future changes in the condition of our resources can be measured and the overall effectiveness of our environmental policies can be evaluated with confidence.

In 1988, the U.S. Environmental Protection Agency's (EPA) Science Advisory Board recommended

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Design of a Comprehensive Monitoring Program

EMAP's objectives call for monitoring the condition of the nation's ecological resources and providing estimates of status, extent, changes, and trends with known confidence (Messer et al. 1991). These objectives can be met only through a statistically designed monitoring network using probability-based sampling of explicitly defined resource populations.

Although an ecological survey as comprehensive as EMAP has never occurred, national or regional probability-based surveys of particular ecological resources are not new. Previous surveys used several different approaches for their design. Some were one-time surveys that were concerned solely with assessing current resource characteristics, while others were continuous monitoring programs (some are still ongoing) that also investigated changes or trends in resource characteristics. A number of features desirable to EMAP, including the following, arise from analyzing the diverse approaches used in these surveys:

- The surveys were designed to estimate the characteristics of an ecological resource population at a point in time or assess trends in the population over time.
- The surveys ensured that samples were spatially distributed over the geographic extent of the resource.
- The probability-based samples were obtained in stages (i.e., by taking an initial sample, then structuring a subsample based on information and questions that derived from the initial sampling phase).
- The change detection surveys either resurveyed the population or were explicitly designed to incorporate repeat visits.

EMAP focuses on the population attributes of ecological resources. The EMAP sampling design builds on the experience gained from previous surveys, incorporates all of the above features, and uses a systematic grid (the

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implementing a program to monitor ecological status and trends that would identify emerging environmental problems before they reach crisis proportions. The next year, EPA refined the focus of its environmental protection efforts by calling for an active confirmation that its programs are truly maintaining or improving environmental quality. The Environmental Monitoring and Assessment Program (EMAP) is part of the Office of Research and Development's (ORD) response to both the Science Advisory Board's recommendation and the Agency's call for "managing for results." EMAP's goal is to monitor the condition of the nation's ecological resources. EMAP data will enable us to evaluate the cumulative success of current policies and programs and identify emerging problems before they become widespread or irreversible.

EMAP represents the foundation for ORD's Ecological Risk Assessment Program. When fully implemented in cooperation with other agencies that share resource monitoring responsibilities, this coordinated research and monitoring effort will provide the information needed to document the current condition of our ecological resources, further the understanding of why that condition exists, and predict what it may be in the future under various management alternatives. Such information will enable EPA to take proactive steps that will minimize future risk or to revise current efforts that fall short of their intended results.

The concept of EMAP was developed in 1987. Since then, several key questions have been formulated that will guide the Program toward meeting its goal: What is the current extent of our ecological resources, and how are they distributed geographically? What proportions of the resources are currently in acceptable ecological condition? What proportions are degrading or improving, in what regions, and at what rates? Are these changes correlated with patterns and trends in environmental stresses? And, finally, are adversely affected resources improving in response to cumulative efforts associated with control and mitigation programs?

These questions pose a challenge that cannot be met without a long-term commitment to environmental monitoring on national and regional scales. Furthermore, this challenge cannot be met efficiently without drawing on the experience and expertise within other federal agencies and organizations that share responsibility for maintaining environmental quality or sustaining our resources.

The EMAP approach to monitoring ensures broad geographic coverage; enables quantitative and unbiased estimates of ecological status and trends; facilitates analysis of associations among measurements of habitat condition, pollutant sources and exposure, and biological condition (indicators); and allows sufficient flexibility to accommodate sampling of multiple types of resources and identification of emerging environmental issues.

EMAP Objectives

- ❑ *Estimate the current status, extent, changes, and trends in indicators of the condition of the nation's ecological resources on a regional basis with known confidence.*
- ❑ *Monitor indicators of pollutant exposure and habitat condition and seek associations between human-induced stresses and ecological condition.*
- ❑ *Provide periodic statistical summaries and interpretive reports on ecological status and trends to resource managers and the public.*

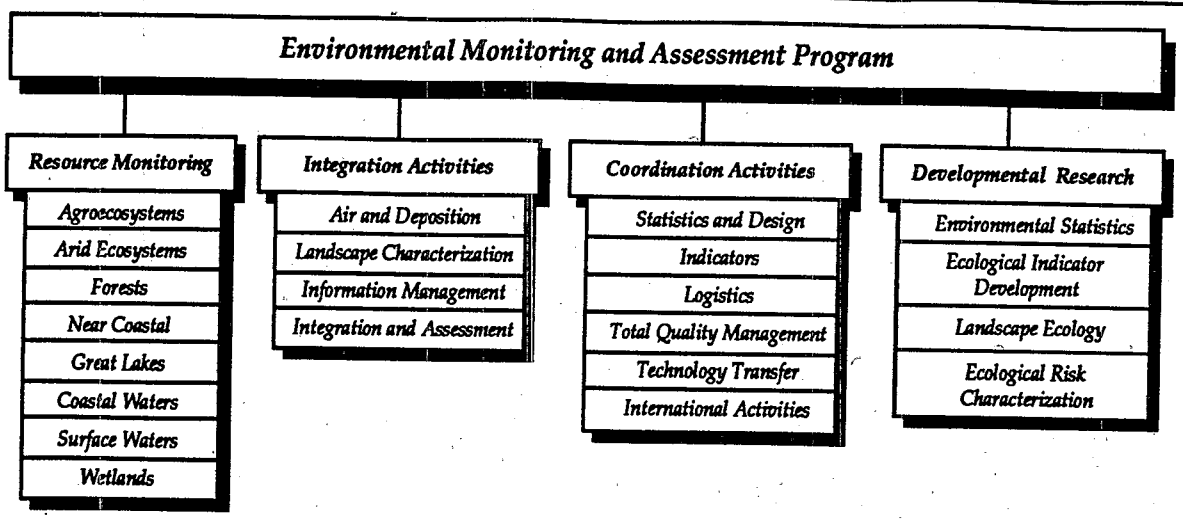
To ensure efficient execution of this approach, EMAP planning and field demonstration projects have involved other organizations within EPA, including the Program and Regional Offices, other federal agencies, and some of the country's finest institutions and universities. Current collaborative efforts are described in the Current Activities section of this issue. As specific plans for implementation are formulated, EMAP will also need to enlist the assistance of State agencies located within the particular areas targeted for monitoring. The development of monitoring plans, which undergo rigorous technical review by national scientific organizations, is also occurring in concert with many university cooperators.

Several long-term, coordinated monitoring efforts will be implemented by EMAP over the next five years. These programs, which will operate on regional scales over periods of years to decades, will collect data from many ecological resource categories: arid ecosystems, agricultural ecosystems, forests, lakes and streams, the Great Lakes, inland and coastal wetlands, estuaries, and coastal waters. Field crews will measure biological, chemical, and physical variables and processes on statistically selected sampling sites for resource classes, such as sage-brush-dominated shrubland, orchard cropland, oak hickory forests, small lakes, emergent estuarine wetlands, or large estuaries. Some of these measurements will also be made by using remote sensing techniques. Data on atmospheric deposition and exposure to other air pollutants will be obtained. Finally, maps, aerial photography, and satellite imagery will be used to describe broad regional patterns of the landscape in areas where sampling is being conducted.

Organizationally, EMAP has four major elements: Resource Monitoring, Coordination, Integration, and Developmental Research.

- ❑ **Resource Monitoring**
  Resource monitoring focuses on collection and interpretation of field data on the ecological condition of the eight resource categories mentioned earlier. Activities to date are provided in the Current Activities section.

- ❑ **Integration**
  Integration activities include several functions that facilitate the acquisition, management, and interpretation of monitoring data. The Air and Deposition and Landscape Characterization Groups provide data that assist all Resource Groups in



interpreting observations on resource condition. EMAP-Information Management facilitates the storage of information and its dissemination to and from the Program as well as among the Resource Groups, Coordination Groups, and the other Integration Groups. The Integration and Assessment Group oversees the acquisition of data from other monitoring networks that cut across or are relevant to two or more Resource Groups. This Group also ensures that the scientific information collected during various EMAP field activities is translated into a form that can be used to answer management questions regarding regional-scale problems. Activities to date for the Air and Deposition, Landscape Characterization, and Integration and Assessment Groups are provided in the Current Activities section. Activities for the Information Mangement Group will be highlighted in future issues of the *Monitor*.

- **Coordination**
  Several coordination activities support EMAP's resource monitoring efforts, including network design and statistical analysis; indicator selection, testing, and evaluation; logistics; and quality assurance. A principal function of the Coordination Groups is to ensure that data collection activities by the Resource Groups are conducted in standardized ways. For example, the Coordination Groups provide complementary network designs and statistical procedures for analyzing data, consistent field and laboratory methods, and quality assurance and quality control protocols.

  Critical coordination functions for maintaining a nationwide program such as EMAP include technology transfer activities and liaison with the international community, other agencies, States, and EPA Regions. The activities of the Statistics and Design Resource Group are highlighted in the feature article of this issue of the *Monitor*, and summaries of progress to date for the other active groups are provided in the Current Activities section.

- **Developmental Research**
  An active program is essential to ensure that EMAP can respond and adapt to new issues; capitalize on improved scientific understanding; and incorporate advances in methods development, data analysis, and reporting techniques, while simultaneously retaining continuity in the long-term data sets it develops. All major groups within EMAP conduct research that is relevant to their specific resource or coordination and integration responsibilities. Additionally, EMAP has identified four major areas of research that are cross-cutting and is currently establishing or contributing to research programs for these areas: environmental statistics, ecological indicator development, landscape ecology, and ecological risk characterization. These programs are an integral part of ORD's Ecological Risk Assessment Program and will be discussed in further detail in future issues of the *Monitor* as their plans are refined. ●

Design *(continued from p. 1)*

EMAP grid) to ensure random selection and appropriate sampling distribution (Overton et al. 1991). EMAP's major sampling design components are the EMAP grid, a two-tier sampling approach, and a rotating sampling schedule. The following sections discuss these components in further detail.

The EMAP Grid

The EMAP design for sampling dictates the following grid requirements:

- Realization of the grid on a single planar surface for the entire United States
- Equal area sampling using regular placement of sampling locations
- Hierarchical structure.

EMAP achieves these requirements by using a randomized systematic triangular grid system.

The EMAP grid-based design emphasizes the geographic distribution of ecological resources. Since EMAP monitors ecological resources on a national scale, a regular grid covering the conterminous United States as well as Alaska, Hawaii, and the Caribbean is necessary.

The uniformity of spatial coverage provided by a grid ensures that each ecological resource can be sampled in proportion to its geographic presence in the United States and that all ecological resources can be included in the monitoring program—thereby establishing a mechanism for sampling such diverse ecological resources as lakes, streams, wetlands, forests, grasslands, estuaries, agricultural ecosystems, and the Great Lakes.

A triangular grid can be conceptualized as a set of points, which, if connected, would form a series of adjacent equilateral triangles. EMAP has selected a two-tiered sampling structure, which is explained in detail in the following section. The first tier is based on a linear point to point distance that is approximately 27 km, yielding a base density of about one grid point per 635 km^2 (see Figure 1). This base density results in approximately 12,600 grid points in the conterminous United States. The grid's placement is determined by a formal randomization to ensure strict adherence to requirements for probability sampling.

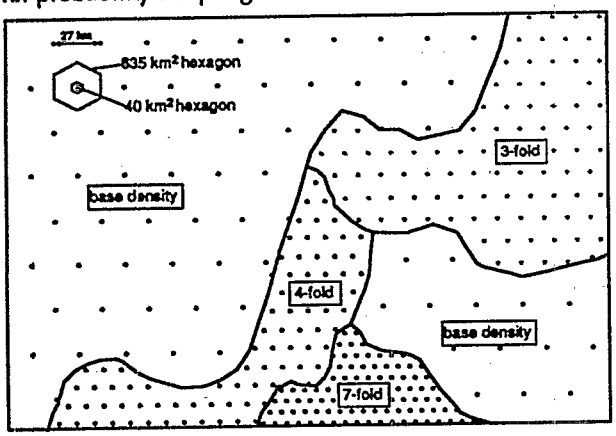


Figure 1. EMAP grid structure with illustration of 3-,4- and 7-fold grid enhancements

In the second tier, the EMAP design achieves comprehensive coverage of ecological resources through the use of sampling frames based on grid points and samples of hexagonal areas centered at the grid points, each having an area of 40 km^2.

EMAP anticipates the need to increase or decrease the base density to satisfy specific sampling requirements. For example, landscape processes may be appropriately described on a larger scale than specified by the base density, whereas some naturally rare or diminishing ecological resources may need an enhanced grid density to obtain an adequate sample size. The natural variability for indicators of ecological condition are incorporated in the design through enhancement of the grid to meet sample size requirements. It may also be appropriate to use an enhanced grid to achieve higher spatial resolution in geographic areas of particular interest. The triangular grid system establishes a hierarchical relationship among grids of various densities that cover the same area (i.e., grids are arranged so that grid points from lower density grids are subsets of higher density grids). Specific multiple factors, e.g., 3-, 4-, and 7-fold, are available to increase or decrease the base grid density and maintain the sampling design requirements.

The Two-Tier Sampling Structure

The probability-based sample of an ecological resource is obtained in two stages: a Tier 1 sample followed by a Tier 2 sample. The Tier 1 sample is used, in conjunction with other information, to estimate resource extent and distribution (i.e., number of lakes, total area of lakes, acreage of forest, etc.) and select the Tier 2 sample. The Tier 2 sample allows detailed data to be obtained on indicators of resource condition. Usually the Tier 2 sample is a subsample of the Tier 1 sample, but it occasionally covers the entire Tier 1 sampling area. Indicator assessment imposes different sampling requirements for different resources; therefore, the Tier 2 sample is selected independently for each resource class, which generally requires field measurements. For some specific indicators, however, information may be obtained by analyzing high resolution remote sensing data.

The characteristics of the ecological resource and the availability of information on the geographic location of the resource—referred to as the frame material—determine how the EMAP grid is used to implement the sampling design. Each resource group currently uses a combination of frame materials, including existing maps and data bases, possibly supplemented by aerial photography or videography, to locate resource occurrences at or within a 40 km^2 hexagon. For example, the Surface Waters Resource Group is using a digitized version of the U.S. Geological Survey 1:100,000-scale maps as well as the River Reach File maintained by the EPA to locate lakes and streams within 40 km^2 hexagons; the Forests Resource Group is using existing forest maps to classify the landscape at each grid point; and the Wetlands Resource Group is using maps produced by the National Wetlands Inventory to identify wetlands for sampling.

Complete land use/land cover classification of the area within the 40 km^2 hexagons was proposed as an alternative approach for EMAP frame development. Such an approach has a number of advantages: (1) it forces reconciliation of all frame materials used by the resource groups, (2) it results in the classification of all ecological resources for 1/16th of the sampling area (each grid point represents a 635 km^2 area; 40 km^2 hexagons are approximately 1/16th of that area), and (3) it establishes a sampling frame structure that enables a quick-design response for new environmental issues. Implementation of this approach on a national scale is restricted by the limitations of existing scientific methodologies for integrating diverse characterization materials. EMAP will continue to investigate alternatives for long-term frame development.

The Temporal Sampling Schedule

EMAP is designed to describe current status and detect trends in a set of ecological indicators throughout a resource population. These two objectives have conflicting design criteria: status is generally best assessed by sampling as much of the resource as possible at a given time, while trends are generally best detected by repeated sampling of the same resource locations at regular time intervals, e.g., at the same time during every year. Meeting both objectives requires a sampling design compromise.

EMAP's design addresses both objectives by rotating through a 4-year sequence. During the first year, one quarter of the total grid points (schematically represented by "◆" in Figure 2) are Tier 1 points and potential Tier 2 sites for that year; during the next year, sites designated as "second-year" ("✚") are available for sampling, and so

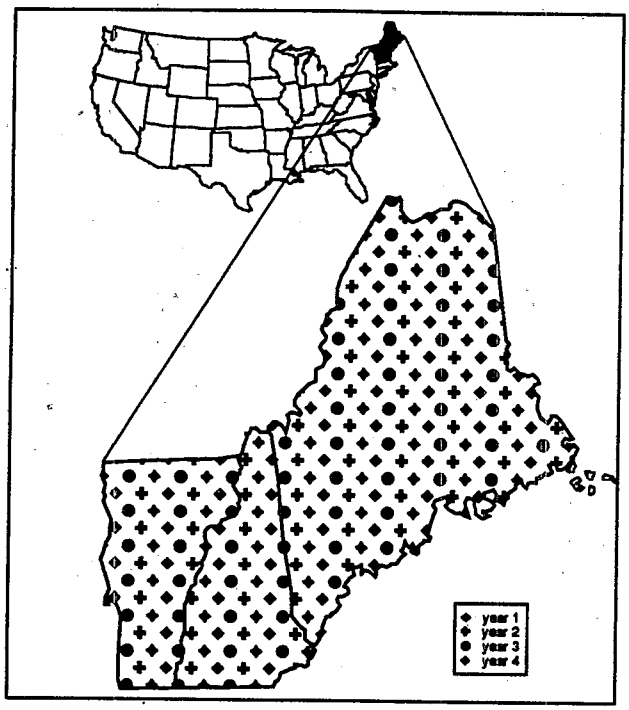


Figure 2. EMAP's temporal sampling schedule.

on. In this manner, all grid points are covered during a 4-year period. A second monitoring cycle begins in the fifth year by revisiting the first year ("◆") sites; the process can continue indefinitely.

The temporal sampling schedule and design has several advantages. Each year's sample provides, in itself, both national and regional estimates of condition, with uniform spatial coverage from year to year. Annual estimates of population parameters are provided for every geographic region and every identifiable population, no matter how dispersed. Revisiting sites on a 4-year cycle provides sufficient time for recovery from measurement stress and allows time for subtle trends to be expressed. The design is well adapted for detecting persistent, gradual change in diffuse subpopulations and for representing ecological indicators accurately.

Application

The EMAP design is currently being implemented by the seven resource groups (Agroecosystems, Arid Ecosystems, Forests, Near Coastal, Great Lakes, Surface Waters, and Wetlands). Implementation activities include identification of ecological resource populations of primary interest, investigation or potential frame materials, and selection of Tier 1 and Tier 2 sample sites. All resource groups have completed a preliminary design, based on the EMAP grid, that is described in their research plans. Actual demonstration studies have been conducted by the Near Coastal Resource Group for estuaries in the Virginian and Louisianian Provinces and by the Forests Resource Group for forests in the Southeastern States and New England. Other resource groups are currently implementing the design in regional demonstration studies (as highlighted in the Current Activities section of the *Monitor*). The following activities conducted by the Surface Waters and Forests Resource Groups illustrate design implementation in greater detail.

The Surface Waters Resource Group's selection of the Tier 2 sample for lakes in the Northeastern United States demonstrates one application of the two-stage process. First, the Tier 1 sample is identified by locating all the lakes within a 40 km^2 hexagon surrounding each grid point (see Figure 3). Second, the Tier 2 sample is selected from the lakes identified at Tier 1, ensuring that the Tier 2 sample is well distributed over the region. Figure 4 shows a randomly drawn hypothetical Tier 2 sample. Although the EMAP systematic grid is used in the selection of the samples, both the Tier 1 and Tier 2 samples reflect the spatial distribution of lakes in the Northeastern United States.

Another example is the sample selection for the New England forest resource. The Tier 1 sample consists of field plots associated with the 263 grid points located in Maine, New Hampshire, Vermont, Massachusetts, Rhode Island, and Connecticut. Based on U.S. Forest Service Forest Inventory and Analysis reports and field visits, 206 of the Tier 1 sample plots were classified as forested. For this particular sampling effort, the Tier 2 sample includes all 206 forested plots. Hence, both the Tier 1 and Tier 2 samples have the systematic grid pattern. If a smaller sample was appropriate for Tier 2, a random subsample of the 206 Tier 1 forested grid points would be taken while constrained to preserve the spatial distribution of the subsample over the forested region.

Summary

The EMAP design for a comprehensive ecological monitoring program is a two-tiered sample structure based on a randomized regular triangular grid. The sample is selected according to strict probability protocols so that estimates of ecological condition have known, quantifiable precision. The adherence to probability sampling ensures that design-based estimators are available for population description and also allows the use of model-based estimators. The design can accommodate multiple spatial scales, both for sampling and reporting purposes, and can be used for a diversity of ecological resources. The design is inherently capable of adapting to new ecological perspectives, the emergence of new environmental issues, and changes in resource emphasis. ●

References and Further Reading

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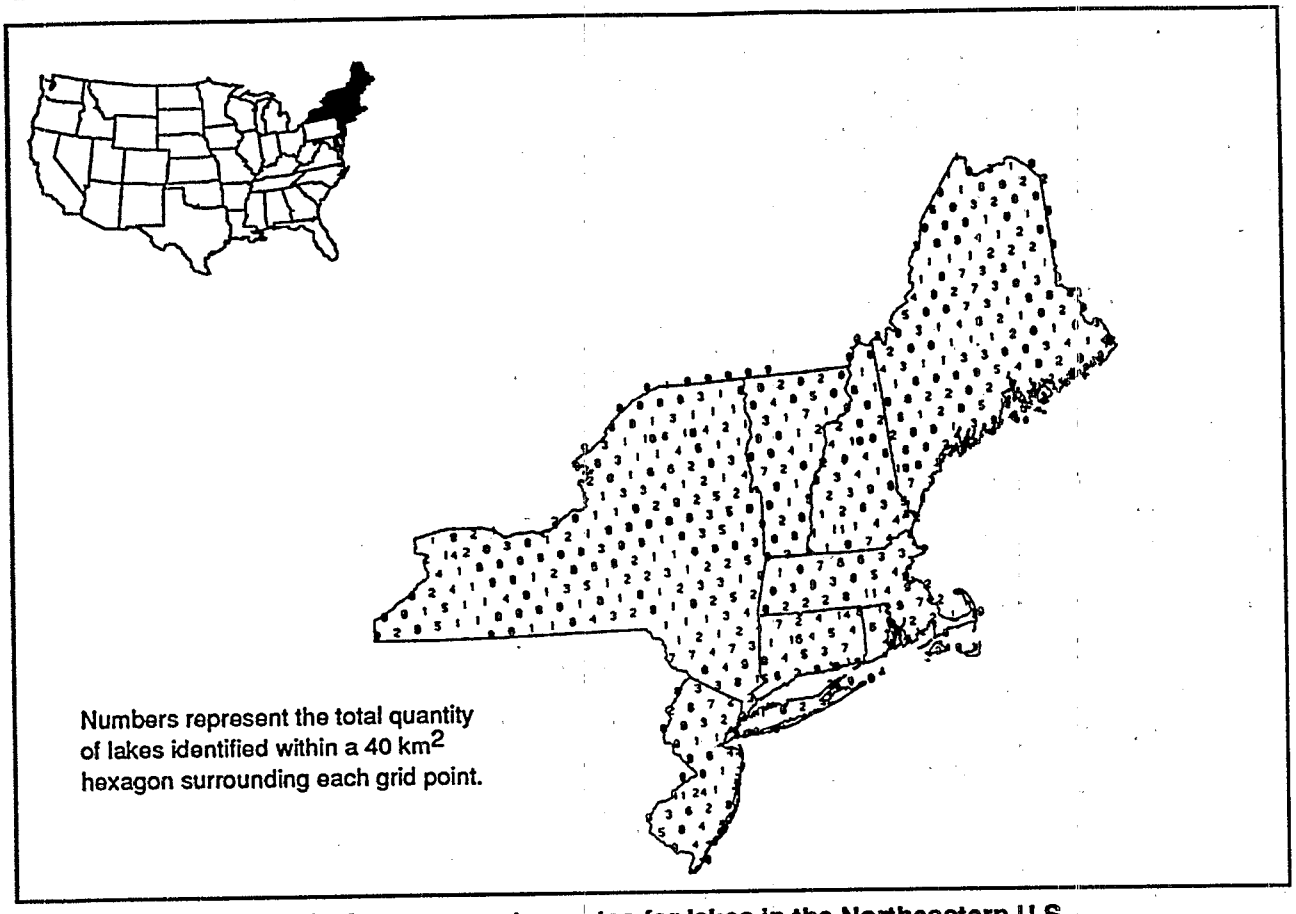

Figure 3. Tier 1 sample, hexagon capture rates for lakes in the Northeastern U.S.

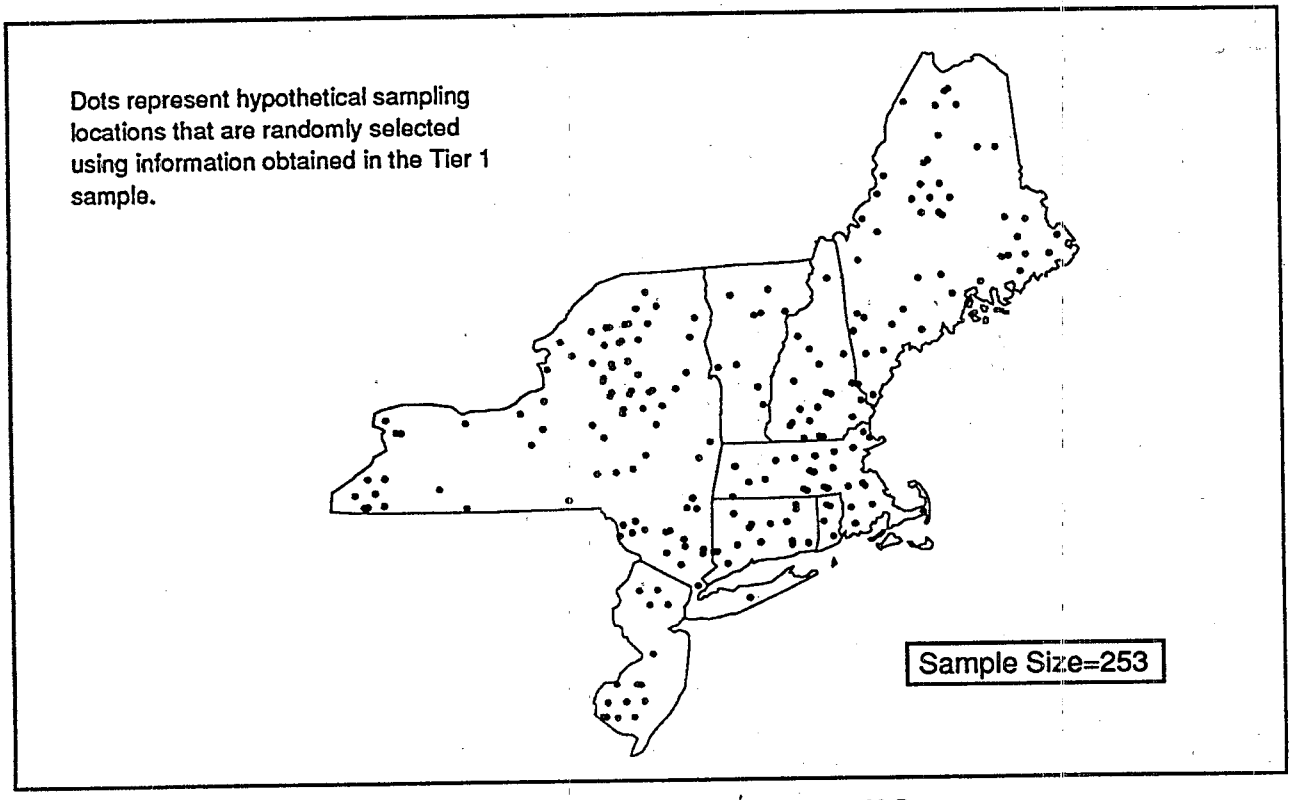

Figure 4. Hypothetical Tier 2 sample of lakes in the Northeastern U.S.

Current Activities

EMAP produced a 15-minute video titled "America's Ecological Report Card." The video provides an overview of the EMAP goals and objectives and a brief introduction to the program's current and planned work. The video will be available from the U.S. Department of Commerce, National Technical Information Service (NTIS), Springfield, VA 22161, in March/April 1992. (To order, call 800-336-4700/703-487-4650 and cite publication number PB92-780865. The cost is not available at this time.)

EMAP Regional Activities

A number of successful interactions between EMAP and the EPA Regions have occurred. One EMAP goal is to formalize these relationships by targeting specific activities for Regional involvement. EMAP implementation is a dynamic process, with the roles of ORD, the Regions, and the States changing over time. Additionally, the interests and capabilities of each Region vary and will influence the areas of active participation. Several efforts were initiated to develop a results oriented yet flexible plan for interaction and cooperation.

Earlier this year each Regional Office designated an EMAP Coordinator. In all the Regions, the designated Coordinator was from the Environmental Services Division (ESD)—a number of Regions chose their ESD Director for this position. A document describing the role of the EMAP Regional Coordinator will be finalized in upcoming months.

In May, 1991, the first EMAP ORD/Regional Coordination Workshop was held in Atlanta, GA (Region IV). Over 70 people attended the workshop, including representatives from the Regions, the States, and the National Governor's Association. The meeting focused on cooperative efforts for initial and long-term implementation of the program.

A Draft EMAP Regional Strategy document—developed for long-term implementation of EMAP—was distributed for comment in September. A final Regional Strategy will be produced once all input has been received. The strategy is expected to facilitate Regional participation in EMAP. Already several notable, short-term cooperative activities between EMAP and the Regions are underway:

- EPA Regions I and II are participating in the Northeast Lakes Pilot Study.
- A workgroup is being formed to define the roles of Regions I, II, and III in implementing future monitoring activities in the Virginian (mid-Atlantic) Province.
- Region IV and several State universities are participating in the implementation of monitoring activities in the Carolinian (southeast) Province.
- Regions IV and VI and several State universities are participating in the Louisianian (Gulf of Mexico) Province Demonstration Project.

Agroecosystems

The EMAP-Agroecosystems Research Plan was completed and underwent peer review in March 1991. The Plan was well received, and interaction with the peer review panel was excellent. While supportive of the approach and progress of the EMAP-Agroecosystems Resource Group, the panel expressed concern in several principal areas: (1) greater use of bioindicators, (2) sampling frame options, and (3) development of a productivity index. These concerns are being addressed as the Agroecosystems Resource Group procedes toward the 1992 pilot study.

The 1992 pilot study will be conducted in North Carolina in cooperation with the U.S. Department of Agriculture's National Agricultural Statistics Service (NASS) and Agricultural Research Service (ARS). Indicators are being developed to address five assessment endpoints: crop productivity, soil quality, water quality, agricultural chemical use, and land use. A final draft of the survey questionnaire for use in interviewing farmers and operators was submitted to NASS for review and to the Office of Manangement and Budget for approval. The Pilot Plan, which is currently being finalized, will contain implementation details, including specific questions to be addressed; samples to be collected; statistical sampling techniques; analytical techniques (for soil and water samples); logistics; quality assurance and quality control; external data required; data management and analysis techniques; graphs, tables, and maps to be produced; and required interactions with other EMAP groups, NASS, and other agencies. The EPA laboratory in Athens, Georgia, has assumed responsibility for developing indicators relating to water quality for the 1992 pilot. Athens lab personnel will continue to have a vital role in agroecosystems program planning and implementation.

The Agroecosystems Resource Group is working closely with the North Carolina representatives of the USDA Soil Conservation Service (SCS) and NASS to develop procedures for determining the soil mapping unit at EMAP-Agroecosystems sample sites using county maps, published soil survey maps, and NASS aerial photographs. The SCS provided a complete list of data elements in the North Carolina State Soil Survey Database, which EMAP-Agroecosystems is evaluating for use in soil quality indicators. NASS also has been working closely with the Agroecosystems Resource Group to develop ARC/INFO (a geographic information system) coverages of agricultural land use intensity in North Carolina. The EMAP-Landscape Characterization group is cooperating with the Agroecosystems Resource Group in acquiring existing land use and land cover data for the Albemarle-Pamlico watershed (North Carolina and Virginia). These data will be used to develop indicators of the ecological condition of agricultural landscapes.

Several indicator development projects are ongoing. The soils from the December 1990 nematode pilot study were analyzed. Indices that have potential for interpreting

nematode community patterns as an indicator of soil health are being evaluated. The study will be continued and expanded this fall, in cooperation with researchers from Oregon State University. In addition to nematodes, the samples will also be analyzed for total and active soil bacteria and fungi. Work also began on developing a standardized measure of crop yield across crops and regions. Standardized yield will be used as a primary measure of crop productivity in the pilot and will eventually be used as a component in a crop productivity index.

Work on statistical, logistical, and information management issues continues. Comparisons of the cost and efficiency of two alternative sampling frames are ongoing. Sample locations (50 from the EMAP hexagon frame and 50 from the NASS rotational panel design) were selected by the Agroecosystems Resource Group statisticians for use in the 1992 pilot. A sampling protocol for collecting soil samples within fields is being developed, as well as a logistics plan for transporting and tracking the soil to the analytic laboratory. The Agroecosystems Resource Group is now equipped with a fully functional ARC/INFO system, and a full-time Information Manager began work in September.

Arid Ecosystems

Arid ecosystems are important ecological resources—comprising nearly 40 percent of the contiguous United States. The Arid Ecosystems Resource Group is charged with developing an integrated, long-term monitoring effort to assess the condition of these resources. In response to this objective, the Arid Ecosystems Resource Group completed its Strategic Monitoring Plan which underwent peer review in March 1991. The research plan addresses the major components of EMAP for arid ecosystems including approach and rationale, design, indicators, data analysis, logistics, quality assurance, information management, and integration and assessment. The Arid Resource Group plans to collect synoptic (full landscape coverage) data using remote sensing techniques and to verify the data through field sampling. The synoptic information, when combined with indicators from selected field measurements and incorporated with historical and retrospective information (e.g., tree ring chronology, pack rat midden data), will collectively determine assessment of long-term trends of arid ecosystem condition.

The Arid Ecosystems Resource Group is evaluating and selecting a suite of indicators for a pilot test in 1992. The relationship of indicators to conceptual models and ecosystem condition are being used in the selection process. This approach should help to improve understanding of how the indicators relate not only to ecosystem structure and function but also to assessment endpoints. It also should provide a framework for incorporating ancillary information from other agencies and data sets that can be useful in assessing trends in arid ecosystems. The indicator evaluation work is a joint effort between the U.S. EPA, the Desert Research Institute, the Idaho National Engineering Laboratory, the Bureau of Land Management, the National Park Service, the U.S. Forest Service, the U.S. Fish and Wildlife Service and several State agencies and private conservation organizations.

The San Pedro Watershed characterization study is being conducted in southeastern Arizona in cooperation with EMAP-Landscape Characterization. The purpose of the study is to develop a multistage remote sensing database for determining spatial extent and composition of upland and riparian ecosystems (those occurring in predominantly arid landscapes, but associated with a sustained source of water, such as a river) via the Brown, et al. hierarchical classification system for biotic communities of North America. Currently, information on species composition and distribution, foliage density, current land use, and other ecological attributes are being acquired for these environments. The project encompasses multistage landscape analysis, classification testing, and indicator evaluation. EMAP-Arid will incorporate these techniques into its overall strategy for the monitoring and assessment of arid ecosystems throughout the western United States.

Forests

The Forests Resource Group's Research Strategy was peer reviewed in March. The review team was impressed with the strategy, current status, and future plans and stated that the experience gained in U.S. EPA programs connected with the National Acid Precipitation Assessment Program provided a solid foundation for EMAP. The review team recommended growth/mensuration, visual damage survey, soil chemistry, and foliar (leaf) chemistry as indicators "ready for operational use" in field monitoring and encouraged further development of an index of tree canopy conditions. Based on the reviewers' comments, a decision was made to use the four recommended indicators, as well as several other experimental indicators, in the FY91 Southeastern Demonstration Project. Other strategic documents developed for FY91 monitoring efforts include a methods manual and QA project plan.

The Forests Resource Group is working closely with the U.S. Forest Service to implement a long-term monitoring effort to assess the condition of U.S. forests. Their first cooperative field effort, the 20/20 study, was conducted during the summer of 1990. Data for five indicators—growth efficiency; vertical vegetation structure (related to wildlife habitat); visual damage indicators of air pollution, injury, disease and insect pests; soil productivity; and chemical analysis of foliage—were collected at 20 forest sites in New England hardwood areas and 20 forest sites in Virginia loblolly pine areas. The processing of data that were collected during this study continues.

Additionally, the second year of monitoring in the Northeast and the first year of monitoring in the Southeast were completed. Monitoring was conducted in Maine, New Hampshire, Vermont, Massachusetts, Connecticut, Rhode Island, Maryland, Delaware, New Jersey, Virginia, Georgia, and Alabama. The Southeastern Demonstration Project, which began in July 1991, measured a set of

indicators (similar to those tested in the 1990 New England and Virginia studies) in loblolly pine forests. A second set of indicators related to wildlife habitat structure, chemical contaminants, and microbial biomass was measured in a subset of sampling sites to evaluate their feasibility for long-term forest monitoring in EMAP. Additionally, the landscape characterization activities for this demonstration project utilized aerial photography and ground sampling to test the following new indicators: photosynthetically active radiation, (which provides a measure of how efficiently trees are converting sunlight into chlorophyll) and vertical vegetation measurements (which are used to assess wildlife habitat conditions). A global positioning system also was evaluated, which uses information from satellites to find precise geographic locations. Field efforts for the Southeastern Demonstration Project were conducted by the U.S. Forest Service, the USDA Soil Conservation Service, the Tennessee Valley Authority, and the southeastern States' forestry agencies.

California and Colorado were the first western States to participate in the Forest Health Monitoring Tier 2 Detection Program. Planning in the western U.S. proceeded separately from the efforts in the eastern U.S. due to major differences in tree species and soil types. The methods and design, however, closely resemble those that are proposed or recently utilized in other Forests Resource Group efforts. Indicators for mosses, lichens (small plants composed of specific fungi and algae living in symbiosis), and mycorrhizae (growths—most frequently found in poor soil—occurring as a result of a symbiotic relationship between certain fungi and the roots of plants and trees) were added for monitoring in the West. Field training for this effort was held at the Blodgett Experimental Forest during July 1991. Sampling activities were completed in August 1991.

Near Coastal

In 1990, EMAP initiated a demonstration project in the mid-Atlantic region (from Cape Cod south to the mouth of the Chesapeake Bay) to evaluate the utility of regional-scale monitoring data for assessing the ecological condition of the nation's estuaries. Information from over 200 sampling sites that were visited during the 1990 Demonstration Project is being analyzed. EMAP scientists are preparing an assessment report that is scheduled for completion and peer review by Winter-Spring 1992. In conjunction with the Demonstration Project, a design workshop was held in May, 1991, to review the statistical design used by EMAP-Near Coastal. A written report was prepared summarizing the workshop's activities and recommendations, which will be incorporated into the assessment report.

Preliminary results from the 1990 Demonstration Project suggest that a number of benthic (bottom-dwelling) indicators were found to discriminate successfully between healthy and degraded sites. The most effective of these were measures of: (1) species richness, (2) the relative abundance of pollution-tolerant and pollution-sensitive species, (3) estimates of the biomass of pollution-sensitive and pollution-tolerant trophic groups, and (4) estimates of the presence of larger, long-lived organisms. Based on these measures, about 19% of the estuarine area of the Virginian Province fails to support benthic populations.

Sediment bioassays using standard methods and sensitive indigenous species indicate that about 8% of the benthic area of the Virginian Province is toxic to test biota. The threat of toxic sediments is highest in small estuarine systems, where 30% of the benthic area exhibits toxic sediments. Fish with visible pathological disorders were found throughout the Virginian Province, although not in significant numbers. Nine of every 1,000 fish caught had pathological disorders of types likely to have been induced by exposure to microbial or chemical contamination. Prior to the 1990 Demonstration Project an estimate of the extent of low dissolved oxygen waters for the Province did not exist. Data collected during mid-summer 1990 indicate that at least 10% of the Province had dissolved oxygen concentrations below a critical threshold of 2 mg/l. The second year of monitoring in the mid-Atlantic estuaries is underway.

The Near Coastal Resource Group's new initiative for 1991 was a demonstration project in the estuaries of the Louisianian (Gulf of Mexico) Province. Sample locations in these estuaries were selected from an area extending from north of Tampa Bay west to the Mexican border. Results from the EMAP-Near Coastal peer review panel report on the Louisianian Province Demonstration Project Plan were positive. The final coordination and planning of the Louisianian Province submersed aquatic vegetation project occurred in May and defined the roles of the participating agencies. The plans proceeded as scheduled, but overflights were postponed until late summer due to the unusual weather conditions experienced in northwest Florida this spring.

In preparation for this summer's sampling activities in the Virginian and Louisianian Provinces, crews from both provinces completed training and certification. Training for the Virginia Province crews placed less emphasis on classroom presentation than previous training exercises and more emphasis on hands-on activities. National Oceanic and Atmospheric Administration and National Marine Fisheries Service personnel provided training assistance in field procedures, photo identification, and fish pathology. Results from the training were positive, and interest in the standardized protocols was expressed by the EPA, Gulf of Mexico Program and other Agency program offices, and several Gulf States resource and water quality agencies. Decisions were reached on the indicators that were used, as well as the location and site maintenance responsibilities for Hydrolab (continuous dissolved oxygen recording units) deployments during summer sampling activities.

Great Lakes

In an effort to provide greater exposure of the EMAP program, an overview of EMAP and EMAP-Great Lakes was presented at the 34th Annual Conference of the International Association on Great Lakes Research. Panel discussion members included representatives of the U.S. Fish and Wildlife Service, the EMAP-Great Lakes Resource Group, the University of Michigan, and Environment Canada.

The Great Lakes Resource Group is developing a program plan that integrates existing Great Lakes monitoring efforts and supplements these efforts with pilot studies that utilize a phased approach for evaluating indicators and design options. Integration endeavors include coordinating Great Lakes, Surface Waters, and Wetlands Resource Group pilot studies. Preliminary discussions include the Wetlands Resource Group's input into the Great Lakes research plan, co-location of sampling stations, and selection of common indicators. The program plan is due for completion in March 1992.

Recent integration efforts also involved coordinating the Great Lakes programs with groups in the U.S., Canada, and Soviet Union.

- Discussions are underway to involve the National Oceanic and Atmospheric Administration (NOAA) in the EMAP-Great Lakes program. Although not directly involved in monitoring activities, NOAA's Great Lakes Environmental Research Laboratory conducts process research in the Great Lakes. A cooperative effort is planned during the 1992 EMAP pilot study in Lake Michigan.

- Efforts to coordinate a Great Lakes sediment evaluation program with Environment Canada are underway, and will focus on developing sediment contamination indicators and evaluating sediment toxicity, benthic community structure, and the relationship between sediment toxicity/ benthic community structure.

- During a meeting on joint ecological studies with a delegation from the Soviet Union, it was decided that initial research efforts will focus on zebra mussels. The zebra mussel, a mollusc species native to Europe, arrived in the Great Lakes region through discharges of ballast water from European ships. Since arriving, zebra mussels have caused damage to industrial pipelines and have raised questions regarding long-term impact to fisheries. The ability of EMAP to assist in assessing the current distribution and ecological impact of the zebra mussel in the Great Lakes is being investigated.

Surface Waters

During the first half of 1991, the Surface Waters Resource Group focused its efforts on preparing for the 1991 summer Northeastern Lakes Pilot Study. Using the EMAP two-tiered sampling approach, a set of 65 lakes was selected. Twenty-nine additional lakes were selected specifically for Temporally Integrated Monitoring of Ecosystems [(TIME) a Clean Air Act monitoring program] using an enhanced grid. A set of 20 additional lakes was identified for field testing of indicators.

In support of the pilot study, several important documents were prepared, including the Research and Monitoring Strategy, the Northeastern Pilot Project Implementation Plan, a field operations and training manual, a Quality Assurance Plan, and a methods manual. In an effort to obtain explicit logistics and stressor information, site questionnaires were prepared for each of the lakes. Information obtained from the questionnaires should supplement data obtained from spatial databases, such as the U.S. Department of Agriculture's Northeast National Resource Inventory, which is being reviewed to identify approaches for characterizing and evaluating the spatial extent of various stressors to lakes and streams.

The Northeastern Lakes Pilot Study field crew training conducted in June 1991 stressed hands-on training with a few classroom sessions to reinforce field work. EMAP-Surface Waters intends to use the Global Positioning System in conjunction with sonar for development of bathymetric maps, and physical habitat characterization work.

Significant progress was made on the development of the indicators using fish. These range from an indicator of biotic integrity based on fish assemblage data, to pathology and tissue residue. Information was gathered on the EPA priority pollutants that have been monitored during the Near Coastal Resource Group's field activities, the EPA National Bioaccumulation Survey, and the U.S. Fish and Wildlife Service National Contaminant Biomonitoring Program. In conjunction with the northeastern monitoring effort, the University of Maine completed a pilot test on the 20 indicator lakes to evaluate the feasibility of a riparian bird survey.

In a related effort, a work group composed of representatives of EPA headquarters and regional offices, the U.S. Food and Drug Administration, the U.S. Fish and Wildlife Service, the Ohio River Valley Water Sanitation Commission, and several other State agencies is developing consistent Federal guidelines for monitoring fish tissue contaminant levels to help States determine the need for fish consumption advisories. Draft guidance for the States is anticipated by the end of FY91. EMAP-Surface Waters will reevaluate the fish tissue contaminant indicator pending results of the guidance.

Future activities of the Surface Waters Resource Group include finding a comparable sediment toxicity indicator for the Surface Waters, Great Lakes, and Estuaries Resource Groups; continuing long-term monitoring; proceeding with the TIME project in the mid-Appalachian region beginning in FY92; and developing a national lake frame from the Office of Water's River Reach File 3 (a

database of hydrographic information for the surface waters of the continental U.S.)

Wetlands

The Wetlands Resource Group is conducting an indicator evaluation pilot study in the coastal marshes of Louisiana and a design evaluation pilot study using data from four States. The indicator evaluation project will compare hydrology, vegetation associations, composition and abundance of wetland species, and other indicators of ecological condition in 20 wetlands considered by coastal wetland experts to be in acceptable condition and 20 wetlands considered to be in unacceptable condition.

Significant planning progress was made for the pilot project at an indicators workshop with representatives from Federal, State, and public interest groups. The discussion topics included EMAP's proposed suite of indicators of salt marsh condition, site selection criteria, and indicator evaluation. Recent accomplishments include finalizing the sampling design and approach for hydrology evaluation, discussing site selection protocols, and developing a Quality Assurance Plan for the study. EMAP coordinated planning with the National Oceanic and Atmospheric Administration and Utah State University to obtain satellite data and videography to compare with field data from the Louisiana Pilot Study. Staff from the U.S. Corps of Engineers' (COE) Waterways Experiment Station will visit the field sample sites to determine whether one of these sites might meet their needs as a reference site. Field activities and training began in September, 1991.

The EMAP-Wetlands 5-year strategy, "The Environmental Monitoring and Assessment Program: Research Plan for Monitoring Wetland Ecosystems," is available for distribution (EPA 600/3-91/010). In May, 1991, a planning workshop was held to discuss collaboration between the U.S. Fish and Wildlife Service (U.S. FWS), National Wetlands Inventory Status and Trends Program and the EMAP-Wetlands Status and Trends Program. A summary report, outlining proposed areas of cooperation, rationale, time lines, and strategies for accomplishing tasks, was prepared. One potential cooperative effort being discussed by EMAP-Wetlands and the Northern Prairie Wildlife Research Center of the U.S. FWS is a collaborative midwestern pilot study in the prairie pothole region of the U.S. Another potential cooperative effort being discussed by EMAP-Wetlands is a southeastern pilot study of bottomland hardwood wetlands. Discussions are with the U.S. Forest Service, the Southeast Consortium for Forested Wetland Research, EMAP-Forests, and EPA Region IV.

EPA is in the process of formalizing an agreement with COE for cooperative wetlands research in the areas of indicator development, functional wetlands classification, and change detection (condition and extent). The agencies initiated discussions regarding long-term monitoring of the Cache River Basin Study Site in Arkansas. Research being conducted at the site by the U.S. Geological Survey and COE is designed to provide detailed process level information necessary for the development of quantitative models that assess the biological functions of bottomland hardwoods. Because of the relatively pristine condition of the site and available background data, EMAP-Wetlands is considering the site as a potential reference bottomland hardwood wetland.

Air and Deposition

The combined air and deposition monitoring and ecological effects monitoring mandated under the Clean Air Act Amendments are being coordinated through a work group process identified as CASTNET (Clean Air Status and Trends Network). Nearly all work being done by EMAP Air and Deposition has been subsumed by the CASTNET process. CASTNET is divided into eight work groups: four monitoring groups—total deposition, aquatic and terrestrial effects, visibility/acid aerosols, and air toxics/great waters—and four work groups that provide infrastructure. Like EMAP, CASTNET is an interagency/intergovernmental/international operation, with participation by EPA, other Federal agencies, universities, State agencies, and Canadian environmental agencies. CASTNET's goals include (1) determining the status and trends of air pollutant levels and their environmental effects, (2) developing a scientific database to better understand causality for policy considerations, and (3) assessing how effectively the Clean Air Act goals are being met.

EMAP will be performing all of the ecological effects monitoring and assessment as required by the Clean Air Act. As part of EMAP-Surface Waters, TIME (Temporally Integrated Monitoring of Ecosystems) will sample for chronic aquatic effects on an annual basis, and LTM (long-term monitoring) will sample for episodic effects 4 to 18 times per year. CASTNET will integrate the ecological effects work being done by EMAP into the air and deposition monitoring done within the network to provide Clean Air Act assessments. All of CASTNET's air and deposition monitoring to meet Clean Air Act Amendment objectives must also be sufficient to meet EMAP program objectives for its other national programs and ecosystems.

The draft CASTNET Technical Design Considerations document is scheduled for the ORD peer review process in FY92. The first phase of siting (10-15 sites) will occur during the second and third quarters of FY92, the same time at which the Clean Air Science Advisory Committee review will be sought for the complete network design. The final design document and plan, with all technical protocols and quality assurance regulations, is scheduled for completion by the end of FY92.

The process to identify site locations during all phases of siting will involve making a preliminary identification based on a particular need (i.e., to improve spatial or temporal resolution, to reduce interpolation errors, or to provide ecosystem-specific and critical ecoregion monitoring). After a potential site location has been determined, maps of existing sites (wet, dry, ozone, visibility, air toxic) will be overlayed to discover if there are existing sites that could be used in their current state, or augmented and upgraded, to fulfill the need for monitoring in that area. Frequent communications with EPA Regional Offices and State agencies are expected.

Landscape Characterization

The principal function of the Landscape Characterization Group is to map ecological resources and compile spatial data on the primary physical anthropogenic and biotic characteristics of the environment to aid in (1) developing sampling frames for use by the EMAP resource groups in selecting sites for monitoring, and (2) interpreting observed ecological condition of resources (e.g., forests, wetlands, lakes, and streams). In support of this goal, the Landscape Characterization Group initiated the Chesapeake Bay Watershed Characterization Project, the Landscape Characterization Accuracy Assessment, the Illinois Wetlands Frame Pilot, and several other strategic endeavors.

The Chesapeake Bay Watershed Characterization Project is a cooperative effort with the EPA's Chesapeake Bay Program Office. The project, initiated in February 1991, is the first large-area demonstration of EMAP's Landscape Characterization multistaged approach for generating landscape characterization data and will provide an opportunity for integrating the spatial data with terrestrial (EMAP-Forests) and aquatic (EMAP-Near Coastal) indicators of environmental condition. The project's progress includes:

- Completing a mosaic of Landsat Thematic Mapper (TM) scenes that cover the entire Chesapeake Bay watershed.
- Initiating automated image processing of 1990 baseline TM imagery to classify land cover within the watershed.
- Acquiring U.S. Fish and Wildlife Service, National Wetland Inventory (NWI) data for the watershed (FY91-92).

The Landscape Characterization Group designed and is testing a three-part accuracy assessment of land use and land cover interpretations made from data obtained during the Ten Hexagon Pilot Project. The Ten Hexagon Pilot Project, initiated in FY90, demonstrated the use of color infrared aerial photography and Landsat TM data for detailed, ecological mapping over ten 40 km^2 hexagons that were located in three different physiographic regions in the eastern United States. The three assessment methods—field verification, aerial photography, and digital airborne videography—will allow the group to gather sufficient reference points for determining the accuracy of the mapped data. In addition, the utility and cost-effectiveness of each accuracy assessment method will be evaluated.

Recent progress in the Illinois Wetlands Frame Pilot study—an initiative designed to provide data for trial applications of different sampling protocols—includes the processing of digital wetland data. Processing has been facilitated by the development of a Geographic Information System (GIS) program that aggregates NWI wetland classification categories into EMAP-Wetlands categories. The program includes a search routine that scans the area near a wetland to determine an appropriate locational category (e.g., next to a river, lake, or isolated basin). The GIS program will be applied to two additional study areas that represent a variety of wetland environments in Washington and the Prairie Pothole region.

Another pilot project is underway to evaluate the sensitivity of the Tier 1-grid (see page 1 feature article) for detecting and estimating different measures and indicators of landscape composition and pattern. The results of this effort will improve EMAP's understanding of the landscape characteristics that EMAP can effectively estimate given its statistical design.

During the next few months, the Landscape Characterization Group will revise its characterization strategy and 3-year agenda. The aim of this effort will be to maintain EMAP-Landscape Characterization objectives while increasing reliance on hierarchy in terms of remote sensing techniques, mapping scales, and classification details.

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-relevent and managerial questions on a regional scale.

Several projects are in progress. A final draft of the "Integration and Assessment in EMAP: Critical Functions for Achieving EMAP's Mission" document was completed. After undergoing review by EMAP Technical Directors, Technical Coordinators, and Steering Committee members, the document was reviewed by a newly-formed mentor group composed of scientists and policy analysts. The final document will be available in FY92. Development of the Group's Example Integrated Assessment Project also is proceeding; several ecoregions were aggregated for this project. An example Integrated Assessment Report is being developed for this effort and will serve as a guideline for interpreting and evaluating policy-relevant information on a regional scale. Its focus will be to present appropriate integrated reporting units and a conceptual outline for the final Assessment Report. Another Integration and Assessment Group effort is a draft of the EMAP Glossary, which is being reviewed by the Steering Committee and Technical Directors. The Glossary will ensure that consistent definitions are used throughout EMAP.

Most recently, the Group began preparing an assessment framework document to illustrate the relationships between assessment objectives, assessment endpoints, conceptual models, data analysis, and integration and interpretation of EMAP data. Several EMAP components (e.g., design, indicators, landscape characterization) are specifically addressed in the framework document. In addition, the Integration and Assessment Group joined with several other EMAP groups to create a pilot of the EMAP Information 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. With the help of the mentor group, Integration and Assessment also began the process of identifying and developing appropriate assessment tools.

Indicators

The Indicators Group completed two important documents during the first half of 1991: "The Indicator Development Strategy for the Environmental Monitoring and Assessment Program" (EPA /600/3-91/023) and an "Analysis of Selected Extant Data for Birds in New England." The development strategy includes (1) a vision of how a fully functional EMAP indicator development project would operate; (2) a framework for determining indicator development needs; (3) criteria and protocols for selecting, evaluating, and reevaluating indicators; (4) procedures for coordinating indicator-related activities among resource groups; and (5) an organization, communication, and coordination plan.

The second report serves as a first year (1990) summary report for the New England Bird Biodiversity Project. This initial report, now in review, suggests that micro-habitat (within a 3 ha circular area) and macro-habitat (within a 50 ha circular area) are equally useful for predicting the presence of common bird species breeding in New England. Report results also suggest that common New England bird species that exhibit similar foraging behavior and habitat use typically have similar population trends. Both results support the idea of trends in bird biodiversity. To confirm these initial results, additional indicators research is being pursued in a 1991 and 1992 cooperative agreement with the University of Maine and cooperating scientists at the EPA Environmental Research Laboratory (ERL-Las Vegas), Environmental Photographic Interpretation Center in Warrenton, VA; Environmental Research Laboratory-Corvallis, OR; U.S. Forest Service, Ft. Collins, CO; and U.S. Fish and Wildlife Service, Laurel, MD. This research will involve, in part, analyses of habitat and landscape features at different spatial scales (e.g., from along Breeding Bird Survey routes to New England region) in relation to temporal trends in bird species richness, abundance, and diversity.

In a related project, validation of landscape indicators and biodiversity, scientists at the University of Maine will address two fundamental needs of EMAP—detection of a real population response to environmental stress given inherent natural variability and detection of large temporal and spatial variation from population processes. This project will involve a thorough analysis of existing data on bird abundance and agricultural statistics to identify bird bioindicators that reflect changes in land use and habitat quality due to agriculture.

During the next few months, the Indicators Group will discuss indicator issues with the staff of all EMAP groups, as well as interested groups outside of EMAP, to formulate and prioritize required activities and to further develop indicator strategies. To provide an effective communication tool, ensure consistency, and assist with presentations and reviews, a database that traces the history and status of all EMAP indicators through time also will be developed. When completed, the database can serve as a prototype for the more complex database proposed in the Indicator Development Strategy document.

Logistics

The long-term objective of the Logistics Group is to provide guidance and support to the resource groups on field operations by enhancing and stream lining EMAP field monitoring efforts through integrated team approaches. To help achieve this objective, standardized logistics plans are being developed for all resource groups implementing field activities. Resource groups that implemented field activities this summer are Near Coastal, Surface Waters, Wetlands and Forests.

Each of the EMAP Resource Groups has a designated logistics coordinator. The coordinators convene bimonthly to discuss logistics issues. These meetings have been effective in addressing logistics problems as they occur. In upcoming months, the Logistics Group will work toward resolving issues related to standardizing the operational procedures associated with communications, bar codes, Global Positioning Systems, and logistics documents.

Total Quality Management

In keeping with the objective of the Total Quality Management Group to provide guidance, support, oversight, and planning assistance to the resource groups on quality assurance and quality control protocols for EMAP monitoring and assessment activities, some portions of the EMAP Quality Assurance Program Plan (QAPP) are being revised. This will ensure that the QAPP will continue to present an integrated strategy for guidance and coordinating quality assurance activities across resource categories, regions, and monitoring programs.

A Quality Assurance Management System Review was performed this spring on EMAP pilot studies conducted in 1990 by a team composed of the EMAP Quality Assurance Technical Coordinator and Quality Assurance Officers from the Office of Modeling, Monitoring Systems, and Quality Assurance and the Office of Environmental Processes and Effects Research. The purpose of this review was to evaluate EMAP's structure for its ability to facilitate the integration of quality assurance into program activities. The findings will provide EMAP management with information on the effectiveness of the current quality assurance program.

Approximately 75 persons representing government agencies, universities, and industry attended the 4th Ecological Quality Assurance Workshop from February 26 to 28, 1991, in Cincinnati, OH. A variety of topics related to biological field monitoring programs were addressed. Planning began for the 5th Ecological Quality Assurance Workshop, which will be held in Toronto during fall 1992. EPA and various Canadian environmental groups tentatively agreed to co-sponsor the workshop.

In addition to assuring compliance with the EMAP Quality Assurance Program Plan, the Total Quality Management Group provides guidance and support for specific data collection and analysis activities of the resource groups. In response to this objective, Quality Assurance Project Plans from the Surface Waters and the Forests Resource Groups were reviewed and comments were forwarded to the respective quality assurance directors. The Total Quality Management Group will review other resource group quality assurance plans as they become available.

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Selle, T. 1991. A GIS Procedure to Create a National Lakes Frame for Environmental Monitoring. Presented at the Eleventh Annual Environmental Systems Research Institute (ESRI) Conference. May 20-24, Palm Springs, CA.

Stevens, D.L., Jr. 1991. A Continuous Universe Generalization of Horvitz-Thompson Estimation. Presented at the IMS-WNAR Western Regional Meeting. July 1-3, Santa Barbara, CA.

Stoddard, J.L. 1991. Long-Term Changes in Watershed Nitrogen Retention: Its Causes and Aquatic Consequences. Presented at a Special Symposium on Environmental Chemistry of Lakes and Reservoirs, American Chemical Society. April 15-19, Atlanta, GA.

Stribling, S. 1991. Application of Q/A Concepts from the Third Ecological Workshop to a Long-Term Aquatic Field Assessment Pilot Study. Presented at the Fourth Ecological Quality Assurance Workshop. February 26-28, Cincinnati, OH.

Turgeon, D., and J. Paul. 1991. NOAA/EPA Federal Marine Monitoring Program. Presented at the Minerals Management Service Marine Monitoring Workshop. June 18-19, Anchorage, AK.

White, D. 1991. Visualizing Quality Begins with Epistemology. Presented at the NCGIA Workshop on Visualization of Spatial Data Quality. June 8-12, Castine, ME.

Recent and Upcoming Events

Neotropical Bird Conservation Program Meeting. September 3-5, 1991, Arlington, VA. *Contact: Dan McKenzie (503) 754-4625 or FTS: 430-4625.*

EMAP-Statistics and Design Workshop. September 4-6, 1991, Portland, OR. *Contact: Tony Olsen (503) 754-4790 or FTS: 430-4790.*

Water Systems Modernization Symposium. September 10-12, 1991, Dallas, TX. *Contact: Dan McKenzie (503) 754-4625 or FTS: 430-4625.*

Arid/Global Indicators Workshop. September 15-17, 1991, Logan, UT. *Contact: Bruce Jones (702) 798-2671 or FTS: 545-2671/Bill Kepner (702) 798-2193 or FTS: 545-2193.*

FY91 Full Information Management Committee Meeting. September 22-26, 1991, New Orleans, LA. *Contact: Gene Meier (702) 798-2237 or FTS: 545-2237.*

EMAP Technical Director/Technical Coordinator Meeting. September 23-27, 1991, New Orleans, LA. *Contact: Tom Dixon (202) 260-7238 or FTS: 260-7238.*

EMAP-Near Coastal Seminar Series: "EMAP-Near Coastal Demonstration Project: Planning, Training and Implementation" and "Overview of Results of the 1990 Demonstration Project," September 4, 1991; "Optimizing Benthic Sampling Procedures," September 17, 1991; "EMAP-Near Coastal Information Management" and "EMAP-Near Coastal Quality Assurance," October 1, 1991; "1991 Virginian Province Sampling Effort," October 15, 1991; "1990 Virginian Province Benthic Community Response," October 29, 1991; and "1990 and 1991 Sediment Toxicity Results," November 21, 1991. Environmental Research Laboratory, Narragansett, RI. *Contact: Dick Latimer (401) 782-3077 or FTS: 838-6077.*

Arid/Global Carbon Flux Meeting. Desert Research Institute, October 2-3, 1991. Reno, NV. *Contact: Tim Ball (702) 673-7323.*

NATO Conference on Desertification. October 10-12, 1991, Lisbon, Portugal. *Contact: Bill Kepner (702) 798-2193 or FTS: 545-2193.*

National Research Council Meeting. October 21-22, 1991. *Contact: Dan McKenzie (503) 754-4625 or FTS: 430-4625.*

Soil Science Society of America Meeting. October 27-November 1, 1991, Denver, CO. *Contact: Sam Alexander (919) 549-4020.*

EMAP-Arid Indicators Meeting. October 28-30, 1991, Logan, UT. *Contact: Bob Breckinridge (208) 526-0757 or FTS: 583-0757.*

Society of Environmental Toxicology and Chemistry. 12th Annual Meeting. November 3-7, 1991, Seattle, WA. *Contact: J. Lazorchak (513) 569-8114 or FTS: 684-8114/Mark Smith (513) 527-8350 or FTS: 778-8350.*

American Statistical Association Meeting. November 4-6, 1991, San Francisco, CA. *Contact: Tony Olsen (503) 754-4790 or FTS: 430-4790.*

Biennial Estuarine Research Federation Meeting. November 11-15, 1991, San Francisco, CA. *Contact: Bor Orth (804) 642-7332.*

Annual NOAA Status and Trends Program QA and Science Meeting. December 10-12, 1991, Beaufort, NC. *Contact: Dick Latimer (401) 782-3077 or FTS: 838-6077.*

Mapping and Classification Forum. USGS, National Mapping Division; EPA, Office of Information Resource Management, and EMAP-Landscape Characterization Resource Group. February 25-26, 1992, Reston, VA. *Contact: Doug Norton (703) 349-8970 or FTS: 557-3110.*

For more information, please contact Carol Finch in EPA's Office of Modeling, Monitoring Systems, and Quality Assurance, (202) 260-9463 or FTS: 260-9463

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