

PROJECT DESCRIPTIONS

Environmental Monitoring And Assessment Program

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Abstract

EMAP Project Descriptions summarizes the projects and activities being undertaken by each of the resource, integration and assessment, and coordination groups which constitute the Environmental Monitoring and Assessment Program. The project descriptions are organized by each EMAP group, and include a description of the current status and plans for each of the resource groups, as well as major products, and cooperating and collaborating institutions for each project.

The document contains Appendices listing major cooperating federal agencies, state and local governments, and universities and other non-governmental organizations; in addition, the document is comprehensively indexed.

Key Words

environmental monitoring—research, indicators (biology)—research, ecology—research, ecology—management, environmental management, risk assessment, statistics research, sampling, USEPA-EMAP.

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Preface

The Environmental Monitoring and Assessment Program (EMAP) is a joint effort of the Office of Modeling, Monitoring Systems, and Quality Assurance and the Office of Environmental Processes and Effects Research, within EPA's Office of Research and Development.

This document has been prepared to provide information on the major projects within EMAP, especially those scheduled to be completed in 1993 and 1994. EMAP was formally initiated in 1990, and many of its component projects are still in stages of planning and pilot studies. Descriptions of the projects contained in this document as well as lists of available products reflect current program plans, but details are subject to change as EMAP plans are refined. This document is the fourth annual list of EMAP projects, and it is anticipated that this document will be updated periodically to reflect current plans.

For further information on any part of EMAP, contact the appropriate EMAP Contact noted on each Project Description, or the General Sources noted on the back page of this document.

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Section 1.0 Overview of the Environmental Monitoring and Assessment Program

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Introduction

Both the incidence and scale of reported environmental problems in the United States 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 concerned that the impact of pollutants and other environmental stresses now extends well beyond the local scale: climate change, acidic deposition, ozone depletion, non-point source pollution, sediment discharges to waterways, and habitat alteration threaten our ecosystems on regional and global scales. Years of scientific study have heightened environmental awareness and have convinced the U.S. public that the ecological processes determining how our ecosystems respond to both natural and anthropogenic disturbances are extremely complex. Unfortunately, the current status of the environment is not accurately or comprehensively documented, which makes it impossible to assess quantitatively where and at what rate degradation or change may be occurring. While we believe that our government's policies and programs are protecting the quality of the environment, we have not as yet been able to prove this contention with currently available data.

Reported problems, for example, may be increasing across extensive areas of the country, or the reports may simply reflect a more informed and vocal public. Further, it cannot be determined whether the policies and programs now in place are effective to restore damaged resources or to protect those perceived to be threatened. Clearly, there is a need for a national baseline against which future changes in the condition of natural resources can be measured and the overall effectiveness of environmental policies can be evaluated with confidence.

In 1988, the U.S. Environmental Protection Agency's (EPA's) Science Advisory Board recommended implementing a program to monitor ecological status and trends that would identify emerging environmental problems before they reach crisis proportions. The next year, EPA called for 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's) 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, thereby contributing to decisions on environmental protection and management. EMAP data will enable policy makers, scientists, and the public to evaluate the success of current policies and programs and to identify emerging problems before they become widespread or irreversible.

EMAP and Ecological Risk

The EMAP Approach

EMAP's data strengthens ORD's Ecological Risk Assessment Program. When fully implemented in cooperation with other agencies that share resource monitoring responsibilities, this coordinated research, monitoring and assessment effort will provide the information needed to document the current condition of our ecological resources, and to understand why that condition exists. Such information will enable EPA to take proactive steps to minimize future risk or to revise current efforts that fall short of their intended results.

Several key questions have been formulated to guide the program toward meeting its goal:

What is the current extent of our ecological resources, and how are they distributed geographically?

What is the current status of the ecological condition of the resources?

What proportions of the resources are degrading or improving, in what regions, and at what rates?

Are these changes correlated with patterns and trends in environmental stresses?

Are adversely affected resources improving in response to control and mitigation programs?

These questions pose many challenges that cannot be met without a long-term commitment to environmental monitoring on national and regional scales. EMAP seeks to answer these questions by addressing the four objectives shown in Figure 1.

Figure 1. The four principal objectives of the Environmental Monitoring and Assessment Program.

EMAP Objectives

- 1** Estimate the current status of, and trends and changes in selected indicators of the condition of the Nation's ecological resources on a regional basis with known statistical confidence;
- 2** Estimate the geographic coverage and extent of the Nation's ecological resources with known statistical confidence;
- 3** Seek associations between selected indicators of natural and anthropogenic stresses and indicators of the condition of ecological resources; and
- 4** Provide annual statistical summaries and periodic assessments of the Nation's ecological resources.

The EMAP approach to monitoring provides many advantages for long-term, large-scale environmental assessment. Some of these are

- broad geographic coverage,
- quantitative and unbiased estimates of ecological status and trends,

- data to support the analysis of associations between indicators of natural and anthropogenic stresses and indicators of the condition of ecological resources, and
- flexibility to accommodate sampling of multiple types of resources and to identify emerging environmental issues.

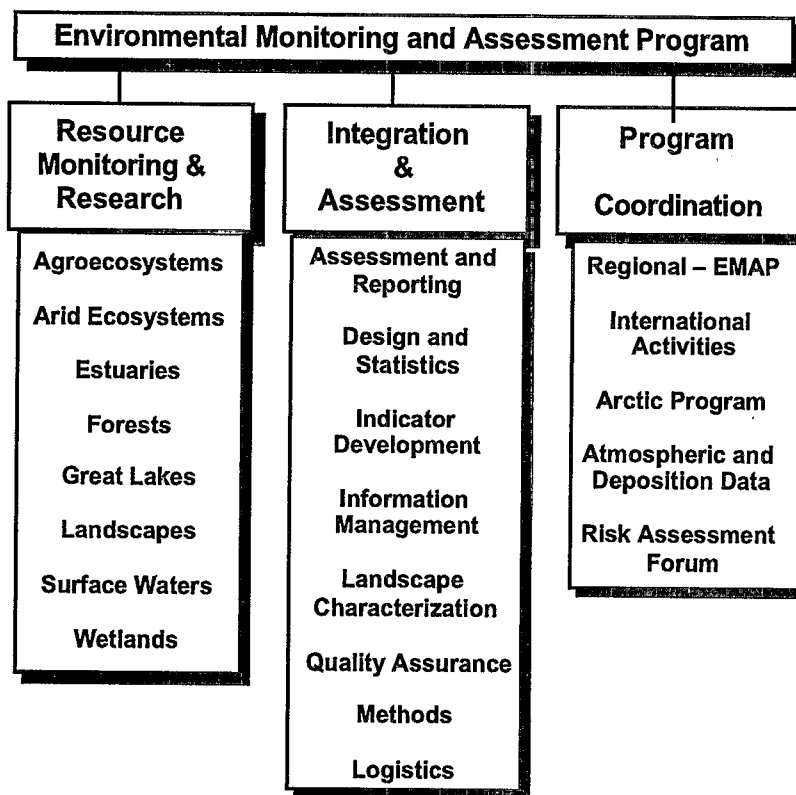
To implement this approach efficiently, EMAP planning, research and field activities have involved other federal agencies and other organizations within EPA, including the program and regional offices. As specific plans for implementation are formulated, EMAP is also enlisting the assistance of state agencies located within the particular areas targeted for monitoring. The development of monitoring plans, which undergo research and verification as well as rigorous technical review by national scientific organizations, is also occurring in concert with many university cooperators. (See below for a discussion of EMAP's cooperative relationships with other organizations.)

EMAP's coordinated monitoring efforts, which will operate on regional scales over periods of years to decades, involve collecting data from eight resource categories: arid ecosystems, agroecosystems, forests, inland surface waters, the Great Lakes, wetlands, estuaries, and landscapes. Field crews will measure biological, chemical, and physical variables and processes on statistically-selected sampling sites for multiple resource classes. Some of these measurements will also be made by using remote sensing techniques. Data on atmospheric deposition and exposure to other selected stressors also will be obtained. Maps, aerial photography, and satellite imagery will be used to describe broad regional patterns of the landscape in areas where sampling is being conducted. The program is undertaking a number of special studies to ensure that it is able to make maximum use of existing environmental monitoring information and systems. Given the scope of its vision, EMAP wants to avoid duplication and is actively building on the experience of past efforts.

EMAP Organization

Organizationally, EMAP has three major elements: Resource Monitoring and Research, Integration and Assessment, and Program Coordination (Figure 2). Resource Monitoring and Research focuses on the identification of appropriate indicators of ecological condition, the collection of field data, and the interpretation of data on the condition of each of the eight EMAP ecological resource categories.

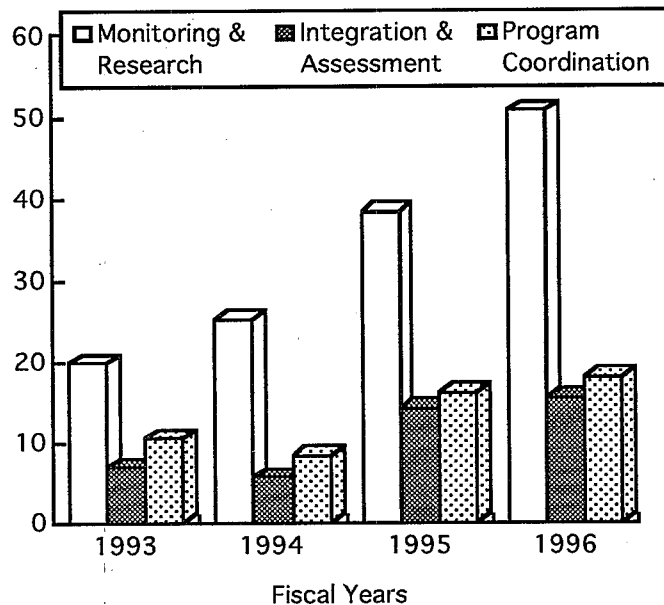
Figure 2. EMAP Structure



Several integration and assessment activities support EMAP's resource monitoring efforts: landscape characterization, statistical analysis and network design, ecological indicator development, information management, assessment and reporting, logistics, methods, and quality assurance. A principal function of the integration and assessment groups is to ensure that data collection activities by the individual resource groups are conducted in compatible ways to enable comprehensive regional and national assessments. Integration and assessment activities also include several functions that facilitate the acquisition, management, and interpretation of monitoring data.

Program coordination includes technology transfer activities through the Regional-EMAP (R-EMAP) program; liaison with the international community, other agencies, states, and related cooperative programs such as the Arctic Contaminants Research Program (ACRP) and the Agency's Risk Assessment Forum; and overall coordination of EMAP's peer review process.

Figure 3. Relative funds distribution for the three elements of EMAP estimated (in \$1,000,000's) for fiscal year 1993 through 1996 (FY94 EMAP Issue Planning Paper, 1993)



The allocation of funds among the three major elements of the program is shown in Figure 3.

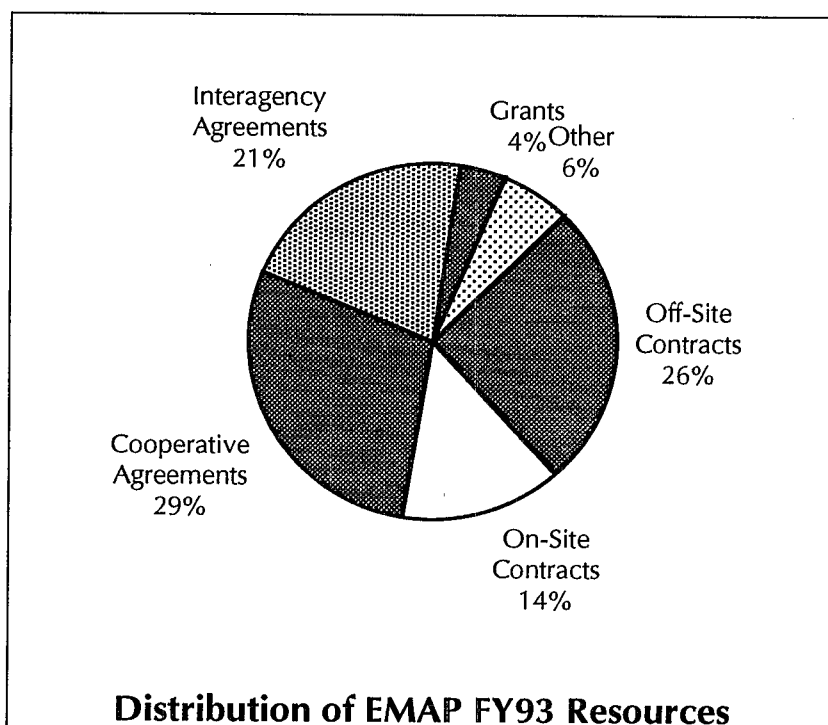
All major groups within EMAP conduct applied and exploratory research that is relevant to their specific resource, coordination, or integration responsibilities.

EMAP as a Cooperative Effort

EMAP will succeed only with the involvement and contributions of a wide range of existing programs, from the local to the national level, in both the public and the private sectors. EMAP has been designed, and is being implemented, as a collaborative effort, with participation from a variety of outside groups including other federal agencies, states, academic institutions and a variety of private and non-governmental organizations.

A diverse group of participants support EMAP as illustrated by the relative distribution of the EMAP budget among various funding vehicles for FY93. (Figure 4, on the next page)

Figure 4. EMAP Disbursements
—estimated for 1993
(FY94 EMAP Issue
Planning Paper, 1993)



Cooperating Federal Agencies

Partnerships with other federal agencies have been developed so that EMAP will be closely coordinated with existing environmental programs and will augment, rather than duplicate, their research efforts. Agencies with expertise in specific natural resource areas (such as the U.S. Department of Agriculture (USDA) Forest Service in forests, and the National Oceanic and Atmospheric Administration (NOAA) in estuaries) increasingly share responsibility with EPA for EMAP's monitoring in that resource. In Appendix C we list seventeen of EMAP's major interagency relationships in program planning, design, field implementation, analysis and assessment reporting.

Details concerning each agency's participation throughout EMAP's various components are presented under the list of contributing institutions for each project description.

Regional, State and Local Participation

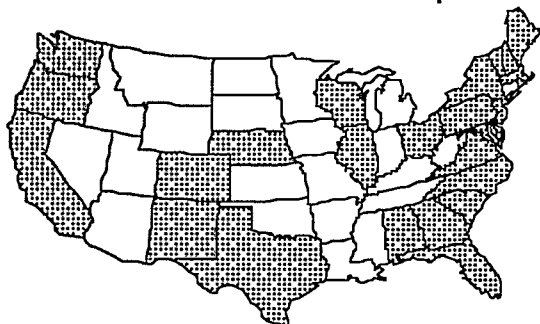


Figure 5. States collaborating in one or more EMAP projects.

Whereas federal agencies participate in EMAP activities in order to augment their own assessments of national or regional environmental conditions or program effects, states, local agencies and special jurisdictions generally look to EMAP to provide new technology or background information. The adjoining map shows which state governments are currently participating in EMAP projects. Appendix D identifies current state and local agency participation with EMAP in more detail. In addition to participating in monitoring of status and trends on the Regional level, EPA Regional and state representatives are helping to identify EMAP's applicability for ecological assessments on state and multi-state scales. One element of this collaboration is the R-EMAP (Regional-EMAP) project described in Section 4 of this document.

In addition to working with other federal agencies, EPA regional offices and states directly, EMAP is also coordinating research with the Agency's geographic initiatives and ORD issues such as the Great Lakes, the Chesapeake Bay, the Gulf of Mexico, south Florida, national wetlands and estuaries, Global Climate Change, Habitat/Biodiversity,

and Eco-Risk. Cooperative research by EMAP and the Risk Assessment Forum (See Section 4 of this document) includes distinguishing ecological change due to natural processes from that caused by human events, measuring ecological recovery from stress, and identifying reference sites with which to assess ecological condition.

Peer Review

As EMAP is a developing program, its concepts, approaches, and strategic plans must be subjected to critical review, tested in regional demonstration projects, and periodically re-evaluated before they are adopted as standard operating procedures. Periodic review and evaluation will determine whether refinements to the program are necessary. EMAP data, plans, and reports are presented for critical review to the scientific community and representatives from government agencies whose missions complement those of EMAP.

Expert peer review is a critical component of EMAP's research, simultaneously serving to strengthen the program's scientific base, and to facilitate communications with significant constituencies. The program supports four levels of peer review to ensure that appropriate attention is given to each project area as well as to EMAP's general merit and relevance. At the highest level, two separate boards review the program's plans, results, and overall direction. The Ecological Effects Committee of the EPA Science Advisory Board evaluates EMAP's relevance to the ORD mission, including consistency with the goals of the Ecological Risk Assessment Program and other ORD activities. A joint committee of the National Academy of Science's National Research Council assesses EMAP's scientific merit and its integration both internally and with other government-sponsored monitoring programs.

Specialized peer-review panels focus on individual EMAP project areas. They determine the scientific merit of research plans and results associated with field tests and full-scale monitoring, as well as cross-program activities including statistical design, quality assurance, and landscape characterization. These panels are assembled from independent scientific organizations including the American Statistical Association and the Estuarine Research Federation, as well as from university faculties and other agencies.

In the third level of EMAP peer review, laboratory, regional, and program office collaborators evaluate the consistency of EMAP's research plans and applications with the missions and procedures of Agency partners. Relevant issues often include personnel and budget, as well as science.

Finally, staff from EMAP's various resource groups periodically publish research articles in national and international peer-reviewed journals. In addition, the program co-sponsors and staff present findings at conferences on ecological research and monitoring topics where members of scientific organizations and institutions have the opportunity to review and respond to EMAP activities and results.

Academic Participation

One of EMAP's strengths derives from the diversity of skills and experience in its extensive network of contacts with academic institutions across the country. As examples of the range of academic participation in the program, the Desert Research Institute of the University of Nevada at Reno is the lead cooperator for the development of ecological indicators and indices for EMAP-Arid Ecosystems, while Oregon State University is leading a sampling

project in Alaska as part of EMAP's support for the Arctic Contaminants Research Program.

While this document is not intended to detail the full extent of university involvement in EMAP, each project description briefly addresses the cooperative research being performed by all institutions involved in the project. In addition, Appendix E provides a comprehensive chart that lists the various roles played by all universities currently participating in the program. Finally, individual academic institutions can also be identified in the index, under "Universities."

Section 2.0 Resource Monitoring and Research

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Introduction: Resource Monitoring and Indicator Development

EMAP monitoring activities for the eight resource groups are still in the demonstration phase. The highest priority for all of the resource groups—even those with the most advanced monitoring databases—is indicator development and evaluation. Steps in the indicator development process include

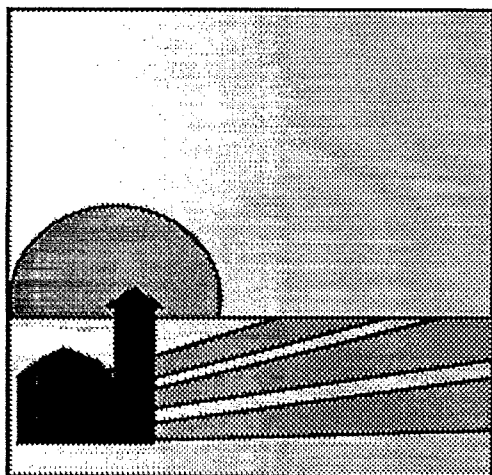
- formulation of assessment questions representing the highest level of social values associated with each resource group;
- indicator development and evaluation based on the assessment questions;
- pilot studies used to evaluate the sensitivity of indicators and to estimate their variance components;
- tests of analytical methods, logistics, field sampling protocols and information management procedures.

Subsequent to satisfactory completion of pilot studies—as verified by peer reviews—demonstration projects are implemented to evaluate the feasibility of conducting regional-scale monitoring of these indicators and to evaluate whether the indicator will meet data quality objectives at regional scales of resolution.

Appendix A summarizes the research and implementation schedule for the eight resource groups from FY93 through FY97.

2.1 Agroecosystems

Introduction



An agroecosystem is a dynamic association of crops, pastures, livestock, other plants and animals, atmosphere, soils, and water. Agroecosystems include not only the field, but also the associated border areas such as windbreaks, fence rows, ditch banks, and farm ponds. Agroecosystems are contained within larger landscapes that include uncultivated land, drainage networks, rural communities, and wildlife. Agricultural landscapes are disturbed by purposeful human activity that significantly alters the original character of the landscapes. The disturbances, while essential or economically advantageous, can result in changes that concern society. These changes include soil erosion, increasing dependency on fossil fuels, contamination of soil, water and crops with agrochemicals, decreased genetic diversity of major crops and livestock, and reductions in the richness and diversity of species inhabiting the landscape.

Modern agriculture is now challenged with producing a sustainable supply of affordable food and fiber in an economically viable manner, while preserving the short-term and long-term ecological integrity of the local, regional, and global environment. In an agroecosystem, a relationship exists between sustainable crop and livestock production; maintenance of air, soil, and water quality; and diversity of wildlife and vegetation in noncrop habitats. The degradation of any one component influences the other components in the agroecosystem and in the surrounding landscape.

To monitor the condition of this resource, EMAP-Agroecosystems has divided the resource into four preliminary classes:

- annually-harvested herbaceous crops;
- perennial fruit and nut crops;
- pasture; and
- farm ponds, windbreaks, and other uncultivated agricultural lands (including fence rows, ditch banks, farm roads, and farmsteads).

The primary environmental or ecological value identified by EMAP-Agroecosystems is sustainability—the ability to maintain or enhance the function of agroecosystems over time.

To address the ecological aspects of sustainability, EMAP-Agroecosystems is focusing on three social values: productivity; the quality of air, water, and soil; and biodiversity. The monitoring program being developed is based upon assessment questions related to these values. Biotic and abiotic condition indicators, such as crop productivity or crop production efficiency, soil quality, soil biotic diversity, insect diversity, and habitat suitability for wildlife, are being developed and evaluated to address each primary assessment question.

Contributing Institutions

The EMAP-Agroecosystems component is an interagency, interdisciplinary, ecologically-based effort that represents a developing partnership between the EPA and the U.S. Department of Agriculture's Agricultural Research Service (USDA-ARS), National Agricultural Statistics Service (USDA-NASS), and Soil Conservation Service (USDA-

SCS). Faculty and staff of North Carolina State University have also played an integral role in the genesis of EMAP-Agroecosystem. The current and increasing commitment from each of these agencies has enabled the development of a sound scientific basis for EMAP-Agroecosystems, and will allow for continued progress towards the conceptual framework and operational infrastructure.

Available and Upcoming Products

| | |
|---|---------------|
| <i>EMAP-Agroecosystems Annual Statistical Summary—An Hypothetical Example</i> | November 1990 |
| <i>EMAP-Agroecosystems Monitoring and Research Strategy:</i> | April 1991 |

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FY92 Pilot Project in North Carolina

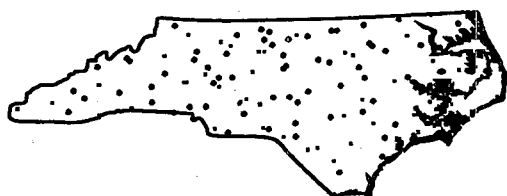


Figure 6. EMAP and NASS Field Sites (EMAP-Ag GIS, 1993)

EMAP-Agroecosystems initial pilot field program was conducted in North Carolina (during 1992). EMAP conducted the pilot cooperatively with the National Agricultural Statistics Service (USDA-NASS) on a single resource class (annually harvested herbaceous crops, including vegetables and forages). Indicators selected for the 1992 pilot included crop productivity, soil quality, land use and landscape structure, pesticide use, farm pond and well water extent and quality, and a biological indicator of ozone concentrations. Sampling was done using the USDA-NASS sampling units (based on square mile—640 acre or 260 hectare—segments), either from 25% of the EMAP hexagon sampling frame, or from one replicate of the USDA-NASS rotational panel sampling frame with an average of three fields selected per segment. The USDA-NASS area frame stratifies segments on the basis of intensity of agriculture prior to selection, and one-fifth of the segments rotate out of the sample and are replaced each year. Both the USDA-NASS and EMAP frames are complete area coverage, probability-based sampling frames.

A major goal of the 1992 pilot was to evaluate the USDA-NASS sampling frame and the EMAP sampling frame in terms of precision of information obtained and costs. Data were collected at two times. In June, a survey questionnaire was completed for each field. In mid-October to mid-December an additional questionnaire was completed with each grower or operator; soil and water samples were taken. This pilot is fully described in the *FY92 Pilot Project Plan* (EMAP-Agroecosystems, 1993).

Data processing and analysis is continuing for the North Carolina pilot. The report on the North Carolina pilot will include a data and statistical summary, a discussion of the indicators tested, the relationship between the two sampling designs, lessons learned on logistical and information management issues, and an assessment of the costs and benefits of working with USDA-NASS.

Contributing Institutions

U.S. Department of Agriculture, National Agricultural Statistical Service (USDA-NASS).

USDA-NASS is a full partner with EMAP-Agroecosystems in the design and implementation of this field monitoring design and survey process. Because USDA-NASS has well-established systems and credibility with farmers who must be surveyed for agroecosystems monitoring, EMAP contracts with USDA-NASS to conduct the field surveying in each state. Similarly, USDA-NASS maintains raw EMAP data under the same confidentiality procedures which are used for the regular USDA-NASS surveys, according to a guarantee by Congressional statute.

Available and Upcoming Products

| | |
|--|----------------------|
| <i>EMAP-Agroecosystems FY92 Pilot Project Plan</i> | <i>October 1993</i> |
| <i>Report on the FY92 Region IV (North Carolina) Pilot Field Program</i> | <i>December 1993</i> |
| <i>Special Report to participants on the FY92 Region IV (North Carolina) Pilot Field Program</i> | <i>December 1993</i> |

FY93 Pilot Project in Nebraska

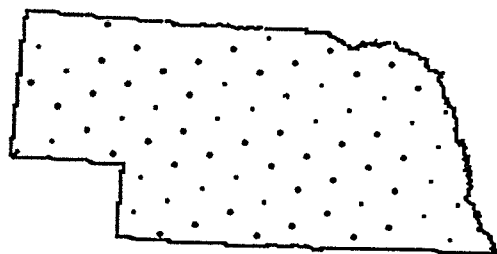


Figure 7. EMAP-Agroecosystems FY93 Pilot Sites in Nebraska (EMAP-Ag GIS, 1993)

Field sampling will continue in FY93 with a pilot study in Nebraska. The pilot is planned as a cooperative program with USDA-NASS and the Soil Conservation Service, again focusing on annually harvested herbaceous crops. The primary objective of the pilot—to evaluate indicators and design issues—resembles that of the FY92 North Carolina pilot, but focuses on an agricultural landscape that is ecologically different. Indicators will be similar to those identified for the first pilot, except that no water sampling will be done, and an increased emphasis will be placed on soil quality indicators. The sampling will again test the two different sampling designs, using 25% of the EMAP hexagons in Nebraska (about 72 locations) and three of the USDA-NASS replications (about 216 locations) in order to achieve better distribution of fields across the state and to reduce respondent burden.

Indicators for use in the Midwest will be developed by evaluating data collected in the field and assessing the ability of these indicators to satisfy EMAP indicator criteria and statistical reliability criteria. Data from the FY92 North Carolina and FY93 Nebraska pilots will be used to establish initial sample numbers needed on a regional basis to meet EMAP data quality objectives. The pilot will also compare the USDA-NASS rotational panel and EMAP hexagon sampling frames in a highly variable agricultural area for efficiency in terms of cost and reliability of estimates. Domain estimation techniques will be used to expand extent estimates to the regional level, and statistical analysis procedures will be further developed and refined.

Contributing Institutions

U.S. Department of Agriculture, National Agricultural Statistical Service (USDA-NASS).

USDA-NASS continues its partnership with EMAP-Agroecosystems to test and implement the field monitoring design and survey process in Nebraska. USDA-NASS enumerators are also collecting selected field samples, such as soil condition indicators, for subsequent laboratory analysis.

U.S. Department of Agriculture, Soil Conservation Service (USDA-SCS).

USDA-SCS state soil scientists will dig soil pits within each of the soil map units crossed by the transect across a field used by USDA-NASS enumerators, in order to obtain soil samples for additional physical and chemical characterization. This activity is part of the continuing effort to develop indicators of soil quality and will aid in determining how soil samples should be taken as well as the parameters that should be evaluated for EMAP.

North Carolina State University (NCSU), Raleigh, North Carolina.
Lead activity in development of the indicator for soil biotic diversity is at NCSU. NCSU provides salary support and laboratory facilities for development of various indicators of biotic diversity.

Available and Upcoming Products

| | |
|---|---------------------|
| <i>Region VII (Nebraska) EMAP Agroecosystems Pilot Plan</i> | <i>October 1993</i> |
|---|---------------------|

Conceptual Model and Assessment Questions

The conceptual model for EMAP-Agroecosystems is in development; it must be formalized, finalized and reviewed through an appropriate peer review panel. This model will guide further improvements in EMAP-Agroecosystems, and will focus ongoing development of assessment questions and condition indicators.

Available and Upcoming Products

| | |
|---|----------------------|
| <i>EMAP-Agroecosystems Revised Strategy Plan</i> | <i>December 1993</i> |
| <i>Manuscript for journal article: EMAP-Agroecosystems Monitoring Program</i> | <i>December 1993</i> |

Potential Condition Indicators for Agroecosystems

This project will explore, develop, and evaluate new condition indicators for agroecosystems with emphasis on insect diversity, wildlife, farm ponds, and socioeconomic factors. The project will also continue development of new soil-quality indicators, with the goal of selecting several potential research indicators for field testing in FY94, and shall be responsible for leading development of soil quality indicators. A review of existing literature and a workshop of experts will initiate this effort; potential cooperators for indicator development will be identified through these workshops.

Contributing Institutions

North Carolina State University (NCSU), Raleigh, North Carolina.
NCSU provides the leadership and personnel for developing indicators of soil biotic diversity.

U.S. Department of Agriculture, Soil Conservation Service (USDA-SCS).

An USDA-SCS soil scientist will join the EMAP Agroecosystems Resource Group in FY94 as indicator lead for soil quality.

Available and Upcoming Products

| | |
|---|-----------------------|
| <i>Journal Article: Nematode Community Structure as an Indicator of Soil Biotic Diversity</i> | <i>December, 1993</i> |
| <i>Report on insect indicators available for use in monitoring agroecosystems</i> | <i>December 1993</i> |

FY94 Demonstration and Pilot Field Projects

EMAP-Agroecosystems will engage in a Pilot Field Program in Regions IV (North Carolina) and VII (Nebraska) in FY94. Indicator development will be the primary goal of each of the pilots with emphasis on the resource classes of annually harvested herbaceous crops in both pilot areas, and windbreaks in Region VII only. Specific new indicator field programs in Region VII will concentrate on the condition or suitability of windbreaks adjacent to agricultural fields as habitat for wildlife. In Region IV, emphasis will be on monitoring insect biodiversity in fields, in border areas around fields, and in farm ponds. Other indicators of soil quality, crop productivity, and land use will also be used in each pilot.

An opportunity also exists to coordinate EMAP-Agroecosystems activities with those of the EMAP groups for Surface Waters, Forest Health Monitoring, Landscapes, Landscape Characterization, Indicators, and Assessment and Reporting in the Mid-Atlantic Highlands Assessment (MAHA) project being implemented by EPA Region III. If funds are available, EMAP-Agroecosystems, with USDA-NASS and USDA-SCS, is planning to participate in the MAHA project as a field demonstration for FY94. (See the discussion of this Regional-EMAP project in Section 4 of this document.)

Contributing Institutions:

U.S. Department of Agriculture, National Agricultural Statistical Service (USDA-NASS).

USDA-NASS will continue to conduct the field monitoring for the Region III demonstration and for the Region IV and VII pilot field projects.

U.S. Department of Agriculture, Soil Conservation Service (USDA-SCS).

The USDA-SCS will support the soils components of the demonstration and pilot monitoring projects.

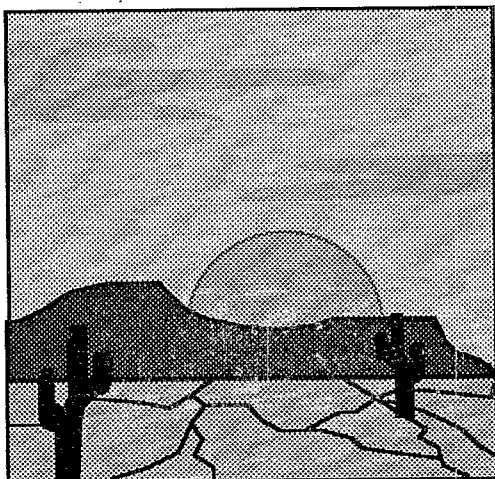
EPA Region III.

Environmental Services Division of EPA Region III is coordinating a comprehensive environmental monitoring and assessment process for the Mid-Atlantic Highlands.

Available and Upcoming Products

| | |
|---|------------------|
| <i>North Carolina and Nebraska Pilot Plans for 1994</i> | <i>June 1994</i> |
| <i>Mid-Atlantic Highlands Demonstration Plan</i> | <i>June 1994</i> |

Introduction



2.2 Arid Ecosystems

Arid ecosystems are terrestrial systems characterized by a climatic regime where the potential evapotranspiration exceeds precipitation, annual precipitation ranges from less than 5 cm to 60 cm (2 to 24 inches), and air temperatures range from -40° to $+50^{\circ}$ Celsius (-40° to 122° F). Arid ecosystems include desert scrub, grasslands, prairies, chaparral, open woodland, alpine tundra, and associated riparian communities, but exclude intensively managed agriculture such as irrigated farmlands. Arid ecosystems formerly occupied nearly 40 percent of the conterminous area of the United States. Additionally, arid ecosystems include the Arctic Desert of Alaska. About 65 percent of the arid ecosystems in the 11 western states are in public ownership.

The EMAP-Arid Ecosystems program (EMAP-Arid) is evaluating and selecting indicators of arid ecosystem condition relative to three important social values—productivity, biotic diversity and aesthetics. Condition indicators of productivity will include estimates of net primary productivity (NPP) and changes in NPP. For instance, changes in photosynthetic activity relative to environmental stress will be measured from remotely placed sensors (aircraft or satellites), which can evaluate spectral reflectance via statistical comparisons such as Normalized Difference Vegetation Index (NDVI). Possible biotic diversity indicators include vegetation composition, abundance and structure. Aesthetic values will be addressed using fractal dimensions, connectivity, and other indicators of landscape patterns.

EMAP-Arid initiated field research in 1992 with a pilot study in the Colorado Plateau (comprising parts of the states of Arizona, Colorado, New Mexico and Utah) in 1992. The pilot evaluated indicators, logistic feasibility, and the relation between field data and remotely sensed information. EMAP-Arid also has developed a Desertification Susceptibility Index as an example of how EMAP condition and stressor indicators can be used to assess ecological conditions at a regional scale.

Contributing Institutions

U.S. Department of Agriculture, Forest Service (USDA-FS).

U.S. Department of Agriculture, Soil Conservation Service (USDA-SCS).

U.S. Department of Interior, Bureau of Land Management (BLM).

U.S. Department of Interior, Fish and Wildlife Service (FWS).

U.S. Department of Interior, National Park Service (NPS).

University of Arizona, Tucson, Arizona.

University of Nevada, Desert Research Institute, Biological Sciences Center, Reno, Nevada.

Navajo Nation, Window Rock, Arizona.

Grand Canyon Trust, Flagstaff, Arizona.

Society for Range Management, Steering Committee on Unity and Concepts and Technology, Brookings, South Dakota.

Available and Upcoming Products

| | |
|--|--|
| <i>Arid Ecosystems Strategic Monitoring Plan</i> | <i>June 1991</i> |
| <i>Arid Colorado Plateau Pilot Study—1992, Implementation Plan</i> | <i>January 1993</i> |
| <i>Remote Sensing Techniques in the Analysis of Change Detection. D.A. Mouat, G.G. Mahin, J. Lancaster</i> | <i>Geocarto International (2) 1993: pp. 39-50.</i> |
| <i>Colorado Plateau Pilot Study Fact Sheet</i> | <i>June 1992</i> |
| <i>The Spectral Indicator Fact Sheet</i> | <i>September 1993</i> |
| <i>Remote Sensing Examination and Assessment of the Upper San Pedro River Watershed, Arizona</i> | <i>December 1993</i> |

EMAP Contact:

William G. Kepner
U.S. EPA Environmental Monitoring Systems Laboratory
P.O. Box 93478
Las Vegas, NV 89193-3478
(702) 798-2193

GIS Technology Integrated with Condition Indicators

Desertification is considered a significant process of land degradation in arid, semi-arid and subhumid ecosystems because it results in a loss of productivity and diversity. The causes of desertification often include human activities related to land use, and its impacts can be exacerbated by climatic events such as long-term drought. This initiative proposes using Advanced Very High Resolution Radiometer (AVHRR) imagery and sample-based datasets to develop indicators (e.g., of climate, erosion potential, grazing pressure, forage potential) which collectively could be integrated into a model to assess desertification. Because geographic information systems (GIS) is a tool which can evaluate and correlate spatial data crucial to desertification studies, GIS can provide an opportunity to explore integration of indicator data.

Integrating GIS technology with condition indicators will facilitate plans for the required demonstration-level study on desertification of the Colorado Plateau scheduled by EMAP-Arid for FY95.

Available and Upcoming Products

*Desertification Susceptibility User Interface
(GIS Software)*

November 1993

Workgroup on Nominal or Subnominal Ecological Condition

Under this project, EMAP-Arid will continue its focus on problems related to desertification by convening a workgroup of university and EPA scientists. This workgroup will determine condition thresholds which relate to nominal, marginal, and subnominal categories for selected indicators of rangeland condition. Through the Committee on Unity and Concepts and Technology of the Society for Range Management, an international, professional association of range scientists, the workgroup will explore how certain ecological indicator results can, separately and in combination, be partitioned into condition classes. EMAP-Arid's focus is the development of ranking criteria related to indicators of susceptibility to desertification, particularly those that can be employed on a regional scale. Although EMAP-Arid is specifically interested in the four states which comprise the Colorado Plateau, the workgroup will broaden its activity throughout the eleven western states.

Available and Upcoming Products

*"Multidimensional Monitoring for Assessing
Sustainability of Arid Ecosystems," in
Proceedings of the 25th International
Symposium on Remote Sensing and Global
Environmental Change. Breckenridge, R.P., W.
G. Kepner, D. A. Mouat.*

September 1993

Indicator Plot Design Pilot Study

EMAP-Arid has identified and placed priorities on a number of research indicators, only a few of which have been subjected to field testing. An evaluation of suitable plot sizes and shapes is required for the array of measurements currently under study within the EMAP-Arid indicator categories of vegetation, soil properties, and spectral measurements. This project will determine the optimum field plot size and shape for selected indicator measures within arid ecosystems by conducting uniformity trials with nested plot designs in three EMAP-Arid resource classes, followed by a determination of plot size and shape variances. Information derived from the pilot study will be crucial to developing a regional demonstration study for the entire Colorado Plateau in FY95.

Available and Upcoming Products

Field Operations and Training Manual

September 1993

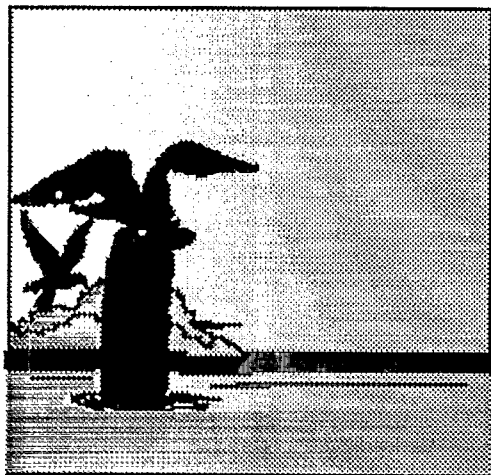
Quality Assurance Manual

September 1993

Final Implementation Plan

May 1994

Introduction



2.3 Estuaries

Estuaries are semi-enclosed bodies of water where freshwater mixes with seawater. Estuaries include fjords, bays, inlets, sounds, lagoons and tidal rivers. The outer boundary is the coastal waters, and the inland boundary is the limit of tidal influence. The important role estuaries play in sustaining the health and abundance of marine fishes, shellfish, and birds has long been recognized. The EMAP-Estuaries data collection program was initiated in 1990 with a demonstration project in the Virginian Province which stretches from Cape Henry to Cape Cod on the mid-Atlantic coast. Since 1990, EMAP-Estuaries has continued the collection of monitoring information in the Virginian Province on an annual basis (rotating among a series of sites distributed throughout the estuaries of the Province, based on EMAP-Estuaries' adaptation of the EMAP design methods). In 1991, EMAP-Estuaries began monitoring in the Louisianian Province (the Gulf Coast from the Mexican Border to the panhandle of Florida), including the modification and calibration of indicators for the diverse conditions of the Gulf Coast. Since inception monitoring has continued in the Louisianian Province.

In 1993, pilot monitoring activities will begin in the Carolinian Province, with responsibilities for managing the provincial monitoring residing with the Strategic Assessment Branch of NOAA, a close collaborator with EMAP-Estuaries throughout the program. Analysis, review, writing, and publication of summarized monitoring data, and the results of pilot studies in the Virginian Province and elsewhere will lead to a number of publications. EMAP-Estuaries has also amassed a considerable volume of monitoring data, which is nearly ready for release to the public, and which has already been shared with a number of collaborators such as EPA's Chesapeake Bay Program.

In addition to "internal" monitoring and assessment activities, EMAP-Estuaries has developed an aggressive outreach program for actual and potential users of EMAP-Estuaries information. This effort has been well received by EPA regional offices and many of the larger coastal and estuaries programs which have their own responsibilities for long-term monitoring and assessment. A variety of collaborative efforts are underway to share efforts and data to maximize mutual benefits. EMAP-Estuaries has also invested considerable efforts in sharing design and methods expertise with other groups.

EMAP Contact

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1 Sabine Island Drive
Gulf Breeze, FL 32561
Telephone: 904/934-9244

Program and Operations Center

The Program and Operations Center is designed to provide EMAP-Estuaries with support for planning and coordinating its entire research and monitoring program. The Center also conducts assessment and evaluation activities.



Figure 8. Biogeographical Provinces of Estuaries (EMAP Draft Program Guide, 1993)

The Center will conduct assessments and prepare special reports to address EMAP-Estuaries questions on societal, regulatory, scientific, management, and policy issues. In addition, the Center provides EMAP-Estuaries with the statistical and design services required to conduct its monitoring and assessment functions using a probability-based design compatible with EMAP's major design components.

The Program and Operations Center will perform a variety of additional functions, including reviewing and preparing reports, evaluating the results of technical workshops, and preparing briefing materials. The Program Center will provide support for contaminant assessments, evaluations of indicator response across the Virginian and Louisianian Provinces, and development of an indicator and sampling design strategy for 5-year implementation. The Program Center also will analyze data from the Virginian and Louisianian Provinces to determine the advantages of random vs. systematic site location; develop a classification scheme for large estuaries, small estuaries, and tidal rivers; conduct power analyses using existing and model-based strategies; and refine the confidence interval approach used to date.

Cooperating Institutions

Estuarine Research Federation (ERF).

The ERF provides a high level of peer review to EMAP-Estuaries, ranging from continuing review of the group's research plan, to review of the monitoring plans and assessment reports from each of the group's province-based regional demonstration projects.

University of Rhode Island (URI) Kingston, RI.

URI manages the field monitoring phases of EMAP-Estuaries activities in the Virginian Province.

U.S. Department of Interior, Fish and Wildlife Service (FWS).

FWS has supplied laboratory analytical and research support for indicator development and assessment planning.

U.S. Department of Commerce, National Oceanic and Atmospheric Administration (NOAA).

NOAA is a full partner in many aspects of the EMAP-Estuaries design, monitoring and assessment processes, including the management of future Carolinian Province monitoring.

Available and Upcoming Products

| | |
|--|-----------------------|
| <i>Cross-Province Indicator Evaluation Report</i> | <i>September 1993</i> |
| <i>Annual Report on Available GIS Analytical Functions</i> | <i>September 1993</i> |
| <i>EMAP-Estuaries Indicator and Design Strategy</i> | <i>September 1993</i> |

Virginian Province

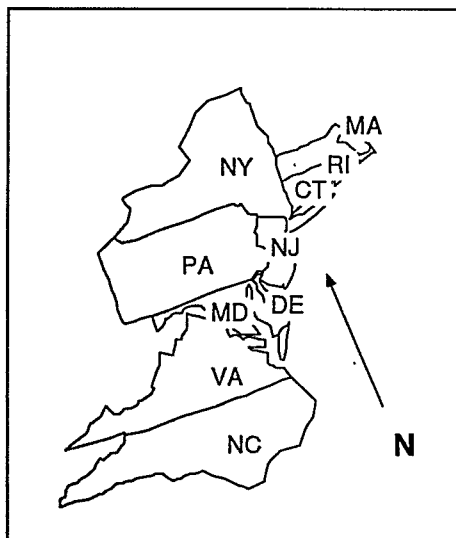


Figure 9. States of the Virginian Province—Cape Cod to Cape Hatteras

The Virginian Province includes Long Island Sound, Delaware Bay, and Chesapeake Bay. Monitoring of estuarine areas in this province began in 1990, and addresses the four main contributors to overall estuarine condition defined by EMAP: ecosystem quality, biotic integrity, consumptive uses, and non-consumptive uses.

Specific steps that EMAP-Estuaries will take in the Virginian Province include

- continuing field sampling (including water quality, benthic, and fin fish abundance measures);
- processing and evaluating benthic infauna samples;
- characterizing sediments;
- processing and evaluating 1993 sediment contaminants;
- assessing 1993 fish pathology, and sediment toxicity;
- providing automated data processing support for the management of 1992 and 1993 data;
- conducting statistical analyses of 1992 data;
- reporting the findings of the 1992 monitoring effort;
- publishing manuscripts of the results of the 1991 and 1992 Virginian Province activities; and
- performing quality control and quality assurance at all levels of the province's program.

In 1993, the Virginian Province will continue and expand interactions with other federal and state activities, including EPA's Chesapeake Bay Program, the Maryland/Delaware Inland Bays Program, Region II's R-EMAP project, states and the EPA Regional Offices. The Virginian Province research plan also will expand technology transfer efforts by sponsoring a Virginian Province User Network Workshop, participating in EMAP-Estuaries research indicator workshops, and participating in an EPA Region III indicator workshop.

Cooperating Institutions

EPA Chesapeake Bay Program, Annapolis, MD.

EMAP-Estuaries and the Chesapeake Bay Program have embarked on a number of joint activities, including common monitoring stations for dissolved oxygen, an attempt to reconcile differing benthic monitoring methods, and collaboration on several other data-sharing activities.

EPA Maryland/Delaware Inland Bays Program.

The Inland Bays program is adapting EMAP techniques to perform detailed studies of water quality and associated land use.

EPA New York/New Jersey Harbor Estuary Program.

Supported by a R-EMAP grant from EMAP, The NY/NJ Harbors Estuary Program is cooperating with EMAP-Estuaries in monitoring activities.

Available and Upcoming Products

| | |
|---|-----------------------|
| <i>Statistical Summary for 1992 Data Collection</i> | <i>September 1993</i> |
| <i>Training Manuals</i> | <i>July 1993</i> |
| <i>1993 Data Base</i> | <i>September 1993</i> |

Louisianian Province

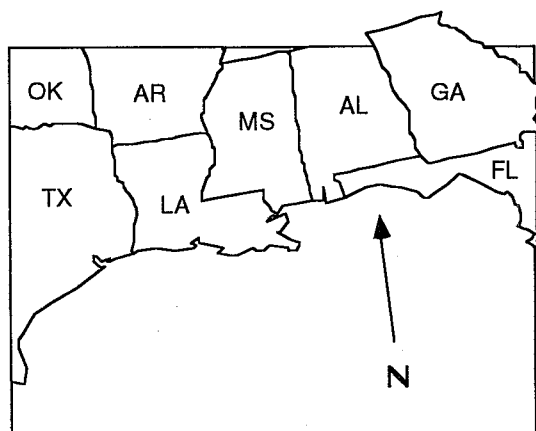


Figure 10. States of the Louisianian Province—Texas to Florida

The Louisianian Province comprises the Gulf of Mexico coastal areas of Texas, Louisiana, Mississippi, Alabama, and the Florida Panhandle. Demonstration monitoring in this area began in 1991. Monitoring in the Louisianian Province addresses the four main contributors of overall estuarine condition: ecosystem quality, biotic integrity, consumptive uses, and non-consumptive uses. To monitor and assess these contributors accurately, the province will conduct

- continuing field sampling (including water quality, benthic, and fin fish abundance measures);
- processing and evaluating benthic infauna samples ;
- characterizing sediments ;
- processing and evaluating 1993 sediment contaminants ;
- assessing 1993 fish pathology, and 1993 sediment toxicity
- providing automated data processing support for the management of 1992 and 1993 data;
- conducting statistical analyses of 1992 data;
- reporting the findings of the 1992 monitoring effort;
- publishing manuscripts of the results of 1991 and 1992 Louisianian Province activities; and
- performing quality control and quality assurance at all levels of the province's program.

The Louisiana Province will continue and expand its interactions with other Gulf of Mexico activities. These interactive efforts are important in developing joint assessments and participating in technology transfer. The Gulf of Mexico Program, EPA Regions IV and VI, NOAA National Status and Trends (NS&T) Program and the Gulf States are among the entities which will work with the Province on its monitoring and assessment activities.

Contributing Institutions

NOAA, National Marine Fisheries Service, Gulf Coast Regional Laboratory.

The National Marine Fisheries Service Regional Laboratory is providing ongoing support to EMAP-Estuarines in the areas of indicator development and assessment planning and reporting.

Texas A&M University and the University of Mississippi.

Both universities are supplying services to analyze monitoring samples. In addition, Texas A&M coordinates much of the field monitoring.

Available and Upcoming Products

| | |
|---------------------------------|--------------------|
| <i>Training Manuals</i> | <i>May 1993</i> |
| <i>1992 Statistical Summary</i> | <i>August 1993</i> |
| <i>1993 Statistical Summary</i> | <i>June 1994</i> |

Carolinian Province

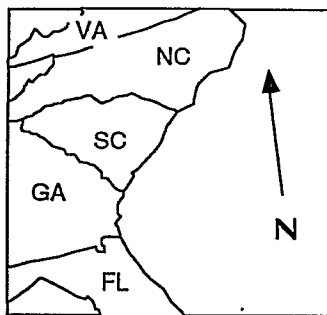


Figure 11. States of the Carolinian Province—Cape Hatteras to Cape Canaveral

The Carolinian Province includes coastal and estuarine areas of the East Coast of the United States from Cape Hatteras to the Indian River Lagoon in northern Florida. Extensive areas of tidal salt marshes and mud flats are ecological features that distinguish this province from the Virginian and Louisianian Provinces. Research in the Carolinian Province provides EMAP with the opportunity to identify region-specific problems of this unique area.

In the Carolinian Province, EMAP will refine assessment questions and monitoring technologies and will develop joint strategies to meet information needs of EPA and NOAA. A proposed pilot study in the province will accelerate the development of an interagency program to assess the condition of the Nation's marine resources and will combine EPA's EMAP-Estuaries and NOAA's National Status and Trends (NS&T) into a unified planning and management entity.

In 1993, EMAP-Estuaries will plan and prepare for full-scale implementation of monitoring activities in the province by developing the sampling design and logistical plans. EMAP-Estuaries will then be able to refine assessment questions to focus on region-specific issues, and calibrate EMAP-Estuaries indicators to unique Carolinian Province physical and biological conditions. The program in the province also will assess the feasibility of incorporating measures of fish population condition into EMAP-Estuaries assessments and will develop and calibrate indicators of shellfish population condition.

Since tidal wetlands constitute a vital component of this province, EMAP will develop indicators to map the extent and condition of tidal wetlands and submerged aquatic vegetation (SAV). The Carolinian Province team will conduct a joint wetlands and estuaries workshop to review the findings of the Louisianian wetland pilot project, develop areal estimates for the Carolinian Province, evaluate submerged aquatic vegetation and tidal marsh productivity, biomass, and other indicators of tidal marsh condition, and evaluate one or more faunal indicators that reflect critical functions of the tidal marshes in the Carolinian Province.

EMAP-Estuaries will conduct indicator development and user workshops; participate in regional and state coordinated workshops; and develop field operations and logistics manuals and a quality assurance plan for implementing a monitoring demonstration project for next year. The Province team also will evaluate existing data on dissolved oxygen, collect new data, calibrate the benthic community indicators developed in the Virginian and Louisianian Provinces, as well as collect and review pertinent scientific literature. For fish population indicators, the Carolinian Province will determine the feasibility of developing a multi-species compositional index and in order to classify Carolinian estuaries into different fish habitats. The province group also will review data from nearshore juvenile fish surveys and will identify methods to measure pollution loadings and land use in the Carolinian Province.

Also in 1993, EMAP-Estuaries in the Carolinian Province will identify and measure selected point and non-point source pollution loadings for the province's estuaries, and will identify available information on land use and land cover in the Carolinian Province.

Contributing Institutions

*National Marine Fisheries Service Regional Laboratories,
Charleston, South Carolina.*

South Carolina Marine Resources Division, Columbia, South Carolina.

University of South Carolina, Columbia, South Carolina.

University of Georgia, Athens, Georgia.

Duke University, Durham, North Carolina.

University of North Carolina, Chapel Hill, North Carolina.

2.4 Forest Health Monitoring

Introduction



Forests cover approximately one-third of the United States and are an important part of the United States economy, culture, and ecology. EMAP follows USDA's definition of forests: Forest land has at least 10% of its surface area covered by trees of any size or formerly having had such trees as cover and not currently built-up or developed for agricultural use. In response to legislative mandates and concerns for our environment, several government agencies have been working together to develop a program to monitor the condition of the Nation's forests. This multi-agency effort, called the Forest Health Monitoring (FHM) program is jointly funded by the EMAP-Forest Health Monitoring resource group (EMAP-FHM) and the U.S. Forest Service. Other contributing agencies and groups include the National Association of State Foresters and individual state forestry agencies, the Tennessee Valley Authority, the USDA Soil Conservation Service, the U.S. Department of Interior's Bureau of Land Management, Fish and Wildlife Service, and the National Park Service.

Increasing concern about documented and potential effects of air pollutants, global climate change, and a variety of insect, disease, and other interacting stressors on forest ecosystems has been the motivation behind Forest Health Monitoring. The FHM program is designed to help resource managers and policy makers manage the Nation's forest resources, allocate funds for research and development, and evaluate environmental policy.

When fully implemented, the Forest Health Monitoring program will include three levels of monitoring. The most general and widespread activity, and the one in which EPA and the Forest Service are full partners, is termed Detection Monitoring. This effort is currently being conducted on more than 700 sites every year in 14 states by the state forestry agencies, with indicators based primarily on tree growth, visual leaf and canopy crown rating, and bioindicator plants.

In addition to Detection Monitoring, EMAP-FHM is conducting two demonstration projects in the East to expand the range of forest condition indicators used in Detection Monitoring, and to test the application of the EMAP sampling design. One demonstration is located in the southeastern loblolly-shortleaf pine forests. The second demonstration is being conducted in collaboration with the Southern Appalachian Man and the Biosphere (SAMAB) Program and the Tennessee Valley Authority (TVA) to test biological indicators in the Southern Appalachians and to experiment with various modes of integrated ecological assessment.

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(919) 549-4020

Detection Monitoring

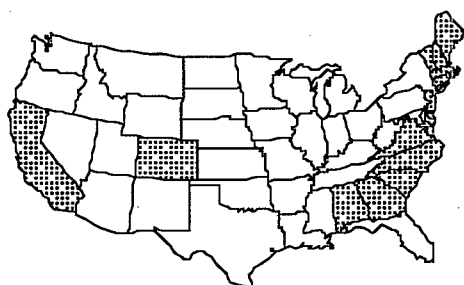


Figure 12. Detection Monitoring States
(EMAP-FHM Issue Plan, 1993)

Cooperating Institutions:

The location of the Detection Monitoring network on the EMAP sampling grid has been an important basis for cooperation in establishing the interagency Forest Health Monitoring program. Detection Monitoring field work is funded by the Forest Service. EMAP-FHM supports the field work with information management, quality assurance, and data assessment services. Extensive data sets developed in Detection Monitoring have led to the development of assessment strategies and integration with auxiliary data. The data have been used to demonstrate the effectiveness of the EMAP design and to evaluate new design options.

U.S. Department of Agriculture, Forest Service (USDA-FS).

USDA-FS works closely with participating state foresters to conduct field sampling, interact with land owners, and assimilate FHM results in state forest management practices. USDA-FS personnel also help plan and carry out program activities in key areas such as indicator development, quality assurance, information management, and assessment.

State Forestry Agencies.

State forestry agencies hire and supervise the Detection Monitoring field crews in the 14 states where Detection Monitoring is currently being conducted.

Available and Upcoming Products

1992 Annual Statistical Summary

October 1993

Southeastern Loblolly- Shortleaf Pine Demonstration

EMAP-FHM is collecting indicator data from the 1993 rotation plots on the EMAP sampling grid in the loblolly-shortleaf pine forests of Virginia, North Carolina, South Carolina, and Georgia. Indicators under evaluation are site condition, growth and regeneration, visual crown rating, damage and mortality, foliar chemistry, soil productivity, stemwood chemistry, vegetation structure, lichen community and chemistry, dendrochronology, air pollution bioindicators, and root disease. Also during FY93, EMAP-FHM will produce an interim report to assess the indicator data collected in FY92. The potential use of the indicators as core indicators for regional assessment will be evaluated following the two-year demonstration.

The demonstration project addresses the following questions:

- How do different indices compare in their ability to identify forest ecosystems in subnominal condition?
- What is the ratio of total measurement error to natural and spatial variability on a regional scale?
- Is there a correlation between regional patterns in condition indicators and regional natural or anthropogenic stresses (e.g., climate, incidence of pests, air pollution, and land management practices)?
- What is the temporal variability of the index period (June-August) and how does this compare to data quality objectives for the detection of meaningful trends in the indicators?
- What are the operational characteristics (e.g., time expenditure, difficulty of measurement, equipment and manpower requirements, impact on the plot, and laboratory analysis costs) of proposed condition indicators?

Cooperating Institutions

U.S. Department of Agriculture, Forest Service (USDA-FS).
USDA-FS personnel serve as lead scientists for several indicators. They have major responsibilities for field crew training, quality assurance, data analysis and assessment, and reporting activities.

Tennessee Valley Authority (TVA).

TVA is responsible for providing logistics support for field training and monitoring activities.

State Forestry Agencies.

State forestry agencies in Virginia, North Carolina, South Carolina and Georgia are responsible for locating plots and obtaining landowner permission.

State Soil Conservation Service Offices in Virginia, North Carolina, South Carolina, and Georgia.

The state soil conservation Service offices provide soil scientists to collect soil data.

Available and Upcoming Products

| | |
|--|---------------------|
| <i>1992 Annual Statistical Summary</i> | <i>October 1993</i> |
| <i>1993 Annual Statistical Summary</i> | <i>August 1994</i> |
| <i>Complete Report on Two-Year Demonstration</i> | <i>August 1994</i> |

Southern Appalachian Man and the Biosphere Project

The ecological resources of the Southern Appalachian Man and the Biosphere (SAMAB) Reserve have been recognized internationally through UNESCO's Man and the Biosphere (MAB) Program. The reserve encompasses a region of high biodiversity representing a mixed mesophytic ecosystem. The SAMAB project complements the southeastern loblolly-shortleaf pine demonstration by allowing scientists to field test and evaluate indicators in a different and highly diverse type of forest ecosystem. This cooperative effort between EMAP-FHM and the SAMAB consortium opens the way for future cooperation between SAMAB and other EMAP resource and cross-cutting groups, including Surface Waters, Agroecosystems, Landscapes, and Landscape Characterization.

Cooperating Institutions:

Tennessee Valley Authority (TVA).

TVA will share costs for this demonstration project with EMAP.

U.S. Department of Agriculture, Soil Conservation Service (USDA-SCS).

USDA-SCS is providing information resources and technical advice on soils-related components of the demonstration.

State Forestry Agencies

State forestry agencies in Alabama, Georgia, North Carolina, South Carolina, Tennessee, and Virginia are responsible for locating plots, obtaining landowner permission and providing assessment advice for the demonstration.

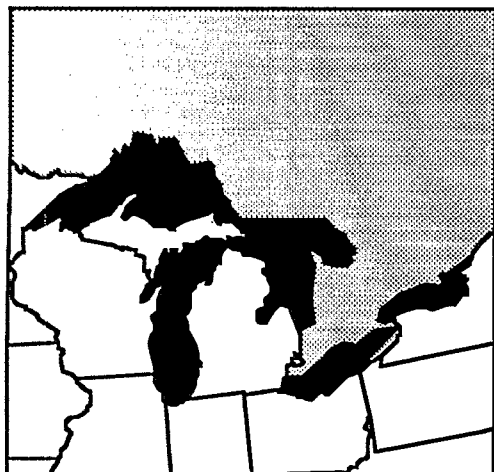
University of Tennessee (UT), Nashville, Tennessee.

UT provides logistics and field staff support to the SAMAB demonstration project.

Available and Upcoming Products*SAMAB Project Report (1992 Data)**August 1993*

2.5 Great Lakes

Introduction



The Great Lakes basin is one of the largest freshwater ecosystems in the world and the most intensively used freshwater resource in North America. The key environmental issues facing the Great Lakes are

- point and non-point source nutrient control,
- toxic substance control,
- remedial programs,
- inadequate information,
- science policy and allocation of research resources ,and
- need to define an effective ecosystem approach to planning for Great Lakes management.

Four of the five Great Lakes are regulated by legislation developed in Canada and the United States, whereas the fifth, Lake Michigan, lies entirely in the United States. The management, protection, and development of the Great Lakes is under the jurisdiction of two federal governments, the province of Ontario, and eight U.S. states, along with numerous municipal, provincial, state, federal, regional, and international agencies.

EMAP-Great Lakes (EMAP-GL) will evaluate the condition of the lakes with respect to three social values: biotic integrity, trophic condition, and fishability. As a surrogate measure for overall biotic integrity, EMAP-GL will focus on three major types of indicators: benthic macroinvertebrates, primary producers, and fish. EMAP-GL is being designed to report on the overall condition of each individual Great Lake. In addition, four population groups have been identified for special analytical attention because they have distinctive physical characteristics: offshore areas, nearshore areas, harbors and bays, and wetlands.

Pilot monitoring activities began in Lakes Superior and Michigan in 1992, and will continue as pilots through 1993, with specific attention to nearshore waters and testing of fish indicators. EMAP-GL will also be working with EMAP-Wetlands to design a wetlands monitoring pilot project.

EMAP Contact

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Diatoms: Indicators of Biotic Integrity and Trophic Status

EMAP-GL will assess the method and frequency for future monitoring of diatom populations. The effort will focus on sediment trap samples because the method affords time-integration samples, does not require an index period, and the collection time period is known. The study will allow an assessment of the feasibility of the sediment trap method. If the sediment trap method is unacceptable, the short core method will be employed. This will lead to the overall formulation of EMAP-GL's strategy for diatom populations.

Cooperating Institutions

University of Michigan, Ann Arbor, Michigan.

U.S. Department of Commerce, National Oceanic and Atmospheric Administration (NOAA).

Benthic Communities in Lake Michigan

Benthic communities are major elements of the Great Lakes index of biotic integrity. Benthic communities can be used to determine the impact of contaminants and habitat modification in the Great Lakes. For this pilot project, EMAP-GL will sample over 60 near-shore and 12 offshore stations to determine the condition of the benthic communities, the sediment toxicity, physical conditions of the sediments, and the chemical contaminant content. This project will allow EMAP-GL to

- classify benthic invertebrate community assemblages according to environmental conditions as one approach to determining nominal conditions;
- examine annual, seasonal, and operator variability in the methods; and
- investigate spatial variance in benthic community structure in the offshore resource class.

Cooperating Institutions

National Water Research Laboratory of Environment Canada, Toronto.

U.S. Department of Commerce, National Oceanic and Atmospheric Administration (NOAA).

Sampling for Fish in the Great Lakes

Fish are a major component of the Great Lakes ecosystem due to their roles as major predators, as potential controlling factors in community structure, and as the source of significant economic income. Fish are an important aspect of determining biotic integrity; lake trout and walleye populations have been proposed as indicators of overall ecosystem condition. Estimates of lake trout currently are determined by the states while forage fish sampling is conducted by the Fish and Wildlife Service. Although the results of these monitoring programs are usually reported on a lakewide basis, none of the current sampling programs is based on a probability design. EMAP-GL will work with FWS to explore data from existing fish assessment programs and conduct pilot studies on alternative sample designs and indicators that will allow estimates of environmental condition with known confidence.

Cooperating Institutions

U.S. Department of Interior, Fish and Wildlife Service

Nearshore Sampling in Lake Michigan

Although indicators of trophic status have been routinely monitored in the Great Lakes for over 15 years, this monitoring focused almost entirely on offshore areas of the lakes. Thus, there is little information on the temporal and spatial variability of these indicators in nearshore areas of the lakes. Similarly, little systematic evaluation of spatial and temporal variations in benthic communities has been conducted. EMAP-GL will initiate a cooperative agreement to sample and evaluate measures of biotic integrity and trophic status in the nearshore

resource class of Lake Michigan. Indicators of benthic community composition and trophic status will be measured during several seasons at proposed EMAP nearshore probability sample locations. These locations will also provide data to investigate alternative class boundaries that have been proposed based on combinations of depth and distance from shoreline. This project will allow EMAP-GL to

- determine the spatial and temporal variability of indicators of benthic community composition in the nearshore resource class of Lake Michigan,
- determine the spatial and temporal variability of indicators of trophic status in nearshore Lake Michigan, and
- evaluate the impact of various proposed boundaries between the offshore and nearshore resource classes on estimates of conditions.

Offshore Pilot Monitoring for Trophic Status in Lake Michigan and Lake Superior

Trophic status is one of the primary research issues for EMAP-Great Lakes. Measurements of trophic status have been the focus of historical and existing monitoring programs through a binational agreement between the U.S. and Canada. EMAP-GL will collect samples during the spring and summer from offshore sampling stations in Lake Michigan and Lake Superior using probability-based sampling designed to produce statements of offshore trophic status with known confidence. Samples will measure chlorophyll, particulate organic carbon nutrients, and optical characteristics. This project will permit EMAP-GL to

- determine the trophic status of the offshore resource class of Lakes Michigan and Superior using existing limnological indicators,
- evaluate the index period by comparing estimates of trophic status in spring and summer sampling periods with historical data,
- identify potential indicators of biotic integrity and trophic status for nearshore areas of both lakes,
- determine the temporal and inter-lake variability of indicators, and
- evaluate the impact of proposed resource class boundaries on estimates of condition.

2.6 Landscapes

Introduction

Landscape ecology is the study of the spatial interactions of ecological resources at scales ranging from a few millimeters to several kilometers (Golley 1987). The bounding or classification of landscapes into units is based on the scale and boundaries of landscape processes and questions being addressed. EMAP-Landscapes uses the emerging discipline of landscape ecology to organize information on ecological condition at the regional level. For land cover-related processes such as succession and biotic composition and flow, EMAP-Landscapes applies Forman and Godron's (1986) definition of a landscape: "a heterogeneous land area composed of a cluster of interacting ecosystems that is repeated in similar form throughout." For water-related processes and monitoring questions, a landscape is defined as a watershed or basin.

Because landscape patterns are thought to reflect ecological processes operating within and among ecological resources, these patterns provide a set of indicators that can be used to address ecological status and trends at a variety of scales. Landscape patterns are an important determinant of the intrinsic stability and sustainability of certain ecological processes. These processes, in turn, result in production and sustainability of ecological goods and services. These services include the provision of water—of suitable quality, in desired quantities, and at the appropriate times—as well as the production of food, fiber, timber, and other valued products.

The primary benefit to EMAP of this approach is a framework for addressing status and trends in ecological values that transcend several scales and ecological resource categories, including biological diversity, water quality, quantity and timing, and productivity.

EMAP-Landscapes is proposing a five-step monitoring approach, beginning with an initial status determination from Landsat Multi-Spectral Scanner data (Step 1). Yearly change detection analyses would derive primarily from the AVHRR (Step 2), with five-year change detection analyses using trend information from AVHRR imagery plus ancillary data from other monitoring programs such as the USDA Soil Conservation Service's Natural Resources Inventory (Step 3). Ten-year resamples of landscape status and determination of change or trends would employ MSS or Landsat-Thematic Mapper™ data (Step 4). Finally, more detailed assessments of areas undergoing change, as determined by Steps 2–4, would take place as needed (Step 5).

First among major activities for EMAP-Landscapes is the development of a detailed research plan for this approach; followed by a peer review. Additionally, EMAP-Landscapes is focusing on technical and operational issues that must be resolved to implement a landscape monitoring program, including specifically:

- identifying landscape values and assessment questions;
- developing conceptual models;
- identifying and testing landscape indicators; and
- identifying landscape units to be monitored.

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Landscape Monitoring Approach

To meet its objectives, EMAP-Landscapes is developing a comprehensive multi-year monitoring strategy that is based primarily on remote sensing data. Since change detection will be an important part of this approach, close cooperation is anticipated with the North American Landscape Classification Consortium (NALC), a joint effort of EPA, the National Atmospheric and Space Administration (NASA), and USGS. Close coordination with EMAP-Landscape Characterization is also anticipated, since this component is establishing standards and approaches for use of spatial information in EMAP.

EMAP-Landscapes is developing a research plan that describes an approach to monitoring landscape status and trends relative to specific societal values. In addition to proposing a comprehensive monitoring strategy for landscapes, the plan will identify key research and development issues that must be resolved in order to implement the proposed approach, and will recommend approaches and strategies for resolving these issues. The research plan and proposed strategy will undergo an external peer review. Parts of the plan will also be submitted for publication in journals.

Cooperating Institutions

University of Nevada, Desert Research Institute, Reno, Nevada.
The Institute is developing strategies and approaches for the change detection portion of the overall approach, especially as they relate to remote sensing science.

North American Landscape Classification Consortium (NALC).
NALC, a joint effort among EPA, NASA, and USGS, is providing coordination of imagery acquisition schedules for Landsat-TM™ and MSS, and collaboration on change detection techniques and issues of spatial data quality assurance.

U.S. Department of Energy, Oak Ridge National Laboratory (ORNL), Oak Ridge, Tennessee.
ORNL is providing technical leadership for the overall landscape monitoring approach, especially in the areas of landscape indicators, conceptual models and assessments.

University of Ottawa, Canada.
The university is providing refinement of societal values to be addressed in the monitoring program, as well as assessment questions and conceptual models.

University of Arizona, Tucson, Arizona.
The University of Arizona is providing methods and approaches for large-scale monitoring using remote sensing.

University of New Mexico, Albuquerque, New Mexico
UNM is developing innovative techniques for analyzing landscape indicators at multiple-scales that have been developed in conjunction with work on the Sevieta Long-term Ecological Research (LTER) site.

University of California -Santa Barbara

UCSB is developing innovative techniques for dealing with spatial data analysis.

Tennessee Valley Authority (TVA)

TVA is applying procedures and approaches for sampling designs and analysis of landscapes.

Available and Upcoming Products

*Research Strategy to Implement a National
Landscape Monitoring Program*

December 1993

Landscape Values and Conceptual Models

EMAP uses a values-driven approach to develop its monitoring components. This involves identification of social values, formulation of assessment questions, development of conceptual models that relate to identified values, testing and selection of indicators, evaluation of sampling design options, and development of implementation specifics. Value identification and refinement and development of conceptual models are critical in developing the overall program and in selecting indicators. EMAP-Landscapes has identified three primary types of values:

- biological diversity,
- water quality, quantity and timing, and
- socio-economics, including aesthetics.

Research is needed to characterize these values more fully, as well as to identify other social values relevant to the landscape monitoring program. Additionally, a set of assessment questions relative to each value must be formulated. EMAP-Landscapes proposes an extensive literature search, and a series of workshops and meetings with technical experts and environmental managers.

EMAP-Landscapes is currently developing a series of conceptual models for landscapes. This series will likely include four fundamental processes occurring within and among landscape scales: biotic, nutrient, energy, and water flows and fluxes. EMAP-Landscapes will develop these models from existing literature or data on landscapes as they relate to landscape values, and through workshops and meetings.

Cooperating Institutions*U.S. Department of Energy, Oak Ridge National Laboratory (ORNL),
Oak Ridge, Tennessee.*

Landscape scientists from ORNL are providing leadership in developing conceptual models for this project and are taking the lead on writing the journal article.

University of Ottawa, Canada.

A university cooperator is conducting an extensive literature search on landscape values and is organizing workshops to refine landscape values. The university also has the lead for writing a journal article.

Tennessee Valley Authority.

TVA is assisting in the development of conceptual models for biological diversity in landscapes.

Available and Upcoming Products

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| <i>Journal Article - Landscape Conceptual Models</i> | <i>September 1994</i> |
| <i>Journal Article - Landscape Values</i> | <i>September 1994</i> |

A National Landscape Assessment: Relationship of Bird Abundance and Species Richness to Landscape Patterns

Breeding bird species richness is an important component of overall species richness in ecosystems across the United States. It is also a relevant component of biological diversity and is an ecological resource valued by the public. This project will involve characterization, by EMAP 640 square-kilometer hexagons, of breeding bird parameters derived from the National Breeding Bird Survey (species presence and abundance). Landscape metrics, including measures of dominance, connectivity, and clustering (e.g., patch sizes) also will be compiled by hexagon and then compared against breeding bird parameters. These hexagons completely tile the lower 48 States and EMAP-Landscapes anticipates characterizing each of these for breeding bird and landscape parameters.

This project will benefit both EMAP-Landscapes and ORD's Habitat/Biodiversity program. EMAP-Landscapes will gain a national assessment of landscape pattern and will determine if landscape indicators derived from the AVHRR satellite are related to breeding bird species abundance and richness. This relationship is important because EMAP-Landscapes is proposing to use AVHRR-derived landscape indicators for yearly assessments of major landscape change, and such changes should be relevant to ecological conditions that that society values. The habitat/biodiversity program will gain an increased understanding of the relationships between breeding birds and landscape attributes, and variations in these relationships in different landscape settings. If a strong relationship exists, it may be possible to use AVHRR-derived landscape status and trends to address relative risks to breeding birds.

Cooperating Institutions

U.S. Department of Energy, Oak Ridge National Laboratory (ORNL), Oak Ridge, Tennessee.

ORNL staff will research landscape indicators for the project and will produce national assessments of landscape indicators.

Oregon State University (OSU), Corvallis, Oregon.

OSU will research spatial statistics necessary to compare breeding bird and landscape data.

U.S. Department of Interior, Fish and Wildlife Service (FWS).

Scientists from the Service's National Breeding Bird Survey will be assisting in the compilation of bird data on hexagons nationally.

U.S. Department of Agriculture, Forest Service (USDA-FS).

USDA-FS will use the landscape and breeding bird data to evaluate a risk assessment protocol currently under development for assessing risk to national biological diversity.

U.S. Department of Interior, U.S. Geological Survey (USGS), EROS Data Center, Sioux Falls, South Dakota.

The EROS Data Center will apply an AVHRR-based classification scheme to derive characterizations of ecological resource types to be used in landscape assessments.

University of Maine, Augusta, Maine.

A cooperator from the University of Maine will coordinate the overall assessment.

Available and Upcoming Products

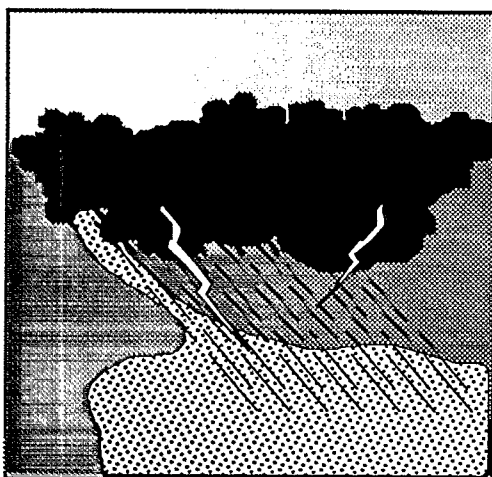
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|---|------------------|
| <i>Manuscript—National Assessment of Landscapes Using AVHRR imagery</i> | <i>July 1994</i> |
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| <i>Manuscript—National Assessment of Breeding Birds</i> | <i>July 1994</i> |
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|---|-----------------------|
| <i>Manuscript—Relationship between AVHRR- derived Landscape Patterns and Breeding Birds</i> | <i>November, 1994</i> |
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2.7 Surface Waters

Introduction



Inland surface waters consist of all of the Nation's lakes (other than the Great Lakes), reservoirs, rivers and streams. The intent of the EMAP-Surface Waters (EMAP-SW) program is to describe status and trends in indicators of the condition of lakes (including reservoirs but excluding the Great Lakes) and streams within the United States with respect to

- biological integrity - the sustainability of a balanced, integrative adaptive community of organisms having a species composition, diversity and functional organization comparable to that of the natural habitat of the region;
- trophic condition - algal and macrophyte abundance comparable to undisturbed systems of the region; and
- fishability - the presence of catchable game fish that are safe to eat.

Currently, EMAP-SW's two primary regional monitoring projects are in the Northeast lakes and the Mid-Atlantic highland streams. In addition, EMAP-SW conducts many smaller monitoring activities.

A second objective of EMAP-SW is to develop an updated and nationally consistent estimate of surface water extent. This effort is necessary because the number and distribution of lakes and streams have been estimated from maps of varying ages and spatial variation. Changes in surface water extent also have occurred with time.

The third objective of the EMAP-SW program is to identify associations between indicators of environmental stresses and indicators of environmental condition. EMAP-SW has begun to develop a diagnostic strategy to aid in selecting useful indicators of environmental stress in four general categories: hydrologic modifications, physical habitat alterations, chemical stressors, and biological stressors (e.g., fisheries management and harvesting, introduction of exotic species).

Available and Upcoming Products

| | |
|-----------------------------|---------------|
| EMAP-SW Research Plan | March 1991 |
| Surface Waters Pilot Report | February 1993 |

EMAP Contact

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Northeast Lakes Demonstration

Through its fieldwork in 1991, EMAP-SW has been able to evaluate trophic state and biological condition indicators on a regional scale. EMAP-SW is currently using five condition indicators of biological integrity that are being developed for lakes:

- macroinvertebrate community index,
- fish index of biological integrity,
- zooplankton community index,
- index of diatom integrity, and

- a riparian bird index.

EMAP-SW is also currently refining two indicators of lake-trophic status: trophic condition index and percent of macrophytic cover.

In its third field season, EMAP-SW will work with the EPA Regions and the FWS to implement additional indicators of biological integrity. Approximately 80 lakes will be visited across the geographic region to collect biological condition indicators based on chlorophyll a, macrophytes, fish, riparian birds, zooplankton, benthos, and sedimentary diatoms. Additional measures will be taken to test the hypothesis that poor biological conditions are associated with either hydrologic, physical habitat, chemical, or biological modifications.

To address fishability values, EMAP-SW is analyzing whole fish tissue for heavy metal and organic residue concentrations. These analyses are being conducted as part of both the Northeast lake demonstration and Mid-Atlantic stream pilot study.

Cooperating Institutions

U.S. Department of the Interior, Fish and Wildlife Service (FWS).
FWS will help to develop an interagency management committee to plan the project's field implementation.

State University of New York, College of Environmental Sciences and Forestry (SUNY-Syracuse).
SUNY has a cooperative agreement with the FWS to conduct the field sampling.

Dartmouth College, Dartmouth, New Hampshire.
Dartmouth College will conduct analysis of zooplankton including species enumeration and development of an index of biotic integrity for zooplankton.

University of Maine, Augusta, Maine.
The University of Maine is conducting the chemical analyses of regional water samples. They also are conducting studies to evaluate and test riparian bird indicators.

Queens College, City University of New York, Flushing, New York.
Queens College is enumerating diatom species and developing an index of biotic diversity using diatoms.

University of Nevada, Las Vegas (UNLV).
UNLV is performing the fisheries analyses, including the consideration of an index of biotic integrity for lake fish assemblages.

Oregon State University (OSU) Corvallis, Oregon.
OSU has a cooperative agreement to assess physical habitat and the regional chemical conditions for the population of Northeast lakes.

EPA Regions.
EPA Regions I and II are responsible with the FWS for regional planning, auditing field crews, and state liaison. Region II also is conducting the Temporally Integrated Monitoring of Ecosystems (TIME) project to address the acid rain issue.

States.

The states of Connecticut, Massachusetts, Maine, New Hampshire, New Jersey, New York, Rhode Island and Vermont are identifying lake access points and reference lakes, and are reviewing field protocols.

Available and Upcoming Products

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|---|----------------|
| <i>Field Operations Manual</i> | June 1993 |
| <i>Annual Statistical Summary for 1992 Data</i> | October 1993 |
| <i>Annual Statistical Summary for 1993 Data</i> | September 1994 |

Stream Condition in the Mid-Atlantic Highlands

Stream activities in the Mid-Atlantic Highlands are part of EPA Region III's Mid-Atlantic Highland Assessment (MAHA) project. This represents the first EMAP-SW regional-scale stream pilot. This project will evaluate reference conditions and biological condition indicators, including the macroinvertebrate condition index and fish index of biological integrity, in streams in two ecoregions in the Mid-Atlantic Highlands. The project also will monitor stream data collected as probability samples to describe regional stream condition. Portions of this project will provide a higher level of detail than the standard EMAP sampling density. EMAP-SW will sample approximately 50 streams in the Mid-Atlantic Highlands of Region III for biological condition indicators (fish, macrobenthos, and periphyton).

Cooperating Institutions

EPA Region III.

EPA Region III is responsible for the overall Mid-Atlantic Highland study. In conjunction with the states, Region III is managing the field monitoring not only for EMAP-SW but also for monitoring 180 other surface water sites in the same general area.

States.

The states of Maryland, Pennsylvania, Virginia, and West Virginia have identified reference sites for the calibration of EMAP-SW monitoring; they have also provided staff from each of the states to work on the field monitoring teams. These states will be key to developing a comprehensive assessment of the results.

Smithsonian Institution, Washington, DC.

The Smithsonian Institution is performing the fish identification for the Mid-Atlantic Highlands studies.

Oregon State University (OSU), Corvallis, Oregon.

OSU is determining the physical habitat attributes for each site and estimating regional chemical condition.

University of Maine, Augusta, Maine.

The University of Maine is performing the chemical analyses for samples collected in this study.

Available and Upcoming Products

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| <i>Draft Field Operations Manual</i> | March 1993 |
| <i>Annual Statistical Summary</i> | June 1994 |

Analysis of Existing Data on Lake Fish

Few lake investigators have addressed the questions of status and trends in fish assemblages or how these data may describe biological integrity of lakes. These issues are key to the success of EMAP. An exhaustive literature review, particularly on fish, must be done to

determine the applicability of different biological assemblages for assessing biotic integrity. EMAP-SW will identify and evaluate existing data sets and literature for the ability to determine the variance components needed to evaluate status and trends in EMAP and indicators of lake condition based on fish assemblages.

Cooperating Institutions

University of Nevada, Las Vegas (UNLV).

UNLV is conducting the literature search and analysis of existing data bases on lake fish assemblages.

Wisconsin Lakes Inter-Agency Pilot

The Intergovernmental Task Force on Water Quality Monitoring is developing a comprehensive framework for coordinating the various information needs for water quality monitoring, including the need for national, regional, and local status and trends. EMAP-SW goals for this pilot project are to evaluate method protocols, establish reference sites and test biological indicators in Midwest lakes. The goals of this Task Force overlap with the goals of EMAP-SW. Therefore, EMAP-SW will participate in pilot activities that may affect national efforts to obtain reliable data on status and trends. EMAP-SW will develop a pilot activity to illustrate how the Inter-Governmental Task Force on Water Quality Monitoring might coordinate interagency monitoring in the United States.

Cooperating Institutions

U.S. Department of Interior, U.S. Geological Survey (USGS).

An interagency agreement was initiated with USGS to conduct a comparison of methods, a comparison of program objectives for monitoring among EPA, the State of Wisconsin, USGS and the FWS, and a comparison of reference site selection criteria. The USGS also will coordinate sampling activities as part of the Wisconsin Inter-Agency Pilot study.

U.S. Department of Interior, Fish and Wildlife Service (FWS).

FWS will be assisting USGS with the comparative studies.

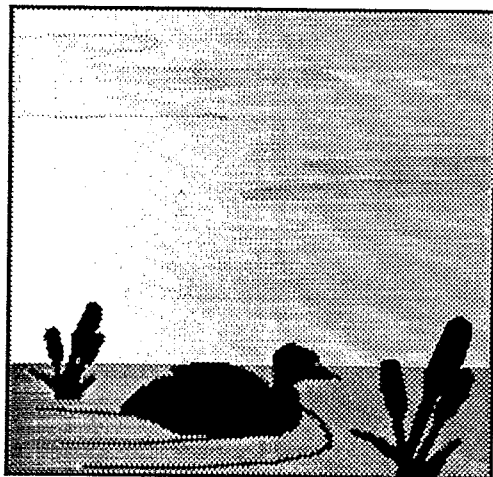
EPA's Office of Water and EPA Region V.

The Office of Water and Region V also will be assisting USGS in these comparative studies.

The State of Wisconsin.

The State of Wisconsin is providing the facilities for the project team, local knowledge of reference sites, historical perspective on monitoring in Wisconsin and assisting with the comparative studies.

Introduction



2.8 Wetlands

In wetlands, water saturation or shallow covering by water is the dominant factor determining the nature of soil development as well as the types of plant and animal communities living in the soil and on its surface. Wetlands are lands transitional between terrestrial and aquatic systems: common names ascribed to wetlands—marshes, swamps, potholes, bogs, fens, and pocosins—attest to the variety of wetland types. EMAP-Wetlands has aggregated 56 wetland types used by the FWS National Wetlands Inventory into twelve classes. From these twelve classes, the current program is focusing on three wetland classes which constitute 80% of the vegetated wetlands in the United States:

- **Estuarine Emergent** - These salt marshes are the dominant type of wetlands in coastal areas and are critical in providing integral functions associated with the overall condition of estuaries and marine resources.
- **Palustrine Emergent** - These areas are a major wetland class in the Midwest and are crucial to the production of waterfowl for much of the Nation.
- **Palustrine Forested** - These areas occur predominately in the Southeastern part of the United States and provide many of the values ascribed to wetlands, e.g. flood attenuation and timber production.

While wetlands provide people with many values and functions, EMAP-Wetlands has chosen four social values to examine initially:

- **Biological Integrity**—The sustainability of a balanced, integrated, adaptive community of organisms having a species composition, diversity, habitat, and functional organization comparable to that of natural wetlands in the region.
- **Productivity** —The quantity or quality of any service or product that wetlands provide to society (e.g. timber production, wildlife, or recreation).
- **Flood Attenuation** —The ability of wetlands to temporarily store water and dampen peak flows.
- **Water Quality Improvement**—The ability of wetlands to assimilate nutrients, trap sediments, or otherwise reduce downstream pollutant loads.

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Estuarine Emergent (Salt Marsh) Pilot Phases I and II

Estuarine emergent wetlands comprise only about five percent of the total wetland resources of the Nation but are among the most productive fish and shellfish nursery grounds in the country and are thus the most studied. EMAP-Wetlands initiated a 1991 pilot study in Louisiana because this is where a large portion of the estuarine emergent resource resides and where much previous research had

been conducted. The primary objectives for this Phase I pilot study were to

- test the ability of a proposed suite of ecological indicators to detect differences between degraded and (relatively) non-degraded salt marshes;
- evaluate the spatial variability of indicators among hydrologic basins, within degraded and non-degraded salt marshes, as well as within sample sites;
- evaluate different measurement protocols to develop standard techniques; and
- identify logistical issues important for future field sampling programs in the Gulf Coast salt marshes.

Results of the Phase I Pilot Study were incorporated into an indicator evaluation report. This report provides statistical summaries of variability components within individual sites, among sites, and within individual basins. Also, the Phase I Report provides recommendations for wetlands indicators. Specifically, the report highlights three classes of indicators:

- those that would be most useful in regional demonstrations,
- those which require further evaluation, and
- those which are insufficiently robust to provide reliable indications of wetland condition.

For Phase II, EMAP-Wetlands will

- test indicators recommended in Phase I;
- conduct additional indicator research at selected sites along the Gulf Coast;
- evaluate additional biotic indicators, including macroinvertebrate diversity and abundance, and indicators that reflect cumulative effects over time, such as sediment depth;
- select and collect information from approximately 50 probability-based sites along the entire Gulf Coast (Florida, Alabama, Mississippi, Louisiana, and Texas); and
- evaluate relationships between remotely-sensed and ground-truthed information at approximately 20 sites in the eastern Gulf of Mexico.

Cooperating Institutions

U.S. Department of Interior, Fish and Wildlife Service, National Wetlands Inventory (NWI).

The NWI is conducting research in the eastern Gulf of Mexico (AL, FL, and MS) to determine the relationships between remote sensing and selected ground measurements of wetland condition.

National Oceanic and Atmospheric Administration (NOAA).

NOAA is analyzing existing Thematic Mapper™ databases in relation to ground measurements of wetlands in Louisiana and Texas.

University of Florida, Tallahassee.

The University of Florida will be collaborating with the NWI to make ground measures at locations where the NWI has remote sensing information.

Louisiana State University (LSU), Shreveport.

LSU has participated in the evaluation of indicators of wetland condition in Louisiana. The University will be conducting additional indicator evaluation research in coastal areas of both Louisiana and Texas.

Utah State University Salt Lake City.

Utah State is evaluating the utility of using relatively inexpensive videographic imagery to assess wetland condition.

Available and Upcoming Products

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| <i>Final Phase I Report</i> | <i>December 1993</i> |
| <i>Gulf-wide Data Report, Phase II</i> | <i>April 1994</i> |
| <i>Video Imagery Analysis</i> | <i>May 1994</i> |

Palustrine Emergent (Prairie Potholes) Pilot Study

This pilot study focuses on developing and testing indicator performance and begins to address some of the variability questions associated with wetlands indicators for palustrine emergent wetlands. The research will provide an evaluation of indicators, candidate reference sites, and index variability. These will provide the basis for an EMAP-Wetlands Regional Demonstration Research Plan.

The specific FY93 activities include:

- testing remotely-sensed and ground-level indicators for their ability to discriminate between wetlands in highly disturbed agricultural landscapes and those in least disturbed (grassland) landscapes across the Prairie Pothole Region,
- evaluating sample plot, index period, and annual variability of indicators,
- evaluating different measurement protocols to develop standard techniques, and
- identifying logistical issues important for future field sampling programs in the prairie pothole region.

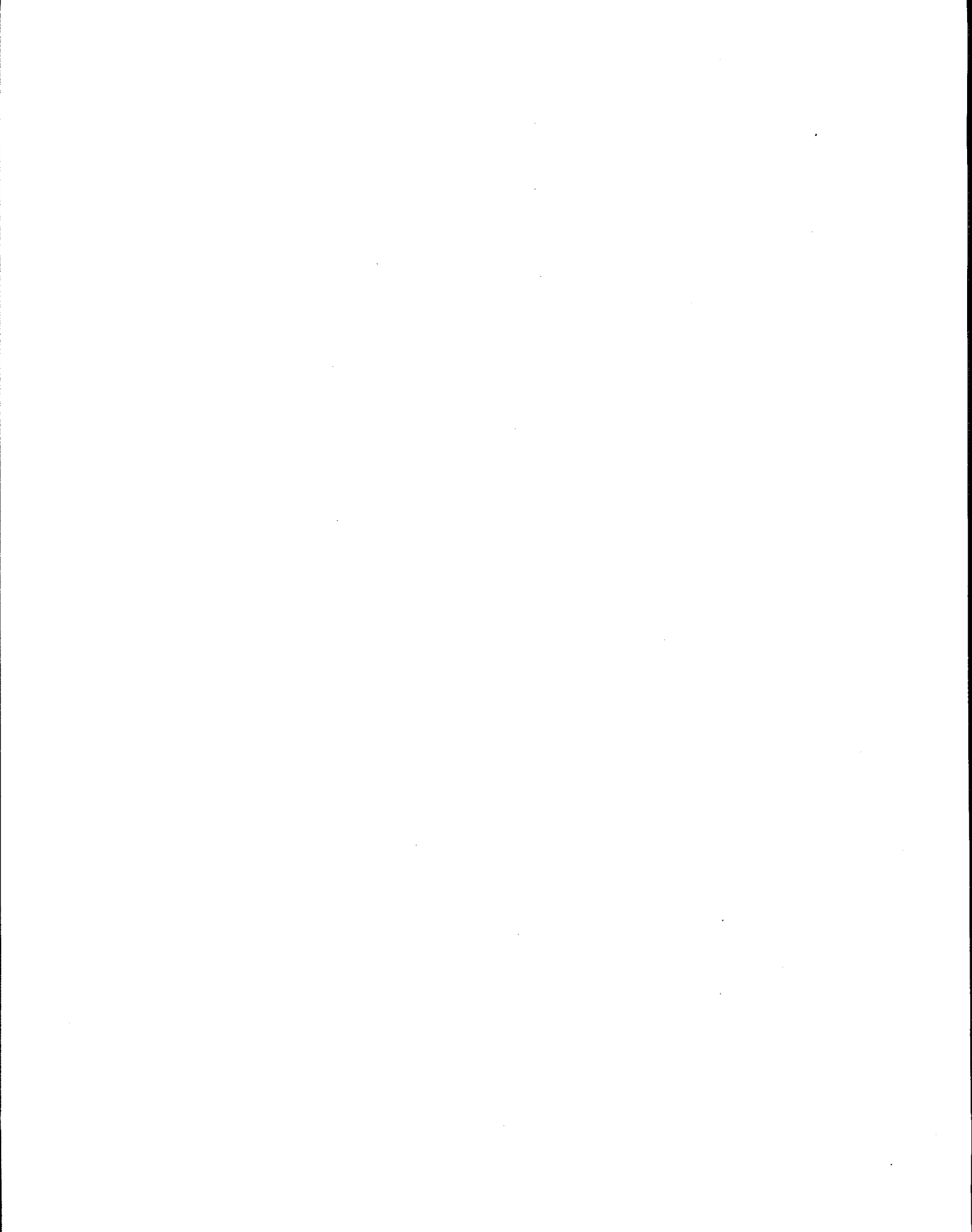
Cooperating Institutions

U.S. Department of Interior, Fish and Wildlife Service (FWS).
FWS is conducting research on the response of selected biotic indicators to highly disturbed and relatively undisturbed agricultural areas. They are relating condition of the wetlands to surrounding landscape characteristics. In addition, the NWI is in the process of digitizing its entire Prairie Potholes database for use by EMAP-Wetlands for sample site selection and characterization.

North Dakota State University, Fargo, North Dakota.
North Dakota State is cooperating with FWS to assess abiotic indicators of soil condition in disturbed and undisturbed areas.

Available and Upcoming Products

| | |
|--------------------------------------|------------------|
| <i>Interim Report</i> | <i>May 1996</i> |
| <i>Final Report on Demonstration</i> | <i>June 1997</i> |



Section 3.0 Integration and Assessment

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Introduction

The eight integration and assessment groups conduct research on issues such as combining information from different statistical designs, providing guidance on indicator development, formulating models to link condition indicators with social values, and designing procedures for classifying nominal-subnominal scores for resource condition.

Several of the integration and assessment groups are based at the EMAP Research and Assessment Center at Research Triangle Park, North Carolina, in order to promote the constant communication and cross-group discussion which are essential to the development of integrated assessment products.

These groups also work closely with the resource groups to ensure there are common and compatible indicators, information management systems, designs, landscape classification systems, and assessment and reporting procedures. Appendix B shows the FY93 to FY97 schedule for conducting research for, and providing guidance to, the resource groups.

3.1 Assessment and Reporting

Introduction

The EMAP-Assessment and Reporting (EMAP-A&R) group provides guidance to ensure that data collected and analyzed by EMAP are interpreted and presented in formats that can be understood by clients in a consistent way and that are relevant to policy concerns. Guidance is delivered to the resource groups both for assessments of individual ecological resources and for the reporting requirements of multiple resource assessments.

In FY91, the draft EMAP Program Guide was prepared and reviewed by EPA's Science Advisory Board, with special attention to the assessment and reporting aspects of the program's overall agenda. As a result of SAB comments and reviews, EMAP-A&R has prepared several additional documents, including a revised *EMAP Program Guide*, an *Assessment Framework*, and a *Regional Acidic Deposition Assessment Case Study* for the EPA Risk Assessment Forum.

In late FY92 and early FY93, EMAP-A&R, in conjunction with EMAP-Indicators, conducted a series of workshops with each of the EMAP resource groups to focus on three fundamental issues:

- identification of important social values for each ecological resource and for EMAP as a whole (e.g., for use in multiple resource assessments and in the selection of cross-resource indicators),
- formulation of assessment questions related to these values, and
- development and evaluation of indicators of ecological condition to address the assessment questions.

Further development of this project is discussed below.

Available and Upcoming Products

| | |
|---|-----------------------|
| <i>EMAP Assessment Framework</i> | <i>July 1993</i> |
| <i>EMAP Master Glossary</i> | <i>August 1993</i> |
| <i>Parallel Analysis of Assessment Paradigms in Various Disciplines and Programs: Lessons Available to EMAP</i> | <i>August 1993</i> |
| <i>EMAP and Policy Analysis: Giving Assessment Primacy</i> | <i>August 1993</i> |
| <i>EMAP Program Guide</i> | <i>September 1993</i> |
| <i>State of the Science in Assessment</i> | <i>September 1993</i> |
| <i>Role of Nominal/Subnominal in EMAP</i> | <i>September 1993</i> |
| <i>Regional Acidic Deposition Case Study</i> | <i>October 1993</i> |

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EMAP Advisory Panel and Workshops

EMAP-A&R will invite nine nationally-recognized panelists with expertise in ecological indicators, assessment science, and resource economics to attend a workshop to be held in 1993. This workshop will help EMAP-A&R respond to EPA's Science Advisory Board's (SAB's) June, 1993, review of EMAP-A&R's activities.

This post-SAB review workshop will help plan any actions or necessary modifications resulting from the SAB's comments. The panel will review the individual products of EMAP-A&R, the proposed programmatic focus and direction, and the existing and planned EMAP-A&R research activities as well as their potential impact on the scientific and regulatory communities. The panel will provide both oral and written summary comments regarding the results of these meetings.

Determination of Social and Societal Values

Public and private decision-makers want and need better information about the values of ecosystems in weighing the advantages and disadvantages of human actions that may impact ecological resources. A frequent problem is the lack of information about

- physical, chemical, and biological changes to ecosystems;
- the social or economic consequences that might result from alternative management approaches and interventions; and
- the "value" or benefits of those actions.

This project will link social values to ecological indicators and regional-scale assessments that are the basis of EMAP's approach. The project will address two basic needs:

- An assessment of the use of new or existing methods to determine the social values of ecosystems and
- Directions on how to apply the most promising methods to determine social values for one or more case studies.

The project plans to incorporate monitoring data from EMAP-Surface Waters and EMAP-FHM, in either the Northeast or Southeast United States. This will enable the definition of case studies which will demonstrate assessments for each resource group and at site-specific and regional scales.

The products of this project will provide preliminary conclusions to validate social values for an EMAP assessment as well as confirm the methods that were used to determine them.

Development of EMAP Reporting Guidelines

This project will develop and produce reporting guidelines for use by all components of EMAP. Reporting guidelines outline the specific formats, procedures, consistency and standardization criteria, visualization techniques, and other requirements that all formal EMAP reports must meet. EMAP-A&R will also prepare similar standards for *ad hoc* EMAP products. This document will be preceded by the development of a formal Strategic Plan and a Research Plan for EMAP-A&R.

Available or Anticipated Products

| | |
|--|-----------------------|
| <i>Assessment and Reporting Strategic Plan</i> | <i>March 1994</i> |
| <i>Assessment and Reporting Research Plan</i> | <i>June 1994</i> |
| <i>EMAP Reporting Guidelines Version 1.0</i> | <i>September 1994</i> |

Regional Ecosystem Assessment Prototype

This project will produce a regional ecosystem assessment prototype (REAP) that will combine EMAP data from multiple resource groups and auxiliary datasets. It will involve the development and refining of a visual assessment matrix and accompanying descriptive text, which can serve as a model for future EMAP assessments.

The project will begin with a review of existing research literature and interviews with scientists directing research efforts currently underway within academic and governmental sectors, in order to enable REAP to take advantage of state-of-the-science knowledge about ecosystem characteristics, especially the factors which differentiate nominal or sub-nominal (stressed) ecosystems.

The project will select a region with at least two biogeographic provinces. REAP will develop a scenario that assesses, for demonstration purposes, resource categories, specific values, stressors, and indicators of ecological condition. Any readily available data will be acquired on the extent and distribution of selected ecological resources in the region, and on four to eight stressors that would potentially affect the selected condition indicators. Finally, GIS and other visualization tools and techniques will be used to display the extent and distribution of the resources, to overlay the condition of the resource for each biogeographic province, and to superimpose possible stresses.

Available and Upcoming Products

| | |
|---|-----------------------|
| <i>Survey of Assessment Literature and Projects</i> | <i>September 1993</i> |
| <i>REAP Version 1.0</i> | <i>September 1993</i> |

Symposium on Ecosystem Health

EMAP-A&R is contributing to the planning and sponsorship of the First International Symposium On Ecosystem Health And Human Medicine, to be held at the University of Guelph in Ottawa, Canada, in June, 1994. Ecosystem health and human medicine are increasingly seen as necessary approaches to environmental management. This emerging, transdisciplinary field bridges the social, health, and ecosystem sciences in fostering new systematic methodologies for the diagnosis, prognosis and treatment of ecosystems under stress.

This project will provide an opportunity for professionals working in ecosystem science and management, medical and health sciences, environmental ethics and law, and ecological economics to take part in the development of integrated approaches to evaluating, monitoring and rehabilitating ecosystems at landscape levels. Themes of the symposium will include:

- approaches to assessing ecosystem health,
- the interface of human health and ecosystem health , and
- environmental management and policy.

Cooperating Institutions

Environment Canada, Forestry Canada, The Royal Society of Canada, and the U.S. Environmental Protection Agency are co-sponsors of the Symposium.

Other groups cooperating in the conference include:

The Desert Research Institute, University of Nevada, Reno, Nevada.

The International Society for Ecological Economics, Solomons Island, Maryland.

The International Society for Aquatic Ecosystem Health.

The International Society of Ecosystem Health and Medicine.

The Laboratory of Ecotoxicology, London, England.

The National Institute of Public Health and Environmental Protection, London, England.

The University of Guelph, Ottawa, Ontario, Canada.

3.2 Design and Statistics

Introduction

EMAP is based on a survey sampling design and analysis strategy. EMAP-Design and Statistics (EMAP-D&S) develops and coordinates the implementation of the statistical framework for this sampling design and its associated analysis strategy. Now that the conceptual framework for the sampling design has been established, research is needed to ensure that the framework addresses the attributes of the ecological resources as it is applied. As each EMAP resource group specifies its sampling design, EMAP-D&S will coordinate implementation across groups to ensure consistency with the conceptual framework. EMAP-D&S also conducts research on environmental statistics to address statistical issues presented by a long-term ecological monitoring program sampling over time and space.

EMAP's sampling design considers all ecological resources on a national basis, with regional levels of resolution. This monitoring approach will produce estimates with known statistical confidence, not only for a specific point in time but also annually over time. EMAP-D&S is producing customized sampling designs that address specific issues presented by the attributes of each EMAP resource group. Statistical estimation procedures are being documented, or developed when necessary, for each application. A key part of the design process is the specification of procedures for conducting statistical power and precision analyses required by EMAP data quality objectives. EMAP-D&S also coordinates with regional, state, and international groups with an interest in EMAP's design.

An integral part of EMAP-D&S's activities is statistical research to address issues identified during development and implementation of sampling design, analysis, and procedures. The initial design-based, status estimation and trend detection procedures will be evaluated to determine how well they perform when applied to resource group sampling-design problems. Through the development of improved procedures, the precision of status estimates and trend detection power can be strengthened. Other issues that EMAP-D&S will address are

- removal of the impact of measurement error on cumulative function status estimates,
- statistical graphics presentation of EMAP estimates,
- evaluation of global grid models for sampling designs,
- multi-stage statistical procedures for extent estimation, and
- trend estimation procedures for regional populations.

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Available and Upcoming Products

| | |
|--|----------------|
| Design Report for EMAP by S. Overton, D. White and D. Stevens, EPA/600/3-91/053 | May 1990 |
| <i>The Ecological Geography of EMAP</i> by D. Norton and T. Slonecker. GeolInfo Systems | November 1990 |
| "Cartographic and Geometric Components of a Global Sampling Design for Environmental Monitoring," Cartography and Geographic Information Systems, Vol. 19, No. 1, 1992, pp. 5-22 by White, Kimerling and Overton | January 1992 |
| EMAP Design Video | July 1993 |
| Journal Article on EMAP Sampling Design | April 1993 |
| Status Estimation: Procedures and Algorithms Guidance | August 1993 |
| Annual Statistical Summary Statistical Graphics Guidance | September 1993 |
| Trend Power Analysis: Procedures and Algorithms Guidance | September 1993 |
| Extent Estimation Statistical Framework | October 1993 |
| Existing Data Procedures for Discrete Population Estimation | February 1994 |

Design Coordination

Coordination of the sampling design activities across EMAP is critical to achieve an integrated program. This task provides technical statistics consultation as requested by EMAP resource groups to assist their implementation of sampling design and analysis procedures.

Status Estimation Research

Status estimation procedures must be developed concurrently with the development of sampling designs. Although some status estimation procedures currently exist as general models, others are needed to address the estimation issues arising from modified sampling designs being proposed by EMAP resource groups. These designs are required, in some cases, to incorporate the unique features of specific ecological resources. The objective of this task is to conduct statistical research required for annual statistical summaries.

The design-based status estimation procedures currently being documented and used do not incorporate all the information available; therefore current procedures result in unnecessarily high variance estimates. Additional research on the procedures being applied will lead to improved variance estimates and hence will result in narrower confidence intervals with better coverage. Currently, status variance estimates do not include an adjustment for measurement error. Completion of this project will enable bias in the percentile estimates to be reduced.

The near-term requirements for this project are directed at research critical for use in annual statistical summaries. One area that the research will concentrate on is *design-based* and *model-assisted* status estimation procedures for cumulative distribution functions (CDFs). Another area of research will center on the procedures for the deconvolution of indicator measurement error from the

estimated cumulative distribution function to arrive at the estimated ecological resource population cumulative function.

Contributing Institutions

Oregon State University (OSU), Department of Statistics, Corvallis, Oregon.

OSU has provided continuing support for EMAP-D&S activities, with special focus on status estimation issues.

Available and Upcoming Products

| | |
|---|----------------------|
| <i>Comparing Sampling Designs for Monitoring Ecological Status and Trends: Impact of Temporal Patterns</i> | <i>January 1993</i> |
| <i>Statistical Properties of Designs for Sampling Continuous Functions in Two Dimensions Using a Triangular Grid</i> | <i>February 1993</i> |
| <i>An Extension of the Horvitz-Thompson Theorem to Point Sampling from a Continuous Universe</i> | <i>March 1993</i> |
| <i>Efficiency of Least Squares Estimators in the Presence of Spatial Autocorrelation</i> | <i>April 1993</i> |
| <i>Using "Found" Data to Augment a Probability Sample: Procedure and Case Study</i> | <i>May 1993</i> |
| <i>Comparison of Variance Estimators of the Horvitz-Thompson Estimator for Randomized Variable Probability Sampling</i> | <i>June 1993</i> |
| <i>Probability Sampling and Population Inference in Monitoring Programs</i> | <i>July 1993</i> |
| <i>Explanatory Models for Ecological Response Surfaces</i> | <i>November 1994</i> |

R-EMAP Design Support

This project provides technical support to EPA Regions in the development of their R-EMAP sampling designs, and consults on their application of statistical analysis procedures to ensure their studies are consistent with EMAP-D&S guidance. It is critical that R-EMAP studies are conducted with sampling designs that are consistent with that of EMAP, since the Regions will combine EMAP resource group information and R-EMAP information in their assessments.

Global Grid Development



Figure 13. Hexagon Grid imposed on North America (from Design Report for EMAP, 1990)

There is a need to establish global baseline data on reference ecological conditions against which future conditions can be compared and changes documented with statistical confidence. This need has grown in importance with the increasing complexity, scope, and social importance of environmental issues. As a consequence, monitoring programs must provide quantitative, scientific assessments of the complex effects of stresses on ecosystems. Currently a number of existing national programs and countries monitor environmental conditions on a large scale; however, all of these monitoring programs have different sampling design philosophies.

The EMAP sampling grid is based on a geometric model of the earth, and it addresses the primary requirements for a probability-based sampling design based on a systematic grid. The approach has limitations, however, in

- the selection of the map projection,
- the model's arbitrary orientation on the globe, and
- the choice of base grid density.

Several similar approaches have been identified in the literature that appear to address these limitations and that may result in wider acceptance of a common geometric model.

EMAP-D&S has been working to develop a geometric model of the earth that is suitable for use in applications of probability-based sampling designs of ecological resources as well as in the analysis and management of geographic data from a global perspective. EMAP-D&S will also document the issues relevant to the selection of a geometric model, and will identify known potential alternatives. Another project consists of conducting research on revised EMAP models to illustrate the advantages of considering alternatives.

EMAP-D&S will hold a workshop for international experts to discuss the merits of several evolving alternative geometric models including EMAP's current model, a revised EMAP model, and a model developed by NASA researchers. This workshop will evaluate the utility of alternative global monitoring designs as well as the ability of these designs to evaluate the condition of major ecosystems on a global scale. The results of this workshop will allow EPA to determine if EMAP's current design should be modified to satisfy the requirements of global-scale monitoring programs.

Each of the designs to be debated at the workshop will be evaluated on its ability to

- to estimate the spatial extent of various habitat types throughout the world;
- to estimate the condition, and changes in conditions, on a regional scale, of biomes throughout the world; and
- to provide a framework to organize and manage existing monitoring data.

Contributing Institutions

Oregon State University (OSU), Department of Statistics, Corvallis, Oregon.

The university has provided ongoing support for EMAP-D&S activities, and is providing considerable support to the technical problems of selecting an improved geometric model, and logistics support for the international workshop.

United Nations Environment Programme (UNEP), Nairobi, Kenya. UNEP is providing international sponsorship and support for the conference.

Available and Upcoming Products

| | |
|--|------------------|
| <i>Working Paper on Global Grid Issues</i> | <i>Fall 1993</i> |
|--|------------------|

| | |
|---|-------------|
| <i>Development of a Global Grid Model for Environmental Surveys</i> | <i>1994</i> |
|---|-------------|

Environmental Monitoring and Statistics Research

Concerns expressed about the EMAP sampling design frequently arise because research has been inadequately performed and communicated in natural resource statistics. General statistical research may provide the foundation for statistical techniques required in natural resource monitoring programs but will not be directly applicable or be published in the natural resource literature. It is only by initiating an effort similar to the biostatistical research of the National Institutes of Health that the specialized statistical needs of the ecological community will be met.

To help meet the statistical needs of ecological monitoring and assessment programs, EMAP will conduct and support collaborative research in emerging areas of statistics that have immediate application to ecological programs. This project will address specific research needs of EMAP and other national environmental monitoring programs, such as: the impact of measurement errors on natural resource surveys; resource extent estimation, especially as related to multi-stage estimation using remote sensing and ground survey information; and model-based estimation of cumulative functions in complex surveys.

Contributing Institutions

Several universities are actively cooperating in the development of a more aggressive research agenda for the natural resource sciences. Among the leaders, but not the only groups in this endeavor, are Penn State University (State College, PA), the University of Texas (Austin, TX), Oregon State University (Corvallis, OR), the University of Washington (Seattle), and the State University of New York, College of Environmental Sciences and Forestry (Syracuse, NY).

Available and Upcoming Products

| | |
|--|-----------------------|
| <i>Variance Estimation in the EMAP Strategy for Sampling Discrete Ecological Resources</i> | <i>January 1994</i> |
| <i>Properties of Design-Based Estimators of Distribution Functions</i> | <i>February 1994</i> |
| <i>An Application of Geostatistical Tools to Design-Based Variance Estimation</i> | <i>March 1994</i> |
| <i>A Framework for Evaluating the Sensitivity of the EMAP Design</i> | <i>April 1994</i> |
| <i>Pairwise Inclusion Probability Approximations in Random-Order, Variable Probability Systematic Sampling</i> | <i>August 1994</i> |
| <i>Density Estimation Procedures in Spatial Modeling of Ecological Resources</i> | <i>September 1994</i> |
| <i>A Temporal Dynamic Model for Compositional Monitoring Data</i> | <i>September 1994</i> |
| <i>Potential of Adaptive Sampling for Status Estimation</i> | <i>September 1994</i> |

3.3 Indicator Development

Introduction

Indicator selection and development is critical to the EMAP goal of monitoring and assessing the condition of the Nation's ecological resources and contributing to decisions on environmental protection and management. EMAP's Indicator Development program is designed to

- prepare and implement a strategy for indicator development and evaluation;
- develop procedures for ensuring the consistency, compatibility and comparability of indicators among EMAP resource groups; and
- conduct research on ecological indicator concepts and methodology to support the program.

The goals of EMAP-Indicator Development (EMAP-Indicators) are to provide suites of indicators with which to measure the status of, and trends and changes in, the condition of ecological resources and to provide diagnostic procedures to associate selected anthropogenic and natural stressors with condition indicators.

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Summary and Revision of EMAP's Indicator Development Strategy

EMAP drafted its first Indicator Development Strategy in 1991. This strategy was revised the following year in an attempt to resolve some conceptual and terminology issues. Since the revision, EMAP has refined its programmatic objectives and has striven to clarify and simplify its conceptual framework. In the fall of 1992, workshops on indicators were held to incorporate these developments into the strategy. A summary of the workshop will be completed to give Indicator and Assessment and Reporting Technical Coordinators as well as the resource group Technical Directors a tool with which to explain the indicator strategy to various EPA program offices and other important client groups in the coming year. The summary and the revised strategy should help the Coordinators and Directors to determine if the values and assessment questions currently identified by EMAP are indeed the important issues facing decision-makers.

Available and Upcoming Products

| | |
|---|----------------|
| Ecological Indicators, Vol. 1&2. 1992. <i>McKenzie, DH, DE Hyatt, and VJ McDonald,</i> <i>eds. Elsevier (Chapman Hall), New York.</i> | June 1992 |
| <i>Summary of indicator workshops</i> | September 1993 |
| <i>Revised Indicator Development Strategy</i> | September 1993 |

Review: Conceptual Models for Indicator Development and Resource Assessment

Conceptual models play a central role in EMAP's indicator development strategy. These models identify

- the biotic and abiotic structural components of a resource;
- the interactions among a resource's structural components;
- external forcing functions that maintain the resource; and
- the endogenous and exogenous factors, including stressors of concern, that affect the resource's structure and function.

This project will review available literature on conceptual and mathematical models that could be used by EMAP resource groups as conceptual models of their resources. The project will also provide technical assistance and coordination for modeling efforts. This activity will help ensure that models developed by one resource group are logically consistent with those of other resource groups.

Available and Upcoming Products

Review and Guidance on Development of Conceptual Models

March 1994

Development of Cross-Cutting Assessment Questions and Indicators

During a series of meetings between an EMAP-Indicators review team and each resource group, it was determined that there are many questions and issues that need to be addressed from a cross-resource perspective. Through this project, a workgroup consisting of EMAP-Indicators and EMAP-Assessment and Reporting will schedule four cross-resource workshops for FY93 and early FY94. These workshops will initiate the identification of social values and the formulation of assessment questions that must be addressed from a multiple-resource and landscape perspective.

Available and Upcoming Products

Summary of cross-cutting social values, assessment questions and indicators for aquatic EMAP resource groups

April 1994

Summary of cross-cutting social values, assessment questions and indicators for terrestrial EMAP resource groups

July 1994

3.4 Information Management

Introduction

Information Management (IM) within EMAP is the vehicle with which the total EMAP program manages information from field collection through publication of results. As such, EMAP information management requires comprehensive integrated scientific information systems that facilitate communication of environmental data from diverse sources spatially (over distance) and temporally (over time) in a form that users can easily access. Allowing analysis of EMAP data across heterogeneous networks of personal and scientific computers, the technical goal of EMAP-Information Management (EMAP-IM) is an environmental open system. This open system is not one large computer system but a distributed system composed of resource group systems, a Central EMAP system, and other appropriate systems within EPA and other federal agencies such as NASA, NOAA, and USDA-FS. This distributed open system supports the delivery of EMAP information products, consisting of the Annual Statistical Summaries, Environmental Assessment Reports, and databases of processed information provided by the resource groups. To accomplish this, each resource group supports a networked database node containing its own monitoring data and associated assessment products.

The EMAP Central node contains information of interest to all resource groups, such as taxonomic classifications, and national summaries and assessments. These EMAP information management systems must operate compatibly within the EPA Information Resources Management (IRM) infrastructure and follow federal IRM standards. EMAP-IM activities are guided by these requirements:

- They must facilitate access by major program participants to monitoring and assessment data of known integrity, quality and pedigree;
- They must support nationwide data collection activities; and
- They must provide flexible data access, capable of meeting the needs of different users and technologies.

To develop this open system EMAP-IM has adopted an evolutionary approach consisting of three major integrated processes. These processes are: (1) Proof-of-Concept, (2) Technology Transfer, (3) Enterprise. In FY93, EMAP-IM has focused on the development and implementation of the proof-of-concept (POC). The purpose of the POC is to verify all concepts used in the development of EMAP information management systems by developing functioning prototypes. When these concepts are proven, they are released as new versions of EMAP Central and resource group systems. Based on requirements defined by the Estuaries and Forest Health Monitoring resource groups, a first version of EMAP information management systems was demonstrated in May, 1993.

The development of EMAP's information management systems involves the following major functional teams:

- *User Interaction and Planning*—facilitates defining user requirements and provides user support, training, documentation and consultation on the effective use and continued development of the EMAP information management system;

- *IM Architecture*—provides the design, data, module interface, system administration, and security standards, quality assurance standards and procedures, implementation strategies and strategic plans;
- *Systems Engineering*—based on user specifications developed by User Interaction and Planning, provides for system development from proof-of-concept versions through operating systems;
- *Systems Support and Operations*—maintains hardware and system configuration for the Central node, assists ORD laboratories in their operational support of EMAP resource group nodes, acquires new hardware and software, and operates information management systems;
- *GIS Interface*— provides spatial and geographical analytical tools for EMAP information management systems;
- *Interagency Data Interchange*—provides an active, aggressive approach to establishing information exchange standards and methods with other agencies for the purposes of integrating related information;
- *Advanced Technology Evaluation*—provides interfaces to the ecological science and information science communities to identify new information technologies for incorporation into EMAP;and
- *Computer Science Direction*—provides primary scientific direction for development efforts and provides technical peer reviews from a scientific and engineering standpoint.

EMAP's development method ensures a successful system through the use of an iterative design approach. This approach specifically seeks users requirements to drive development and entails a continuous cycle of analyzing, prototyping, developing, delivering, assessing user feedback, and evolving.

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User Interaction and Planning

The primary focus of the user interaction and planning team is to determine user requirements and plan their integration into the system development process. For the proof-of-concept, Joint Application Development (JAD) sessions identified the requirements of EMAP-Forest Health Monitoring, EMAP-Estuaries, and Central EMAP users. For Technology Transfer, the User Interaction and Planning team has published a plan to identify user requirements for all EMAP resource and coordinating groups. The team develops user materials, (e.g. training curricula and documentation) and will be responsible for planning and coordinating the transfer and implementation of newly developed IM products to EMAP's coordinating and resource groups.

Available and Upcoming Products

| | |
|---|-----------------------|
| <i>Proof-Of-Concept Design Specifications v 1.0</i> | <i>September 1993</i> |
| <i>Proof-Of-Concept User—Documentation</i> | <i>October 1993</i> |
| <i>Proof-Of-Concept Training Program</i> | <i>October 1993</i> |
| <i>Proof-Of-Concept User Test Specifications</i> | <i>October 1993</i> |
| <i>Technology Transfer Plan</i> | <i>August 1993</i> |
| <i>Enterprise Modeling Plan</i> | <i>December 1993</i> |

Information Management Architecture

This team is tasked with the identification, development and promulgation of standards for EMAP's information management systems. This work will establish an EMAP-IM infrastructure of standards, policies, procedures and technology that encompasses and supports all aspects of systems development, implementation and integration. This project provides support in the specific areas of:

- data architecture standards;
- process architecture standards;
- technology architecture standards;
- network standards;
- system development life cycle standards;
- security standards and procedures;
- quality assurance standards and procedures;
- configuration management standards and procedures; and
- data administration activities.

It is important to note that the standards that are produced are not static. As new technologies or new user requirements are identified for incorporation into EMAP systems, the appropriate standards are updated to guide new EMAP information management development efforts. In addition to standards support, the architecture function supplies data administration support for EMAP-IM. Data, process, and technology models of all EMAP information management systems are managed in such a way that they are accessible to all components of EMAP-IM to serve as building blocks or templates for new EMAP information management systems.

Available and Upcoming Products

| | |
|---|-----------------------|
| <i>Proof-of-Concept Standards Manuals</i> | <i>August 1993</i> |
| <i>Proof-of-Concept Operations Procedures</i> | <i>May 1993</i> |
| <i>Proof-Of-Concept Security Policy</i> | <i>May 1993</i> |
| <i>Proof-Of-Concept Standard Quality Assurance Models</i> | <i>May 1993</i> |
| <i>Quality Assurance Guidelines for System Architecture</i> | <i>May 1993</i> |
| <i>Repository Configuration Management Procedures</i> | <i>September 1993</i> |

Systems Engineering

The systems engineering team is responsible for implementing the requirements specifications developed by user interaction and planning for EMAP information management systems design and implementation. EMAP-IM system engineering functions will include coding, integrating, and testing each version of the EMAP Central System and all centrally developed software tools. For the proof-of-concept, the systems engineering team has designed and populated distributed Oracle databases for EMAP Central, EMAP-Forest Health Monitoring, and EMAP-Estuaries nodes, and developed Oracle and SAS interfaces to these databases. All EMAP information management systems are developed in accordance with standards developed and promulgated by the IM architecture team.

Available and Upcoming Products

| | |
|---|-----------------------|
| <i>POC Distributed Database Design Specifications</i> | <i>September 1993</i> |
| <i>Proof-of-Concept Distributed Databases</i> | <i>October 1993</i> |
| <i>Proof-of-Concept Version 1</i> | <i>December 1993</i> |

Systems Support and Operations

The systems support and operations team is responsible for implementing operational standards set by the EMAP-IM architecture team and the operations of the EMAP Central system and networked database node. This operational support includes but is not limited to:

- configuration management,
- testing,
- quality assurance,
- maintenance of an information (data) inventory,
- system administration and security,
- operations staffing and facilities, and
- hardware and software procurements.

The systems support team uses its experience to assist the ORD laboratories in their operations of EMAP resource group systems and networked database nodes. This team will coordinate with Agency groups offering centralized services such as the National Data Processing Division (NDPD) and the Office of Information Resources Management. As an example, this team recently worked with NDPD's Telecommunications Branch to establish TCP/IP network connections to support the Proof-of-Concept.

Available and Upcoming Products

| | |
|--|----------------------|
| <i>POC Configuration Management System</i> | <i>December 1993</i> |
| <i>POC Change Control System</i> | <i>December 1993</i> |

Geographic Information Systems Interface

An integral part of the information management architecture is the Geographic Information Systems (GIS) Interface. Currently under development, this is an electronic link between the EMAP information management system that handles field monitoring data and the Geographic Reference Database that handles spatial data for the program. The purpose of this team is to support the ongoing development of that interface and its integration with ongoing information management efforts.

Available and Upcoming Products

*GIS Components for POC Prototype**October 1993***Interagency Data
Interchange**

Data from other agencies, inter-governmental groups, EPA Regions and states may be required to produce EMAP assessments. In turn, these agencies may need access to EMAP data for their own reporting processes. The Interagency Data Interchange (IDI) team represents EMAP-IM to related programs with the specific charter of designing and/or adopting data interchange standards. The IDI team is also responsible for designing EMAP's Directory Catalog structure. To accomplish this, the IDI team is examining the applicability of the various data directory and catalog solutions currently being proposed by other agencies such as NASA's Master Directory and those identified by the Consortium for International Earth Science Information Network (CIESIN). EMAP-IM will also explore and prototype procedures, standards, and technologies that will allow EMAP to meet user needs for data many years after collection.

Available and Upcoming Products

POC Dataset Inventory and Directory *November 1993**POC Directory and Catalog Requirements* *October 1993**Evaluation of External Data Sources for EMAP* *November 1993**EMAP Guidelines for External Data Integration* *October 1993***Advanced Technology
Evaluation**

This team provides computer science research and evaluation support to EMAP-IM. Activities include maintaining knowledge of the state-of-the-art in technology related to EMAP information management efforts, and facilitating smooth insertion of new technology into the EMAP-IM infrastructure.

Available and Upcoming Products

Spatial SQL (Structured Query Language) Paper *August 1993***Computer Science
Direction**

This team provides the primary computer and information sciences direction for EMAP information management development efforts and serves as a scientific and strategic planning resource to EMAP-IM. It represents EMAP information management systems development to the information sciences community and coordinates technical peer reviews from a computer sciences and information engineering standpoint. The peer review panel consists of external research and computer scientists who are experts in the field of scientific information systems.

Available and Upcoming Products

*EMAP-IM Five-Year Strategic Plan**September 1993*

Cooperating Institutions

The following EPA organizations are participating in the design of EMAP information management systems:

The Office of Information and Resources Management (OIRM) of the Office of Administrative Resources Management (OARM).

OIRM's National Data Processing Division (NDPD), Research Triangle Park, North Carolina.

The Office of Water

The Center for Environmental Statistics of the Office of Policy, Planning and Evaluation's Environmental Statistics and Information Division (OPPE/ESID).

Current EMAP-IM system development efforts have focused on EMAP's Estuaries and Forest Health Monitoring resource groups. For these resource groups, EPA has cooperative partnerships with NOAA for Estuaries and the USDA Forest Service for Forest Health Monitoring.

Established information management standards serve as the foundation for information management system development. The following institutions have set standards and guidelines for the major aspects of information management and telecommunications. Whenever possible, EMAP-IM has adopted or built upon the work of these institutions.

Environmental Protection Agency,
Office of Administration and Resources Management,
Office of Information Resources Management,
Information Management Data Administration
Group,
Geographic Information Systems Group,
National Data Processing Division

U.S. Department of Commerce,
National Institute of Standards and Technology (NIST).

International Standards Organization, Geneva, Switzerland.

American National Standards Institute, Washington, DC.

3.5 Landscape Characterization

Introduction

Spatial information describing the geographic coverage and extent of resources is important for assessing ecological status and trends. The goal of EMAP-Landscape Characterization (EMAP-LC) is to provide the spatial information for this evaluation. EMAP-LC's major objectives are:

- to develop and implement a geographic reference database (GRD),
- to develop a land-cover classification system, and
- to generate land cover information.

EMAP-LC also supports EMAP-Design and Statistics (D&S) in sampling frame development and extent estimations, and complements EMAP-Information Management in the area of spatial data.

The development of a hierarchical land-cover classification system is a critical unifying component for EMAP, as well as for other programs within EPA and other government agencies. The EMAP classification system is being developed in collaboration with the U.S. Department of Interior, Fish and Wildlife Service (FWS) Gap Analysis Program (GAP), and will be compatible as much as possible with other classification systems.

Generation of comprehensive, national land-cover information will be accomplished at several scales and levels of detail. Land-cover data for EMAP will support sampling frame development, resource extent estimates, assessments, and landscape monitoring. Research collaborators in this effort include the Fish and Wildlife Service, the Department of Energy's Oak Ridge National Laboratory (ORNL), NASA, USGS, and the Global Change Research Program.

To achieve its objectives, EMAP-LC is focusing on five major priorities:

- *Developing the EMAP Geographic Reference Database (GRD).* This is the spatial data infrastructure for EMAP that will ensure that EMAP resource groups, other partner agencies, and the federal and scientific community can operate with the same data infrastructure. The EMAP GRD fits into a larger federal spatial data infrastructure. Ultimately, all federal partners will have access to the same data layers and operate with the same level of data quality.
- *Developing an EMAP land-cover classification system.* This hierarchical system will have precisely defined classes that meet the specifications of EMAP resource groups while facilitating information exchange with other agencies involved in similar efforts.
- *Generating land-cover data.* EMAP-LC will collaborate with other agencies to acquire national land-cover data. In addition, EMAP-LC will work with EMAP resource groups to identify more detailed land-cover data that meets the needs of specific groups.

- *Supporting sample frame development.* This effort will document the sampling frame material and frame development strategies being used by each of the resource groups. EMAP-LC and EMAP-D&S will then analyze this information to ensure frame compatibility for integrated, multiple resource assessments.
- *Supporting extent estimations.* EMAP-LC, in collaboration with EMAP-D&S, will generate estimates of resource extent at a variety of spatial scales.

As part of its service activities for other EMAP groups, EMAP-LC is conducting a number of special technology transfer or joint development projects described below in the context of their major priorities.

EMAP Contact:

Denice M. Shaw
EMAP Research and Assessment Center
U.S. EPA (MD-75)
Research Triangle Park, NC 27711
Telephone: 919/541-2698

Geographic Reference Database

Geographic data are required in EMAP to provide the context for the sampling data of the resource groups and for regional ecological assessments. The EMAP Geographic Reference Database (GRD) is a program-wide database for EMAP users, containing descriptions of available data, its quality, and ownership. EMAP's GRD will also contain certain well-documented, quality-assessed, spatial data sets. EMAP's GRD will describe and reference spatial data at various scales for a variety of physical, biological, and cultural themes, including land cover, ecoregions, physiographic regions, soils, watershed boundaries, and political boundaries.

EMAP-LC focuses on acquiring data sets that will benefit the largest number of users. In addition, EMAP-LC will continue to develop and refine the EMAP GIS interface as a user-friendly tool that enables the exploration of EMAP field data and other relevant data in a spatial context. Overall, GRD development efforts will facilitate data sharing, appropriate use of the data, and effective data management. EMAP-LC will work with EMAP-IM to ensure EMAP's GRD is consistent with EMAP-IM's planning efforts.

Cooperating Institutions

EPA's Office of Information Resources Management (OIRM) of the Office of Administration and Resources Management (OARM). OIRM is providing enhancements of existing spatial data coverage for inclusion or reference in the EMAP GRD. OIRM also is working with EMAP-LC to develop the Agency's Spatial Data Management Plan. OIRM's National Data Processing Division is helping to evaluate hardware, software, and telecommunications.

U.S. Department of Interior, U.S. Geological Survey (USGS). USGS's National Mapping Division is constructing federal data clearinghouse from which EMAP resource groups will derive some of their spatial data. The Water Resources Division of USGS has base cartographic data on-line. The GRD will provide a link to this central clearinghouse. EMAP's use of USGS data results in updates and improvements in USGS databases. EROS Data Center, a division of the National Mapping Division, will archive, manage, and distribute Thematic Mapper™ and other large spatial data sets for EMAP. In addition, USGS's Water Resources Division contributes

to the EMAP's GRD by exploring the use of Internet to support interagency communication and data exchange.

University of California--Santa Barbara (UC-SB).

UC-SB's National Center for Geographic Information Analysis is cooperating on research issues of quality assurance for spatial data sets.

Available and Upcoming Products

| | |
|-----------------------------|-----------------------|
| <i>EMAP GIS Interface</i> | <i>October 1993</i> |
| <i>GRD Development Plan</i> | <i>September 1993</i> |

Land-Cover Classification System Development

EMAP-LC and the Fish and Wildlife Service--Gap Analysis Program (GAP) are developing a joint system that will serve as the high end (i.e., coarse resolution) of a standard classification hierarchy for land cover used by EMAP, GAP, and other relevant programs. At lower levels (i.e., finer resolutions) of this common hierarchy, EMAP resource groups and other partner programs may diverge into their own resource class divisions to meet their specialized research needs. A dictionary is being developed that identifies and describes the classification systems currently in use by the various resource groups and compares each of them to various classifications.

Cooperating Institutions

U.S. Department of Interior, U.S. Geological Survey (USGS), National Mapping Division.

The USGS National Mapping Division is currently developing a master resource classification system for all federal agencies, into which the efforts of EMAP and GAP will link.

Available and Upcoming Products

| | |
|---|----------------------|
| <i>Land-Cover Classification Dictionary</i> | <i>December 1993</i> |
|---|----------------------|

Land Cover Generation

Land-cover data at a range of scales are critical to meeting EMAP's objectives of estimating condition and extent of the Nation's ecological resources. Because partner agencies have similar needs for land-cover data, EMAP has made a commitment to lead an interagency team in the development of a national land-cover database using Landsat Thematic Mapper™ satellite imagery. EMAP-LC will also identify and access satellite imagery at a variety of other scales, as well as aerial photography, in order to meet specific needs of individual EMAP resource groups.

The Land Cover Generation project comprises six major components:

- *Planning and Coordination.* A plan will be developed to suggest procedures and strategies to be implemented;
- *Classification System.* The EMAP Classification System will be further refined and assessed;
- *Data Acquisition.* The legal aspects of data licensing and sharing will be investigated as well as the coordination of data acquisition with ongoing or planned efforts by other federal or state programs;
- *Data Processing.* The algorithms and operations will be addressed and technically peer reviewed;

- *Accuracy Assessment.* Accuracy assessment procedures will be tested and refined;
- *Data Management.* Efforts will be explored to collaborate with other federal agencies who have effectively managed large volumes of data.

Cooperating Institutions

U.S. Department of Interior, U.S. Geological Survey (USGS), National Mapping Division, EROS Data Center, Sioux Falls, South Dakota.

EROS is supplying and classifying AVHRR Imagery (1 square kilometer resolution) for use by EMAP.

North American Landscape Classification (NALC Consortium and Similar Joint Efforts.

NALC (composed of USGS, NASA, and EPA) is acquiring for EMAP's use historic multi-spectral scanner images from cameras used on early Landsat satellites that produced pictures with 80-meter resolution. This data will be tested for its ability to produce meaningful change detection results.

In addition to NALC, an informal association of FWS-GAP, USGS's National Water Quality Assessment (NAWQA) Program, the EROS Data Center, and NOAA's Coastwatch-Change Analysis Program are working with EMAP-LC to contribute areas of expertise in acquiring, processing and managing Thematic Mapper™ data (30 meter resolution). A similar group, involving EROS, NASA, FWS, BLM, NALC, USDA Forest Service, Federal Emergency Management Agency, (FEMA, and the Army Corps of Engineers are working with EMAP-LC to purchase 800 scenes of SPOT (a French satellite, which produces images with 10-meter resolution) imagery in the north central United States.

Regions and States.

EPA Regions III and VI are helping to coordinate acquisition and processing of Thematic Mapper™ data for their regions and states within their regions.

The states of Illinois, Pennsylvania, and New Mexico are helping to acquire and classify Thematic Mapper™ data for EMAP and other programs.

Sampling Frame Development

A sampling frame specifies the individual units of a population from which samples may be selected. Currently, the EMAP resource groups, each working independently with one or more federal agencies, have identified short-term solutions for frame development. EMAP-LC will compare each of these solutions and identify and clarify issues resulting from the differences. The frame development activity has four major objectives:

- To understand sampling frames being used and to anticipate their limitations for making holistic assessments of resource conditions;
- To develop approaches for sampling frames that will allow EMAP to minimize these limitations in the short-term;
- To develop a strategy for defining a common EMAP sampling frame, potentially based on a nationwide land cover database; and

- To provide support to the Wetlands resource group for continued efforts in the Prairie Potholes digitization effort.

Available and Upcoming Products

Draft Report on Resource Group Sampling Frames

December 1993

Extent Estimation

The second objective of EMAP is to estimate the geographic coverage and extent of resources with known statistical confidence. Currently, EMAP resource groups are using distinct and potentially incompatible processes for estimating the distribution and extent of resources. Potential discrepancies between the processes include diverse data sources, methods, statistical designs, and classification systems. EMAP-LC will identify, document, and classify these processes, and then guide the strategy for producing integrated extent estimations that are compatible across resource groups.

The extent estimation activity has three main objectives:

- To document the current extent estimation methods proposed by the resource groups well enough to anticipate difficulties that may preclude comprehensive, national estimations of resource extent;
- To develop an approach that will allow EMAP to minimize these difficulties in the short term;
- To develop strategies for extent estimation based on probability sampling as well as synoptic data.

Available and Upcoming Products

Draft Report (Proposed Solutions)

December 1993

Chesapeake Bay Watershed Pilot

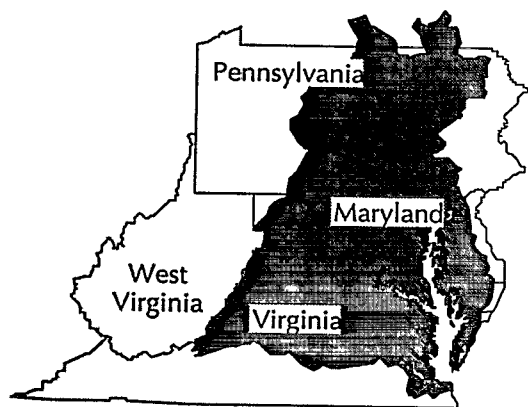


Figure 14. The Chesapeake Bay Watershed

The Comprehensive Chesapeake Bay Plan will demonstrate how the five major components of EMAP-LC—Classification, Land Cover Generation, Extent, Frame Support, and the Geographic Reference Database—may be integrated into the overall Landscape Characterization plan, and applied to the resource groups represented in the Chesapeake Bay. This location was selected because of the availability of land-cover data at multiple scales and the availability of ancillary spatial data. This project will include collaboration with resource groups, EPA Region III, the Chesapeake Bay Program Office, the Mid-Atlantic Highlands Assessment (MAHA), and the six states that have land in the watershed.

Thematic Mapper™ data for the Chesapeake Bay watershed were classified using the proposed national classification system. It is important to the continued development of the EMAP land-cover dataset that the quality of the classified Thematic Mapper™ data be assessed. This task will be undertaken by two collaborating universities; results will be systematically documented in the pilot metadata system developed for the Chesapeake Bay Watershed project.

Cooperating Institutions

Towson State University, Towson, Maryland, and Pennsylvania State University, State College, Pennsylvania.

Both universities are conducting assessments of the quality of the EMAP classification in the Chesapeake Bay Watershed pilot project.

Available and Upcoming Products

| | |
|---|----------------------|
| <i>Report: Accuracy Assessment Protocols for EMAP</i> | <i>August 1993</i> |
| <i>Report: Standard Methods for Thematic Mapper™ Classification (at a regional scale)</i> | <i>August 1993</i> |
| <i>Chesapeake Bay Watershed Thematic Mapper™ Land Cover Characterization Pilot Plan</i> | <i>July 1993</i> |
| <i>Chesapeake Bay Watershed Final Report</i> | <i>November 1993</i> |

Resource Group Pilot Support

EMAP-LC will provide continued support for three ongoing resource group pilot projects. One project involves remotely-sensed indicator development for EMAP-Forest Health Monitoring, another involves photointerpretation for EMAP-Agroecosystems, and the third involves digitizing for EMAP-Wetlands sampling frame development.

The EMAP-FHM task involves developing and testing remotely-sensed indicators of forest conditions in the state of Georgia by comparing measurements from high-resolution aerial photography with field indication measurements. The objective of this project is to refine aerial forest monitoring techniques to serve as an option to costly ground-based indicator measurements.

The EMAP-Agroecosystems task involves acquiring and preparing imagery, establishing control points, and generating land use/land cover data in the state of North Carolina.

For EMAP-Wetlands, EMAP-LC will provide support to complete the digitizing of the National Wetlands Inventory (NWI) maps for the Prairie Potholes region, so that the wetland sampling frame can be properly drawn.

R-EMAP Technical Assistance

The Regional-EMAP (R-EMAP) project was developed as a partnership between EMAP and EPA's regional offices and states to promote the use of EMAP technology, methods, and concepts in regional, state, and local monitoring efforts. Seven R-EMAP proposals have been initiated this year (see Section 4 of this document). Regional office GIS teams have expressed interest in coordinating with the larger EMAP GIS infrastructure for standards, data sharing, interface development, and communication. Such coordination will provide the regional GIS R-EMAP efforts with support that will benefit them individually and provide consistency among the R-EMAP projects.

R-EMAP will hold two yearly workshops in addition to monthly conference calls for the R-EMAP GIS staff. EMAP-LC also will distribute the EMAP GIS interface to the R-EMAP GIS staff with guidance for incorporating their respective data sets.

3.6 Quality Assurance

Introduction

The EMAP-Quality Assurance (EMAP-QA) component ensures that EPA quality assurance guidelines are reflected in EMAP research and management procedures. EMAP-QA provides guidance to the EMAP resource groups on data review, validation, and verification requirements and on documenting data quality objectives for emerging research fields such as ecological indicators and geographic information processing. These efforts ensure that independent research results can be used and compared.

EMAP Contact

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401 M Street, S.W.
Washington, D.C. 20460
(202) 260-5775

Development of EMAP Data Quality Objectives

EMAP-QA is working to develop guidance on requirements for documenting research data quality goals and validation criteria in planning documents for data collection operations. EMAP-QA requires internal guidance specific to its needs that can serve as a basis for data quality objectives (DQO) training. This project will develop examples of the DQO process to be applied as examples of indicators from past EMAP monitoring projects.

The EMAP-Quality Assurance Plan, and the EMAP Management Systems Review

EMAP-QA is developing a management plan to address requirements for planning, implementing, and assessing the quality of its environmental data collection operations. Implementation of the Quality Management Plan is evaluated through EMAP Management Systems Reviews (MSR). The Management Systems Review protocol prepared for EMAP-Forest Health Monitoring will provide guidance to EMAP-QA both for its evaluation of the operating plan and in providing feedback and monitoring of the program.

Quality Assurance, Configuration Management, and Security Planning Support for EMAP-Information Management

Quality Assurance functions assuring adequate access to information about quality assurance and quality control enable quality assessments to include security and techniques of configuration management as part of the database architecture. These functions will enable EMAP-QA to assist EMAP-Information Management in responding to quality management requirements for EMAP. This joint project will also help resource groups plan and develop basic information management capabilities through prototyping and technology transfer.

Available and Upcoming Products

| | |
|--|-----------------------|
| <i>EMAP Quality Management Plan</i> | <i>September 1993</i> |
| <i>Quality Assurance Proof-of-Concept Prototype</i> | <i>September 1993</i> |
| <i>Plan for Forest MSR and Implementation</i> | <i>September 1993</i> |
| <i>Draft 1994 Quality Assurance Annual Report and Workplan</i> | <i>September 1993</i> |

3.7 Methods

Introduction

The EMAP-Methods component is identifying, standardizing, and ensuring the consistent documentation of sampling and measurement methods used by the EMAP resource groups in order to maximize the comparability of estimates for use in regional and national assessments. Activities include the development of a program-wide methods database to document existing procedures for measuring given parameters and to track the introduction of and changes to program methodologies. EMAP-Methods also demonstrates methods applications and taxonomic identification techniques.

EMAP Contact

Gary Collins

U.S. EPA Environmental Monitoring Systems Laboratory
26 W. Martin Luther King Drive
Cincinnati, Ohio 45268-1525
(513) 569-7174

EMAP-Methods Guidance Document

Currently, methods manuals developed and used by the various EMAP resource groups are in various formats and stages of development. EMAP-Methods will produce a standard format for such methods manuals based on ORD standards and with input from EMAP Technical Directors and Technical Coordinators. The resulting manuals will provide methods specifications for projects in the pilot, demonstration, and implementation phases of development.

Methods Data Base

Within EMAP, there is the potential for resource groups to duplicate efforts by evaluating essentially identical methods. To avoid duplicative effort, EMAP-Methods is developing a database that will be tied to the EMAP-Indicators database, and both will become part of the EMAP metadata. Ultimately, EMAP-Methods will identify and organize the sampling and measurement methods being used by EMAP resource groups to assure comparability of estimates of environmental condition across groups and through time.

Methods Validation Protocols

This activity involves developing acceptable protocols for evaluating both field and observational sampling methods and chemical or physical analytical methods. These protocols can then be adapted to EMAP requirements. This project will standardize the pilot, demonstration, and implementation phase methods requirements.

Establish a Taxonomic Coding System for EMAP

As an ecological as well as a biological monitoring program, EMAP needs a system for classifying animals and plants. A taxonomic coding system will not only benefit the EMAP resource groups, but also simplify tasks for EMAP-Information Management. This coding system will reduce the likelihood that resource groups will use incompatible coding systems.

Available and Upcoming Products

| | |
|--|----------------------|
| <i>Taxonomic Coding Systems Options Document</i> | <i>July 1993</i> |
| <i>Draft Methods Format Guidance</i> | <i>August 1993</i> |
| <i>Preliminary EMAP Methods Database</i> | <i>October 1993</i> |
| <i>Draft Validation Protocols for Chemical/Physical Analysis Methods</i> | <i>November 1993</i> |

3.8 Logistics

Introduction

EMAP-Logistics assists EMAP resource groups with planning and implementing fieldwork. Activities include developing specific logistics plans for each resource group and identifying common field procedures among groups in order to achieve maximum efficiency and cost effectiveness. This component provides guidance for all aspects of field logistics, including pre-field planning, crew training, site access permission, equipment acquisition and maintenance, sample tracking, safety, and public relations. The planned Geographic Positioning System (GPS) project will also help EMAP-Logistics communicate with and support EMAP-Information Management.

In addition to facilitating field operations for the various resource groups by activities such as training, equipment acquisition and site access, EMAP-Logistics is focusing on two specific projects to benefit EMAP resource groups: the publication of previously written EMAP training guidance, and guidance on the use of GPS.

EMAP Contact

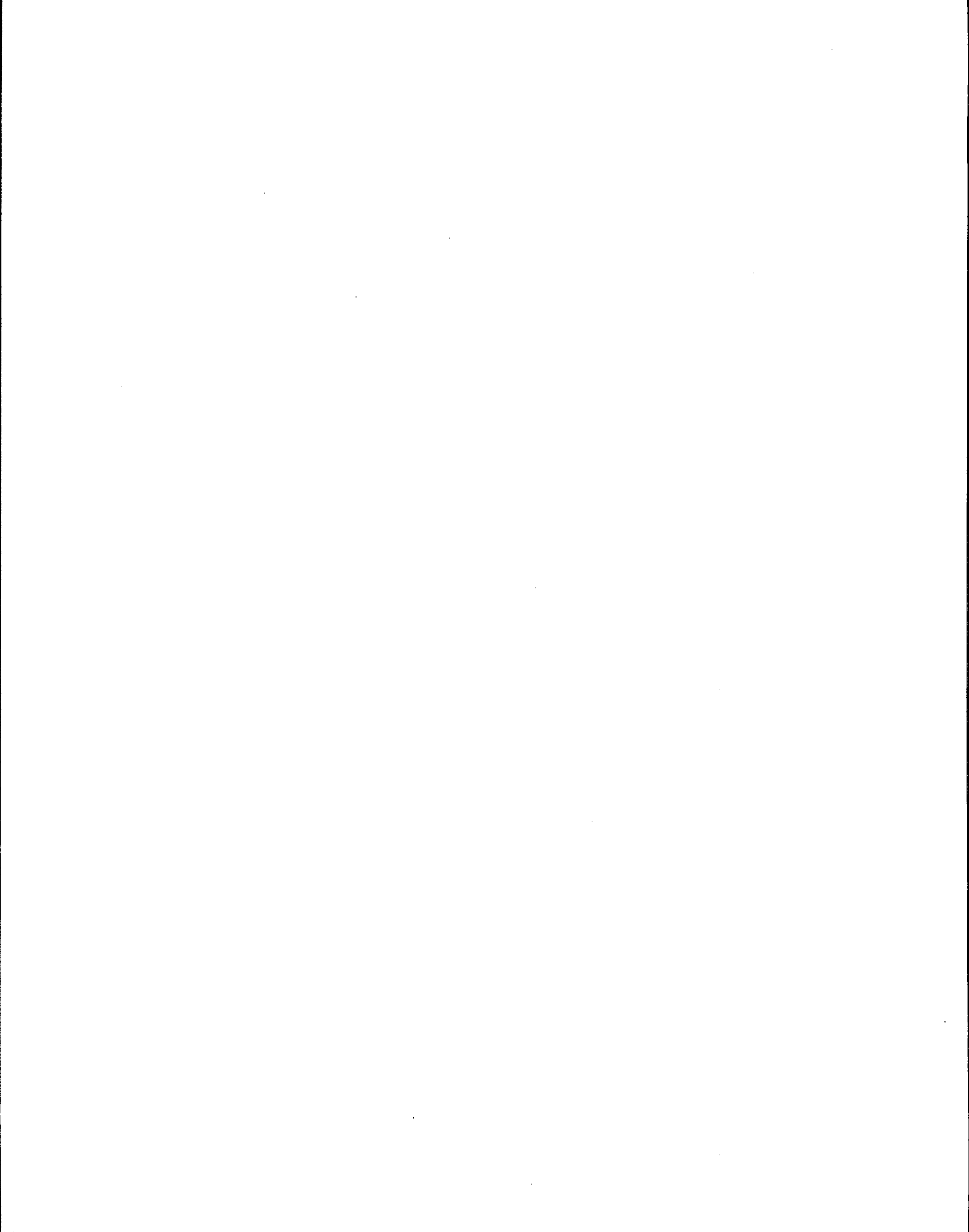
Daniel Heggem
U.S. EPA Environmental Monitoring Systems Laboratory
P.O. Box 93478
Las Vegas, Nevada 89193-3478
(702) 798-2278

Geographic Positioning Systems (GPS)

EMAP is evaluating the use of GPS which is used by EMAP to identify sampling locations with improved accuracy for repeated visitation. This project will entail a thorough investigation of GPS based on the experience of the EMAP and OIRM GIS workgroups, which have conducted both field testing and literature reviews. The recommendations which come from this investigation will be the basis for a GPS guidance document for use by the EMAP resource groups. This document will include the EPA locational data policy and the recent guidance released by the Office of Information Resources Management, and will also include recommendations for GPS equipment, training, operations, and data storage and use procedures. In addition, examples of a range of GPS applications, as successfully applied in the field by EMAP resource groups, will be included in the EMAP-Logistics guidance.

Available and Upcoming Products

| | |
|-------------------------------|-----------------------|
| <i>Paper on EMAP Training</i> | <i>September 1993</i> |
| <i>EMAP GPS Document</i> | <i>September 1993</i> |



Section 4.0 EMAP Program Coordination

Introduction

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Program Coordination projects are organized to address many of the program-wide communication and client service requirements of EMAP. The largest Program Coordination element is the Regional-EMAP program, which is a special program of targeted resources to assist EPA regional offices in applying and adapting EMAP data and methods to the policy management and decision-making needs of administrators in the regional offices. The Regional-EMAP project is organized from the EMAP Research and Assessment Center in Research Triangle Park, North Carolina, where it is able to take advantage of many of the diverse scientific and technical resources which make up EMAP.

EMAP-International provides EMAP information and technical resources to several bilateral and multilateral environmental initiatives, including especially the environmental monitoring activities of the United Nations Environmental Programme.

EMAP Program Coordination also supports research being conducted as part of the United States' contribution to the Arctic Contaminants Research Program. This support includes both logistics assistance and adaptation of EMAP methods to the special needs of the Arctic program.

Program Coordination supports all of the resource groups by obtaining air quality, atmospheric deposition, general climate data and support for research in regional climatic indicators. Program Coordination activities also include direct support for the Risk Assessment Forum in addition to individual collaboration agreements between the Risk Assessment Forum and individual resource and integration groups.

Introduction

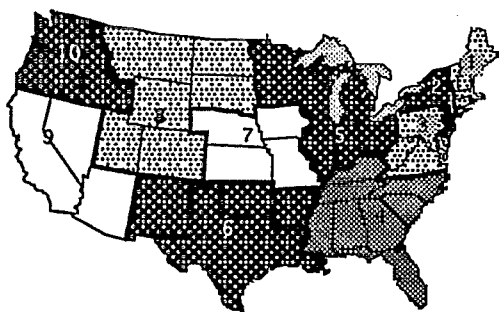


Figure 15 The Ten EPA Regions

4.1 Regional-EMAP (R-EMAP)

R-EMAP, the Regional Environmental Monitoring and Assessment Program, is an evolving partnership between EMAP and EPA's regional offices that promotes the use of EMAP technology, methods, and concepts at regional, state, and local scales. R-EMAP's objectives are to

- evaluate and improve EMAP concepts for state and local use,
- assess the applicability of EMAP indicators at differing scales, and
- demonstrate EMAP's utility for resolving issues of importance to EPA regions and states.

Through R-EMAP, each region proposes to apply an EMAP monitoring and assessment approach to high-priority projects identified by the region's comparative risk assessment process. R-EMAP projects are proposed by the EPA Regional Environmental Services Division Directors, are peer reviewed both internally and externally by an independent group of scientists, and are approved and funded by EMAP.

The brief project descriptions which follow identify the activities being undertaken by the seven regional projects that have planned field operations beginning in FY93. Three EPA Regional Offices (IV, V and VIII) are currently involved in planning activities for projects which will begin field operations in FY94.

R-EMAP projects are designed to yield useful information for decision-makers within one to two years. R-EMAP activities will assist in demonstrating the applicability of the EMAP approach, not only for national and regional assessments, but for smaller-scale, short-term applications. In addition, the enhanced interaction among EMAP, EPA regional offices, states, and local governments will help to fill the gap between the national EMAP program and the states. Since each region selects the R-EMAP projects from a list of previously-identified risk-based problems, the program will enhance EPA's effort to reduce ecological risk by utilizing data of known scientific quality in the decision-making process.

EMAP Contact

Rick A. Linthurst
EMAP Research and Assessment Center
U.S. EPA (MD-75)
Research Triangle Park, NC 27711
(919) 541-4909

R-EMAP Projects

Region I: Fish Tissue Contamination in the State of Maine

This Region I project is designed to determine the status of fish tissue contamination in high-value lakes within the State of Maine. The implications of tissue concentrations in terms of ecological risk, and the percentage and numbers of lakes in Maine at risk will be evaluated. The project will also help to determine what lake characteristics are associated with sensitivity to contamination. This project will complement Region I's strategic planning activities, especially in the area of resource protection, as well as Maine's efforts to initiate a comprehensive toxic monitoring program.

Cooperating Institutions

Maine Department of Environmental Protection (DEP), Augusta, ME.

The Maine DEP provides field crews to collect fish, sediment and water samples. DEP will also publish the project's final report.

Maine Department of Inland Fisheries and Wildlife, Augusta, ME.

The Department of Inland Fisheries and Wildlife is also providing field crews for the data collections phases of the Region I project.

Maine Health and Environmental Testing Laboratory, Augusta, ME.

The state's testing laboratory will provide the analyses for PCBs, pesticides, selected metals, and miscellaneous other parameters.

Available and Upcoming Products

| | |
|--|------------------------|
| <i>Detailed Work Plan</i> | <i>September, 1993</i> |
| <i>Statistical Summary of Data Collected in 1993</i> | <i>May, 1994</i> |
| <i>Final Assessment Report</i> | <i>March, 1995</i> |

Region II: Sediment Quality of the NY/NJ Harbor System and Regional Validation of EMAP-Like Indicators of Sediment Quality

Recent reviews of existing data suggest that a number of sites in the New York/New Jersey harbor estuary have contaminated sediments, although the actual extent is unknown. This Region II project will provide information on the extent and magnitude of sediment degradation throughout the New York/New Jersey harbor system and within specific sub-basins, helping to develop a needed sediment management strategy. The project will apply EMAP's sampling design at a suitably enhanced resolution to assure that results are capable of conveying the extent of sediment contamination with known statistical confidence. Field and laboratory methods will be comparable with EMAP's standard systems to ensure that results can be related to conditions in other parts of the country.

Cooperating Institutions

New York/New Jersey Harbor Estuary Program (NY/NJ HEP)

The NY/NJ Harbor Estuary Program provides matching funds and management support to the Region II R-EMAP project.

U.S. Department of Commerce, National Oceanic and Atmospheric Administration (NOAA).

NOAA will serve as a cooperating source of technical assistance to the NY/NJ Harbor Estuary Program, and will provide data from a

similar NOAA-sponsored study of sediment contamination in Newark Bay.

State environmental agencies in New Jersey and New York Staff and resources from both states will be made available for technical assistance and other support to the program.

Hudson River Foundation, Kingston, NY.

The Hudson River Foundation will provide technical assistance to the project through the NY/NJ HEP, and will also provide administrative support in the form of contract administration for project RFPs and some R-EMAP chemical analyses.

Available and Upcoming Products

| | |
|---|--------------------|
| <i>Region II R-EMAP Design Workshop Summary</i> | <i>August 1993</i> |
| <i>Region II R-EMAP Statistical Summary</i> | <i>March 1994</i> |
| <i>Sediment Quality Assessment—Final Report</i> | <i>June 1995</i> |

Region III: Surface Water Quality Indicators in the Mid-Atlantic Highlands

In this project, Region III will conduct field investigations and sample collection at reference sites of known environmental condition, indicator testing sites, and probability-based estimate sites. The project will establish biological reference conditions of the Central Appalachian Ridge and Valley ecoregion, define the range of natural biological variability of the ecoregion, quantify the differences between conditions in the ridges and the valleys, and define the current biological status of Ridge and Valley streams. The results of this project will also assist EPA in identifying associations between impaired conditions and potential causal factors, and between the current status and the results of EPA's 1986 National Stream Survey. This project is also part of a planned integrated ecological assessment of forests, streams, and agroecosystems in the Mid-Atlantic Highlands in FY94 and following years.

Cooperating Institutions

Institutions cooperating in the Mid-Atlantic Highlands Assessment (MAHA) include

- divisions of EPA's Region III;
- water pollution control and wildlife protection agencies in the states of Maryland, Pennsylvania, Virginia and West Virginia; these agencies provide lead biologists for field crews and help provide access to monitoring sites.
- other federal agencies, including especially the Fish and Wildlife Service regional office in Amherst, Massachusetts; FWS provided technical assistance and field staff to support fish sampling activities;
- universities in the region that have been involved in indicator review and will be involved in assessment implementation.

Available and Upcoming Products

| | |
|---|-------------------|
| <i>Annual Statistical Summary of Data Collected in FY93</i> | <i>July 1994</i> |
| <i>Pilot Implementation of Regional Assessment</i> | <i>March 1994</i> |
| <i>Assessment Reports</i> | <i>April 1995</i> |

Region VI: Characterization of Toxic Pollutants in Selected Texas Estuaries

Region VI will collect samples from 53 sites using the EMAP probability-based sampling design and analyze them using EMAP methods. These samples will be used to estimate the extent of toxic pollutants in sediment and fish at the sites. The results of this survey will directly answer region and state questions regarding potential problems. The project will also provide direct empirical evidence to test the EMAP statistical sampling system's ability to adapt to different levels of spatial resolution.

Cooperating Institutions

Texas Gulf Coast Research Laboratory, Galveston, Texas.
The Gulf Coast Research Laboratory in Galveston will process all sediment samples for benthic macroinvertebrates.

The Geochemical and Environmental Research Group (GERG), Texas A&M University, Lubbock, Texas.
GERG will provide all field sampling for this project, and will conduct chemical analyses of the water, sediment and tissue samples, using the same tests and standards applied to EMAP-Estuaries monitoring in the Louisianian Province.

Available and Upcoming Products

Characterization of Toxic Pollutants in Selected Texas Estuaries: Data and Conclusions

June 1994

Region VII: Estimating the Status of the Health of Fisheries

Region VII will measure the quality of fisheries that fall within the Region's four-state area of Iowa, Kansas, Missouri, and Nebraska. The project will study the associations between fisheries quality and the habitat and chemical or physical indicator data. This project will provide a cost-effective approach to assessing the condition of fisheries and will allow EPA to evaluate environmental indicators.

Cooperating Institutions

Kansas Department of Wildlife and Parks, Topeka, Kansas.
The Kansas DWP is organizing and overseeing two field crews to collect all of the field data for Kansas, and is donating part of the costs of personnel and equipment.

Nebraska Department of Environmental Quality, Lincoln, Nebraska and the Missouri Department of Natural Resources, Jefferson City, Missouri.

The two state departments are overseeing the collection of state data on fisheries by groups at their respective state universities.

Available and Upcoming Products

Measuring the Health of Fisheries in Region VII— Final Report

March 1996

Region IX: Assessment of Aquatic and Riparian Ecosystems in a Highly Modified, Agriculturally Influenced Environment

Region IX has identified agriculture as a significant source of ecological risk in the region. Since EPA's programs are not designed to address agriculture in a coordinated or resource-intensive way, Region IX developed a study to evaluate the current condition of aquatic biota in the agricultural area of the California Central Valley. This project will facilitate short-term policy decisions to protect surface waters. In addition, it will contribute to the formulation to scientifically sound, long-term monitoring strategies.

California Fish and Game Agency, Sacramento, California. This agency will conduct field sampling and Fish and Game Laboratory

Cooperating Institutions

staff will sort and identify organisms to the lowest possible taxonomic level for the macroinvertebrate indicator.

Available and Upcoming Products

| | |
|-----------------------|--------------------|
| <i>Interim Report</i> | <i>Summer 1994</i> |
| <i>Final Report</i> | <i>Fall 1995</i> |

Region X: Biological Assessment of Wadeable Streams in the Coast Range Ecoregion and the Yakima River Basin

Region X plans to conduct a long-term monitoring and assessment effort that will collect fish and macroinvertebrate assemblage samples as well as physical habitat and selected water column chemistry parameters in wadeable streams. These samples will help EPA's regional office to judge the status of first- through third-order streams in the Coast Range Ecoregion and the Yakima River Basin. The Region also will evaluate the possibility of identifying associations between the status of these streams and surrounding land uses.

Cooperating Institutions

Oregon Department of Environmental Chemistry, Eugene, Oregon.
The Department will assist in collecting fish and macroinvertebrate assemblage samples as well as physical habitat and selected water column chemistry parameters in wadeable streams for the Coast Range Ecoregion. The Departmental laboratory will also process the samples collected and perform the taxonomic identifications of macroinvertebrates.

Washington Department of Ecology, Olympia, Washington.
The Department will assist in collecting fish and macroinvertebrate assemblage samples as well as physical habitat and selected water column chemistry parameters in wadeable streams in the Coast Range Ecoregion and the Yakima River Basin. The Department will also process samples from the field collection.

Available and Upcoming Products

| | |
|--|-----------------------|
| <i>Region X Pilot Study Report</i> | <i>April 1994</i> |
| <i>First-Year Monitoring Final Report</i> | <i>September 1995</i> |
| <i>Second-Year Monitoring Final Report</i> | <i>August 1996</i> |

4.2 International Activities

Introduction

While EMAP focuses on the environment in the United States, it recognizes the interdependency of the world's economic and ecological resources. Consequently, the Program established EMAP-International to pursue the following activities:

- Cooperate with the United Nations (UN) and other international organizations in planning and conducting global-scale assessments of ecological condition. These studies will utilize data from existing monitoring networks to assess the condition of the world's resources.
- Provide technical assistance on design and indicators development for countries desiring to establish their own ecological monitoring programs.

Several countries including those of the Baltic and Eastern European regions have requested EPA assistance to develop their own ecological monitoring programs. Thus, EMAP-International's short-term objectives include

- developing a framework for specific long-term ecological monitoring plans for these regions;
- providing technical assistance to the regions that want to establish a probability-based ecological monitoring program; and
- testing indicators in the environments of regions with a variety of ecological stresses.

EMAP-International supports projects that facilitate cooperation between countries and institutions to ensure that ecological resources are monitored and maintained in an optimal manner. The goals of EMAP-International are to encourage the development of global-scale environmental monitoring networks and to extend the EMAP concept on an international basis.

EMAP Contact

Harold U. Kibby
U.S. EPA Environmental Research Laboratory
200 SW 35th Street
Corvallis, OR 97333
Telephone: (503) 754-4679

Earthwatch

Earthwatch is an outgrowth of the UN's Global Environmental Monitoring Systems (GEMS) within the United Nations Environmental Programme (UNEP). In collaboration with the international scientific community and other relevant organizations, Earthwatch gathers, integrates, analyzes, and reports data and information about the environment. Earthwatch uses this information to

- provide the international community with authoritative assessments on the condition of specific components of the environment in response to specific policy and management questions;
- identify global and regional monitoring and assessment needs;
- coordinate global and regional monitoring and assessment programs; and
- provide the UN and member nations advice on emerging environmental threats.

EPA will participate in Earthwatch's activities to ensure the compatibility of EMAP approaches and data with that from other countries and to provide leadership for conducting international global environmental assessments. Joint activities include coordinating and defining a set of indicators for describing and following trends in the condition of the environment, identifying relevant policy questions for further analysis, establishing a data base of existing monitoring and assessment programs, identifying additional monitoring needs, and recommending appropriate sampling designs.

Cooperating Institutions

United Nations Environment Programme, Global Environmental Monitoring Systems (UNEP/GEMS), Nairobi, Kenya.
Precise terms of the relationship between UNEP/GEMS and EMAP are still being defined, but, in general, EMAP will serve as a consultant to the United Nations' program for the selection of indicators of ecological condition.

Available and Upcoming Products

| | |
|--|------------------|
| <i>Database on Existing Monitoring and Assessment Programs</i> | <i>July 1994</i> |
|--|------------------|

| | |
|---|----------------------|
| <i>Report on Recommended Environmental Indicators</i> | <i>November 1995</i> |
|---|----------------------|

Technical Assistance

Monitoring networks provide quantitative, scientific assessments of the complex effects of stressors on ecosystems, and are important tools for determining the condition of the environment. Currently, countries and programs are developing new and improved monitoring networks at a rapid pace, and EPA anticipates that each network has the potential to improve on some aspect of monitoring and assessment science.

EMAP-International will supply technical assistance to other countries on a first-come, first-served basis, providing that the major portion of resources is covered by funding outside of EMAP. Three different levels of technical advice may be provided, depending on the nature of the request. These levels are

- a sample grid and a description of EMAP's design concept to any country that requests the information,
- training on frame development and selection of specific sample points for countries with capabilities to conduct continuous monitoring and assessment programs in the future, and
- a hands-on workshop led by a team of experts to explain the EMAP design, field methods, and suggested indicators that specific regions may want to develop.

EMAP will also evaluate the potential of other networks to improve specific elements of EMAP, and the program will implement modifications as appropriate.

Cooperating Institutions

Bowling Green University, Bowling Green, Ohio.

A proposal is being evaluated for Bowling Green to provide technical assistance to environmental protection programs in countries around the Baltic Sea.

4.3 Arctic Programs

Introduction

Scientists throughout the world are increasingly aware of the importance of the Arctic's fragile ecosystems and the risks for these systems from various human activities. The major problems for Arctic ecosystems are

- atmospheric transport and deposition of toxic pollutants (including acidic deposition);
- releases of, and exposure to, radioactive materials;
- industrialization (especially resource extraction activities, such as mining, smelting, and petroleum production);
- release of pollutants into marine systems; and
- threats from global warming.

To address these issues, EMAP will provide information on monitoring designs to the eight circumarctic nations that constitute the Arctic Monitoring and Assessment Program (AMAP). The objectives of these countries are to

- document concentrations of Arctic contaminants;
- evaluate recent history and probable sources of contaminants;
- determine possible food web effects and biological response indicators; and
- interpret results from an international perspective.

Three specific activities are currently proposed for direct participation by EMAP in the Arctic Contaminants Research Program. These are described below.

EMAP Contact:

Dixon Landers
U.S. EPA -Environmental Research Laboratory
200 Southwest 35th Street
Corvallis, OR 97333
503//754-4600

Support for Arctic Contaminants Research Program (ACRP)

The Arctic Contaminants Research Program (ACRP) is a research initiative of EPA's Office of Environmental Processes and Effects Research (OEPER), as part of the United States contribution to the Arctic Monitoring and Assessment Program. EMAP will provide support for helicopter and aircraft operations to sample Arctic habitats for the status and extent studies of the ACRP. This portion of the ACRP uses an EMAP grid to identify sampling sites for a probabilistic study of contaminant concentrations. Aircraft are also used for food web and sediment coring studies that are performed on a less extensive geographic scale.

Indicators of Organic Contaminants

Organic contaminants are one of the key problem areas for Arctic ecosystems. EMAP will help to develop and implement appropriate, quality assured, analytical methods for analyzing a suite of indicators of organic contaminants of lichen, moss, soil, sediment,

fish and mammals most likely to occur in Arctic environments. asks to support indicator development include

- analyzing bulk samples to gain experience with general organic contamination problems in the Arctic,
- identifying candidate organic contaminants to be studied,
- analyzing the routine samples, and
- reporting the data.

Cooperating Institutions

Texas A&M, Lubbock, Texas.

Texas A&M is the lead cooperating institution for the development of indicators of organic contaminants for the ACRP.

Pilot Study of Organic and Inorganic Contaminants

EMAP will design and implement a probability survey based on the EMAP grid to determine the current status of U.S. Arctic terrestrial resources with regard to inorganic and organic contaminants. Activities include selecting and sampling 35 sites per year from this sample frame for lichens, mosses, and soils; interpreting and publishing a study to address issues of spatial and temporal variability, and establishing the growth rate of target lichen species based on growth studies already underway. EMAP's spatial approaches will demonstrate the flexibility of the grid to address environmental management issues at a sub-regional scale.

Cooperating Institutions

Oregon State University (OSU), Corvallis, Oregon.

OSU has the lead for the development of probability survey methods for determining the status of organic and inorganic contaminants for the ACRP.

Available and Upcoming Products

| | |
|--|-----------------------|
| <i>Draft of Variability Paper</i> | <i>June 1993</i> |
| <i>Lichen Growth Study Preliminary Results</i> | <i>September 1993</i> |

4.4 Administrative Liaison

Introduction

In addition to the Regional-EMAP projects and the program's international activities, EMAP Program Coordination also involves supporting the monitoring and assessment activities of the resource and cross-cutting groups by providing administrative support and common information resources that are used by all groups, such as climate and air deposition data and coordination with the Agency's Risk Assessment Forum. Administrative Liaison also provides general support services (such as publishing the *EMAP Monitor* and the annual *EMAP Project Descriptions*), and provides support to the program-wide peer review process.

The sections below describe EMAP activities to acquire of air and climate data and to support the Agency-wide Risk Assessment Forum.

EMAP Contact:

Thomas L. Baugh
EMAP Headquarters
U.S. EPA (RD-680)
401 M Street SW
Washington, DC 20460
202/260-8936

Atmospheric and Acid Deposition Data

EMAP is supporting existing and new ozone and acid deposition monitoring sites under the Clean Air Status and Trends Network (CASTNET). The purpose of this network is to collect deposition and air quality data throughout the country, enabling the exploration of relationships between ecosystem condition and status with trends in air quality. CASTNET is providing EMAP resource groups with resulting data on atmospheric pollutants over broad geographic areas.

Acquisition and Interpretation of Climate Data

To improve its ability to detect temporal trends, characterize changes in status, and establish associations between ecological condition and human induced stress, EMAP must account for climate variability. To do so, EMAP is obtaining data from the National Weather Service, in a format which can support the exploration of associations between observed ecological conditions and selected, large-scale climatic stresses. This activity will determine the needs of EMAP's resource groups for climate data, and will assemble and interpret climate data as a stressor of ecosystems.

Regional Climate Indicators

This activity is intended to improve understanding of the relationship between regional climate characteristics (means and variability) and selected indicators of ecosystem condition using state-of-science methods and data. The activity will evaluate proposed climate indicators to determine if they meet the following criteria:

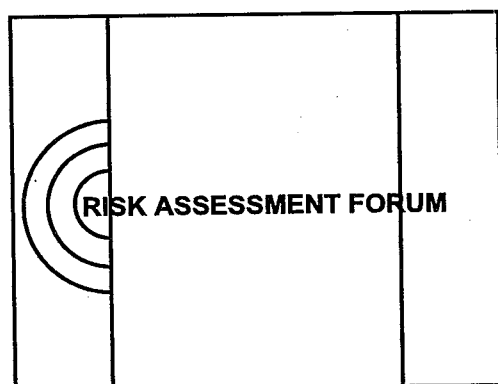
- They are unambiguously interpretable,
- They are responsive at a regional scale,
- They possess a high signal-to-noise ratio, and

- They are relatively stable throughout the indexing period(s).

By staying abreast of the rapid changes in nationwide weather-monitoring technology, EMAP will have access to increased data for monitoring and assessment activities.

The collection and acquisition of all of the above data (air quality, deposition, and climate) require cooperating with many other organizations including federal agencies (the Departments of Interior, Energy, and Defense); state and local governments; the governments of Canada, Mexico, and Europe; and international groups such as the UN's World Meteorological Organization.

Risk Assessment Forum



Issue Papers

As a fundamental component of the Office of Research and Development (ORD) Ecological Risk Assessment Program, EMAP is contributing to the development of ecological risk assessment guidelines through ORD's Risk Assessment Forum (RAF). RAF recently published its *Framework for Ecological Risk Assessment* to offer starting principles and a simple structure as a basis for later Agency-wide guidance on ecological risk assessment. RAF is expanding the *Framework's* principles through the development of issue papers and case studies, including two EMAP case studies. RAF is also developing an interactive training course for risk assessors to explore framework principles.

RAF is developing eight issue papers to provide a bridge between the basic principles of the *Framework* and more detailed guidance to be provided in future Agency-wide ecological risk assessment guidelines. Topics for the issue papers are

- ecological significance;
- conceptual model development;
- characterizing exposures, disturbances, and the stress regime;
- effects characterization;
- biological stressors;
- ecological recovery;
- uncertainty in ecological risk assessment; and
- risk characterization.

To ensure the issue papers are relevant to EMAP, RAF has included EMAP-recommended scientists as team members in the development of the issue papers. Issue papers will be peer-reviewed at a series of workshops, revised, then published in FY94.

Risk Assessment Case Studies

EPA's Science Advisory Board (SAB) recently concurred with the RAF's plans to continue and expand the EMAP-funded case studies developed in 1991 and 1992. The case studies provide descriptions of research that will contribute to the development of future guidance and will offer insight into the ecological risk assessment process. Six case studies are presently under

development, including two from EMAP concerning estuaries and arid ecosystems.

Available and Upcoming Products

| | |
|-------------------------------------|--------------------|
| <i>First Case Study Report</i> | <i>July 1993</i> |
| <i>Second Case Study</i> | <i>Fall 1993</i> |
| <i>Issue Paper Workshop Reports</i> | <i>Winter 1993</i> |

Appendices

**Appendix A. Resource Monitoring and
Research Groups: Implementation
Schedule FY93–97**

**Appendix B. Integration and
Assessment Groups: Implementation
Schedule FY93–97**

**Appendix C. Cooperating Federal
Agencies**

**Appendix D. Cooperating State and
Local Agencies**

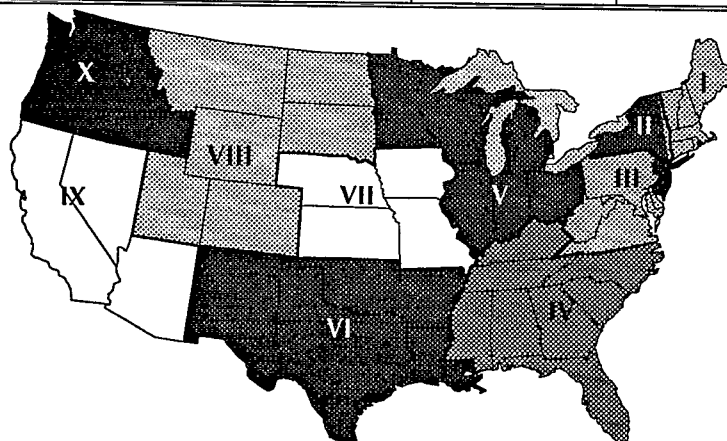
**Appendix E. Cooperating Universities
and Non-Governmental Organizations**

Appendix A:**Resource Monitoring and Research Groups**

* EPA Regions are indicated by number in each panel

FY93 - 97 Implementation Schedule*

| Resource Group | Current Year FY 1993 | FY 1994 | FY 1995 | FY 1996 | FY 1997 |
|---------------------------------|--|--|---|--|---|
| Estuaries | Field Activities Pilot Demo Implementation 4 1,2,3,4,6 | 1,4 4,6 1,2,3 | 1,4 1,2,3,4,6 | 9,10 1,2,3,4,6 | 9,10 1,2,3,4,5,6,7,8,9,10 |
| Products | △ VA '91 Prov Stat. Sum △ LA '91 Prov Stat. Sum | △ Statistical Summary △ & Assessment | △ Statistical Summary △ & Assessment | △ Statistical Summary △ & Assessment | △ Statistical Summary △ & Assessment |
| Great Lakes | Field Activities Pilot Demo Implementation 5 5 | 5 | 5 5 | 2,3,5 5 5 | 2,3,5 5 |
| Products | △ Example Statistical Summary | △ Example Assessment | △ Statistical Summary △ & Assessment | △ Statistical Summary | △ Statistical Summary |
| Surface Waters | Field Activities Pilot Demo Implementation 3 1,2 | 7,10 3 1,2 | 4,5,6,7,8,9 7,8,10 1,2,3 | 7,9 4,5,6,7,8,9 1,2,3,7,8,10 | 7,9 1,2,3,4,5,6,7,8,9,10 |
| Products | △ 1991 NE Lakes Rept △ 1992 Peer Rev. Memo | △ Indicator Report △ 1992 Lakes Stat Sum | △ Statistical Summary | △ Statistical Summary △ & Assessment | △ Statistical Summary △ & Assessment |
| Wetlands | Field Activities Pilot Demo Implementation 5,8 4,6 | 4 4,5,6,7,8 | 1,2,3,4 4,5,6,7,8 | 1,2,3,4,8,10 4,5,6,7,8 | 1,2,3,4,8,10 4,5,6,7,8 |
| Products | | △ Statistical Summary | △ Statistical Summary | △ Statistical Summary | △ Statistical Summary |
| Forest Health Monitoring | Field Activities Pilot Demo Implementation 1,2,3,4,8,9 | 5,8,9,10 1,2,3,4,8,9 1,2,3,4 | 5,10 1,2,3,4,8,9 1,2,3,4,8,9 | 6,7 5,8,9,10 1,2,3,4,8,9 | 6,7 1,2,3,4,5,8,9,10 |
| Products | △ 1992 Statistical Sum △ 1992 SAMAB Report △ 1991 GA & SE Demo | △ 1993 Stat Sum △ 1992 SE Demo Final △ 1992 SAMAB Rept | △ Statistical Summary △ & Assessment | △ Statistical Summary △ & Assessment | △ Statistical Summary △ & Assessment |
| Arid | Field Activities Pilot Demo Implementation 6,8,9 | 6,8,9 | 9 6,8,9 | 9 6,8,9 | 9 6,8,9 |
| Products | | △ Example Statistical Summary | △ Statistical Summary | △ Statistical Summary | △ Statistical Summary |
| Agroecosystems | Field Activities Pilot Demo Implementation 7 | 3,4,7 | 5,9 | 6,9 | 6,8,10 3,4 |
| Products | △ Statistical Summary | △ Statistical Summary △ & Assessment | △ Statistical Summary △ & Assessment | △ Statistical Summary △ & Assessment | △ Statistical Summary △ & Assessment |
| Landscapes | Field Activities Pilot Demo Implementation | | | | |
| Products | △ Research Plan | △ Journal: Landscape Values △ Report: Landscape Monitoring Design | △ Journal: Conceptual Models | △ Journal: Landscape Scales △ Journal: AVHRR & Scales | △ Journal: Landscape Indicators △ Report: Landscape Status |



U.S. Environmental Protection Agency Regions

Appendix B:

Integration and Assessment Groups
FY93 - 97 Implementation Schedule

| Integration and Assessment Group | | Current Year FY93 | FY94 | FY95 | FY96 | FY97 |
|----------------------------------|--------------------------------|---|--|---|---|---|
| Landscape Characterization | Planning and Peer Review | <ul style="list-style-type: none"> ● LC Research Plan 1.0 ● Strategic Plan ● GIS Geographic Reference Database Development Plan | <ul style="list-style-type: none"> ● Peer Review of LC Plan/Program ● LC Plan 2.0 | | | |
| | Guidance and Assistance | <ul style="list-style-type: none"> ▲ GIS Interface; Style Guide; User's Guide ▲ Complete Digitizing of Midwest Prairie Potholes ▲ Proposed Classification Categories ▲ Land Cover Classification System ▲ Evaluation Reports for Resource Sampling Pilots | | | | |
| | Research and Development | <ul style="list-style-type: none"> ■ Report on <i>Chesapeake Bay Watershed Pilot Study</i> ■ Journal Article on "EMAP's Geographic Reference Database" ■ Interim Report (with Design and Statistics) on <i>Extent Estimation Methods Survey</i> ■ Evaluation: LC Measurements vs. Indicators | | | | |
| Design and Statistics | Planning and Peer Review | <ul style="list-style-type: none"> ● Establish Advisory Committee | | | | |
| | Guidance and Assistance | <ul style="list-style-type: none"> ▲ Status Estimation Procedures and Algorithms ▲ Procedures for Integrating External Data ▲ Statistical Graphics Guidance for EMAP Reports ▲ Trend Detection Power Analysis Procedures ▲ Approaches for Resource Extent Estimation ▲ Framework for Estimation of Ecological Extent | | <ul style="list-style-type: none"> ▲ Approaches to Regional Trend Detection ▲ Frame Development and Evaluation | <ul style="list-style-type: none"> ▲ International Symposium on <i>Environmental Resource Monitoring</i> | |
| | Research and Development | <ul style="list-style-type: none"> ■ Interim Report (with Landscape Characterization) on <i>Extent Estimation Methods Survey</i> ■ Journal Article: "EMAP Sampling Design" ■ Working Paper on "Global Grid Enhancements" | | | | <ul style="list-style-type: none"> ■ Model-Based Estimation for Resource Surveys |
| Indicator Development | Planning and Peer Review | <ul style="list-style-type: none"> ● Revised Indicator Strategy | | | | |
| | Guidance and Assistance | <ul style="list-style-type: none"> ▲ Synopsis of Values, Questions, and Indicators by Resource Group ▲ Cross-Cutting Questions and Indicators for Terrestrial Groups ▲ Cross-Cutting Questions and Indicators for Aquatic Groups ▲ Model Development Case Studies ▲ Nominal/Subnominal Standards and Procedures ▲ Refined Indicator Testing ▲ Integrated Endpoint-Indicator Guidance | | | | |
| | Research and Development | | <ul style="list-style-type: none"> ■ Use of Conceptual Models in Indicator Development | <ul style="list-style-type: none"> ■ Agro Framework ■ SW Endpoints-Indicators | <ul style="list-style-type: none"> ■ SW Framework ■ NC Endpoints-Indicators | <ul style="list-style-type: none"> ■ NC Model Framework |
| Information Management | Planning and Peer Review | <ul style="list-style-type: none"> ● EPA/IRM Review ● SAB Review of Plan ● Information Management Plan 1.0 ● Report on Information Management Enterprise Model | | <ul style="list-style-type: none"> ● EMAP Information Management Plan 2.0 | | |
| | Guidance and Assistance | | <ul style="list-style-type: none"> ▲ Proof-of-Concept User Documentation | | | |
| | Research and Development | <ul style="list-style-type: none"> ■ High-Level Architecture ■ Information Management Requirements ■ Summary Report on IM Proof-of-Concept Study ■ Pilots ■ EMAP-IM 1.0 | | <ul style="list-style-type: none"> ■ Pilots ■ EMAP-IM 2.0 | <ul style="list-style-type: none"> ■ Pilots ■ EMAP-IM 3.0 | <ul style="list-style-type: none"> ■ Pilots ■ EMAP-IM 4.0 |
| Assessment and Reporting | Planning and Peer Review | <ul style="list-style-type: none"> ● Review of Draft Integration & Assessment Plan ● Integration and Assessment Plan, version 1.0 | | <ul style="list-style-type: none"> ● Integration and Assessment Plan, version 2.0 | | |
| | Guidance and Assistance | | <ul style="list-style-type: none"> ▲ Spatial Models ▲ Data Integration ▲ Assessment Questions | <ul style="list-style-type: none"> ▲ Guidance for Methods ▲ Societal Values to Questions ▲ Non-Monetary Benefits | | |
| | Research and Development | <ul style="list-style-type: none"> ■ Regional Assessment Prototype ■ Framework for Assessment | | <ul style="list-style-type: none"> ■ Pilot/Demo Integrated Assessment | | |

Appendix C. Cooperating Federal Agencies and Programs

| <i>U.S. Government Department</i> | <i>Agency or Program</i> | <i>Acronym</i> | <i>EMAP Component(s)</i> |
|---------------------------------------|---|-----------------------|---|
| US Department of Agriculture | Agricultural Research Service | USDA-ARS | Agroecosystems |
| US Department of Agriculture | National Agricultural Statistical Service | USDA-NASS | Agroecosystems |
| US Department of Agriculture | Forest Service | USDA-FS | Forests (USDA/FS has the administrative and technical lead for EMAP-Forests) Arid Ecosystems Landscape Characterization |
| US Department of Agriculture | Soil Conservation Service | USDA-SCS | Agroecosystems Arid Ecosystems Forests (USDA/FS has the administrative and technical lead for EMAP-Forests) Landscape Characterization |
| US Department of Commerce | National Oceanic and Atmospheric Administration | NOAA | Estuaries (NOAA has participated in design and will implement monitoring in Carolinian Province) Landscapes Landscape Characterization Great Lakes Wetlands |
| US Department of Defense | US Army Corps of Engineers | USACoE | Landscape Characterization |
| US Department of Interior | Bureau of Land Management | BLM | Arid Ecosystems Forests (BLM has provided several FTE positions to EMAP-Forests) Indicators |
| US Department of Interior | Fish and Wildlife Service: National Wetlands Inventory | USDOI/ FWS/ NWI | Wetlands Forests Landscape Characterization Estuaries |
| US Department of Interior | Fish and Wildlife Service: National Contaminants Program | USDOI/ FWS | Surface Waters |

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|---|--|---------------|--|
| US Department of Interior | Geological Survey: Water Resources Division | USGS | Surface Waters |
| US Department of Interior | Geological Survey: National Mapping Division | USGS/ NMD | Landscape Characterization Landscapes |
| US Department of Interior | National Park Service | USDOI/ NPS | Forests Arid Ecosystems |
| US Department of Energy | Idaho National Engineering Laboratory | DOE | Design and Statistics Indicators Terrestrial Systems (Forests, Agroecosystems- and Arid Ecosystems) |
| US Department of Energy | Oak Ridge National Laboratory | DOE/ ORNL | Design and Statistics Indicators Landscapes |
| US Department of Energy | Pacific Northwest Laboratory | DOE/PNL | Information Management Design and Statistics |
| National Aeronautics and Space Administration | | NASA | Landscape Characterization Landscapes |
| US Food and Drug Administration | | FDA | Estuaries |
| Tennessee Valley Authority | | TVA | Forests Landscapes |

Appendix D. Cooperating State and Local Agencies

| <i>State or Local Agency</i> | <i>EMAP Component</i> | <i>Description of Activity</i> |
|--|--|---|
| Alabama Department of Environmental Management | EMAP-Estuaries Louisianian Province | Agency participates in field monitoring |
| Mobile Bay Estuary | EMAP-Estuaries | Provided special summary of data results from Louisianian Province monitoring |
| California | Design and Statistics R-EMAP | State tested and subsequently adopted EMAP sampling design for surveys of fish and amphibians — now being applied to ecological monitoring in general California Fish and Game Agency and the Regional Water Quality Control Board are cooperating in a special assessment with Region IX of aquatic and riparian systems in the Central Valley |
| Southern California Bight | EMAP-Estuaries | Using EMAP-E monitoring design to extend usefulness of current outfall monitoring |
| San Francisco Bay | EMAP-Estuaries | Joint EMAP-E/San Francisco Bay NEP toxics monitoring pilot project planned for wetlands in FY94 |
| Chesapeake Bay Program (involves Virginia, Maryland, Pennsylvania, New York, West Virginia, and Delaware) | Estuaries Landscape Characterization Landscapes | CBP using EMAP data to supplement existing monitoring Jointly monitoring dissolved oxygen with EMAP Several joint assessment and special study activities Provided land use/ land cover for 69,000 mi ² Chesapeake watershed Study of associations between land use/ land cover patterns and environmental quality |
| Colorado | Forests Arid Ecosystems | State cooperated with both groups in joint indicator development project for riverine woodlands in arid ecosystems |
| Connecticut | Estuaries Forests Surface Waters | Supported monitoring in Long Island Sound and riverine estuaries Participating in Forest Health Monitoring field studies State participated in lakes pilot and demonstration monitoring |

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|---|---|--|
| Delaware | Estuaries Design & Statistics Indicator Development Landscape Characterization | Participating in monitoring State applying EMAP approaches to meet 305(b) (States Rivers Report) reporting requirements Agreement to share GIS information |
| Delaware Estuaries Program (involves Delaware, New Jersey, New York, Pennsylvania) | Estuaries | Using EMAP design to organize long term environmental monitoring EMAP provided a special fact sheet and data summary of monitoring results in Delaware estuary |
| Florida | Estuaries | Participating in Louisianian Province monitoring; EMAP-E preparing special fact sheets and data summaries for monitoring conducted in state waters |
| Indian River National Estuaries Program (NEP) | Estuaries | Technical assistance in monitoring design and information about EMAP methods |
| Sarasota Bay NEP | Estuaries | Technical assistance in monitoring design and information about EMAP methods |
| Tampa Bay NEP | Estuaries | Used EMAP design to organize Tampa Bay long-term environmental monitoring |
| Georgia | Forests | Participated in loblolly/shortleaf pine forest indicator development |
| Great Lakes National Program Office (GLNPO) (involves Wisconsin, Minnesota, Michigan, Indiana, Ohio, Pennsylvania, and New York) | Estuaries | Design of Regional-EMAP Project Lake Sampling methods for Lake Michigan |
| Gulf of Mexico Program (involves Florida, Alabama, Mississippi, Louisiana, and Texas) | Estuaries | Providing data for basic environmental background for GoMP Direct interaction with states of Alabama, Texas, and Florida Advice on general monitoring and assessment design Fact sheets and monitoring summaries provided on a state-by-state basis |
| Illinois | Landscape Characterization | State funding EMAP for statewide land use/land cover characterization |

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| Long Island Sound Estuary Program (involves Connecticut, Rhode Island, and New York) | Estuaries | Virginian Province results provided in fact sheets and summaries for Long Island Sound Shared data on dissolved oxygen and other contamination in the Sound Pilot joint monitoring project Design of new dissolved oxygen monitoring |
| Maine | Surface Waters | Supported the Lakes Pilot and Demonstration monitoring projects |
| Maine: Casco Bay Program | Estuaries | Cooperation on the design and field and lab methods employed for monitoring |
| Maryland | Forests | Participating in field studies for Forest Health Monitoring |
| Maryland-Delaware Inland Bays | Estuaries | Adapting EMAP design and field methods to monitoring requirements |
| Massachusetts | Forests Surface Waters | Participating in Forest Health Monitoring field studies Supported the Lakes Pilot and Demonstration monitoring projects |
| The Navajo Nation | Arid Ecosystems | Participating in the planning and field studies for the demonstration monitoring of the Colorado Plateau |
| Nebraska | Agroecosystems | Supported 1993 Pilot and indicator development |
| New Hampshire | Forests Surface Waters | Participating in Forest Health Monitoring field studies Supported the Lakes Pilot and monitored project logistics |
| New Jersey | Estuaries Surface Waters Landscape Characterization | Supported monitoring in Virginian Province and riverine estuaries Supported the Northeast Lakes Pilot and demonstration monitoring projects Agreement to share GIS information |
| New Jersey-New York Harbors Estuary Program | Estuaries | Used densified EMAP sampling grid for monitoring design |
| New Mexico | Landscape Characterization | State funding EMAP to provide statewide land use/land cover characterization |
| New York | Surface Waters | Provided planning, field monitoring and analysis support to Lakes pilot project |
| North Carolina | Agroecosystems Forests | Supported 1992 pilot project Participated in loblolly/shortleaf pine forest indicator development |

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|--|----------------------------|--|
| Ohio | Surface Waters | Provided EMAP with state monitoring data to test indicators |
| Oregon | R-EMAP | The State Department of Environmental Chemistry will work with Region X in a biological assessment of wadeable streams in the Coast Range |
| Pennsylvania | Landscape Characterization | State funding EMAP to complete statewide land use/land cover characterization |
| Rhode Island | Estuaries | Participated in monitoring |
| | Forests | Participating in Forest Health Monitoring field studies |
| | Surface Waters | Participated in monitoring |
| Southern Appalachian Man and the Biosphere Reserve (involves Alabama, Tennessee, Kentucky, North Carolina, South Carolina) | Forests | Participated in forest indicator development |
| | Landscapes | Developing joint assessment approach |
| South Carolina | Forests | Participated in loblolly/shortleaf pine forest indicator development |
| Texas | R-EMAP | The State Water Commission is actively cooperating with EPA Region VI in a study of toxic contamination of selected estuaries |
| Vermont | Surface Waters | Planning, field monitoring and logistics support to Northeast Lakes Demonstration |
| Virginia | Estuaries | Participating in Virginia Province monitoring |
| | Forests | Participated in loblolly/shortleaf pine forest indicator development |
| Washington | R-EMAP | The State Department of Ecology will work with Region X in a biological assessment of wadeable streams in the Coast Range and the Yakima River Basin |
| Wisconsin | Surface Waters | The state is a pilot site for the development of a model of coordinated surface water monitoring, under the auspices of the Interagency Task Force on Water Quality Monitoring |
| Association of State and Interstate Water Pollution Control Administrators | Surface Waters | Working cooperatively with the ASIWPCA's state water monitoring task force |

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| National Association of State Departments of Agriculture | Agroecosystems | Recruits enumerators for USDA-NASS-conducted field monitoring |
| National Association of State Foresters | Forests | Association assumes lead in presenting Forest Health Monitoring program to State Foresters — Third partner with USDA-Forest Service and EMAP |
| National Governors Association | | Serves as lead for ORD technology transfer issues |

Appendix E. Cooperating Universities and Non-Governmental Organizations (NGOs)

| <i>University or NGO</i> | <i>EMAP Component</i> | <i>Project</i> |
|--|--------------------------------------|---|
| Bowling Green University | International Activities | Technical assistance to Baltic nations |
| Dartmouth College | Surface Waters | Northeast Lakes demonstration |
| Desert Research Institute of the University of Nevada | Landscapes | Development of a landscape monitoring paradigm |
| Duke University | Estuaries | Carolinian Province monitoring planning |
| Estuarine Research Federation | Estuaries | Peer review of plans and implementation |
| Grand Canyon National Trust | Arid Ecosystems | Conceptual approach for integrating GIS with environmental indicators to assess desertification |
| International Standards Organization (ISO) | Information Management | EMAP information systems architecture |
| Louisiana State University | Wetlands | Estuarine emergents (salt marsh) pilot project |
| | Landscapes | Development of a landscape monitoring paradigm |
| North Carolina State University | Agroecosystems | Overall design of EMAP-Agroecosystems |
| Oregon State University | Arctic Contaminants Research Project | Pilot study of organic and inorganic contaminants in the U.S. Arctic |
| | Design and Statistics | Investigations in statistical and sampling issues |
| | Landscapes | Relationship of species richness to landscape scales and attributes in the United States |
| Society for Range Management | Arid Lands | Workgroup on nominal/subnominal ecological condition related to desertification |
| South Dakota State University | Arid Lands | Workgroup on nominal/subnominal ecological condition related to desertification |
| State University of New York (SUNY), College of Environmental Sciences and Forestry (Syracuse) | Surface Waters | Northeast Lakes demonstration |

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|---|--------------------------------------|--|
| Texas A&M University | Arctic Contaminants Research Program | Indicators of organic contaminants in the Arctic environment |
| | Estuaries | Louisianian Province monitoring and assessment planning |
| | R-EMAP Project for Region VI | Characterization of toxics in selected Texas estuaries |
| The Nature Conservancy | Landscapes | Relationship of species richness to landscape scales and attributes in the United States |
| Towson State University | Landscape Characterization | Chesapeake Bay watershed landscape characterization |
| United Nations Environment Programme-Global Environmental Monitoring System | International Activities | Technical assistance to Earthwatch |
| United Nations Environmental Programme | Design and Statistics | Global monitoring designs |
| University of Arizona | Arid Ecosystems | Workgroup on nominal/subnominal ecological condition related to desertification |
| | | Indicator plot design pilot study |
| University of California-Santa Barbara | Landscape Characterization | Development of a geographic reference database |
| | Landscapes | Relationship of species richness to landscape scales and attributes in the United States |
| University of Georgia | Estuaries | Carolinian Province monitoring planning |
| University of Maine | Indicators | Cross resource development of wildlife indicators |
| | Landscapes | Relationship of species richness to landscape scales and attributes in the United States |
| | Surface Waters | Northeast Lakes demonstration |
| University of Michigan | Great Lakes | Diatoms as indicators of biotic integrity and trophic status |
| University of Mississippi | Estuaries | Louisianian Province monitoring and assessment planning |
| University of North Carolina | Estuaries | Carolinian Province monitoring planning |
| University of Ottawa | Landscapes | Development of a landscape monitoring paradigm |
| University of Rhode Island | Estuaries | Management of program operations |

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|---------------------------------|-----------|---|
| University of South Carolina | Estuaries | Carolinian Province monitoring planning |
| University of Tennessee | Forests | Southern Appalachian Man And the Biosphere demonstration project |
| Utah State University | Wetlands | Estuarine emergents (salt marsh) pilot project |

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