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Project Summary

Environmental Monitoring and Assessment Program: Agroecosystem Pilot Field Program Plan—1993

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The Agroecosystem Resource Group (ARG) of the Environmental Monitoring and Assessment Program (EMAP) has developed a 5-year (1991-1995) strategy for the development, evaluation, and implementation of a suite of indicators for monitoring agroecosystem status and trends on a regional and national basis. The 5-year period includes time to test concepts relating to design, indicators, quality assurance, logistics, information management, data analysis, assessment, and reporting at the pilot and demonstration program stages. A primary emphasis is on the development of close working relations between personnel from the U.S. Department of Agriculture's (USDA) National Agricultural Statistics Service (NASS) and Soil Conservation Service (SCS) and the ARG. The 1993 Pilot Project in Nebraska will test all aspects of the monitoring program for a selected suite of indicators. This 1993 pilot will have sufficient flexibility to allow a number of innovative approaches to be examined in the various facets of the pilot. Results will be utilized to plan for a regional demonstration project and address specific concerns of applying the program indicators in a different geographic area of the country. In addition, results will assist the ARG in establishing a set of core indicators for use in monitoring the status, trends, and condition of the Nation's agroecological resources.

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

Introduction

In 1993 a Pilot Field Program will be conducted in Nebraska by members of EMAP's ARG. EMAP is an EPA interagency, interdisciplinary initiative to monitor the condition of the Nation's ecological resources. The USDA's Agricultural Research Service (USDA–ARS) was asked to give technical leadership to the Agroecosystem component, one of six resource categories within EMAP. Accordingly, the Technical Director of ARG is with the USDA-ARS. The ARG asked the USDA's NASS to cooperate in the development and data collection aspects of the Pilot Field Program. In addition, the ARG asked the USDA's SCS to participate in the collection and characterization of soils and the analysis of soil samples from agroecosystem sampling units. These 4 agencies are the principal cooperators in the Pilot, which is an important developmental step towards the implementation of a plan for monitoring the ecological condition of agroecosystems in the U.S.

The mission of the ARG is to develop and implement a program that will monitor and assess the condition and extent of the Nation's agroecosystems from an ecological perspective through an interagency process. The specific objectives of the ARG parallel the overall EMAP objectives. When fully implemented the program will:

- Estimate the status, trends and changes in selected indicators of the condition of the Nation's agroecological resources on a regional basis with known confidence.
- Estimate the geographic coverage and extent of the Nation's agroecological resources with known confidence.
- Seek associations between selected indicators of natural and anthropogenic stresses and indicators of the condition of agroecological resources.
- Provide annual statistical summaries and periodic assessment of the Nation's agroecological resources.

An agroecosystem is a dynamic association of crops, pasture, livestock, other plants and animals, atmosphere, soils, and water. The agroecosystem includes not only the field, but also the associated border areas such as windbreaks, fence rows, ditch banks, and farm ponds. Agroecosystems interact within larger landscapes, which include uncultivated land, drainage networks, human communities, and wildlife.

The sustainability of agroecosystems is of primary importance to the people of the U.S. and the world. Although there are several aspects of sustainability, the ARG is interested in the ecological sustainability of agroecosystems. An agroecosystem is ecologically sustainable if it maintains or enhances its own long-term productivity and biodiversity, the biodiversity of surrounding ecosystems, and the quality of air, water and soil.

The EMAP-Agroecosystems monitoring effort is based upon assessment questions related to three societal values. The three societal values for agroecosystems are the component of ecological sustainability—quality of air, water, and soil; productivity; and biodiversity.

The ARG has developed a multiyear program to establish the national implementation of a suite of indicators by 1997. The first stage of the program (1990) encompassed the initial evaluation of: (1) statistical designs; (2) existing monitoring programs (NASS, Soil Conservation Service, and Economic Research Service); (3) assessment endpoints and associated indicators (for their availability, validity, variability, and cost); (4) data management and analysis techniques; and (5) derived outputs. During 1990, a national monitoring strategy was developed on the basis of these evaluations. In the second stage of the program (1991) in-depth examinations were conducted of several areas critical to the planning and implementation of Pilot Field Programs: (1) statistical design options; (2) measurements associated with specific indicators and assessment endpoints; (3) sampling protocols; (4) cooperation with NASS; (5) logistics; (6) total quality management; and (7) information management. The 1992 Pilot Field Program in North Carolina, conducted in cooperation with USDA–NASS tested aspects of the monitoring program with a limited suite of indicators. Experience from the 1992 Pilot has been utilized to improve vital aspects of the planned 1993 Pilot Field Program. Experience from the pilot programs will be used to develop (based upon availability of funds) regional demonstrations which will eventually lead to national implementation.

Rationale and Objectives

Agroecosystems are managed intensively for the benefit of people. As a result, activities in agroecosystems are often influenced by government programs and regulations and by socioeconomics. These perturbations are beyond the realm of traditional ecology and provide a series of challenges to the establishment of an ecological monitoring program for agroecosystems.

The Agroecosystem monitoring program will be carried out through a combined survey and sampling approach. Information on inputs and management practices will be obtained directly from the grower, soil samples, and on-site measurements. All of this information will be integrated into indices such as crop productivity, production efficiency, soil quality, and habitat suitability.

Region VII and the state of Nebraska were selected for the 1993 Pilot Field Program for several reasons:

1. The physiographic diversity of the state is representative of typical midwestern agroecosystems (intensively cropped areas) and western agroecosystems (sparsely cropped areas); the state contains a transition zone between these types of agroecosystems; and the state contains an area (Platte River Basin) where intensively managed agroecosystems intrude into an area of nonintensively managed systems.
2. Nebraska contains a transition between agroecosystems and arid ecosystems, which will allow for the careful definition of the areas of responsibility of the ARG and the Arid Lands Resource Group.
3. EPA Region VII expressed strong interest in the Agroecosystem monitoring program.

The 1993 Pilot Field Program has four major objectives:

1. Empirically evaluate an initial suite of indicators to evaluate the ability of an indicator to address the assessment questions and societal values of interest; establish an initial range of values and variance for each indicator across a midwestern region; assess components of variability of indicators within and among sample units; identify the usefulness and sensitivity of each indicator in determining ecological condition; and determine the cost-effectiveness of each indicator.
2. Compare the relative efficiency, in terms of cost and precision, of the EMAP Hexagon Design and the NASS Rotational Panel Design for use in a national agroecosystem monitoring program.
3. Develop and refine plans for key components of the monitoring program, including sampling, logistics, total quality management, data analysis, summarization, and reporting and information management.
4. Develop and evaluate additional measurements that will address specific indicators, including soil quality, biological components, and landscape structure.

The 1993 Pilot Field Program is not intended to be a full implementation of the agroecosystem monitoring program, but will provide information essential to the successful development of regional demonstration projects. The Pilot Field Program represents an essential step in program development to fully consider issues critical for the success and implementation of a national monitoring program.

Design and Statistical Considerations

The ARG has two sampling plans under consideration for long-term monitoring, each of which uses the NASS Area Frame segments as the basic sampling unit. The two plans differ in the way the segments to be used for indicator sampling are selected. The Pilot study will evaluate the results of a sampling strategy based on using the EMAP Hexagon Design to select the NASS segment to the Rotational Panel Plan which uses a subset of segments from the NASS June Enumerative Survey.

Data analysis will include (in addition to a simple statistical summary of the indicator results): (1) estimation of variance components to help determine future field sampling strategies; (2) correlation analysis to understand relationships among indicators as well as spatial patterns of the indicators; and (3) comparison of the variance and cost efficiencies of the two sampling plans.

Indicators

Five indicators were selected for evaluation in the 1993 Pilot Field Program. These are: (1) crop productivity; (2) soil quality—physical and chemical; (3) soil biotic diversity; (4) land use and cover; and (5) agricultural pest management.

Crop Productivity

Crop productivity has four facets of interest to EMAP-Agroecosystems: total production in a region, yield (production per unit land area), yield as a biological response indicator adjusted for inputs, and production efficiency (production per unit input). The first two measures are already reported by the USDA–NASS. Accordingly, EMAP–Agroecosystems is gathering new information primarily for the third and fourth facets of crop productivity which emphasize the ecological condition of the system. Information will be gathered via questionnaire on crop production inputs and practices and on yield estimates. These data, as well as soils data, if necessary, will be used to convert yield estimates to estimates of productivity and to provide conversion factors that will allow comparisons of production efficiency among crops. The possibility of converting yield values to values of net primary productivity will also be examined.

Soil Quality–Physical and Chemical

The focus of soil quality assessment for agroecosystems will be on the presence, extent and change in those soil properties that are (1) important to the functioning of the soil system, (2) known to be affected by agricultural land management, and (3) can be adequately measured in one sampling period at a regional scale. The short-term objective is to determine the range and frequency distribution (in proportion of land area) of individual measures and to begin evaluation of how well the chosen measurements (organic carbon, clay content, pH, cation exchange capacity, base saturation, and lead concentration) and derived indices will reflect changes in soil condition.

Two sampling methods will be used in the Pilot. In one method, NASS enumerators will sample the plow layer within fields by taking soil samples (2.5 x 20 cm deep) along one or more transects within each selected field. These samples will be mailed to the SCS Soil Analysis Laboratory in Lincoln, NE to be analyzed for particle size, pH, organic C, cation exchange capacity and exchangeable cations, and available phosphorus and calcium carbonate equivalent. In a second method, in approximately 40 fields, SCS State soil scientists will visit a field after the NASS enumerator and will dig a 50-cm deep soil characterization pit. The soil scientists will record the soil series and will take samples for analysis in up to four horizons. Samples will be submitted to the SCS Soil Analysis Laboratory and will be analyzed for particle size, pH, organic C, cation exchange capacity and exchangeable cations, available phosphorus, calcium carbonate equivalent, bulk density, 15-bar water retention and aggregate stability. Results of the two sampling methods will be compared.

Soil Biotic Diversity

Nematodes are ubiquitous in terrestrial soils and trophic or functional groups of nematodes are present at several critical positions in the soil food web. Additionally, the abundance and size of nematodes makes sampling easier and less costly than for other microflora and fauna. Nematode community structure, as quantified with one or more ecological indices (diversity index, maturity index) based upon trophic groups or families of nematodes, is being investigated as a possible indicator of soil biotic diversity or soil "health." Populations of nematodes in soil samples (from the Rotational Panel Design only) will be quantified for five trophic groups: plant parasites, bacterivores, fungivores, omnivores, and predators and index values for various aspects of community trophic structure will be calculated. Specific indices will include the maturity index, a measure of degree of community disturbance, and Shannon's diversity index—a measure of trophic diversity. Additionally, samples from 20 rangeland sites that are paired with sampled fields will be taken and analyzed in order to compare trophic diversity and degree of disturbance of soil communities between tilled fields and rangeland areas.

Land Use

Agricultural landscapes are characterized by spatial and temporal patchiness on many scales. Changes in land use patterns may foreshadow ecological changes in agricultural landscapes or may themselves be the result of ecological changes. Land use will be monitored at multiple scales using area frame materials from the USDA–NASS and survey data collected by USDA–NASS. Measures of land use will include agricultural land use intensity, overall land cover, overall land cover diversity, production land use, and production land use diversity.

Agricultural Pest Management

Pest management information will be collected in the fall survey questionnaire. Information on type and amount of each pesticide used on the selected field will be collected from the grower. The target insect pest will also be identified for each insecticide application. In addition, because the Integrated Pest Management (IPM) practices are viewed as a sustainable agricultural practice, questions will be asked about the farmer's familiarity with the concepts and practices associated with IPM. The prevalence and spatial distributions of IPM practices will be assessed. Pesticide application information will be used primarily as associative information for the indicators of crop productivity and soil biotic diversity.

Quality Assurance

The purpose of quality assurance is to ensure that the data will yield sound and unbiased conclusions related to the principal questions being addressed. Quality Assurance (QA) for the Agroecosystem Program is being developed in conjunction with USDA ARS, NASS, and SCS to assure the reliability of measurements. The development of a QA plan is an iterative process and information collected in this pilot will enhance future QA plans. Key components of QA include data quality objectives, standard operating procedures, QA project plans, audits, QA annual reports, and work plans. Because the ARG is a cooperative effort between the EPA, ARS, SCS, and NASS, the ARG will take full advantage of QA procedures already employed by NASS and SCS.

Logistics

Implementation of the Agroecosystem Pilot Project has required detailed logistics planning, including coordination and oversight of all support and data collection activities. Logistical issues that have been addressed by the ARG include: staffing, design of survey questionnaires, communications, training, safety, sampling schedule, site access and reconnaissance, procurement and inventory control, field operations, laboratory operations, waste disposal, information management, qual-

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ity assurance, cost tracking, and review of logistics.

From the standpoint of logistics, working with NASS has several benefits. Based on the integrity and reliability of their personnel, NASS has developed a relationship over time with the agricultural community which will greatly facilitate the collection of data. Additionally, NASS has a fully developed infrastructure for the collection of agricultural data, including well-developed logistical procedures and strict quality controls. Use of this infrastructure greatly reduces the resources that would be needed for the ARG to develop similar procedures.

Information Management

The Agroecosystem 1993 Pilot Field Program will require that data be obtained, stored, manipulated, integrated, and analyzed. New and existing data will come from many sources, including joint ARG–NASS data collection efforts, the SCS analysis laboratory, the nematode identification laboratory, other government agencies, cooperating non-governmental organizations, and academic institutions. A major component of the Agroecosystem Pilot is the development of a close working relationship with NASS. Confidentiality of data, and consequently data security, are particularly critical issues to the ARG–NASS relationship. Privacy of individuals who respond to NASS data collection efforts is protected by law that provides for these data being kept confidential and for release only in an aggregated format that will not enable individual respondents to be identified. Goals of the 1993 program are to develop fully functional data documentation facilities, develop a sampling tracking protocol, and evaluate data security protocols.

Conclusion

The Agroecosystem Pilot Field Program for 1993 in Nebraska will test concepts relating to design, indicator development, data analysis, quality assurance, logistics, and information management. A primary emphasis is the development of close working relations between personnel from NASS, SCS, and the ARG. This 1993 pilot will have sufficient flexibility to test a number of innovative approaches. Results will be utilized to evaluate program components essential to the development of regional and national monitoring programs.

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The complete report, entitled "Environmental Monitoring and Assessment Program: Agroecosystem Pilot Field Program Plan—1993," (Order No. PB94-144573/AS; Cost: $36.50, subject to change) will be available only from:

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