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Project Summary

Agroecosystem Monitoring and Research Strategy: Environmental Monitoring and Assessment Program

Walter W. Heck, C. Lee Campbell, Robert P. Breckenridge, Gerald E. Byers, Alva L. Finkner, George R. Hess, Julie R. Meyer, Thomas J. Moser, Steven L. Peck, John O. Rawlings and Charles N. Smith

To project, manage, and use agroecosystem resources effectively, the condition of these resources must be known. Concern about the documented and potential effects of anthropogenic stressors in the environment, changing conservation and land use programs, and use of agricultural chemicals has been a major reason for the development of the EPA–Environmental Monitoring and Assessment Program (EMAP)/the Agroecosystem component. In addition to the anthropogenic stressors, the program is concerned with how these may affect a host of naturally occurring stressors. The Agroecosystem component of EMAP is developing an ecologically based monitoring initiative to determine status and trends in land use and agroecosystem health. The Agroecosystem Resource Group (ARG) has identified over 100 possible indicators, has chosen 16 high priority indicators and is developing details on five of these for use in a 1992 pilot study. The Technical Director for the ARG is with the Agricultural Research Service of the USDA and the ARG is both a multidiscipline and multiagency group.

The purpose of this document is to present a "Monitoring and Research Strategy" for the agroecosystems of the U.S. It should serve as an overview for other State and Federal agencies interested in participating. Monitoring issues such as design, indicator selection and development, analysis, information management, and assessment are covered in the Strategy.

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

This document is both a conceptual strategy and an implementation plan for monitoring the ecological condition of agroecosystems in the United States. It represents the combined effort of the Agroecosystem Resource Group (ARG). The plan is viewed by the ARG as a living document that will serve as a basis for discussion of goals, objectives, concepts, and approaches.

The agroecosystem monitoring program described in this document is one component of the Environmental Monitoring and Assessment Program (EMAP), a national program administered by the U.S. Environmental Protection Agency's (EPA) Office of Research and Development (ORD). In response to recommendations by the EPA Science Advisory Board, Congress and the public, EPA is designing EMAP in cooperation with other agencies and organizations. EMAP is organized into seven resource categories to facilitate interagency cooperation and to make the best use of scientific expertise. Interdisciplinary groups of scientists, called "Resource Groups", are responsible for developing strategies for the collection, analysis and integration

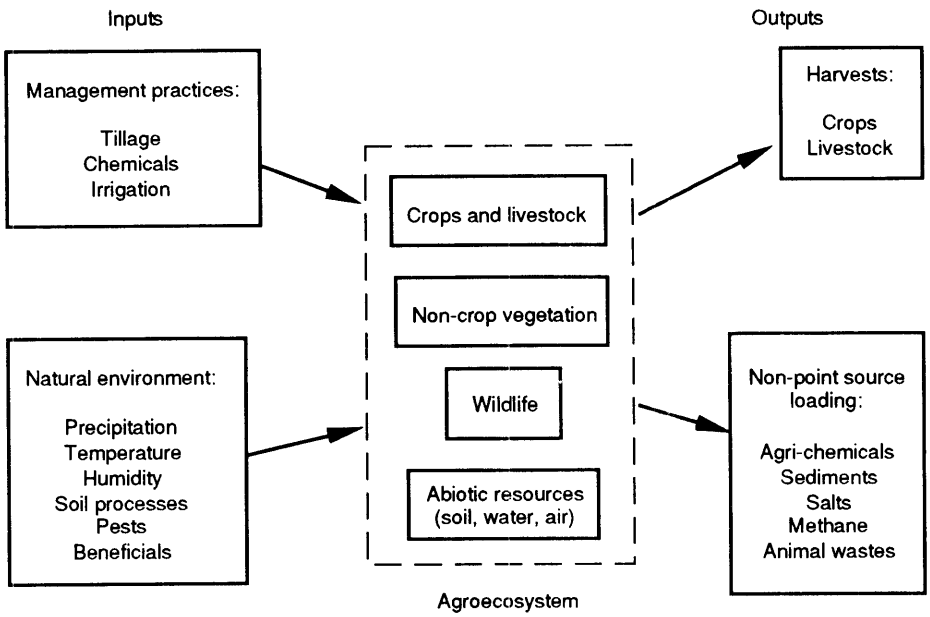

Figure 1. *A conceptual model of agroecosystems.*

of data from each of the ecological resources. In addition, seven crosscutting coordination groups have been established to assist the resource groups and to ensure total quality management, consistency and integration of activities across the program.

For EMAP, agroecosystems are defined as land used for crops, pasture and livestock; the adjacent uncultivated land that supports other vegetation (hedgerows, woodlots, etc.) and wildlife; and the associated atmosphere, underlying soils, groundwater, and drainage networks (first and second order streams, ponds, and irrigation drainage networks). A simplified conceptual model (Figure 1) of an agroecosystem shows both natural and anthropogenic inputs and both desirable and undesirable outputs. The conceptual model and the definition of agroecosystems illustrate how the Agroecosystem program is being designed as a holistic approach that considers all constituent components of agroecosystems.

Agroecosystems have more impact on our daily lives than any of the other terrestrial ecosystems, because they provide us with food and fiber and influence the quality of our environment. Farmers have the stewardship of more of the global environment than any other group; in the United States, crop land accounts for approximately 443 million acres, nearly 20%, of the total U.S. land area.

Although agricultural systems are often viewed as relatively simple, they are far more complex than they may appear initially. The periodic and chronic disturbances that are an inherent part of agricultural management place agroecosystems among the most rapidly changing landscapes on earth. A healthy agroecosystem balances sustainable crop and livestock production with maintenance of air, water and soil integrity and supports populations of wildlife and vegetation in associated non-crop habitats. The degradation of any one component influences the other components in the agroecosystem and in adjacent, linked ecosystems.

The mission for the ARG is to develop and implement a program to monitor and evaluate the long-term status and trends of the nation's agricultural resources from an ecological perspective through an integrated, interagency program. The objectives of the Agroecosystem program parallel the overall EMAP program objectives, but focus more specifically on agroecological resources. When fully implemented, the program will meet the following objectives: 1) estimate the current status, extent, changes and trends in indicators of agroecosystem condition on a regional basis with known confidence; 2) monitor indicators of pollutant exposure and habitat quality and seek associations between anthropogenic stresses and agroecosystem condition; and 3) provide periodic statistical summaries and interpretive reports on agroecosystem condition to the public, the scientific community, and to policy-makers.

Assessment endpoints that encompass the concept of agroecosystem health will be developed to focus the interpretation of indicator data. Assessment endpoints are a quantitative or quantifiable expression of the environmental value, such as agroecosystem health, to be monitored and assessed. Good assessment endpoints have social and biological relevance, an unambiguous operational definition, are accessible to prediction and measurement, and are susceptible to the environmental stressors of concern. Assessment endpoints are long-term societal values that will not change over time, even when specific stressors or specific issues do change. After careful consideration of important scientific, social, economic and environmental issues concerning agriculture, agroecosystems, and their associated surroundings, three assessment endpoints were identified that summarize the essence of the issues. These are: 1) sustainability of commodity production; 2) contamination of natural resources; and 3) quality of agricultural landscapes. Although members of the ARG agree on the basic issues addressed, they are still debating the terminology and organization of these endpoints.

Sustainability of commodity production refers to the capacity of a particular agroecosystem to maintain a level of crop or livestock productivity that provides for basic human food and fiber needs, and an economically viable livelihood for farmers without polluting or seriously depleting soil, water, wildlife, fossil fuel or other resources. Continual removal of biomass from agricultural fields necessitates inputs or adjustments to maintain productivity; however, long-term sustainability of agroecosystems can be masked in the short-term by management practices. Inputs, outputs, socioeconomic factors, and the use of natural resources will be considered in the assessment of agronomic sustainability.

Contamination is defined as the presence of anthropogenically-related stressors that have direct or indirect effects on the sustainability, productivity, structure or function of the agroecosystem. Contaminants can be found in the air, soil, water, and biota of agroecosystems, and may include air pollutants, agricultural chemicals, animal and municipal wastes, water pollutants, and genetically-altered organisms. Contaminants can also be trans-

ported from agroecosystems. On a regional and national scale, managed agricultural systems contribute to nonpoint source pollution through loss of agricultural chemicals and sediments carried to streams and rivers. On a local level, managed agricultural systems can be pollution point sources, such as pesticide drift from aerial spraying, that can impact immediately adjacent areas.

The quality of agricultural landscapes refers to the various ways in which the landscape matrix is modified or employed for agricultural and non-agricultural purposes over time. Agricultural land use patterns exert a major influence on ecological processes. For example, landscape heterogeneity may affect soil erosion, water quality, crop-pest interactions, ecological diversity and the spread of diseases. A vital characteristic of landscape modification is the extent to which the surrounding landscape can support populations of non-crop vegetation and wildlife. An assessment of agroecosystem health and the development of sustainable agricultural systems must consider landscape level processes over time and the coupling of natural and agricultural components of the landscape.

The Agroecosystem program is designed to evaluate the health or condition of U.S. agroecosystems. The program is designed to complement existing monitoring efforts such as those carried out by USDA/National Agricultural Statistics Service (NASS), USDA/Soil Conservation Service (SCS)–National Resources Inventory (NRI), USDA/Economics Research Service (ERS) and the USDC Bureau of the Census by adding an essential *ecological dimension* to current data collection, compilation and interpretation. The program will utilize existing monitoring data where possible and will provide new data on trends in the condition of crop and non-crop resources which will be interpretable from environmental, ecological, agricultural or agroecological viewpoints.

The EMAP program has established a four-tier approach to ecological monitoring. Tier 1 emphasizes landscape characterization and estimates of extent of resource and land use; Tier 2 provides estimates of condition and trends; Tier 3 concentrates on detailed diagnostics; and Tier 4 represents research sites established to answer specific cause-effect questions. The Agroecosystem program currently focuses primarily on Tier 2 with some activities at Tier 1. Tier 2 involves field sampling to provide measurements of status and trends in indicators of agroecosystem condition on a regional basis.

The planned data collection approach is through a cooperative program with the National Agricultural Statistics Service (NASS) under which NASS enumerators collect all or most of the Agroecosystem indicator data. The Agroecosystem program will cooperate with NASS in one of two ways for Tier 2 sampling. NASS currently samples over 16,000 segments annually in the June Enumerative Survey (JES) and has been involved in agricultural surveys since 1954. The first, the Hexagon Plan, uses the NASS primary sampling unit (PSU) located at the centroid of the EMAP hexagons. Using the NASS stratification, approximately 3,200 hexagons would be selected at random to achieve optimum allocation. The selected segment, identified by the centroid, would then be used for the duration of EMAP. The second plan, the Rotational Panel Plan, takes advantage of the NASS sample and uses approximately 20% (approx. 3,200) of the segments used in the NASS JES sample. The NASS sample has five interpenetrating replicates of the total sample, designed such that each replicate rotates out of the sample after five years. Initial investigation seems to indicate that the RPP may have advantages over the Hexagon Plan. This is currently being explored theoretically and will be tested during the pilot.

Field sampling protocols for obtaining indicator data at the field level from the sample segment are being developed in close cooperation with NASS. Among the statistical issues involved are selecting the field, choosing the sampling points and determining the appropriate sampling density within the field. Field sampling techniques will be evaluated during a 1992 pilot, as well as sampling protocols, the effectiveness of the training manuals for NASS, and interaction with the NASS enumerators. Throughout the survey process, the ARG will be alert to the kinds of errors that may occur and will take steps to control, minimize and measure them.

Initial analyses of the monitoring data will be directed toward the routine summarization of indicator values that measure ecosystem health. Interpretive analyses will be aimed at understanding the correlation structure among the indicators, regional spatial patterns and concordance of spatial patterns for stressor and response indicators, time trends, and the development of health indices for the agroecosystem. In addition to the indicator variables themselves, extensive information will be collected on ancillary data to facilitate interpretation of indicators.

The Agroecosystem program will obtain, store, manipulate, integrate and analyze data. These data will come from many sources, including joint Agroecosystem-NASS collection efforts, from other EMAP Resource Groups, other government agencies, cooperating non-government agencies, and academic institutions. The information collected and created by the program will be available, at some level, to researchers in these same agencies and institutions. Researchers must know what data are available, where they are located, and how they can be accessed. Information about methods used to collect data, including details about data quality, must be available. To ensure that data are of the highest quality, carefully designed procedures for the movement and manipulation of data, from field collection through analysis, are planned as an information management effort. Because the data are to be widely available, there must be a policy and mechanism which protects the privacy of the individual respondents. Thus, confidentiality of data, and consequently data security, are critical issues for the ARG. The Agroecosystem program objectives require that data be collected from individual growers and operators.

From the standpoint of information management, working with NASS is the best approach because: 1) the relationship of NASS with the agricultural community will facilitate data collection; 2) NASS provides confidentiality of data to individual farm operators; 3) NASS has a fully developed infrastructure for the collection of agricultural data, including strict quality controls; and 4) NASS has developed the computer resources to organize, analyze, and quickly report on large volumes of data.

The database developed from the Agroecosystem program will provide essential data for conducting ecological risk assessments. Such assessments estimate the effects of both anthropogenic and natural activities on ecological resources and allow the significance of those effects to be interpreted with quantified uncertainty estimates. The primary role of the Agroecosystem program in the overall risk assessment process is to identify and quantify agroecological hazard related to the assessment endpoints which can then be used in risk assessment. Hazards will be identified within agroecosystems through the use of indicators of ecosystem condition. Overall risk assessment will be facilitated through effective information exchanges and monitoring linkages with other ecosystem resource groups.

The ARG will communicate findings on condition and status and trends through at least four types of informational outputs. Annual statistical summaries and illustrative maps will be published within nine months after the collection of the last sample information for each year. Interpretative reports will be produced at ir-

Table 1. *Implementation Schedule and Budget Needs for 1991-1995*

Year/Stage	No. of States	No. of sites	Estimated Cost (budgeted) $millions
1990 Planning	–	–	$ 0.45
1991 Final planning/ field research	–	–	0.40
1992 Southern pilot	1	200 (100)	1.3 (0.80)
1993-Sourthern Regional Demonstration	8	400	
-North Central Pilot	1	100	2.4 (2.40)
1994-Southern Implementation	8	400	5.5 (4.16)
-North Central Regional Demonstration	4	200	
-Western Pilot	1	100	
1995-Southern Full Implementation	13	400	7.0 (6.2)
-North Central Implementation	9	300	
-Western Regional Demonstration	3	200	
-Northeastern Pilot	1	100	

Table 2. *Long-Term Strategy: Technical and Administrative Personnel Needs*[1/]

	91	92(approved)	93	94-Est.	95-Est.
Technical Director	1.0	1.0	1.0	1.0	1.0
Deputy TD (EPA)	0.5	1.0	1.0	1.0	1.0
Associate TD	.35	.35	.35	.35	.35
Scientific Staff	1.25	2.0	4.0	7.0	9.0
Research Associates	1.75	1.5	6.0	5.0	8.0
Statisticians	2.0	1.3	3.5	5.0	5.0
Information Managers	0.5	1.0	2.0	2.5	3.0
QA/QC Staff	–	–	0.5	1.0	2.0
Logistics Staff	–	–	0.5	1.0	2.0
Technicians	1.5	1.0	3.0	10.0	18.0
Support Staff	1.0	1.5	3.0	4.0	7.0
Total	9.85	10.65	21.85	37.85	56.35

[1/] This does not include staff of the NASS who actually carry out the surveys.

regular intervals. Research papers will also be prepared periodically.

Summary implementation schedule and budget needs for 1991 through 1995 are shown in Table 1; minimal personnel needs to accomplish the planned implementation are shown in Table 2.

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Mention of trade names or commercial products does not constitute endorsement or recommendation for use.

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Walter W. Heck is with the U.S. Department of Agriculture, Agricultural Research Service, Raleigh, NC. C. Lee Campbell, Alva L. Finkner, George Hess, Steven L. Peck, and John O. Rawlings are with North Carolina State University, Raleigh, NC. Robert P. Breckenridge is with the Idaho National Engineering Lab, Idaho Falls, ID. Gerald E. Byers is with Lockheed Engineering & Sciences Co., Las Vegas NV. Julie R. Meyer is with ManTech Environmental Technology, Inc., Research Triangle Park, NC. Tom Moser is with ManTech Environmental Technology, Inc., Corvallis, OR. ***Charles N. Smith*** *is with the U.S. Environmental Protection Agency, Environmental Research Laboratory, Athens, GA*

Ann M. Pitchford *is the EPA Project Officer (see below).*

The complete report, entitled "Agroecosystem Monitoring and Research Strategy: Environmental Monitoring and Assessment Program,"(Order No. PB93-100071/AS; Cost: $35.00, subject to change) will be available only from:

National Technical Information Service
5285 Port Royal Road
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The EPA Project Officer can be contacted at:

Environmental Monitring Systems Laboratory
U.S. Environmental Protection Agency
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