UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

OFFICE OF
THE ADMINISTRATOR

July 30, 1991 EPA-SAB-EPEC-91-011

The Honorable William Reilly
Administrator
U.S. Environmental Protection Agency
401 M Street, S.W.
Washington, D.C. 20460

Dear Mr. Reilly:

The Ecological Monitoring Subcommittee of the Ecological Processes and Effects Committee of the SAB has reviewed of the Program Plan for the Environmental Monitoring and Assessment Program (EMAP). The charge to the Subcommittee was to 1) examine the adequacy of the Program Plan in describing EMAP to the scientific community and to EPA Program and Regional Offices; 2) determine if the Program Plan's description of the interface between EMAP and Risk Characterization is adequate to establish linkages between the two elements of the ecological risk assessment paradigm; and 3) evaluate whether or not the overall EMAP approach outlined in the Program Plan will contribute to EPA's mission of managing for environmental results.

The Subcommittee recommends that the Program Plan be divided into two documents. One part should be a short overview addressed to the general public. The second should be an expanded version directed to the scientific/technical community. The draft Program Plan reviewed by the Subcommittee attempted to address both audiences and by so doing compromised its ability to meet the needs of either audience. A revision of this document should not wait until all of our recommendations have been addressed, but rather EPA should use the Program Plan to document stages in the development of EMAP. It may be useful to issue additional volumes of the plan periodically to describe changes that have been made in the program based on the results of the demonstration and pilot studies and other continuing research and assessments.

The Subcommittee believes that EMAP can significantly contribute to the ecological risk assessment paradigm being developed by the Agency. However, the Program Plan does not adequately explain how EMAP fits into ecological risk assessment. Based on the draft Program Plan and the briefings presented during the review, it is evident that EMAP has the potential to assist the Agency manage for results. However, the Program Plan could more effectively communicate EMAP's role and contributions

to this mission by more clearly describing the goals and objectives of the program. Examples of the kind of ecological issues that EMAP can and cannot address should be included in the Program Plan.

A major concern of the Subcommittee was the lack of information in the Plan on how the various components of EMAP will be integrated and how status and trends will be assessed. Information presented to the Subcommittee during the review indicated that this aspect of EMAP was still being developed. The Subcommittee recommends that this component of EMAP be given a high priority, since it is essential to the success of EMAP.

Based on the review of the Program Plan, the Subcommittee recommends that the following critical components of EMAP be earmarked for future review by the SAB:

* Progress with Indicator Selection
* Integration and Assessment Component
* Results of the Demonstration Projects- particularly Near Coastal and Forest Ecosystems
* Landscape Characterization Approach

The SAB appreciates the opportunity to conduct this scientific review and looks forward to receiving your response.

Sincerely,

Raymond C. Loehr

Dr. Raymond Loehr, Chairman
Science Advisory Board

Kenneth L. Dickson

Dr. Kenneth Dickson, Chairman
Ecological Processes and Effects Committee

EPA U.S. Environmental Protection Agency Washington, DC
EPA-SAB-EPEC-91-011

Report of The Ecological Monitoring Subcommittee of The Ecological Processes and Effects Committee

Evaluation of The Program Plan for EMAP

A SCIENCE ADVISORY BOARD REPORT July, 1991

U.S. ENVIRONMENTAL PROTECTION AGENCY
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ABSTRACT

This report presents the conclusions and recommendations of the U.S. Environmental Protection Agency's Science Advisory Board following a review of EPA's Program Plan and a briefing on ecological risk characterization for the Environmental Monitoring and Assessment Program (EMAP). This is the second in a series of reviews by the SAB of the components of EMAP. The Subcommittee recommended that EPA revise its Program Plan to clarify the purpose, goals, and objectives of EMAP and explain how EMAP can support policy decisions. They recommended that EMAP further examine its role in risk assessment; one which is critical toward accomplishing Agency goals. The Subcommittee recommended that EMAP illustrate the integration and assessment portion of its program using data from the Near-Coastal and Forest pilot projects and present this analysis to the SAB for review.

KEY WORDS: Environmental Monitoring; Ecosystem assessment; ecological risk assessment.

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Academic Affairs
University of New Mexico
Scholes Hall 108
Albuquerque, New Mexico 87131

CONSULTANTS

Dr. Daniel Goodman
Montana State University
Department of Biology
Louis Hall
Bozeman, Montana 59717

Dr. Allan Hirsch
Director
Washington Office
Midwest Research Corporation
6 Skykline Place, Suite 414
5109 Leesburg Pike
Falls Church, Virginia 22041

Dr. John Neuhold
Department of Wildlife Sciences
College of Natural Resources
Utah State University
Logan, Utah 84322

Dr. William H. Smith
Professor of Forest Biology
School of Forestry
and Environmental Studies
Yale University
370 Prospect Street
New Haven, Connecticut 06511

Dr. William Winner
Department of General Science
Wenger Hall 355
Oregon State University
Corvallis, Oregon 97331-6505

SCIENCE ADVISORY STAFF

Dr. Edward S. Bender
Biologist & Executive Secretary
U.S. Environmental Protection Agency
Science Advisory Board
401 M Street, SW.
Washington, D.C. 20460

Mrs. Marcy Jolly
Secretary to the Executive Secretary

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1.0 EXECUTIVE SUMMARY

The Ecological Monitoring Subcommittee of the Ecological Processes and Effects Committee of the Science Advisory Board (SAB) reviewed a Program Plan for the Ecological Monitoring and Assessment Program (EMAP) and received a briefing on the relationship between EMAP and activities to develop Ecological Risk Assessment Guidelines within EPA. The Subcommittee was asked to: 1) review the adequacy of the Program Plan to describe the EMAP approach for risk based environmental management; 2) review the interface between EMAP and Risk Characterization; and 3) assess EMAP's potential to support the Agency's mission of managing for environmental results.

The Subcommittee found that while the Program Plan had many useful concepts, it was somewhat confusing because it did not explain that EMAP is part of an integrated strategy for assessing risks to natural ecosystems. The Subcommittee recommended that EMAP revise the plan and divide it into two documents, one targeted to a general audience and another one with more detailed information for the scientific community. The plan needs to be carefully edited to eliminate some of the overstatements and inaccuracies, to recognize EMAP's role in quantifying the uncertainty of its own results, and to explain that the program is evolving based on its own experience. The Subcommittee also recommended that EMAP carefully articulate and document its interim goals and establish some criteria for judging its success. Finally the plan should give more explanation of how EMAP can be used to address major policy issues that face the Agency as part of risk reduction.

The Subcommittee believes that EPA's use of ecological risk assessment is a significant and positive trend for assessing anthropogenic risks to ecosystems. However, the plan does not explain how EMAP will fit into the assessment of relative risks nor does it include this as part of the strategy for selection of indicators. The Subcommittee recommends that EMAP further examine how its data can feed into the various Risk Assessment paradigms being considered by the Risk Assessment Guidelines development team.

The Subcommittee recommends that EMAP analyze its goals and objectives with respect to their position along a continuum from change detection through ecological risk assessment. The location along this continuum will determine the monitoring capabilities, methods and research needs of EMAP. The current plan reflects a mixture of goals; consequently the Subcommittee cannot currently evaluate how well EMAP can contribute to the mission of the Agency. The Subcommittee recommends that EMAP use its data from the Near-Coastal and Forest pilot projects to illustrate the integration and assessment portion of the program. The Subcommittee would like to review such analysis in the near future.

Overall, while the Subcommittee commends the EMAP for tackling an important but difficult task, much attention and thinking needs to be focused on the Program Plan, the linkages with risk assessment, and the integration and assessment of EMAP data in order for success to be sure.

2.0 INTRODUCTION

The Ecological Monitoring Subcommittee of the Ecological Processes and Effects Committee of the Science Advisory Board (SAB) met on March 18-19, 1991, to review a Program Plan for the Ecological Monitoring and Assessment Program (EMAP) and to receive a briefing on the relationship between EMAP and activities to develop Ecological Risk Assessment Guidelines within EPA. This was the second review of aspects of the EMAP program by this Subcommittee. Previously the Subcommittee had reviewed the Indicators document (EPA-SAB-EPEC-91-001). This review was conducted at the request of the Office of Research and Development (ORD).

2.1 Statement of the Charge

The Acting Director of EMAP, Dr. Frederick Kutz, requested that the SAB review the EMAP Program Plan. As part of the review, the Subcommittee was requested to address the following questions:

> Does the EMAP Program Plan adequately describe the approach EMAP is pursuing to achieve the Program objectives and contribute to EPA's risk based approach to environmental management? Will this Program plan be useful in describing EMAP to the scientific community and to EPA Program and Regional Offices?
>
> Has the interface between EMAP and Risk Characterization been described sufficiently in the Program Plan so the linkages between these two elements in the ecological risk assessment paradigm are evident?
>
> Based on written and oral presentations, is EMAP moving in a direction that, following implementation, will permit it to contribute to the Agency's mission of managing for results?

2.2 Subcommittee Review Procedures

The Environmental Monitoring Subcommittee (EMS) is a standing group of the Ecological Processes and Effects Committee of the SAB and was established to review critical components of the EMAP program, including the identification and selection of

indicators, landscape characterization, and the analysis and interpretation of results from the demonstration and pilot projects. The Subcommittee relies on the results of peer reviews, which may include some members or consultants to the Subcommittee, as a source of detailed comments on particular technical issues. The Subcommittee has also established a liaison with a committee at the National Research Council that is also reviewing EMAP over a three year period.

The EMS has established its agenda in response to specific requests from the Office of Research and Development and through follow-up to its own questions. The Subcommittee membership is drawn from the members and consultants of EPEC and supplemented as appropriate with additional expertise to address particular scientific issues and questions.

3.0 COMMENTS ON THE EMAP PROGRAM PLAN

3.1 General Comments

When EMAP was formulated (1988), it was conceived as part of an integrated strategy to improve EPA's capability for assessing risks to natural ecological systems from current and emerging regional-scale environmental pollutants. This strategy had three major components; an Environmental Monitoring and Assessment Program (EMAP), that would serve to characterize, classify, and quantify trends in the status of ecological resources and pollutant exposure; a Core Ecological Research Program (CERP), that included EMAP and would also focus on developing tools to predict ecosystem-level responses to incremental changes in anthropogenic activities; and an Ecological Risk (Ecorisk) Program, that allows monitoring and research output to be integrated into quantitative estimates of ecological risk, at all levels of organization. The draft Program Plan reviewed by the Subcommittee does not explain this combined strategy which is essential to the establishment of a final operational design but also will be critical in the future for the interpretation of EMAP results.

The development of a Program Plan and a long-term development and implementation strategy should help EMAP to identify the questions that can be addressed by this program and to inform potential users and the public about the need to obtain these data. In addition, EMAP must develop a strategy for explaining how the data are collected and evaluated and for reporting the results to users and interested parties.

3.1.1 Need to Describe Evolving Nature of EMAP

The EMAP Program Plan conveys the impression that the program's design is much more fixed than is actually the case. The briefings that the Subcommittee received indicated that

various fundamental elements are still evolving through testing and pilot scale evaluations. The landscape characterization, sampling design, and the nominal-subnominal concept are examples of this testing and evolution. The Subcommittee supports this more flexible approach and believes that the document would have greater scientific credibility if it identified for each major program element the questions and uncertainties that have to be resolved before the program becomes fully operational.

The draft also does not reflect in positive terms that the EMAP will conduct a five year or more test and development effort to ensure that the design was appropriate, that the selected bioindicators were in fact going to be useful and that the data management, integration and assessment activities will be effective in meeting both scientific and risk management needs.

A concise, clear statement of sampling strategy is needed for the Program Plan. This statement should include a specific definition of Tiers 1, 2, 3, and 4. It should explain how 40-hexagon units will be selected and how all resource categories will be sampled. The Plan should also discuss sampling for Tier 3 and 4.

EMAP consists of a number of interrelated components. To communicate this complexity, it would be valuable to develop a flow chart that describes the important parts of the Program Plan and the interrelations among them.

3.1.2 Target Documents Toward Specific Audiences

The current document tries to do too much for too many audiences. It is too long and technical for a general audience and too general for the scientist. The Subcommittee recommends that the document be rewritten as two documents: 1) one a general overview of the rationale and framework for the program addressed to parts of EPA, other agencies, and other interested parties; 2) the other as a detailed scientific document directed to the scientific community.

The overview should emphasize the need for EMAP to monitor ecological variables that are indicative of ecological organization that might be important to society. For instance, it could explain what could happen to society if our ecosystems should fail to serve our environmental needs. It should explain that EMAP will measure indicators of ecological status that could be useful signals of long-term regional, national and global trends that may have an impact on food production and human welfare.

The overview should also emphasize the importance of interagency cooperation in implementing the plan giving details on how EMAP findings will contribute to the missions of other

agencies, and about the need for other agencies to contribute data and information to EMAP. From this document, a brief overview could be derived for the general public.

The detailed document should specifically set forth the expectations of the program and the expected deliverable products along with time lines for the deliverables. The detailed program plan should outline an approach for attaining products as well as detailing methods for demonstrating products. The plan should also show how results will be appraised and evaluated and explain the iterative nature of the program.

While it may be clear to environmental scientists that decades of monitoring may be required to detect subtle ecological changes, the less experienced may expect the same results within a few years. This could result in loss of confidence and support for the program.

3.1.3 Recognize and Explain Uncertainties

In its attempt to present a forceful case for EMAP, the Program Plan does not adequately portray the uncertainty involved in assessing environmental conditions and trends. The uncertainty has many components in addition to the usual statistical sense. Has the ecosystem changed in important ways that are not adequately reflected in the indicators? How certain is one of the affects of the observed changes on ecosystem functions or communities (e.g., Are they beneficial or detrimental?)? These and other issues deserve honest discussion in the Program Scope and Integration and Assessment sections of program plan. Concepts defining uncertainty should be developed in a style which helps the decision maker evaluate the degree of emphasis that should be placed on EMAP within the constellation of environmental research, assessment, and management approaches. Furthermore, the decision maker furnished the products of monitoring and assessment must have some quantification of the uncertainty involved in the interpretation of results for use in risk management decisions. Therefore, attention must be given in the Program Plan for development and implementation of methodologies that will quantify the uncertainty.

The language of the draft implies that this is a fully designed effort ready to go on line and to produce results. Moreover it treats several pilot projects (coastal, Northeastern forests, wetlands) as if they were already fixed components rather than clearly indicating that they were part of a systematic testing effort to determine the appropriateness of the bioindicators chosen. It would strengthen the document (at least from a scientific viewpoint) to indicate that these projects are part of the preliminary test and evaluation effort that will lead to definition of the routines needed for environmental monitoring.

3.1.4 Eliminate Overstatements and Inaccuracies

The Program Plan should be reviewed for the accuracy of the biological concepts and facts. Overstated or inaccurate statements in the Plan can reduce the ultimate acceptance of the program. For instance on page 35 of the draft, it is stated that the presence of large indigenous bivalves is a measure of the habitat's ability to support shellfish. This is not necessarily true. Over-harvest can diminish stocks below maintenance levels in some areas while the physical and chemical habitat remains viable relative to shellfish. Another example can be found on the same page where it is claimed that chemical contaminants in sediments can be used as a direct measure of exposure. Again this is not necessarily true. Sediment-associated contaminants may not be biologically available.

Another aspect of the report that deserves consideration involves better justification for some elements in the program. For instance it is difficult to imagine how the presence of large indigenous bivalves could be considered more important as an indicator than plankton populations. It would appear that the program has drawn this conclusion since the former is included but plankton is not, yet there is growing evidence that the coastal planktonic community in some parts of the world is changing due to anthropogenic factors.

3.1.5 Establish Performance Standards

The Program Plan needs to have a discussion of the criteria (performance standards) to be used to determine if EMAP is accomplishing its goals and objectives. How will it be determined if EMAP is effective? While the Program Plan includes some discussion of Peer Evaluations and QA/QC efforts, it does not identify performance standards which can be used to judge the success of the program. A discussion of interim goals and the criteria for judging success will increase EMAP's credibility.

3.1.6 EMAP and Policy Issues

The draft does not make a strong linkage between the science that will be undertaken and its relation to at least some policy issues. This effort is supposed to be decades in length and costly (at least by previous standards). It would strengthen the document if some examples of policy related issues or questions that EMAP may address could be included. These would serve as illustrations of the potential uses for the scientific data that may result from this program. How, for example will this program relate to the requirements of the new Clean Air Act amendments? The Act calls for a continuation of NAPAP related studies on the impact of acid precipitation. Does EMAP have a role here? What about the assortment of issues dealing with Climate Change? Are there potential regional versus national questions of policy

nature for which this program will be able to provide valuable scientific data and insight? By including such material in the Introduction it will present a stronger rationale for EMAP in both in the policy and science communities.

The current description of EMAP has focused on various aspects of approach and procedure. However, currently the Program Plan description does not carefully analyze the specific types or individual questions that can be answered by the program. A useful illustration of the capabilities of EMAP would be to present several critical environmental issues and then analyze just how the issues would be evaluated and answered from the EMAP design.

3.1.7 Indicator Selection Process

The process for selecting indicators for monitoring environmental change is not stated in a simple, clear fashion. Although criteria for such indicators are listed, it is not obvious how the criteria were determined, or why they should exist. More useful than criteria would be the outline of a process for selecting these indicators and documenting how they are quantitatively related to the assessment products that will be developed by EMAP. The Subcommittee previously made recommendations that EMAP should clarify the indicator selection process and standardize the criteria used to evaluate indicators among ecosystems (EPA-SAB-EPEC-91-001, November, 1990). These recommendations should also be reflected in the revisions of this plan.

The Plan must show how indicators will be used to monitor environmental change and accomplish other programmatic goals. The use of indicators might build on issues such as those outlined in the NRC volume, Biologic Markers of Air-Pollution Stress and Damage in Forests (1989, National Academy Press, 363 p.).

Natural variability of indicators must be taken into account in order to determine when environmental change has occurred. More specifically, the natural variability for the chosen indicators must be known or measured. Without an estimate of variability, it is not clear how indicators could be used to distinguish between changed and unchanged environments. Further, the variability of indicators chosen for environmental monitoring may be affected by anthropogenic stresses. How will EMAP detect environmental change in cases where the variability of an indicator response is not predictable?

Most of the resource groups have selected indicators. However, no analysis has been presented that evaluates the relationship between the selected indicators and ecosystem state. This analysis may in part be accomplished during pilot studies

but no rationale is given as to how the indicators might be analyzed or how to decide the allocation of investment between pilot studies and the operational survey.

One aspect of indicators that has not been mentioned in the Program Plan is the coefficient of variation (CV) of indicators among samples and over time. The CV in natural systems often becomes greater when change is imminent before mean values change sufficiently to detect trends. It becomes a good early warning indicator of change. Covariance analysis and multiple regression techniques are also useful (especially in pilot studies) in determining which indicators are the significant ones to be measuring. It would be useful in the section on indicators to go into some detail to explain how indicators will be finally selected and what purpose they will serve.

4.0 RISK ASSESSMENT AND EMAP

It was not clear from the Program Plan document or briefing how EMAP relates to Ecological Risk Assessment. Some additional information needs to be included in the Program Plan to explain the potential application of EMAP results to regional and global scale Ecological Risk Assessments.

A major and positive trend in EPA's approach to environmental protection is the incorporation of the concept of ecological risk assessment into its monitoring and assessment as well as its management activities. How EMAP will fit into the assessment of relative risks is discussed superficially in the chapter on Program Scope, but it should be integral to other considerations of the Program Plan. In particular, this should be a key consideration in the strategy for indicator selection, i.e., by the selection of indicators which are subject to exposure and susceptible to effects which characterize large risks. Additional discussion along these lines should be added to the indicator chapter.
(See earlier SAB reports "Evaluation of the Core Research Program for Ecology "EPA-SAB-EPEC-90-019 and "Evaluation of the Ecological Indicator Report for EMAP" EPA-SAB-EPEC-91-001)

The Plan needs to present a focused discussion of "Risk Assessment," from the perspective of EMAP, in order to give clarity to the entire EMAP mission. This should be done so as to build the underpinnings for EMAP. The discussion of "Risk Assessment" should come early in the Plan, present a relevant definition of assessment, a rationale for it, and a specific list of assessment products.

The concepts of "Indicators" will evolve to become more functional once the products of risk assessment are known. In addition, the criteria for selecting indicators may change from

those currently in the Plan, and the difference between "Indicators" and "End Points" will become more lucid.

References to ecosystem "health", "disease", and other such analogues to the field of medicine should be dropped. The analogies between medical sciences and ecological science are not sound, nor are they effective in communicating specific ideas related to the purposes of EMAP.

Based on the written documents and discussions at the review, it is evident to the Subcommittee that some linkage has been developed between EMAP and Risk Assessment activities within EPA. This linkage was most evident in discussion related to the Risk Assessment Forum activities to develop Ecological Risk Assessment guidelines. The Subcommittee recommends that more effort be expended by the EMAP team to examine how data developed by EMAP can feed into the various Risk Assessment paradigms being considered by the Risk Assessment guidelines development team. Additional effort is also needed to coordinate with the ecological risk assessment research program, particularly research in areas of ecosystem behavior.

5.0 EMAP IMPLEMENTATION

As noted earlier, EMAP should develop a strategy and a flow chart to describe how data are collected and monitored. Considerable effort should also be given to landscape characterization (describing the physical habitats that are associated with the EMAP sampling frames).

5.1 Defining Assessment and Integration

The Subcommittee felt strongly that any environmental monitoring and assessment program must be fundamentally driven by the assessment aspects rather than the other way around. That is, monitoring should primarily be done to provide the data base appropriate to and necessary for assessing ecological integrity. However, there are several different levels of scientific capabilities that can be categorized as "assessment." In one sense, this can be visualized as a continuum, with the following, increasingly complex levels:

> Change Detection - i.e., the capability to detect changes in the state of selected ecological endpoints and indicators, and to characterize those changes in the context of natural spatial and temporal variability, that is to distinguish the signal of change from the noise of ecological variability.

Evaluation of the Ecological Significance of Change - going beyond the statistical significance of the previous level are issues of ecological significance, that is, categorizing the status of ecological resources measured by ecological endpoints and indicators, with cognizance of natural variability and ecological importance.

Change/Stress Association - establishing statistical or spatial/temporal pattern associations between particular ecological endpoints and indicators and particular anthropogenic stress.

Establishment of Causality - establishing cause-and-effect relationships between specific changes in ecological endpoints and particular anthropogenic stress, with cognizance of interactions among multiple anthropogenic stresses, and natural variability.

Predictive Capability - all of the previous levels are essentially interpretive and retrospective utilizing historical and monitoring data to establish change and causality, but predictive capability is intrinsically prospective, and would require development of predictive tools that go beyond mere monitoring and retrospective assessment -

Ecological Risk Assessment - this is a much broader process that involves hazard identification, exposure characterization, stress/response/recovery relationships specific to both stress type and ecological endpoint, including predictive effects assessments, risk characterization, and risk communication.

The strong consensus of the Subcommittee is that EMAP needs to specify clearly where along this continuum its goals and objectives lie presently and in the future. Moreover, the Subcommittee recognized that location along the assessment continuum determines the monitoring capabilities, methodology requirements, and research needs of the EMAP program. The information provided to the Subcommittee through the presentations, verbal dialogue, and supporting documentation does not offer a clear picture of EMAP assessment goals; consequently, we believe that meeting the request of the third charge to the Subcommittee (specifically to evaluate how well EMAP can

contribute to the mission of the Agency) cannot be done without further input, review, and dialogue.

To address this issue the Subcommittee suggests the following: EMAP needs to explore the implications of each point along the assessment continuum with respect to: 1) monitoring design and sampling scheme; 2) selection and characterization of ecological endpoints and indicators; 3) assessment methodologies and criteria for interpretation of monitoring data: 4) new methodology development and research needs, and 5) resources that can be brought to bear directly within EMAP and collaboratively with other agencies. In so far as possible, the ongoing pilot or case studies could be used to illustrate the types of issues and level of resolution appropriate for each assessment capability.

Once the implications of this continuum are explicitly considered, EMAP needs to pick the place or places along the continuum toward which the program is focused. This election will provide the basis for identifying what additions to the present monitoring plans may be required. For example, if detecting change is the sole goal, the present monitoring scheme might be adequate. However, that needs to be explicitly demonstrated through calculation of what density of information over space or time, given natural variability, is required to detect a specified level of change over a specified time period. This is a calculation that apparently has not yet been made. The Subcommittee believes that EMAP,as designed, could detect changes and evaluate the ecological significance of changes.

If, on the other hand, a higher expectation for assessment capability is selected for EMAP, additional components will need to be specified; for example, to provide predictive capability to assess the environmental effects of legislation or regulation will require such elements as ecological modeling, more detailed and more process oriented field data collection, and whole ecosystem manipulations, among other approaches, and these elements may need to be added to EMAP or developed through specific research projects under the Core Ecological Research Program.

Whichever level of assessment goals is selected, the Subcommittee cautions EMAP not to oversell its program beyond those goals. The Subcommittee feels just providing a data base to detect and document environmental change across landscape, regional, and national-scales is worthy goal in itself, but if this is the selected goal for EMAP, the Program Plan should make clear that higher level assessment activities could not be done by EMAP and that EMAP would only be a contributor to such assessment. The concern is that promising more than is feasible for a particular design and level of resources can eventually undermine the credibility and longevity of EMAP as it failed over time to meet expectations. Limited goals need no apologies; more

expansive goals must have concomitant monitoring and assessment design and funding resources.

5.2 Preparation for NRC Review

EMAP is currently being reviewed by a number of scientific bodies, including the National Research Council (NRC). The current description of the EMAP has focused on various aspects of approach and procedure. However, currently the Program Plan does not carefully analyze the specific types or individual questions that can be answered. A useful test of the Program design would be to raise a number of questions concerning regional environmental issues and then to analyze just how the questions would be evaluated and answered from the EMAP design. Without such development, the reviews of EMAP, including that from the NRC, are sure to be difficult and raise topics for criticism.

5.3 EMAP-Landscape Characterization

The initial plans for the EMAP-Landscape Characterization project were to describe environmental resources as statistical populations, identify individual resource units for sampling, and document the current status of major ecosystem types and land uses. These objectives were to be based on the tier concept, with the Landscape Characterization Program focusing on "Tier 1" which is to consist of a 6% sample from 12,6000 40-square-kilometer hexagons uniformly spaced across the nation.

The current EMAP-LC project appears to be somewhat disjointed. Since many of the remaining parts of EMAP depend upon the Land Characterization component, action should be taken now to better focus and organize the effort. There are two fundamental classes of problems. First, and as ably and amply described by the June 25-28, 1990 Peer Review, there are several technical issues which have not been addressed or which have been incorrectly addressed. These concerns involve each aspect of the LC program. Second, the EMAP-LC focus appears to have shifted from addressing the demands of Tier responsibilities to ten unrelated projects which, though each has some value, will not collectively begin to address the issues raised by the Peer Review Panel.

A working group should be established to assist the EMAP-LC effort. This Working Group should consist of several experts in geo-reference data analysis and in integration and analysis approaches that will be required in EMAP.

6.0 SUMMARY OF RECOMMENDATIONS

For the Program Plan, the Subcommittee recommends that EMAP develop a long term strategy and divide the existing document

into two parts. One part should be a short overview addressed to the general public and the second should be an expanded version of the plan which would explain the types of questions that EMAP can address, the sampling strategy for EMAP, quantify the uncertainty that may be involved in the interpretation of the data and describe the criteria for judging the success of the program. Because EMAP is evolving, the Program Plan should also be subject to periodic revisions to reflect modifications and adjustments that will be made in response to lessons that are learned in the demonstration and pilot projects. It may be useful to issue the plan in volumes that describe the stages in the development of EMAP.

The Subcommittee recommends that more effort be expended by the EMAP team to examine how its data can feed into various Risk Assessment paradigms being considered for the ecological risk assessment guidelines. The Subcommittee also recommended that EMAP develop a flow chart of the monitoring and assessment process to show reviewers how questions can be analyzed and answered by EMAP.

The Subcommittee recommends that EMAP analyze its short and long term goals for the integration and assessment of data. The Subcommittee believes that this analysis will help EMAP to set its directions and objectives and refine its monitoring programs. The Subcommittee recommends that EMAP use existing data from its demonstration and pilot projects for Forest and Near Coastal Ecosystems for this analysis and present the results to the SAB for review later in 1991.