



AN SAB REPORT: EVALUATION OF THE ENVIRONMENTAL MONITORING AND ASSESSMENT PROGRAM (EMAP) RESEARCH STRATEGY AND RESEARCH PLAN

**PREPARED BY THE
ECOLOGICAL PROCESSES AND
EFFECTS COMMITTEE**

September 30, 1997

EPA-SAB-EPEC-97-009

Honorable Carol M. Browner
Administrator
U.S. Environmental Protection Agency
401 M Street, SW
Washington, DC 20460

Subject: Science Advisory Board (SAB) Report: Evaluation of the Environmental Monitoring and Assessment Program (EMAP) Research Strategy and Research Plan

Dear Ms. Browner:

The Science Advisory Board's (SAB) Environmental Processes and Effects Committee (EPEC) reviewed the Environmental Monitoring and Assessment Program (EMAP) Research Strategy and Research Plan on May 14, 1997. The Committee was impressed with the excellent advances in the state-of-the-science that have been made in several areas. In particular, the Committee applauds advances by EMAP in the critical area of landscape characterization. The Committee's perception of the current EMAP was bimodal. On the one hand, there was serious concern based on presentations made to EPEC that many of the advances made in EMAP's initial phase on important issues like development of ecological indicators and the implementation of pilot studies were being lost in the transition to Phase 2; in essence, that EMAP is stuck in a cycle of periodic reinvention.

Overall, while the Committee felt there are many strengths to the program, it believes that EMAP is still trying to do too many things simultaneously, rather than doing a few things well. The Committee believes that EPA needs to focus EMAP, and suggests the use of regional pilot studies and intensive research sites to provide the mechanism for that focus. EPEC strongly recommends that, following appropriate revisions, the program move ahead with implementation.

We appreciate the opportunity to review this document, and look forward to the response from the AA, Office of Research and Development (ORD) concerning the issues we have raised.

Sincerely,

/signed/
Dr. Genevieve Matanoski, Chair
Executive Committee
Science Advisory Board

/signed/
Dr. Mark A. Harwell, Chair
Environmental Processes and Effects
Committee

NOTICE

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ABSTRACT

The Ecological Processes and Effects Committee (EPEC) of the Science Advisory Board (SAB) met on May 14, 1997 to review the Environment Monitoring and Assessment Program (EMAP) Research Strategy and Research Plan. The Committee's perception of the current EMAP was bimodal. On the one hand, there was serious concern based on presentations made to EPEC that many of the advances made in EMAP's initial phase on important issues like development of ecological indicators and the implementation of pilot studies were being lost in the transition to Phase 2; in essence, that EMAP is stuck in a cycle of periodic reinvention. On the other hand, the Committee was impressed with the excellent advances in the state-of-the-science that have been made in several areas, despite the recent period of institutional turmoil. In particular, the Committee applauds advances by EMAP in the critical area of landscape characterization. In summary, while the Committee felt there are many strengths to the program, it believes that EMAP is still trying to do too many things simultaneously, rather than doing a few things well. EPA needs to focus EMAP. The Committee's suggests the use of regional pilot studies and intensive research sites to provide the mechanism for that focus. EPEC strongly recommends that, following appropriate revisions, the program move ahead with implementation.

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1. EXECUTIVE SUMMARY

The Ecological Processes and Effects Committee (EPEC) of the Science Advisory Board (SAB) met on May 14, 1997 to review the Environment Monitoring and Assessment Program (EMAP) Research Strategy and Research Plan. The review was requested by the Office of Research and Development (ORD) whose charge to the SAB asked:

- a) Does the EMAP strategy support the [Office of Science and Technology Policy's Committee on Environment and Natural Resources] CENR National Monitoring Framework and EPA Program Offices?
- b) Does the intramural EMAP program on ecological indicator development, coordinated with the [ORD Science To Achieve Results] STAR solicitations, respond to this research need?
- c) Does the development of Index Sites as outdoor laboratories in the national parks ([National Park Service] NPS and [US Geological Survey] USGS) and selected estuaries ([National Oceanic and Atmospheric Administration] NOAA) add this dimension to the EMAP?
- d) Do the focused geographic demonstration pilot studies (initially in the Mid-Atlantic region) combine these elements?

The Committee's perception of the current EMAP was bimodal. On the one hand, there was serious concern based on presentations made to EPEC that many of the advances made in EMAP's initial phase on important issues like development of ecological indicators and the implementation of pilot studies were being lost in the transition to Phase 2; in essence, that EMAP is stuck in a cycle of periodic reinvention.

On the other hand, the Committee was impressed with the excellent advances in the state-of-the-science that have been made in several areas, despite the recent period of institutional turmoil. In particular, the Committee applauds advances by EMAP in the critical area of landscape characterization.

The Committee noted a major disconnect between the EMAP strategy and the establishment of environmental goals and endpoints. The Committee strongly recommends that EMAP take direct cognizance of the EPA Environmental Goals Project, and that it engage the Program Offices and the Regional Offices in identifying the environmental goals for which environmental monitoring and assessment are essential to evaluate progress.

While EMAP's current focus on indicator development appears to be focused on effects indicators, it is imperative to develop both ***effect indicators*** and ***stressor indicators*** to meet the component of EMAP's goal that relates to "identifying emerging problems before they become widespread."

The Committee recommends that the next EMAP-supported STAR solicitation focus on landscape, terrestrial, and coastal indicator development, as well as new methodologies for doing integration and assessment. The Committee also recommends that the EMAP research program contain a strategic component for the development of the next generation of indicators. Specifically, research to develop "real-time" biosensors of the status of ecosystems should be initiated.

The Committee also recommends that future solicitations under the STAR Program on EMAP-related issues be closely coordinated with EMAP to ensure the optimal balance between soliciting innovative research ideas and soliciting scientific advances that will have direct near-term utility to the EMAP Program. One important mechanism for identifying critical research areas is for EMAP to develop explicit conceptual models, following the problem formulation component of EPA's ecological risk assessment framework. Further, the Committee recommends that EMAP consider the advances made in risk ranking, such as through the ongoing SAB Integrated Risk Project (IRP), as a means of prioritizing stressors and, thereby, indicators for monitoring and assessment.

Finally, the Committee recommends that EMAP take close cognizance of the new developments on biocriteria in its indicator development activities. The Committee noted that ecological effects indicators are primarily appropriate at landscape-, ecosystem-, community-, and in some cases population-levels, but indicators at lower levels (e.g., individual, molecular) have never been demonstrated to be useful to describe ecological effects. Bioindicators are sometimes appropriate to describe exposure to stressors, but ecological effects are not directly or necessarily indirectly linked to lower scales of organization. Consequently, the Committee recommends that ecological effects indicator development concentrate on population- and higher-level scales. The Committee also recommends that indicators include both biotic and abiotic measures.

The Committee has a number of concerns about the EMAP collaboration with the National Park Service (NPS) in establishing the initial set of Index Sites. First, there is serious concern that NPS lost much of its scientific expertise when the National Biological Survey (now the USGS Biological Resources Division) was formed. Second, in general there are severe limitations on destructive sampling in national parks, which would significantly diminish the Agency's ability to acquire critical information on the ecological systems in the parks. EPA's use of the existing NPS Index Sites, if they are to be continued, should be limited to monitoring of selected stressors, rather than

monitoring for effects.

Having said this, the Committee strongly supports the concept of Index Sites for intensive monitoring and stressor-effects assessments, particularly when site selection for comprehensive monitoring maximizes the utility of, and interaction with, strong existing monitoring programs. A key recommendation from the Committee is that the selection of locations for intensive monitoring should be primarily science based and directed by suitability for hypothesis testing.

In summary, while there are many strengths to the program the Committee believes that EMAP is still trying to do too many things simultaneously, rather than doing a few things well. The message is focus, focus, focus, and the use of regional pilot studies and intensive research sites provides the mechanism for that focus. We strongly recommend that, following appropriate revisions, the program move ahead with implementation.

2. INTRODUCTION

The Ecological Processes and Effects Committee (EPEC) of the Science Advisory Board (SAB) met on May 14, 1997 to review the Environment Monitoring and Assessment Program (EMAP) Research Strategy and Research Plan. The review was requested by the Office of Research and Development (ORD) with the following specific charge issues:

- a) Previous peer reviews recommended that EMAP develop a close working relation with EPA Program Offices and other federal monitoring efforts. Does the EMAP strategy support the [Office of Science and Technology Policy's Committee on Environment and Natural Resources] CENR National Monitoring Framework and EPA Program Offices?
- b) Previous peer reviews recommended that EMAP initiate a focused research program on indicator development. Does the intramural EMAP program on ecological indicator development, coordinated with the [ORD Science To Achieve Results] STAR solicitations, respond to this research need?
- c) Previous peer reviews recommended that the EMAP design be modified to include a set of nonrandomly selected sentinel sites with intensive data collection. Does the development of Index Sites as outdoor laboratories in the national parks ([National Park Service] NPS and [US Geological Survey] USGS) and selected estuaries ([National Oceanic and Atmospheric Administration] NOAA) add this dimension to the EMAP?
- d) Previous peer reviews recommended that EMAP combine effects-oriented and stressor-oriented monitoring approaches. Do the focused geographic demonstration pilot studies (initially in the Mid-Atlantic region) combine these elements?

The Committee's comments are based on review of the March 1997 drafts of the EMAP Research Strategy and the EMAP Research Plan, and presentations made during the review meeting by EMAP programmatic and scientific leaders. Since the inception of EMAP, EPEC or its subcommittees have reviewed and commented on various aspects of the program (see, for example, SAB 1991a,b; 1992; 1994; and 1995). In 1995, the Committee was briefed on the transition of EMAP from an independent EPA program to a component of a federally coordinated, multi-agency program. This multi-agency effort to coordinate and integrate federal monitoring efforts was conducted under the auspices of the interagency Committee on Environment and Natural Resources (CENR) and was a priority of then-EPA Assistant Administrator for

Research and Development Robert Huggett. The current review, however, represents the Committee's first opportunity to provide formal comments on the restructured EMAP following its significant transformation two years ago and as it enters a second major phase of development.

3. GENERAL FINDINGS AND RECOMMENDATIONS

3.1 Building on Past EMAP Successes

The Committee's perception of the current EMAP was bimodal. On the one hand, there was serious concern based on presentations made to EPEC that many of the advances made in EMAP's initial phase on important issues like development of ecological indicators and the implementation of pilot studies were being lost in the transition to Phase 2; in essence, that EMAP is stuck in a cycle of periodic reinvention. For example, EMAP representatives stated that a substantial cooperative agreement has been established with the National Research Council (NRC) to conduct a study on the issue of ecological indicators, yet the Committee noted that a major workshop on indicators convened by EMAP in Phase I resulted in a two-volume book and a peer-reviewed EPA report on ecological indicators. Those products, along with many other reports and peer-reviewed publications engendered by EMAP, either by EPA or academic scientists, constituted a significant advance in the definition and implementation of ecological indicators. Consequently, the Committee is concerned that little value will be added by another panel covering much the same ground.

In order to take advantage of the distinguished panel assembled by the NRC, the Committee recommends that EMAP work with the NRC to redirect its cooperative agreement to an activity that will add more value. Possible emphases include: 1) reviewing and advising the larger CENR program; 2) assessing the research needed to make major advances in the field of landscape ecology and its applicability to national environmental monitoring and assessment; or 3) focusing attention on terrestrial bioindicators and landscape indicators. The main point is to avoid spending effort on indicators that have already been reviewed over and over, and that are in use and widely accepted (as is the case with many aquatic indicators). In any event, the Agency should give careful consideration to schedule and timing, so that the NRC is reviewing relevant and up-to-date material that might be used by EPA, instead of producing a report that comes out after EPA has already adopted a particular suite of indicators.

The Committee emphasizes that nothing here is meant as criticism of the NRC EMAP indicators panel or of the important advisory contributions that NRC panels in general can provide to the Agency. To the contrary, review and advice by the NRC constitute an essential component in achieving the policy goal of the Agency to base its decisions on sound science; the previous NRC review of EMAP (NRC 1995) is a case in point. The Committee urges EMAP to use the NRC strategically.

Other issues, such as the apparent termination of the ecological resource teams

and their pilot studies, led the Committee to conclude that institutional instability in the

EMAP Program has caused not only a lack of progress over the past two years, but even regression and loss of much that had been gained previously.

On the other hand, the Committee was impressed with the excellent advances in the state-of-the-science that have been made in several areas, despite the recent period of institutional turmoil. In particular, the Committee applauds advances by EMAP in the critical area of landscape characterization, including: the continued development of the thematic mapper landscape database for the U.S.; the development of methodologies to communicate landscape-level characterizations to the scientific community, as well as to decision-makers and the general public; advances in developing landscape-level indicators that are synthetic and represent changes of significance to society; and the institution of a Multi-Spectral Scanner (MSS) database on spectral changes associated with changing landcover type. Similarly, the Mid-Atlantic Integrated Assessment (MAIA) activity exemplifies precisely the tremendous value of integrating databases and indicators across resource types; MAIA is characterizing a specific region in a way that directly supports decision-makers, in this case as represented by a representative from EPA's Region III Office. This pilot study demonstrates the utility of a real-world application in facilitating the integration and assessment mission of EMAP that EPEC has frequently emphasized requires focused attention. And the MAIA pilot illustrates how far existing and anticipated databases can be taken in informing the public and decision-makers about the health of their environment, answering questions that they might otherwise not have contemplated.

In summary, the Committee believes that EMAP is still trying to do too many things simultaneously, rather than doing a few things well. The message is focus, focus, focus, and the use of regional pilot studies and intensive research sites provides the mechanism for that focus. We strongly recommend that, following appropriate revisions, the program move ahead with implementation.

3.2 Linking EMAP with Other Agency Efforts

The Committee noted a major disconnect between the EMAP strategy and the establishment of environmental goals and endpoints. The EMAP plan currently envisions development of indicators and selection of Index Sites as occurring prior to interactions with managers and the public on the identification of goals. This approach is directly contrary to the concept of balance between the scientific investigations and the deliberations of society articulated by the recent NRC panel on risk characterization (Stern and Fineberg, 1996), as well as EPA's own policies relating to community-based environmental protection and planning for ecological risk assessment. The Committee strongly recommends that EMAP take direct cognizance of the EPA Environmental Goals Project, and that it engage the Program Offices and the Regional Offices in identifying the environmental goals for which environmental monitoring and assessment are essential to evaluate progress. That environmental monitoring must be goal-driven

is a fundamental precept that is essential to the success of EMAP. This cannot be stated in stronger terms.

In addition, the Committee conducted a review of the Office of Water's Index of Watershed Indicators (IWI) Program the day following the EMAP review. As a consequence, EPEC recommends that closer ties between these two programs be developed, including, among other things, IWI use of EMAP databases and expertise in its indicator development, and EMAP use of the IWI linkages to the states and its success in graphical outputs and use of the Internet. If done properly, these two programs can be mutually supportive and demonstrate the best of collaboration between a research activity and a practical application designed to improve the availability and understanding of environmental information for decision-makers and the public.

Further suggestions for coordination opportunities with EPA Program Offices and Regions are contained in section 4.1.

3.3 The Need for Conceptual Models

The goal of EMAP is to “monitor the condition of the Nation’s ecological resources to evaluate the cumulative success of current policies and programs, and to identify emerging problems before they become widespread” (EPA, 1997). A critical element of meeting this goal is to develop effects and stressor indicators that provide explicit information about the condition of the Nation’s resources. EMAP has developed a number of indicators of ecological condition and has evaluated their efficiency through a variety of demonstration studies. In addition, EMAP has engaged the ecological research community in developing indicators via funding of an Indicator Initiative through EPA’s extramural grants program (the Exploratory Research Program). The Committee commends these efforts and encourages the Agency to continue this research focus. In addition, EMAP has fostered the development of criteria to evaluate the efficacy of candidate effects indicators via establishment of an advisory committee, the Committee to Evaluate Indicators for Monitoring Aquatic and Terrestrial Environments. All of these efforts are meritorious and, considering the central role of indicators to accomplishing EMAP’s goal, seem reasonable and prudent. At this stage in the development or evolution of EMAP, however, it is critical to articulate clearly a conceptual model relating stressor indicators to effects indicators in aquatic and terrestrial ecosystems as a means of focusing future research on indicators development that will most effectively decrease uncertainty.

The EPA ecological risk assessment process has been advanced recently through the use of conceptual models. These models are explicit graphical representations of how societal drivers lead to environmental stressors, how these stressors affect the key ecological endpoints of ecological systems at risk, and, finally,

how these ecological endpoints are characterized by specific measures or indicators of condition and trend. The Committee strongly recommends that EMAP use the conceptual model construct developed in EPA, as illustrated by the OW/ORD watershed ecorisk case studies, as a focusing mechanism for the selection of specific indicators relating to specific environmental stressors or conditions. As one example of this, conceptual models should be developed for each regional pilot study, identifying the major anthropogenic and natural stressors, the major ecological system types, and the specific suite of ecological endpoints that relate to the environmental goals established for the region.

A clear conceptual model could help in assessing the appropriateness of the current suite of indicators, identify gaps in the available indicators, and by so doing channel the Indicator Research Program in directions that will best assist EMAP in meeting its goal. While EMAP's current focus on indicator development appears to be focused on effects indicators, it is imperative to develop both ***effect indicators*** and ***stressor indicators*** to meet the component of EMAP's goal that relates to "identifying emerging problems before they become widespread." Monitoring status and trends in stressors can provide early warning of emerging problems, rather than waiting until ecological effects become apparent. Thus the conceptual models should attempt to identify the major stressors effecting the ecological integrity of ecosystems (biological integrity).

4. RESPONSES TO CHARGE QUESTIONS

4.1 EMAP's Relation to National Monitoring Efforts and EPA Program Offices

Charge Question 1: Does the EMAP strategy support the CENR National Monitoring Framework and EPA Program Offices?

The EPA staff presented an overview of the CENR framework and provided copies to EPEC of the March 1997 draft of the CENR framework document (CENR, 1997). The Committee finds that the EMAP Research Strategy and Research Plan do support the CENR framework. This is not surprising, since much of the framework appears to have been derived from, or at least is consistent with, the EMAP Program in Phase I as well as Phase II. The Committee believes that EMAP can become a central component of the CENR activity, thereby significantly leveraging the resources EPA invests in EMAP. One example is EMAP's role in organizing the Multi-Resource Landscape Characterization effort (MRLC), which involves voluntary coordination by a number of federal agencies interested in satellite imagery-based mapping of the entire U.S. This and other facilitating roles of EMAP in the CENR process are critical, and the Committee encourages their continuation.

However, the support of EMAP to the EPA Program Offices is less clear. It is obvious that the methodologies and products generated by EMAP should be of considerable utility to the Program Offices, but information was not presented to the Committee on how much support actually occurs, or what the role of the Program Offices has been in developing the new EMAP strategy. The Committee noted several specific areas in which EMAP support to the Agency would be useful: for example, EMAP should have a major influence on the present revisions to the Clean Water Act section 305(b) water quality reporting program, implemented by the Office of Water (OW), EPA Regional Offices, and the states. Other obvious linkages should exist between EMAP and the Agency's community-based environmental protection initiatives, the development of non-point source regulations, watershed assessments (including the Office of Water's Index of Watershed Indicators), and assessments of the efficacy of regulations on regional air quality. However, EMAP's measurement agenda must not be too tightly tied to the needs of the moment, as the Committee also notes that one of the most important ways in which a successful EMAP can support EPA Program Offices is by identifying emergent problems that these offices have not yet identified.

Previous peer reviews by EPEC and others have noted the greater success EMAP has had in coordinating and supporting inter-agency activities than in supporting intra-agency programs. This may still be the case; we would like to hear from the Program Offices on their perspectives on the utility of the new EMAP program. In any

event, the Committee recommends that EMAP redouble its efforts to provide scientific support to EPA Program Offices and Regions. The MAIA pilot demonstrates how useful that partnership can be.

4.2 Development of Ecological Indicators

Charge Question 2: Does the intramural EMAP program on ecological indicator development, coordinated with the STAR solicitations, respond to [the need to initiate a focused research program on indicator development]?

The Committee was not provided with copies of the Science to Achieve Results (STAR) request for applications (RFAs) that EMAP supported relating to indicator development, nor was information presented on the nature of the proposals received or those selected for funding, so EPEC cannot reach a conclusion on how well the STAR solicitations addressed the need for indicator development. However, several individuals on EPEC expressed concerns that, based on RFAs they had seen, the requests might not lead to research sufficiently focused to be of value to the EMAP Program in the near-term.

The Committee also noted that, in general, a great deal of research has been done over the past decade or so on the development and application of indicators of freshwater aquatic systems, but very little comparable research has been done on terrestrial, estuarine, or marine indicators. Further, landscape-level indicators continue to require substantial development. Consequently, the Committee recommends that the next EMAP-supported STAR solicitation focus on landscape, terrestrial, and coastal indicator development, as well as new methodologies for doing integration and assessment.

The Committee also recognizes the need for development of the next generation of indicators and recommends that the EMAP research program contain a strategic component for such development. Specifically, research to develop "real-time" biosensors of the status of ecosystems should be initiated. Currently we assess ecosystem health after-the-fact, typically by examining predominantly species-level abundance data. One limitation of this approach is that it does not characterize rapid responses to episodic stressors, making it difficult to sample and thus identify cause(s) of effects. By comparison, real-time biosensors could provide rapid and continuous information about ecosystem status. With advances in telemetry, computing power, microelectronics, and molecular biology, it should be possible to develop effective real-time monitoring systems for terrestrial and aquatic ecosystems. The Agency's Indicator Research Program should lead the way in this important area.

The Committee recommends that future solicitations under the STAR Program

on EMAP-related issues be closely coordinated with EMAP to ensure the optimal balance between soliciting innovative research ideas and soliciting scientific advances that will have direct near-term utility to the EMAP Program. As discussed in section 3.3, one important mechanism for identifying critical research areas is for EMAP to develop explicit conceptual models, following the problem formulation component of EPA's ecological risk assessment framework.

Further, the Committee recommends that EMAP consider the advances made in risk ranking, such as through the ongoing SAB Integrated Risk Project (IRP), as a means of prioritizing stressors and, thereby, indicators for monitoring and assessment. The presentation to the Committee by the Region III representative makes a good case for this, as the ranking of stressors by Region III closely parallels the IRP findings; even greater linkage would result if the risk ranking methodologies were directly applied in the EMAP pilot studies.

Finally, the Committee recently conducted two reviews of biocriteria documents prepared by the Office of Water. The Committee recommends that EMAP take close cognizance of the new developments on biocriteria in its indicator development activities. The Committee noted that ecological effects indicators are primarily appropriate at landscape-, ecosystem-, community-, and in some cases population-levels, but indicators at lower levels (e.g., individual, molecular) have never been demonstrated to be useful to describe ecological effects. Bioindicators are sometimes appropriate to describe exposure to stressors, but ecological effects are not directly or necessarily indirectly linked to lower scales of organization. Consequently, the Committee recommends that ecological effects indicator development concentrate on population- and higher-level scales. The Committee also recommends that indicators include both biotic and abiotic measures.

4.3 Index Sites

Charge Question 3: Does the development of Index Sites as outdoor laboratories in the national parks (NPS and USGS) and selected estuaries (NOAA) add this dimension to the EMAP [to include a set of nonrandomly selected sentinel sites with intensive data collection]?

The Committee has a number of concerns about the EMAP collaboration with the National Park Service (NPS) in establishing the initial set of Index Sites. First, there is serious concern that NPS lost much of its scientific expertise when the National Biological Survey (now the USGS Biological Resources Division) was formed. Consequently, the value added of NPS scientists doing on-the-ground monitoring and assessments is questioned. In contrast, the development of a joint program with NOAA on selected estuaries, which apparently has not yet materialized, offers the promise of tremendous additional scientific expertise, databases, and assessment experience.

Second, in general there are severe limitations on destructive sampling in national parks, which would significantly diminish the Agency's ability to acquire critical information on the ecological systems in the parks.

The Committee also has serious concerns about the location of the Index Sites selected. The initial set of Index Sites seems to have derived more from the existence of a set of NPS sites searching for a mission, rather than from selection of a suite of sites selected for their potential to answer questions about specific hypotheses and stressor-effects relationships. For example, use of the Everglades and Virgin Island National Parks as sites for assessing the effects of increases in UV-B radiation is very unlikely to provide useful results for two reasons. First, UV-B levels are quite high at those low latitudes, and are not expected to change as dramatically as UV-B levels at higher latitudes. Secondly, monitoring for UV-B effects without specific hypotheses to be tested and rigorous controls to be established simply cannot distinguish any UV-B-caused effects signal from all the other, usually much more consequential, natural and anthropogenic changes occurring at the sites. For example, changes in phytoplankton density and species are a frequent occurrence, and it will be very hard, if not impossible, to attribute specific changes in phytoplankton community structure to changes in UV-B. This is just a single example of the difficulties that will arise with the current sampling strategy with respect to characterizing causality of observed ecological effects. These, and other examples that could be discussed, suggest that EPA's use of the existing NPS Index Sites, if they are to be continued, should be limited to monitoring of selected stressors, rather than monitoring for effects.

Further, the Committee recommends that EMAP not invest significant funds in the NPS sites; for example, EMAP representatives noted the stated request by the Virgin Islands National Park for EMAP funds to rebuild its air monitoring system, destroyed by a recent hurricane. While this would be a policy issue for the Agency to decide, the Committee does not believe this is an appropriate allocation of the limited funding resources for science in EMAP.

The proposed selection of Index Sites appears largely driven by a single set of stressors, i.e., those associated with atmospheric deposition. This set of stressors is important, but consideration must also be given to other stressor groups. The SAB's *Reducing Risk* and other risk ranking processes should inform the selection of the stressors of focus for Index Sites. Further, the Committee recommends that site selection emphasizing a particular stressor be done in close concert with the cognizant EPA Program Office; for example, selection of Index Sites to monitor for stress and effects associated with atmospheric deposition or UV-B should be coordinated with EPA's Office of Air and Radiation. Current gaps in rural air pollution monitoring as well as available data concerning rural air monitoring should be systematically reviewed. A very desirable characteristic of air pollution monitoring sites would be the ability to

establish a gradient of deposition or exposure that would facilitate effects-hypothesis testing.

Finally, the Committee noted the difficulty of monitoring for ecological effects in the absence of controlled experimentation. For example, it is a fact that many variables can influence an ecological effects indicator, and this will lead to an inability to interpret cause-and-effect relationships unless there are carefully controlled conditions. It is clear that confounding effects will be a major problem in interpreting monitoring data from the current set of Index Sites. As noted in previous reviews, the Committee wishes to emphasize in the strongest possible terms that monitoring to demonstrate cause-and-effect relationships between anthropogenic stressors and ecological effects is unlikely to succeed unless the monitoring is coupled with carefully designed experimental manipulations.

Having said this, the Committee strongly supports the concept of Index Sites for intensive monitoring and stressor-effects assessments, particularly when site selection for comprehensive monitoring maximizes the utility of, and interaction with, strong existing monitoring programs. Index sites as envisioned in the revised EMAP can serve a variety of roles in developing our understanding of ecological resources. Monitoring stressors and ecological effects at sites that are representative of different ecosystems and different stressors can provide information on stressor-response relationships. Conversely, choosing sites remote from anthropogenic stressors can produce baseline "reference information" against which to compare impacted sites. A key recommendation from the Committee is that the selection of locations for intensive monitoring should be primarily science based and directed by suitability for hypothesis testing.

Appropriate candidate Index Sites for EMAP would include the NOAA sanctuaries and estuarine reserves, the NSF-sponsored Long Term Ecological Research (LTER) and Land Margin Ecological Research (LMER) sites, the DOE and DOD ecological research sites, and the US Forest Service network of forest sites. The criteria for selection of Index Sites should include the availability of a historical database, the existence of considerable expertise and experience with the site and its response to stressors, location along stressor gradients, the leveraging with value-added resources from the collaborating institution, and geographical and ecosystem type representativeness.

The Committee offers the following specific comments on the Index Site selection criteria in the EMAP Research Strategy:

EMAP Criterion 1: sites should be of interest to multiple federal agencies

Sites should NOT be restricted to federal lands. Consideration should also be

extended to sites of interest to other institutions, such as states, universities, the Nature Conservancy, or other protected land stewards.

EMAP Criterion 2: selected sites should represent all major ecosystem types

The Committee emphasizes the importance of establishing Index Sites in each of the primary ecological resource groups. The Committee found the current list of resource categories too aggregated and recommends that all of the major categories of ecological resources that were identified in the original EMAP program be retained. This would mean, for instance, separating agricultural resources from semi-arid, forests, and other system types currently aggregated into a terrestrial category. Further, the Committee recommends that EMAP explicitly reconstitute the resource groups, which were described by one EMAP presenter as having been disbanded but still functional.

Separation of ecological resource groups, however, should NOT ignore the important interaction of ecosystem types. For example, the linkage of upland forests, river systems, and estuarine areas is critically important at the landscape scale.

EMAP Criterion 3: Sites should have long-term accessibility

While long-term accessibility is critical, long-term ability to sample freely and, perhaps, manipulate system components is equally important for hypothesis testing of cause-effects relationships. As a result, the selection of National Park sites may be undesirable because of the NPS's restrictions on destructive sampling and the changes in park operational policy that may be associated with changes in individual park administrators.

EMAP Criterion 4: EMAP monitoring should link with existing monitoring and/or ecological effects research

Clearly, these linkages are valuable, particularly when leveraging and cooperation can advance or expand the total monitoring/research output. Again, however, we express reservation about the selection of National Park sites because the Department of Interior has greatly reduced or eliminated research and monitoring efforts in national parks.

4.4 Geographic Demonstration Pilot Studies

Charge Question 4: Does the focused geographic demonstration pilot studies (initially in the Mid-Atlantic region) combine these elements [effects-oriented and stressor-oriented monitoring approaches]?

The Committee finds the Mid-Atlantic Integrated Assessment (MAIA) pilot to be a major success in advancing the mission of EMAP in a way that demonstrates its utility, focuses integration and assessment activities, and builds upon extensive existing databases and expertise. Both effects-oriented and stressor-oriented monitoring approaches are well-combined and have already yielded interesting relationships that were not anticipated by traditional CWA 305(b) reporting methods. It is clear to the Committee that EPA Region III has developed productive partnerships with state and other federal agencies that have leveraged data acquisition efforts and that serve as an excellent example for future geographic pilot studies. The work performed by the Landscape Ecology and Landscape Characterization groups within the MAIA region has provided important landscape-scale stressor data, and has greatly contributed to the success of the demonstration pilot study. The Committee was positive about the changes made in the Landscape Ecology program since its last presentation.

While the Committee noted with approval the use of the MAIA study for the purpose of integration and assessment activities, EPEC continues to recommend that integration and assessment across resource types and across spatial scales be maintained as an explicit task of the EMAP Program, drawing on the experiences of the resource groups and using the regional studies as much as possible, but also working more theoretically, including through the extramural program, to develop the necessary methodologies.

Given the productivity and achievement of MAIA and the Landscape Ecology Programs, the Committee recommends that MAIA be continued through more monitoring and assessment activities, with investment of additional funds and effort. In addition, given the maturity and success of the research in the MAIA region, the Committee recommends that EMAP initiate a second regional pilot study as soon as possible and allocate the resources commensurate with the importance and payoff of these regional assessments.

5. LITERATURE CITED

- CENR (Committee on Environment and Natural Resources). 1997. Integrating the Nation's Environmental Monitoring and Research Networks and Programs: A Proposed Framework. Prepared by the Environmental Monitoring Team, CENR, National Science and Technology Council. Washington, DC
- National Research Council. 1995. Review of EPA's Environmental Monitoring and Assessment Program. National Academy Press, Washington, DC.
- Science Advisory Board. (EPA-SAB-EPEC-91-001). Evaluation of the Ecological Indicators Report for EMAP.
- Science Advisory Board. (EPA-SAB-EPEC-91-011). Evaluation of the Program Plan for EMAP.
- Science Advisory Board. (EPA-SAB-EPEC-LTR-92-008). Review of the EMAP Program Plan and Concepts for Integration and Assessment.
- Science Advisory Board. (EPA-SAB-EPEC-LTR-94-004). Review of the Environmental Monitoring and Assessment Program's Draft Risk Assessment Framework.
- Science Advisory Board. (EPA-SAB-EPEC-LTR-95-002). SAB Review of the Environmental Monitoring and Assessment Program Landscape Component.
- Stern, P.C. and H.V. Fineberg (Eds). 1996. Understanding Risk: Informing Decisions in a Democratic Society. National Academy Press, Washington, DC. 249p.
- U.S. EPA. 1997. Environmental Monitoring and Assessment Program (EMAP) Research Strategy 1997. Office of Research and Development, Washington, DC (January 1977). 15p.

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