

Board of Scientific Counselors

Office of Research and Development
United States Environmental Protection Agency

Ecological Research Program Review

Report of the Subcommittee on
Ecological Research

April 1, 2005
Revised August 16, 2005

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**REPORT OF THE
BOARD OF SCIENTIFIC COUNSELORS**

ECOLOGICAL RESEARCH PROGRAM REVIEW

**Office of Research and Development
U.S. Environmental Protection Agency**

**APRIL 1, 2005
REVISED AUGUST 16, 2005**

SUBCOMMITTEE ON ECOLOGICAL RESEARCH

Dr. Michael T. Clegg—University of California, Irvine, Chair
Russel Frydenborg—Florida Department of Environmental Protection
Dr. John P. Giesy—Michigan State University
Dr. Richard Lowrance—USDA Agricultural Research Service
Dr. Sue A. Thompson—Pennsylvania Biodiversity Partnership
Dr. R. Eugene Turner—Louisiana State University
Dr. Jianguo Wu—Arizona State University

EPA CONTACT

Greg Susanke, Designated Federal Officer
U.S. Environmental Protection Agency

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I. EXECUTIVE SUMMARY

Structure of the Program Review

The Executive Committee of the Board of Scientific Councilors (BOSC) of the Office of Research and Development (ORD) within the U.S. Environmental Protection Agency (EPA) has agreed to undertake a series of reviews of major ORD research programs. This report addresses the review of the Ecological Research Program (ERP). The evaluation is based on the review of a large volume of written materials describing the ERP Multi-Year Plan (MYP), individual research projects, and budgetary information.

The Ecological Research Subcommittee, chaired by Dr. Michael Clegg from the University of California–Irvine, conducted this review. Other members included Russel Frydenborg, Florida Department of Environmental Protection; Dr. John P. Giesy, Michigan State University; Dr. Richard Lowrance, U.S. Department of Agriculture (USDA) Agricultural Research Service; Dr. Sue A. Thompson, Pennsylvania Biodiversity Partnership; Dr. R. Eugene Turner, Louisiana State University; and Dr. Jianguo Wu, Arizona State University. A list of the Subcommittee members is included in Appendix A.

The review was conducted from February through April 2005. The Subcommittee members met twice via conference call prior to a site visit for orientation to the Federal Advisory Committee requirements and to discuss the review procedures. A 3-day site visit was conducted at the EPA facility in Research Triangle Park (RTP), North Carolina, from March 7-9, 2005. The site visit featured direct presentations by ERP program leaders and scientists and it provided time for the BOSC Ecological Research Subcommittee to question EPA staff on program details. Subsequent to the RTP meeting, a conference call was held on April 1, 2005, to finalize the draft report.

Objectives of the Review

The objectives of the review were to evaluate: (1) program relevance and quality; (2) program design and implementation; (3) progress achieved towards meeting long-term goals (LTGs); (4) stakeholder involvement and the degree to which research is consistent with needs articulated at regional and local levels; and (5) the degree to which research “outputs” are being used by stakeholders. The ERP’s research is organized into three LTGs and this report provides an analysis of the ERP in the context of each of the LTGs. The report then considers the ERP in holistic terms and provides specific conclusions and recommendations to improve the program’s effectiveness and impact. A major purpose of this review, therefore, is to assist the ERP to adapt to new requirements and expectations as it works to meet the needs of the nation.

Conclusions and Recommendations

As noted above, the review was focused on assessing progress towards meeting the three LTGs of the ERP:

- ✧ **LTG 1:** By 2010, national policy makers will have the tools and technologies to develop scientifically defensible assessments of the state of our nation's ecosystems and the effectiveness of existing national programs and policies.
- ✧ **LTG 2:** By 2010, states and tribes apply improved tools and methods to protect and restore their valued ecological resources.
- ✧ **LTG 3:** By 2012, decision-makers understand the importance of ecosystem services and make informed, proactive management decisions that consider a range of alternative outcomes.

In general, the Subcommittee found the ERP to be a high-quality scientific program that is providing essential technical information to the regulatory offices within EPA as well as to state, local, and tribal governments to assist these entities in addressing novel problems of environmental management. In particular, the Subcommittee concluded that results of the program's research are relevant and of direct use to states and tribes in protecting and restoring ecological resources. The program is developing major tools for measuring environmental health, and these tools are being adopted in the field. The quality of the ERP science is high and compares favorably with ecological research in academic, non-governmental, and private sectors. Program leadership appears to be very good.

There is a need for improved integration among the three LTGs. To gain additional investment leverage, more emphasis should be placed on collaboration between EPA scientists and scientists outside the Agency. Moreover, processes designed to facilitate communication between the ERP and its stakeholders need to be improved. There also is a need for a formal performance evaluation to assess the integration of the various research projects in the context of the LTGs of the ERP. The articulation of research goals and priorities is not always clear to those inside or outside the organization. In this context, it is crucial that a new MYP be developed that aligns with current resource constraints and that better integrates the three LTGs.

The ERP is undergoing substantial budget reductions and short-term approaches to budget reductions are being successfully implemented. The long-term impacts of these short-term solutions, however, threaten to disproportionately reduce the ERP's effectiveness. In particular, a budget reduction strategy focused almost entirely on extramural programs will have disproportionate costs because the leveraging of outside resources may be compromised and productive connections with academic, non-governmental, and private sector researchers may be undermined. Plans need to be developed for a long-term equilibrium that balances the research portfolio against expected resource constraints. This will entail a difficult priority-setting process, but if done effectively, it will maximize the effectiveness of the ERP over the long term.

II. INTRODUCTION

EPA relies on expert external review to assess the scientific quality and performance of its research programs. This report communicates the findings of a review of EPA's Ecological Research Program. The ERP is one of nine research programs within ORD and it represents one of ORD's largest budgetary components. ORD performs and funds research that provides technical standards and scientific information to support EPA's broad mission of protecting and restoring the environment and specifically to support EPA's various regulatory functions.

Many customers and stakeholders utilize ORD's research products. Foremost among these are the regulatory offices of EPA that are mandated to provide technical standards for regulatory decisions. These technical standards must be grounded in well-documented scientific knowledge. Other important customers include state regulatory entities, tribes, and local governments. The stakeholder population also includes non-governmental organizations (NGOs) that have a stake in environmental conservation; the private sector that must adapt to and implement regulatory decisions which in turn require clear and understandable technical standards; and finally, the general public that has a strong stake in EPA's mission of protecting, sustaining, and restoring the health of the nation's ecosystems. To achieve this broad goal, EPA must devise scientifically valid measurements of the health of the environment and this requires an intensive program of ecological research.

The BOSC's Ecological Research Subcommittee conducted this review (see Appendix A for a list of the Subcommittee members). Prior to the review, the Subcommittee met twice via conference call (February 17 and March 3, 2005) for orientation to the Federal Advisory Committee requirements and to discuss the review procedures. The review was conducted at the EPA facility in RTP, North Carolina, from March 7-9, 2005. Subsequent to the RTP meeting, a teleconference was held on April 1, 2005, to finalize the draft report. The review meeting at RTP and the three teleconferences were conducted as open meetings under the guidelines of the Federal Advisory Committee Act (FACA). A list of the Subcommittee conference calls and meetings is provided in Appendix B.

The format of this review is relatively new. The BOSC has just begun an intensive review process for the various ORD research programs and this is only the third review in that series. An impetus for the BOSC review is the Office of Management and Budget's (OMB) Program Assessment Rating Tool (PART) evaluation system. The ERP received a "Results Not Demonstrated" rating in its recent PART evaluation. Based on this rating, an external review appeared in order to more fully assess the strengths and weaknesses of the ERP and to identify ways to improve the program. A major purpose of this review, therefore, is to assist the ERP to adapt to new requirements and expectations as it works to meet the needs of the nation.

The charge to the Subcommittee was to review the ERP's work and products using the following eight general questions as guidelines:

1. Is the focus of the program relevant to and consistent with EPA's strategic goals? Does it develop a scientific foundation that will lead to attainment of the program's stated

environmental outcomes? Are potential public benefits of the program clearly articulated? What would be the minimum research program that would be both effective and successful?

2. Does the program have a logical and comprehensive design with clear goals, priorities, and schedules to track progress toward those goals?
3. Do the design and implementation of the program's structure facilitate attainment of outcomes through integration of research across the program?
4. Has the program made significant progress toward each of its long-term goals?
 - a. Do the research results address the key research questions?
 - b. Is the rationale to address the questions clearly articulated?
 - c. Does the program follow a long-term plan to address the logical sequence of the questions?
 - d. Is progress to address the questions being made in a timely fashion?
 - e. Does the research reflect the current state-of-the-science, and meet the current and future needs of the Agency, science, and program customers?
5. What is the scientific quality of the program's research products? Does the program ensure high quality research through competitive, merit-based funding? If funds are not competitively awarded, what process does the program use to allocate funds? Does this process ensure that quality is maintained?
6. Is the stakeholder involvement in the development of the program clearly and adequately articulated?
 - a. Does the program effectively engage stakeholders in its planning?
 - b. Does the program have a process for using the results of the research, along with stakeholders' feedback, to identify key research gaps and to update the program's research agenda?
 - c. Are potential public benefits clearly articulated?
 - d. What are the impediments, if any, to collaboration with other organizations?
7. Are the program's research results being used by clients and stakeholders? Are these research results consistent with the needs articulated by the Agency's program and regional offices?
8. Will the program's completed and planned outputs lead to the intended outcomes that are protective of our ecological resources?

This report discusses the above charge questions as they relate to the ERP's three revised LTGs:

- ✧ **LTG 1:** By 2010, national policy makers will have the tools and technologies to develop scientifically defensible assessments of the state of our nation's ecosystems and the effectiveness of existing national programs and policies.
- ✧ **LTG 2:** By 2010, states and tribes apply improved tools and methods to protect and restore their valued ecological resources.

- ✧ **LTG 3:** By 2012, decision-makers understand the importance of ecosystem services and make informed, proactive management decisions that consider a range of alternative outcomes.

Each of the above LTGs is reviewed in the context of the charge questions, followed by a discussion of the integration of all LTGs to assess the program holistically, and finally a list of conclusions and recommendations.

III. RELEVANCE

A. Charge Questions

1. Is the focus of the ERP relevant to and consistent with EPA's strategic goals? Does it develop a scientific foundation that will lead to attainment of the ERP's stated environmental outcomes? Are potential public benefits of the program clearly articulated? What would be the minimum research program that would be both effective and successful?

- 4e. Does the research reflect the current state-of-the-science, and meet the current and future needs of EPA, science, and the ERP's customers?

B. Specifics for Program Elements

LONG-TERM GOAL 1

By 2010, national policy makers will have the tools and technologies to develop scientifically defensible assessments of the state of our nation's ecosystems and the effectiveness of existing national programs and policies.

Question 1: The focus of the ERP is entirely relevant and consistent with EPA's strategic goals. The Agency's strategic goals are: (1) clean air, (2) clean and safe water, (3) land preservation and restoration, (4) healthy communities and ecosystems, and (5) compliance and environmental stewardship. To achieve these strategic goals, it is critically important for national policy makers to have accurate, reliable, and timely information on the status and trends of the nation's environmental conditions, so that proper policies can be made and actions taken accordingly. To this end, scientifically sound and practically effective tools and technologies must be made available to national policy makers, and this will be accomplished through LTG 1. These tools and technologies include a scientifically sound design framework, reliable ecological indicators, and effective monitoring protocols and actions. Products from LTG 1 are *most* relevant to environmental problems and policy issues at the national level.

Through LTG 1, the ERP has developed a probability-based design and sampling framework that is solid in theory and efficient in practice. This framework has been successfully used for measuring, assessing, and monitoring the status and trends of ecosystem conditions at the national, regional, and local scales. A comprehensive scientific foundation that emphasizes the integration between pattern and process across systems, scales, and levels of biological organization continues to be built and refined. These salient characteristics of the scientific foundation are reflected in a number of projects, including the Environmental Monitoring and Assessment Program (EMAP), the Mid-Atlantic Integrated Assessment (MAIA), and landscape

studies. This developing scientific foundation is appropriate for achieving the ERP's expected environmental outcomes.

The potential benefits to the public of the ERP's research are evident and clearly articulated. The products of LTG 1 are crucial for national policy makers and also for public awareness of the nation's environmental conditions.

It is difficult to define the minimum research program for protecting the environment. All of the ERP's present research projects seem necessary to understand and deal with the nation's different environmental issues across different scales. Removing any part of the program would certainly not enhance the functionality and outputs/outcomes of the ERP.

Question 4e: The research of LTG 1 is evidently of high scientific quality, and reflective of the state-of-the-art in broad-scale environmental research, particularly in developing statistical design and sampling strategies for measuring and monitoring ecosystem conditions. Because landscapes are large enough to incorporate multiple interacting ecosystems and major regimes of human influences on them, while still small enough for insightful mechanistic explorations, landscape-level indicators provide critically important information for legislators and policy-makers at the national level and decision-makers and stakeholders at the local level. The ERP has developed a suite of such indicators in recent years, and this research represents cutting-edge science. Empirical testing of these indices as well as additional core research in this extremely important area, however, are clearly needed.

LONG-TERM GOAL 2

By 2010, states and tribes apply improved tools and methods to protect and restore their valued ecological resources.

Core research and problem-driven research undertaken by ERP staff, cooperators, and grantees form the basis for many of the tools and methods employed by states and local entities, both public and private, to protect and restore ecological resources. This function of the ERP is not only consistent with, but is essential to, EPA's core mission to protect human health and safeguard the natural environment—air, water, land—upon which life depends. Safeguarding the nation's environment is intrinsically linked to activities at the state, tribal, and local levels.

The scientific research produced and supported by the ERP in support of LTG 2 ranges in quality from good to excellent. Results from these projects have answered key questions on processes in natural systems and have resulted in a greater understanding of the affects of anthropogenic activities on the physical, chemical, and biological integrity of the nation's waters and air. The ERP research represents major contributions to ecosystem science. Examples of this research include stressor identification techniques for specific biological impairment determination, advanced watershed stormwater models for pollutant reduction, and novel microbial and genetically based ecological assessment procedures.

Results of the ERP research are relevant and of direct use to states and tribes in protecting and restoring ecological resources. Model case studies by collaborators (for example, Maryland's Green Infrastructure assessment) have had "on-the-ground" impacts in land conservation. Most of the ERP's research, however, has not yet translated into direct conservation and restoration

activities, other than the handful of collaborative examples. These outcomes are expected to occur in more states and tribes over time.

Although there are numerous potential public benefits of the ERP's research, these benefits are not always clearly articulated, even at the program level, and are rarely explicitly included as a goal in individual research projects. This lack of an outcomes-based research paradigm hampers the program from producing research that fully meets both the future and current needs of clients, especially those outside of EPA (e.g., states and tribes). Although examples were given in the onsite presentations of states routinely and effectively applying ERP-derived tools, no formalized tracking system that quantifies the extent of this application was evident and no specific uses by tribal entities were highlighted.

LONG-TERM GOAL 3

By 2012, decision-makers understand the importance of ecosystem services and make informed, proactive management decisions that consider a range of alternative outcomes.

LTG 3 is the ERP's outreach component with the goal of developing sophisticated tools to enable decision-makers to make decisions that enhance ecosystem services. Although this goal has elements of more basic and applied research, scientists working on LTG 3 seek people/institutions with specific problems that can be used as case studies for critical resources management issues. To date, these site-specific projects have been used as proof-of-concept exercises, coordinated through either regional or program offices, such as the Office of Water (OW) and the Office of Air Quality Planning and Standards (OAQPS).

The research, tools, and analytical technologies developed under the ERP represent the most comprehensive federal government research program examining the provision of ecosystem services and the communication of these to decision-makers. LTG 3 is a highly relevant activity that is central to EPA's mandate of improving environmental quality and protecting and restoring the health of the nation's ecosystems. ORD and particularly the ERP are uniquely suited and positioned to address these issues.

In addition to being relevant to the federal role, the major projects under LTG 3 address critical complex questions facing local and state governments. The major projects described under LTG 3 and the questions framed for future research will provide both new scientific knowledge about the provision and value of ecosystem services and new decision tools to allow decision-makers and the public to address alternative futures with varying levels of ecosystem services.

The projects presented during the site visit demonstrate an excellent balance between development of new information and conceptualizing new analytical methods for the future, while also providing clients with tools for addressing current issues. Quantifying and demonstrating future scenarios with varying levels of ecosystem services, will provide the scientific foundation needed to make informed decisions. Many of these decisions are made at a local level with tools that currently are inadequate to consider cumulative effects of the loss or gain of ecosystem services. The tools developed under LTG 3 will provide the scientific foundation for better decision-making and thus help in attainment of environmental benefits.

All projects presented under LTG 3 have the specific objective of providing information on ecosystem services and ecosystem functions to either specific or hypothetical decision-making groups. For some major projects and tools, potential public benefits are clearly articulated. For example, the Willamette Basin alternative futures research has led to an atlas of the basin and to a clear focus among regional governments on using the tools developed under LTG 3 to increase the level of future ecosystem services within the large river (see Box 1).

Box 1: The Willamette River Basin Case Study

The ERP worked with the Oregon Governor's office, EPA Region 10, Oregon State University, University of Oregon, and numerous stakeholders to develop an alternative futures analysis of the Willamette River Basin, a 30,000 km² basin undergoing urbanization and intensification of agriculture and forestry in a water-limited environment. The scientists used a reconstruction of historical land use and new analytical tools to develop three alternative future scenarios: plan trend (current state and local policies and practices extrapolated); development (current state and local land use regulations relaxed to spur development); and conservation (land and water allocation to conservation increased).

The evaluation criteria were indicators of either the need for or provision of ecosystem services: population density in urban growth areas; urbanized area; rural developed area; prime farmland; water availability for urban, industrial, and agricultural uses; water consumed; changes in streamflow; area in conifer forest > 80 years old; habitat for amphibians, birds, mammals, and reptiles; percent of riparian areas in natural vegetation; population densities of 17 birds and mammals; cut-throat trout habitat; and fish species abundance and richness.

Results showed that population densities in urban growth areas doubled under both the current trend and the conservation scenarios, but increased much less under the development scenario. Urbanized areas and rural growth areas increased under all scenarios, but increased most under the development scenario. Prime farmland decreased in all scenarios, but decreased most in the development scenario. In general, the conservation scenario conserved ecosystem services as measured by the indicators. Of particular interest in this semi-arid water-limited region, water consumption increased in all scenarios, but increased least with the conservation scenario.

Information from the Willamette Project has been used by the Oregon Governor's office, state agencies, and stakeholder groups to frame policy discussion about future growth in the Willamette Basin and the state. The successful project was the impetus for state establishment of the Institute for Natural Resources to provide science-based information on ecosystem services and growth to Oregon decision-makers.

In some cases, projects at an earlier stage of development have not yet manifested public benefits, but the potential benefits are articulated. The goal and sub-questions form a body of work that should proceed as a whole. Because the ongoing work focuses on the delivery of tools to understand societal benefits of ecosystem services, new research on the provision of these ecosystem services is essential. Conversely, the important outcomes of LTG 3 will not be

realized unless the decision support systems and analytical techniques to project and communicate alternative future development scenarios are available and applied. Thus, the entire research and technology development program is necessary.

IV. SCIENTIFIC AND COMPETITIVE QUALITY

A. Charge Questions

2. Does the ERP have a logical and comprehensive design with clear goals, priorities, and schedules to track progress toward those goals?
3. Do the design and implementation of the ERP's structure facilitate attainment of outcomes through integration of research across the ERP?
- 4a. Do the research results address the key research questions?
- 4b. Is the rationale to address the questions clearly articulated?
- 4c. Does the ERP follow a long-term plan to address the logical sequence of the questions?
- 4d. Is progress to address the questions being made in a timely fashion?
5. What is the scientific quality of the ERP's research products? Does the ERP ensure high quality research through competitive, merit-based funding? If funds are not competitively awarded, what process does the ERP use to allocate funds? Does this process ensure that quality is maintained?
8. Will the ERP's completed and planned outputs lead to the intended outcomes that are protective of our ecological resources?

B. Specifics for Program Elements

LONG-TERM GOAL 1

By 2010, national policy makers will have the tools and technologies to develop scientifically defensible assessments of the state of our nation's ecosystems and the effectiveness of existing national programs and policies.

Question 2: LTG 1 activities are organized in terms of three related, but distinctive, components: (1) statistically valid and scientifically defensible design frameworks, (2) a suite of reliable ecological indicators for different ecosystems, and (3) environmental monitoring. Goals for each component are clearly defined. The priorities of LTG 1 activities are clearly placed at the national level, which is appropriate because LTG 2 and LTG 3 deal mainly with the state and local levels, respectively. In other words, each goal has its own focal level of organization and corresponding spatial scale, and this scheme is, in principle, both scientifically sound and practically feasible.

LTG 1 is particularly important because it provides an overall conceptual framework and technical guidelines for the other LTGs. To assure both high scientific quality and relevance to EPA's mission, LTG 1 projects should encourage close collaborations between EPA's own researchers and external high-caliber scientists who have broad visions and pertinent knowledge and skills. Such collaborations can be accomplished through open grant competition with an explicit requirement for collaboration with EPA researchers. In addition, although the design

principles of LTG 1 are sound, improved planning and better-coordinated cross-level integration are needed. Also, more systematic plans and mechanisms for increased tracking of the outputs and outcomes of research projects must be developed as part of the research cycle.

Question 3: The new structure of the ERP with three LTGs seems scientifically sound and practically feasible. Products of LTG 1 are *most* relevant to environmental problems and policy issues at the national level, whereas LTG 3 deals *primarily* with local-scale environmental issues that may frequently involve local ecosystems (e.g., lakes, streams, or forest habitats) or local landscapes (watersheds or mosaics of different ecosystems) (see Figure 1). LTG 2 is *mainly* targeted at environmental problems and policy issues at the state level, often spanning over a region. This suggests that in order to achieve desirable outcomes, each LTG must emphasize interactions and collaborations with relevant agencies and stakeholder groups at its focal level. For example, the expected outcomes of LTG 3 are unlikely to be accomplished without directly involving local decision-makers and stakeholders. Having a focal level or scale for each LTG facilitates use-inspired research, which is consistent with the mission of EPA, but does not, and should not, imply that the three LTGs can be achieved separately without interactions or coordination. On the contrary, a major advantage of such a hierarchical framework is both to highlight the primary targeted user group and to provide pathways to effectively integrate across scales and programs. Products of LTG 1 should influence and have influenced activities of LTG 2, which in turn have bearings on LTG 3. The same is true the other way around. To date, the ERP has demonstrated such two-way interactions to some extent with some excellent examples.

The ERP has a logical and comprehensive design, which is adequate for ORD's planning process and for demonstrating progress toward its overall goals.

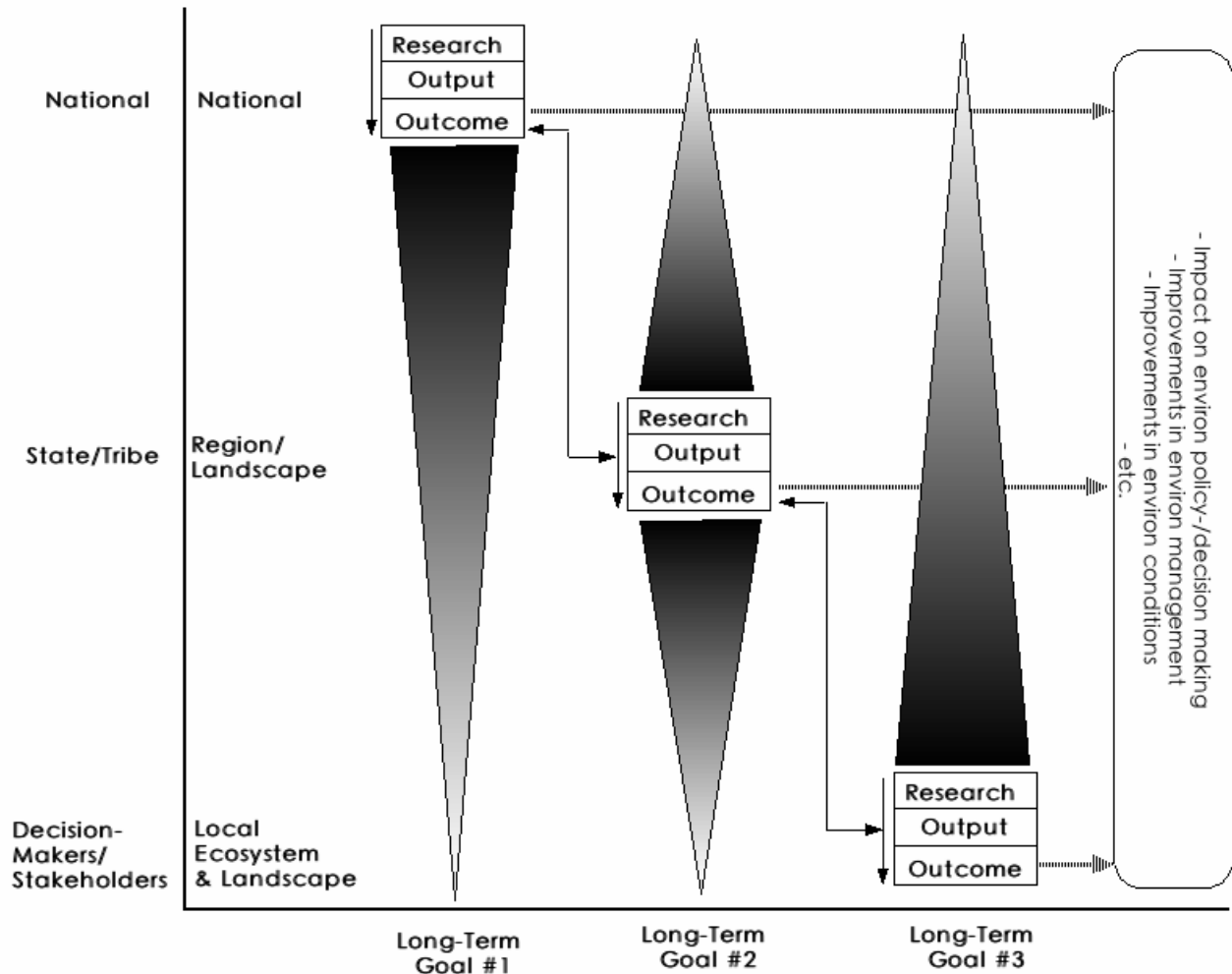
Questions 4a and 4b: The results of LTG 1 are quite relevant to its key research questions. The probability-based design framework has served well for multiple-scale sampling and monitoring activities at the national, state, and local levels. A suite of indicators for landscape integrity and ecosystem health has been developed. These methods and tools have produced valuable information on the nation's ecosystems that is critically important to policy makers and decision-makers.

Question 4c: The three LTGs are well designed and follow a multiple-scale, hierarchical framework that facilitates addressing environmental issues at the national, state, and local levels. LTGs are well articulated and are not only relevant, but also crucial, to the overall mission of EPA. The realization of these LTGs requires continuation of high-quality research conducted by EPA researchers and outside scientists collaboratively as well as secure long-term funding.

Question 4d: Research under LTG 1 has made tremendous progress in terms of both research output and environmental outcomes. Timely progress also has been made to address important research questions. For example, a statistically sound, scientifically defensible, and practically feasible design and sampling framework was developed early through EMAP, and has been widely used by and provided guidance to a variety of projects at the national and regional scales ever since. Based on this framework, extensive efforts have been made to develop methods and tools to measure and monitor conditions of different ecosystems and landscapes across the nation (e.g., EMAP-WEST, Coastal Ecosystem Assessment, West Rivers).

Figure 1. Subcommittee Interpretation of the Organizational Levels and Spatial Scales at Which Each LTG Operates

Organizational Level/Spatial Scale



LONG-TERM GOAL 2

By 2010, states and tribes apply improved tools and methods to protect and restore their valued ecological resources.

Questions 5 and 8: Although the implementation of the ERP's structure has demonstrated the capability to achieve beneficial environmental outcomes, the formal integration between individual research components should be better. Cooperation exists among many projects, but the need for integration between some projects, although implicit, should be better articulated by ORD management. This would improve synergy between investigators and enhance the overall body of research, which is generally of excellent quality.

Based on the quality of research, substantial advances toward achieving LTG 2 are apparent. Examples of these efforts include the Modeling and Stressor Identification procedures, which have played key roles in watershed restoration through the Total Maximum Daily Load (TMDL) program and the Multimedia Pollutant studies, which have led to mercury reduction in the Everglades and elsewhere. Several other projects, such as the recent development of microbial and genetic tools, should reasonably expect to achieve outcomes when more mature. A key to the success of all the LTG 2 research efforts will be educating state and local decision-makers on the benefits of the tools, as well as training appropriate end users.

The research questions are clearly formulated to address factors most responsible for degrading our environment. The rationale behind the research is scientifically sound and appropriate, including physical, chemical, biological, landscape, and modeling components. The research is structured in a logical sequence to allow results from projects to build on others, although the formal integration of individual projects should be better articulated and incorporated into the strategic planning process.

The overall body of research generated by the ERP, in terms of quality and ability to produce beneficial environmental outcomes, is superior. Without the ERP's leadership in this arena, many important advances in environmental assessment and the development of strategies for effective ecological management would not exist. Stringent quality assurance procedures are followed throughout the ERP's research process, from sampling to data analysis. Peer review and feedback, including input from academic and government scientists, is routinely followed, resulting in a solid scientific program.

ORD's Science To Achieve Results (STAR) grants program is an excellent example of the successful implementation of a competitive funding process, which when coupled with the ERP's guidance and understanding of complex environmental issues, can lead to research results that are directly applicable to environmental problems at the state and tribal level.

When funds are not competitively awarded, the ERP appears to use a "best professional judgment" approach to allocate funds, coupled with a post-award assessment of the project's success. Based on the successful results associated with these projects, quality appears to have been maintained, although a more formal evaluation is warranted.

LONG-TERM GOAL 3

By 2012, decision-makers understand the importance of ecosystem services and make informed, proactive management decisions that consider a range of alternative outcomes.

Although the initiatives included as elements of LTG 3 are very ambitious, the goals are clearly stated and achievable. Because LTG 3 has not been the subject of an MYP, the specifics of schedules are difficult to evaluate. The three component questions around which the future activities will be developed are clear and should lead to measurable outcomes. Some connections between LTG 3 components and other LTGs are not clear. Although the potential for these connections is obvious and necessary, integration of all three LTGs should be made explicit in the revised MYP. For example, a clear connection between EMAP and the Regional

Vulnerability Assessment (ReVA) Program was not evident, although the two are clearly parallel projects. The program description would be improved by providing clear linkages with the other two LTGs.

The research results that were presented have done an excellent job of addressing the key research questions. The ERP research has made numerous advances in both integrative ecosystem science that explicitly includes socioeconomic constraints (Willamette Basin, MAIA) and in developing general tools for integrated assessments (ReVA). The rationale for the key questions is clear, but it is not always clear how individual projects are initiated. As there are many ways that projects might be initiated, some of which are beyond the control of the ERP, clear documentation of the criteria for project selection is desirable.

It is understood that a revised MYP is now being developed. Because LTG 3 is proposed as a completely new element in the overall research strategy, the Subcommittee can make only an overall assessment and give general guidance on program direction. The research is clearly long-term and will need to incorporate feedback from clients who help implement the pilot programs. As the MYP is revised, an integrated program structure should be developed that explicitly states the relationships between program elements and packages them in a way that allows the tracking of results and progress toward longer-term goals and the reporting of short-term outcomes. LTG 3 was not part of the 2003 MYP, but includes elements of the earlier LTG 3 and LTG 4 as well as new elements that focus on the development of forecasting models and analytical tools that will allow the assessment of ecosystem services. The Subcommittee understands the rationale for this proposed LTG and endorses the goals and approach.

The research currently being conducted and that which is proposed to be conducted under LTG 3 represents state-of-the-science in assessing complex systems and developing tools to understand and enhance ecosystem services. The scientific quality of the program is very good to excellent. We received varied information on how peer review is used within the organization. Peer review and quality assurance for the STAR Program were mostly good, although some inconsistencies occurred. If there is a program for internal peer review of projects, it was not evident. It would strengthen the internal research program to have external peer review of projects.

V. PERFORMANCE

A. Charge Questions

2. Does the ERP have a logical and comprehensive design with clear goals, priorities, and schedules to track progress toward those goals?
3. Do the design and implementation of the ERP's structure facilitate attainment of outcomes through integration of research across the ERP?
- 4d. Is progress to address the questions being made in a timely fashion?
- 6b. Does the ERP have a process for using the results of the research, along with stakeholders' feedback, to identify key research gaps and to update the ERP's research agenda?
7. Are the results of ERP research being used by clients and stakeholders? Are these research results consistent with the needs articulated by EPA's program and regional offices?
8. Will the ERP's completed and planned outputs lead to the intended outcomes that are protective of our ecological resources?

B. Specifics for Program Elements

LONG-TERM GOAL 1

By 2010, national policy makers will have the tools and technologies to develop scientifically defensible assessments of the state of our nation's ecosystems and the effectiveness of existing national programs and policies.

Question 2: LTG 1 activities are organized in terms of three related, but distinctive, components: (1) statistically valid and scientifically defensible design frameworks, (2) a suite of reliable ecological indicators for different ecosystems, and (3) environmental monitoring. Goals for each component are clearly defined. The priorities of LTG 1 activities are clearly placed at the national level, which is appropriate because LTG 2 and LTG 3 are more focused on the state and local levels, respectively.

Question 3: LTG 1 program maturation has been accompanied by standardization of the conceptual approaches and the experienced solicitation and involvement of stakeholders. These positive developments have drawn strong support from a core group of statisticians and geographic information system (GIS) experts (among others) within the ERP that has an institutional memory, experience, and professional skills that are nationally significant. Their activities have been a positive and significant influence on LTG 2 and LTG 3 activities, as well.

Question 4d: Progress to address the research questions is being made in a timely fashion, but articulation of those goals and the planning involved in the processes leading to these goals need to more clearly permeate the science culture. The idea is not to homogenize an individual's scientific talents and perspectives so communication skills are emphasized over science skills,

but that the programmatic elements are masterfully and more completely articulated on behalf of the whole.

Question 6b: The Subcommittee believes that more effective processes and formal mechanisms are needed that allow better communications between the ERP and its clients. The experience of some members of the Subcommittee is that dissemination of important research results is slow to reach the end users.

Question 7: The stakeholders and clients are using the results in a variety of ways, some of which are obvious and others that are not so obvious. The National Coastal Assessments have led to an increasing number of states either issuing their own reports using the protocols and sampling strategies developed by the ERP, or joining together to issue regional summaries. These are in addition to the EPA documents produced by the ERP staff and their collaborators. This tangible outcome is monitored. For example, in 2000, no states were directly involved in these reports (as state or regional reports), but by 2005, a minimum of 12 states will participate. At this rate, the goal of reaching all coastal states should be nearly completed in a few years.

Question 8: In the opinion of the Subcommittee, the ERP has resulted in the desired outcomes, and its present activities and future (planned) outputs are consistent with the conclusion that protection of the nation's ecological resources is enhanced.

LONG-TERM GOAL 2

By 2010, states and tribes apply improved tools and methods to protect and restore their valued ecological resources.

Performance measures of the ERP's planning process and measures for demonstrating progress toward overall program goals do not appear to be strictly established, although they can be extracted from the body of research.

There is a need to develop a formal performance evaluation that assesses the degree of integration between various research projects to help improve cooperation between individual research investigators.

Clear and substantial progress toward LTG 2 was demonstrated in much of the mature research, although this could not readily be evaluated for research at earlier stages of development. Each research component should issue a periodic report that more clearly details the incremental progress made toward expected outcomes. This would allow an adaptive management strategy to keep projects "on track" and internally integrated.

Stakeholder input to identify research gaps does occur, but the process of briefing decision-makers on research results as well as on applicability of the research currently is informal or often lacking. The effectiveness of this aspect of the program could be improved by establishing timely and regular communications with a broad array of stakeholders using an established procedure in conjunction with appropriate EPA program offices.

The ultimate use of the products is dependent upon factors beyond the control of the ERP, but the above outreach process would improve the utilization of pertinent results. States, tribes, and

local governments should be urged to seek the ERP tools appropriate for carrying out their specific environmental protection missions. For example, nonpoint source pollution can be mitigated through judicious land use decisions, which almost exclusively are made at the level of local government. If utilized by local government resource managers, the ERP products, such as landscape and predictive models, would more directly achieve desired outcomes.

The results of the ERP are thoroughly consistent with the expressed needs of EPA program and regional offices. EPA program offices present the ERP with a prioritized list of research issues developed through interactions with stakeholders. There is a reasonable expectation that the environmental protection tools generated by the ERP will translate into beneficial outcomes when the research matures and the tools are implemented at appropriate levels of government.

LONG-TERM GOAL 3

By 2012, decision-makers understand the importance of ecosystem services and make informed, proactive management decisions that consider a range of alternative outcomes.

It is not clear how progress is tracked, but it is assumed that this is the primary responsibility of program managers and lead scientists on the projects. Very good progress in this area has occurred during the past 5 years and it is expected that this progress will continue in the future with adequate funding and scientific resources.

The component of the ERP aggregated under LTG 3 is well positioned to make significant contributions in the near- and long-term. While it is understood that science is a continuing process, it is evident that research products are being adopted and used. The review process should be structured in such a manner that useful products and technology can be transferred to clients in a timely and efficient manner while the tools are further refined and adapted to additional situations and applications. To identify key research gaps and to update the projects, the Subcommittee suggests reviews of individual projects by external scientists and stakeholders. Currently, LTG 3 does not have a plan for internal periodic assessment, but it is assumed that this will be part of the MYP.

The results, products, and tools generated by LTG 3 are being used by clients. At this point, the main clients are involved with the pilot projects. Other clients are being developed through online use of the ReVA and Restoration Plus (RePlus) tool kits. Research results, such as the use of ReVA with the Sustainable Environment for Quality of Life (SEQL) program and the use of research results to inform decision-making by state agencies, such as the Wisconsin Department of Natural Resources, demonstrate that the ERP is meeting needs of clients and stakeholders. The research program will lead to the intended outcomes if the research products and tools are applied by the regions, states, tribes, and local governments. There is good evidence that this is occurring and with continued involvement of clients in the research through pilot projects, it should continue. As with ReVA and some of the new technologies to enhance water management for ecosystem services, there should be specific plans to make all tools and technologies available to users such as state governments, planning agencies, and private consultants. This will require commitment of resources to technology transfer through both in-person and online training.

VI. LEADERSHIP

A. Charge Questions

- 4e. Does the research reflect the current state-of-the-science, and meet the current and future needs of EPA, science, and the ERP's customers?
- 6a. Does the ERP effectively engage stakeholders in its planning?
- 6b. Does the ERP have a process for using the results of the research, along with stakeholders' feedback, to identify key research gaps and to update the ERP's research agenda?
- 6c. Are potential public benefits clearly articulated?
- 6d. What are the impediments, if any, to collaboration with other organizations?
7. Are the ERP's research results being used by clients and stakeholders? Are these research results consistent with the needs articulated by EPA's program and regional offices?

B. Specifics for Program Elements

LONG-TERM GOAL 1

By 2010, national policy makers will have the tools and technologies to develop scientifically defensible assessments of the state of our nation's ecosystems and the effectiveness of existing national programs and policies.

Question 4e: The research of LTG 1 is evidently of high scientific quality and reflective of the state-of-the-art in broad-scale environmental research, particularly in developing statistical design and sampling strategies for measuring and monitoring ecosystem conditions. Because landscapes are large enough to incorporate multiple interacting ecosystems and major regimes of human influences on them, while still small enough for insightful mechanistic explorations, landscape-level indicators provide critically important information for legislators and policy makers at the national level and decision-makers and stakeholders at the local level. The ERP has developed a suite of such indicators in recent years, and this research represents cutting-edge science. Empirical testing of these indices, as well as additional core research in this extremely important area, however, are clearly needed.

Question 6a: The LTG 1 program initially tended to develop methodologies and approaches that were independent of stakeholder involvement once the basic national needs were identified. Stakeholders increasingly are more involved in the process, from implementation of the conceptual designs and sampling protocols to field-testing and regional-application, and then to the stage where there is a firm engagement of LTG 1 products within a formal framework. The LTG 1 sub-program is now at a point where stakeholders from many regions are interested in adopting the methodologies, in some cases before EPA has resources to assist them.

Question 6b: More effective processes and formal mechanisms appear to be needed that allow better communication between the ERP and its clients. These processes and mechanisms may be sufficient, but were not evident to the Subcommittee because of time constraints.

Question 6c: The public benefits are well appreciated within the ERP science culture, and among many state agencies. The Subcommittee members heard several verbal assessments and read others that led to the conclusion that the public benefits were appreciated by the states. The Subcommittee was not able to assess whether the public benefits were articulated well across the entire spectrum of stakeholders, probably because of the time constraints involved in this assessment. The Subcommittee recognizes that the public benefits are numerous and that they are articulated within the culture of EPA and state agencies, but perhaps not clearly articulated to all stakeholders, including the general public, in the same way.

Question 6d: There are no obvious impediments to collaboration with other organizations. The three LTGs, each focusing mainly, but not exclusively, on a relatively explicit level of organization and corresponding geographic scales, should facilitate the process of identifying and working with collaborative organizations outside EPA.

Question 7: The Subcommittee believes that research results are being used by clients and stakeholders as illustrated in the boxes included in this report.

LONG-TERM GOAL 2

By 2010, states and tribes apply improved tools and methods to protect
and restore their valued ecological resources.

The ERP scientists and collaborators frequently are leaders in their respective scientific fields and ORD has clearly supported outstanding research in many areas of ecosystem science. The ERP is a valuable and integral part of EPA and essential to carrying out EPA's mission. The ERP's leadership within the scientific community is evidenced by the participation of its scientists on editorial boards, review panels, conferences, and other academic or information exchange gatherings. There is evidence that the ERP scientists take a leadership role in disseminating research results in many states, but this is not uniformly true for a variety of reasons, some of which are beyond their control.

The process for stakeholder engagement in research planning is unclear. In many cases, it appears to be *ad hoc* with fortuitous partnerships formed based on requests from entities or similar interests. Although these partnerships have produced results that may translate into useful products for states and tribes in general, implementation of a strategic planning process that involves broad stakeholder input will increase these opportunities.

LONG-TERM GOAL 3

By 2012, decision-makers understand the importance of ecosystem services and make informed, proactive management decisions that consider a range of alternative outcomes.

ORD scientists and collaborators working on LTG 3 are among the leaders in this research in the United States. No other federal research agency has as extensive or advanced program in transferring tools to assess the provision of ecosystem services. Although numerous collaborators and stakeholders already are engaged, the process of identifying and engaging them could be more transparent. It would be very useful if resources were available to fund cooperative development of the pilot projects and if these could be focused on areas with a wide variety of resource management and environmental quality issues. In particular, when dealing with rural areas and insuring the provision of ecosystem services as rural areas develop, stakeholders representing agriculture and forestry should be more clearly involved as there is a significant amount of terrestrial ecosystem assessment, landscape ecology, and ecosystem modeling being conducted to understand how agriculture and forest practices affect ecosystem services. Although the Subcommittee assumes that some level of coordination exists among these activities, this was not apparent in the information presented to the Subcommittee. Increased interactions among LTG 3 research scientists with other elements of ORD focusing on socioeconomic research may result in significant opportunities to further leverage resources. In addition, there was no evidence of interactions with the international community. Programs addressing the issues outlined in LTG 3 are the subject of research programs in other countries. The Subcommittee recommends that review of other ongoing programs will strengthen elements of LTG 3.

VII. COLLABORATIONS

A. Charge Questions

5. What is the scientific quality of the ERP's research products? Does the ERP ensure high quality research through competitive, merit-based funding? If funds are not competitively awarded, what process does the ERP use to allocate funds? Does this process ensure that quality is maintained?
- 6a. Does the ERP effectively engage stakeholders in its planning?
- 6b. Does the ERP have a process for using the results of the research, along with stakeholders' feedback, to identify key research gaps and to update the ERP's research agenda?
- 6c. Are potential public benefits clearly articulated?
- 6d. What are the impediments, if any, to collaboration with other organizations?
7. Are the results of the ERP being used by clients and stakeholders? Are these research results consistent with the needs articulated by EPA's program and regional offices?
8. Will the ERP's completed and planned outputs lead to the intended outcomes that are protective of our ecological resources?

B. Specifics for Program Elements

LONG-TERM GOAL 1

By 2010, national policy makers will have the tools and technologies to develop scientifically defensible assessments of the state of our nation's ecosystems and the effectiveness of existing national programs and policies.

Question 5: The quality of the science is adequate to high, depending on the standards used and the subject area. The results from the congressionally mandated atmospheric deposition program are exceptionally good, and meet internationally recognized science quality standards among independent scientists active in the field, and have grounded EPA's policies in science. The monitoring and assessment program has an excellent statistical design and more than adequate sampling protocols, and is well on its way to accomplishing its leadership and implementation goals. Because it also is in the first decade of what is a very long-term monitoring program, the scientific quality of the monitoring and assessment program is not yet fully evident. The program has very effectively engaged some state agencies, but with an anticipated focus on Agency-style documents (primarily reports) and less so on peer-reviewed literature that is more widely distributed and which receives greater scrutiny (and concurrently, expanded opportunities for improvement). The emphasis on fuller disclosure of the science products and their implementation will eventually gain greater prominence as monitoring continues beyond the alpha phase and generates results extending over several decades. Much of the research is done through noncompetitive funding directly to stakeholders, which are primarily states, as a direct and intentional result of the integration of stakeholders into the field program.

Question 6a: LTG 1 research can be further improved by more systematically and proactively engaging decision-makers and stakeholders at local, state, and national levels.

Question 6b: More effective processes and formal mechanisms appear to be needed that allow better communication between the ERP and its clients. These processes and mechanisms may be sufficient, but were not evident to the Subcommittee because of time constraints.

Question 6c: The potential benefits to the public and stakeholders are clearly articulated.

Question 6d: There are no obvious impediments to collaboration with other organizations. The three LTGs, each focusing mainly, but not exclusively, on a relatively explicit level of organization and corresponding geographic scale, should facilitate the process of identifying and working with collaborative organizations outside EPA.

Question 7: The research results of LTG 1 have been widely used by clients and stakeholders. Numerous examples exist in the documents and presentations provided to the Subcommittee. More formal mechanisms for facilitating communications with regional offices and keeping track of outreach activities, however, appear to be needed, although the Subcommittee is willing to accept that these mechanisms exist, but were not revealed to the members during the course of the Subcommittee's deliberations.

Question 8: LTG 1 addresses some of the most pressing and challenging environmental research questions today, and is extremely relevant to EPA's mission. The research activities under LTG 1 so far have been quite productive, resulting in important outcomes. Maintaining the strength of LTG 1 is imperative for the continued success of the ERP. The accomplishments of the ERP are critical building blocks to achieve EPA's overall goals and objectives of protecting and restoring the nation's ecosystems. The ERP, however, cannot by itself accomplish all of EPA's stated goals and objectives because of the size and complexity of the problems at hand. High-quality involvement makes enhancement more likely, and demonstrably so where there has been enough time to move from program beginnings to maturation and implementation.

LONG-TERM GOAL 2

By 2010, states and tribes apply improved tools and methods to protect and restore their valued ecological resources.

ORD has a superb track record of collaboration with a variety of partners at the level of specific research projects (see Box 2 and Box 3). Such collaborations, especially for LTG 2 projects, seem typically to be the result of "willing and able" partners expressing an interest in working with EPA. Targeted outreach to nontraditional partners should be pursued as part of a strategic communication process involving stakeholders.

Box 2: Mercury Contamination in the Everglades

During EPA-sponsored monitoring of a hazardous waste site in Florida, mercury was detected in fish tissue at unacceptable levels, even though mercury was not a contaminant of concern at the site. The ERP scientists were instrumental in providing intellectual energy and funding to diagnose this mystery, which involved complex multimedia dynamics. These included understanding the sources of mercury in air, atmospheric deposition patterns, and biological magnification of mercury through the Everglades food web. This culminated in diagnosing the causes behind the fish consumption advisories and adverse effects on the Florida panther, an endangered species. In approximately 10 years, the ERP-assisted research was directly connected to a beneficial environmental outcome—reductions in regional mercury emissions and subsequent improvements in biological health and continued safeguarding of human health.

LONG-TERM GOAL 3

By 2012, decision-makers understand the importance of ecosystem services and make informed, proactive management decisions that consider a range of alternative outcomes.

Collaboration on specific pilot projects has been excellent and the Subcommittee expects this to continue. Collaboration would be enhanced by the ability to enter into cooperative research projects that address specific resource management issues. Outcomes would be enhanced by identifying and collaborating with representatives of expected user groups at the outset of pilot projects, in addition to the specific project collaborators. This could be accomplished by convening broad-based user groups to comment on specific pilot projects at an early stage of the projects.

Box 3: Biological Assessment and TMDLs

Florida routinely employs a probabilistic sampling design to conduct statewide bioassessments of streams and lakes, both of which are based upon the ERP LTG 1 products for assessing environmental health. When degradation is detected in the biological communities, staff utilizes the principles of Stressor Identification (an ERP LTG 2 tool) to reasonably determine the pollutant(s) responsible for the adverse biological effects. Various ERP-based models then are used to establish Total Maximum Daily Loads (components of LTG 3) for pollutant reduction throughout localized watersheds. Continued monitoring over a 5-year cycle will establish the degree of biological recovery, which is the desired environmental outcome. This entire process would not be possible without the various assessment procedures and applications produced by the ERP.

VIII. RESOURCES

A. Charge Question

Question 1: What would be the minimum research program that would be both effective and successful?

Resources, both intramural and extramural (i.e., STAR), are adequate for measured progress, but are clearly inadequate to undertake other than a handful of extensive projects, such as the Willamette Basin study and ReVA/SEQL. Currently, there are many issues that are important to clients, both intramural and extramural, that cannot be addressed because of resource limitations. The ERP has done an excellent job of using cooperation with the programs of various groups within and outside of government to extend the resources available. The ERP scientists often provide expertise and obtain the necessary information for proof-of-concept or model parameterization by their participation in ongoing projects.

The ERP has done an excellent job of leveraging resources, but a fairly poor job of documenting the magnitude of these leveraged funds. The ERP should institute a mechanism to track these contributions so that they can be articulated and reported in a quantitative manner. Additional project funds are needed to develop more pilot projects.

The loss of the STAR Program would hurt the integrity of the entire ERP. Something similar to STAR must be maintained in accordance with the three LTGs to assure the quality of the ERP's collaboration, efficiency, leveraging of funds, and intellectual capital.

IX. INTEGRATION AND FUTURE DIRECTIONS

EPA must perform scientific research to provide the baseline knowledge to establish technical standards for regulatory decisions and to provide appropriate tools and methodologies to those who are charged with measuring and conserving the health of our national environment. This section addresses the appropriateness of the ERP's three LTGs and their integration; the ERP's effectiveness in meeting its responsibilities to its customers; and, to the extent possible, an assessment of the future directions of ERP research. In evaluating the program and its LTGs, it is important to reiterate that ORD has a research mission with the primary responsibility of developing scientific knowledge, tools, and methodologies to serve the mission of the regulatory offices of EPA as well as to meet the technical and scientific needs of state governments and tribes. In this sense, these EPA regulatory offices are the customers of ORD and its constituent research programs. Other important customers include other federal agencies, states, tribal governments, and decision-makers.

The ERP has many substantial accomplishments to its credit and the BOSC Ecological Research Subcommittee rates the overall quality of the research as good to excellent. Variation exists among the projects as is inevitably the case within any large and complex organization, but overall, EPA and the nation are well served by the research accomplishments within the ERP. In many cases, there is ample evidence of demonstrated outcomes, for example the Willamette River Basin project (see Box 1) and the wide implementation of the results of EMAP across the nation. Other programs that deserve specific mention include the successful adoption of bio-indicators as measures of environmental health, the MAIA research program, and the various programs focused on developing tools to assess the water and air quality of our nation.

Following the disappointing PART review, the ERP's LTGs were revised and reduced from four to three. The new LTGs thus supersede, in part, the current MYP. This review took place in the context of both budgetary changes and changes in the formulation of the ERP goals. Moreover, the review contains elements that are new to the BOSC, so the situation is quite fluid and this review needs to be viewed within this very dynamic context. In responding to the charge questions, the appropriateness of both the reformulated LTGs and the budget reduction strategy in the context of the goals was discussed. Because the PART review challenged the ERP to explain more effectively how its research leads to concrete outcomes in the field, this question received considerable attention. Standard questions about program quality and performance that are a normal review component also were included in this review.

This is a challenging time for the ERP in terms of budget. The past 2 years have witnessed substantial budget reductions (see Figure 2) and the ERP recently has experienced a disappointing PART review. The budget for Fiscal Year (FY) 2005 is not yet finalized (as of March 2005 when the review materials were provided to the Subcommittee) and Congress has not acted on the FY 2006 budget request and thus the trajectory may change, but current data suggest a reduction of approximately 25 percent over a 2-year period (see Figure 2). Despite major reductions in budget, almost no changes have occurred in full-time equivalent (FTE) employees supporting the ERP (see Figure 3). This disjunction reflects the fact that virtually all

Figure 2. Total Ecological Research Program Resources, 2001-2006 (total dollars in millions)

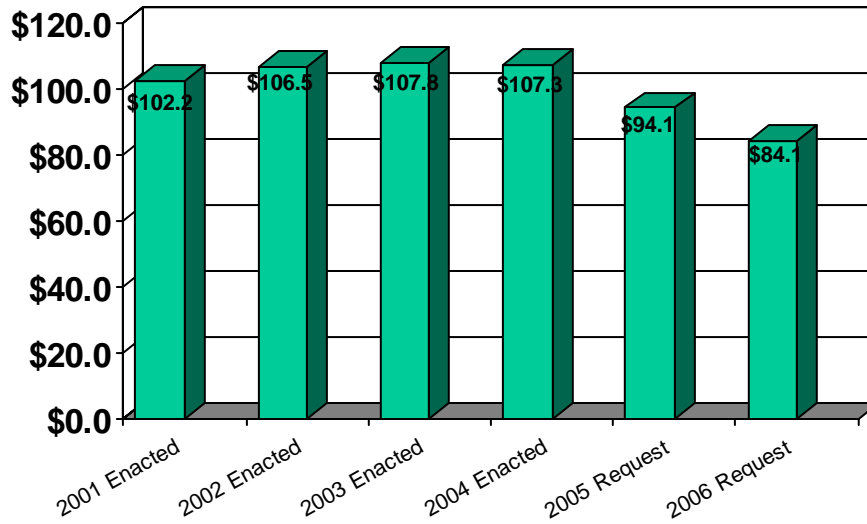
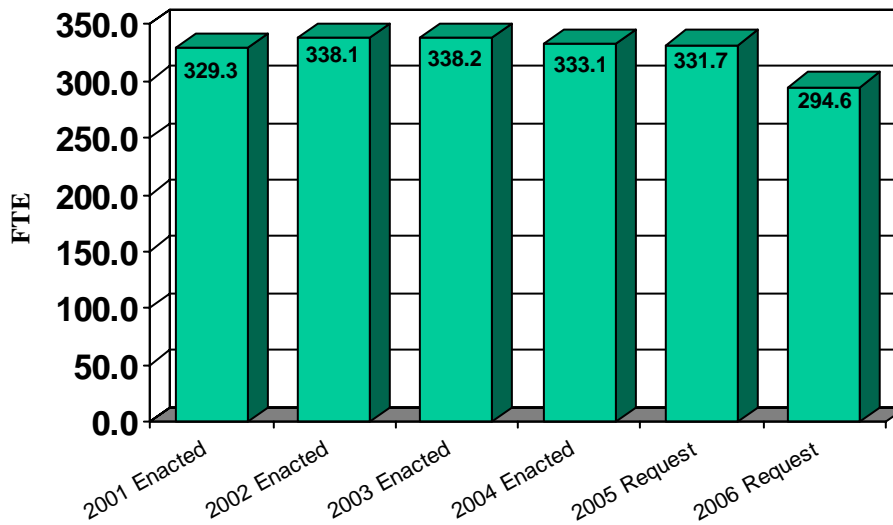


Figure 3. Total Ecological Research Program Resources, 2001-2006 (full-time equivalents)



of the budget reductions were in extramural programs, particularly in the STAR Program. The present and future budgetary uncertainties make it difficult to comment on future directions. Maintaining the current research portfolio and extending it into the future is both essential and of high priority in meeting EPA's mission of protecting, sustaining, and restoring the health of the nation's ecosystems. Nevertheless, current budgetary constraints dictate a full re-evaluation of the priorities of the ERP. Future directions must be re-evaluated in light of current and expected future budgetary resources.

As interpreted by this Subcommittee based on the presentations, the three LTGs have a consistent logic (see Figure 1). The LTGs appropriately capture the mandate to develop scientific knowledge, tools, and methodologies that serve the mission of EPA's regulatory offices and meet the information needs of state governments and tribes. LTG 3 imposes the special challenge of reaching local and regional decision-makers. The ERP must depend on other EPA offices to implement programs in the field and to work directly with decision-makers, and the program should not be asked to take on an extension role when other components of EPA are better equipped to assume such a responsibility. Thus, the ERP clearly is dependent on other EPA offices to create demonstrated outcomes in the field. It certainly is appropriate to expect the entire Agency to function as a seamless organization even though the BOSC reviews are piece-meal and are not intended to look at the total organizational context.

X. FINDINGS AND RECOMMENDATIONS

The ERP is of good to high quality and program leadership is very good. The Subcommittee is impressed with the substantial accomplishments of the ERP as evidenced by the variety of excellent tools, methods, and research outcomes documented in the materials provided for the review. The findings and recommendations below suggest areas for improvement, but it should be emphasized that the ERP is fulfilling its mission as well as providing good value to the nation. The Subcommittee's findings and recommendations are presented below by LTG:

- ✧ The integration of LTG 1 with the other LTGs can be further improved through designing research projects specifically for cross-level integration and by reinforcing rules set by research programs for close collaborations between EPA and outside researchers at the national, regional, and local levels. This integration can be facilitated by working with other federal agencies, such as the National Science Foundation, U.S. Department of Agriculture, National Aeronautics and Space Administration, and National Oceanic and Atmospheric Administration, to develop multiple-scale, interdisciplinary, place-based, and use-inspired research programs.
- ✧ Although the overall quality of research under LTG 1 is excellent, high transparency in research design, implementation, and evaluation and close collaborations with external scientists must be maintained to assure that this high-quality research will persist.
- ✧ Research for all three LTGs would be improved by collaborations with international scientific communities. This is important because many environmental problems are either physically connected or ecologically similar worldwide and because such scholarly exchange among countries will help improve the global environment in which we are embedded.
- ✧ Clear and substantial progress toward LTG 2 was demonstrated in much of the mature research, although this could not be readily evaluated for research at earlier stages of development. Stakeholder input to identify research gaps does occur, but the process to brief decision-makers of results and accept feedback currently is informal or often lacking. The effectiveness of this aspect of the program could be improved by establishing timely and regular communications with a broad array of stakeholders using an established procedure.
- ✧ LTG 3 is a newly reorganized program element, and there is an opportunity to develop an explicit research plan. The Subcommittee suggests that the plan include specific programs and projects with specific deliverables and timelines such that, in the future, progress can be tracked and the quality, efficiency, and impact of the program elements can be evaluated. Furthermore, the BOSC should review the MYP when it is developed.
- ✧ LTG 3 requires better integration with, and articulation of, outcomes at local levels. This is essential to achieve EPA's mandate, but the Agency must be aware of the dangers of asking a very good research organization to take on responsibilities that it is not structured to accomplish. Responsibilities for communication and dissemination of results certainly rest

with the ERP, but other elements of EPA also have responsibilities for client and stakeholder communication. It is important to recognize that ORD has a primary research mission. There is a danger in assigning other priorities to ORD because the research mission may be compromised. The time and talents of ORD's research scientists need to be focused on the research mission. At the same time, careful tracking of outcomes is essential to assure that the research conducted by the ERP is appropriate and that it addresses customer priorities.

- ✧ Currently, there is no plan for an extramural component to LTG 3. The Subcommittee members believe that, historically, partnering with other federal, state, and tribal agencies; academic institutions; and NGOs has been very successful. This has increased the productivity of the program by leveraging the resources and creativity of these partners. The Subcommittee understands that difficult decisions need to be made relative to resource allocations, but suggests that the elimination of extramural programs will result in disproportionately less productivity and creativity. The Subcommittee recommends that some form of extramural cooperation be re-established to leverage resources and continue to provide flexibility in the research program.
- ✧ More rigorous program-wide mechanisms should be in place to maximize collaborations between EPA researchers and external scientists. This assures that the ERP research is of the highest scientific quality and of utmost relevance to EPA's mission. Close collaborations between EPA researchers and external scientists are vital. Mechanisms for forging and maintaining such collaborations need to be in place to assure intellectual vitality and openness to new ideas. For example, open grant competitions, such as STAR, should be slightly modified with an explicit requirement for collaboration with EPA researchers. Such collaborations make the best use of intellectual and logistic resources within and outside EPA; facilitate high-quality scientific output that is intimately tied with the goals of the ERP; and promote scholarly exchanges and information sharing that enhance EPA's research capacities. For the ERP to be most productive and relevant, it is crucial to create a research environment in which the ERP's own researchers can feel excited about, and rewarded by, external collaborations rather than feeling pressured for competing resources with outsiders.
- ✧ EPA and ORD must increase involvement of stakeholders (especially external stakeholders) in setting research priorities and targeting research efforts (adaptive research management).
- ✧ Effective communication is vital and must be viewed as an essential step in turning research results into outcomes. Moreover, those charged with administering the organization must receive timely and appropriate measures of research effectiveness.
 - Clearly articulate specific outcomes of research projects, including linked performance indicators.
 - Institute a formal process for sharing and disseminating research results to stakeholders.
- ✧ Critical scientific peer review is the standard measure of quality in judging among potential research investments and this standard has served our nation very well. The ERP utilizes peer review in judging many, but not all, aspects of its research portfolio. There is room for improvement in the application of peer review to potential projects within the organization.

At the same time, EPA should be generally complimented on its dedicated efforts to implement peer review across the organization.

- ✧ The ultimate concern of EPA is to measure and improve the health of the nation's environment, yet some things are missing from what might be viewed as a well-balanced research portfolio.
 - The ERP program is heavily oriented towards aquatic ecosystems and EPA's mission of conserving the nation's water resources justifies this focus. Moreover, many terrestrial issues are indirectly addressed through the aquatic program. Nevertheless, a balanced research portfolio also requires attention to impacts on terrestrial ecosystems, especially relative to clean water and nonpoint source pollution. It is important to better integrate ERP research with assessments of terrestrial ecosystems done by other entities, especially other federal agencies.
 - Improving the health of the environment clearly requires a better understanding of human motivations and behavior. Some projects such as the MAIA involve a social science component, yet this dimension of science is largely absent from the ERP portfolio. It may be that these responsibilities lie elsewhere in ORD and the Subcommittee's review failed to see the full picture. Nevertheless, we urge the ERP to be mindful of the full spectrum of research required to meet the goals of EPA.
- ✧ More could be done to improve the tracking of outcomes. Specifically, EPA, ORD, and the ERP need to work harder to foster better communication among EPA offices, with the other elements of the Executive Branch of government, and with external stakeholders. The Subcommittee urges that more be done to integrate new research paradigms into an "outcomes-based mentality" and that these efforts include specific provisions for tracking on-the-ground outcomes. Somewhere within EPA, but not necessarily within ORD, there needs to be a focus on better integration of scientific results into stakeholder education and decision-making.
- ✧ The recent budget reductions have been difficult for the ERP, and the decision to take these reductions in extramural programs is understandable when viewed from the perspective of salvaging an effective research organization. This may appear to be a reasonable short-term response to weathering a storm, but it is dangerous. EPA and ORD should take a broader view and consider how to achieve maximum results in a new permanent budgetary environment. Clearly, abandoning extramural research grants is not a cost-effective strategy in this circumstance. Competitive research grants, as embodied in STAR and other programs, leverage considerable resources as well as bring new thinking and approaches into the organization. They also connect the organization to one component of the external customer base. The lost leveraging capability, reduced connection to other sources of innovation, and weakening of communication channels, over the long term, will disproportionately diminish the cost-effectiveness of EPA's research.

APPENDIX A: BOSC ECOLOGICAL RESEARCH SUBCOMMITTEE MEMBERS

Dr. Michael T. Clegg¹
Department of Ecology & Evolution
University of California
Irvine, CA 92697-1010
Tel: 949-824-4490 or 949-824-4489
E-mail: mclegg@uci.edu

Dr. Sue A. Thompson
Pennsylvania Biodiversity Partnership
16 Terminal Way
Pittsburgh, PA 15219-1209
Tel: 412-481-4100
E-mail: thompson@pabiodiversity.org

Russel Frydenborg
Florida Department of Environmental Protection
2600 Blair Stone Road
Tallahassee, FL 32399-2400
Tel: 850-245-8063
E-mail: russel.frydenborg@dep.state.fl.us

Dr. R. Eugene Turner
Coastal Ecology Institute
Louisiana State University
Baton Rouge, LA 70803
Tel: 225-578-6454
E-mail: eturne@lsu.edu

Dr. John P. Giesy²
Department of Zoology
Michigan State University
East Lansing, MI 48824-1222
Tel: 517-353-2000
E-mail: jgiesy@aol.com

Dr. Jianguo (Jingle) Wu
School of Life Sciences
Arizona State University
P.O. Box 874501
Tempe, AZ 85287-4501
Tel: 480-965-1063
E-mail: jingle.wu@asu.edu

Dr. Richard Lowrance
Agricultural Research Service
USDA-ARS
P.O. Box 748
Tifton, GA 31794
Tel: 229-386-3894
E-mail: lorenz@tifton.usda.gov

¹ Member of BOSC Executive Committee and Chair of the Ecological Research Program Subcommittee.

² Member of BOSC Executive Committee.

APPENDIX B: BOSC ECOLOGICAL RESEARCH SUBCOMMITTEE MEETING DATES

17 February 2005 Teleconference

Participants:

Subcommittee Members: Michael T. Clegg, Russel Frydenborg, John P. Giesy, Richard Lowrance, Sue A. Thompson, R. Eugene Turner, Jianguo Wu

EPA Attendees: Steven Hedtke, Jennifer Robbins, Kevin Summers, Greg Susanke

Other Participants: Stefanie Nelson, The Scientific Consulting Group (SCG)

3 March 2005 Teleconference

Participants:

Subcommittee Members: Michael T. Clegg, Russel Frydenborg, John P. Giesy, Richard Lowrance, Sue A. Thompson, R. Eugene Turner, Jianguo Wu

EPA Attendees: Deb Gonima, Kevin Summers, Greg Susanke

Other Participants: Stefanie Nelson, SCG

7-9 March 2005 Site Visit at EPA Facilities, Research Triangle Park, North Carolina

Participants:

Subcommittee Members: Michael T. Clegg, Russel Frydenborg, John P. Giesy, Richard Lowrance, Sue A. Thompson, R. Eugene Turner, Jianguo Wu

EPA Attendees: Rochelle Araujo, Mark Bagley, Joan Baker, Thomas Barnwell, Allen Basala, William Benson, Roger Blair, Benjamin Blaney, Michael Blum, David Bolgrien, Patricia Bradley, Arden Calvert, Timothy Canfield, Robin Dennis, Robert Dyer, Virginia Engle, Gary Foley, Tome Fontaine, Jonathan Garber, Deborah Gonima, Iris Goodman, Richard Greene, Steven Hedtke, Jeffrey Herrick, Robert Hetes, Virginia Houk, Laura Jackson, William Jenkins, John Johnston, Bruce Jones, Janet Keough, Daniel Kluza, Lorelei Kowalski, Gail Lacy, James Lazorchak, Timothy Lewis, Deborah Mangis, Michael McDonald, Megan Mehaffey, Bruce Mintz, Marirosa Molina, Jewel Morris, Wayne Munns, Anne Neale, Susan Norton, Robert Olexsey, Tony Olsen, John Paul, Steve Paulsen, Gina Perovich, Drew Pilant, Robert Puls, Jack Puzak, Mary Reiley, Denise Sailstad, Victoria Sandiford, Gregory Sayles, Stephen Schmelling, Nathan Schumacker, Victor Serveiss, Mark Shanis, Michael Slimak, John Stoddard, Elise Striz, Kevin Summers, Greg Susanke, Ginger Tennant, Jo Ann Thompson, Paul Wagner, Randall Waite, Thomas Wall, David Walters, Jordan West, Joseph Williams, Dorsey Worthy

Other Participants: Tom Atkeson (Florida Department of Environmental Protection), Roger Batterman (Wisconsin Department of Environmental Protection), Vicki Bott (Bowman) (University of North Carolina–Charlotte Urban Institute), Stefanie Nelson (SCG), Kathryn Saterson (Duke University), Robert Stevens (Florida Department of Environmental Protection), Scott Urquhart (Colorado State University), Lexia Weaver (University of North Carolina–Chapel Hill)

1 April 2005

Teleconference

Participants:

Subcommittee Members: Michael T. Clegg, Russel Frydenborg, John P. Giesy, Richard Lowrance, Sue A. Thompson, R. Eugene Turner, Jianguo Wu

EPA Attendees: Kevin Summers, Greg Susanke

Other Participants: Stefanie Nelson, SCG

APPENDIX C: LIST OF ACRONYMS

BOSC	Board of Scientific Counselors
EMAP	Environmental Monitoring and Assessment Program
EPA	U.S. Environmental Protection Agency
ERP	Ecological Research Program
FACA	Federal Advisory Committee Act
FTE	Full-Time Equivalent
FY	Fiscal Year
GIS	Geographic Information System
LTGs	Long-Term Goals
MAIA	Mid-Atlantic Integrated Assessment
MYP	Multi-Year Plan
NGOs	Nongovernmental Organizations
OAQPS	Office of Air Quality Planning and Standards
OMB	Office of Management and Budget
ORD	Office of Research and Development
OW	Office of Water
PART	Program Assessment Rating Tool
ReVA	Regional Vulnerability Assessment
RTP	Research Triangle Park
SEQL	Sustainable Environment for Quality of Life
STAR	Science To Achieve Results
TMDL	Total Maximum Daily Load
USDA	U.S. Department of Agriculture