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

OFFICE OF THE ADMINISTRATOR
SCIENCE ADVISORY BOARD

Honorable Stephen L. Johnson
Administrator
U.S. Environmental Protection Agency
1200 Pennsylvania Avenue, N.W.
Washington, D.C. 20460

Subject: SAB Advisory on the EPA Ecological Research Program Multi-Year Plan

Dear Administrator Johnson:

EPA's Office of Research and Development requested that the Science Advisory Board (SAB) provide advice on the Agency's draft *Ecological Research Program Multi-Year Plan FY 2008 – 2014* (Plan). The Plan presents proposed goals, objectives, and research questions for EPA's Ecological Research Program and also lays out an implementation strategy for the Program. In response to the Agency's advisory request, the SAB Ecological Processes and Effects Committee (Committee) reviewed the draft Plan. To augment the expertise on the Committee for this advisory activity, several SAB committee members with expertise in valuation of ecosystem services also participated in the review. The enclosed advisory report provides the advice and recommendations of the Committee.

EPA's draft Plan articulates a new strategic direction that focuses on quantifying ecosystem services and their contribution to human health and well-being. The SAB strongly supports this strategic direction and commends the Agency for developing a research program that has the potential to be transformative for environmental decision making as well as for ecological science. The SAB finds that the research focus on ecosystem services represents a suitable approach to integrate ecological processes and human welfare. The Ecological Research Program's focus on ecosystem services can provide a sound foundation for environmental decisions and regulation based on the dependence of humans upon ecological conditions and processes.

Although the SAB strongly supports the new strategic direction of the Ecological Research Program, we have a number of concerns about the draft Plan. Most of these are

related to the tension between stating an important and ambitious vision and producing a practical implementation plan for a future that includes a limited and uncertain budget. The SAB is extremely concerned that the resource allocation for the Ecological Research Program is too small to accomplish the ambitious program goals. Studying ecosystem services is a new field and the ORD staff skill set may be insufficient to conduct all of the research proposed in the Plan. We therefore strongly encourage EPA to provide additional intramural and extramural support (e.g., through STAR grants) for the Ecological Research Program, not only for technical elements but also for critical outreach/education efforts.

The SAB also finds that the decadal overview of proposed ecological research would be most useful if it included more detailed information concerning the knowledge gaps, research questions, variables, geographic scales, and sites to be investigated. Similarly, clear identification of the Agency's research partners and clients would facilitate collaborative interactions. We therefore recommend that EPA revise the Plan according to the following suggestions:

- Clarify why and how various research products will be developed and used;

- Clearly identify the clients of the Program and target outreach efforts to educate those clients;

- Explicitly recognize the role that emerging new ideas will play in the development of an adaptive program that stays on the cutting edge to respond to a rapidly changing arena for environmental and human welfare;

- Clarify existing and planned interactions among proposed program components and with other federal agencies involved in assessment of ecosystem services to avoid duplication of effort and promote coordination and synergy;

- Describe how partnerships with non-governmental organizations, professional societies, private businesses, and foundations, including international partnerships, can be enhanced to accomplish stated goals and objectives;

- Provide a more transparent explanation of the process used to select sites for place-based demonstration projects; and

- Explain how program success will be evaluated on the basis of progress toward specifying relevant ecological endpoints and production functions, not on the basis of achieving the ultimate goals of EPA's research and regulatory mission.

Thank you for the opportunity to provide advice on this important topic. The SAB looks forward to receiving your response to this advisory.

Sincerely,

Dr. M. Granger Morgan, Chair
Science Advisory Board

Dr. Judith L. Meyer, Chair
Ecological Processes and Effects Committee

U.S. Environmental Protection Agency
Science Advisory Board
Ecological Processes and Effects Committee

Augmented for the Advisory on the EPA Ecological Research Program Multi-Year Plan

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APPENDIX A. SPECIFIC COMMENTS ON THE ECOLOGICAL RESEARCH PROGRAM MULTI-YEAR PLAN A-1

1. EXECUTIVE SUMMARY

EPA's Office of Research and Development requested that the Science Advisory Board (SAB) provide advice on the Agency's draft *Ecological Research Program Multi-Year Plan FY 2008 – 2014* (Plan). The draft Plan was reviewed by the SAB Ecological Processes and Effects Committee (Committee). To augment the expertise on the Committee for this advisory activity, several SAB committee members with expertise in valuation of ecosystem services also participated in the review. The draft Plan presents proposed goals, objectives, and research questions for EPA's Ecological Research Program and also lays out an implementation strategy for the Program. The Plan articulates a new strategic direction that focuses on quantifying ecosystem services and their contribution to human health and well-being. EPA has stated that the overall goal of the Program is to change the way decision makers understand and respond to environmental issues by making clear the ways in which policy and management choices affect the type, quality, and magnitude of goods and services that are received from ecosystems.

EPA sought the SAB's advice on: 1) the appropriateness and utility of the new strategic direction in offering meaningful contributions to ecological sciences and providing research that will be useful to decision makers; 2) the adequacy of the goals, objectives, and questions in contributing significantly to meeting the overall purpose of the Program; 3) the logic model and implementation approach in the Plan; 4) anticipated challenges to achieving the overall goal of the Ecological Research Program; 5) suggestions for measuring annually over the next five years the progress, productivity, efficiency, and effectiveness of the Ecological Research Program; and 6) recommendations to enhance EPA's ability to leverage available resources within and outside the Agency. The Committee has provided comments and recommendations to improve the Plan in response to the charge questions. Our recommendations are listed as bullets throughout this advisory report.

Strategic direction and focus of the Program

The Committee strongly supports the new strategic direction of the Ecological Research Program. We commend the Agency for developing a research program that has the potential to be transformative for environmental decision making as well as for ecological science. The research focus on ecosystem services represents a suitable approach to integration of ecological processes and human welfare for the purposes of a public environmental management agency. The research program's focus on ecosystem services can, if properly funded, provide a sound foundation for environmental decisions and regulation based on the dependence of humans upon ecological conditions and processes. Although the Committee supports the overall strategic direction of the Program, we have a number of concerns about EPA's draft Plan. Most of these are related to the tension between stating an important and ambitious vision and producing a practical implementation plan for a future that includes a limited and uncertain budget. The following recommendations are provided to improve the discussion of the strategic vision and how it will be accomplished:

- The Committee finds that the long-term goals of the program are unlikely to be accomplished in the proposed time frame with current resources. We find the lack of grant support to be particularly worrisome given the limited EPA expertise available in certain areas and the fact that ecosystem services is a relatively young and rapidly developing field of science; we therefore strongly encourage EPA to provide additional funds for research on ecosystem services through the Agency's STAR program.

- To strengthen the justification of research priorities and clarify how work will be accomplished, we recommend that the discussion of priorities in the Plan include the logic leading to: a) accomplishing initial goals; b) selecting geographic locations for research; and c) identifying the scales of efforts.

- The overarching goals of the Program cannot be accomplished without basic ecological research. We therefore recommend that knowledge gaps be identified in the plan along with the basic research needed to fill these gaps, and that completion of this basic research be encouraged (e.g., through grants to researchers).

- The intended audience of the Plan (decision makers of whom the general public are the ultimate decision makers) and the range of decision types supported by the Ecological Research Program should be explicitly described "up front" in the Plan.

- The Plan should provide greater detail on how EPA will accomplish intra-program coordination and inter-institutional collaboration on the proposed research.

- The Plan would do well to recognize that the environment, institutions, and human welfare are changing at an unprecedented rate, and as new situations, new priorities, and new ideas develop, EPA should remain nimble enough to identify new "services," ask new questions, and apply new measurement techniques.

- The relationship between ecosystem service valuation and the application of ecological risk assessment should be described in the Plan. There is a strong connection between the current vision outlined in the Plan and EPA's long history of engagement in ecological risk assessment.

Research goals and questions

In the Plan, EPA has identified five long-term goals to guide its research agenda. The Committee has provided comments and recommendations on the goals, related research questions and objectives.

Long-term Goal 1 envisages development of a decision support platform that offers EPA, states, local communities, and resource managers the ability to integrate, visualize, and maximize the use of diverse data, models, and tools at multiple scales for decision

making. The Committee supports Long-term Goal 1 and offers the following recommendations for improvement.

- Long-term Goal 1 should be restructured to integrate the elements of human health and well-being and ecosystem services valuation into one effort that must rely heavily on individuals and agencies outside of the core ecological research proposed; similarly, outreach and education should be integrated with the decision support platform into one effort, addressing how decision makers would be targeted for outreach and education. A more comprehensive outreach and education plan should be developed to address human capital and resource needs. In addition, EPA should explicitly identify potential clients who will use the decision support platform.

- The discussion of Long-term Goal 1 does not clearly describe how EPA will find the expertise to accomplish valuation of ecosystem services, development of the decision support platform, and outreach and education, including coordination and collaboration with other units in EPA and/or through outside cooperators. In the Plan, the discussion of the key role of ecosystem services value information should be clarified to indicate what original valuation research will, and will not, be conducted within the ecological research plan.

- The Committee recommends that EPA focus on research that will be conducted to predict changes in ecosystem services rather than evaluating alternative valuation methods. This approach will take advantage of the available expertise within EPA's Office of Research and Development (ORD).

- The Committee recommends that EPA more thoroughly describe how the decision platform would work. This description should indicate whether the decision support platform is intended to support actual decisions or to teach decision makers about the importance of ecosystem services using illustrative case studies. EPA should also describe how mapping, monitoring, and modeling research accomplished in other components of the research plan would be coordinated with work to develop the decision support platform.

- As further discussed in Section 4.2 of this advisory report, the Committee is concerned about the overall feasibility of accomplishing Long-term Goal 1. We therefore recommend that development of the decision support platform be identified as a long-term objective, not a short run test of the Ecological Research Program's effectiveness.

Long-term Goal 2 envisages developing a publicly accessible, scalable national atlas, an inventory system, and models for selected ecosystem services. The Committee finds that the work to be conducted under this goal may be one of the strongest parts of the Ecological Research Program given that EPA has extensive experience in mapping and monitoring. We note that more detailed information is needed to understand how the maps and models developed under Long-term Goal 2 would be incorporated into the

decision support tool. We offer three key recommendations concerning Long-term Goal 2:

- The Committee recommends that EPA focus effort on developing forecasting models from information in available databases.

- The atlas of selected ecosystem services should be linked to models that can predict changes in ecosystem services. Monitoring data should lead directly into the atlas and support the forecasting models.

- The Committee recommends that EPA coordinate with other federal agencies to identify and review all federal agency ecosystem services, inventory, mapping, and monitoring type projects in order to determine how they can provide data to meet the objectives the Ecological Research Program. This review could be conducted through a workshop, with the aim of coordinating all of the federal agency components to provide synergy and avoid duplication of effort. Subsequent to the workshop, a regular assessment of ecosystem services in time and space would be a very important product.

Long-term Goal 3 calls for an assessment of the positive and negative impacts on ecosystem services resulting from changes in nitrogen levels at select locations and within select ecosystems. The Committee finds that this is an important area of ecological research. However, given the relatively modest effort that can be undertaken with available resources, we are concerned about substantial stand-alone investments in this area. The following recommendations are provided:

- The fundamental question to be addressed by the nitrogen assessment is not clearly articulated. A more detailed description and justification of the research to be conducted should be developed.

- Opportunities for coordination and collaboration with research conducted in the place-based and wetlands components of the ecological research plan should be vigorously pursued, including systematic replications of nitrogen studies across the different places and systems.

- The Committee recommends that EPA partner with other federal agencies conducting research on reactive nitrogen as related to human health issues to reduce duplication of effort.

Long-term Goal 4 of the Plan focuses on investigation of the dynamics of ecosystem service flows in two priority ecosystems, wetlands and coral reefs. The Committee finds that the long-term goal of assessing ecosystem services in wetland ecosystems is appropriate, but notes that it will be a challenge to address the complex spatial and temporal issues of ecosystem processes and their linkages to ecosystem services (and ultimately to valuation of those services). In this regard it will be important to coordinate research activities across many research entities (e.g., EPA, universities, and other federal

agencies). Chances of success could be improved by initially undertaking pilot projects where tangible products can be developed within a three-year period.

- The Committee recommends that detailed implementation plans be developed by EPA to accomplish Long-term Goal 4 and that these plans receive outside peer review. It is particularly important to undertake projects related to multi-stressor diagnosis and subsequent ranking and linkage to ecosystem attributes and services.

- Initial projects to accomplish Long-term Goal 4 should focus on a small set of representative wetland systems and perhaps also include a national assessment.

- Although coral reef ecosystems are globally important, the Committee finds that they are a relatively low priority in the U.S. We recommend that EPA undertake projects in other more common "human dominated" ecosystems that provide services to more U.S. citizens, and greater opportunities for coordination and collaboration with other studies within the ecological research program.

Long-term Goal 5 calls for place-based research to investigate ecosystem services. The Committee finds that there is a lack of adequate and transparent explanation in the Plan regarding the selection of areas where this research will be conducted. We therefore recommend that:

- The Plan should contain a transparent explanation of the process used to select sites for place-based demonstration projects. In Section 4.1 of this advisory report we have suggested principles that could guide selection of these sites.

- The Committee also recommends that transboundary issues be explicitly considered in the place-based projects.

Implementation Strategy

The Plan contains a logic model that describes how the Ecological Research Program will be designed, planned, implemented and managed. The Committee has provided a number of comments and recommendations concerning: 1) the logic model; 2) anticipated challenges to achieving the overall program goal; 3) measuring program progress, productivity, efficiency, and effectiveness; and 3) enhancing EPA's ability to leverage available resources.

Logic model

The Committee finds that the construct of the logic model in the Plan is a sensible way to represent program activities, products, and outputs. A similar approach has been suggested in a recent National Research Council (NRC, 2008) report.

- As discussed in Section 4.3 of this advisory report, the Committee recommends that EPA consider adapting some of the terminology and structure of the NRC logic

model and more clearly identify the role of partnerships in accomplishing research goals.

Challenges to achieving goals

The Committee has identified the following four broad categories of challenges facing the Ecological Research Program: 1) the ambitious nature of the overarching research questions and annual performance goals; 2) scientific and technical issues to be overcome in developing specific methodological or tactical approaches; 3) difficulties that may be encountered in extending program outputs to partners to support decision making processes; and 4) availability of resources (including institutional capabilities).

The Committee finds that the most serious challenge facing the Ecological Research Program is the limited availability of resources. The long-term goals of the program are unlikely to be accomplished in the proposed time frame with current resources. The ORD staff skill set may not be sufficient to address the issues and conduct all of the work needed to achieve long-term program goals. Valuation and benefit assessment is one particular area where additional expertise is needed. If ecosystem services are to be properly evaluated, EPA will need expertise to ensure that well-being is parameterized in an accurate multidimensional manner. This should include consideration of non-western value systems, notably those of native Americans. Furthermore, assessing ecosystem services is a new and rapidly developing area of research that will benefit from the diversity of insights and approaches provided by independent investigators. Given these conditions, we find the lack of grant support to be particularly problematic, and therefore strongly encourage EPA to provide additional funds for ecological research through the Agency's STAR program.

Suggestions for measuring progress, productivity, efficiency, and effectiveness

The Committee notes that the recent NRC (2008) report cited above provides relevant recommendations for evaluation of research and development programs at EPA. In Section 4.5 of this advisory report we have offered some additional recommendations. We generally find that, given the visionary intentions of the Plan and the current lack of detailed research implementation plans, it is premature to prescribe specific measures to evaluate annual performance and progress goals. However, we recommend that:

- At this formative stage an assessment of the Plan as it develops should include monitoring, evaluation and adjustment of objectives as partnerships and collaborations within and outside EPA evolve. Such an adaptive management approach requires flexibility and vigilance to capitalize on opportunities that arise.

Recommendations for enhancing EPA's ability to leverage available resources within and outside the Agency

The Committee finds that the success of the Ecological Research Program is likely to depend in large measure upon its ability to leverage available resources within and

outside of EPA. In Section 4.6 of this advisory report we have offered a number of specific recommendations in this regard, summarized below.

- The Memoranda of Understanding to be developed with federal partners should be more than agreements to cooperate. The memoranda should state who will do specific work when there is overlap, and how resources will be shared.

- ORD should use its available people, infrastructure, and data to leverage in-kind services and collaborate with other groups/agencies. In this regard, there are ample partnership opportunities. ORD can partner with other agencies within the U.S. (e.g., U.S. Fish and Wildlife Service, U.S. Forest Service, and National Park Service).

- ORD should consider working with professional societies to sponsor sessions or symposia for presenting results of work to accomplish the Plan's goals and soliciting feedback from stakeholders and end users. In addition, ORD should consider partnerships with private business, NGOs, and such organizations as non-profit foundations to raise funds to conduct research and development activities.

- ORD should make the STAR program a priority in efforts to leverage resources. The following will help achieve the Plan's goals: enhancing the STAR Graduate Fellowships program; providing funds for non-targeted, exploratory extramural research to develop tools and procedures to accomplish the goals of the Plan; and developing a competitive grants program to run summer credit workshops for teachers through STAR.

- ORD should partner with professional societies, publishing companies, media outlets, and NGOs to develop and disseminate education and outreach materials to professionals, teachers, and the lay public. Some suggested approaches that could be developed in partnership with other organizations include: workshops, symposia, and sessions at meetings, WIKI blogs, presentation materials for educators and public forums, media resources including cable television educational networks, and 10-15 min video clips that can be used in classroom settings.

- ORD should also consider international partnerships, particularly for dealing with cross-border issues.

2. INTRODUCTION

EPA's Office of Research and Development requested that the Science Advisory Board (SAB) provide advice on the Agency's draft *Ecological Research Program Multi-Year Plan FY 2008 – 2014* (Plan). The draft Plan was reviewed by the SAB Ecological Processes and Effects Committee (Committee). To augment the expertise on the Committee for this advisory activity, several SAB committee members with expertise in valuation of ecosystem services also participated in the review. The draft Plan presents proposed goals, objectives, and research questions for EPA's Ecological Research Program and also lays out an implementation strategy for the Program.

For the past ten years the EPA Ecological Research Program has focused on: 1) developing monitoring tools and indicators to determine the status of and trends in ecological resources and the effectiveness of national programs and priorities; 2) developing diagnostic tools and methods to determine causes of ecological degradation; 3) developing tools and methods to forecast the ecological impacts of actions taken by states, tribes, and EPA offices; and 4) developing environmental restoration tools and methods to improve the ability of states, tribes, and EPA offices to protect and restore ecological condition. EPA's draft *Ecological Research Program Multi-Year Plan FY 2008 - 2014* articulates a new strategic direction for the Program that focuses on quantifying ecosystem services and their contribution to human health and well-being. This new approach takes the focus of the Program beyond traditional ecological endpoints such as biological, chemical, and physical condition. EPA has stated that the overall goal of the new Program is to change the way decision makers understand and respond to environmental issues by making clear the ways in which policy and management choices affect the type, quality, and magnitude of goods and services that are received from ecosystems.

The Committee strongly supports the new strategic direction of the Ecological Research Program. We commend the Agency for developing a research program that has the potential to be transformative for environmental decision making as well as ecological science. The research focus on ecosystem services represents a suitable approach to integration of ecological processes and human welfare for the purposes of a public environmental management agency. The research program's focus on ecosystem services can provide a sound foundation for environmental decisions and regulation based on the dependence of humans upon ecological condition and processes. While the Committee supports the overall strategic direction, we have a number of concerns about EPA's draft Plan. These concerns are further discussed in various sections of this advisory report. The Committee has provided comments and recommendations to improve the Plan in response to the charge questions. Our recommendations are listed as bullets throughout this advisory report.

3. CHARGE TO THE COMMITTEE

EPA's Office of Research and Development sought advice from the Science Advisory Board on the strategic direction and focus of the Ecological Research Program, the

research goals and objectives in the Plan, and the Agency's strategy for implementation. The following specific charge questions were provided to the Committee.

Focus of the Program

1. The strategic direction of the Ecological Research Program (Program) is to: a) characterize and quantify the type, quality, and magnitude of services that ecosystems provide; b) develop new methods to quantify and forecast how services respond to stressors; and c) combine these and existing tools for assessing the benefits of alternative management decisions. Please comment on the appropriateness and utility of this strategic direction in: 1) offering meaningful contributions to the ecological sciences and 2) providing research that will be useful to decision makers at EPA and other levels of governance.

Research Goals and Questions

2. The Ecological Research Program includes five long-term goals, associated objectives, and research questions. Please comment on the adequacy of the goals, objectives, and questions in contributing significantly to meeting the overall purpose of the program. In reviewing each research goal please consider the following:

    - Are the research questions appropriate? If changes are needed in the research questions, please indicate how they should be changed.
    - Are the descriptions of planned research adequate to characterize the intended results, and is the planned research appropriate for accomplishing the goals?
    - Please comment on needed improvements in and clarification of the goals and objectives as well as additions or eliminations to be considered in future program development.

Implementation Strategy

3. The Ecological Research Multi-Year Plan lays out the process by which ORD intends to accomplish research. Please comment on the logic model approach and provide any recommendations that should be considered in developing implementation plans.

4. Please comment on anticipated challenges to achieving the overall goal of the Ecological Research Program Multi-Year Plan based on the Program as presented. What recommendations does the Committee have to overcome the most significant of these challenges?

5. What suggestions does the committee have for measuring annually over the next five years the progress, productivity, efficiency, and effectiveness of the Ecological Research Program?

6. Does the Committee have any recommendations on how EPA can better enhance its ability to leverage available resources within and outside the Agency?

4. RESPONSE TO CHARGE QUESTIONS

4.1 Charge Question 1. Please comment on the appropriateness and utility of the strategic direction of the Plan in: 1) offering meaningful contributions to the ecological sciences; and 2) providing research that will be useful to decision makers at EPA and other levels of governance.

The Committee unanimously supports the conceptual framework of EPA's draft Ecological Research Program Multi-year Plan. The conceptual framework of the Plan focuses on creation of an integrated systems-based approach to identify, inventory, monitor, map, and model ecosystem services. In addition, the conceptual framework focuses on quantifying ecosystem services and their contribution to human health and well-being. The research focus on ecosystem services represents a suitable approach to the integration of ecological processes and human welfare. The Committee finds that EPA's focus on ecosystem services provides an appropriate foundation for environmental decisions and regulation based upon the dependence of humans upon ecological condition and processes. The conceptual framework for the program is thus tightly linked to the mission and agenda of EPA, and represents the leading ideas of the international ecological community. The vision outlined by EPA is a plan to develop the next generation of environmental management support technologies that build on risk assessment. The Committee finds that the resulting knowledge and tools will more completely support effective evaluation of management alternatives and improved communication of benefits to the public than is presently the case.

However, the Committee has a number of concerns about EPA's draft Plan. Most of these are related to the tension between stating an important and ambitious vision and producing a practical implementation plan for a future that includes a limited and uncertain budget. Our suggestions for improvement are related to maintaining the large and influential vision while appropriately defining the most pressing questions, scales, variables, and geographic locations to be investigated. We have eight major recommendations related to the overall adequacy and appropriateness of the strategic direction outlined in the Plan. These recommendations are aimed at improving the potential for contribution to ecological science and providing research that will be highly useful to decision makers.

Recommendations to improve the potential contribution of the ecological research program to ecological science and decision making

- The vision and direction described in the Plan are sufficiently important to merit substantial investment by EPA. The long-term goals of the program cannot be accomplished with current resources (funding and personnel) dedicated to this effort. It is our understanding that EPA is dedicating approximately $68 million per year of Office of Research and Development staff time to support the ecological research program but is not providing any grant funding or other additional extramural

support. We recommend that Science to Achieve Results (STAR) program funds and other EPA resources be directed toward the ecological research program. The research program is advancing an area of ecological science that is new, where innovative and exploratory research will be needed to accomplish the important goals of the Program, and it is appropriate that extramural funding be focused there. The Plan is closely related to all five of the strategic goals defined in EPA's 2006 – 2011 Strategic Plan (U.S. EPA, 2006), and the Committee recommends that those connections be communicated clearly in order to support substantially increased EPA investment in the Ecological Research Program.

- The vision outlined in the Plan is ambitious and important, and we recommend that the title of the document reflect this vision. In addition, as a challenge, we recommend that long-term goals (stretch goals) be clearly identified as such and presented in the Plan first, followed by a sequence of short-term priorities and measurable outcomes (i.e. an implementation plan). These measurable outcomes should be the basis for program evaluation criteria and metrics. The discussion of priorities in the Plan should include the logic leading to: a) accomplishing initial goals for first efforts at addressing ecosystem services; b) selecting geographic locations for research; and c) identifying the scales of the planned efforts. The discussion of the priorities should be clear and honest about current resources and leveraging past investments.

- The Program goals cannot be accomplished without answering basic science questions. It is recommended that knowledge gaps be identified in the Plan, and that EPA plan and appropriately fund the basic research needed to fill these gaps. In particular, empirical data are needed to test hypotheses regarding why changes in ecosystem services are occurring, and at which scales. Identification of knowledge gaps will allow the key basic science questions to be elaborated in the separate sections of the Plan, and provide both the rationale and intellectual construct for contributing to ecological science.

- Among the most complex challenges facing EPA is the rate of change: new environmental problems, new socioeconomic situations, and new threats to ecosystem services arise. A 10-year plan that is assiduously held to is very likely to miss opportunities for making the largest impacts, unless it has a review cycle and adaptive management plan. We recommend that not only the progress, but the vision and implementation, be reviewed frequently enough to allow nimble responsiveness and maximal effectiveness.

- It is recommended that the intended audience of the Plan and the range of decision types supported by the Ecological Research Program be more clearly described "up front" in the document. It would be helpful to include in the Plan a matrix or table of decision types (i.e., the types of choices being made at various decision-making levels) vs. decision makers (i.e., governmental, industrial, private organizations, etc.). The Committee notes that it is particularly important to elaborate issues of scale (local vs. regional).

- The Committee recommends that EPA collaborate with other federal agencies and academic scientists to conduct a scientific community assessment of status and trends of ecosystem services in the U.S. (similar to the Intergovernmental Panel on Climate Change [IPCC] assessments). Such an assessment would be an appropriate and very important output from the research that is described in the Plan. This assessment would be a high impact, visible product from EPA that could have a large influence on decision-makers.

- The Committee recommends that EPA include in the Plan an organizational plan for inter-institutional collaboration. The importance of inter-institutional collaboration is an issue that arose repeatedly in the Committee's discussion of the Plan. The Committee notes that the assessment of status and trends in ecosystem services could provide an opportunity for such collaboration. While we understand the challenges associated with developing a large collaborative research program, we find that if EPA were to lead an effort to undertake the assessment suggested above, the payoff would be large for science and management. The effort would be a visible contribution to a national initiative. One venue for an assessment of status and trends in ecosystem services would be collaboration with the National Center for Ecological Analysis and Synthesis, which could provide data analysis support, as well as support services for a series of workshops.

- The Committee notes that there is a strong connection between the current vision outlined in the Plan and EPA's long history of engagement in risk assessment. We recommend that this connection be explicitly discussed in the plan. The relationship between ecosystem services valuation and the application of ecological risk assessment should be described in the Plan. The Committee finds that ecosystem services assessment is an activity that will provide decision makers with information to translate ecological risk assessments into management strategies for achieving sustainable future environmental protection.

4.2 Charge Question 2. Please comment on the adequacy of the goals, objectives, and questions in contributing significantly to meeting the overall purpose of the program.

In the Plan, EPA has identified five long-term goals to guide its research agenda. These five goals are: 1) by 2014, provide on-line decision support that offers EPA, states, local communities, and resource managers the ability to integrate, visualize, and maximize the use of diverse data, models, and tools at multiple scales to generate and understand the consequences of alternative decision options on the sustainability of ecosystem services and human well-being; 2) by 2013, deliver publicly accessible, scalable national atlas, inventory system, and models for selected ecosystem services that can be quantified directly or indirectly; 3) by 2013, provide an assessment of the positive and negative impacts on ecosystem services resulting from changes in nitrogen levels at select locations and within select ecosystems; 4) by 2015, provide guidance and decision support tools to target, prioritize, and evaluate policy and management actions that

protect, enhance, and restore ecosystem goods and services at multiple scales for two specific ecosystem types, wetlands and coral reefs; and 5) by 2013, complete four site-specific demonstration projects that illustrate how regional and local managers can proactively use alternative future scenarios to conserve and enhance ecosystem goods and services in order to benefit human well-being and secure the integrity and productivity of ecological systems.

In the discussion of each long-term goal in the Plan, EPA has outlined the science questions and objectives to be addressed. The Committee provides the following comments on each of the long-term goals and related research questions and objectives:

Long-term Goal 1 – Effective Decision Support

The Committee commends EPA's Office of Research and Development (ORD) on expanding its vision for an ecological research agenda to include a component targeted directly at ensuring that its products are useful for decision making. This goal is not only appropriate but also essential if the Plan is to be part of a catalyst that helps to address the concern that ecosystems are being degraded because they are perceived as "free and limitless," and their full value is not reflected in individual and policy decisions. In addition, the Committee agrees with ORD that it is important to recognize and incorporate into the vision for this long-term goal the overall objectives of outreach and education, valuation of ecosystem services, and estimation of ecological production functions. All of these are important objectives that, if met, will enhance the Agency's ability to accomplish its mission and contribute to improved decision making.

Although the Committee supports Long-term Goal 1 and the overall research objectives included under this goal, we have several concerns about EPA's proposed plan to accomplish the goal. These concerns focus on: 1) how the plan is structured; 2) specific means to accomplish the goal; and 3) overall feasibility of accomplishing the goal.

Structuring the Plan to accomplish Long-term Goal 1

As reiterated throughout the Plan, some of the information needed to evaluate tradeoffs regarding ecosystem services in the context of decision making concerns the value or benefits of changes in service flows. These values reflect the impact of service flow changes on human health and well-being. In order to influence decisions, information about these values in turn must be communicated to the public (through outreach and education) and to decision makers (through the decision support platform). EPA describes the following four research program elements to accomplish Long-term Goal 1: 1) Human Health and Well-being (HHWB) (i.e., research to help decision makers understand links between ecosystem services and human health and well-being); 2) Ecosystem services valuation (ESV) (i.e., research to give decision makers constructs to describe ecosystem values in a way that supports assessment of tradeoffs); 3) Outreach and Education (OE) (i.e., outreach to decision makers to ensure that research will meet their needs and be applied with confidence); and 4) Decision Support Platform (DSP)

(i.e., research to develop and make available tools for decision makers operating in different circumstances, communities, spatial scales, and levels of complexity and uncertainty). The Committee finds that acknowledging the important roles of all of these elements is appropriate to an ecological research program within the ecosystem services framework, but they do not seem to be logically structured within Long-term Goal 1 and many aspects of these program elements may be outside the purview of ecological research per se. The following recommendations are provided to restructure this part of the Plan:

- The Committee recommends combining and integrating the HHWB and ESV elements of the Plan, clearly identifying which aspects of HHWB and ESV are to be accomplished within the Ecological Research Program, and which are to be accomplished through cooperation and collaboration with other units within and outside of EPA. The logic of separating HHWB and ESV elements is not clear. The whole purpose of ecosystem service valuation is to determine the value of the impacts of changes in the flow of ecosystem services on human well-being (including changes in well-being stemming from changes in health outcomes). Thus, these two elements should logically be combined and integrated. On page 22 of the Plan it is suggested that they will be "closely coordinated," but an explicit plan for using the output of the HHWB health outcomes as an *input* into the ESV is needed. In addition, explicitly linking the HHWB and ESV research will provide a conceptual basis for thinking about the linkage of ecological systems and indicators of human well-being in the context of the ecosystems services framework, which is likely to be a difficult task. The separate treatment of human health under the current structure may also give it more prominence in the study of ecosystem services than is warranted, since it is not clear that this is a major component of the impact of ecosystem services on human well-being. The Ecological Research Program should explicitly rely upon cooperation with the various medical, economic and other social sciences (mostly residing in other EPA units and outside agencies) to help identify, define, and quantify the values to ecosystem services to human health. The Ecological Research Program should focus on developing the ecological production functions of the ecosystems services framework.

- The Committee recommends combining the DSP and OE elements. If the purpose of the OE element is to reach out to decision makers to ensure that the DSP meets their needs (as stated on page 21 of the Plan), then it would seem logical to combine these two elements into a single coordinated and integrated element which would draw from the ESV work. In fact, much of what is described as the means by which the OE objectives will be met (on page 34 of the Plan) appears to link closely to the DSP. The Committee also notes that many aspects of the DSP and OE sections pf the Plan will require cooperation with scientists in other agencies and parts of EPA, rather than being totally (or even largely) developed by ORD Ecological Research Program staff. The need for such cooperation is discussed in other sections of this advisory report.

Means to accomplish key research under Long-term Goal 1

The Committee is concerned that the Plan does not clearly describe how EPA will provide the expertise to accomplish research in three key areas: 1) valuation of ecosystem services; 2) development of the decision support platform; and 3) outreach and education.

Valuation of ecosystem services

One of the overarching research questions articulated on pages 8- 9 of the Plan concerns the impact of "changes in ecosystem services on human well-being and on the services' monetary and non-monetary value." However, the Committee notes that developing these ecosystem service values is a major research undertaking by itself (EPA Science Advisory Board , 2008a) and, despite the repeated reference in the Plan to ecosystem service values, it is not clearly indicated how these values will be determined and used, for example, in the DSP. The Plan mentions "partnering" with other EPA offices, organizations, or individuals to determine values. The Committee supports such partnering, but it is not clear what role these partners would play. The Plan seems to recognize this as a potential problem (see page 17 of the Plan), but does not articulate a strategy for addressing the problem. There is reference on page 22 of the Plan to drawing on the expertise within EPA's National Center for Environmental Economics (NCEE), but it is not clear what is intended here. The Committee questions whether NCEE will be doing original valuation research that is specifically related to the Ecological Research Program. Information the Committee has received suggests that the NCEE commitment to this effort is limited. The Committee notes that, in general, NCEE has a strong focus on supporting regulatory impact analyses and therefore cannot devote resources to the goals of the Plan commensurate with what is required unless additional resources are provided. In addition, the recent SAB review of the ORD budget suggests there is little, if any, funding available for valuation research through external (STAR) grants (U.S. EPA Science Advisory Board, 2008b). The Committee further notes that, even though valuation or benefits assessment is listed as one of the Plan's overarching research goals, on page 16 (Figure 5) the Plan indicates that valuation work will receive a very small share (only 2%) of Ecological Research Program resources (U.S. EPA Office of Research and Development, 2008). Thus, it appears that the Program will not generate much (if any) original valuation research, either through ORD directly or through its partners in the Plan. If this is true, a statement to clearly indicate such should be included at the very beginning of the Plan where the issue of valuation is first introduced. Throughout the Plan, there is discussion about the key role of value information, but it is not clear what valuation research will be undertaken. Therefore the Committee recommends that:

- In the Plan, the discussion of the key role of ecosystem services value information should be clarified to indicate what original valuation research will, and will not, be conducted.

The Committee finds that without additional resources ORD does not have the expertise to conduct valuation itself or the capacity to fund this type of research by others. However, ORD can benefit from and provide valuable input into valuation efforts conducted (and funded) by others. All ecosystem services valuation exercises, regardless of the specific valuation method used require as input predicted changes in the flow of

ecosystem services. EPA's Ecological Research Program can play a critical role in estimating the ecological production functions that can be used to generate predicted changes in service flows stemming from alternative decisions or management options (and the associated changes in stressors). The Committee notes, however, that even this will require the interdisciplinary interaction of a team comprised of ORD scientists and social scientists.

The identification of ecosystem *services* requires information not just about the functions, processes, and bio-physical state of ecosystems but also about the (potential or actual) human uses or the contributions to well-being associated with those systems. Consideration of non-Western value systems, notably those of native Americans will be important to ensure that well-being is parameterized in an accurate multidimensional manner. This suggests that the identification, measurement and mapping of ecosystem services cannot be based solely on bio-physical information but must also incorporate information relating to social, economic, cultural or other population characteristics that affect the extent to which ecosystems contribute to human well-being. For example, maps and models of the relevant characteristics (and projected future characteristics) of the humans/societies near (and downstream from) a wetland are required to translate the particular water captured, filtered and stored into a "service" that is of value to people. These same human/social characteristics are frequently cited in the Plan as potential sources of stressors on wetlands, reinforcing the need for measures and models (and maps) of relevant human/social characteristics.

Incorporating this information to identify and measure changes in services does not, however, mean that the Plan must include an assessment of alternative valuation methods (as currently articulated in the Plan). While such an assessment is important, given ORD's expertise, the Committee recommends that:

- In the Plan, EPA should focus on research that will be conducted to predict changes in the ecosystems that provide selected ecosystem services rather than on evaluating alternative valuation methods for those services. This research focus will take advantage of the expertise available within ORD.

The Committee notes that this is a complicated area requiring extensive consideration of a number of issues (EPA Science Advisory Board, 2008a), and there is the potential for misinterpretation if not done very carefully. For example, the plan suggests that the Science Advisory Board Committee on Valuing the Protection of Ecological Systems and Services (CVPESS) has recommended the use of "donor-based" methods of valuation based on stocks and flows of energy. The Committee notes that this assertion is incorrect. CVPESS did *not* recommend the use of "donor-based" methods. This subject was debated by the CVPESS, but it is a controversial approach that is rejected by many, if not most, economists, as well as others on the Committee. This is an important consideration because "buy-in" from economists, social scientists, and others involved in the valuation and policy making process is essential to the success of the Plan. The Committee notes that this is just one example of the issues that can arise in valuation, but it illustrates why the Committee is concerned about this aspect of the Plan.

Decision Support Platform (DSP)

The Committee finds that in the Plan, several aspects of the discussion concerning the DSP are unclear. First, the Plan does not clearly identify the user community for the DSP. There are numerous references in the Plan to decision makers who are the intended audience for the DSP. However, it is likely that in many cases the users of the DSP may be analysts rather than decision makers. These analysts, in turn, provide information to the decision makers. It is important that the types of decision makers comprising the audience of the DSP be clearly identified. The Committee questions, for example, whether the DSP audience includes decision makers in industry. The Committee finds that EPA will miss a major opportunity if the Plan does not address how industry would use this information and tool set to factor ecosystem services into their day-to-day project designs and funding decisions. The Committee notes that clients (stakeholders) who will use the DSP must be identified early in the process, and their involvement in the decision process must be continuous. The Panel therefore recommends that:

- In the Plan, EPA should explicitly identify potential clients who will use the DSP. This will allow outreach efforts to be targeted more specifically. The Panel notes that any computer-based environmental decision tool needs to be marketed to show its utility. Achieving widespread use among a variety of clients will require a variety of approaches.

A second concern about the discussion of the DSP in the Plan is that it does not clearly describe how the DSP would work. The Committee questions, for example, whether the DSP is intended to provide support for *actual* decisions (in which case it must include specific information relevant to the particular decision context), or simply to *teach* decision makers about the importance of ecosystem services using illustrative case studies so that they will be more likely to incorporate consideration of ecosystem services in future decisions. The Committee notes that it may be a relatively easy task to collect information about ecosystem services in one place on an internet website for easy access by decision makers. Similarly, teaching tools can be easily developed and made available to decision makers. However, it is much more difficult to develop a meaningful interactive decision support tool for direct use in evaluating specific policy options. The nature and scope of the decisions relating to the provision of ecosystem services are likely to be varied in scale (e.g., local, regional, national) and geography (e.g., consideration of sites at different locations). Therefore, development of a single decision support tool that could simply be adapted (e.g., through re-parameterization) to specific contexts seems nearly impossible. If EPA envisions a suite of tools in the DSP, it is not clear how they would be designed (e.g., by ecosystem type or scale). Again, it might be possible to put various ecological models (with estimated ecological production functions) into the DSP, but in order to evaluate tradeoffs, information about values is needed. The Committee questions whether the DSP will contain specific valuation information that can be combined with estimated ecological production functions for use in evaluating tradeoffs. The Committee notes that it can be quite dangerous to combine specific valuation information with estimated ecological production functions since this

will inevitably involve the difficult task of evaluating benefits transfer which, if not done carefully, can be very problematic. The Committee therefore recommends that:

- In the Plan, EPA should more clearly describe how the DSP would actually work. This description should indicate whether the DSP is intended to provide support for *actual* decisions or to *teach* decision makers about the importance of ecosystem services using illustrative case studies. The Plan should describe the suite of tools envisioned in the DSP and how these tools would be designed.

In the Plan, the DSP is often described as an instrument bringing together and making available whatever models and measures are developed under any of the other four Long-term Goals. The Committee finds that the DSP could more effectively promote coordination if it worked more to encourage convergence among the separately developed models and measures. In this sense, a less flexible platform that required all projects/investigators to negotiate in the direction of common mutually acceptable models and measures might be more advantageous. There is also some indication that research to be completed under Long-term Goals 1 and 2 (Effective Decision Support and National Inventory, Mapping and Monitoring) could conflict and compete over models and measures. As discussed in the Plan, ORD's intention seems to be that the work under these two goals would be complementary, with the maps and models developed under Long-term Goal 2 being designed to be easily incorporated as both tools and contents in the DSP. However, it is not clear in the Plan how the required collaboration between research projects conducted under Long-term Goals 1 and 2 would be achieved operationally. Similarly, models and measures for development under the other goals are destined for use in the DSP, but it is not clear that they are constrained in any way to promote convergence across goals/projects. Therefore, the Committee recommends that:

- In the Plan, EPA should clearly describe how mapping, monitoring and modeling research conducted under Long-term Goal 2 (and modeling work proposed under other long-term goals) would be coordinated with work to develop the DSP. EPA should describe how collaboration on these research projects would be achieved operationally.

Outreach and Education (OE)

Long-Term Goal 1 of the Plan contains an OE component. The Committee notes, however, that OE has not historically been a significant part of ORD's work and, therefore, additional expertise may be needed in this area. The Plan alludes to the use of participatory, deliberative processes. This will require expertise in the use of these types of processes, but there appears to be limited (if any) expertise in this area within ORD. Aside from direct work on decision-aiding processes of this type, the OE component of the plan could seek to educate the general public about ecosystem services, under the assumption that one way to influence decision makers is to generate pressure from consumers and voters. This suggests the need for a more comprehensive OE plan, which will require human capital resources to provide necessary education. In particular, the

Committee finds that efforts to "teach the teachers" could be very useful. The Committee recommends that:

- EPA should develop a more comprehensive OE plan addressing human capital resource needs to provide the education. The committee supports the Agency's plans to pursue opportunities for partnering with outside groups for these types of activities. The partnership with National Geographic is a good example of the kinds of activities needed.

Overall feasibility of accomplishing Long-term Goal 1

A major concern of the Committee relates to the overall feasibility of accomplishing Long-term Goal 1. The plan to accomplish this goal is ambitious, and the Committee questions whether ORD can realistically achieve the objectives and accomplish the tasks set out here. The following factors (some of which have already been discussed) contribute to this concern:

- The design of decision support tools that can adequately address specific decision contexts will be difficult, given the wide diversity of: 1) needs of specific decision makers; 2) types of ecosystem services being addressed; 3) relevant geographical scales; 4) relevant jurisdictions; and 5) specific locations of interest.

- Development of the DSP is likely to be very time-consuming and costly.

- There is not currently sufficient expertise within ORD to conduct the proposed research. Much of the research requires social and decision science expertise, which is generally lacking in ORD. Although the plan calls for partnerships with other units within EPA (e.g., NCEE) or outside, the nature and strength of these commitments is unclear. For example, the commitment articulated by NCEE is fairly limited and certainly not sufficient to meet the research objectives regarding valuation included in the plan. Relying on the good will of partners to meet the objectives and annual performance goals of a major part of the plan is risky.

- Although the ORD identifies decision support as a fundamental, driving force for the Plan, the resources devoted to this part of the Plan constitute a small percentage of total resources available to the Ecological Research Program.

- The timing of the work related to this objective is unclear. While it may be useful to collect currently available information about ecosystem services and their value(s) in a central on-line location in the early years of the Plan, the main payoff from the decision support will come much later when new research results and decision tools are available and incorporated into this platform. Alternatively, the DSP could be designed and then "tested" using the place-based projects in the Multi-Year Plan. The Committee finds that in all of these

cases, the objective of having a fully operational decision support platform in place within five years may be unrealistic.

Concerns about the feasibility of this part of the Plan are particularly worrisome because ORD has suggested that ultimately the success or failure of the Plan hinges on the success or failure of the decision support platform. The Committee recognizes the need to ultimately justify the ORD ecological research program based on its ability to affect decisions. However, we recommend that:

- Development of the DSP should be a long-term objective and not a short run test of the program's effectiveness (based on metrics such as the number of users of the decision support platform). The committee believes that ORD can contribute to this long run objective through other parts of the Plan even if it does not produce the type of fully operational decision support platform envisioned in the plan within the next five years.

Long-term Goal 2 – National Inventory, Mapping, and Monitoring

Long-term Goal 2 envisages developing a publicly accessible, scalable national atlas, an inventory system, and models for selected ecosystem services. The Plan states that these research products will enable EPA, state and local governments, non-governmental organizations, and other decision makers to assess the likely effects of management actions on ecosystem services. The Committee finds that the work to be conducted under Long-term Goal 2 may be one of the strongest parts of the Ecological Research Program Multi-year Plan because EPA has extensive experience in developing environmental inventories, mapping, and monitoring. The maps and resulting models developed under Long-term Goal 2 should definitely be incorporated into the Decision Support Platform of Long-term Goal 1. However, the Committee notes that more detailed information is needed to completely understand how this would happen. We presume that such information will appear in an implementation plan to be developed by ORD. The Committee has some concern that in the Plan the notion of ecosystem services remains too focused on human health and well-being. Under this perspective, the Arctic National Wildlife Refuge would have no value other than its ability to produce oil. The use of valuation has merit in the management of human-dominated landscapes, but a major aspect of resource management, namely non human-dominated systems, should also be considered in research questions and objectives under Long-term Goal 2. In this regard, the key for the Ecological Research Program is to be sure that research addresses all ecological components and processes that are important to the provision of any services identified as relevant to EPA mandates and responsibilities. In addition, it is important that adequate attention is given to identifying all of the services to which any given component or process contributes, including services not explicitly targeted within a given policy or decision-making context. With regard to Long-term Goal 2, the Committee provides the following specific comments and recommendations concerning: 1) forecasting models, the atlas of ecosystem services, and modeling expertise; and 2) the need for coordination of federal agency monitoring activities.

Forecasting models, the atlas of ecosystem services, and the need for modeling expertise

Considerable data have been accumulating from numerous federal monitoring programs; Olsen et al. (1999) identify at least 15 of these programs. Some of these monitoring programs are based on probability sampling, others on site characteristics. Sampling occurs at different spatial and temporal scales, resulting in different lengths of series. Thus far, the monitoring programs have been used largely to determine status and trends. The Committee finds that EPA now needs to address questions such as: How and why are ecosystems and ecosystem services changing?; How are ecosystems being affected by humans?; and finally How might management decisions reduce negative consequences, or even result in beneficial gains? The Committee also finds that the idea of developing a scalable national atlas is a good one; the atlas can be an excellent communication tool but it should be linked to modeling efforts. The Committee specifically recommends that:

- EPA's Ecological Research program should plan to develop forecasting models from the information in available databases.

- The atlas should be linked to the models that can predict changes in ecosystem services. The monitoring data should lead directly into the atlas and the forecasting models; by doing so EPA will be capable of assessing the consequences of choices. The demonstration projects are the places to try to forge the connections between the maps, models, and forecasting tools.

- The Plan proposes development of an Ecological Research Program "Community of Practice for Modeling." This is a laudable idea, but the Committee questions who will participate, and where will these modelers come from? The Committee recommends that EPA invest in meeting the need for graduate education to produce the next generation of modelers, and notes that industry has apparently started to do so.

Review of monitoring projects by the "federal family"

As previously mentioned, numerous federal agencies are conducting ecosystem monitoring activities. Given resource constraints, it is important to ensure that these activities are well planned and coordinated. In this regard, the Committee provides a number of recommendations.

- EPA should collaborate with other federal agencies to conduct a review of all federal agency ecosystem/ecosystem services inventory, mapping, and monitoring type projects. This review could be conducted through a workshop similar to the type conducted by the National Center for Ecological Analysis and Synthesis (NCEAS, 2008). This review should bring together all of the various federal agency components as a "federal family" to optimize coordination and synergy out of all these different monitoring programs.

- The suitability of various databases for use in developing EPA's Ecological Research Program products should be assessed as soon as possible and definitely before 2013. One of the goals of the workshop recommended above would be to determine whether the scales of sampling and measurement are small enough. Programs like EPA's EMAP were set up for inference at regional scales that may be too large for what is desired by the EPA's proposed Ecological Research Program.

- The Committee finds that, subsequent to the workshop mentioned above, a regular, high visibility assessment of ecosystem services in space and time could be the most important product to come out of EPA's Ecological Research Program. The Committee recommends that EPA conduct such an assessment. It could be patterned after the Intergovernmental Panel on Climate Change model, which has certainly garnered international attention. EPA's Ecological Research Program has the mapping and landscape ecology expertise to carry out this work.

- The Committee recommends that EPA provide some examples in the Plan to illustrate the link between ecosystem structures/functions and ecosystem services. For example, water provisioning is an ecosystem service that could be linked to a wide range of interconnected ecosystem structures and functions.

Long-term Goal 3- Nitrogen Assessment

Long-term Goal 3 of the Plan calls for an assessment of the positive and negative impacts on ecosystem services resulting from changes in nitrogen levels at select locations and within select ecosystems. The Committee commends ORD for providing in the Plan a more than ample background discussion of the importance of reactive nitrogen (Nr) to terrestrial and aquatic ecosystems. We agree with the assertion in the plan that this is an important area of ecological research. However, given the relatively modest effort that can be undertaken with available resources, we have some concern about investing effort in this area. The following comments and recommendations are provided to improve this part of the Plan.

- The Committee recommends that a more detailed description of the research proposed under Long-term Goal 3 be provided. The Committee expects that it is EPA's intention to provide this in the implementation phase of the program. At this point, however, the major question posed by the Committee is: What is the fundamental question to be addressed by the Nitrogen Assessment? Some Committee members found that the nitrogen assessment section of the Plan was well written and that the proposed research described seemed to be tractable. However, other Committee members found that the description of the research was so general that it was difficult to evaluate.

- The Committee recognizes that EPA intends to initially undertake a modest Nitrogen Assessment at specific locations and eventually expand this to a national effort. However, there is some sentiment among the Committee that perhaps the Nr research

could be dropped in favor of focusing more effort in other areas of the Ecological Research Program (e.g., outreach and education). The Plan clearly describes the importance of Nr to ecosystems. However, the Committee finds that the Plan does not clearly or convincingly state why EPA's Ecological Research Program should include a Nitrogen Assessment, particularly at the limited level proposed.

- The Committee recognizes the potential value of investigating Nr because it represents a cross media approach for evaluating ecosystem services and it also impinges on human health. However, there are a number of other agencies (e.g., U.S. Department of Agriculture, and National Oceanic and Atmospheric Administration) and some programs within EPA (e.g. Office of Air and Radiation) conducting scientific studies and research on Nr as related to human health issues. The Committee therefore recommends that ORD partner with other federal agencies and EPA offices conducting scientific studies and research on Nr as related to human health issues to reduce the chance of duplication of effort. Through such partnerships, ORD might eventually contribute to a better understanding of the significance of Nr to ecosystem services flows and human health and well-being.

- The discussion of Long-term Goal 3 in the Plan should contain a clearer explanation of why Nr was chosen for study rather than other chemicals. The Plan clearly states that Nr can have both positive and negative effects on ecosystem services and that both the positive and negative ends of the spectrum must be examined. We strongly agree with that conclusion and note that this departure from the "negative only" approach is commendable. However we question the rationale for choosing to study only N as opposed to other substances such as mercury whose negative effects on services might be easier to assess. Furthermore, we question why ORD has chosen to assess N instead of P; both affect plant productivity.

- The Plan states that the nitrogen assessment will begin by taking advantage of ongoing studies in wetlands and coral reefs. The Committee finds that concentrating Nr research on wetlands would be profitable, but we note that it would also be profitable to concentrate on terrestrial systems (e.g., in the western U.S. where N is often limiting productivity). Although coral reefs are important in many parts of the world, they do not have a high importance to the majority of U.S. citizens (see below).

Long-term Goal 4 – Ecosystem Assessments

Long-term Goal 4 of the Plan focuses on investigation of the dynamics of ecosystem service flows in two priority ecosystems, wetlands and coral reefs. The Plan states that both of these ecosystems deliver a wide range of services (e.g., fish and fiber production, water supply support, water purification, climate regulation, flood regulation, coastal protection, recreational opportunities, and tourism). Furthermore, the plan indicates that these systems are in serious decline (Dahl, 2005; Wilkinson, 2004) and that efforts to manage and protect them have been inadequate. The Committee finds that the long-term goal of assessing ecosystem services in wetland ecosystems is entirely appropriate, but

notes that it will be a challenge to address the complex spatial and temporal issues of ecosystem processes and their linkage to ecosystem services (and ultimately their valuation). These areas will require significant resources for research extending beyond those currently identified (i.e., the availability of EPA ORD scientists). In addition, while we recognize that the purpose of the Plan is to provide a visionary "big picture" of EPA's goals and objectives for ecological research, we note the need to address many complex issues concerning project design and uncertainty associated with the research to be completed under Long-term Goal 4. ORD has indicated that these critical details (some of which are described below) will be addressed in follow-up implementation plans. The Committee provides the following recommendations to further develop and implement Long-term Goal 4:

- The follow-up implementation plans that will describe many complex issues concerning project design and uncertainty associated with research to be completed under Long-term Goal 4, and other long-term goals, should receive outside peer review.

- The initial projects to be undertaken by EPA to accomplish Long-term Goal 4 should focus on a small set of representative wetland systems and perhaps also include a national assessment. This would produce useful examples for different user groups.

- The Committee finds that, although coral reef systems are globally important, they are a relatively low priority in the U.S. We recommend that ORD undertake projects in more common human-dominated ecosystems that provide services to more U.S. citizens.

- Research efforts under Long-term Goal 4 should be integrated with some of EPA's other multi-year programs to more efficiently utilize resources.

- The Committee recommends that, as research on this exciting area is accomplished, ORD develop a strong, active, iterative adaptive management process that modifies the process and coordinates efforts across the many research entities (e.g., EPA ORD laboratories, universities, National Science Foundation, NOAA, and Department of the Interior). It is critical that this process and the approaches used receive "buy-in" now from these potential partners to ensure the success of this effort. Given today's funding climate, joint partnership is essential.

- The Plan should acknowledge that this approach is an extension of the EPA Ecological Risk Assessment (ERA) framework and relate the process to the risk assessment framework of Problem Formulation, Exposure and Effects Characterization, Risk Characterization, and Risk Management. The many critical issues and recommendations identified in the 2007 U.S. EPA Science Advisory Board (2007) report on improving ecological risk assessment (EPA Science Advisory Board, 2007) should be incorporated into the Plan. In this regard, spatial and temporal issues are particularly important.

- The Committee recommends that in the Plan, ORD acknowledge and tackle multi-stressor diagnosis and subsequent ranking/linkage to ecosystem attributes, and then to services. Understanding "why" (i.e., causality) ecosystem services are lost in multi-stressor systems is a key missing piece. This work is critical to the success of the overall approach articulated in the Plan. If such work is not undertaken, there will be substantial uncertainty in the model predictions and thus in EPA's ability to validate the approach. For example, if databases do not effectively characterize the spatial/temporal components of "background" or "reference," then it will not be possible to link a stressor with an adverse effect (or service loss), nor evaluate the effectiveness of a Best Management Practice (BMP) in restoring an ecosystem attribute (and service). It is critically important to establish sound linkages among biophysical processes. Such work should be regularly reviewed by external experts. This could be done as part of the implementation plan.

- As discussed above, funding this effort will be a challenge. To improve the chances of success, the Committee recommends that ORD follow a strategy of undertaking one or two simpler pilot projects initially, where tangible products showing the process from beginning to end can be produced within a three-year period. This approach would increase the likelihood of new and continued funding, allowing for "proof of concept" and additional stakeholder buy-in. Simultaneously, long-term projects could be proceeding. There will undoubtedly be continual advances in the tools being created and the ability to value services each year, so work under Long-term Goal 4 should continue to advance for many years to come.

Long-term Goal 5 - Place Based Demonstration Projects

Long-term Goal 5 of the Plan calls for place-based research to investigate ecosystems services. ORD has chosen to focus on four different areas for proposed place-based demonstration projects: Tampa Bay, the Midwest (13 "breadbasket" states); the Willamette River; and the coastal Carolinas. Figure 22 on page 94 of the Plan provides a partial map of the United States showing the location of these areas. There was a diversity of opinion among Committee members regarding the suitability of these four different areas for place-based demonstration projects. During the Committee's deliberations, it became clear that this diversity of opinion was due to a lack of adequate and transparent explanation in the Plan regarding the specific choices. The Committee recognizes that there are no 'perfect' choices, but notes that a high degree of acceptability can be obtained by well rationalized, transparent choices. We therefore recommend that:

- The Plan should contain a transparent explanation of the process used to select sites for place-based demonstration projects. To this end, we recommend that the following organizing principles be used (along with others as appropriate, so long as they are transparent) for selecting and justifying different areas for place-based demonstration projects. Whether more or less than four such areas will be chosen will be governed by these principles:

- The areas must be widely representative of the major ecological areas in the U.S. where humans live or on which they rely.

- Historic, current and projected future changes to ecosystem services in these areas must be documented/predicted (in this regard we support use of the concept of "ecosystem services districts and operational management options" discussed on page 5 of the Plan).

- It must be possible to generalize/transfer the findings of place-based investigations to other geographic areas/systems in the U.S. (and also, where appropriate, outside of the U.S.)

- The selected areas as a set should provide opportunities for systematic comparisons and contrasts in important ecosystem services, structures and functions, as well as opportunities for collaborative studies in concert with the wetland (and coral reef or alternative ecosystem) and the nitrogen study components of the Ecological Research Program. For each selected area, appropriate data must be available on the local ecology, ecosystem services, and changes in those services.

- Adequate local resources (EPA or other [partner] staff and facilities) must be available.

- Although not an organizing principle, it is also highly recommended that local decision-makers be supportive of these efforts in their area.

- When the choices are made, they should be shown on a map that includes all U.S. States and Territories, which is not presently the case in Figure 22 on page 94 of the Plan. This will provide transparency regarding key ecological areas excluded (e.g., Alaska is presently excluded but not included on the figure).

- In the Plan, some clarification of the text that supports the final choices is needed. The Plan should indicate that: a) scales differ for a purpose - large and small scales need to be chosen (both within and between component studies) to attempt to determine what scale is most tractable/useful, and b) biofuels are not the only focus in the Midwest. With regard to the latter point, we note that the only mention in the Plan of life-cycle assessment (LCA) is in the Long-term Goal 5 in relation to biofuels. LCA is a useful means for visualizing and assessing different alternative actions relative to management alternatives. We therefore provide the following recommendation concerning LCA:

- We strongly urge EPA to consider expanding the application of LCA in the Plan beyond biofuels, at least in the form of demonstration projects that could be used to show the utility and need for this approach relative to future decision making.

- The Committee emphasizes the importance of coordination and attention to interrelationships across the place-based demonstration projects. This is explicitly

mentioned in the Plan: ORD has apparently a designated place-based coordinator, and there is specific mention in the Plan of relationships to the nitrogen theme and the wetlands ecosystems project. However, we find that the brief descriptions of the individual projects do not show how such coordination will be operationally achieved. The usefulness of the "quintain" approach discussed on page 93 of the Plan (i.e., a function or condition studied in multiple cases to evaluate similarities and differences in order to better understand the whole) (Stake, 2006) would be more evident if a strategy for cross examination of functions and services were explained in more detail.

- The Committee strongly recommends that transboundary issues be explicitly considered in the place-based projects. Due to atmospheric transport, such issues will apply to all projects, even those geographically isolated from political borders. We were surprised that transboundary issues were not discussed or considered in the discussion of Long-term Goal 5, particularly since the proposed mid-Western place-based demonstration project includes the border with Canada and the Great Lakes, which are managed by Canada and the U.S. as one entity.

4.3 Charge Question 3. Please comment on the logic model approach and provide any recommendations that should be considered in developing implementation plans.

In the Plan, ORD has provided a logic model that describes how the Ecological Research Program will be designed, planned, implemented, and managed. The model also summarizes: 1) how research results will be communicated to users, and 2) the types of outcomes and specific environmental results that the research program is designed to achieve. This model is summarized in Figure 4 on page 14 of the Plan. The Committee finds that the logic model approach articulated by ORD is a reasonable way to represent the research activities that comprise the Plan. The logic model construct of inputs and activities focused on particular outputs and, more importantly, outcomes is sensible. Indeed, the Plan states explicitly that, without appropriate outcomes, research efforts and the results that will follow are of little utility. A similar approach is shown for EPA research in general in the recent National Research Council (NRC, 2008) report**.** This NRC report, *Evaluating Research Efficiency in the U.S. Environmental Protection Agency*, discusses the difficulty of evaluating research programs in terms of results, which are usually described as outputs and ultimate outcomes. NRC (2008) notes that between outputs and ultimate outcomes are many kinds of "intermediate outcomes" that have their own value as results and can therefore be evaluated. The logic models in the Ecological Research Program Multi-Year Plan and in the NRC report both show the sequence of research, including inputs, outputs, intermediate outcomes, and ultimate outcomes. By placing efforts into the structure of this kind of logic model, the Ecological Research Program can in essence work backward from desired outcomes, and can improve the potential that research efforts will be appropriately framed. The Committee does, however, have the following comments and recommendations that ORD should consider as it refines and implements this logic model.

- The outputs and outcomes listed in the model are generic; considerable thought and attention must be put into ensuring that the appropriate specific outcomes are formulated.

- The Committee recommends that ORD consider adapting some of the terminology and structure of the NRC logic model, particularly when research outputs are formulated. ORD should consider including intermediate outcome boxes in the model as shown in Figure 4-1 on page 37 of the NRC (2008) report (outcomes from the research itself, and outcomes from users of the research). In addition, it will be critical that careful analysis and oversight of these outputs and outcomes occurs through time, and that feedback from outcomes is used to reevaluate both the necessary inputs and the activities, thus completing the loop suggested in the Figure 4 of the Plan.

- The Committee recommends that feedback loops be explicitly incorporated into the logic model. It is important to ensure that the outputs lead to useful outcomes; if they do not, then the Ecological Research Program must address and adjust its activities. Such feedback loops, while implied in the logic model structure, are not explicitly described. In addition, this mechanism will be an important way for the Ecological Research Program to get feedback on the quality and utility of the research and tools being provided.

- The Committee recommends that the logic model explicitly identify linkages to partners that are collaborating in research activities. The model shown in Figure 4 of the Plan appears to be internal to the EPA Ecological Research Program, even though many partners will be collaborating in the research activities. Thus, it is important that the transfers to and from other users be collaborative in nature, and not passive. This is necessary for other offices within EPA, other users of the data from a management perspective, and the outside research community. These linkages need to be shown in the model. As noted elsewhere, the Committee is very concerned that the relatively small investment in outreach and education, only 1% of the total effort overall, will not provide what will be necessary to ensure these collaborations and transfers. Therefore, the Ecological Research Program will have to find creative partnerships to ensure that these interactions occur and that they are collaborative.

- In addition, the “Externalities” identified in Figure 4 of the Plan should not be defined as such, at least not within the terminology of economics. It is recommended that a more appropriate term, such as external forcing functions, be used to identify these important drivers.

4.4 Charge Question 4. Please comment on anticipated challenges to achieving the overall goal of the Ecological Research Program Multi-Year Plan based on the Program as presented.

The Committee has identified a number of challenges and research opportunities that the Ecological Research Program will face as it strives to achieve program goals. It is

important to clarify that the Committee does not view these challenges necessarily as shortcomings, but rather inherent issues that will persist and must be explicitly addressed. The Committee recognizes four broad categories of challenges that are associated with: 1) the nature of the overarching research questions and annual performance goals; 2) specific methodological or tactical approaches; 3) efforts to extend program outputs to partners and other user groups in order to support decision-making processes; and 4) resources, including institutional capabilities. Many of these challenges were clearly articulated in the Plan. The Committee has also identified a number of cross-cutting ecological research opportunities to improve and contribute to a variety of EPA programs. We provide the following comments on these challenges and opportunities.

Challenges associated with the nature of overarching research questions and performance goals

The Committee commends the authors of the Plan for articulating an ambitious and exciting vision for the Ecological Research Program. The Committee finds that the vision is appropriately bold and far-reaching, but we find that it would be helpful to focus the vision on the timeline in the Plan (i.e., articulate the specific pieces that can actually be accomplished in the proposed timeframe). Several members of the Committee felt that the specific long-term and annual performance goals were particularly ambitious given the limited resources and short time span of the Plan. Achieving fewer or narrower goals is generally preferable to falling short of overly-ambitious aims. The Committee recommends that the organization of the Plan be altered to more clearly distinguish between the long-term goals of the Program and the short-term specific objectives that might actually be accomplished. Separating the vision statements and long-term goals into a separate section at the beginning of the Plan would make it clear that these are not intended to be accomplished in full within the time and resources of the current Multi-Year Plan. Subsequent sections of the document could focus on the short-term goals and objectives intended to be accomplished within the current Plan. In light of the need to focus the goals, the Committee notes that reducing possible redundancy and increasing connection/interaction with previous or current work of other agencies is imperative. Two other general areas of concern are related to the heavy emphasis on the utilitarian values of ecosystem services, particularly as related to human health, and the comparatively little attention given to understanding the effects of multiple stressors on ecosystem services. As noted above adequate attention should be given to identifying all of the services to which any given ecosystem component or process contributes, including services not explicitly targeted within a given policy or decision-making context. Consideration of the effects of multiple stressors will be important in developing ecological production functions for targeted ecosystem services.

Challenges associated with specific methodological or tactical approaches

Given the ambitious nature of the Plan, the Committee finds that there are a number of methodological challenges EPA scientists are likely to encounter. Although some of these challenges were explicitly recognized in the Plan, it seems useful to highlight them. Several methodological challenges relate to the use of data. Clearly, developing metrics

for appropriate ecosystem services and connecting those indicators to human health and well-being is a subject of tremendous debate and will not be easily resolved. Similarly, identifying the appropriate spatial and temporal scales of analysis and application is exceedingly difficult, yet the Program's success ultimately depends on getting this right. Data management itself will likely pose challenges. These challenges involve not only data manipulation, storage, metadata documentation, and analysis, but also acquisition (i.e., dealing with data gaps) and validation of data. Quantifying and articulating uncertainty is a clear research opportunity related to data collection, analysis and model development. The Committee also recognizes that certain perceived challenges and opportunities may derive from the fact that operational/tactical plans and implementation strategies are still under development.

Challenges associated with extending program outputs to partners and other user groups to support decision making

The Committee recognizes that the ultimate success of the Ecological Research Program lies in the extent to which it can support decision-making and regulatory processes. Notably, decision-making tools such as risk assessment, life cycle assessment, and the Natural Resource Damage Assessment and Recovery process (NRDAR) need to connect seamlessly to the proposed research program. While the Committee finds that the goals of the Ecological Research Program are relevant to decision makers, we are concerned that implementation of a successful outreach and education program is likely to be a serious challenge for a number of reasons. Most notably, we find that fully engaging the diverse group of stakeholders and users will be difficult due to the diversity of their needs and their capabilities to participate in the development of and/or use of the decision support platform. Active engagement seems essential given the reality that few users are likely to train themselves. Clearly, meeting the needs of users is further complicated by the conflicting jurisdictional responsibilities of agencies and organizations. Therefore, the Committee recommends that:

- Efforts be made immediately to enlist the input and cooperation of potential users/clients of the Ecological Research Program to better insure that the planned research will address issues of greatest interest to them, and that research outcomes can be communicated in a way that meets the most important user needs.

- Direct links should be established between outcomes of place-based demonstration project research and policy and regulatory processes. This is necessary in order to demonstrate the relevance and applicability of the Ecological Research Program to its partners.

In addition, the Committee is concerned that only 1% of the total budgetary resources of the program are allocated to outreach and education. We find that this amount is insufficient to support effective outreach efforts.

Challenges associated with availability of resources, including institutional capabilities

The Committee applauds the authors and contributors to the Plan for seeking to tackle some of the most important, cross-cutting questions that we face in environmental protection. Moreover, we see that, simply by virtue of working through and developing strategies to deal with the inherent challenges, efforts to develop the Plan represent a tremendous opportunity to advance the way that ecological research is conducted. The limited availability of resources is the most serious and potentially problematic challenge to the Ecological Research Program. With the absence of funding in competitive grant programs, such as STAR, to fund partner efforts, the program will face challenges in funding the necessary work and providing incentives for partner involvement. The lack of grant support is particularly problematic for involving academic partners. As recognized in the Plan, the current Ecological Research Program staff skill set will not by itself, be sufficient to address the issues and conduct the work needed to achieve program goals. Reliance on partners for work to accomplish particular program objectives is risky but, given the available program resources, that would seem to be unavoidable at this point. In this context, the Committee recommends:

- Cooperators and collaborators, both within and outside of EPA be identified as soon as possible and explicit agreements be drafted that specify what work is to be accomplished when by each partner.

4.5 Charge Question 5. What suggestions does the committee have for measuring annually over the next five years the progress, productivity, efficiency, and effectiveness of the Ecological Research Program?

The recent NRC (2008) report on evaluating research efficiency provides recommendations for the evaluation of research and development programs at EPA. The Committee notes the following key recommendations provided by the NRC in this regard: 1) EPA and other agencies should only apply quantitative efficiency metrics to measure process efficiency of research programs. Process efficiency can be measured in terms of inputs, outputs, and some intermediate outcomes; it does not require ultimate outcomes. 2) EPA and other agencies should use expert review panels to evaluate the investment efficiency (i.e., an indication of whether an agency is doing the right research and doing it well) of research programs. The process should begin by evaluating the relevance, quality, and performance of the research. 3) The efficiency of research programs at EPA should be evaluated according to the same overall standards used at other agencies. In fact, the Plan indicates that EPA does intend to use expert peer review panels (e.g., the Agency's Board of Scientific Counselors, and the Science Advisory Board) for future evaluation of the program.

The Committee provides the following more specific comments and recommendations concerning measurement of progress, productivity, efficiency, and effectiveness of the Ecological Research Program. We suggest that measured progress toward the visionary goals and objectives in the more detailed implementation plans should focus on the ecological structures and processes that contribute toward the production of goods and services, that themselves contribute toward human health and well-being. The following recommendations are provided in this regard:

- Goals and objectives should be monitored, reevaluated and adjusted as needed to capitalize on evolving and emerging partnerships and other opportunities to leverage the limited resources of the Ecological Research Program.

- The stated goals and research objectives of the Plan should be focused on the identification and articulation of the ecological processes and structures that contribute toward ecosystems services that have been identified in collaboration with ecological, medical, and social scientists in the Agency.

- Specific research objectives should be operationally defined so that progress and attainment can be clearly determined and quantified.

- In the specification of ecological production functions for targeted ecosystem services, the Ecological Research Program should maintain a broader ecosystems perspective to assure that the effects of multiple stressors on the multiple services that arise from these systems are adequately acknowledged and addressed.

The Committee finds that, given the visionary intentions of the Plan and the lack as yet of detailed research implementation plans, it is premature to prescribe specific measures to evaluate annual performance/progress goals for the program. However, as development of the research plan goes forward, the authors of the Plan should specify goals and associated research objectives for the individual projects and for the program as a whole that are within the purview, expertise and control of the Ecological Research Program. As noted above, specific objectives should be operationally defined in a way that: 1) allows clear determination of whether they have been achieved and 2) can be subjected to quantitative measures of the extent of accomplishment. The Committee further recommends that:

- At this formative stage of the new ecosystems services paradigm, the program assessment should include monitoring, evaluation and adjustment of objectives as partnerships and collaborations within and outside the Agency evolve. Such an adaptive management approach requires flexibility and vigilance to capitalize on opportunities that arise as the program continues to develop, and an explicit plan for coordinating activities and products across the multiple projects and themes of the Ecological Research Program.

The Committee finds that it is appropriate for the Ecological Research Program to set research goals based on contributions to understanding ecological service flows, and through those service flows protection of human health and well-being. However, the program should not claim responsibility (or allow itself to be held responsible) for achieving the ultimate goals of the entire EPA research and regulatory mission. As illustrated in Figure 1 below, the identification of relevant ecological services must be based on a dialog between Ecological Research Program ecologists and the medical and social scientists, regulators and decision makers representing EPA programs that are responsible for determining and valuing environmental and human health and well-being

goals of the Agency. The key role for the Ecological Research Program in this context is to research and articulate the appropriate ecological endpoints and the intermediate ecological structures and processes (ecological production functions) that contribute to identified services. Thus, the evaluation of the success of the Ecological Research Program should be gauged in terms of progress toward effective specification of relevant ecological endpoints and production functions, with special attention to the effects of individual and multiple stressors that come under the purview and regulatory control of the EPA. The Ecological Research Program has the further responsibility to the Agency and to citizens of the country and the world to investigate and bring attention to ecological processes and structures that contribute to additional, non-targeted ecological services and potential services.

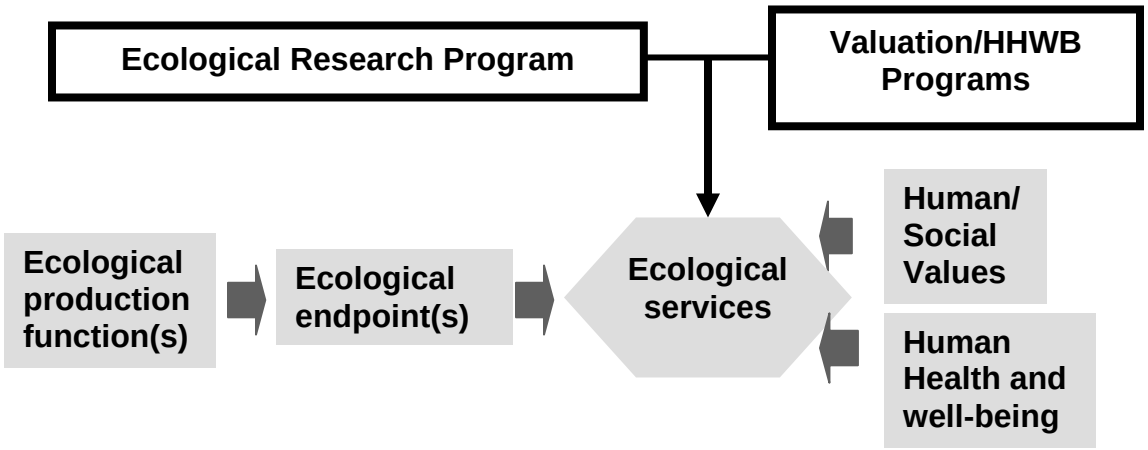

Figure 1. The role of EPA's Ecological Research Program in an Ecosystem Services Paradigm

4.6 Charge Question 6. Does the Committee have any recommendations on how EPA can better enhance its ability to leverage available resources within and outside the Agency?

As stated above, the Committee finds that the success of the Ecological Research Program is likely to depend in large measure upon its ability to leverage available resources within and outside of EPA. Based on information received by the Committee, and our deliberative discussions, we have separated our comments on ways to leverage resources into three topical areas. These three areas of concern are: 1) practical aspects of implementation; 2) financial support for implementation; and 3) outreach and education.

Practical aspects of implementation

Because the Plan lays out a new approach, the Committee finds that there is a need to avoid the perception that the Plan is being imposed upon the user community by ORD.

Thus, the Committee finds that there is a need to articulate a multi-level approach to the Plan (i.e., research products will be developed at different levels for various users). In addition, more input is needed from the end-users to identify the research products that would be most useful. The Committee also finds that there is a need to survey a broader community (e.g., municipalities, land mangers, industry) on how Ecological Research Program resources can be used most effectively.

In the Plan, ORD has identified potential partners for the development of new methods and has indicated that memoranda of understanding will be developed to provide arrangements for collaborative partnerships. For example, the Plan cites a memorandum of understanding that has been developed with the Gund Institute for Ecological Economics to allow the sharing of data from study sites. The Committee provides three recommendations concerning collaborative partnerships:

- The Committee recommends that the memoranda of understanding to be developed with federal partners need to be more than agreements to cooperate. Specifics should be provided concerning who will do specific work when there is overlap, and how to share resources. During the Committee's discussions with EPA it was made clear that this is indeed the intent, but this needs to be articulated more clearly in the Plan.

- Because there will be a need for access to expertise that may not be available "in-house," the Committee also suggests that ORD utilize Special Government Employees as part-time consultants or advisors to quickly bring expertise to particular issues.

- The success of the Plan is largely dependent on developing an effective outreach and education program, but the plan to develop an outreach program is not well developed. The Committee recommends that in the Plan ORD provide a section in the "vision" paragraphs to outline how the Agency will achieve outreach and education goals. As stated above, this has not historically been a significant part of ORD's work; therefore additional expertise may be needed in this area.

Financial support for implementation

It was made clear during the Committee's discussions with ORD that there are limited resources available to achieve the goals of the Plan. Therefore, it is important that ORD consider reallocation or redistribution of existing resources to take advantage of opportunities for partnerships with other groups and agencies. We provide six recommendations in this regard:

- The Committee finds that ORD's available people, infrastructure, and data represent leverage opportunities. We suggest that ORD use these opportunities as leverage to offer in-kind services and collaborate with other groups/agencies. In this regard, there are ample partnership opportunities. ORD can partner with other agencies within the U.S. (e.g., U.S. Fish and Wildlife Service, U.S. Forest Service, National Park Service). For example, if a terrestrial place-based or ecosystem project is added

to the Ecological Research Program, ORD can take advantage of U.S. Fish and Wildlife Service resources and expertise in existing projects. In addition, funding incentives for cross-agency collaborations could enhance these partnerships.

- ORD should consider active partnerships with other agencies outside the U.S. and thus gain the ability to address transboundary issues (e.g., watershed or airshed issues).

- The Plan proposes partnerships with a number of nongovernmental organizations (NGOs). Beyond partnering with nongovernmental organizations, the Committee recommends that ORD consider working with professional societies to sponsor sessions or symposia in order to present results of work to accomplish the Plan's goals and solicit feedback from stakeholders and end-users. For example, partnerships with the following organizations could be considered: Society of Environmental Toxicology and Chemistry; North American Benthological Society; Ecological Society of America; North American Association of Environmental Educators; Association of Environmental and Resource Economists; and International Society for Ecological Economics.

- The Committee also suggests that ORD consider partnerships with private business, foundations, NGOs, and such organizations as non-profit foundations to raise funds to conduct research and development activities.

- We strongly encourage ORD to make the STAR program a priority in efforts to leverage resources and achieve goals by: enhancing the STAR Graduate Fellowships program; providing funds for non-targeted, exploratory extramural research to develop tools and procedures to accomplish the goals of the Plan; and developing a competitive grants program to run summer credit workshops for teachers through STAR.

- The Committee recommends that ORD consider requiring or expecting leverage from universities in order to obtain ORD funding. Leverage can come in the form of reduced indirect costs or tuition and fee waivers. ORD could also consider providing matching funds or supplements to existing graduate and teacher education programs.

Outreach and education

As stated previously, the success of the Plan is largely dependent on outreach and education activities. Unless the human capital needed to bring expertise into the valuation process is developed, and the stakeholders and end-users are provided the education needed to use the information, the tools and techniques developed will likely not be used. To accomplish this, the Committee provides the following two recommendations:

- We recommend that ORD partner with professional societies, publishing companies, media outlets, and NGOs to develop and disseminate education and outreach

materials to professionals, teachers, and the lay public. Some suggested approaches that could be developed in partnership with other organizations include: workshops, symposia, and sessions at meetings, WIKI blogs, presentation materials for educators and public forums, media resources including cable television educational networks, and 10-15 min video clips that can be used in classroom settings.

- We also recommend that ORD partner with community groups to enhance education and outreach activities. It will be important to take advantage of local traditional eco-knowledge to address the issue of "sense of place" to gain acceptance of the valuation approach by end-users.

5. CONCLUSION

EPA's draft *Ecological Research Program Multi-Year Plan FY 2008 – 2014* articulates a new strategic direction that focuses on quantifying ecosystem services and their contribution to human health and well-being. As stated above, the Committee strongly supports this strategic direction and commends the Agency for developing a research program that has the potential to be transformative for environmental decision making as well as for ecological science. We find that the research focus on ecosystem services represents a suitable approach to integration of ecological processes and human welfare for the purposes of a public environmental management agency. The Ecological Research Program's focus on ecosystem services can therefore provide a sound foundation for environmental decisions and regulation based on the dependence of humans upon ecological condition and processes. While we support the strategic direction taken by EPA, we have concerns about the Agency's draft Plan. The most serious challenge facing the Ecological Research Program is the limited availability of resources. We find that the long-term goals of the program are unlikely to be accomplished in the proposed time frame with current resources. Furthermore, the ORD staff skill set may be insufficient to address the issues and conduct all of the work needed to achieve long-term program goals. Given these concerns and the fact that studying ecosystem services is a field in its infancy, the lack of grant support is particularly worrisome. We strongly encourage EPA to provide additional intramural and extramural support (e.g., through STAR grants) for the Program. .

We have provided a number of recommendations to improve the long-term goals, research objectives, and implementation strategy in the Plan. Our recommendations focus on: 1) providing additional information to clarify how various research products will be developed and used; 2) identifying and engaging as soon as possible clients who will use the research products and targeting outreach efforts to educate those clients; 3) working with other federal agencies to avoid duplication of effort and promote coordination and synergy; 4) retaining the important long-term visionary goals, but clearly identifying some relatively narrow goals and objectives that can be accomplished on schedule with limited resources; 5) providing a more transparent explanation of the process used to select sites for place-based demonstration projects; 6) evaluating program success on the basis of progress toward specifying relevant ecological endpoints and production functions, not achieving the ultimate goals of EPA's research and regulatory

mission; and 7) effectively partnering with other federal agencies, NGOs, professional societies, private businesses, and foundations to leverage available resources.

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APPENDIX A. SPECIFIC COMMENTS ON THE ECOLOGICAL RESEARCH PROGRAM MULTI-YEAR PLAN

The following specific comments on various parts of the draft Ecological Research Program Multi-Year Plan are offered by individual Committee members.

Page ii:

- Ecological Research Program personnel do not appear to include many social scientists. The Plan refers to a valuation team, but the individual named as the lead is an ecologist, not a social scientist. Similarly, the person named as the human well-being lead is a biologist. Without more direct involvement from other disciplines, and more expertise specifically related to valuation, it is not clear that ORD will have the capacity to develop a meaningful decision support platform that meets Long-term Goal 1.

Page 1, Introduction:

- This part of the Plan should indicate how EPA will use lessons learned from other programs. The U.S. Forest Service and others have been managing ecological services for many years with varying amounts of success. It is not clear how this experience base was or will be used in the creation of the Plan.

Page 3:

- The list of “pioneering examples” on this page is a bit hard to fit into the plan for the future.

Page 4:

- Ecosystem services are defined here as “the products of ecological functions or processes that directly or indirectly contribute to human well-being, or have the potential to do so in the future.” A concern about this definition is that it emphasizes the products rather than the processes that are the foundation for those products.

Page 5:

- The third bullet on this page indicates that enhancing understanding of ecosystem impacts that emerge over longer time scales, including threshold responses or tipping points, is reflected in the Ecological Research Program’s ongoing suite of grants investigating threshold behavior and regime shifts in aquatic systems. Examples of these research efforts (and findings) should be provided. This is a critical area and it is not apparent that the agency has invested much to support it.

Page 6, Table 1:

- This table presents priority ecosystem services, but it is not clear why or how this list was generated from the full set. What was the rationale, for instance, for having cultural services or nitrification in this table? The logic behind the selections should be clearly presented. The lists of examples in the right three columns (regulating services, provisioning services, cultural services) appear to be incomplete.

- Habitat and biodiversity are not services. Both are very important but neither is a supporting service as defined in this table. Human well-being is derived from habitats and from having a biologically diverse condition in that habitat. Trying to use a structural measure such as acres of habitat as a measure of ecological service will lead to confusion and possibly double counting of benefits. Clearly there is a need to define the set of services that flow generally from specific habitat types (e.g. low marsh, high marsh, freshwater marsh, tidally flushed marsh), but these would not be separate services. Biodiversity is another structural measure of condition and we all might agree that more diversity is better. However, if an upper limit to biodiversity is exceeded the process relationships that under lie ecological communities degrade.

- The list of ecosystem services in this table should be prioritized. If (or when) resources become limiting, there should be a structure in place for deciding what is most important. This would mean making *a priori* value statements, but some of those ecosystem services are directly related to current human physical well-being, others to future physical well-being. Some are related to apparent economic status or current human psychological well-being.

Page 8:

- The proposed approach to measuring achievement of goals (i.e., by considering how the information is used by decision makers) is asking a great deal from a science that is not yet developed.

- A simpler statement of general research questions presented here might be, “how and why are ecosystem services changing, how are they being impacted by humans, what are the consequences for human health and welfare, and how might management decisions reduce negative consequences?” More specific questions could address the theories and hypotheses to be tested. For example, how are different temporal or spatial scales to be integrated? One of the leading models for doing this, the hierarchical patch dynamics paradigm (Wu and Loucks, 1995), or another framework could be presented as a starting point.

Page 9:

- The mention of multiple stressors here is a positive feature.

- The top two bullets and paragraph on this page are good but the research questions will be very difficult to address. Answering these questions will likely take more resources and time than envisioned. We know that ecological responses to identical

stressors can differ widely across regions, landscape, and social context. Much more work in a variety of contexts will need to be done in order to sufficiently answer the broad questions of 1) what are the effects of multiple stressors on ecosystem services at multiple scales over time and 2) what is the impact of changes in these services on human well-being and on the services' monetary and non-monetary value.

- It is surprising here that two "priority ecosystems" leapt to the fore so quickly. Does this mean that the rest of the long-term goals are not national in scope? What is the rationale for selecting priority ecosystem types and priority geographic regions? There is no mention of investigating multiple stressors.

- In the general approach provided here, how does "landscape characterization" fit with ecosystem services discussed in the rest of the Plan?

- The usefulness of "maps" as described here and on page 43, paragraph 2) is critical, but the examples given are complex issues that cannot be crudely modeled. Good data and an understanding of interlinking processes are needed. This requires substantial research.

- With regard to research outputs, the focus seems to be on carbon and nitrogen. How can one model these two biologically driven cycles without knowing the impacts of other key stressors (e.g., habitat, metals, organics, temperature, and hydraulics)? Will these impacts be defined?

- Output #2 "stressors" should have a clearly corresponding counterpart that reflects not just things that degrade services (stressors) but also our ability to restore, reclaim, enhance services. We want to be able to predict not just losses, but our ability to achieve *gains*. Later in the document it is clear that gains are being considered, but it does not come through in this section.

Page 10:

- The first two bullets on this page do not seem to be different from one another.

- The last paragraph showing incremental changes in services due to a management action or the effect of an environmental stressor is good but it will require years of study of pre and post monitoring of best management practices – or an in-depth understanding of interlinking ecosystem processes which are modeled. The time frame required to accomplish this is uncertain.

Page 11:

- It is necessary to establish ecological "baselines" in order to measure both losses and gains. "Baselines" should be given more emphasis in the Plan. Very little progress can be demonstrated until the Ecological Research Program can make a case for the baselines it is using.

- The tables on pages 11 and 12 refer to several specific examples of "services." These services include nutrient removal, temperature regulation, habitat, and food and goods. These services are also those described in the Millennium Ecosystem Assessment. However, there is a conceptual inconsistency with these services that acts as a barrier to clarity. "Nutrient removal" and "temperature regulation" are *processes*. Habitat and food and goods are *outputs of processes*. How do you measure a process? By measuring the inputs to and outputs of that process. A more consistent focus on the desirable (and undesirable) *outcomes* would be preferable as the focus of measurement.

Page 12, Figure 3:

- This figure represents a potentially misleading and easily abused approach. Applying monetary values to each of these services can be very divisive and open to "interpretation". How much social value is applied to rice farming for example compared to fishing? This graph shows we should never farm food since the loss of natural services will always exceed the food production.

Page 13:

- It would be useful to see where inputs from other agencies and partners enter the logic model on this page. What or who will drive the cooperation among the 7 research laboratories? How will partners be enlisted into the program? How will research be funded?

- Timing of the long-term goal outputs (pages 13 and 15 and figure 5) makes it appear that the place-based demonstration projects would be running in parallel with the mapping and model development and be completed prior to the decision support tools. This seems out of order. One would expect the place-based projects to be an opportunity to test the tools, models, and maps.

Page 14, Figure 4:

- The logic model presented here appears to be a useful way to characterize the relationships among the planning and implementation components of the proposed research activities within the Ecological Research Program. The model is less useful as a way to clearly place the Program activities in the larger environmental policy, planning and management context. The "Externalities" component in the model identifies a number of potential constraints coming into the Program, but it does not provide sufficient representation of environmental and social "inputs" (triggers, goals, etc) such as environmental changes (from local floods to global climate change) and social changes (population and demographic shifts, land development, etc). Nor does the model show where Program research outputs go, such as to support EPA policy making to protect relevant ecosystems functions and structures, to improve and sustain the levels of ecosystems services that are enjoyed by citizens, and providing

scientific information to help educate publics about ecosystems services to secure support for the protection of important ecosystems.

- Outputs like peer-reviewed publications that are intermediate between doing the research and observing outcomes are also important because there is still widespread scientific skepticism that the concept of ecosystem services can be made operational. Publications in journals such as Science, Nature, and Ecological Applications will lead to more widespread acceptance of the concept among skeptical scientists. It is legitimate for the Plan to focus on the research enterprise, but some acknowledgment (in text and/or in the logic model figure) of where the Program fits in the larger context would be a useful addition. Figure 4 makes it appear that the Ecological Research Program is internal to EPA and it also appears that the Program is isolated from the EPA Program Offices, Regions, and other ORD research programs. Relationships between the Ecological Research Program and other research plans should be acknowledged. Interactions with global change would include collaboration on issues of carbon sequestration; interactions with the Office of Water could relate to development of nutrient criteria as well as wetland and mitigation evaluation procedures. Establishing a linkage with the Human Health Research Program seems particularly important. Another potential health link would be with the Centers for Disease Control and Prevention.

- The logic model does not include reference to the quality of the research. Users will not adopt implementation of items developed in the first three steps unless they are part of adequate quality for making decisions. The model also needs feedback loops in case the models, maps or tools do not work. In addition, the cost of tools does not seem to be part of the process for evaluating how good the tools are. The tools should be cost effective relative to the resources being protected.

- In the logic model, why are the management options research outputs? Typically, one would specify some possible options or policies under consideration and the research would evaluate the impacts.

- The objective is not to ensure human well-being by conserving and enhancing ecosystem services. What if there are tradeoffs (as there inevitably will be), either between different ecosystem services and/or between ecosystem services and other things that contribute to human well-being? Is the long-term environmental outcome goal separate from a goal of enhancing human well-being?

Page 15:

- The five goals that are proposed here are individually important, but it is less clear whether they are collectively sufficient or the most important goals for EPA's ecological research efforts. The Plan points out that the Ecological Research Program is one of several research programs within and outside of EPA and that the stated goals are intended complement those of the other programs. However, the brief description in the Plan does not convincingly show how the five goals and the noted

efforts to cooperate with the other programs combine to cover the most important research needs of the Agency. The EPA should make a more comprehensive study of the interrelationships among the research programs cited (and others) and work vigorously to secure effective interrelationships and coordination among them.

- Similarities between the decision support tool mentioned here and EPA's CADDIS system (U.S. EPA, 2008) should be mentioned.

- Uncertainty should be addressed in Long-term Goal 2 –National Mapping, Inventory, and Modeling.

Page 16, Figure 5:

- The figure illustrating the planning and implementation framework is confusing. Coordination and integration among the five goals of the proposed program are within the control of the Program. Such coordination is rightly a stated intention of the Program and the organization of the goals and projects implies an effective structure for achieving that end. However, the Plan does not adequately describe how the coordination implied by the intersecting cells in Figure 5 will be operationally achieved. There should be budget to support activities such as bringing project and theme leads (the bottom row and last column of the matrix) together periodically to assure that useful coordination is planned and implemented, that schedules are set and upheld (or revised) so that progress on the separate themes and projects allows for timely and mutually beneficial sharing and integration of data, methods, models and other information that is developed. In the Plan, more emphasis should be placed on how coordination among the goals/themes/projects will be operationally achieved. It might be useful in this regard to define coordination activities as a sixth goal of the Ecological Research Program. In addition, the resources allocations for the years 2008 – 2014 should be identified. It would seem that some projects will need more resources at the start and others will need more towards the end. Furthermore, it is difficult to evaluate the Program if the laboratories and leads are not identified.

Page 17:

- The rationale for allocation of the resource percentages to each long-term goal should be provided here.

Page 18:

- In Table 2 it is not apparent how the "overarching issues" of sustainability and global change relate to the "high priority topics" of endocrine disruptors, Hg, and nanotechnology. It is a concern that these high priority topics have a human health focus. There needs to be a focus on natural stressors (e.g., habitat, temperature, flow, meteorological events) that are linked directly to human activities and climate change and are front and center for stressors and local to global impacts.

- The challenge presented here for EPA laboratories is great. They are likely to be entrenched in institutional momentum and tradition which will be difficult to change. In the second paragraph on this page it is stated that the Ecological Research Program has a close working relationship with the Global Change and Water Quality Programs. This relationship should be documented.

Page 19:

- In the third paragraph on this page it is stated that the Ecological Research Program is developing new methods to enhance, maintain, or restore the full range of water-related ecosystem services. This should be documented.

Page 20:

- The purpose of including Table 3 is not clear. The table requires some additional discussion. The Ecological Research Program workforce is indicated as internal, which contradicts what has been stated elsewhere, namely that there will be considerable reliance on outside collaborators.

Page 21:

- It is stated here that accomplishing Long-term Goal 1 will be one of the biggest challenges and that EPA has the least ability and internal expertise to deal with this. EPA should look externally and enlist the help of the academic community in addition to expanding internal resources.

- When creating a large multi-model system to be used in a decision making context as described in Section 1.0, some systematic across the board validation would appear to be prudent.

Page 22, Section 1.1.1:

- The projects identified here include “associations between the condition of stream habitat and sportfishing revenue.” That kind of study has been done before; what has not been included in those kinds of analyses are other forms of recreation and spiritual renewal that are also dependent on condition of stream habitat.

Page 23:

- The discussion of decision tools is a nice “capstone” for the Plan but, in many cases, the science questions are a bit artificial, and could be better stated as scientific objectives.

- It seems unusual to use the terms “homes protected from flooding” and “recreational user days” to describe “population and human health issues.” Also, terms like “urban greenspace and indicators of mental function” should be avoided. Doesn’t this mean

that urban greenspace can be valuable for a variety of reasons? "Mental function" sounds either too vague or too peculiar.

Page 24:

- In developing a classification system of ecosystem services (Section 1.2.1), some recognition of regulatory structure should be acknowledged if this approach is to be useful to managers.

- In Section 1.1.2 recommend considering the increasing incidence of asthma and its relationship with air pollution. This seems to be a high priority as compared to nitrogen.

Page 25, Section 1.1.3:

- Collaboration with some National Science Foundation research programs (e.g., Long-term Ecological Research Program, Human and Natural Systems – formerly Biocomplexity) with social science expertise would help in Section 1.1.3.

- In the first bullet on this page, proposed work to conduct a spatiotemporal analysis of disease with sale of medical supplies/pharmaceuticals requires further justification.

- The Ecological Research Program should ensure that at least one of the demonstration projects described here and elsewhere focus on an ecosystem service that can be taken "all the way to the end product." That is, define an ecosystem service that can indeed be characterized, quantified, valued and its relationship to human health and well-being made clear. For example, the Plan suggests endpoints such as "reduced flood insurance payments, recreational expenditures, and reduced costs of mosquito control measures per wetlands area as potential endpoints." Page 25 of the Plan mentions "estimates of morbidity and mortality from air pollution levels under alternative scenarios of urban design." This should be feasible.

Page 26:

- The section lacks identification of specific efforts to include and/or to coordinate with relevant social science on human health and well-being. All long-term goals adhere to the ecosystem services framework and have at least one "valuation" objective, but it is not clear where the required measures of health and well-being will be obtained. The service targets of the Ecological Research Program can generally safely be assumed to be associated with human health and well-being (or at least they are all things that people generally care about), but there is little or no indication of any explicit effort to quantify and confirm specific associations within or across the particular themes/projects. For example, research is proposed to identify the ecological processes and structures in wetlands that affect the quantity, quality, spatial distribution (and timing) of fresh water. But there is no reference to how the models and maps of this (potential) service will be related to (e.g., overlaid with)

relevant measures and/or projected characteristics of human/social "consumers" (demanders) of this service or where measures of such social characteristics will be obtained. Among possible sources of relevant social value information are the many national surveys conducted regularly by the U.S. government (U.S. EPA Science Advisory Board, 2008a) and focused surveys conducted by other regional, state, and local agencies.

- The annual performance goals listed in Table 4, beginning with 2010 as a target data for development and testing of the preliminary human health and well-being indicators tied to ecosystem services, seem to be very ambitious. Development in this area will have to occur before results can be communicated to the client base described in Table 7.

- One example of valuation of certain ecosystem services from the Willamette River Basin is the Willamette Ecosystem Marketplace (www.willamettepartnership.org). The Marketplace conceives of a multi-credit bank for the Willamette Basin. Associated with this, the Willamette Partnership is a water quality trading program to cool the Willamette River. The Partnership integrates elements of ecosystem services into a "mitigation bank site" where credits can be bought and sold. The existence of the Partnership and the Marketplace means that environmental consequences are viewed as part of the economic system, rather than external to it.

- The way valuation is described here raises the concern that exploitation and alteration of natural and wild lands could increase.

Page 27:

- The plan includes the development of an Ecosystem Services Classification System comparable to that used by the Census Bureau for industrial goods. However, it is not clear that this type of standardization will be feasible, given the place-specific nature of ecosystem services. Nevertheless, some recognition of regulatory structure should be acknowledged if this approach is to be useful to managers.

Page 28, Figure 7:

- The very philosophical Long-term Goal 1 described here may be quite elusive. Will the Program really address the question of what economic valuation methods are most "efficacious" for valuing ecosystem services (as shown on Figure 7, page 28)? The current staff within ORD does not appear to have the needed expertise for answering this science question, and there is no meaningful discussion of any external funding for this component of the research.

Pages 28-29:

- While the development of ecological production functions is an important objective, the description of this component of the Plan suggests some confusion about the

concept of production functions. For example, economic production functions provide information about *technological* possibilities for substitutability, they do not provide any information about scarcity or the *availability* of complementary services. Likewise, production functions are not used for describing human well-being.

Page 31:

- The Plan makes reference to the use of information from the market for carbon offsets as a source of valuation information, but prices from tradable permit markets do not provide value information (except under *very* limited conditions).

Page 32, Section 1.3.1:

- Regarding outreach and education, it should be noted that client groups that will be receptive to using the ecosystem services approach include local watershed groups and the national nongovernmental organizations they work with (e.g., American Rivers, River Network, Waterkeepers). Another potentially interested client would be developers of conservation subdivisions. Assessing ecosystem services arising from those developments could be coupled with analyses of home prices, etc.

Page 33:

- The use of NGOs to quickly enhance outreach and education activities is novel, innovative and should be encouraged. This is how NGOs make a living, so why not take advantage?

- Regarding the text on pages 33 and 35 (Sections 1.3.1 and 2.0), client groups that will be receptive to using an ecosystem services approach include local watershed groups and the national NGOs they work with (e.g., American Rivers, River Network, Waterkeepers). Another potential interested client would be developers of conservation subdivisions. Assessing ecosystem services arising from those developments could be couples with analyses of house prices, etc.

Page 35:

- A more comprehensive education and outreach plan is needed here.

Page 43, Section 2.1:

- EPA has a good deal of experience in monitoring (e.g., Olsen et al., 1999). What is proposed under Long-term Goal 2 is at a scale and effort far greater than any of the current monitoring programs. Agency program scientists will need to devote a great deal of thought to deciding what variables will be monitored, and at what spatial and temporal scales. The temporal scales do not have to be the same, even within a single monitoring program. As an example, the Oregon Plan for Salmon and Watersheds (run by the Oregon Department of Fish and Wildlife) has various sets of sampling

sites (called panels) sampled at different frequencies: every year, every three years, every nine years, and every twenty-seven years (the multiples of three were chosen to coincide with salmon return periods). Yet, at any given point in time, information from all the sites, even though the sampling frequencies are different, can be combined in a statistically valid manner (based on statistical modeling results). Thus, information from different temporal and spatial scales of monitoring may be combined, as long as temporal/spatial correlation or other models have been developed to tie the pieces of information together.

Page 44:

- On this page and also in Figure 13 on page 96 it is difficult to visualize concrete results from some of the general statements (e.g., "quantifying ecosystem services"). More detail would be helpful.

- A concern here is that the definition of ecosystem services to be monitored explicitly excludes ecological processes and functions as services. By excluding processes and functions one is only monitoring current state and not the underlying processes that generate that state. It apparently excludes rate measures, which would not appear to make sense if one is trying to measure provision of a service. An additional concern is that defining ecosystem services as those that are directly used by humans does not represent the value of natural systems and communities for their own sake (i.e., existence value).

Page 45:

- Table 9, identifying core ecosystem services, is incomplete. Will climate change and nonpoint source runoff be considered? More information should be provided to indicate how this table was developed. What were the criteria for selection of services? On the next page, it is stated that biodiversity is directly measurable. This is possible with diversity indices, but that is feasible only with certain taxonomic groups. Which components will be chosen? In streams, for example, diversity of algae, macroinvertebrates, and fish respond differently to stressors.

- The atlas idea (Fig. 11) is an excellent communications tool; people are very comfortable looking at maps. The Willamette Futures Project has used an atlas successfully to display different scenarios for land cover change and changes in certain ecosystem services as part of its public product. Figure 11 also mentions "responsive, low variability indicators for estimating ecosystem services". EPA experienced a fair amount of difficulty in developing appropriate ecological indicators for EMAP, so this is probably a tall order for at least some of the indicators. (How does one derive a meaningful, low variability indicator out of responses that often exhibit high variability?) Because different ecosystem services will require development of different indicators, this will indeed complicate the framework for a monitoring design (e.g., require sampling at different spatial and temporal scales)

- The last paragraph on the page leaves the reader hanging because there is no answer to the obvious question of how the Program addresses the data gaps identified by Carpenter et al. (2006).

Page 46:

- The long-term goal monitoring component in Figure 11 (also described in the second paragraph on page 48 and the first paragraph on page 49) will require much future research.

Page 47:

- The first 4 bullets on this page all are based on best professional judgment and thus need some outside critical review in the process to ensure quality science.

- This and other parts of the Plan would be strengthened by adding examples showing how relationships between direct measures of ecosystem structure and function have been quantifiably linked to ecosystem services. What services have been demonstrated to be measurable and mapable? This proof of concept is a crucial piece that is missing from the Plan.

Page 49:

- The science questions identified on this page (as well as on pages 50, 86, 87, and 111) are very complex. Given the state of the science, it is unlikely that these questions can be completely addressed within a period of several years.

- Regarding the issue of "census vs. sample" addressed on this page, given the place-specific nature of ecosystem services, it is inevitable that many resources will need to be sampled. Ecosystem attributes such as land cover, desertification, and wetlands (mentioned as data gaps in the 2006 Millennium Ecosystem Assessment) are examples of candidates for censusing, along with any ecosystem services derived from land cover measures that can be derived from satellite imagery. Where a census is not possible, only a probability sample can yield statistically valid estimates of uncertainty. Probability sampling occurs in many, but not all, of the various national monitoring programs described in Olsen et al. (1999). It must be added that probability sampling does not rule out having sites such as Long Term Ecological Research Program (LTER) sites, which provide extremely useful information on biological and ecological processes for scientists. It would indeed be useful (as the Ecological Research Program proposes) to take the current national monitoring programs that are based on probability sampling (starting with the EPA Office of Water's national aquatic survey indicators) and see how responses presently recorded could be used to develop indicators of ecosystem services for a national inventory.

Page 52:

- The annual performance goals presented in Table 10 are ambitious and may be unrealistic given that there is little current infrastructure set up to monitor services. If resources are limited, what will be diverted to address these goals?

Page 53, Figure 12:

- Some of the research questions listed here are management questions. Where is it clearly expressed that the Program will establish cause-effect relationships that can reliably predict effects to ecological resources to support decision making? The Plan should clearly indicate how parts of the Program support the development of establishing cause and effect and how these relationships are used at various levels of the environmental management process.

Page 56:

- The community of practice for ecosystem services modeling is not adequately described. Who will participate? How inclusive will it be?

Page 57:

- The modeling described here is a very large challenge. The annual performance goals presented here for modeling are unrealistic given the general approach. Where will the modelers come from? An education plan is needed to support this goal. An investment in graduate education is needed to move forward on this goal.

Page 61:

- Why does the first bullet on this page focus on fecal coliform impairment? EPA has established that *E. coli* is a more useful indicator.

Page 62:

- Haven't landscape metrics as indicators of Great Lakes coastal wetland quality (first bullet on the page) already been developed?

- More detailed information should be provided in paragraph two on this page to indicate how EPA will collaborate with the U.S. Geological Survey and National Oceanic and Atmospheric Administration. These collaborations have been problematic in the past.

- The Plan mentions research teams exploring mapping techniques for different services. Reference to or examples of some products from these teams would provide greater confidence in the feasibility of what is being proposed.

Page 64:

- The annual performance goals presented here for mapping are tractable. EPA has the expertise to accomplish them. However, it will be a challenge to obtain the data needed for the maps.

Page 67:

- It is good that the N example on this page illustrates both positive and negative effects. It is surprising that there is no mention of hormesis.

Page 69:

- The U.S. Army Corps of Engineers Institute for Water Resources would appear to be a natural partner in the nitrogen and ecosystem assessments.

Page 70:

- A concern here is that a net benefits approach would yield management decisions such as allowing fertilization of oligotrophic systems to produce stronger recreational or commercial fisheries.

- The outcomes section of the goal provided in Figure 15 states that economists will convert ecosystem response functions to monetary values where possible. Are these in-house economists? If not, is there funding for this research?

Page 72:

- It is difficult to tell how the ecosystem assessments will be performed. There are numerous references in this section of the Plan to generating value or benefit estimates for wetlands and coral reefs (as well as for specific demonstration projects) but no indication of who will do this research. In addition, it is not clear whether data from the place-based assessments in Long-term Goal 5 will be used for the ecosystem assessments. If so, will data from other studies also be incorporated? This would seem to be necessary, particularly for the coral reef assessment.

- Answering the question posed in the first bullet on this page (What are the current spatial extent and condition of ecosystems?) will require very long-term research. Answering the other questions on this page will also be difficult and will require several years to address at a minimum.

Page 74:

- Much research on wetlands and coral reefs has already occurred at the local scale. For wetlands, modeling strategies have been developed for the Willamette Futures Project and the Tampa Bay watershed. Further research should be able to use these modeling strategies to map different wetland scenarios at scales larger than simply the

local level. For coral reefs, it appears that first "landscape characterization" will occur at the level of the eastern Caribbean. Though it is not a trivial effort to build a model linking coral reefs to human health and well-being, just communicating information on projected declines associated with urban development may prove useful. As previously noted in this advisory report, the decision to conduct research on coral reefs is not well justified.

Page 75:

- The SAB report on ecological risk assessment (U.S.EPA Science Advisory Board, 2007) addresses multi-scale research needs.

Page 76:

- The importance of wetlands on hydrological connectivity should be mentioned in the first paragraph on this page.

Page 77:

- It is surprising that storm surge protection was not included as an ecosystem service in "Figure 16. Does that mean that salt marshes are not included in the assessment?

Page 82:

- The first bullet on this page indicates that the proposed research will determine the best methods (monetary and non-monetary) to value wetland services at multiple scales. It will be difficult to determine the best methods to value wetlands if the extent of the importance of wetlands is not known.

Page 84 – 85:

- It will be important to make sure that models mentioned for valuing, assessing, and forecasting ecosystem services can show predictive relationships. Adequate data will be needed to do this. In this regard, some of the models/frameworks in EPA's CADDIS system are not effective.

Page 92:

- This section has not clearly indicated how selection of places will "make the concept of ecosystem services districts an operational management option." The concept of ecosystem services districts is not mentioned. How did that concept shape the way the places were selected?

Page 93:

- The research questions outlined here are good and they relate to testable hypotheses. One concern is that the research is focused only on temperate and tropical areas. The U.S. also includes arctic regions, and those regions are experience considerable changes as a result of global climate change.

Page 95:

- It should be clearly indicated here that, with the exception of humans and endangered species, the focus is not on effects to individual organisms, but rather on impacts to populations or communities of organisms. Thus, although biodiversity is important, it is not necessarily the key issue (cf. Ridder, 2008).

Page 99:

- The choice of the Willamette here makes considerable sense because much work has already been done on ecosystem services in this region. In producing the impressive work visualizing future scenarios for the Willamette Basin, work with landscape architects proved particularly valuable. Collaboration with this group should be explored.

Page 105:

- The Midwestern landscapes and coastal Carolina components are less developed, which is somewhat of a concern, particularly for the Midwestern landscape since it is so much larger and potentially more complex than any of the other place-based activities. The problems being faced by coastal Carolinas are no different than are being faced by Georgia. Why was this project cut off at the Carolinas? In many respects state protections on coastal development are much stricter in the Carolinas than in Georgia, which provides considerable opportunities for useful comparisons.

Page 110, Section 6.0:

- There should probably be several layers of annual review of progress. Each ORD laboratory could meet at least twice during the year and review progress of internal research initiatives. An annual meeting of the ORD laboratories and partners to report research findings in symposia or workshops could promote stronger interactions and information exchange.

Page 111:

- Concerning interaction with organizations, a proven way for EPA and the Ecological Research Program to take advantage of all the ecological and other scientific expertise in the marketplace is to put out requests for proposals for investigator initiated research. The EPA Environmental Monitoring and Assessment Program made good progress with the help of EPA STAR and other grants. EPA should continue with this model of making research progress.

- It is stated here that the Program has been developed with "less-than-usual input from stakeholders within the Agency." This is unfortunate because the Program has set as a goal decision maker acceptance of ecosystem services as a valid basis on which to make environmental decisions. Succeeding in this task requires input from decision makers as the program is being developed.

Page 117:

- It is not possible to comment on performance measures since they have not yet been developed. However, as previously noted, to the extent that some of the annual performance goals are very ambitious, the Program runs a risk of low performance ratings.

Page C-1:

- Important outcomes from the previous multi-year plan are listed here for 2009 and beyond. What happens to these outcomes with the new direction of the Program?

Other specific comments:

- A key issue will be delivering information to decision makers at the political level and ensuring that this information is heard and appropriately acted upon. To this end there is a need to develop short, effective briefing notes (similar to press releases) that can be delivered to Congress.

- It is appropriate that EPA establish appropriate linkages with at least its neighbors, Canada (via Environment Canada) and Mexico. Further, there are similarities with the European Union Water Framework Directive and other similar measures that strongly suggest linkages also be established with the European Union.

- The new strategic direction is good in that it is less fragmented and more holistic. It recognizes the reality that human beings need to take responsibility for changes they are making to the environment and specifically determine what changes should occur and what should not (cf. Chapman, 2007).

- The Plan lacks a clear discussion of what will be done with monitoring data. There is a need to identify specific questions to be answered and the specifications of how the data are to be collected. In this regard power calculations are needed. This should be part of the more detailed implementation plan.

- Time and space remain among the most difficult features of a system to analyze because of the lack of independence of each factor. Bayesian tools can be used for dealing with spatial relationships. It is not clear that the Plan sets the stage for the decadal long sampling programs that will be necessary for the Program.

- The specific strategy to build conceptual models that are clearly causal should be included in implementation plans. At this point it is not clear how these models will be built, tested, and applied. Oreskes et al. (1994) should be consulted for useful information on this subject.
- ubject.