

# Ecological Benefits Assessment
# Strategic Plan




United States
Environmental Protection
Agency


**Key to front cover photos:**

***Saw Palmetto (Georgia):*** A natural source of commercially valuable pharmaceuticals.

***Striped Morning Sphinx (Arizona):*** One of many no-cost natural pollinators.

***Ocean dunes vegetation restoration (New Jersey):*** Recreating the natural dune form's erosion resistance to protect property.

***Hiking by a National Forest stream (Virginia):*** High-quality water is one of the most valuable goods from wild lands; about 66 percent of the nation's freshwater resource originates in forests.

***Kayaking (Washington):*** Watercraft use on high-quality waters provides significant enjoyment and income for rural economies.

***Commercial fishing in the Chesapeake Bay (Maryland):*** The majority (roughly 80%) of fish sold and consumed nationally are wild-caught and dependent on healthy aquatic ecosystems.

***Recreational birding (Massachusetts):*** In 2001, more than 66 million adult American wildlife watchers, including nearly 46 million birders, spent $38.4 billion on equipment and recreational trips.

***Timber harvest (Mississippi):*** Continued timber harvest depends on sound and sustainable management of forested ecosystems.

**Key to back cover photos:**

***Recreational fishing (Florida):*** More than 34 million American adults in 2001 enjoyed fishing trips and spent more than $35 billion in recreation-dependent local economies.

***Active floodplain collecting sediment (Virginia):*** Floodplains perform the service of settling out excess sediment and reducing downstream floods, improving water quality, and protecting property.

***Green Drake Mayfly (Virginia):*** Fly fishing for trout imitates natural prey such as mayflies, whose dense hatches entertain America's 4.1 million flyfishers.

***Osprey (Maryland):*** The aesthetic enjoyment of sights like ospreys at the nest is difficult to put a price on.

***Blueberries (West Virginia):*** Wild plants were the origin of all our food crops, whether now domesticated or wild-harvested.

***Canada Geese (West Virginia):*** Independent of wildlife watching, recreational hunting by 13 million Americans involved spending more than $20 billion in 2001, more than $13 billion of it on game birds.

***Outdoor photographer (North Carolina):*** In 2001, nearly 14 million Americans photographed wildlife near their homes and another 8 million took trips to photograph wildlife.

***Black Rat Snake (Virginia):*** An important provider of natural rodent pest control.

**(all photos by Doug Norton, USEPA Office of Water)**

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# Ecological Benefits Assessment
# Strategic Plan


UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, DC 20460

## Notice

This report has been subjected to peer and internal reviews and has been approved for publication as an EPA document. It describes policy-relevant actions and recommendations that were developed by a cross-Agency workgroup to assist EPA Offices. These actions and recommendations do not constitute Agency policy or represent formal EPA strategic planning. Mention of trade names or commercial products does not constitute endorsement or recommendation for use.

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# FOREWORD

Given the increasingly complex tradeoffs inherent in environmental protection, the U.S. Environmental Protection Agency (EPA) recognizes the need to improve its ability to assess the potential ecological benefits of its environmental policy decisions. Towards this end, EPA has developed this *Ecological Benefits Assessment Strategic Plan* (hereafter referred to as the EBASP or "the Plan").

The EBASP has been developed by a workgroup involving management and staff from several EPA offices. Participating offices include the Office of Policy, Economics, and Innovation (OPEI); Office of Research and Development (ORD); Office of Water (OW); Office of Air and Radiation (OAR); Office of Prevention, Pesticides and Toxic Substances (OPPTS); and the Office of Solid Waste and Emergency Response (OSWER). The EBASP has undergone broad internal Agency review, and a preliminary version of the Plan was reviewed by EPA's Science Advisory Board (SAB) Committee on Valuing the Protection of Ecological Systems and Services.

The EBASP promotes an integrated process for assessing ecological benefits that requires sustained interdisciplinary work by both natural and social scientists. It highlights important actions that would help the Agency achieve steady improvement in the ecological benefits assessments it conducts to support its environmental decisionmaking. The EBASP focuses on institutional and technical considerations that arise most often in national-level ecological benefits assessments and where there are statutory requirements for conducting benefit-cost analyses (BCA). Hence, the intended primary audience of the EBASP includes EPA managers and staff in offices conducting ecological benefits assessments and those engaged in research that supports such assessments. Rather than articulating specific research projects or committing Agency program offices to particular courses of action, the Plan is intended to inform the development of office-specific Action Plans and Multi-Year Plans for research. Broad institutional actions are described to facilitate cooperation across offices to improve Agency benefits assessments.

Completion of this Plan is the first of several steps intended to improve EPA's ability to assess the ecological benefits of its policies. Importantly, its development already has promoted increased communication across offices and between ecologists and economists in the Agency. The actions outlined herein should help to build on this momentum, providing the basis for sustained improvement in the Agency's ability to account fully for the ecological benefits of its environmental policy decisions.

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# ACKNOWLEDGMENTS

The workgroup thanks the many individuals who participated in discussions and information gathering meetings in the early stages of the Plan's development in 2002 and 2003. These include EPA ecologists, economists, and managers, and staff from other federal agencies. Appreciation also extends to the many Agency staff who reviewed earlier drafts of the Plan.

In addition to EPA staff who became authors of the EBASP or members of the EBASP steering committee, many EPA staff members participated in the early informational meetings that helped to inform this Plan. These included staff from the Office of Air (OAR); the Office of Prevention, Pesticides and Toxic Substances (OPPTS); the Office of Policy, Economics, and Innovation (OPEI); the Office of Research and Development (ORD); the Office of Solid Waste and Emergency Response (OSWER); and the Office of Water (OW).

Numerous staff from other federal agencies also contributed to the informational meetings, including staff from the U.S. Department of the Interior (U.S. Fish and Wildlife Service, the U.S. Geological Service, and the Bureau of Land Management), the U.S. Department of Commerce (National Oceanic and Atmospheric Administration), the U.S. Army Corps of Engineers, and the U.S. Department of Agriculture (U.S. Forest Service and Natural Resources Conservation Service). Valuable comments on early drafts of the EBASP were provided by EPA staff from across the Agency. The workgroup also would like to thank EPA's Science Advisory Board Committee on Valuing the Protection of Ecological Systems and Services for their detailed review of a preliminary draft of portions of the Plan.

The workgroup would like to thank G. Tracy Mehan, III (former Assistant Administrator, OW), Thomas Gibson (former Associate Administrator, OPEI), Paul Gilman (former Assistant Administrator, ORD), Lee Mulkey (former Associate Director for Ecology, ORD National Risk Management Research Laboratory), as well as Al McGartland (Director, National Center for Environmental Economics [NCEE]) and Elisabeth LaRoe (former Director, Water Policy Staff) for their instrumental roles in the initiation and continued support of the development of the Plan.

Sabrina Lovell of OPEI, NCEE, served as the EPA Task Order Manager for the EBASP contractor support provided by ICF Consulting under the direction of Beth Binns. Margaret McVey of ICF Consulting provided extensive assistance throughout the development of the plan. George Van Houtven of Research Triangle Institute assisted in developing the EBASP Bibliography (available from http://yosemite.epa.gov/ee/epa/eerm.nsf/vwRepNumLookup/EE-0485A?OpenDocument), and Peter Bonner of ICF Consulting facilitated the information gathering meetings. Sandra Seymour of ICF provided logistical support. For further information, please contact Sabrina Lovell.[1]

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# LIST OF ACRONYMS

| | |
|---|---|
| **ACE** | U.S. Army Corps of Engineers |
| **BCA** | benefit-cost analysis |
| **CAA** | Clean Air Act |
| **EBAF** | Ecological Benefits Assessment Forum |
| **EBASP** | Ecological Benefits Assessment Strategic Plan |
| **EERS** | Environmental Economics Research Strategy |
| **EMAP** | Environmental Monitoring and Assessment Program |
| **EPA** | Environmental Protection Agency |
| **ETV** | Environmental Technology Verification |
| **GEAE** | generic ecological assessment endpoints |
| **HAP** | hazardous air pollutant |
| **ICR** | information collection request |
| **NCEE** | National Center for Environmental Economics |
| **NRC** | National Research Council |
| **OAR** | Office of Air and Radiation |
| **OMB** | Office of Management and Budget |
| **OMEP** | Office of Marine and Estuarine Protection |
| **OPA** | Office of Policy Analysis |
| **OPEI** | Office of Policy, Economics, and Innovation |
| **OPPE** | Office of Policy, Planning, and Evaluation |
| **OPPTS** | Office of Prevention, Pesticides, and Toxic Substances |
| **ORD** | Office of Research and Development |
| **OSWER** | Office of Solid Waste and Emergency Response |
| **OW** | Office of Water |
| **RABA** | Risk Assessment for Benefits Analysis |
| **SAB** | Science Advisory Board |
| **SDWA** | Safe Drinking Water Act |
| **STAR** | Science To Achieve Results |
| **WTA** | willing to accept |
| **WTP** | willing to pay |

# EXECUTIVE SUMMARY

The ecological benefits of environmental policies depend on the effects of those policies on the activities of individuals, households, and firms, and other public and private groups. These in turn affect ecosystem functions and services, such as drinking water supply, commercial and game fish, food and fiber, timber, natural pollination and pest control, outdoor recreation, energy and nutrient cycling, pollutant filtration, and protection of property from weather extremes.

In principle, economic valuation methods can estimate the net benefits—benefits minus costs—of any environmental policy in monetary terms. This facilitates comparisons among policy alternatives to support decisionmaking. In practice, however, ecological benefits, which are the contributions to social welfare derived from ecosystems, are notoriously difficult to evaluate. Several factors contribute to this challenge, including a limited understanding of the linkages between ecological and economic systems.

The overall goal of this *Ecological Benefits Assessment Strategic Plan* (EBASP or "Plan") is to help improve Agency decisionmaking ***by enhancing EPA's ability to identify, quantify, and value the ecological benefits of existing and proposed policies***. The Plan's intended primary audience includes managers and analysts in EPA Program Offices, and natural and social scientists across the Agency. It focuses primarily on opportunities to improve ecological benefits assessments conducted at a national level. The Plan also communicates priority research needs to EPA's principal natural and social science organizations, ORD and OPEI. The specific objectives of the Plan are to:

1. Identify the major technical and institutional advancements that would facilitate performance of rigorous and comprehensive ecological benefits assessments on a routine basis;

2. Describe a road map of specific actions that the Agency can take to promote those advancements; and

3. Describe mechanisms to facilitate the adaptive implementation of the EBASP, including periodic adjustments to reflect progress in the state of knowledge.

Table E-1 summarizes the actions recommended and described more fully in Chapter 3 of the EBASP. The table also recommends a timeframe for initiating each action, in terms of the short, medium, and long run. Short-run actions should be initiated first—for example, during the next 1 to 2 years. Medium- and long-term actions either are lower priority or may require some results from one or more of the short- or medium-term actions, respectively, before commencing. We fully expect that different offices will want to implement different actions as dictated by their specialized goals and needs. In some cases, it may be advantageous for multiple EPA offices to pool their resources to support actions that are mutually beneficial.

The Plan does not specify which office should implement each action; those decisions must be made by present and future office management and staff. In Chapter 4, implementation activities are described that will help EPA initiate the actions and activities discussed in Chapter 3. These include the formation of an Agency oversight committee, an Agency-wide ecological benefits assessment forum, and individual office action plans. These strategic activities should help ensure that continued progress on improving ecological benefits assessment occurs in the years ahead.

## TABLE E-1: AGENCY ACTIONS TO IMPROVE ECOLOGICAL BENEFITS ASSESSMENT.

| ACTION | TIMING (Short, Medium, or Long Term) |
|---|---|
| **Action 3.1-1:** *Promote formal and informal opportunities for improving communication among disciplines.* | Short and ongoing |
| **Action 3.1-2:** *Provide basic training in the fundamentals of other disciplines.* | Short to Medium |
| **Action 3.1-3:** *Increase interdisciplinary participation in assessing ecological benefits.* | Short and ongoing |
| **Action 3.1-4:** *Expand the use of ecological risk assessment information in economic benefits assessments.* | Short |
| **Action 3.1-5:** *Conduct program-specific problem formulation workshops.* | Short |
| **Action 3.1-6:** *Develop guidelines for planning and conducting ecological benefits assessments.* | Medium |
| **Action 3.1-7:** *Review and update Agency guidelines for developing Analytic Blueprints.* | Short |
| **Action 3.1-8:** *Develop generic ecological benefits assessment endpoints.* | Medium |
| **Action 3.2.1-1:** *Revise environmental monitoring programs to include indicators relevant for benefits assessments.* | Medium to Long |
| **Action 3.2.1-2:** *Increase coordination of long-term, large-scale data collection efforts across the Agency, and identify new efforts where needed.* | Medium |
| **Action 3.2.1-3:** *Develop methods for using information from short-duration and localized monitoring programs in ecological benefits assessments of long-term, large-scale policies.* | Medium to Long |
| **Action 3.2.1-4:** *Develop improved methods to measure inherent variability in ecological benefits assessments.* | Long |
| **Action 3.2.1-5:** *Develop improved methods to identify and reduce knowledge uncertainties in ecological benefits assessments.* | Medium |
| **Action 3.2.2-1:** *Incorporate and improve consideration of behavioral responses to environmental policies.* | Medium |
| **Action 3.2.2-2:** *Identify priority areas where trade-offs between risks are critical and enhance capacity for relative risk assessments.* | Medium |
| **Action 3.2.2-3:** *Invest in research on methods to estimate expected stressor reductions from ecologically based pollution controls.* | Medium |
| **Action 3.2.2-4:** *Increase and improve ex-post analysis of the effects of EPA policy, including remediation or restoration projects.* | Medium to Long |

| | |
|---|---|
| **Action 3.2.3-1:** *Develop capacity for population modeling applicable to ecological benefits assessment.* | Medium |
| **Action 3.2.3-2:** *Improve linkages between stressor exposure data and effects on populations.* | Medium |
| **Action 3.2.3-3:** *Identify and develop critical community-level modeling capacity.* | Medium |
| **Action 3.2.3-4:** *Develop capacity to model ecosystem processes for ecological benefits assessment.* | Medium |
| **Action 3.2.3-5:** *Improve ability to measure and to model changes in ecological endpoints across spatial scales.* | Long |
| **Action 3.2.3.-6:** *Expand use of linked ecological-economic models in ecological benefits assessment.* | Medium |
| **Action 3.2.4-1:** *Support research to adapt and apply economic valuation methods that are best suited for valuing changes in ecological goods and services.* | Medium |
| **Action 3.2.4-2:** *Improve survey methods by expanding pre- and post-survey validity testing.* | Long |
| **Action 3.2.4-3:** *Improve capacity and methods for benefit transfer for ecological goods and services.* | Medium |
| **Action 3.2.5-1:** *Evaluate rating and ranking procedures to complement economic valuation.* | Long |
| **Action 3.2.5-2:** *Evaluate analytical methods based on ecological-economic system properties.* | Medium |
| **Action 3.2.5-3:** *Conduct trial applications of hybrid decision approaches in future benefits assessments.* | Long |
| **Action 3.3-1:** *Provide direct support to studies relevant to Agency ecological benefits assessments.* | Medium to Long |
| **Action 3.3-2:** *Improve communication with outside researchers about the Agency's needs for ecological and economic research.* | Short |
| **Action 3.3-3:** *Increase coordination of data collection, monitoring programs, and research with other agencies.* | Medium to Long |
| **Action 3.3-4:** *Explore approaches for facilitating approval of information collection requests (ICRs) related to collecting information from the public for use in ecological benefits assessments.* | Medium |

# 1 INTRODUCTION

Society benefits from both a healthy environment and a strong economy, but difficult and complex tradeoffs are inherent in these and other sometimes competing goals. EPA recognizes the need to improve its ability to evaluate the benefits and costs of its environmental policy decisions. Ecological benefits, which are the contributions to social welfare derived from ecosystems, are especially difficult to evaluate. The Agency has developed the EBASP to improve its ability to identify, quantify, and value the ecological benefits of its policies to provide decisionmakers with better information for choosing among policy alternatives.

The EBASP is the most recent in a series of efforts designed to improve the methods and data available for evaluating Agency policies. In 1998, the Agency published *Guidelines for Ecological Risk Assessment* (USEPA 1998). In 2000, EPA published its *Guidelines for Preparing Economic Analyses* (USEPA 2000a), an update and expansion of its *Guidelines for Performing Regulatory Impact Analyses* (USEPA 1983, 1991). The Economic Guidelines acknowledge that the current state-of-the-science is sometimes insufficient to characterize many of the impacts of Agency policies accurately or to value those impacts in monetary terms for comparison with expected costs. In 2002, EPA published *A Framework for the Economic Assessment of Ecological Benefits* (USEPA 2002a), which draws from both the Ecological Risk Assessment Guidelines and Economic Guidelines to assist EPA analysts in conducting economic assessments of ecological benefits.

Implementation of these guidelines, however, requires appropriate methods, models, and data, the availability of which are limited for many types of ecological benefits. The complexity of interacting ecological and economic systems creates substantial conceptual and technical difficulties for estimating ecological benefits. Thus, much work remains before rigorous, comprehensive, and interdisciplinary evaluations of the ecological benefits of EPA policies can be performed on a more routine basis.

## 1.1 GOAL AND OBJECTIVES OF THE PLAN

The overall goal of the EBASP is to help improve Agency decisionmaking by ***enhancing EPA's ability to identify, quantify, and value the ecological benefits of existing or proposed policies***. Our vision is one of rigorous, comprehensive, and interdisciplinary ecological benefits assessments supporting the design and selection of policy alternatives.

The specific objectives of the Plan are to:

1. Identify the major technical and institutional advancements that would facilitate performance of rigorous and comprehensive ecological benefits assessments on a routine basis;

2. Describe a road map of specific actions that the Agency can take to promote those advancements; and

3. Describe mechanisms to facilitate adaptive implementation of the EBASP, including periodic adjustments to reflect progress in the state of knowledge.

The Plan is organized as follows. The remainder of this section describes the intended audience and scope of the Plan. Section 2 describes current ecological benefits assessment practices at EPA, the nature of the challenge facing the Agency, and an integrated approach to ecological benefits assessment that emphasizes

interdisciplinary collaboration. Section 3 describes a variety of key institutional and technical actions that would help the Agency improve its ability to conduct comprehensive and accurate ecological benefits assessments on a more routine basis. The Plan concludes by proposing a structure and a process to implement and adapt the EBASP (Section 4). Information about the state-of-practice of ecological benefits assessment in the Agency, and about previous efforts focusing on ecological benefits assessment, is provided in two appendices.

## 1.2 INTENDED AUDIENCE AND SCOPE

The EBASP emphasizes the role of benefits assessments in designing and evaluating proposed or existing Agency policies. We define "policies" broadly as encompassing all actions that the Agency may take. The Plan is primarily focused on the rule-making or regulatory process at the national level where BCAs often are required. Ecological benefits assessment in this context arguably requires the greatest rigor in predicting the biophysical and economic impacts of each policy alternative and the valuation (generally in monetary terms) of these impacts. Other decisionmaking contexts may not require a formal BCA as considered here. However, the usefulness of improved methods for quantifying and valuing the ecological benefits of EPA policies will not be limited to situations requiring BCA, and so the actions proposed in this Plan will have implications beyond the narrow scope defined here.

The Program Offices of EPA are largely responsible for developing and evaluating Agency policies that apply nationwide, so the managers and analysts in those offices are a key audience for the Plan. In addition, the substantial advances needed in the science that supports ecological benefits assessment require the concerted effort of EPA's natural and social science researchers, located largely in ORD and OPEI. These audiences can use the priorities communicated in the Plan to help guide their internal planning processes and to inform external partners of EPA's research needs. Although not among the Plan's primary target audiences, the EBASP also may be of value to EPA Regional Offices, other federal agencies, and state and local decisionmakers.

# 2 AGENCY ECOLOGICAL BENEFITS ASSESSMENTS

Virtually all government policies, including environmental policies, have both advantages and disadvantages. When the advantages and disadvantages of a policy are obvious to all concerned, few will debate the appropriate course of action. However, ecological benefits may come about through indirect pathways, they may be distributed widely across the population, or there may be little agreement about their value. In these situations, quantifying ecological benefits can play an important role in the decisionmaking process. Clear articulation of the benefits derived from EPA policies can help communicate the rationale for taking action and promote consensus by providing more information about the advantages and disadvantages of various alternatives.

BCA is an accepted economic approach for comparing the advantages and disadvantages of policies in a consistent format to help decisionmakers make more informed choices (Arrow et al., 1996). Support for BCA has increased over time, as reflected in Executive Order 12866, the Safe Drinking Water Act (SDWA), and in parts of the Clean Air Act (CAA). BCA estimates the net benefits to society as a whole by comparing the expected benefits accruing to those made better off by a policy to the expected costs imposed on those made worse off. BCA can be used prospectively to provide information to decisionmakers for choosing among proposed alternative policies. It also can be applied retrospectively to determine whether a policy has been successful, to learn from any unintended consequences, or to determine whether further action is needed. Furthermore, the results of BCAs can be useful for communicating to the public the value of EPA's regulatory programs and for providing guidance for its voluntary programs.

Formal BCA is not required in all regulatory contexts, such as when Congress legislates specific pre-determined environmental policy objectives. In fact, certain statutes prohibit consideration of benefit-cost information in regulatory decisions. For example, the Food Quality Protection Act requires the Agency to set limits on pesticide residues in food, without regard to the cost of meeting those standards. Yet even when BCA is not required, quantifying the benefits of policy provides important information. Situations where quantified benefits are critical include allocating limited resources across restoration projects to obtain the greatest impact and measuring the Agency's performance in meeting its strategic goals.

This plan is premised on the belief that the Agency faces a new and growing demand for more rigorous and comprehensive ecological benefits assessments. Meeting this need will require concerted, interdisciplinary efforts. This section explains why we focus on ecological benefits, discusses the nature of the challenge in measuring those benefits, and presents a simple conceptualization of an interdisciplinary approach to assessing the ecological benefits of EPA policies.

## 2.1 FOCUS ON ECOLOGICAL BENEFITS

In the EBASP, ecological benefits refer to the contributions to social welfare derived from ecosystem goods and services (Table 1 provides definitions of these and related terms used throughout the Plan). EPA policies may discourage or restrict activities that are harmful to theenvironment, may encourage or require activities to restore damaged ecosystems, or may combine these approaches. The ecological benefits of such policies depend on how the policies influence the behavior of individuals, households, and other public or private groups, which in turn affect the quantity, flow, and timing of stressors in the environment. Reductions in

## TABLE 1: DEFINITIONS OF ECOLOGICAL BENEFITS TERMS USED IN THE EBASP.

**Ecological benefits[a]:** Contributions to social welfare of ecological goods and services. In the EBASP, the term applies specifically to net improvements in social welfare that result from *changes* in the quantity or quality of ecological goods and services attributable to EPA policy.

**Ecological functions or processes[a]:** Characteristic physical, chemical, and biological activities that influence the flows, storage, and transformations of materials and energy within and through ecosystems, such as the uptake of nitrogen from soil by vegetation.

**Ecological goods and services[a]:** Outputs of ecological functions or processes that directly or indirectly contribute to social welfare or have the potential to do so in the future. Some outputs may be bought and sold, but most are not marketed (Table 2).

**Social welfare:** Human well-being, measured at some aggregate level.

**Stressors:** By-products of human activity that impact ecological functions or processes, including past activities that leave ecosystems in a degraded condition.

**Ecological Benefits Assessment:** Evaluation of the expected changes in social welfare resulting from EPA policies via changes in ecological functions or processes; outcomes are described qualitatively and are quantified in physical and monetary terms when possible.

**Quantification:** Expression of benefits in numerical units.

**Valuation:** Process of estimating the worth, merit, or desirability of something. In the EBASP, the term is used more specifically to mean estimating the worth of a wide variety of environmental conditions in common units that can be aggregated and compared.

**Monetization:** Valuation in monetary (dollar) terms. Also "economic valuation" or "monetary valuation."

**Ecological Risk Assessment[b]** is an evaluation of the likelihood that adverse ecological effects may occur or are occurring as a result of exposure to one or more stressors.

**EPA policies** are any plans, actions, or guiding principles, adopted by EPA to reduce environmental risks by implementing, encouraging, or discouraging particular activities that affect the environment. Policies can include regulations, formal guidances, permits, funding decisions, educational initiatives, and environmental management plans, among others.

[a]Adapted from Freeman (2003), Daily (1997, 2000), King (1997), and Whigham (1997).
[b]USEPA 1998.
[c]USEPA 2000a.

stressors should improve ecological functions or processes and lead to increases in ecosystem goods and services enjoyed by society at large. Table 2 lists examples of ecosystem goods and services, categorized according to the types of economic benefits they provide: market or non-market and direct-use, indirect-use, or non-use.

The focus in this Plan is on the value of changes in ecosystem goods and services that result from EPA policies (as defined in Table 1). In this document, "ecological benefits assessment" refers to both the quantification of relevant ecological outcomes in physical terms and to the estimation of the social value of those outcomes. Further, the term "ecological benefits" refers to the net ecological benefits of an EPA policy, considering any negative as well as positive changes in ecological services that might result. A benefits assessment should begin with qualitative descriptions of ecological outcomes. Because changes in social welfare are difficult to quantify directly, changes in the condition of ecosystems *per se* may be taken as measures of benefits when the relationship between ecosystem conditions and social welfare is conceptually clear. The Plan recognizes the importance of nonmonetary measures of social value in many situations and proposes research into supplemental assessment approaches.

**TABLE 2: TYPES OF ECOLOGICAL BENEFITS CATEGORIZED BY BENEFITS TYPE.**

| Benefit Category | | Explanation | Examples |
|---|---|---|---|
| Market | | Generally relate to primary products that can be bought or sold as factors of production or final consumption products | • Food and water sources: commercial fish and livestock, game fish and wildlife, drinking water<br>• Building materials: timber<br>• Fuel: methane, wood<br>• Clothing: leather, fibers<br>• Medicines: nature-derived pharmaceuticals |
| Non-market | Direct-use | Directly sought and used or enjoyed by society; includes both consumptive uses and nonconsumptive uses | • Consumptive recreational: fishing, hunting<br>• Nonconsumptive recreational: boating, swimming, camping, sunbathing, walking, climbing, bird watching, sightseeing, enjoyment of visual amenities |
| | Indirect-use | Indirectly benefit society; may be valued because they support offsite ecological resources or maintain the biological and/or biochemical processes required for life support | • Maintenance of biodiversity<br>• Maintenance and protection of habitat<br>• Pollination of crops and natural vegetation<br>• Dispersal of seeds<br>• Protection of property from floods and storms<br>• Water supply (e.g., groundwater recharge)<br>• Water purification<br>• Pest and pathogen control<br>• Energy and nutrient exchange |
| | Non-use | Benefit does not depend on current use or indirect benefits; individuals might value the resource without ever intending to use it or might have a sense of environmental stewardship; includes bequest value, existence value, and cultural/historic value | • Perpetuation of an endangered species<br>• Wilderness areas set-aside for future generations |

Sources: Principe (1995), Daily et al. (1997), and USEPA (2000b, 2002a).

## 2.2 NATURE OF THE CHALLENGE

Assessing the broad variety of ecological benefits potentially affected by EPA policies is challenging. Despite significant advances made by natural scientists in understanding ecosystem services and the natural processes that provide them, knowledge of these complex systems remains incomplete. Likewise, economists regularly confront problems when estimating the benefits of proposed policies, in part because the values of ecological goods and services are difficult to estimate, particularly when the effects of policy changes cannot be articulated clearly, and in part because the data and methods needed for benefits assessments often are limited. Even the institutional characteristics of the Agency can impede effective collaboration among the Agency's natural and social scientists in addressing these issues. Opportunities for improving the ecological benefits assessments that the Agency conducts can be identified by examining these challenges more closely.

Current Agency benefits assessments often are incomplete with respect to identifying, quantifying, and valuing changes in ecological goods and services, as illustrated in Figure 1. During the early stages of an assessment (i.e., planning and problem formulation), some benefits may go unrecognized because complex ecosystems and their interactions with economic systems are not understood completely. As the assessment proceeds, recognized benefits may remain unquantified, much less monetized, because of methodological

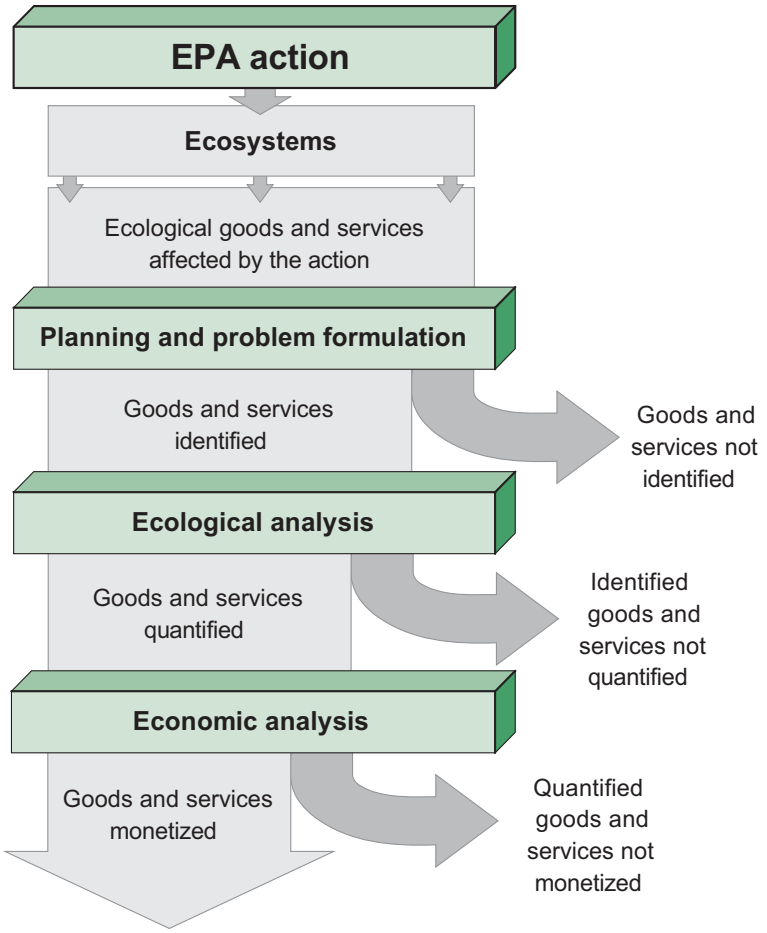


**Figure 1:** Representation of the benefits assessment process indicating where some ecological benefits may remain unrecognized, unquantified, or unmonetized.

and data limitations. Tables 3 and 4 illustrate how the diversions shown in Figure 1 can limit the Agency's ability to estimate the value of the ecological benefits of policies to protect air quality. The strategy communicated in this Plan is intended to help reduce these diversions and improve the rigor and comprehensiveness of ecological benefits assessments at EPA.

## TABLE 3: ECOLOGICAL BENEFITS OF THE CLEAN AIR ACT.

In *The Benefits and Costs of the Clean Air Act: 1990 to 2010* (USEPA 1999), EPA presented an extensive assessment of the outcomes of regulations that addressed many sources of air pollution. Under the Clean Air Act (CAA), EPA established regulations that set maximum ambient air quality levels for several types of pollutants. The Agency, supported by independent panels of physical and social scientists and public health experts, conducted an extensive assessment of the impacts of these regulations, including estimates of the ecological benefits (USEPA 1999).

To assess the benefits of CAA regulations, analysts developed conceptual models linking the reduction in pollutants to ecological benefits. Some of these benefits are identified in Table 4. The complete list of benefits can be found in Appendix E of the report (USEPA 1999). Generally, analysts need to assess the effectiveness of EPA actions in achieving reductions in pollutants. Control technologies and emission limits specified in EPA's CAA regulations have several directly measurable effects, but other effects would need to be estimated. Reductions in ambient concentrations of pollutants over particular ecological systems, including water bodies, forests, and agricultural areas, would need to be estimated with the aid of air dispersion models. Ambient concentrations of certain pollutants directly influence some ecological benefits, such as visibility at national parks. For most situations, however, the relationship between pollutant concentrations and ecological goods and services depends on ecological functions. For example, analysts first would need to estimate how reductions in atmospheric pollutants affect timber and crop growth, or fish and wildlife mortality and morbidity, to quantify changes in production or populations. For the CAA assessment, if changes in ecological goods and services could be quantified, analysts could attempt to estimate the value of those changes to society.

The third column in Table 4 lists the benefits of regulations under the CAA that analysts were able to quantify in physical units, such as additional tons of timber per acre harvested or the additional number of days of clear viewing at national parks. For example, analysts were able to estimate the relationship between reductions in ozone and increased timber growth. On the other hand, due to data limitations, analysts were unable to quantify the relationship between reduced acid deposition and timber growth. Of those benefits that were quantified, even fewer could be measured in monetary terms, as shown by the last column in Table 4.

The regulatory assessment experience with the CAA illustrates some of the challenges of determining the effect of EPA policies on ecological outcomes and benefits. If plausible connections between emission sources and ecological changes cannot be quantified, the outcomes of the policy cannot be estimated in physical or dollar terms. Estimating the relationships between changes in emissions and changes in ecosystem processes, ecological goods and services, and the value of those services, requires appropriate ecological and economic data, much of which currently is not available.

## TABLE 4: SELECTED ECOLOGICAL BENEFITS OF REDUCTIONS IN AIR POLLUTANTS IDENTIFIED IN THE ANALYSIS OF THE CLEAN AIR ACT.

| Pollutant reduced | Ecological benefits identified | Quantified? | Monetized? |
|---|---|---|---|
| Particulate matter | Improved visibility at national parks | yes | yes |
| Acidic deposition | Improved recreational freshwater fishing | yes | yes[a] |
| | Increased productivity of commercial forests (e.g., timber and non-timber forest products) | no | no |
| | Improved commercial freshwater fishing | no | no |
| | Reduced watershed damages (e.g., improved water filtration and flood control) | no | no |
| | Improved recreational amenities in terrestrial ecosystems (e.g., forest aesthetics and nature study) | no | no |
| | Maintained existence value and option values for ecosystems impacted by acid deposition | no | no |
| Nitrogen deposition | Reduced nitrogen deposition for eastern estuaries | yes | no |
| | Increased productivity of commercial fishing, decreased productivity of agriculture and forests | no | no |
| | Reduced watershed damages (e.g., improved water filtration and flood control) | no | no |
| | Improved recreation in estuarine ecosystems (e.g., recreational fishing, aesthetics, and nature study) | no | no |
| | Maintained existence value and option values for ecosystems impacted by nitrogen deposition | no | no |
| Tropospheric ozone | Increased commercial timber yields[b] | yes | yes |
| | Increased tons of carbon sequestered in forests | yes | no |
| | Increased agricultural yields[c] | yes | yes |
| | Improved recreational amenities in terrestrial ecosystems (e.g., forest aesthetics and nature study) | no | no |
| | Maintained existence value and option values for ecosystems impacted by ozone | no | no |
| Hazardous air pollutants (HAPs) deposition | Improved commercial and recreational fishing | no | no |
| | Maintained existence value and option values for ecosystems impacted by HAPs (e.g., biodiversity values) | no | no |

Source: USEPA (1999), adapted from Tables 7-5 and 7-11.
[a]Analysis was restricted to the Adirondacks.
[b]Analysis was restricted to a limited set of timber species.
[c]Analysis was restricted to a limited set of agricultural crops.

## 2.3 AN INTERDISCIPLINARY ECOLOGICAL BENEFITS ASSESSMENT PROCESS

Improving Agency ecological benefits assessments will require a new approach that emphasizes interdisciplinary teamwork. Traditionally, natural scientists at EPA have focused primarily on assessing risks, while economists have focused primarily on assessing the costs and benefits of regulations (Appendix A). Because ecological risk assessments typically are designed to address questions different from those addressed by ecological benefits assessments, the immediate value of risk assessment results to benefits assessments often is limited. Benefits assessments at the Agency historically have been the responsibility of economists, receiving limited input from the natural scientists. Increased collaboration among EPA's natural and social scientists and analysts will improve ecological benefits assessments at the Agency in several ways, including helping to identify appropriate ecological endpoints, collecting the necessary data, and developing and applying the appropriate methods to quantify and value changes in those endpoints.

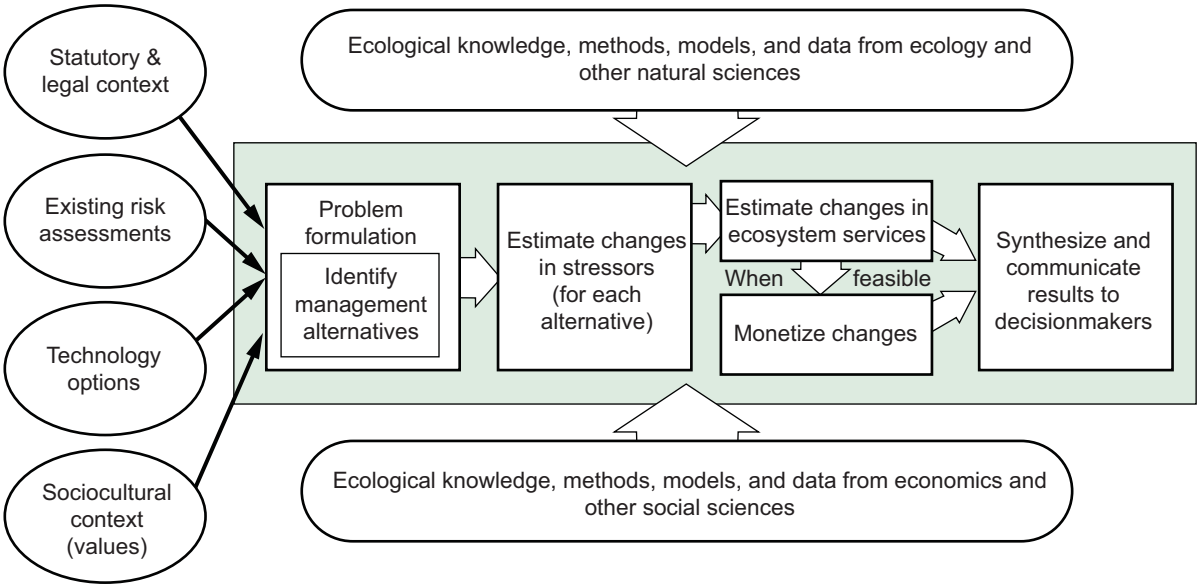


**Figure 2:** Interdisciplinary approach for ecological benefits assessment.

Figure 2 depicts a collaborative approach for ecological benefits assessment that builds on the conceptual foundations of the Agency's ecological risk assessment framework and borrows from its terminology (USEPA 1998). The assessment approach emphasizes collaborative interaction among Agency decisionmakers, social scientists, natural scientists, and analysts throughout the process. Such collaboration should begin at the earliest stages of the process, with identification of the need to evaluate alternative policy options for a decision. The options under consideration may be defined partly by the statutory and legal context under which EPA operates, information from existing risk assessments, and technological and socioeconomic considerations. The best science available would then be applied to understand how each policy option would change the environmental stressors they are intended to control, to forecast changes in the affected ecosystems and the services they provide, and to estimate the economic value of the change in those services.

The first step of the assessment is problem formulation: defining the scope of the problem and potential relationships among policy alternatives, stressors, and ecological changes. Both social and natural sciences are critical in developing the conceptual model of how policy ultimately impacts social welfare and identifying the appropriate benefits assessment endpoints. Analysts next determine the extent to which alternative policies reduce the quantity, flow, and timing of stressors into the environment. This phase also depends on multiple disciplines. Social sciences are needed because EPA policy impacts human activity, and firms and individuals will respond to those policies in ways that may enhance or mute the impact. Natural sciences are needed to evaluate the technical effectiveness of the policies. Given changes in stressors, analysts next estimate the changes in ecosystem processes and changes in the output of ecological goods and services. This is primarily the domain of ecology and natural sciences. Where possible and appropriate, the changes in social welfare resulting from changes in the quantity or quality of ecological goods and services are estimated. This primarily is the domain of the social sciences. Even in these later phases, however, interdisciplinary teamwork is important, and both disciplines are required to synthesize and communicate findings to decisionmakers. The output of the process is a comprehensive package of synthesized information that supports selection of the best policy alternative. Although outlined linearly in Figure 2, the new approach for ecological benefits assessment is iterative to help ensure that decisions are made with the best information available. For example, the assessment itself might identify other policy options, or different linkages between stressors and ecosystem changes—information that could be incorporated in a subsequent pass through the process.

Successful implementation of this approach will require new mechanisms to enhance the collaboration that is so critical for comprehensive assessments. Increased research attention at the intersection of natural and social sciences can provide the advanced tools and information needed to ensure the rigor of those assessments. The Agency has identified the priority actions needed in these areas to realize the goals of this Plan. These actions and a road map for sustained progress toward improved ecological benefits assessment are described in the following two sections.

# 3 IMPROVING ECOLOGICAL BENEFITS ASSESSMENTS

EPA can reach its goal of improving decisionmaking by conducting rigorous, interdisciplinary assessments of the ecological benefits resulting from its policies. This section discusses a variety of strategic actions, grouped into three main areas, that should enhance EPA's ability to identify, quantify, and value the ecological benefits of its policies. The areas of focus are:

- Institutional arrangements that foster interdisciplinary analyses and provide analysts with appropriate guidance and tools;
- Interdisciplinary research that directly supports ecological benefits assessments, including broad methodological development and specific studies about resources, stressors, localities, and policies; and
- Coordination of efforts with external partners.

The actions described below respond to institutional opportunities within EPA and the evolving science-based needs of environmental decisionmaking. Although this list does not exhaust the possibilities for improvements in this area, these actions were judged to be among the most important and promising avenues for EPA to pursue in the coming years. The importance of these actions was recognized through reviews of existing practices in EPA (Appendix A) and other agencies, consideration of previous efforts to improve ecological benefits assessment (Appendix B), evaluation of feedback from staff within EPA, and consideration of input from EPA's SAB Committee on Valuing the Protection of Ecological Systems and Services. The actions in the next section are intended to provide a general direction for the Agency. Specific actions are to be developed by EPA's Program Offices, ORD, and OPEI according to their individual needs and capabilities (as described in Section 4).

## 3.1 INSTITUTIONAL ARRANGEMENTS

Rigorous ecological benefits assessments require collaboration between many disciplines and specialties. Professionals in engineering, chemistry, hydrology, and atmospheric sciences are needed to evaluate the effectiveness of control measures and the fate and transport of stressors through the environment. Biologists and ecologists are needed to estimate how changes in stressors affect ecological conditions and processes. Economists and other social scientists are needed to assess the value that society places on changes in the goods and services that affected ecosystems provide and to predict how people respond to policies. Policymaker participation is critical for establishing objectives and placing the assessment in context. Their participation also is important to make certain that they understand how to interpret and use the information provided by the assessment. For this collaboration to work effectively, EPA must ensure communication among all of the participants in the process. Two specific actions that can help facilitate communication are:

**Action 3.1-1:** *Promote formal and informal opportunities for improving communication among disciplines.* EPA can stimulate communication between natural and social scientists by promoting greater interaction within the Agency and through grants supporting interdisciplinary research.

Suggested activities include:

- Organized workshops, symposia, and seminars to encourage the transfer of knowledge and skills;
- Exchange of personnel through temporary staff assignments (details) among offices to immerse staff in the culture and practices of other disciplines, and to educate them about missions and needs of other parts of the Agency; and
- Creation of an interdisciplinary Web site with reference information about the basics of both economics and ecology to foster information exchange.

**Action 3.1-2:** *Provide basic training in the fundamentals of other disciplines.* In the near-term, analysts, scientists, and policy staff involved in ecological benefits assessments should be provided crossdisciplinary training. Such training would enhance understanding of the concepts, approaches, and methods of others involved in the assessment process, improving the effectiveness of communication supporting benefits assessments.

**Institutional Actions To Promote Interdisciplinary Assessments**

*Facilitate communication among disciplines*

*Provide crossdisciplinary training*

*Ensure interdisciplinary participation*

*Expand the use of ecological information*

*Conduct problem formulation workshops*

True collaboration among natural and social scientists in planning and executing assessments helps to ensure that those assessments are rigorous and comprehensive. Collaboration begins and is especially crucial in the overall planning stage of the action development process and assessment formulation. Throughout the assessment process, continued collaboration is needed to evaluate and interpret interim results and to ensure that any needed changes in focus or direction of the assessment are recognized. Three actions that can promote crossdisciplinary collaboration during planning and performance of ecological benefits assessments are:

**Action 3.1-3:** *Increase interdisciplinary participation in assessing ecological benefits.* From the outset of each assessment, policy analysts, economists, and natural and social scientists should be assembled into interdisciplinary teams to conduct the assessment. Social scientists should participate in the development of conceptual models describing the causal relationships between stressors, endpoints, and human welfare, and natural scientists should participate in the development of valuation studies, especially if surveys are used to elicit social values. Broad participation can be ensured through better use of Analytic Blueprints (see Action 3.1-7 on the next page).

**Action 3.1-4:** *Expand the use of ecological risk assessment information in economic benefits assessments.* Although Agency risk assessments and benefits assessments often differ in their purposes and objectives, they share many data and methodological needs. EPA should initiate an effort similar to the Risk Assessment for Benefits Analysis (RABA) project focused on ecological benefits. RABA was conducted under the Agency's Risk Assessment Forum to evaluate methods for expanding the use of human health risk assessment information in economic benefits analysis. The interdisciplinary nature of RABA has been key to its success. Like RABA, the first step in the new effort would be to conduct one or more case studies for quantifying and monetizing ecological benefits. The case studies would require collaboration among analysts from different fields and should provide valuable insights for making interdisciplinary collaboration routine.

**Action 3.1-5:** *Conduct program-specific problem formulation workshops.* The Agency's approach for ecological risk assessment provides a successful model for planning benefits assessments—*problem formulation.* Problem formulation workshops would allow those involved in an ecological benefits assessment to consider the complex relationships among policy alternatives, stressors, and ecosystem goods and services. A primary product of these workshops will be a set of conceptual models, relating policy alternatives to ecological benefits, which should help identify the full range of ecological benefits that may result from each alternative. Led by ORD and OPEI in conjunction with a program office, these workshops also would foster interdisciplinary collaboration and highlight specific research needs. They could form a basis on which program offices could build assessment teams, as well as provide valuable information useful for the development of assessment guidelines (see Action 3.1-6).

The rigor of EPA's benefits assessments can be improved by providing clear standards for analysts to follow and for managers to use to judge the quality of assessments. Three actions that can address this issue are:

**Action 3.1-6:** *Develop guidelines for planning and conducting ecological benefits assessments.* Clear guidelines assist practitioners in meeting the standards of the Agency and assist decisionmakers in evaluating the appropriateness and quality of the planned analysis and final assessment. An interoffice and interdisciplinary workgroup would be necessary to develop guidelines that address key issues in implementing the approach shown in Figure 2. These issues include:

- Construction of conceptual models linking policy alternatives to changes in ecological endpoints, ecosystem goods and services, and ecological benefits;
- Identification of appropriate and consistent temporal and spatial scales of analyses;
- Selection of appropriate analytical tools; and
- Development of approaches for reducing and describing uncertainty in estimates of ecological changes and the value of those changes.

The new guidelines should build on *A Framework for the Economic Valuation of Ecological Benefits* (USEPA 2002a). This effort could be supported by issue papers, topically oriented workshops and instructive case studies. Guidelines development could be overseen by a newly created Ecological Benefits Assessment Forum (described in Section 4).

**Action 3.1-7:** *Review and update Agency guidelines for developing Analytic Blueprints.* EPA develops an Analytic Blueprint at the start of each new regulation development to guide the analysis of policy alternatives (USEPA 2003b). Scientific and economic analyses are addressed separately in the current Blueprint approach. Revising the guidelines for preparing Analytic Blueprints to encourage greater integration and interdisciplinary analysis throughout the regulatory development process would be an important step toward improving the Agency's benefits assessment approach.

**Institutional Actions To Promote Rigorous and Comprehensive Assessments**

*Develop assessment guidelines*

*Update guidelines for Analytic Blueprints*

*Develop generic ecological benefits assessment endpoints*

**Action 3.1-8:** *Develop generic ecological benefits assessment endpoints.* EPA recently published its *Generic Ecological Assessment Endpoints (GEAEs) for Ecological Risk Assessment* (USEPA 2003a) to guide consideration of endpoints potentially important for all of its ecological risk assessments. Developing a similar set of ecological benefits assessment endpoints that encompass key ecosystem goods and services for routine consideration in ecological benefits assessments would provide analysts with an initial list to consider in constructing conceptual models (see Action 3.1-6).

## 3.2 INTERDISCIPLINARY RESEARCH TO SUPPORT ECOLOGICAL BENEFITS ASSESSMENT

EPA is committed to basing its environmental protection decisions on good science. Greater emphasis on research to fill critical gaps in the understanding of natural and social systems also would help improve the Agency's ability to conduct rigorous and comprehensive ecological benefits assessments on a more routine basis. Although the intention of this Plan is to support the evaluation of policies, in the broad sense, much of the research described below may support other situations in which the estimation of the benefits of ecological changes or conditions is important.

The research actions recommended in this section focus on two overarching issues and three key points of connection between policy and social welfare. The overarching issues are: (1) establishing baseline scenarios; and (2) characterizing uncertainties in assessments. The points of connection are: (1) how EPA policies alter the exposure of ecological systems to stressors; (2) how changes in stressors influence ecological functions and outputs; and (3) how changes in ecological outputs influence social welfare. Several research actions on the use of supplemental approaches that help characterize, rank, and/or measure the effects of policy are recommended.

### 3.2.1 OVERARCHING ISSUES

A primary objective of ecological benefits assessment is to support the selection of the best policy among alternatives. Policy impacts are measured against the baseline case, in which ecological systems are left to develop without the influences of new EPA policy. Monitoring programs can provide information to document current ecosystem conditions and to track trends in those conditions through time. Monitoring programs are key to improving EPA's ability to measure and characterize natural variability in ecosystems. Many of EPA's existing monitoring efforts are designed to assess compliance in a policy context and may be localized or of short duration. Others, such as ORD's Environmental Monitoring and Assessment Program (EMAP), were initiated to provide information about the status and trends of the nation's ecosystems generally (USEPA 2002b). Three actions that can improve the usefulness of monitoring programs for ecological benefits assessments are:

**Action 3.2.1-1:** *Revise environmental monitoring programs to include indicators relevant for benefits assessments.* EPA periodically should evaluate the indicators used in its monitoring programs for their relevance to ecological benefits assessment. Working within the context of those programs, the Agency should seek opportunities to incorporate new or modified indicators that are informative of relationships among Agency policies and changes in valued ecosystem goods and services. Recommendations for new indicators should be based on the recent considerations highlighted by the National Academy of Science in its report on *Valuing Ecosystem Services* (NRC 2000). The most useful indicators will be those that either measure the flow of ecosystem goods or services directly or can be combined with other environmental or economic indicators to measure such flows, and those that are at least potentially responsive to EPA policies.

Opportunities should be sought to expand the use of multi-metric indices that condense information on ecosystem conditions to reflect net changes and that can simplify analytic resource requirements for ecological benefits assessments. Indicators should be developed to reflect the generic ecological benefits assessment endpoints recommended in Action 3.1-8.

**Action 3.2.1-2:** *Increase coordination of long-term, large-scale data collection efforts across the Agency, and identify new efforts where needed.* Filling the gaps that occur among the environmental data collection activities of EPA's programs will improve the Agency's ability to assess the effects of its policies. This can be done by increasing support for large-scale data collection efforts that provide critically needed information about ecosystems, especially about those currently under-represented in EPA's ongoing monitoring efforts, such as terrestrial systems. Increasing the available information on current ecological conditions and processes in these systems will lead to more accurate and robust estimates of benefits. Support should be leveraged by coordinating with the monitoring efforts of other agencies (see Action 3.3-3).

**Action 3.2.1-3:** *Develop methods for using information from short-duration and localized monitoring programs in ecological benefits assessments of long-term, large-scale policies.* The Agency and others devote substantial resources to short-term and focused data collection efforts. These efforts provide valuable insights about ecosystem condition and processes and are critical for tracking and evaluating policy performance. However, the data derived from these efforts could be better utilized in ecological benefits assessments of larger scale policies, including those at the national level. The Agency should explore methods to aggregate data collected in short duration and localized monitoring efforts to estimate trends in ecosystem conditions, measure natural variability, and track performance on larger scales.

A critical element of a rigorous benefits assessment is the sensitivity of results to alternative assumptions about the functions of ecological systems and social values. EPA seeks to reduce uncertainties in its estimates of ecological benefits where possible, and to characterize accurately the uncertainties that exist. Two sources of uncertainty often are recognized that require different characterization strategies. Virtually all ecological and economic processes are subject to "inherent variability" (also referred to as "natural variability" or "stochasticity"), that cannot be reduced but can be accounted for with appropriate computational tools. More difficult to address is "knowledge uncertainty," including errors or gaps in estimation methods that arise either from a lack of knowledge or mistaken assumptions about relationships between policy changes, ecological conditions, and social welfare. Two actions that can help EPA improve its ability to characterize and reduce uncertainties in its ecological benefits assessments are:

**Action 3.2.1-4:** *Develop improved methods to measure inherent variability in ecological benefits assessments.* To improve characterizations of variability in ecological benefits assessments, the Agency should invest in

**Supporting Research: Overarching Issues**

*Incorporate relevant indicators in environmental monitoring programs*

*Increase coordination and development of long-term, large-scale environmental monitoring*

*Develop methods for aggregating data from short-term and local monitoring programs*

*Develop improved methods to measure inherent variability and characterize uncertainty*

*Develop improved methods to identify and reduce knowledge uncertainties in ecological benefits assessments*

research to refine methods for incorporating probabilistic outcomes into benefits assessments using Monte Carlo techniques, interval mathematics, and other approaches. EPA's ongoing environmental monitoring efforts can provide valuable information about the frequency and magnitude of apparently random changes in ecological systems (see Actions 3.2.1-1, -2, and -3).

**Action 3.2.1-5:** *Develop improved methods to identify and reduce knowledge uncertainties in ecological benefits assessments.* Issues of model misspecification and uncertainties in parameter estimates are well-known in both ecological and economic fields. Some of these effects can be measured or characterized. Special focus is needed on uncertainties associated with linkages between ecological and economic models, as these have received relatively less attention in previous research. As part of all of the actions described in the following sections, EPA should investigate sources of uncertainty and methods for characterizing and measuring it.

### 3.2.2 IMPACTS OF POLICY ON STRESSORS

The effectiveness of any policy is influenced by two key factors: the behavioral responses of individuals and groups affected by the policy, and the technical efficacy of their responses. In addition to traditional command-and-control regulations, EPA policies include economic incentives, performance standards, information campaigns, and voluntary programs. Information on how the targeted communities respond to different policies helps to predict how those policies influence stressors in the environment. Sometimes, behavioral responses result in a substitution of the original environmental risks with different risks, such as increases in another stressor or a change in media through which a stressor passes.

**Action 3.2.2-1:** *Incorporate and improve consideration of behavioral responses to environmental policies.* EPA should ensure consideration of behavioral responses to regulation in its development of guidance for benefits assessments and by revising the guidelines for Analytical Blueprints. EPA also should support applied studies that characterize and quantify behavioral responses to a variety of regulatory strategies, including traditional command-and-control, economic incentives, voluntary programs, and information campaigns.

**Supporting Research: Policy Impacts on Stressors**

*Improve consideration of behavioral responses to environmental policy*

*Enhance capacity for relative risk assessment*

*Support research to quantify the effectiveness of ecologically based pollution controls*

*Increase and improve ex-post analysis*

**Action 3.2.2-2:** *Identify priority areas where trade-offs between risks are critical and enhance capacity for relative risk assessments.* EPA should revise the guidelines for development of Analytic Blueprints to reflect the importance of identifying when analyses of trade-offs among risks are needed in the development of policy (i.e., when one or more policy options may decrease some risks while increasing others). Increased training of risk assessors and the development of new methods for evaluating relative risks among stressors and pathways also would improve the Agency's ability to account for risk-risk trade-offs that may arise from indirect human behavioral responses to policies.

Technical efficacy concerns the extent to which the measures taken are effective in reducing stressors. EPA often has relied on mechanical technologies for pollution control, and the Agency's Environmental

Technology Verification (ETV) Program (USEPA 2006) has a long history of research on the effectiveness of such technologies. The more recent emphasis on performance-based regulations has broadened the scope of pollution control to include many ecologically based measures, such as maintenance of vegetative buffers or rehabilitation of damaged ecological structure or function.

**Action 3.2.2-3:** *Invest in research on methods to estimate expected stressor reductions from ecologically based pollution controls.* Estimating reductions in stressors is necessary for predicting the extent of changes in ecological benefits assessment endpoints and requires the use of atmospheric, hydrologic, and other fate and transport models. Whereas some of these models are well developed, others require further refinement for specific situations, regions, and scales. In some cases, research on the influence of key parameters is required. For example, models may need to account for the effects of scale-related parameters, such as the location of a restoration project within a watershed, width of vegetation buffers, or shape of habitat patches. Research also should address sources of variability and uncertainty, especially those contributing to downside risk or irreversibilities.

**Action 3.2.2-4:** *Increase and improve ex-post analysis of the effects of EPA policy, including remediation or restoration projects.* Evaluation of policy alternatives across EPA programs could be improved by stronger firsthand evidence and a firm understanding of the past effectiveness of similar actions, including the extent of successfully restoring lost goods and services. Improving ex-post analyses involves identifying and tracking appropriate indicators (see Action 3.2.1-1) and supporting applied research to detect and measure site-specific changes in the quantity, flow, and timing of stressors and ecological responses in the environment. EPA should increase available empirical data by making post-project monitoring and reporting a condition of project funding (see Action 3.3-1). In the longer term, the Agency should analyze results of individual policies and projects to identify patterns and conditions that determine the effectiveness of policies across regional scales. Related research, which would support and benefit from more and better ex-post analysis, includes methodologies to synthesize data from different environments and monitoring efforts (see Action 3.2.1-3), measurement of the effectiveness of ecologically mediated controls (see Action 3.2.2-3), and improvements in fate and transport models.

### 3.2.3 IMPACTS OF CHANGES IN STRESSORS ON ECOLOGICAL ENDPOINTS

Rigorous benefits assessments require understanding and quantifying how ecological systems will respond to changes in stressors. A substantial portion of the Agency's ecological research portfolio addresses how environmental stressors affect ecological systems. This provides valuable information for risk assessments, some of which is pertinent to benefits assessment. A reorientation of some ecological research according to two concepts, however, could further improve EPA's benefits assessments. First, research should be more interdisciplinary. Including social scientists in ecological research projects can help improve the applicability of the research in benefits assessment. Second, more research should apply a "production function" perspective. This approach views certain socially important ecological goods and services as outputs of ecological processes, analogous to the way that human-made goods and services are outputs of industrial or service sector processes. The five actions that could help the Agency implement these two concepts as it adapts its ecological research portfolio are:

**Action 3.2.3-1:** *Develop capacity for population modeling applicable to ecological benefits assessment.* Biological populations may be valued by society as marketable commodities for a variety of uses, including hunting and fishing; non-consumptive recreational uses; pollination, seed dispersal, and other indirect uses;

and simply their existence. Many population models exist, particularly for commercial fish and forestry species. Models for other species of interest to the Agency, however, are lacking. In the ecological research community as a whole, attention increasingly is being paid to collecting data and developing models for more species in more locations. EPA should take advantage of this opportunity to incorporate population modeling more rigorously into its decision-support systems. A comparative survey of available population modeling approaches and their relative strengths and weaknesses for use in ecological benefits assessments would be an important first step. Gaps in existing modeling approaches should become priorities for new research. On one side, research should link model parameters, such as reproduction and mortality, to exposure to stressors. On the other side, research should align population model outputs with economic models of social welfare.

**Action 3.2.3-2:** *Improve linkages between stressor exposure data and effects on populations.* As indicated in Action 3.2.3-1, a critical requirement for expanding the use of population modeling is the linkage between key population parameters and exposure to stressors. In this way, analysts can estimate how changes in the quantity, flow, or timing of stressors lead to changes in a population. EPA ecological risk assessments often are based on laboratory experiments that determine lethal doses or lethal concentrations, but these metrics generally cannot be translated directly into changes in population abundances or viabilities. Further, they do not always account for sublethal effects that might significantly alter population dynamics. A more complete understanding of how stressors impact population dynamics would account for both the direct (lethal and sublethal) effects of stressors on organisms, and their effects on intra- and interspecific interactions between organisms. Expanded use of both laboratory- and field-derived data in population models could help to predict a wider range of potential effects.

**Action 3.2.3-3:** *Identify and develop critical community-level modeling capacity.* Two situations call for more extensive ecological modeling. First, the proximal impact of stressors is often on species that do not affect social welfare directly, but which contribute to the production of species that are valued directly, such as harvested species. EPA should support further development of models of species interactions (known as community or food web models) so that indirect effects of changes in stressors on social welfare may be better quantified. Second, society often values species assemblages that are highly diverse, independently of the value derived from the abundances of particular species within the assemblage, as often is the case with bird watching activities. EPA should adapt existing models, and develop more models as needed, that explicitly include community-level attributes, such as species richness or other measures of diversity, as state variables for use in ecological benefits assessments.

**Supporting Research: Stressor Exposure on Ecological Endpoints**

*Develop capacity for population modeling*

*Improve linkage between stressor exposure and population model parameters*

*Develop capacity for community-level modeling*

*Identify and develop critical community-level modeling capacity*

*Improve ability to measure and to model changes in ecological endpoints across spatial scales.*

*Expand use of bioeconomic models*

**Action 3.2.3-4:** *Develop capacity to model ecosystem processes for ecological benefits assessment.* Many environmental policies may produce ecological benefits through changes in ecosystem processes. Examples

of ecosystem processes that generate ecological goods or services valued by society are groundwater filtration, which may improve the purity of drinking water (a marketable commodity), and groundwater recharge, which can help maintain the persistence of wetlands and thereby support recreational hunting activities through otherwise dry seasons. One way to account for ecosystem processes in benefits assessments is to treat them as production functions that may be influenced by the presence of stressors (e.g., a degraded environment produces fewer services or lower quality goods). Research in this area should focus on the current limitations in EPA's ability to describe the influence of the quantity, flow, or timing of stressors on ecosystem processes. Research in this area should:

- Identify the ecological goods and services of importance to society and the processes that support them;
- Survey existing approaches for modeling these ecosystem processes as production functions;
- Focus on critical inputs and parameters affected by stressors responsive to EPA policies;
- Develop both mechanistic and statistical approaches, as well as approaches applicable at multiple geographic scales;
- Conceptually model critical ecosystem processes as production functions, identifying inputs and parameters affected by stressors under EPA authority; and
- Identify the most important remaining gaps and support data collection and research to develop improved or new approaches to fill these gaps.

**Action 3.2.3-5:** *Improve ability to measure and to model changes in ecological endpoints across spatial scales.* Measures of changes in ecological endpoints can vary depending on the spatial scale that is under consideration, from field plots and streams to river basins or larger scales. Extrapolating across scales could lead to under- or overestimation of the benefits of a policy. Given the variation and interconnectedness of ecosystems, EPA should invest in geospatial approaches that collect spatially referenced data to improve models of the impacts of changes in stressors on ecological endpoints, which generally are not distributed uniformly over space. In addition to those that can account for spatial heterogeneity, models are needed that are designed specifically for applications at a variety of scales, including watersheds, regions, and the entire country, because many EPA policies are implemented at those scales. Such models should be able to characterize baseline ecosystem conditions and the natural variability of ecosystems at different scales as well as predict potential impacts caused by policy alternatives.

**Action 3.2.3.-6:** *Expand use of linked ecological-economic models in ecological benefits assessment.* Models of ecological processes and economic models of human behavior can sometimes be linked. An advantage of such linked models, sometimes called "bioeconomic models," is that they can provide the ability to account for ecological dynamics and human behavioral feedbacks that may result from policy changes in an integrated manner. A variety of bioeconomic models have been developed for use in forestry and fishery applications, but there is

**Supporting Research: Ecological Endpoints and Social Welfare**

*Develop and apply valuation methods to address EPA needs*

*Improve survey methods through pre- and post-survey validity testing*

*Improve capacity and methods for benefit transfer*

opportunity for making wider use of this approach in EPA benefits assessments. Particular areas of need include:

- Bioeconomic models that relate EPA policies to changes in stressors, ecological processes, and socially valued goods and services;
- Adapting or developing models that incorporate recreational uses activities, including nonconsumptive use; and
- Incorporating non-use values into bioeconomic models.

Bioeconomic models can also be useful for identifying critical ecological and economic data to be collected in research supporting ecological benefits assessment.

### 3.2.4 IMPACTS OF CHANGES IN ECOLOGICAL ENDPOINTS ON SOCIAL WELFARE

Understanding the relative values that society places on ecosystem goods and services is critical for designing effective and efficient environmental policies. Economists have developed a variety of methods for estimating the value of environmental changes. Some economic valuation methods may be more appropriate for certain situations, but all have limitations that may hinder analysts' abilities to estimate values. A key difficulty arises from the fact that few ecological goods and services are linked directly to a market, which otherwise would provide some information about social value.

When evaluating different policy options, EPA may undertake original valuation studies, or as more often is the case, may transfer results from previous valuation studies to estimate the value of new policies. This latter practice is known as "benefit transfer." Enhancing EPA's ability to estimate the economic value of ecological changes in benefits assessments requires supporting applied, interdisciplinary valuation research and methods development. Three actions that could help the Agency make improvements in this area are:

**Action 3.2.4-1:** *Support research to adapt and apply economic valuation methods that are best suited for valuing changes in ecological goods and services.* Research is needed that combines both stated preference approaches and revealed preference approaches to take advantage of their combined strengths. Other promising areas for advancement include:

- Adapting hedonic pricing models to estimate the implicit value of a wider variety of environmental amenities and conditions;
- Adapting random utility models to estimate the value of a wider variety of ecological goods and services from observed demand for similar or related market goods and services, or for nonmarket activities, such as outdoor recreation;
- Estimating explicit production function models to incorporate indirect effects (see Action 3.2.3-3); and
- Applying mathematical optimization techniques to estimate the value of ecological resources and to design more cost-effective strategies for targeting ecological restoration and protection activities.

Research in these areas also should examine sources of uncertainty in these methods and means of measuring variability.

**Action 3.2.4-2:** *Improve survey methods by expanding pre- and post-survey validity testing.* In addition to estimating values for particular policy changes, stated preference surveys can provide a better understanding of the kinds of changes in the environment that are most meaningful to the public in general. This in turn can help identify ecological endpoints on which to focus in EPA's environmental monitoring programs. Two key factors influence the quality of information obtained from surveys to estimate values of ecological goods and services: (1) how well the respondents comprehend the good or service being valued (i.e., the attributes of the ecological resources that may change under alternative policy scenarios); and (2) how well the researcher can interpret respondents' answers to survey questions. In conducting original studies, EPA should use accepted survey design methods, including focus groups and pre-testing, to address the first factor. More importantly, however, natural and social scientists should design the survey together so that it appropriately bridges the outputs of ecological data and models to potentially valuable ecological goods and services. The second factor calls for rigorously testing various hypotheses about the motivations underlying survey responses. Expanded use of techniques developed through research in the psychology of decision-making, including focus groups, debriefing, and experimental design protocols, could be helpful here. EPA should review these techniques and compile a guidance document for benefits assessment practitioners.

**Action 3.2.4-3:** *Improve capacity and methods for benefit transfer for ecological goods and services.* Conducting original studies in support of specific benefits assessments often is not feasible. EPA can pursue a number of strategies to improve assessments that rely on information from studies conducted outside of the policy context in question with a specific focus on ecological goods and services. Examples of such strategies are:

- Conduct and support interdisciplinary valuation studies to cover a larger variety of ecological endpoints, including generic ecological benefits assessment endpoints (see Action 3.1-8), and situations;
- Assess the influence of both the changes in ecological and economic variables and the features of the policies that bring about those changes so that transferred estimates of value may be adjusted appropriately for new policy scenarios; and
- Support research to characterize sources of variability and uncertainty in benefit transfer.

Increased research on integrative benefit transfer methods, such as meta-analysis, and their application also should improve the Agency's ability to synthesize results from multiple studies for more accurate and precise transfers to new cases.

### 3.2.5 SUPPLEMENTAL APPROACHES

Monetizing benefits is useful in part because it allows different types of benefits to be combined and compared directly to costs, or to the benefits of alternative policies. Furthermore, dollars are a familiar medium of exchange and may be more easily understood by the public than unfamiliar biophysical measures of benefits. However, because combining different benefits into a single unit of measurement can mask critical differences that may be important to policymakers and stakeholders, approaches that explicitly rate or rank multiple attributes of different policy options are sometimes preferred. For example, experts might be asked to rate policy alternatives according to attributes such as expected cost and feasibility as well as predicted ecological, health, and social outcomes. Policymakers or stakeholders then might be asked to weight the relative importance of these attributes.

Whether ecological benefits are to be given a relative weight or be fully monetized, a preference elicitation process often is required. Because choices involving ecological relationships tend to be unfamiliar, procedures that allow for the construction of these preferences may have advantages over those that assume they are formed already. Preference construction techniques may involve, for example, embedding iterative cognitive tasks within a survey or conducting structured group discussions prior to administering a survey. Group discourse also may encourage individuals to form preferences that reflect public policy concerns to a larger degree as compared to surveys of individuals.

Some have argued that the complexity and indispensable life-support role of ecological systems are sufficient reasons to develop valuation approaches that are founded on biophysical analysis rather than individual welfare. Policy analysis using models of material or energy flows through linked, ecological-economic systems may be a useful complement to standard economic analysis. Three actions that could improve EPA's ability to apply supplemental valuation approaches in ecological benefits assessments are:

**Action 3.2.5-1:** *Evaluate rating and ranking procedures to complement economic valuation.* EPA should determine the usefulness of rating and ranking approaches, including multi-attribute approaches, as supplemental methods for valuing ecological changes. This evaluation should consider the internal consistency and robustness of values elicited by each approach, the degree to which each approach is consistent with democratic processes, and the ability of each approach to describe long-term ecological, financial, and social outcomes of policy alternatives objectively.

**Supporting Research: Supplemental Approaches**

*Evaluate rating and ranking procedures*

*Evaluate biophysical approaches to valuation*

*Apply hybrid decision approaches in field trials*

**Action 3.2.5-2:** *Evaluate analytical methods based on ecological-economic system properties.* Various biophysical approaches for measuring ecological changes in non-monetary terms have different strengths and weaknesses. These approaches should be reviewed and compiled to develop a reference document for benefits analysis practitioners and to identify areas where additional research is needed. Special attention should be paid to the unique assumptions underlying each approach and how directly each approach can be related to policy.

**Action 3.2.5-3:** *Conduct trial applications of hybrid decision approaches in future benefits assessments.* The supplemental approaches referred to above are not mutually exclusive, nor are they necessarily incompatible with monetary valuation methods. Various hybridizations of standard economic approaches with constructive, discourse-based or systems-based approaches also can be useful for policy analysis. Hybrid approaches can be developed and their performance evaluated to determine their usefulness for Agency decisionmaking.

## 3.3 COORDINATION WITH PARTNERS

The challenges EPA faces in improving ecological benefits assessments are substantial, as are the opportunities for major advancement, especially if Agency efforts can be combined with those of partners in other organizations and academia. Because EPA relies heavily on science and best practices developed outside of the Agency, better communication and coordination of research efforts will be crucial to improve Agency benefits assessments. EPA also could increase its influence on the direction of outside research and leverage additional resources for internal activities through better communication. Actions that could help improve Agency coordination with outside partners include:

**Action 3.3-1:** *Provide direct support to studies relevant to Agency ecological benefits assessments.* Grant programs, such as the ORD's Science To Achieve Results (STAR) program, provide funding to external research institutions to address the Agency's needs for ecological, economic, and interdisciplinary research. Requests for proposals through such programs could be designed to help promote the actions outlined in this Plan, especially by:

- Applying a production function approach that links changes in stressors to changes in ecological goods and services of relevance to the Agency; and
- Emphasizing the transferability and scalability of results across ecoregions, geographic and temporal scales, and landscape contexts.

**Action 3.3-2:** *Improve communication with outside researchers about the Agency's needs for ecological and economic research.* Increased communication with academic researchers will help encourage more policy-relevant studies that EPA can use in benefits assessments (see Action 3.2.4-3). Some key points to communicate include the importance of:

- Using generic ecological benefits assessment endpoints (see Action 3.1.7) and other priority endpoints for both ecological and economic studies;
- Establishing baseline conditions and trends in ecosystems of concern;
- Using standardized indicators and other measures to quantify policy-relevant endpoints (see Actions 3.1-8 and 3.2.1-1); and
- Focusing on incremental changes in stressors, ecological goods and services, and social welfare.

Methods for communicating needs include: participation by EPA staff in professional meetings; publication of position papers, press releases, and journal articles; and support for new venues, including print or online journals, books, and workshop proceedings for high-quality applied research. Development of standard methods for under-represented ecological endpoints

**Coordination With Partners**

*Support studies relevant to Agency policies*

*Improve communication of Agency research needs*

*Increase coordination of data collection and research across agencies*

*Expedite procedures for collecting information about public values*

could help fill some of the knowledge gaps that exist in Agency benefits assessments and currently are filled through applications of benefit transfer and best professional judgment.

**Action 3.3-3:** *Increase coordination of data collection, monitoring programs, and research with other agencies.* The quality and quantity of data supporting ecological benefits assessment can be enhanced by leveraging EPA's efforts and resources with those of other agencies. EPA can work with its partners to coordinate and consolidate ecological data collection and socioeconomic surveys. Promising opportunities for leveraging resources include:

- Continued support for the international Earth Observation System of Systems (http://www.epa.gov/geoss/index.html);
- Coordination with domestic partners to leverage resources for the long-term monitoring of a wider array of ecosystems; and
- Coordination of collection and sharing of data to reduce duplication.

**Action 3.3-4:** *Explore approaches for facilitating approval of information collection requests (ICRs) related to collecting information from the public for use in ecological benefits assessments.* The ability to complete rigorous ecological benefits assessments will be enhanced by incorporating more information about the values society places in ecosystem goods and services. An efficient approval process for EPA's ICRs would help ensure that surveys and other data collection instruments can be administered in a timely and effective manner. EPA should coordinate with other federal agencies to explore options that facilitate more rapid review and approval of ICRs.

Implementing the actions described in this section will require a sustained effort, one that is fully coordinated throughout the Agency and with its external partners. An overall approach to implement these actions for improving ecological benefits assessments is described in the next section.

# 4 IMPLEMENTATION

Section 3 identified strategic actions needed to realize this Plan's goal of helping to improve Agency decision-making by enhancing EPA's ability to identify, quantify, and value the ecological benefits of existing and proposed policies. Sustained progress towards this goal requires a strategy to implement these actions effectively. This section proposes a structure and process to implement and adapt over time EPA's strategy, and identifies near-term implementation priorities.

EPA is a large and complex organization with two research offices, ORD and OPEI, and multiple program offices operating under a variety of statutes. The implementation structure and process outlined in this section emulates or uses existing Agency elements and functions to coordinate activities and refine priorities. Its structural elements include an oversight committee at a high management level and a staff-level forum. Its process for informing the actions of Program Offices, ORD, and OPEI relies on the development of program-specific Action Plans. By identifying programmatic priorities and needs, these Action Plans form the basis for discussion and coordination of ecological benefits assessment improvement activities across the Agency.

## 4.1 INSTITUTIONAL STRUCTURE

Improving ecological benefits assessments requires a supportive institutional structure. Two groups within the Agency are envisioned to provide that support. The first would be at a high management level to provide guidance and direction. The second would be at the staff level to provide practical assistance and technical expertise. Both would operate across the Agency's offices.

### 4.1.1 OVERSIGHT COMMITTEE

A high-level Agency committee is needed to oversee and guide progress toward rigorous, interdisciplinary benefits assessments supported by good science. An Oversight Committee, with technical and management representation from across the Agency, ultimately would be responsible for implementing the strategy described in this document. The Oversight Committee would coordinate activities among offices, promote new institutional arrangements, and monitor general progress toward Agency goals.

A primary responsibility of the Oversight Committee would be to consider Program Office Action Plans and the research agendas of ORD and OPEI (see below) to identify cross-Agency priorities for improving ecological benefits assessment. One of its functions would be to leverage resources to support those priorities. Key considerations for identifying cross-Agency priorities include:

- Relevance to the overall goal of this Plan and the actions it outlines;
- Significance to multiple offices, regulations, and policies;
- Likelihood of success; and
- Opportunity to leverage external resources and expertise.

An important first step in implementing the EBASP would be for the Oversight Committee to supervise revisions to the guidelines for preparing an Analytic Blueprints to promote:

- Formation of interdisciplinary assessment teams (Action 3.1-3);
- Coordination of information between ecological risk and benefits assessments (Action 3.1-4);
- Consideration of behavioral responses to regulations (Action 3.2.2-1); and
- Consideration of risk trade-offs (Action 3.2.2-2).

In the near term, the Oversight Committee would be responsible for developing performance measures and tracking the success of EPA's efforts to improve ecological benefits assessment. The Committee also would be responsible for the periodic review of the EBASP to set goals reflecting the changing needs of environmental protection and the evolving state-of-the-science.

The Science Policy Council may be well-positioned to take on the responsibilities of an Oversight Committee and could be so charged by the Administrator upon release of this Plan.

### 4.1.2 ECOLOGICAL BENEFITS ASSESSMENT FORUM

A staff-level forum, open to all analysts in the Agency, could provide an effective means of exchanging knowledge and promoting good practices for ecological benefits assessment. This forum also could provide a convenient source of expertise to advise EPA offices and the Oversight Committee. The Agency's Economics Forum and Risk Assessment Forum provide potential models for an Ecological Benefits Assessment Forum (EBAF), which would serve as a central point for Agency-wide communication, discussion, and evaluation of crosscutting issues related to ecological benefits assessment. Its primary roles would be to ensure consistency in practices across the Agency, provide technical assistance to analysts, and facilitate the flow of information.

In implementing this Plan, the EBAF would be responsible for developing guidelines for planning and conducting ecological benefits assessments (Action 3.1-6), and for developing generic ecological benefits assessment endpoints projects (Action 3.1-8).

The EBAF could undertake other activities described in Section 3 within its primary role. These include:

- Providing advice on adapting and developing monitoring programs (Actions 3.2.1-1 and 2);
- Reviewing and disseminating methods for characterizing and measuring variability and uncertainty (Actions 3.2.1-4 and 5);
- Reviewing and disseminating available population models (Action 3.2.3-1); and
- Reviewing and disseminating supplemental approaches for policy analysis (Actions 3.2.5-1, 2 and 3).

The EBAF also could be the lead group for the Agency to coordinate the collection of ecological and socioeconomic data with other federal agencies (Action 3.3-3).

An Ecological Benefits Assessment Forum should be charged upon release of this Plan.

## 4.2 PROCESS

This Plan describes a series of broad actions that are meant to provide direction for the Agency to improve ecological benefits assessment. Defining specific activities, particularly supporting research, should be left to individual offices. Program Offices should develop Action Plans and research projects that address their specific needs but that also reflect the overall goal and actions described in this Plan. The Agency's research offices, ORD and OPEI, would then use these Action Plans, along with the EBASP itself and additional input from the Oversight Committee, to inform their research agendas.

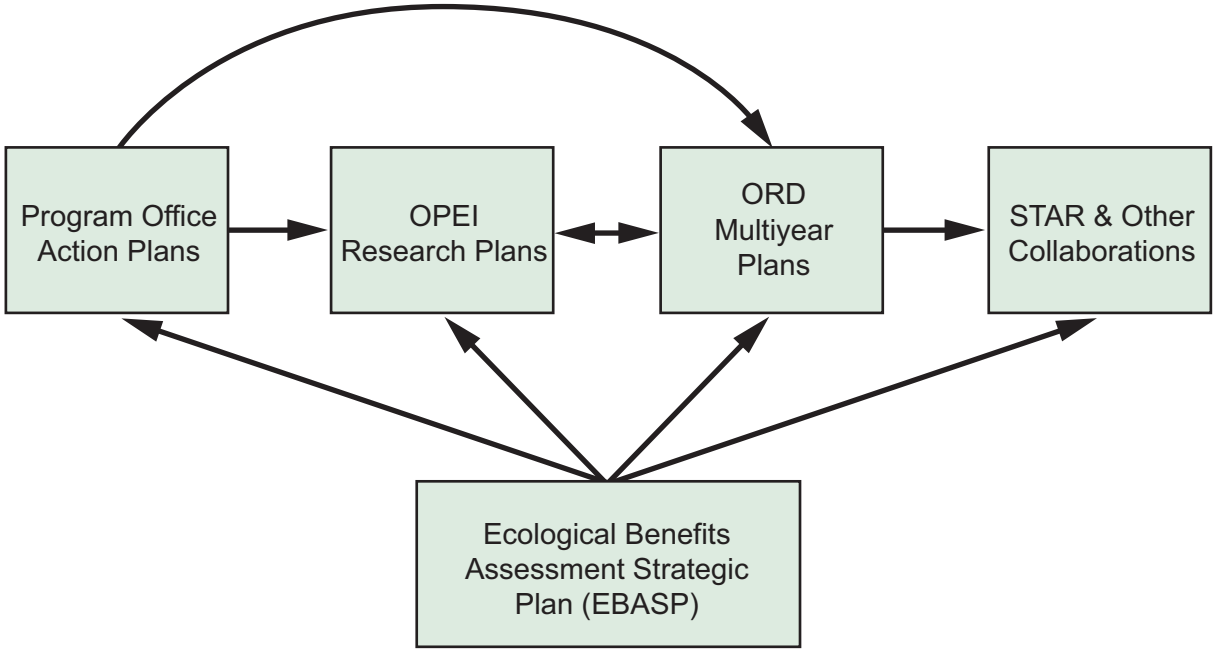


**Figure 3:** Research planning and implementation relationships.

Relationships among the planning activities in the Agency are illustrated in Figure 3. The EBASP can play a central role in communicating the overall goals and direction to improve Agency ecological benefits assessments. The Plan communicates broad actions that would lead to more rigorous, comprehensive, and interdisciplinary benefits assessments, and identifies the mechanisms that the Agency could use to facilitate implementation. Actual implementation will be supported through the development of Program Office Action Plans, research planning in ORD and OPEI, and interactions with external partners through STAR and other grant programs and coordination activities.

### 4.2.1 PROGRAM OFFICE ACTION PLANS

Individual EPA Program Offices operate under different statutory mandates and generally are concerned with different stressors, although the potential for substantial overlap exists in many instances. Different stressors, different media, and different regulatory authority imply that Program Offices will have different needs relative to ecological benefits assessment. At the same time, multiple offices may be concerned with a similar set of ecological endpoints that influence social welfare. Furthermore, many benefits assessments will have similar components regardless of which office conducts them. The differences will lie in the specifics of the policy and the stressors involved.

To help inform Agency efforts, each Program Office should create an Action Plan that identifies its needs for monitoring data, analytical methods, and targeted research. Plans should indicate short-term (1-2 years), medium-term (up to 5 years), and long-term requirements. Research activities should follow from the actions described in this Plan and indicate how they further programmatic and Agency goals. Action Plans would be considered by the Oversight Committee, which would identify cross-Agency priorities based on considerations like those noted in Section 4.1.1.

Research needs should reflect the office's statutory mandates and the office's mission under EPA's current Strategic Plan. These considerations will help articulate the office's regulatory and policy priorities. In addition to informing EPA's internal process for identifying priority research needs, the Action Plans can play a key role in communicating the Agency's needs to external researchers (Action 3.3-2). By placing research needs in context, the Action Plans may help encourage relevant studies in academic and other research institutions. Equally important, Action Plans should specify any new institutional arrangements that the office intends to make to foster interdisciplinary assessments and ensure rigorous assessments.

Development of Action Plans should be one of the first steps taken to implement the EBASP. Program Offices may use a number of mechanisms to develop their Action Plans, including the problem formulation workshops described in Action 3.1-5. Action Plans should be updated periodically to reflect evolving office needs and should be designed to assist the Oversight Committee in implementing the broad actions described in this Plan.

### 4.2.2 ORD AND OPEI RESEARCH

Broadly speaking, research conducted by the Agency can be described as problem-driven or core (USEPA 2001). Problem-driven research focuses on specific environmental problems reflecting immediate regulatory and policy requirements. Core research seeks to improve fundamental understanding of the key biological, chemical, physical, economic, and human behavioral processes that underlie environmental systems. Problem-driven and core research are not entirely separable. In fact, they are highly complementary and interactive. Both problem-driven and core research contribute to EPA's ability to conduct ecological benefits assessments by improving understanding of ecological and economic systems, and enhancing EPA's ability to quantify changes in those systems.

ORD focuses on developing the ecological and human health science and technology needed to fulfill EPA's mission. ORD engages in a multiyear planning process, which identifies and communicates the direction of its research program in 5- to 10-year time horizons. Planning is based on Agency priorities and needs,

direction from ORD senior leadership, and external advice. The ultimate goal of the planning process is the alignment of resources to best address the Agency's evolving needs.

NCEE, housed within OPEI, fulfills a mission similar to ORD's with respect to economic science. NCEE's mission is to advance the practice of economics within EPA by developing new economic methods and by promoting the use of established methods to new areas. NCEE provides assistance to other EPA offices through its research products, review of economic analyses of proposed EPA policies, and publication of economic guidance materials. NCEE works with ORD's grants funding program on a continuing basis to communicate research needs. Periodic workshops and seminars sponsored by NCEE also help disseminate EPA's research needs, original research by EPA staff, and EPA-funded research.

ORD and OPEI, based in part on the priorities communicated by the Oversight Committee, can use the EBASP and program-specific Action Plans to guide development of their research agendas. ORD and OPEI plans for research supporting ecological benefits assessment should be updated regularly as old goals are reached and new goals are established. ORD and OPEI should coordinate to: provide cross-disciplinary training (Action 3.1-2); provide technical support for problem-formulation workshops (Action 3.1-5); lead the development and adaptation of monitoring programs (Action 3.2.1-1 & 2), including coordination with external partners (Action 3.3-3); communicate research needs to external partners through STAR and other mechanisms (Action 3.3-1); support new publication outlets (Action 3.3-2); and lead EPA's efforts to facilitate data collection (Action 3.3-5).

## 4.3 CONCLUSION

Improving EPA's ability to conduct rigorous, comprehensive, and interdisciplinary ecological benefits assessments will take time and a strong commitment. EPA will need to facilitate interdisciplinary and cross-office communication, establish and communicate priorities, align resources across the Agency, and plan and conduct a variety of specific research efforts. Some of the strategic actions identified in the Plan can be implemented immediately, while others will require incremental changes in Agency practices and priorities. The Ecological Benefits Assessment Strategic Plan can be a helpful road map to guide continuous improvement in the Agency's ecological benefits assessments that support good decisionmaking using good science.

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# APPENDIX A
# CURRENT STATE OF AGENCY PRACTICE OF ECOLOGICAL BENEFITS ASSESSMENTS

During the past few decades, the Agency has made substantial progress in providing guidance and tools for conducting ecological and economic assessments, particularly with regard to ecological risk assessments and BCAs. In general, however, ecological and economic assessments at the Agency have been pursued independently for the most part. This appendix describes the Agency's current practice of ecological benefits assessment from a general perspective. It focuses separately on the activities of ecological assessments and economic benefits assessments, as these tend to be conducted separately even when ecological benefits are identified as being important during planning stages. Noted are some of the key challenges that ecological benefits analysts face as a result of this practice.

## A.1 ECOLOGICAL ASSESSMENTS

Ecological assessments at EPA take many forms, depending on the legislative mandates and decisions that they support. The forms include prospective risk assessments to evaluate environmental management options (e.g., for a proposed waste site or registration of a pesticide) and retrospective assessments of ecological impacts to diagnose their causes and to evaluate mitigation options (e.g., at a Superfund site). Also included are assessments of ecological responses to stressors (e.g., toxic substances) to support the development of environmental quality criteria (e.g., ambient water quality criteria) and assessments of environment monitoring data to document the condition of the nation's ecosystems (e.g., for EPA's Regional *State of the Environment* reports). In conducting ecological risk assessments, the Agency generally follows the principles outlined in its *Guidelines for Ecological Risk Assessment* (USEPA 1998a).

In conjunction with many other factors, ecological risk assessment plays an important role in Agency decisions. Ecological risk assessment is a process "used to understand and predict the relationships between stressors and ecological effects in a way that is useful for environmental decision making" (USEPA 1998a, pg 1). Figure A-1 shows a stylized representation of a standard ecological risk assessment at the Agency. This figure is consistent with the representation in the *Guidelines for Ecological Risk Assessment* (USEPA 1998a), but it has been generalized and simplified to focus on the key similarities and differences between ecological assessments and economic benefits assessments, which are depicted later in Figure A-2. The shaded box contains the stages of the assessment itself; the arrows from outside the box illustrate how ecological knowledge, methods, models, and data inform each stage.

Problem formulation, the first stage in ecological risk assessment, begins with information from the planning dialogue and includes several activities. Analysts determine the context and scope of the assessment, identify likely stressors and exposure pathways, and select *assessment endpoints* (USEPA 1998a). Assessment endpoints are the ecological entities and their attributes that have a clear relationship with risk management goals (USEPA 1998a, 2003b). Examples of such endpoints are trout abundance and richness of species in a fish community. Analysts then develop a *conceptual model* of the system in which they link the stressors to the endpoints via direct and indirect pathways, considering also the effects of other co-occurring stressors. Problem formulation concludes with the development of an *analysis plan* specifying the data and methods that analysts will use to assess ecological risks.

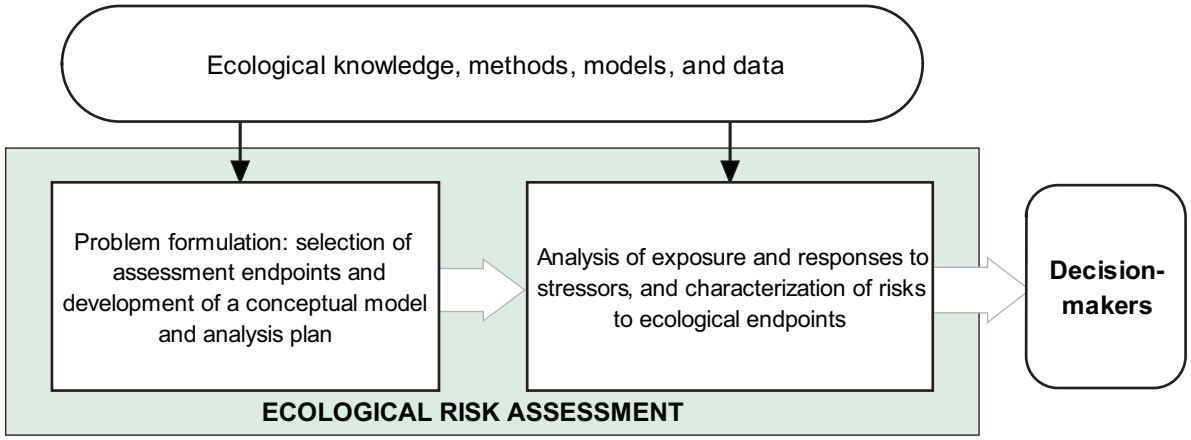


**Figure A-1:** Stylized representation of a standard ecological risk assessment.

The remainder of the ecological risk assessment involves analysis of ecological exposures and responses to exposure (effects) and characterization of risks to (or effects on) the assessment endpoints. Analysis of exposure entails an evaluation of the magnitude of co-occurrence of stressors and ecosystem components (e.g., organisms, populations, and communities) over time and space. Analysis of ecological effects requires the development of stressor-response profiles that describe the likely responses of those ecosystem components to such exposures. Analysis of effects generally is based on data from laboratory and field experiments or observational studies of the same or similar stressors on similar ecosystem components. Risk characterization integrates the exposure and effects assessments to estimate the potential for adverse effects on the assessment endpoints. Ecological risks are communicated to the decisionmakers together with interpretation of the significance of the risks, and possibly with recommendations for actions to mitigate effects, or with assessments of the effectiveness of different mitigation actions.

If the management goal is to protect against unacceptable adverse effects, a risk assessment may need only to identify a level of exposure below which such adverse effects are not expected to occur. In such cases, a full description of a stressor-response curve is not needed. This is the approach EPA currently uses to establish ambient water quality criteria and cleanup goals for Superfund sites (Stephan et al., 1985; USEPA 1997). Other management goals (e.g., the selection of best management options where some adverse effects cannot be avoided) may require an evaluation of changes in ecological endpoints in response to changes in exposure levels for different management options, and thus may need full stressor-response curve information. In these cases, estimated changes in the ecological assessment endpoints can be used to characterize the degree of risk reduction associated with alternative management actions.

Although the assessment process described above appears as a series of steps, the process is generally iterative, with information obtained during initial analyses informing refinements or re-evaluations of problem formulation and analysis plans. For detailed information on how the Agency conducts ecological risk assessments, see EPA's *Guidelines for Ecological Risk Assessment* (USEPA 1998a) and *An Examination of EPA Risk Assessment Principles and Practices* (USEPA 2004a).

The Agency also conducts ecological assessments using monitoring data that represent the condition of various ecosystem attributes (e.g., USEPA 1998b, 2004b). EPA can use that information to assess the effectiveness of Agency programs in achieving environmental improvements; identify emerging environmental issues; document changes in ecosystem condition caused by stressors beyond the Agency's immediate influence (e.g., changes in land use); and specify the baseline conditions against which the Agency should evaluate the results of its actions. These data also are intended to support the prioritization of areas and ecosystems for protection via enforcement actions and voluntary programs (USEPA 1998c).

EPA's primary monitoring efforts include its nation-wide EMAP and several regional EMAP efforts (R-EMAP). EMAP is a long-term research effort designed to assess ecosystem conditions and trends across the United States (USEPA 2002). In the Aquatic Resource Monitoring component—the only component implemented at the national level to date—EPA uses the physical, chemical, and biological measurements from specified EMAP sampling locations to develop indications of aquatic ecosystem condition. For more information on EMAP, visit EPA's EMAP Web Site.[1]

## A.2 ECONOMIC BENEFITS ASSESSMENTS

The overall goal of an economic assessment of ecological benefits is to predict the changes in people's well-being that result from changes in ecosystem services. The type of economic analysis that is performed depends on legislative mandates, the type of environmental issues being addressed, and the type of benefits in question. When data or methodological limitations preclude a comprehensive and reliable dollar estimate of ecological benefits, those benefits can be expressed quantitatively (i.e., in biophysical measurements) or even qualitatively. In these situations, an indication of the value of a resource, even absent estimates of change, can provide information to decisionmakers about its relative importance.

Figure A-2 provides a stylized representation of a standard economic benefits assessment of ecological changes as currently practiced at EPA. In general, the problem is defined by legislative statute or possibly by an ecological risk assessment. Once policy options are identified, it usually falls to Agency economists to estimate the benefits and costs of each option. The second stage of the economic benefits assessment is to determine the likely changes in ecological conditions resulting from each potential policy action. Often, the only sources of information readily available for predicting ecological changes are the risk assessment, if one was conducted prior to the benefits assessment, or existing studies in the literature.

In the third stage of the economic benefits assessment, changes in ecological conditions are monetized using one or more economic valuation methods. Economists generally attempt to estimate the value of ecological goods and services based on what people are willing to pay (WTP) to increase ecological services or by what people are willing to accept (WTA) in compensation for reductions in them. To enable a comparison of policy options, a common unit is needed to express the value of ecological goods and services. The dollar is the preferred unit for valuation, because there is an extensive body of literature addressing its application and interpretation and it is easily compared with costs for considering the net effects of alternative policy choices. Three primary approaches for estimating these values exist: market-based methods, revealed preference methods, and stated preference methods (USEPA 2000).

[1] http://www.epa.gov/emap

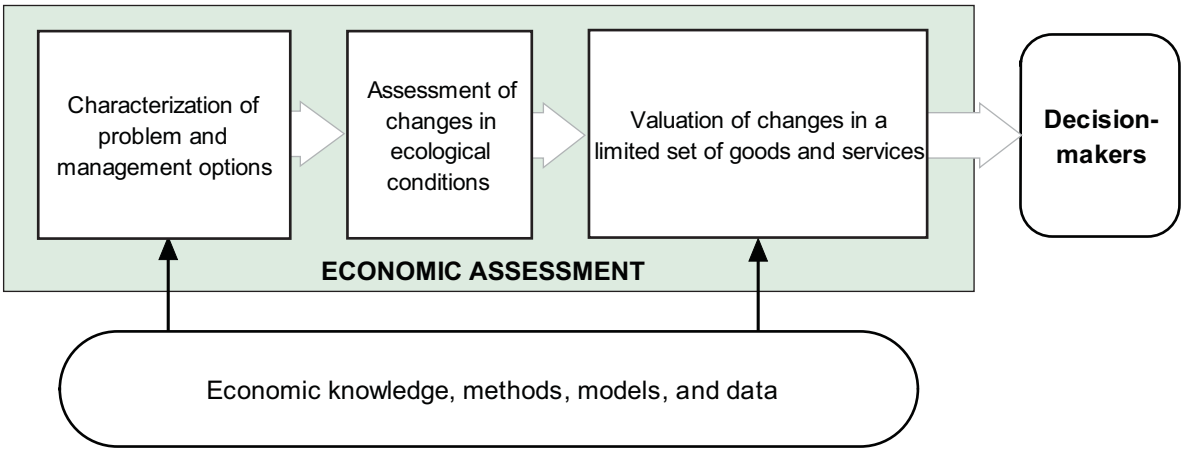


**Figure A-2:** Stylized representation of a standard economic benefits assessment.

Market-based valuation methods can be used to estimate the gains and losses to producers and consumers when ecosystem changes directly affect commercial activities (e.g., agriculture or commercial fishing). In the simplest cases, increases in commercial production can be valued at the price observed in the market. EPA has used market-based approaches for benefits assessments that include changes in ecosystem goods or services. One example is the *Economic Analysis of the Final Revisions to the NPDES and Effluent Guidelines for [Concentrated Animal Feeding Operations] CAFOs* (USEPA 2003a).

Revealed preference methods can be used to value ecosystem services that, although not bought or sold directly, are associated with goods or services traded in markets. These methods are based on the idea that people's behavior, even outside of well-established markets, reveals the value that they place on environmental goods or services. EPA used recreation-demand modeling, a type of revealed preference method, to evaluate actions under the Clean Water Act (CWA); an example can be found in the *Effluent Guidelines, Metal Products and Machinery Final Rule: Economic, Environmental, and Benefits Analysis* (USEPA 2003b).

Unlike revealed preference methods, which rely on observed behavior, stated preference methods elicit people's WTP or WTA from surveys that describe hypothetical situations. For example, survey respondents may be asked how much they would be willing to pay to be able to boat, fish, or swim in a lake where water quality problems currently prohibit such activities, but where various efforts at clean-up might achieve conditions that allow or favor those activities. Stated preference approaches are the sole means of estimating non-use values, such as existence value, because they are not associated with any observable functioning market. EPA has used the results of stated preference research in its economic analyses. For example, EPA relied heavily on a stated preference study of the value of visibility at national parks in its analysis of the 1991 regulation of sulfur emissions at an Arizona coal-fired power plant to improve visibility in the Grand Canyon (USEPA 1991). The study was funded by EPA and the National Park Service. A detailed description of the survey and its use in the economic analysis can be found in Morgenstern (1997).

The time and resources available for economic benefits assessments at EPA, however, are typically insufficient for conducting original economic valuation studies for each new assessment. Thus, benefits assessments often use values estimated for similar ecological goods and services from existing studies, a practice called "benefit transfer." Most EPA analyses rely on benefit transfer to some extent. Even the Grand Canyon

example cited on the previous page could be considered an example of benefit transfer. The values applied to visibility improvements at the Grand Canyon in the winter months were initially developed as estimates of improvements in average visibility conditions over all seasons at all national parks in California, the Southwest, and the Southeast. For more information on how the Agency conducts economic benefits assessments, see EPA's *Economic Guidelines* (USEPA 2000).

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# APPENDIX B
# PAST AND CURRENT EPA EFFORTS TO IMPROVE ECOLOGICAL BENEFITS ASSESSMENTS

In recent years, EPA, other federal agencies, and a number of nongovernmental organizations have participated in collaborative efforts designed to improve the state-of-the-science and practice of ecological benefits assessment. These efforts have included original research, workshops and symposia, case studies, discourse among organizations, and the development of guidance for Agency staff. The EBASP builds on these past and current efforts by identifying institutional changes and actions to advance the Agency's capabilities in assessing ecological benefits. This Appendix briefly describes important past and current efforts in this area, and in doing so, provides some of the rationale for the development of the EBASP. It also describes the key features of this Plan that distinguish it from other efforts.

## B.1 PAST EPA AND OTHER EFFORTS

In 1981, the President issued Executive Order 12291, which directed federal agencies to assess the costs, benefits, and economic impacts of their major regulations and established a formal review process by Office of Management and Budget (OMB). To assist Agency analysts in meeting OMB requirements, EPA issued its *Guidelines for Performing Regulatory Impact Analyses* (or *RIA Guidelines*, USEPA 1983), which provide a brief description of what was required for assessing costs, benefits, and economic impacts of Agency policies and actions. The *RIA Guidelines* were updated in 1991 with several appendices including the *Analysis of Benefits*, which provide general recommendations on methods of estimating benefits in several categories, including: human health; agriculture, fisheries, and silviculture; materials; recreation; aesthetics; and ecosystems (USEPA 1991). For the last category, the *RIA Guidelines* acknowledge that "estimating the benefits (or damages averted) of environmental regulations that affect ecosystems is perhaps the most complex problem in benefits analysis" (p. A-19). The *RIA Guidelines* further note that many ecosystem service flows may not be apparent, are difficult to understand, and are difficult to measure with conventional economic methods (p. A-20).

Some offices within EPA developed more detailed guidance to help staff conduct economic valuations of at least some ecological changes. For example, in 1990, the Office of Marine and Estuarine Protection (OMEP) and the Office of Policy, Planning, and Evaluation (OPPE) published *The Economics of Improved Estuarine Water Quality: An NEP [National Estuary Program] Manual for Measuring Benefits* (USEPA 1990a). This manual provides guidance on using standard economic valuation techniques to monetize ecological benefits such as recreational swimming, fishing, and boating, and commercial fishing. Around the same time, the Office of Policy Analysis (OPA) was supporting the development of techniques for estimating economic values for a wider range of ecosystem services, including many that typically are overlooked, such as pest and disease control, pollination, microclimate control, and nutrient cycling (draft final report *Ecosystem Services and Their Valuation*, USEPA 1990b).

In its 1990 report *Reducing Risk: Setting Priorities and Strategies for Environmental Protection*, the EPA SAB stated that the value of natural ecosystems was inadequately considered in setting priorities at EPA and insufficient for EPA decisionmaking in general (USEPA 1990c). The SAB identified two key problems: (1) the focus of current economic models on structural attributes of ecosystems rather than ecosystem functions

and relationships, and (2) the fact that current ecological models generally do not describe the "services" of ecosystems. In that report, the SAB recommended that EPA "develop improved analytical methods to value natural resources and to account for long-term environmental effects in its economic analyses" (USEPA 1990c).

Partly in response to SAB's recommendations, OPPE established an Ecosystem Valuation Forum in 1990. A key purpose of the Forum was to assist EPA "in overcoming piecemeal approaches to incorporating ecosystem values into a benefit/cost framework" (Brody and Kealy 1995, p. 67). Its objectives were to improve existing methods and develop new methods for valuing ecosystem services. During 1991 and 1992, the Forum met in a series of public workshops and identified many challenges to valuing ecosystem services, including the limited understanding of the many complex relationships between ecosystems and human well-being. The outcome of this effort was published in a special issue of *Ecological Economics* (1995, Vol. 14) and recommended that economists and ecologists collaborate on additional case studies as a next step in the process of improving ecological benefits assessments. Changing priorities and Agency reorganizations led to the discontinuation of the Ecosystem Valuation Forum.

The issuance of Executive Order 12866 on regulatory planning and review in 1992 reaffirmed requirements for the analysis of social benefits and costs for significant regulatory actions. In addition to those requirements, economic assessments are called for under various administrative statutes (e.g., *Unfunded Mandates Reform Act of 1995*). Recognizing the importance of high-quality economic analysis, in 2000, OMB released its *Guidelines to Standardize Measures of Costs and Benefits and the Format of Accounting Statements* (USOMB 2000).

In 2000, EPA significantly updated and revised its *RIA Guidelines* by publishing the *Guidelines for Preparing Economic Analyses* (USEPA 2000a). The *Economic Guidelines* incorporate the advancements in techniques for benefits estimation, different economic models for assessing costs and other effects, and the greatly expanded data sources and related guidance materials developed since 1983. With respect to ecological benefits, the *Economic Guidelines* provide a categorization scheme based on how directly benefits are experienced by the public and how the benefits relate to the private good/public good continuum. That categorization is intended to help analysts identify which monetary valuation techniques are applicable in different situations. The *Economic Guidelines* assume implicitly that the necessary quantitative information on changes in ecological conditions, processes, and service flows can be provided by ecologists and other natural scientists.

In 2000, the SAB published *Toward Integrated Environmental Decision-Making*, a followup to its 1990 *Reducing Risk* report, which provided a conceptual vision for "the next step" in environmental protection for the United States (USEPA 2000b). The report describes some important considerations for public environmental decisionmaking and the need for broad participation in the decisionmaking process. The SAB recommended that "when evaluating risk reduction options, EPA should strive to weigh the full range of advantages and disadvantages, both those measured in dollars as costs and benefits and those for which there may not be a comprehensive dollar measure, such as sustainability and equity" (USEPA 2000b, p. 39, Recommendation 5). The SAB further recommended that "EPA should seek and develop methods to characterize public values and incorporate those values into goal-setting and decision-making" (USEPA 2000b, p. 40, Recommendation 6).

As a step toward implementing this recommendation, EPA sponsored a public workshop, *Understanding Public Values and Attitudes Related to Ecological Risk Management*, which brought together experts from ecology, economics, psychology, decision science, and anthropology to consider a specific case study (USEPA 2001). The case study chosen for evaluation was nitrogen deposition in Tampa Bay, because data on the ecological services necessary to support economic valuation already had been collected. The centerpiece of the workshop was a series of presentations on research approaches to assess public environmental values associated with the Bay. The workshop took a preliminary step toward implementing one of the suggestions in the SAB report *Toward Integrated Environmental Decision Making* by creating a forum for open discussion on the topic of natural resource valuation. The workshop affirmed that the goal of understanding public values requires the use of social science approaches, which must be selected according to context and fully integrated with the environmental science of the valuation problem.

In 2002, EPA published *A Framework for the Economic Assessment of Ecological Benefits* (USEPA 2002), which was developed by an EPA Science Policy Council workgroup. The *Ecological Benefits Framework* outlines a process by which ecologists and economists can conduct and coordinate an ecological benefits assessment. The steps of an economic benefits analysis, as identified in the *Economic Guidelines*, are matched and associated with the steps of an ecological risk assessment as outlined in EPA's *Guidelines for Ecological Risk Assessment* (USEPA 1998). The *Ecological Benefits Framework* describes a process for conducting assessments of ecological benefits, which assumes that the necessary methods, models, and data are available. Because gaps exist in the state-of-knowledge and available assessment tools, implementation of the *Ecological Benefits Framework* in many cases will require the development of new tools and data. Furthermore, implementing the *Framework* requires that ecological risk assessments provide all of the necessary information for a benefits, which assessment. Risk assessments and benefits assessments, however, often are conducted for different purposes, so in many cases additional ecological analyses will be required to provide all of the necessary information for a benefits assessment.

In 2003, EPA's Office of Research and Development (ORD) published *Integrating Ecological Risk Assessment and Economic Analysis in Watersheds: A Conceptual Approach and Three Case Studies* (USEPA 2003a), which describes ecological risk assessments conducted in three watersheds, followed by economic analyses. The report discusses the successes and shortcomings of attempts to integrate the ecological and economic analyses for each watershed, and it recommends a conceptual approach for integration that could be used in future watershed management efforts. This conceptual approach is similar to that laid out in the *Ecological Benefits Framework*, except that it focuses on local or regional, as opposed to national, decisionmaking and is not limited to the BCA context.

Other federal agencies also have been addressing the challenge of valuing ecological benefits (e.g., NMFS 2000; USACE 1995, 1996, 2003; USDA 1999, 2002; USDOE 1995; USFWS 1985, 1995). For example, in 2001, the U.S. Army Corps of Engineers (ACE) sponsored a workshop on *Improving Environmental Benefits Estimation*, which included representatives from EPA and several other federal agencies. The workshop was part of its overall strategy to improve environmental benefits estimation in its assessments of ecological restoration and multi-purpose projects. One of ACE's goals in holding the interagency workshop was to encourage multi-agency participation in the strategy. ACE has developed a white paper, *Improving Environmental Benefits Analysis*, articulating its strategy (USACE 2003). ACE recognizes that before it can value many of the ecological benefits resulting from its projects, it must invest in long-term research efforts and policy development.

In its revised guidelines for regulatory analysis, *Informing Regulatory Decisions: 2003 Report to Congress on the Costs and Benefits of Federal Regulations and Unfunded Mandates on State, Local and Tribal Entities* (USOMB 2003), OMB discusses ecological benefits in a section entitled *Benefits and Costs that are Difficult to Quantify.* OMB recommends that with BCAs, analysts should present not only monetized benefits, but also any relevant quantitative information and descriptions of unquantified ecological effects.

## B.2 RELATIONSHIP OF EBASP TO ONGOING EPA EFFORTS

A number of ongoing EPA activities and initiatives are aimed at improving the valuation of ecological benefits. In 2003, the SAB convened a *Panel on Valuing the Protection of Ecological Systems and Services.* The purpose of the Panel is "to provide advice to strengthen EPA's approaches for assessing the costs and benefits of actions designed to protect ecological systems and services, to identify research needs to improve how ecological resources are valued, and to support decision-making to protect ecological resources."[2] In addition, the SAB Council, which advises EPA on its assessments of the benefits and costs of the Clean Air Act, has formed an Ecological Effects Subcommittee to guide EPA in quantifying additional ecological benefit categories.

EPA's National Center for Environmental Research (NCER) and National Center for Environmental Economics (NCEE) recently have released their draft *EPA Environmental Economics Research Strategy* (EERS) (USEPA 2003b). The EERS identifies EPA's highest priority research needs in environmental economics, describes the short- and long-term research objectives for each need, describes the resources and tools needed to achieve those objectives, and suggests a timeframe to meet the objectives. The EERS was developed in cooperation with EPA's program and regional offices. Interviews conducted to identify top priorities for the EERS revealed ecological benefits valuation as one of the areas of greatest need. The EBASP complements the EERS by articulating research needs for ecological benefits assessment.

Through its Science To Achieve Results (STAR) grants program and other research mechanisms, ORD is continuing to support research through the Valuation for Environmental Policy[3] grants program, as well as a number of other areas that have the potential to advance methods and data for conducting ecological benefits assessment.[4] Recent solicitations for grants have requested research on ecological classification, monitoring, and indicators, and frequently have focused on aquatic resources. The EBASP will assist ORD in defining key research areas related to ecological benefits valuation.

NCEE and OW, together with the U.S. Department of Agriculture and the U.S. Department of the Army, cosponsored a National Research Council (NRC) project on *Assessing and Valuing the Services of Aquatic Ecosystems.* The NRC committee of academic experts was charged with evaluating methods for assessing services, including intangible ones, and the associated economic values of aquatic and related terrestrial ecosystems. The final report (NRC 2004) focuses on existing economic methods to value ecosystem services quantitatively in support of improved environmental decision-making, including in situations where ecosystem services can be only partially valued. The report also calls for greater collaboration between ecologists and economists in such efforts (NRC 2004).

[2]http://www.epa.gov/sab/panels/vpesspanel.html

[3]Prior to 2003, this was known as the *Decision-making and Valuation for Environmental Policy* program.

[4]http://cfpub.epa.gov/ncer_abstracts/index.cfm/fuseaction/research.search/rpt/abs/type/3

## B.3 THIS EFFORT AND LOOKING FORWARD

The efforts described earlier in this section demonstrate that EPA and other agencies consider improving ecological benefits assessment to be a high-priority need. Several of those efforts were initiated and conducted as independent actions by specific EPA offices, with expectations for next steps and procedures for implementation largely left undocumented. As a result, follow-up activities often did not occur. The preceding material indicates the clear need for improved capabilities in ecological benefits assessment across EPA offices. An Agency-wide mechanism to address this need, however, has not yet been established; because of shifting Agency priorities and reorganization of the single sponsoring office, the Ecosystem Valuation Forum was short-lived, and therefore could not guide the Agency along a sustained and organized effort. Confounding this situation is the near-exclusive focus by past and ongoing activities on economic methods.

The EBASP is intended to improve this situation by devising a road map of actions that will help the Agency steadily improve its ability to identify, quantify, value, and communicate the ecological benefits of its policies. The Plan recognizes that past efforts have been valuable, but also that much work remains to be done. The EBASP distinguishes itself from other efforts by describing and advocating an interdisciplinary approach to ecological benefits assessment, as well as identifying research activities and institutional changes that will improve the Agency's capabilities in this area. The EBASP also provides an implementation approach to help ensure that improvement efforts are sustained.

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